RADIOLARIAN DISTRIBUTION IN CENTRAL INDIAN OCEAN BASIN SEDIMENTS AND ITS PALEOCEANOGRAPHIC SIGNIFICANCE

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BY

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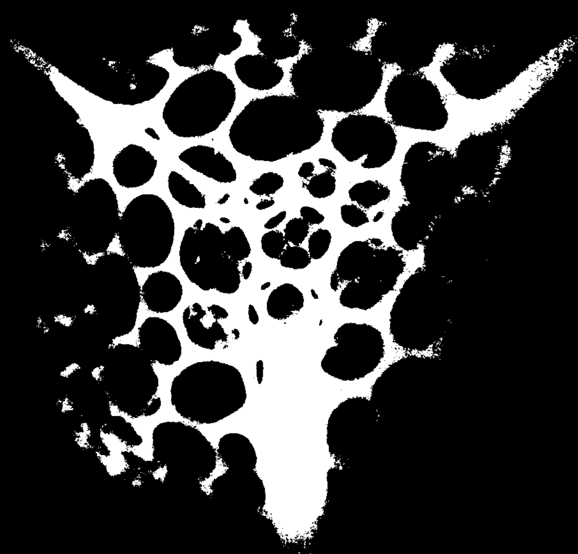

By

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November, 1991

DEDICATED

TO

MY PARENTS

STATEMENT

As required under the university ordinance 0.413, I state that the present thesis entitled *"RADIOLARIAN DISTRIBUTION IN THE CENTRAL INDIAN OCEAN BASIN SEDIMENTS AND ITS PALEOCEANOGRAPHIC SIGNIFICANCE"* is my original contribution and that the same has not been submitted on any previous occasion. To the best of my knowledge the present study is the first comprehensive study of its kind from the area mentioned.

The literature concerning the problem investigated has been cited. Due acknowledgements have been made wherever facilities have been availed of.

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CHAPTERS

PREFACE

In the field of marine geology India has achieved distinction by demarcating the manganese nodule mine site south of equator in the Central Indian Ocean Basin. Survey of polymetallic nodules, commonly known as manganese nodules, was initiated in 1980 by the National Institute of Oceanography, Dona Paula, Goa 403004 with the financial support from the Department of Ocean Development, New Delhi. The project got momentum in the mid-eighties and since then the author has been active participant of the program. Under this project sediment samples were collected from the Central Indian Ocean Basin in order to study the various geological aspects.

The work presented in the thesis encompasses (i) distribution of radiolarian microfossils in the surface sediment samples and (ii) delineation of environmentally dominant radiolarian assemblages within the basin. The work is distributed in eight chapters and details of each chapter is summarized as follows :

The first chapter deals with general introduction of radiolaria, its habitat and uses in marine geological studies, especially the oceanographic changes in geological past. Status of radiolarian data from the surface sediment of Indian Ocean is summarized. The main objective of present study is to quantify the radiolarian data in surface sediment from the Central Indian Ocean Basin, which was lacking so far.

The second chapter deals with historical resume of radiolarian studies in Indian Ocean in general and the Central Indian Ocean Basin in particular. Status of radiolarian studies in the Indian Ocean has been dealt by summarizing earlier works and emphasis is given to the Central Indian Ocean Basin. The basin has been poorly studied in term of surface sediment sample coverage and existing radiolarian data is of qualitative to semi-quantitative nature. Main objective of the thesis is to quantify it and to identify the dominant radiolarian assemblages within the basin, which could be useful in paleoceanographic studies.

The third chapter deals with physiographic and oceanographic setting and sediment types of the Indian Ocean in general and Central Indian Ocean Basin in particular. Surface and sub-surface currents, hydrographic fronts, and bathymetric features of the basin are dealt in detail in order to understand the modern oceanographic parameters existing within the basin and their influence on the radiolarian distribution in surface sediment.

The fourth chapter contains details of onboard sample collection, laboratory procedure to prepare the randomly settled radiolarian slides for the radiolarian counts per gram of dry sediment. The statistical methods used for analyzing quantitative data such as R-mode cluster and Q-mode factor analyses for the identification of statistically significant radiolarian assemblages are summarized briefly in this chapter.

The fifth chapter deals with the taxonomy, systematics of the species and the coarser taxonomic framework for the morpho-groups for the quantification of the radiolarian data. Forty-seven radiolarian morpho-groups were counted in 42 surface samples in order to evaluate the dominant assemblages in the basin. Morpho-groups of radiolaria are dealt in detail and a coherent scheme is framed up before the counting on the basis of widely used concept of coarser taxonomic framework for paleoceanographic studies.

The sixth chapter deals with results and discussion of the study in detail, they are as follows :

1. Radiolarian numbers per gram dry sediment (Rads/g) is obtained which indicates that region near 10^{0}S in the basin is comparatively rich in radiolarian numbers/g.

2. Nassellarian versus Spumellarian ratio varies significantly within the basin.

3. A total of 250 radiolarian species are identified and illustrated in 18 plates. Hundred and seventeen radiolarian species are recorded for the first time from the surficial sediments of the Indian Ocean.

4. Forty-seven morphogroups based on the morphological similarities of the genera and sub-families are framed up in order to obtain a quantitative faunal composition. The percentage data of all forty-seven groups are presented in the Table.

5. R-mode cluster analysis resulted into three major clusters which represent water column characteristics. Q-mode factor analysis resulted into four faunal assemblages. Their distribution within the basin and relation to the oceanographic parameters are discussed in detail.

The seventh chapter deals with the paleoceanographic significance of the present investigation.

Radiolarian factors are compared with assemblages of their siliceous counterpart diatom in the Indian Ocean (Burckle, 1989). Comparison shows good agreement with the diatom distribution and their relation to the oceanographic parameters.

The eighth chapter summarizes the conclusions.

This follows the references cited in the text and explanation to the plates.

ACKNOWLEDGEMENTS

I extend my sincere thanks to Dr. Rajiv Nigam, who has not only introduced and inspired me to the fascinating world of radiolaria, but also keenly guided during entire study. His scholarly insight and thought provoking discussions have completed this thesis from scratch to finish. I am ever indebted to him for his patience on various stages of this study and his encouragements without which the work was quiet difficult.

I express my sincere gratitude to Late Dr. H.N. Siddiquie, the former Director, National Institute of Oceanography, Goa, who extended his generous support to procure radiolarian literature in microfiches (since 1835-1982) from Dr. W.R. Riedel, Scripps Institute of Oceanography, California, without which the task was next to impossible. I also thank to the present Director, Dr. B. N. Desai and to Head of the Geological Oceanography Division, Dr. R.R. Nair, for the facilities and continuous encouragement. Thanks are extended to Prof. T.S.S. Rao, Prof. U.M.X. Sangodkar, and Dr. G.N. Naik for their kind co-operation and support at the Department of Marine Science, Goa University.

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dominance of diatom and radiolarian factors in the region.

CHAPTER 1

1.0 INTRODUCTION

Radiolaria are the unicellular, siliceous, protozoan microplanktons inhabiting in exclusively oceanic and marine environment. Although they inhabit in almost all depths, their abundance maxima mostly coincides with chlorophyll-a maxima in water column. They are colonial, solitary, symbiont, herbivorous, bacterivorous, carnivorous, scavengers and deposit feeders with a wide range in their habitat and food (Anderson, 1983). Kling (1979) reported that majority of the radiolarians prefer upper few hundred meters of water column and after that their abundance decreases drastically. They are the chief microfossils in the siliceous oozes of the world oceans and constitute major part of the preserved silica in fossil record, followed by diatoms and silico-flagellates. Due to their high species diversity, survival through lysocline and various assemblages associated to the characteristic water masses, they have been used world wide in biostratigraphic, biogeographic, paleoclimatic, and paleoceanographic investigations of the oceanic sediments.

The Indian Ocean is poorly studied, compared to the Pacific and Atlantic ocean in term of statistically analyzed quantitative data (Dinkelman, 1974; Molina Cruz, 1977a, b; 1984; Moore, 1978; Moore *et al*. 1980; Morley, 1977; 1979; Pisias, 1986) from the surface sediment as for as radiolaria are concerned. Nigrini (1967), Petrushevskaya (1967) and Johnson and Nigrini (1980, 1982) studied radiolaria in the surface sediment samples from the Indian Ocean, but mostly their work is of qualitative nature. Lozano and Hays (1976), Dow (1978) and Morley (1989a) have made quantitative estimates of radiolarian species/groups in the surface sediment samples from southern Indian Ocean (south of 20^0S). Morley (1989a) classified the radiolarian fauna into 4 assemblages (factors) by using Q-mode factor analysis. In order to obtained transfer functions, these assemblages were regressed into present day summer and winter sea surface temperature of the overlying surface water. Morley (1989b) has further used these transfer functions while studying down core variations in radiolarian fauna and reconstructed the paleoceanography of the region.

As evident from above, the statistically significant quantitative radiolarian data from the surface sediments does not exist north of 20^0S, an attempt has been made to quantify it from equator to 16^0S in the Central Indian Ocean Basin in present study and to identify the extent of water masses present within the equatorial Indian Ocean.

The National Institute of Oceanography, Goa, with the financial support from the Department of Ocean Development, New Delhi, had launched an ambitious project of polymetallic nodule exploration in the Central Indian Ocean Basin. Author had participated in this project actively and took this opportunity to obtain 42 surface sediment samples collected from this region to study radiolarian distribution. It is hoped that this modest beginning (confined to region between equator to 16°S) will enhance the quantitative data base, which was lacking so for.

CHAPTER 2

2.0 HISTORICAL RESUME

In this chapter a brief account on the status of radiolarian studies of the surface sediment from the Indian Ocean with special reference to the Central Indian Ocean is summarized to understand the present research problem.

2.1 RADIOLARIAN RESEARCH IN THE INDIAN OCEAN WITH SPECIAL REFERENCE TO THE CENTRAL INDIAN OCEAN BASIN

Although occurrences of radiolaria in the surface sediment can be traced dating back to 1872, when Ehrenberg encountered radiolaria for the first time in a single sediment sample, the first comprehensive study of radiolaria from the Indian Ocean is of Nigrini (1967). Therefore radiolarian literature of the surface sediment from the Indian Ocean can be classified into two eras i.e. pre and post of Nigrini (1967). Ehrenberg (1872a), Haeckel (1887), Murray (1910), Schott (1939), Keunen (1939), Riedel (1951 a,b), Olausson (1960), Bezrukov (1964), and Hays (1965) are the historical works of pre-Nigrini (1967) era. In present section post-Nigrini (1967) contributions are summarized. Nigrini (1967) identified 45 radiolarian species in 32 surface sediment samples primarily from middle and low latitudes in the Indian Ocean. Out of these 32 surface samples, only four were from the Central

Indian Ocean Basin. Using rank difference of frequency distribution and absolute abundance as the measure, she identified two assemblages i.e. (i) a low latitude assemblage comprising of 12 species extending from 10^0N to 20^0S and (ii) a mid latitude assemblage comprising of 7 species dominating over an area between 35^0-45^0S. She suggested that these two assemblages are separated by a region barren of radiolaria, which corresponds to the subtropical anticyclonic gyre in the Indian Ocean. Contemporarily, Petrushevskaya (1967) identified 75 species in 70 core-top samples scattered from Bay of Bengal to the Antarctic continental margins (on one transact only) and identified five zoogeographic provinces in the Indian Ocean represented by a distinct group of radiolaria. Later, she (1971a) suggested that out of five groups, only two can be used as indicators of specific water masses in the tropical and high latitudes of the Indian Ocean. Lozano and Hays (1976) worked on radiolarians from western antarctic sector of the Indian Ocean and identified antarctic, subantarctic, and subtropical water masses using Q-mode factor analysis of the percentage data of radiolarian species counted in surface sediment samples. Dow (1978) counted 52 radiolarian species/groups in 36 core-top samples from the southeastern Indian Ocean (40-65^0S). Out of 52 radiolarian species counted, only 35 were grouped into 4 distinct assemblages by analyzing the quantitative data using Q-mode factor analysis. Dow (1978) formulated regression equations related to the distribution of three factors which were attributed to the summer and winter sea surface temperature of the region.

Johnson and Nigrini (1980, 1982) recorded "the presence and absence of 74 radiolarian species" in 120 surface sediment samples from entire Indian Ocean extending from 20^0N to 50^0S of equator and from off Australia to off east Africa. By using qualitative data they were able to identify 6 recurrent groups and 9 radiolarian assemblages, and concluded a "marked east-west asymmetry in faunal distribution across the Indian Ocean". Recently, Morley (1989a) identified 42 radiolarian species in surface sediment samples from $20-60^0$S in southern Indian Ocean. He lumped couple of species under single morpho/taxonomic group for counting, because many of them have similar biogeographic provinces apart from "their highly variable morphology and apparent tendency to intergrade". He identified 4 faunal assemblages i.e. the transitional, antarctic, subantarctic and subtropical for southern Indian Ocean by analyzing quantitative data using Q-mode factor analysis.

2.2 SCOPE FOR PRESENT INVESTIGATION

The above literature survey indicates that southern Indian Ocean has statistically sound quantitative database on radiolarian species / groups from the sediment samples (Fig. 1), which is well correlated not only to oceanographic water masses and parameters of southern ocean but also helpful in quantifying summer and winter sea surface temperature of the region (Morley, 1989a). Whereas, northern Indian Ocean has qualitative (presence or absence) to semiquantitative data from surficial sediment samples, which although indicates a trend in water masses, can not be used in assessing the oceanographic variation in geological past due to its qualitative nature. It indicates the need of statistically significant quantitative data for northern Indian Ocean as well. Moreover, as for as the Central Indian Ocean Basin is concerned, even the presence or absence data of Johnson and Nigrini (1980, 1982) is limited to the 46 radiolarian species in 12 core top sediment samples, which is very scanty considering the area of the basin (Fig. 1). Recently, Sharma and Mahapatra (1990) tabulated relative abundance of 92 species in eight latitudinally distributed surface sediment samples from the Central

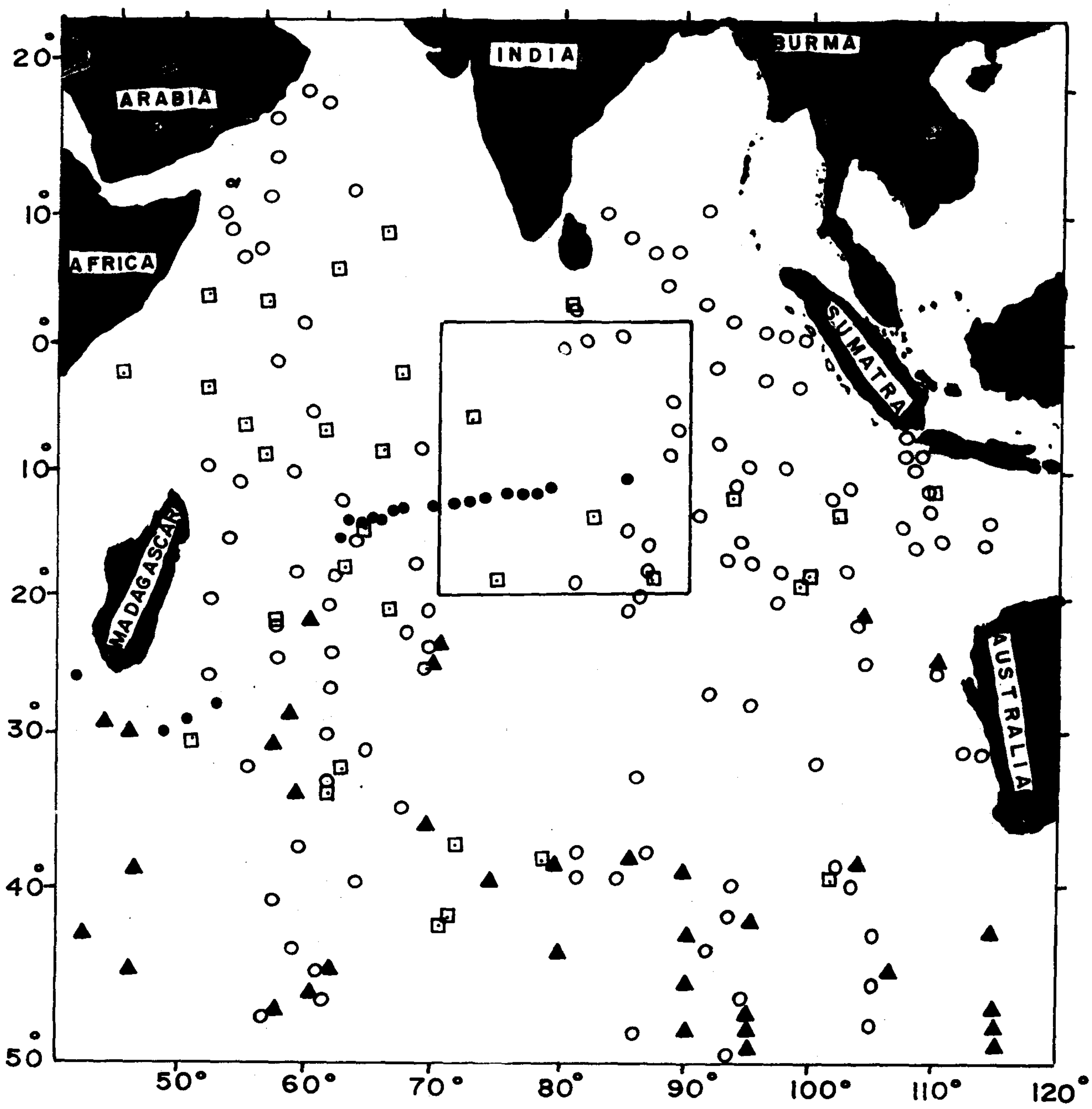


Figure 1. Status of radiolarian data from the surface sediment samples from the Indian Ocean : ▣ = absolute abundance data of Nigrini (1967); o = presence or absence (qualitative) data of Johnson and Nigrini (1980, 1982); • = semiquantitative data of Sharma and Mahapatra (1990) and ▲ = quantitative data of Morley (1989a). Inset outlined area is the area of present study which shows poor sample coverage and qualitative to semiquantitative nature of data available on radiolaria from the surface sediments. (figure modified after Johnson and Nigrini, 1982).

Indian Ocean Basin (hereafter Central Indian Basin), which represents only a part of the basin.

In view of above, 42 surface sediment samples collected as a part of the Survey of Polymetallic nodules program in the Central Indian Basin, sponsored by Department of Ocean Development, New Delhi, are utilized for counting the radiolarian species groups, in order to quantify the data in similar manner. So that quantitative data base can be made available for the region at least between equator to 16^{0}S, which was lacking so for.

In addition to surveys for the exploration of polymetallic nodules and achieving the "claim of manganese nodules mine site", number of surface sediment samples collected under this program were used for mineralogical, sedimentological, geochemical and paleontological studies (PMN Bibliogr. 1991). The paleontological studies are confined to three reports, i.e. one on Quaternary radiolarian biostratigraphy of two short cores (Gupta, 1988) and two on the phosphatic microfossils "the ichthyoliths" from nuclei and substrates of the nodules and crusts (Gupta, 1987, 1991). In view of the limited time available, only systematics and distribution of radiolarians in the basin and their paleoceanographic significance are attempted in this study.

CHAPTER 3

3.0 PHYSIOGRAPHIC AND OCEANOGRAPHIC SETTINGS

In order to understand the spatial distribution of radiolaria in the surface sediments from the Central Indian Basin, the physiographic, oceanographic and environmental parameters of the northern Indian Ocean with special reference to the Central Indian Basin are summarized in this chapter.

3.1 INDIAN OCEAN

3.1.1 PHYSIOGRAPHY, REGIONAL SETTING AND SEDIMENT TYPES

Indian Ocean is bounded by the southern margin of Asia, eastern margin of Africa, western margin of Australia and northern limit of Antarctica, constituting world's third largest ocean. Indian Ocean, compared to the Pacific and Atlantic Oceans, is quite young and is the result of fragmentation of Gondwanaland. Displacement of India, Australia, Africa, and Antarctica from their original places (since <120 Ma) is due to the mid Indian Ocean Ridge, Carlsberg Ridge, SE Indian Ridge, Broken Ridge, 90^{0}E Ridge, which constitute major physiographic features of the Indian Ocean (Fig. 2). This complex physiography plays a major role in the variation of surface and bottom water currents, and hydrographic

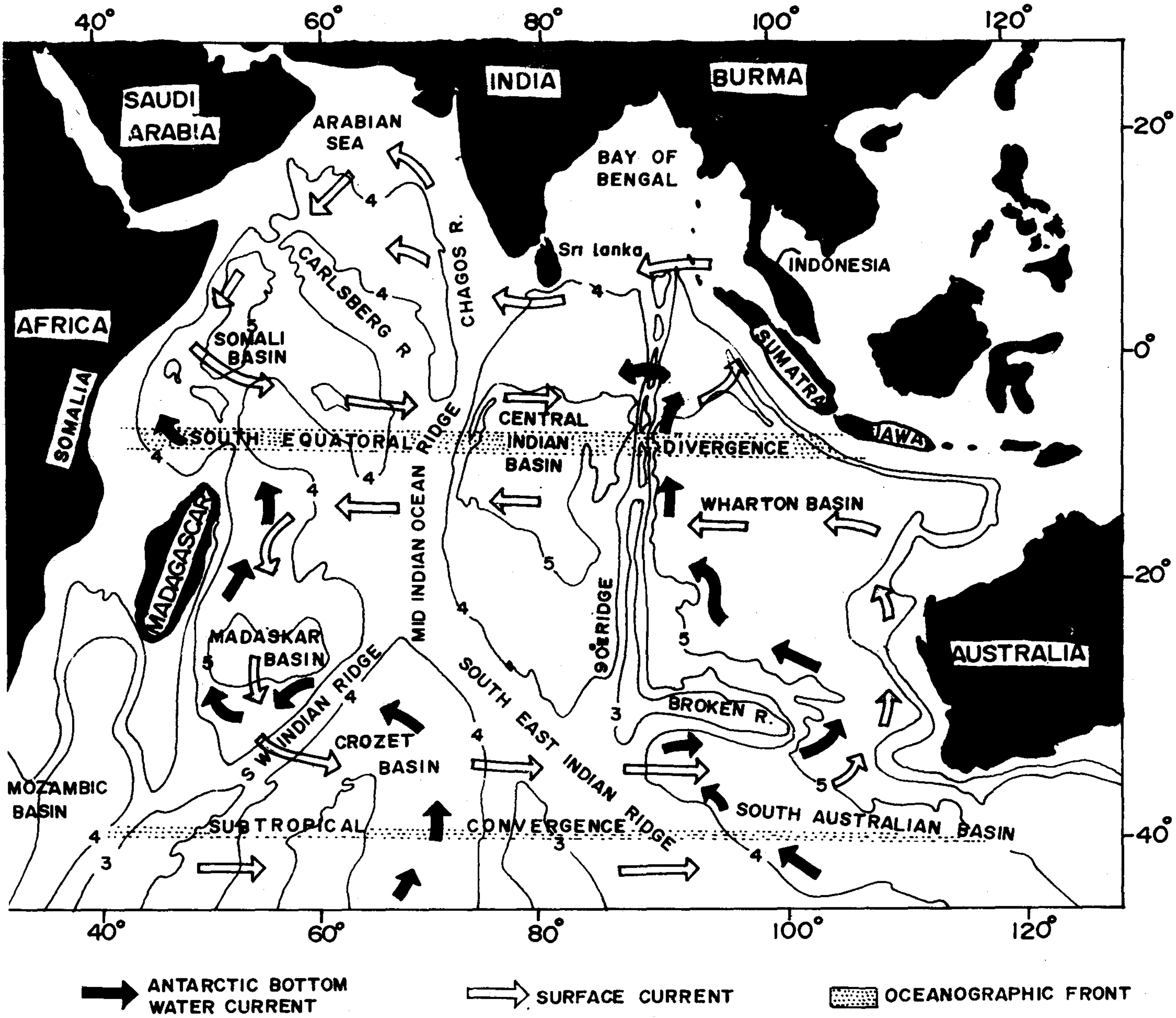


Figure. 2 Physiography and oceanographic settings of the Indian Ocean [compiled after Johnson and Nigrini, (1980, 1982)]. Contours are in km. Open arrows denotes principal surface currents during NE monsoon; filled arrows indicate path of Antarctic Bottom Water (AAWB) Current (Warren, 1974, 1978; Johnson and Damuth, 1979). AABW enters in the Central Indian Basin through the deeper saddles in 90^0E ridge near $3\text{-}5^0$S latitudes. Major frontal zones shown indicate south equatorial divergence, subtropical convergence in Indian Ocean. Bathymetric contours are in km.

fronts in the Indian Ocean. As this ocean is almost land locked from three sides i.e. east, north and west, it receives huge amount of terrigenous sediments and have world's largest and thickest sedimentary deposits i.e. Bengal and Indus fans, in its NE and NW part north of equator (Fig. 3). Influence of terrigenous material has also been traced up to 8^0S in the Central Indian Basin (Nath *et al.* 1989). Ocean floor having depth less than carbonate compensation depth (CCD 4.8 km) are covered by the calcareous ooze (Kolla *et al.* 1976a), whereas deeper areas are covered either by siliceous ooze or by the pelagic clays.

3.1.2 OCEANOGRAPHY

Major oceanographic features of the equatorial Indian Ocean are summarized below to have a better understanding of the environmental characteristics which may be controlling the spatial distribution of the radiolarians.

3.1.2.1 SURFACE WATER CHARACTERISTICS

Surface Current

With the completion of International Indian Ocean Expedition (IIOE), geographical and seasonal variations of major oceanographic parameters are well established (Wyrtki, 1971). The surface currents

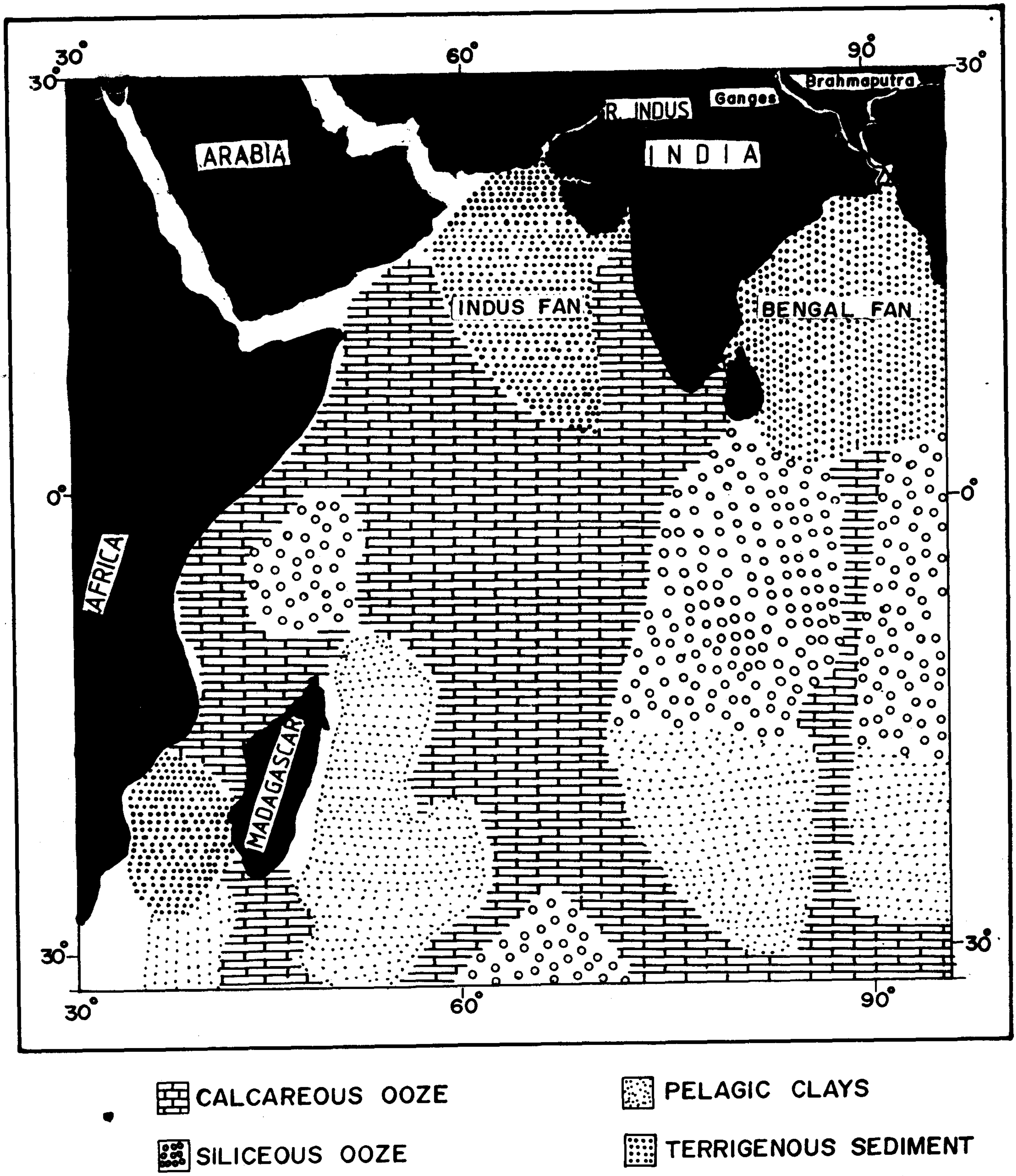


Figure 3. Distribution of calcareous and siliceous oozes, pelagic red-brown clays and terrigenous sediments in the Indian Ocean (after Udintsev, 1976).

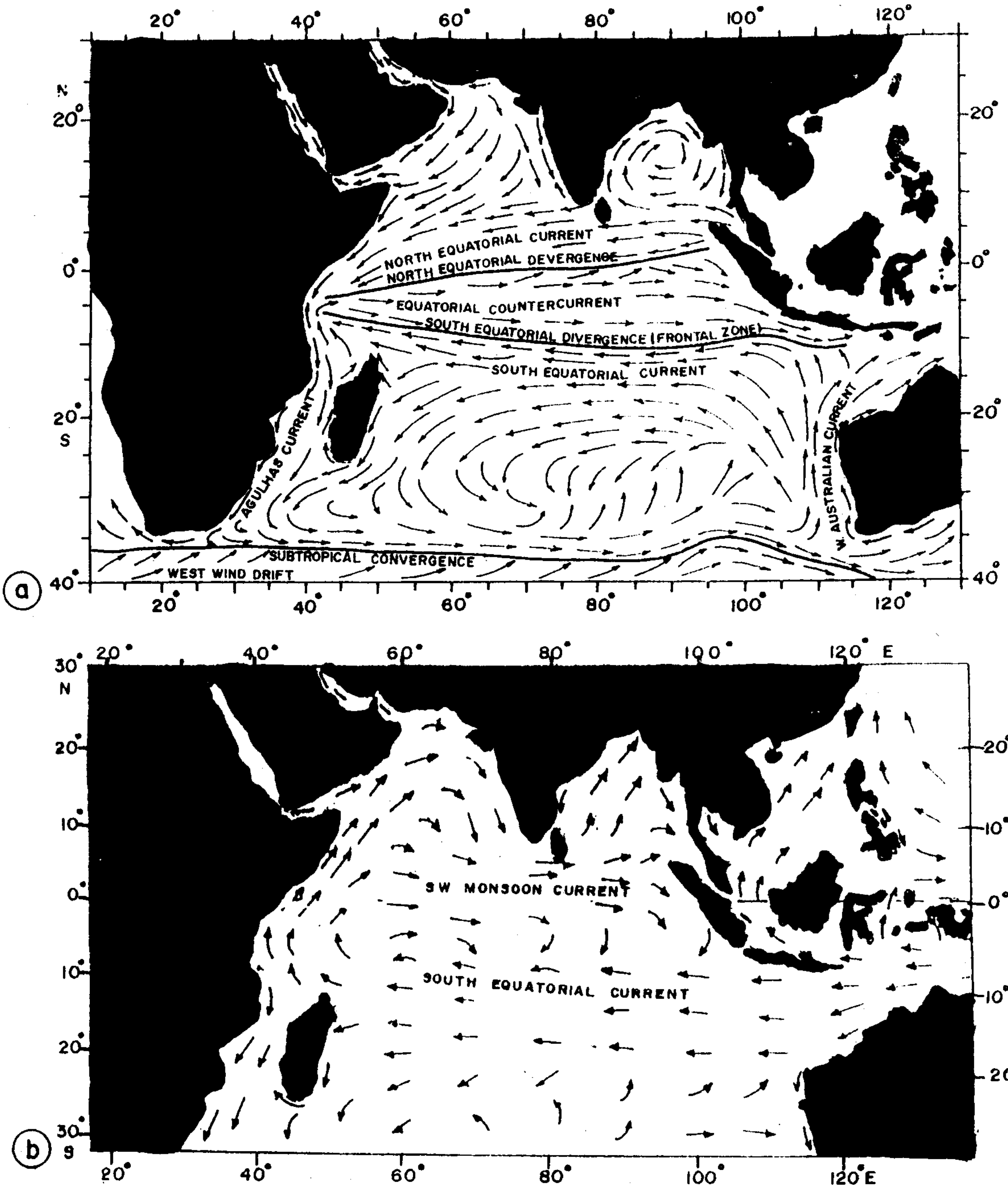


Figure 4. Seasonal surface circulation pattern in the northern Indian Ocean i.e. (a) during February, the peak of NE monsoon (Nov.-April). South equatorial current, north equatorial current, and equatorial counter current are separated by north and south equatorial divergence fronts; (b) during August, the peak of southwest monsoon (June-Sept.) [modified after Prell *et al.* 1980, based on data of Defant, 1961, and Wyrtki, 1973].

(Fig. 4) are chiefly governed by prevailing winds. The surface circulation pattern of the Indian Ocean is summarized in Figs. 2 & 4, with the details of two major seasonal current pattern indicating north and south equatorial currents, equatorial counter current, monsoonal and subtropical gyres.

North Equatorial Current flows in east-west course between 10^0N and $2-3^0$S during north-east monsoon (Nov.-April, Fig. 4 a). It begins near Sumatra and Malaya, passes south of Sri Lanka and then expands to the northwest. Its water accumulates on Somali coast, from where it turns southward towards doldrums near 5^0S. It then turns eastward between 3^0S and $8-10^0$S to form the Equatorial Counter Current. South Equatorial Current originates between Australia and Java, between 8^0S and 20^0S and attains velocity of more than 1 knot. South Equatorial Current is strongest and closest to the equator (reaches up to 7^0S) during southwest monsoon (July - August) period (Fig. 4 b). It is estimated that flow of this current is minimum ($40X10^6m^3/s$) during northeast monsoon (Dec.-February) and maximum ($54X10^6m^3/s$) during south-west monsoon (July-Aug.) exhibiting a strong seasonality (Tchernia, 1980).

Sea Surface Temperature

Indian Ocean witnesses strong seasonality in sea surface temperature (SST) which ultimately governs salinity and the primary productivity. Sea surface temperature varies from 26-29^{0}C during northeast monsoon. Temperature variation is high and localized from region to region in the equatorial Indian Ocean (Fig. 5a). During southwest monsoon period temperature varies from 23-29^{0}C, with a marked regional trend. From 10^{0}N to 4^{0}S temperature varies from 29-28^{0}C, but south of 4^{0}S to 20^{0}S temperature gradient is very high 28-23^{0}C. Isotherms generally have latitudinal trend (Fig. 5 b). South of 4^{0}S to 20^{0}S surface water is cooler compared to the northern part during southwest monsoon.

Salinity

Salinity has seasonal fluctuation and a marked east west zonality, a peculiarity of the equatorial Indian Ocean, is evident (Wyrtki, 1971). During northeast monsoon salinity varies from 32-34.5 ‰. and 34.5-35.5‰. in the east and west of 80^{0}E, with minor fluctuations (Fig. 6 a). During southwest monsoon salinity contrast is very prominent in the equatorial Indian Ocean. East of 80^{0}E salinity is less than 34.5‰., whereas west of 80^{0}E, it is generally more than 34.5‰. (Fig. 6 b). The salinity contrast in the

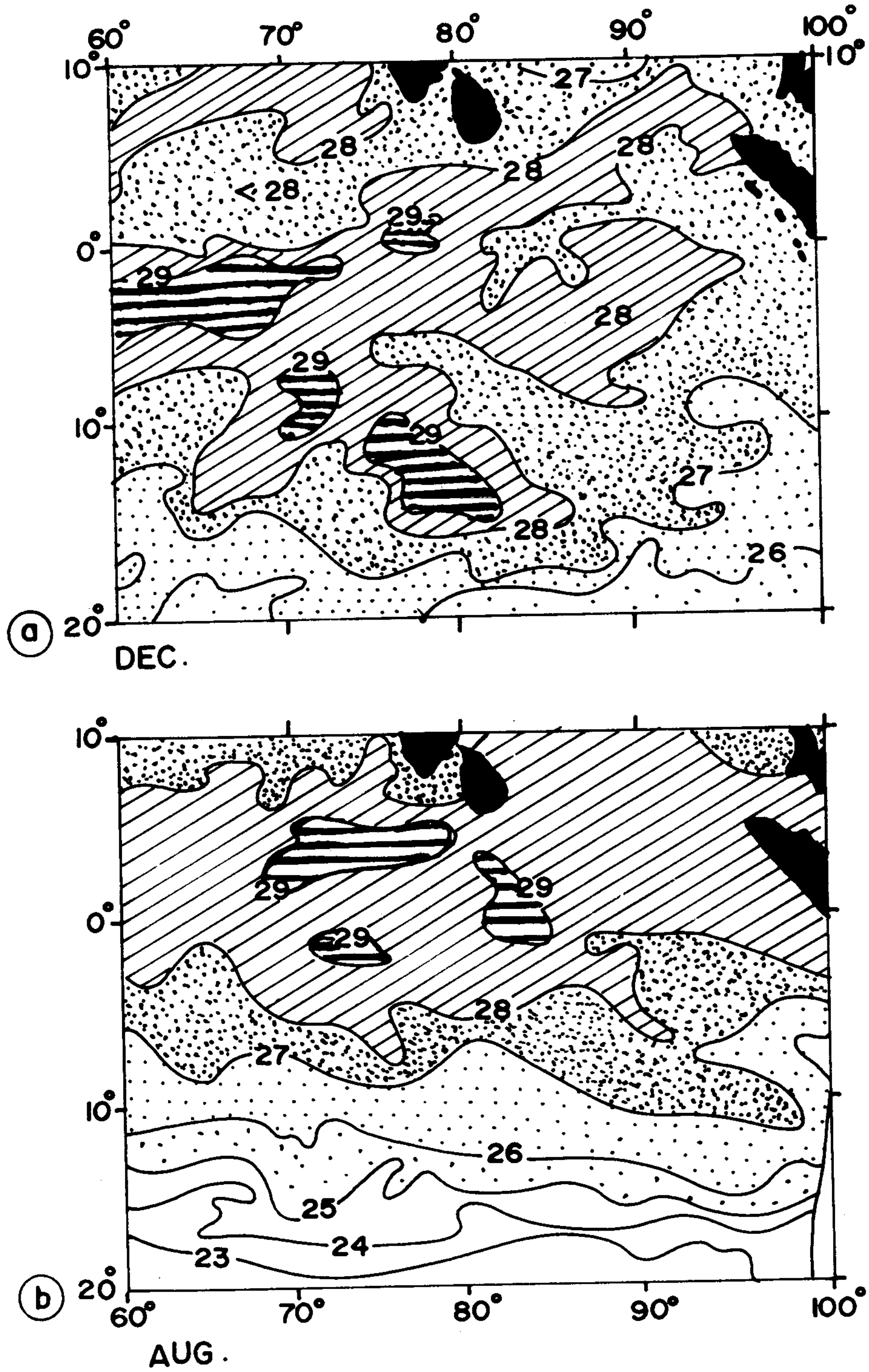
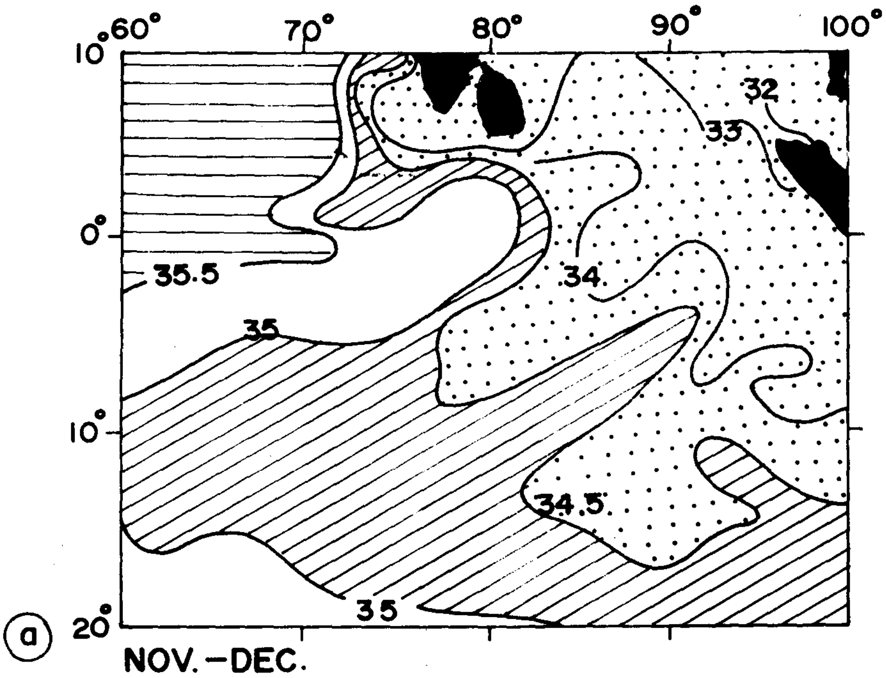


Figure 5. Seasonal variation in sea surface temperature (SST °C) in the equatorial Indian Ocean during (a) December (NE monsoon) and (b) August (SW monsoon) [after Wyrtki, 1973].



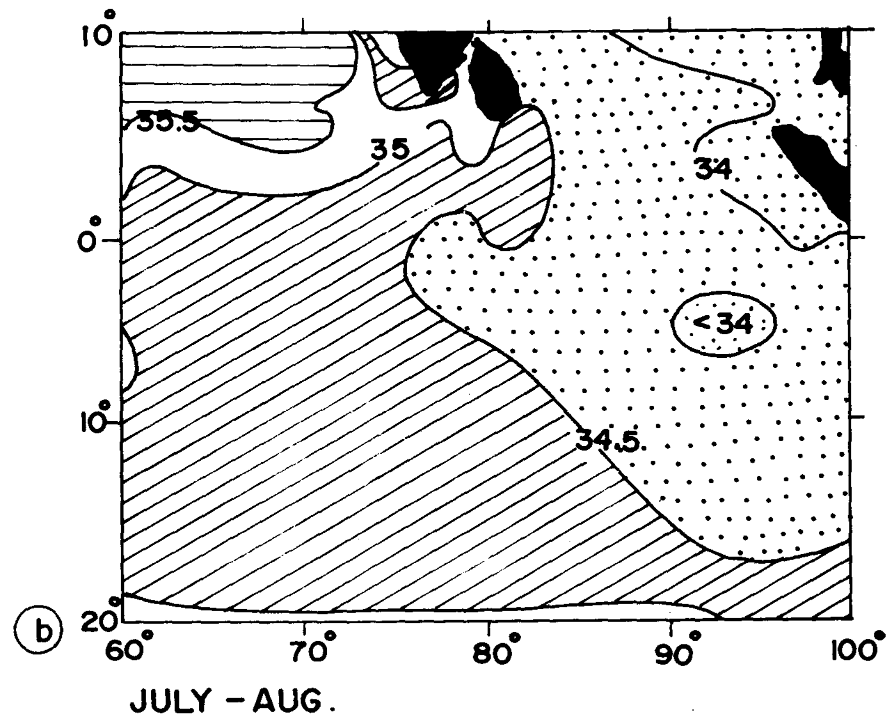


Figure 6. Seasonal variation in salinity (‰) in the equatorial Indian Ocean during (a) Nov.-Dec. (NE monsoon) and (b) July-August (SW monsoon) [after Wyrtki, 1971].

equatorial Indian Ocean is due to wast monsoonal precipitation and fresh water run off from the Bay of Bengal (Tchernia, 1980).

Primary Productivity

Primary productivity in surface water (0-75 m) varies from 1-3 MGC/m^3/d during northeast monsoon. High primary productivity cells are localized near regions off Sumatra at the western equatorial region (Fig. 7 a). During southwest monsoon primary productivity is comparatively higher. Zone having primary productivity 2-5 MGC/m^3/d covers almost entire equatorial Indian Ocean (Fig. 7 b) with highest concentration at few regions between 0-10^{0}N.

3.1.2.2 SUB-SURFACE WATER CHARACTERISTICS

A five layered vertical stratification of watermasses is described in the Indian Ocean. Tchernia (1980) characterized these watermasses as follows i.e. (i) surface water of variable regional characteristics; (ii) central water from 100-700 m depth with 15-10^{0}C potential temperature (C^0), 35.60-34.70 ‰. salinity, 5.5-5.0 ml/l O_2, and 24-26 potential density; (iii) antarctic intermediate water near 1 km depth with 5.0^{0}C potential temperature, 34.50‰. salinity, 4.5 ml/l O_2, and 27.30 potential density; (iv) deep water around 2.5-3.0 km depth with 2.0^{0}C potential

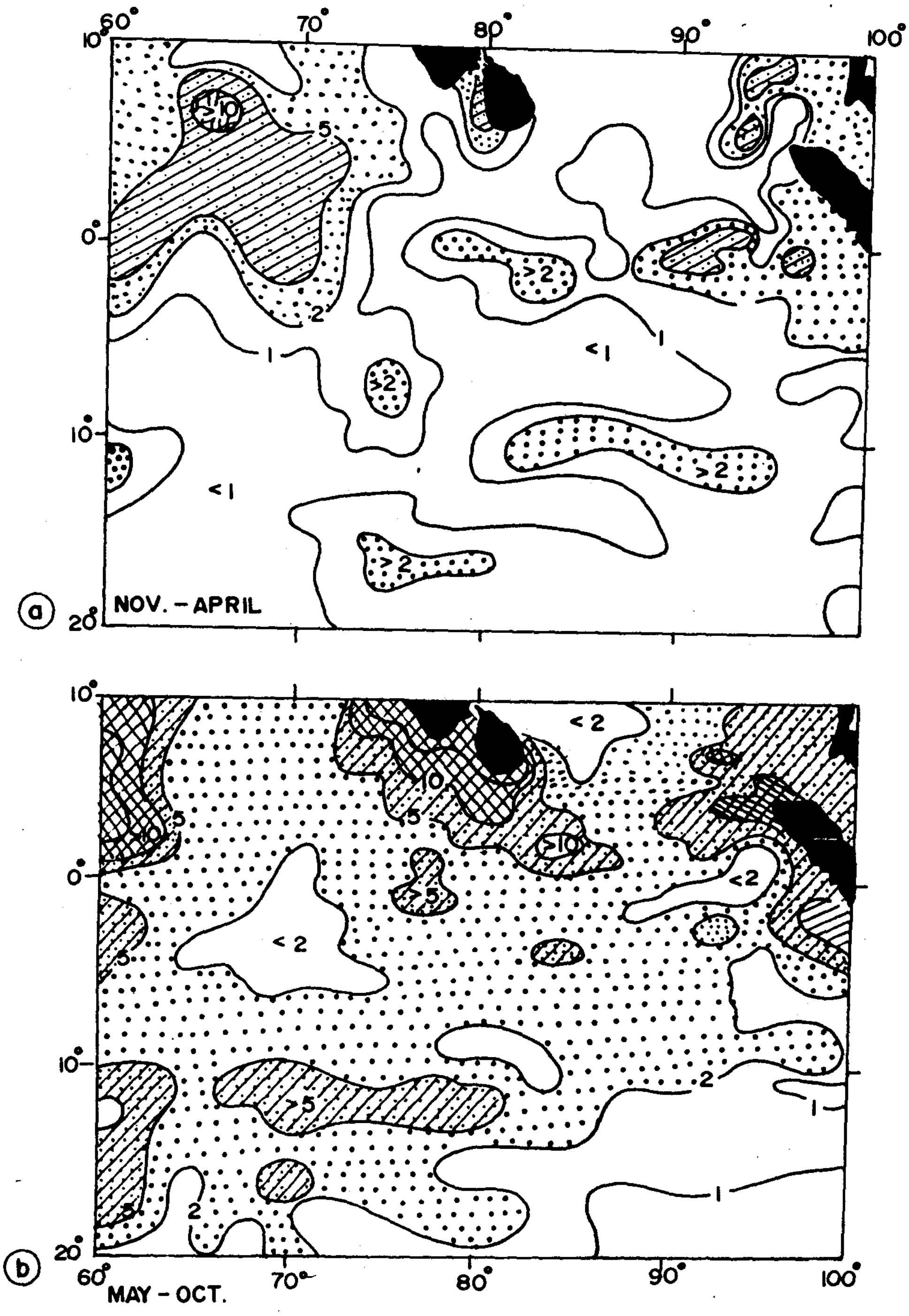


Figure 7. Seasonal variation in surface primary productivity ($MGC/m^3/d$) during (a) Nov-April (NE monsoon) and (b) May- Oct. (SW monsoon) [after Krey and Babenerd, 1976].

temperature, 34.74‰. salinity, 4 ml/l O_2, and 27.70 potential density; (v) bottom water around 4 km depth with 0.5^{0}C potential temperature, 34.70-34.72 ‰, salinity, 4.5-5.0 ml/l O_2, and 27.85 potential density. In northernmost Indian Ocean generally antarctic water characteristics are absent except at places where it has been traced with the help of potential temperature and other characteristics. These north south vertical water structures are separated by a vertical salinity minima from the surface to great depth around 10^{0}S, which is generally termed as 10^{0}S hydrographic front (Fig. 8).

3.1.2.3 BOTTOM WATER MOVEMENT

Sea water starts sinking due to extremely cold (T = -0.7^{0}C), highly saline (34.66 ‰.), O_2 rich (6.0 ml/l), and highly dense (potential density 27.88) water in Weddell Sea, Antarctica (Tchernia, 1980). While spreading to east and north direction this antarctic bottom water penetrates into Indian Ocean between 4-5.5 km water depth. Its potential temperature is below 0^{0}C near the Antarctic Ocean and it increases accordingly while travelling in different basins in the northern Indian Ocean. In the eastern Indian Ocean antarctic bottom water crosses SE Indian Ridge near 110-120^{0}E where it enters into South Australian Basin and reaches into the Central Indian Basin

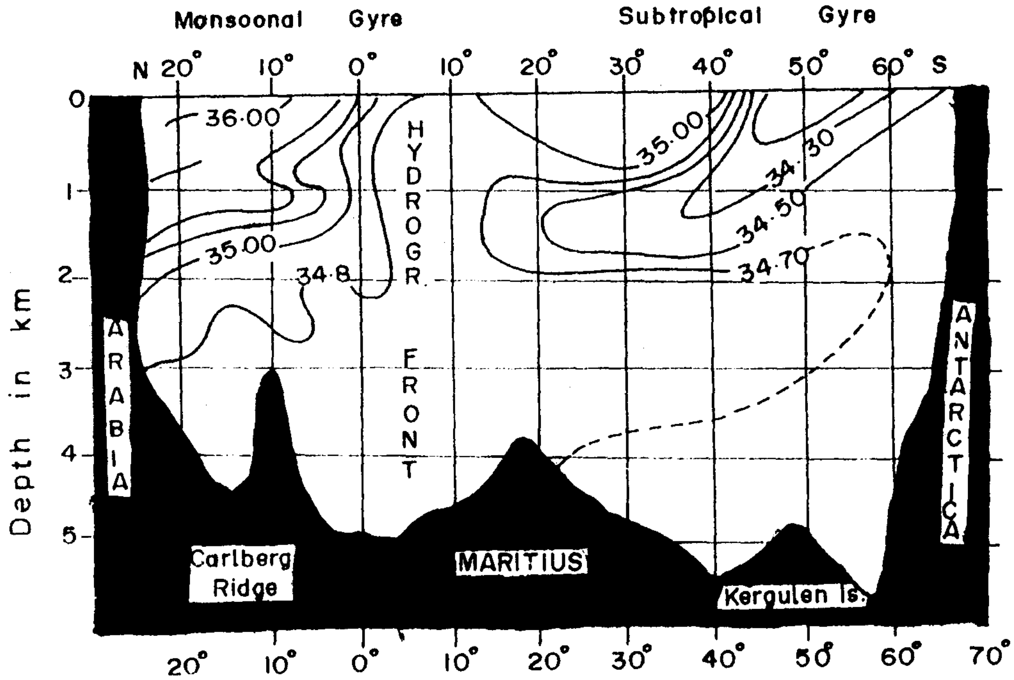


Figure 8. Vertical stratified salinity structure of the Indian Ocean from Arabia in the north to Antarctica in the south. Monsoonal and subtropical gyres are distinctly separated by the hydrographic front at around 10^0S (after Tchernia, 1980).

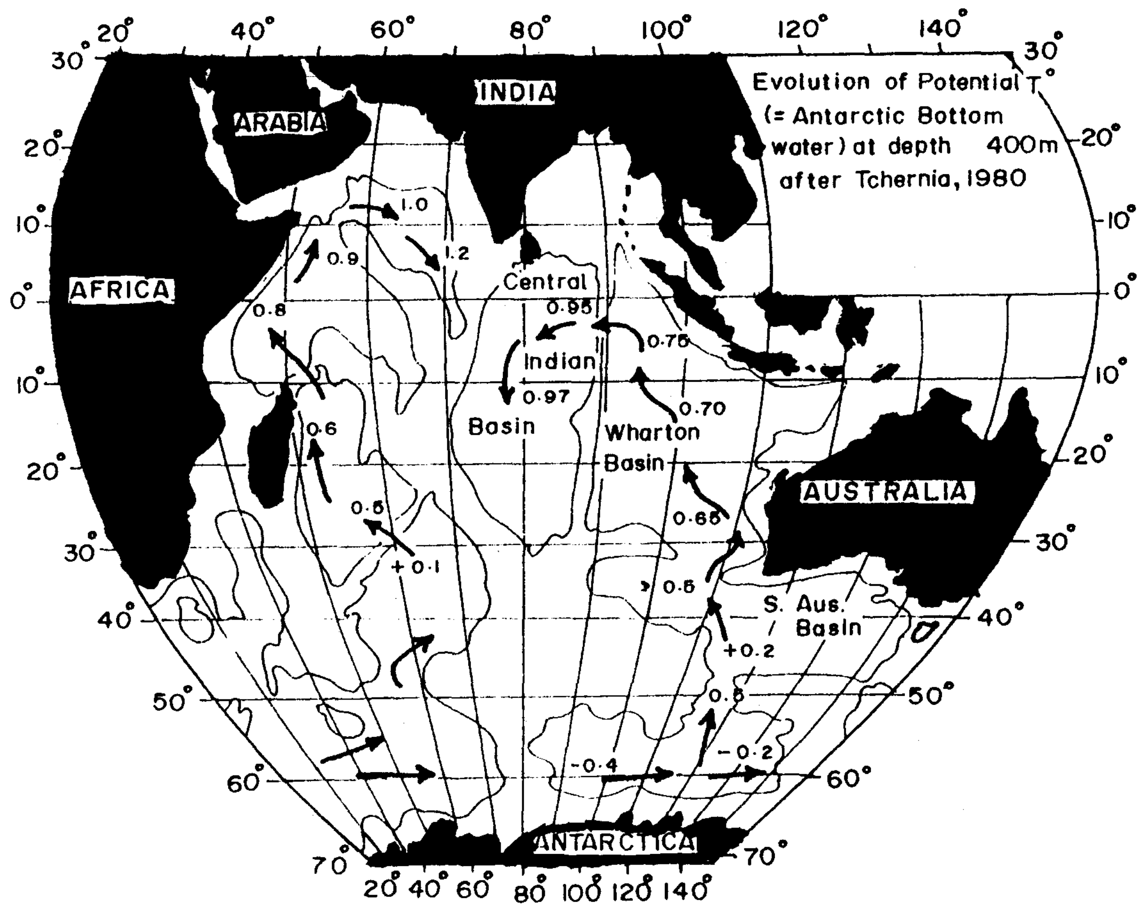


Figure 9. Movement of Antarctic Bottom Water (AABW) in different basins characterized by the potential temperature at 4 km depth in the Indian Ocean (after Tchernia, 1980).

through the deeper saddle of 90^{0}E Ridge after crossing over the Wharton Basin. The potential temperature of the antarctic bottom water is 0.97^{0}C in the Central Indian Basin (Fig. 9). Movement of antarctic bottom water is through SW Indian Ridge on the west from Crozet Basin towards Arabian Basin passing through Madagascar, Mascarene and Somali Basins.

3.2 CENTRAL INDIAN BASIN

Apart from the general oceanographic characteristics of the equatorial Indian Ocean, Central Indian Ocean has its own peculiarities which may also help in interpreting the spatial distribution of radiolarians in the basin. These characteristics are summarized below.

3.2.1 PHYSIOGRAPHY, REGIONAL SETTING AND SEDIMENT TYPES

Central Indian Basin is bounded by 90^{0}E Ridge, SE Indian Ridge, Mid Indian Ridge and Chagos Ridge, and the equator as its eastern, southern, western and northern boundaries respectively (Fig. 10). The eastern boundary of the basin is the 90^{0}E Ridge which is the longest known submarine linear physiographic feature on the ocean floor in the world along the 90^{0}E longitude in the Indian Ocean. In general the

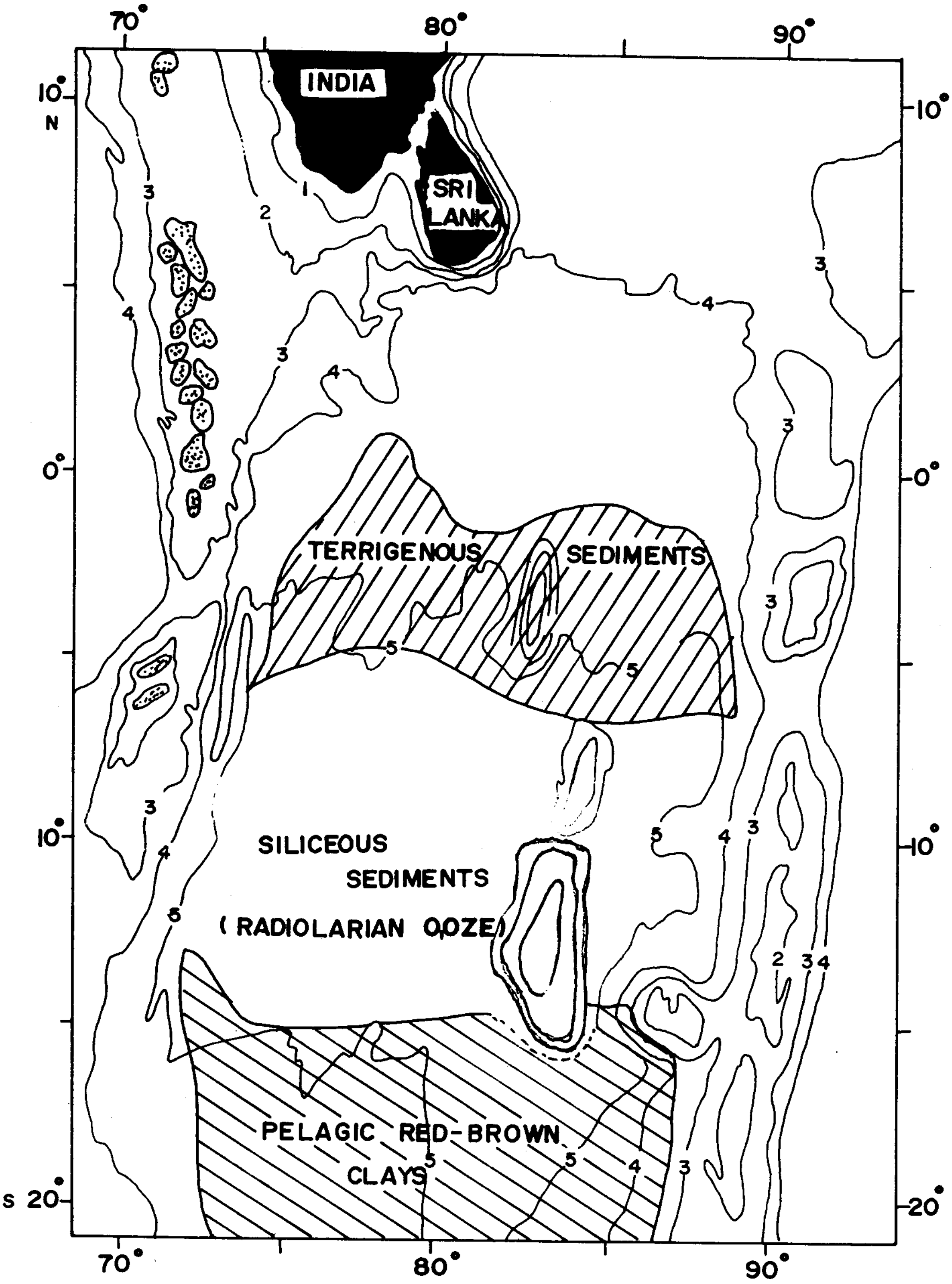


Figure 10. Physiography and sedimentary domains of the Central Indian Basin (Udintsev, 1976). Contours are in Km.

depth on the ridge varies from 2-4 km, but it has few deeper saddles near 5-6^{0}S, where depth is more than 3 km. These saddles are supposed to be the entrance point of the antarctic bottom water (AABW) in the basin. The western boundary of the basin is Mid Indian Ocean Ridge and Chagos Ridge on which depth varies from 3-4 km in general and these ridges crop out above the sea level as the coralline islands of Chagos and Maldives archipelago. Northern side of the basin is comparatively deeper (>4 km depth). Major part of the basin is deeper than 5 km with a few exception like Afrau-Nikitin sea-mounts and abyssal hills. Northern part of the basin receives terrigenous sediments of the distal part of Bengal Fan. These sediment are rich in foraminifers and also called as foraminiferal ooze. Radiolarian ooze and pelagic red-brown clays are other two sedimentary domains of the basin which have boundaries approximately at 5^{0}S and 15^{0}S respectively (Udintsev, 1976). Bathymetric survey at 10 nautical miles interval in the southwestern part of the basin (between 8^0-16^{0}S and 71^0-82^{0}E) by the National Institute of Oceanography Goa, has revealed few seamounts and abyssal hills (Fig. 11) ranging from 200 to 1500 m height with a N-S trend on the sea-floor (Kodagali, 1989 a,b; Kodagali, 1991 mss;

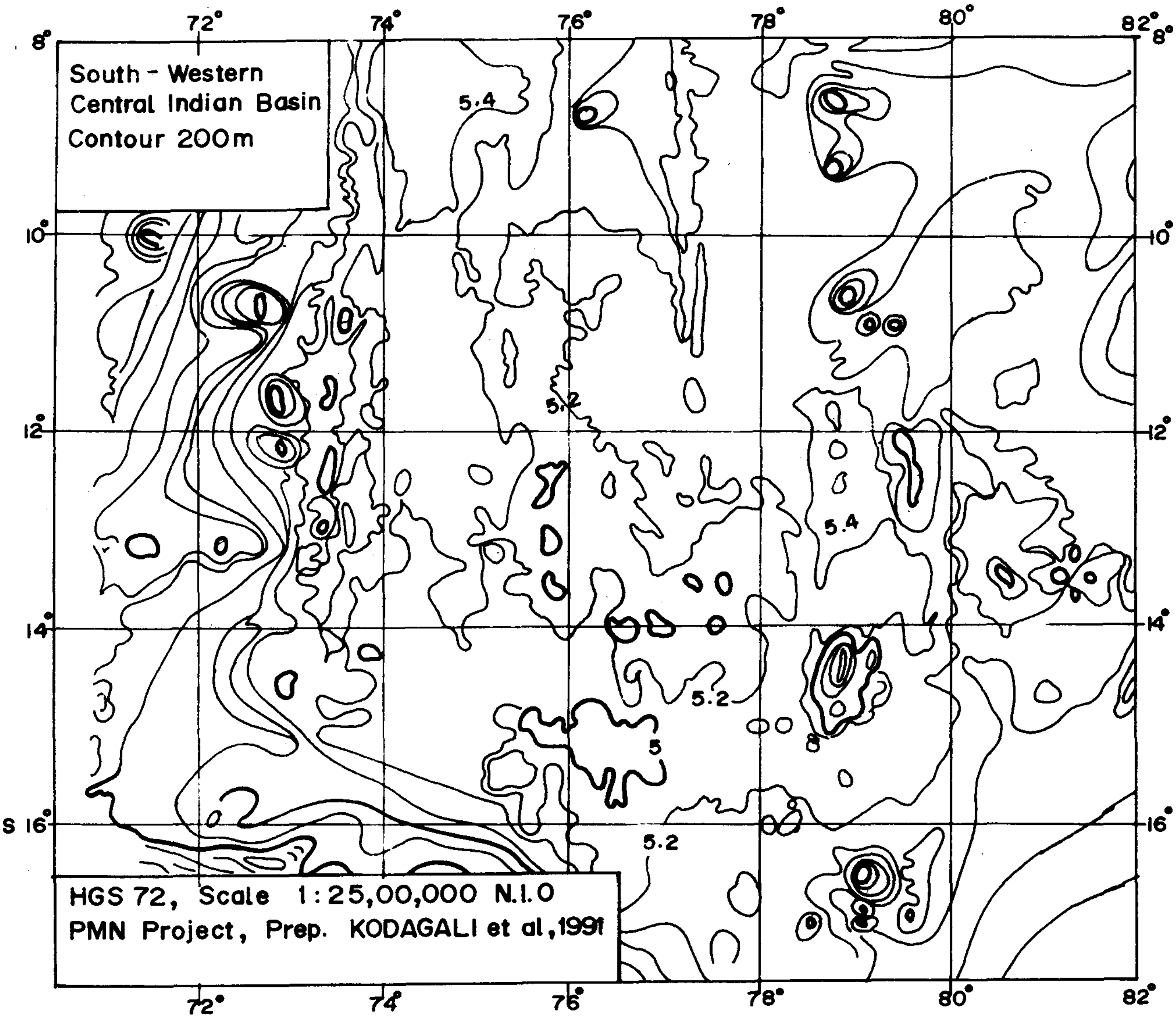


Figure 11. Bathymetric map of the southwestern part of the Central Indian Basin at close grid sounding (10 nm). Contours at 200 m interval. Several seamounts trending in NS directions and abyssal hills are characteristics of the basin floor (after Kodagali *et al.* mss.).

Mukhopadhayay and Khadge, 1990; unpublished restricted charts/maps of the basin).

3.2.2 SURFACE CURRENTS

Central Indian Basin has three main surface currents i.e. (i) North Equatorial Current, flowing east to west between Sri Lanka and Equator; (ii) Equatorial Counter Current, flowing from west to east between equator to 10^0S and (iii) South Equatorial Current, flowing east to west in southern part of the basin during NE monsoon period (Figs. 4 a, b). During southwest monsoon period (July-Aug.) North Equatorial Current and the Equatorial Counter Current of NW monsoon period are replaced by Summer Monsoon Current flowing mainly from west to east between south of Sri Lanka and $5-6^0$S, whereas South Equatorial Current is strongest and closest to the equator near $6-7^0$S. It is estimated that flow of South Equatorial Current is minimum ($40X10^6m^3/s$) during north-east monsoon (Dec.-February) and maximum ($54X10^6m^3/s$) during south-west monsoon (July-Aug.), exhibiting a strong seasonality (Tchernia, 1980).

3.2.3 BOTTOM WATER CURRENTS

During the GEOSECS observation Jacobs and Georgi (1977), Chung and Kim (1980) and Warren (1978) have reasonably well defined the deep water circulation of the Indian Ocean. The abyssal path of bottom water has been traced by Kolla *et al.* (1976b, 1978). Johnson and Damuth (1979) have traced the abyssal current path in the Indian Ocean. Warren (1981, 1982) demonstrated a two layered structure of antarctic bottom water current i.e. (i) upper deep water (2000-3800 m) flowing directly from Antarctica along the eastern flank of the Central Indian Ridge; (ii) the lower deep water (>3800 m) derived from the boundary current in west Australian Basin and flowing across the 90^{0}E Ridge. Whereas, antarctic bottom water (AABW) in the Central Indian Basin is characteristic at 5.0-5.5 km depth with 0.97^{0}C potential temperature, 34.71‰ salinity, 4 ml/l O_2 content, and 27.85 potential density (Tchernia, 1980). In brief AABW crosses the southeast Indian Ridge and flows clockwise around the Black Plateau and Broken Ridge in south Australian Basin (Fig. 2, and Fig. 9) which continues northwards along the 90^{0}E Ridge and some part of the Antarctic Bottom Water Current passes westward through deeper saddles in the 90^{0}E Ridge entering into the Central Indian Basin. The oxygen content (4 ml/l) of the antarctic bottom water (Tchernia, 1980) is the prime source for the oxidizing sedimentary environment within the Central Indian Basin (Nath and Mudholkar, 1989; Pattan and Mudholkar, 1990; Banaker *et al.*, 1991).

3.2.4 SURFACE WATER CHARACTERISTICS

The basin witnesses the strong seasonality in the surface-oceanographic parameters like sea surface temperature, surface currents, nutrient contents and primary productivity. Variation in sea surface temperature and the surface currents between two monsoonal seasons (NE and SW) is summarized in Figs. 12 a & b. Seasonality in sea surface temperature and current pattern is reflected in the nutrient contents like silicate and phosphate in the surface water (Figs. 12 c & d). Chlorophyll-a contents in the surface water show wide variations in the basin in both the monsoonal seasons (Figs. 12 g & h). Potential primary productivity varies in both the seasons and reaches a maximum around 0.5 MGC/m^3/h. However , our study area (0-16^{0}S) shows rather high concentration (0.2-0.5 MGC/m^3/h) during SW monsoon. During NE monsoon concentration varies from 0.05-0.2 MGC/m^3/h (Figs. 13 a & b).

3.2.5 SUB-SURFACE WATER CHARACTERISTICS

As majority of the radiolarians inhabit in the upper 300 m water (Kling, 1979), the variations in physiochemical parameters in 0-300 m water column of the Central Indian Basin are considered in the present study. Subsurface hydrographic characteristics are very seasonal in the basin.

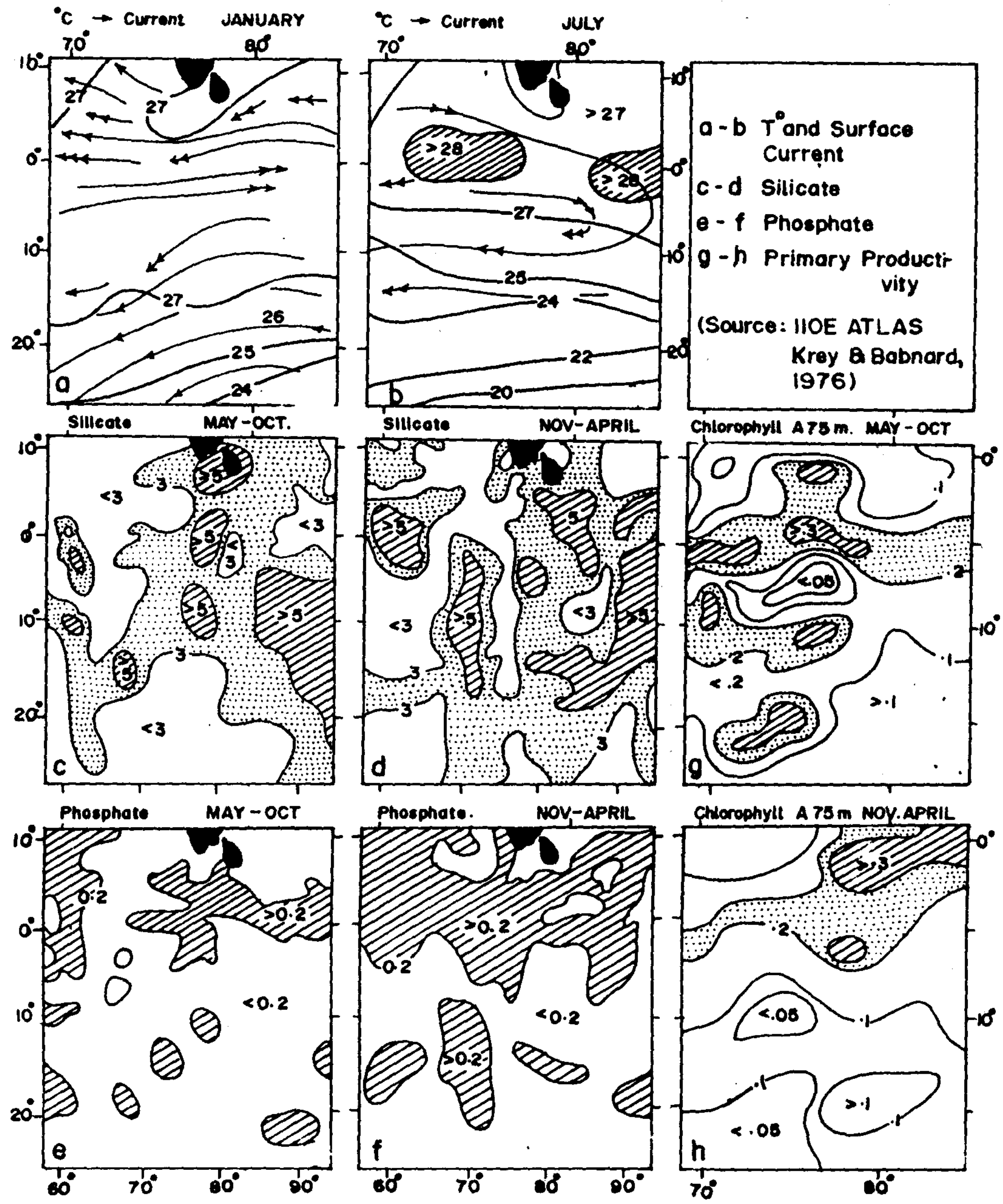


Figure 12. Seasonal variation in oceanographic parameters in the Central Indian Basin i.e. a= surface current and isotherms during January (northeast monsoon = NEM); b = surface current and isotherms during July (southwest monsoon = SWM); c= silicate (µg-atoms/l) in surface water during May-Oct. (SWM); d= silicate (µg-atoms/l) in surface water during Nov.-April (NEM); e= phosphate (µg-atoms/l) in surface water during May-Oct. (SEM); f= phosphate (µg-atoms/l) in surface water during Nov.-April (NEM); g= chlorophyll-a (mg/m^3) in upper 75m water during May-Oct. (SWM); h= chlorophyll-a (mg/m^3) in upper 75 m water during Nov-April (NEM) [after Krey and Babenerd, 1976].

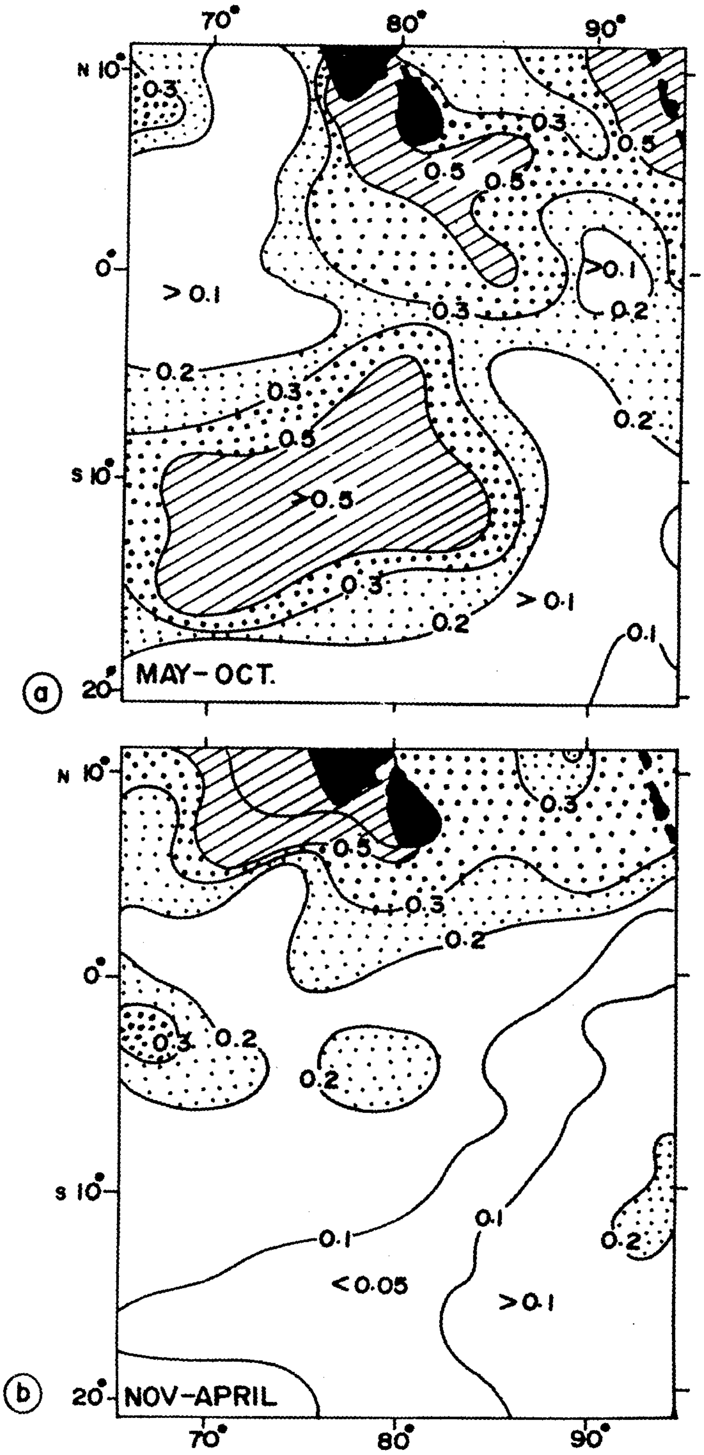


Figure 13. Seasonal variation in potential primary productivity ($MGC/m^3/h$) in the Central Indian Basin during (a) May-Oct. and (b) Nov.-April [after Kery and Babenerd, 1976].

Wyrtki (1971) reported seasonal variations (IIOE, profiles 36 and 37 at 0^0S between $70-90^0E$) in potential temperature from 28^0C to 15^0C, and in salinity (Fig. 14 a) from 34.3‰ to 35.2‰ at the equator within 0-50 m and 100-200 m depth zone during northeast monsoon. During southwest monsoon potential T^0 varies from 26^0C (at 0-50 m) to 14^0C (at 100-200 m), whereas salinity varies from 34.2-34.8 ‰ (0-50 m) to 34.7-35.2 ‰ (100-200 m, Fig. 14 b). During NE monsoon oxygen content in 0-100 m water varies from 2-4.5 ml/l, whereas it is less than 2 ml/l in 100-300 m water depth (Fig. 14 c). During SW monsoon, oxygen content is >3 ml/l in 0-100 m water column, whereas it varies from 1.5-2 ml/l between 100-300 m water column (Fig. 14 d). An oxygen minima layer (<1.5 ml/l) is pronounced between the depth range of 100-200 m water column during southwest monsoon, in an area between $77-90^0E$ (Fig. 14 d). Seasonal variations in vertical hydrographic parameters (IIOE, profiles 29 at 75^0E and 34 at 92^0E) of salinity and oxygen contents are also prominent as one traverses from equator to 20^0S and reflect the effect of hydrographic front at 10^0S (Figs. 14 e, f, g, h).

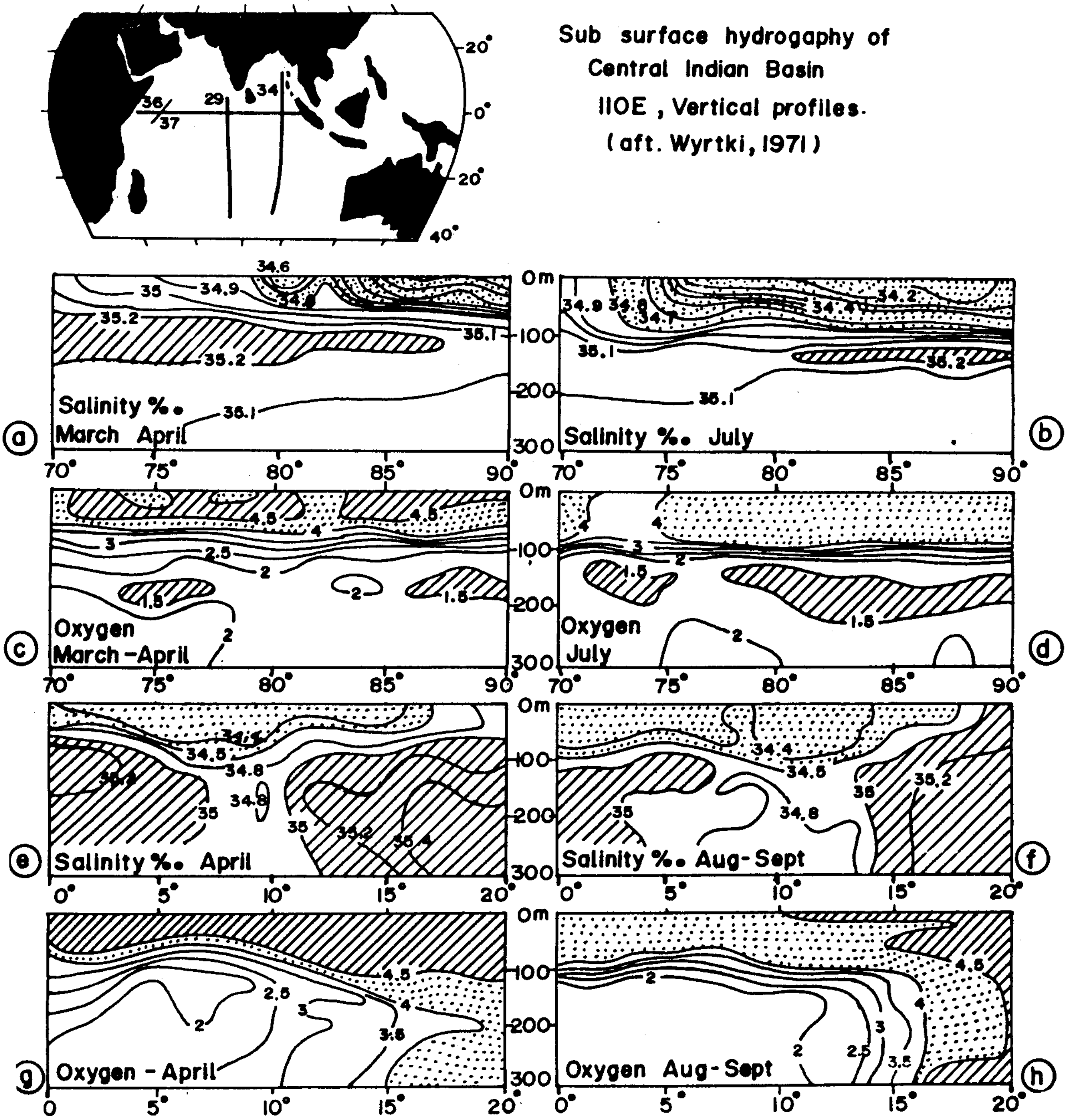


Figure 14. Seasonal variation in subsurface hydrographic parameters in upper 300 m of water column within the Central Indian Basin i.e. salinity structure during (a) March-April and (b) July; oxygen content during (c) March-April and (d) July (IIOE data of vertical profiles at section 36 and 37); salinity structure during (e) April and (f) Aug.-Sept.; oxygen content during (g) April and (h) Aug.-Sept. (IIOE data along profiles 29 and 34, after Wyrtki, 1971).

3.2.6 *HYDROGRAPHIC FRONT AT 10^{0}S*

Monsoonal gyre is separated from the hydrographic front near 10^{0}S by a remarkable salinity minima (Fig. 8) in the surface water extending from Sumatra to Africa and is the result of advection of low salinity water by south equatorial current from the Australia and Indonesian region coupled with Ganges-Bramhaputra fresh water discharge (Wyrtki, 1973; Johnson and Nigrini, 1980). During GEOSECS observations variations were recorded in potential temperature, salinity, oxygen content, silicate, phosphate and nitrate contents in the vertical hydrographic profile along 80^{0}E longitude, which passes from the center of the Central Indian Basin (Fig. 15). In this data set the 10^{0}S hydrographic front is also characterized by sharp gradient in the distribution of potential temperature, salinity, oxygen, phosphate, and nitrate contents (Spencer *et al.*, 1982) in vertical hydrographic profile along 80^{0}E longitude (Fig. 15). It inclines and slopes from 100 m depth at 10-12^{0}S to 800 m at 16-18^{0}S (Wyrtki, 1973).

Physical, chemical, and hydrological parameters described above provide general idea that how important is the monsoon system to understand the distribution pattern of the radiolarians within the basin.

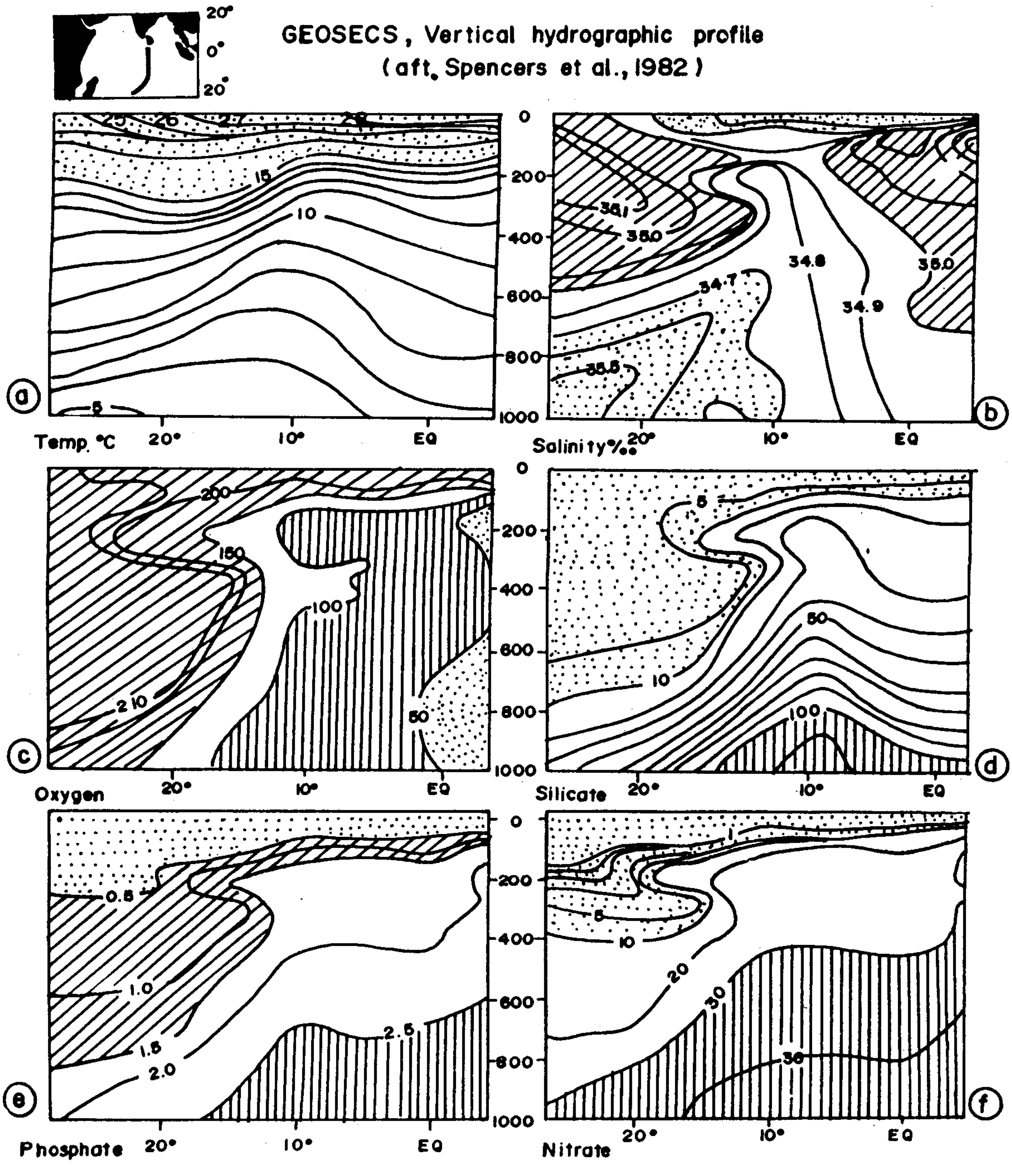


Figure 15. Subsurface variation in upper 1000 m water column of the Central Indian Basin along 80^0E longitude i.e., (a) potential temperature, (b) salinity, (c) oxygen content*, (d) silicate*, (e) phosphate* and (f) nitrate* (* unit MM/Kg; GEOSECS, IIOE, Spencer *et al.* 1982). Note the changes in vertical profiles of hydrochemical parameters near 10^oS, which is known as hydrographic front at 10^oS.

CHAPTER 4

4.0 MATERIAL AND METHODS

The work carried out in this thesis is divided into four steps i.e. (i) onboard collection of the sediment samples, sampling devices, description of the samples, and (ii) the laboratory procedures followed for processing samples, slide preparations, (iii) identification of radiolarian species and counting techniques and (iv) statistical analyses. All these steps are summarized in this chapter.

4.1 ONBOARD COLLECTION OF SURFACE SEDIMENTS

Surface sediment samples were collected from 42 locations using Pettersson grab, spade core-tops, and boomerang grab-tubes during various cruises of *RV GAVESHANI, MV FARNELLA, MV SKANDY SURVEYOR* for the survey of the polymetallic nodules in Central Indian Basin (Fig. 16). Details of the locations, water depth, sediment type, and sampler used are listed in Table 1. Sample numbers are the station numbers of the various cruises and are serialized in ascending order of the vessel used for the cruises.

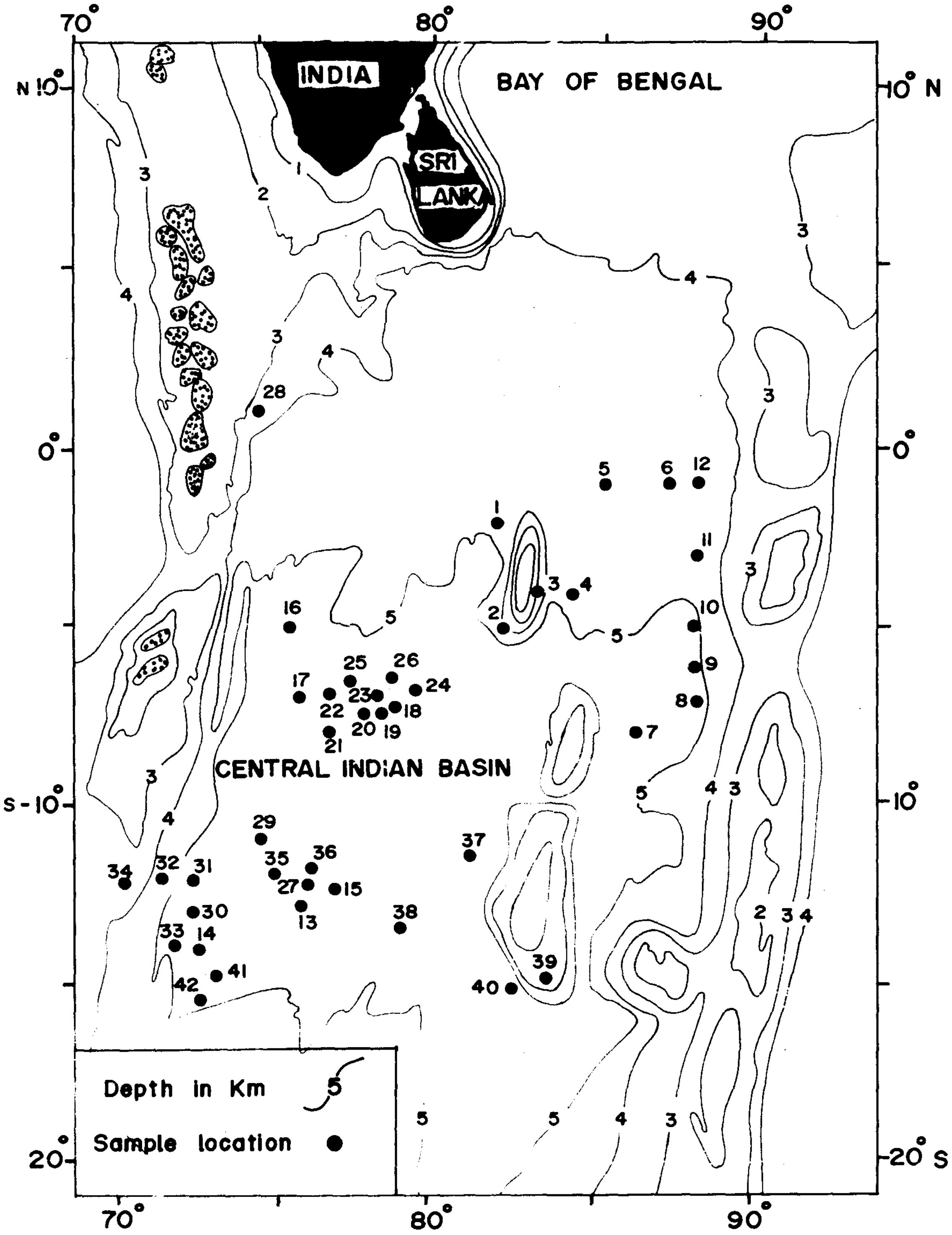


Figure. 16. Location of the surface sediment samples in the Central Indian Basin. Bathymetric contours are in km.

TABLE 1

Latitude, Longitude, water depth, sediment type and sampling device used in the Central Indian Basin.

S.N.	Sample no.	Latitude +=N,-=S	Longitude E	Depth (m)	Sampler used	Nature of Sediment
1.	RVG 2483	-02.050	82.079	4590	PG	Calc.
2.	RVG 2486	-05.000	82.090	4990	PG	Calc.
3.	RVG 2494	-04.000	83.190	3750	PG	Calc.
4.	RVG 2501	-04.000	84.000	4860	PG	Calc.
5.	RVG 2513	-01.080	85.000	4600	PG	Calc.
6.	RVG 2520	-01.125	87.020	4600	PG	Calc.
7.	RVG 2528	-08.070	86.109	5200	PG	Silic.
8.	RVG 2531	-07.012	88.155	5080	PG	Silic.
9.	RVG 2532	-06.001	88.090	5150	PG	Silic.
10.	RVG 2533	-05.075	88.180	5030	PG	Calc/Silic.
11.	RVG 2535	-03.062	88.065	4820	PG	Calc.
12.	RVG 2537	-01.059	88.095	4620	PG	Calc.
13.	F 47	-13.500	73.999	5150	PG	Silic.
14.	F 56	-14.002	73.001	4389	PG	Calc.
15.	F 81	-12.490	77.011	5486	Spd C	Silic.
16.	F 99	-05.000	75.992	4492	PG	Calc.
17.	F 101	-07.027	76.002	5290	PG	Silic.
18.	F 150	-07.444	78.954	NA*	PG	Silic.
19.	F 151	-07.550	78.467	NA*	PG	Silic/Calc.
20.	F 152	-07.489	78.014	NA*	PG	Silic/Calc.
21.	F 153	-08.024	76.967	NA*	PG	Silic/Calc.
22.	F 154	-07.021	76.980	NA*	PG	Silic/Calc.
23.	F 155	-07.004	78.495	NA*	PG	Silic/Calc.
24.	F 156	-07.067	79.500	NA*	PG	Silic/Calc.
25.	F 157	-06.468	77.439	NA*	PG	Silic/Calc.
26.	F 158	-06.500	78.945	NA*	PG	Calc.
27.	F 199	-12.007	76.477	5450	BG t	Silic.
28.	F 379	+01.089	74.670	2475	PG	Calc.
29.	S 105	-11.010	74.985	5022	BG t	Silic.
30.	S 120	-13.006	72.984	4300	BG t	Silic.
31.	S 121	-12.007	73.003	5075	PG	Silic.
32.	S 124	-12.017	73.003	5000	PG	Silic.
33.	S 126	-14.017	72.016	5000	BG t	Silic.
34.	S 127	-11.999	70.990	4750	PG	Calc/Silic.
35.	S 128	-11.969	75.465	3007	BG t	Calc.
36.	S 129	-12.006	76.452	5100	PG	Silic.
37.	S 139	-11.514	81.490	NA*	PG	Silic.
38.	S 183	-13.510	78.979	5388	BG t	Silic.
39.	S 206	-15.090	83.560	NA*	PG	Silic.
40.	S 210	-15.487	82.950	5040	PG	Silic.
41.	S 231	-14.890	73.530	4900	PG	Silic/Calc.
42.	S 241	-15.500	72.991	4650	PG	Cal.

Note : NA* = Depth data not available as the Echosounder did not worked. Sampling devices i.e. PG = Pettersson grab, BG t = boomerang grab with 10 cm plastic tube attached, Spd C = Spade core top.

4.2 LABORATORY PROCEDURES

Sediment samples were oven dried for overnight at controlled temperature of $40^{0}C$ and cooled at room temperature before weighing. Random dry weights were taken between 8-15 g in foraminiferal ooze, 2-5 g in foraminiferal-radiolarian ooze and 1-2 g in the radiolarian ooze domains. Weighed sediments were soaked in distilled water and 10% sodium hexametaphosphate was added. Samples were stirred and left for over night. Later, hydrogen peroxide (30%) was added (50 ml) for removal of organic matter. For removal of calcium carbonate about 30 ml of glacial acetic acid was added. After carbonate removal the material was sieved over 62.5 um mesh under mild water jet. In order to remove the clay infilling within the radiolarian tests an ultrasonic vibration treatment was given for half a minute. After proper and careful rinsing the yields were transferred to 1000 ml beaker to ensure that no radiolarians get spilled out of the beaker while transferring from the sieve.

Randomly settled slides

Randomly settled radiolarian slides (Moore, 1973a) were made to asses the number of radiolaria/g dry sediment in the surface sediments. The method is as follows :

I. A known dry weight of the sediment was processed as described in previous section. Radiolarian yield was transferred in to 500 ml beaker and kept for settling. After one hour, if there was a thin carpet of radiolarians at the beaker floor, radiolaria were transferred in a graduated beaker, stirred thoroughly and were brought into suspension. Half of the water from graduated beaker containing suspended radiolaria was used for the settling technique.

II. A settling tank (5000 ml beaker) of known diameter was filled with 4 liters of clean water. Two preglued and numbered slides tied with rubber bands to a small rectangular platform (height 5 cm), were kept on the floor of the settling tank.

III. Radiolarian yield, full or the half aliquote (step I) as the case may be, depending on the richness of the radiolarian in a particular sample, were stirred thoroughly and gently transferred into the settling tank. Aliquote beaker was washed thoroughly and rinsed water was transferred to the settling tank to ensure that no radiolaria are left out sticking in the aliquote-beaker.

IV. Water column of settling tank was stirred by gentle vertical motion of the perforated stirrer for 5 minutes, to ensure that all radiolaria have come into suspension. Later, tank was left undisturbed for settling of the radiolarians onto preglued slides kept at the platform on the settling floor, as they would have settled in the ocean. It took 25-30 minutes to settle all radiolaria leaving crystal clear water column atop the tank floor.

V. Overlying water, baring 1 cm above the glass slides, was siphoned out. Siphon mouth was kept at least 3 cm above the tank floor, and away from the platform for the settling slides in order to ensure that radiolaria should not jet into siphon.

VI. When about 2 cm water was left over the slides, siphoning speed was reduced to droplets to ensure that any micro turbulence caused by falling water level over the glass slide should not be enough to detach or displace the radiolaria glued over the glass slides till the water dropped down at least 1 cm above the level of slides.

VII. An infra-red heating lamp was put on over the slides in order to evaporate the 1 cm of water left over the platform. After water level had gone down at least 1 cm below the slide platform, slides along with platform were gently lifted up, rubber bands were untied and slides were removed from the platform. Slides were kept on a hot plate (60-90^{0}C) and few drops of the mixture of Canada balsam and xylene was spilled over the slides. Slides were covered by 22 X 50 mm coverslips, and left for a week for curing at 60-65^{0}C in an oven.

VIII. Each slide was scanned for random distribution of radiolaria. An area measuring 1 cm^2 in both slides of the same sample were demarcated by a marker pen and radiolaria were counted. The difference in counts varied from 3-5 % in different samples amounting 97-95 % randomness in the slides made by the technique used.

IX. An area measuring 1 cm^2 was counted for the radiolaria in most of the slides. In some cases, where radiolarian yield was very poor, full slide was counted and the counts were divided by the area of the slide, in order to get radiolaria/cm^2.

X. Counts of radiolaria/cm^2 were computed for the surface area (πr^2) of the floor of the settling tank. Radiolarians per gram dry sediment was found as following.

R = radiolaria/cm^2 X πr^2 (r = radius of settling tank)

(R = number of radiolarians on the floor of settling tank)

$$\text{Radiolarians per gram (Rads/g)} = R \times \frac{1}{\text{Aliqoute}} \times \frac{1}{\text{dry wt of sediment.}}$$

4.3 IDENTIFICATION OF RADIOLARIAN TAXA

All the radiolarian species encountered in present study have been identified using radiolarian literature in microfiches, procured from Dr. William Riedel, Scripps Institution of Oceanography, La Jolla California, particularly the classic taxonomic references since 1835 to 1982. A Guide to modern radiolaria by Nigrini and Moore (1979) has been extensively utilized as the basis of majority of the identification, whereas systematics has been updated by consulting the taxonomic papers published during 1980 to 1990, in order to incorporate the recent taxonomic placement in present work. Coarser taxonomic frame-work proposed by Riedel *et al.* (1985) and its later modifications has been used for the radiolarian morpho-group composition. Mullineaux and Westberg-Smith (1986) has found that the quantitative data on coarser groups can be successfully used for the paleoceanographic studies. However, no such census data on coarser radiolarian groups is available from the modern radiolarian studies. Therefore, a modest attempt has been made to exercise coarser morphogroups from the modern radiolarian study from this basin. Radiolarian morphogroups are counted in the randomly oriented slides for the census data on group composition. Modern statistical techniques (R-mode cluster and Q-mode factor analyses) are used to achieve the statistically sound conclusions in present study.

4.4 STATISTICAL ANALYSES

Statistical analyses are the best way to arrive mathematically sound group or factor or assemblage of microfossils for a particular environment, which can be documented conclusively. Among many multivariate statistical techniques, cluster and factor analyses are widely used to interpret various paleontological studies in India (Nigam and Sarupriya, 1981; Guptha and Nigam, 1984; Nigam and Thiede, 1983; Naidu, 1990) mainly for foraminiferal and nannoplankton studies. However, these techniques are not yet used by Indian radiolarist, though these are widely used by American and European researchers of radiolaria (Moore, 1973b, 1978; Sachs, 1973a,b,c; Morley, 1989a). In present study these techniques are used and are described below briefly.

Cluster analysis

Clustering is the placing of objects into more or less homogeneous groups or assemblages, in a manner so that the relation between groups is revealed. It is an efficient way to display complex relationship among many objects (in this case morphogroups). Percentage data of the forty-seven morphogroups of forty-two samples were used for cluster analysis. First the Spearman rank correlation coefficient (Tate and Clelland, 1957) were calculated and a matrix of 47X47 was obtained for R-mode cluster analysis. Cluster analysis was performed using weighted pair-group averaging method (Davis, 1973). The results are exhibited in form of two dimensional hierarchy dendrogram in which morphogroups are presented along X-axis while similarity level on y-axis.

Factor analysis

Q-mode factor analysis was performed by using program of Kolvan and Imbrie (1971) to study inter-relationship between forty-two samples. Q-mode factor analysis describes the original data set by two matrices, the factor loading and factor score matrices. First matrix gives a measure of the relative abundance of each of the factors, or assemblages in each sample. The loading for each sample can be plotted on a geographical map to show the regional distribution of the particular assemblage or the factor. Second matrix gives the relative importance of each variables (morphogroups) within the identified assemblage or factor (Pisias, 1986).

Q-mode factor analysis has been widely used in radiolarian studies (Moore, 1973b, 1978; Sachs, 1973a,b,c; Molina Cruz, 1977a, 1984; Pisias, 1978, 1986; Morley, 1979; 1989a) in quantifying huge paleontological count-data of various taxonomic groups into few mathematically sound assemblages, which can be very well correlated with the physical, geochemical, and oceanographic processes of the area. Forty-seven morphogroups counted in forty-two samples in present study resulted in a large raw census data. Absolute counts are converted into percentage for the relative abundance of each morphogroup. Percentage data was subjected to Q-mode factor analysis to achieve statistically meaningful assemblages or factors on ND 520 Computer, using factor analysis program (Kolvan and Imbrie, 1971; Fernadez and Mahadevan, 1982). Weighted species composition in each factor (factor scores) and partitioned assemblage composition in each sample (factor loading) were achieved. Out of 10 factors initially searched for, only 4 factors are considered to be significant, which explain 93.51% of the original variance and discussed in chapter 6. The sample communality is used as a measure, how well these factors represent the information preserved in the sample, i.e. a communality of 0.9 means that it represents 81% of the original variance of the sample. Almost all of the samples have communality >0.9. High communalities (>0.9) with a high total variance explained, indicates that the four factors successfully describe major features of the original morphogroup distribution.

4.5 PRESENTATION OF STATISTICAL RESULTS

The raw data is presented in the tables, whereas processed data is presented in the form of X-Y plots. Clusters are presented as dendrogram. Factor loading on geographical location map was performed earlier manually by contouring. Later, SURFER program (Golden Software, USA, 1989) was acquired and it was used for computerized contouring of the factor loading to check any deviation. Manual contours of factors and the computerized one have the similar trends, but the later were smoother and elegant. Therefore, computerized contour plots are presented and an added advantage of three-dimensional plots of the factor loading is incorporated in order to have 3-D visual perspective (at $225^0/45^0$ and $45^0/45^0$ rotation). Three dimensional plots are used for the best possible presentation in nannoplankton biogeographic and paleoceanographic studies (Floden and Haq, 1980; Haq, 1980) and in present study they are utilized for the first time as for as radiolaria are concerned. In three dimensional plots, X and Y axes are the latitudes and longitudes and Z axis is the value of the factor.

CHAPTER 5

5.0 TAXONOMY

Radiolarian classification followed in this thesis is mainly based on Riedel (1967a,b; 1971) and proposed emendments of Petrushevskaya (1971 d). Names of the genera are followed by the original author (with year). But if the genus is modified or emended by subsequent worker (s), it is followed by the word **"emend."** and the name of the worker with the year of emendation. Synonymies of the taxa usually start with original description followed by later emendments. It is followed by the remark, if any.

5.1 SYSTEMATICS

Kingdom PROTISTA Haeckel, 1866

Phylum SARCODINA Hertwig & Lesser, 1874

Class ACTINOPODA Calkins, 1909

Subclass RADIOLARIA Muller, 1858a

Order POLYCYSTINA Ehrenberg, 1838, emend. Riedel, 1967a

Suborder SPUMELLARIA Ehrenberg, 1875

Family COLLOSPHAERIDAE Muller, 1858a

Genus COLLOSPHAERA Muller, 1855, emend. Bjorklund & Goll, 1979

COLLOSPHAERA INVAGINATA **(Haeckel)**

Pl. 1, Figs. 1-2.

Buccinosphaera invaginata Haeckel, 1887, p. 79, pl. 5, fig. 11; Strelkov & Reshetnyak, 1971, p. 365-366, pl. 4, fig. 32 ; Nigrini, 1971, p. 445, pl. 34.1, fig. 2 ; Knoll & Johnson, 1975, p. 63, pl. 1, figs. 3-6; Johnson & Nigrini, 1980, pl. 1, fig. 4; Sanfilippo *et al.*, 1985, p. 650, fig. 4.1; Petrushevskaya & Swanberg, 1990, p. 81, text fig. 8.

Collosphaera invaginata Bjorklund & Goll, 1979, p. 1317, pl. 3, figs. 1-9; Gupta, 1988, pl. 1, fig. 2.

REMARK : Knoll and Johnson (1975) established the evolution of *B. invaginata* from *Collosphaera sp. A (=C. orthoconus)* as its ancestor. Bjorklund and Goll (1979) illustrated and discussed the skeletal similarity between *B. invaginata, C. tuberosa* and *C. orthoconus* and suggested the change in generic name of this species from *Buccinosphaera* to *Collosphaera*. Following morphological similarities between *Buccinosphaera* and *Collosphaera* illustrated by Bjorklund and Goll (1979), Goll (1980) and Gupta (1988) identified this species as *Collosphaera invaginata*. However, Johnson *et al.* (1989) and Petrushevskaya and Swanberg (1990) retained the old

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nomenclature of *Buccinosphaera invaginata* without assigning any reason for ignoring emendations by Bjorklund and Goll (1979). In present study Species has been considered under *Collosphaera* genus for above reason as generic shift from *Buccinosphaera* to *Collosphaera* proposed by Bjorklund and Goll (1979) seems reasonable.

COLLOSPHAERA TUBEROSA **Haeckel**

Pl. 1, Figs. 3-5,28.

Collosphaera tuberosa Haeckel, 1887, p. 97; Nigrini, 1971, p. 445, pl. 35.1, fig. 1; Strelkov & Reshetnyak, 1971, p. 336-337, pl. 4, figs. 24,25; Bjorklund & Goll, 1979, p. 1317, pl. 2, figs. 1-8; Johnson & Nigrini, 1980, pl. 1, fig. 8; Gupta, 1988, pl. 1, figs. 3-4, pl. 2, figs. 1-2.; Petrushevskaya & Swanberg, 1990, p. 80, text-fig. 3.

COLLOSPHAERA ORTHOCONUS **(Haeckel)**

Pl. 1, Fig. 6.

Conosphaera orthoconus Haeckel, 1887, p. 221, pl. 12, fig. 2.

Collosphaera irregularis Haeckel- Knoll & Johnson, 1973, p. 11, pl. 1, fig. 1.

Collosphaera sp. A Knoll & Johnson, 1975, p. 63, pl. 1, figs. 1,2,7.

Collosphaera orthoconus Bjorklund & Goll, 1979, p. 1317 ; Goll, 1980, p. 436, pl. 1, figs. 10-11; Gupta, 1988, pl. 1, fig. 5; Petrushevskaya & Swanberg, 1990, p. 81, text-fig. 4.

COLLOSPHAERA DESAII **Sp. Nov.**

Pl. 1, Figs. 7-8.

Disolenia sp. : Takahashi & Honjo, 1981, pl. 1, fig. 10.

Collosphaera desaii herein

CHARACTER : Shell polygonal to subglobular, perforated and subspherical with 9-14 conical, open mouthed conical to tubular tubules. Pores are subcircular to polygonal and distributed all over the test. Specimens of this species are similar to *Collosphaera orthoconus* and only differ in its tubular openings, whereas in later *(C. orthoconus)* the conical tubules are closed in to conical protuberances. Some of the tubules tend to close into conical protuberance a characteristic feature of *Collosphaera orthoconus* (Paratype, Plate 1, Fig. 8). This feature indicates that the new species may have an ancestral link with *C. orthoconus*.

Measurements of the species are based on twenty specimens.

Size : Shell diameter 120-130 um
Length of tubules 15-20 um;
Base of tubules 20-25 um.
Numbers of the tubules 14.

Holotype : Plate 1, Fig.7;
Paratype : Plate 1, Fig. 8.

TYPE HORIZON : Surface sediments of the Central Indian Basin.

AGE : Quaternary.

ETYMOLOGY : Species is named in honor of Dr. B.N Desai, Director of National Institute of Oceanography, Goa.

REPOSITORY : GOD/NIO, RAD/Cat. 5.

***COLLOSPHAERA POLYGONA* Haeckel**

Pl. 1, Figs. 9-10, 25-27.

?. *Collosphaera huxleyi* Haeckel, 1862, pl. 34, fig. 5.

Collosphaera polygona Haeckel, 1887, p. 96, pl. 5, fig. 13; Strelkov & Reshetnyak, 1971, p. 338, pl. 4, figs. 26-27; Johnson & Nigrini, 1980, pl. 1, fig. 5; Takahashi & Honjo, 1981, p. 144, pl. 1, fig. 3.

COLLOSPHAERA HUXLEYI **Muller**

Pl. 1, Figs. 11,12.

Thalassicolla punctata Huxley, 1851, p. 434, pl. 14, fig. 6 (partim).

Collosphaera huxleyi Muller 1855, p. 238; 1858a, p. 55, pl. 8, figs. 6-9; Popofsky, 1917, p. 241, text figs. 2,3. pl. 13, figs. 1-9; Boltovoskoy & Riedel, 1980, p. 103, pl. 1, fig. 5.

COLLOSPHAERA SP. AFF. C. HUXLEYI **Muller**

Pl. 1, Figs. 14-18.

Collosphaera sp. aff. C. huxleyi Johnson & Nigrini, 1980, pl. 1, fig. 6.

Remark : Due to paucity of material species level could not be resolved.

COLLOSPHAERA ARMATA **Brandt**

Pl. 1, Figs. 19 & 22.

Collosphaera armata Brandt, 1905, p. 334, pl. 10, figs. 17,18; Popofsky, 1917, p. 246, pl. 14, fig. 1; Strelkov & Reshetnyak, 1971, p. 331, text fig. 23.

COLLOSPHAERA CONFOSSA **Takahashi**

Pl. 1, Figs. 20-21.

Collosphaera confossa Takahashi, 1981, p. 154, pl. 2, figs. 4,5.

Collosphaera sp.

Pl. 1, Figs. 13, 23, 24, 29-33, Pl. 2, Figs. 1-3.

Remark : All these specimens show conspecies variations. Hence could not be assigned to any species level (sensu stricto).

Genus DISOLENIA Ehrenberg , 1860a

DISOLENIA ZANGUEBARICA **(Ehrenberg)**

Pl. 2, Figs. 4,7.

Trisolenia zanguebarica Ehrenberg, 1872a, p. 321; 1872b, p. 149, pl. 10, fig. 11.

Solenosphaera zanguebarica (Ehrenberg) Brandt, 1905, p. 330, pl. 10, figs. 28-31; Popofsky, 1917, p. 249, text-fig. 9; Strelkov & Reshetnyak, 1971, p. 360, pl. 10, figs. 74-76.

Disolenia zanguebarica (Ehrenberg) Nigrini & Moore, 1979, p. S5, pl. 1, fig. 3; Johnson & Nigrini, 1980, p. 119, pl. 1, fig. 10; Takahashi, 1981, p. 156, pl. 3, figs. 2-4, 8-9.

DISOLENIA QUADRATA **(Ehrenberg)**

Pl. 2, Figs. 5-6.

Tetrasolenia quadrata Ehrenberg, 1872a, p. 320,; 1872b, p. 301, pl. 10, fig. 20.

Solenosphaera variabilis Haeckel, 1887, p. 113; Riedel, 1953, p. 808, pl. 84, fig. 8.

Solenosphaera pandora Haeckel, 1887, p. 113, pl. 7, figs. 10,11; Strelkov & Reshetnyak, 1971, p. 362, pl. 10, figs. 77-88.

Disolenia cf. variabilis (Haeckel) Benson, 1966, p. 123, pl. 2, fig. 5.

Trisolenia megalactis megalactis (Ehrenberg) Bjorklund & Goll, 1979, p. 1321, pl. 5, figs. 1-21.

Disolenia quadrata (Ehrenberg) Nigrini, 1967, p. 19-20, pl. 1, fig. 5; Johnson & Nigrini, 1980, pl. 1, fig. 9; Takahashi, 1981, p. 157, pl. 5, figs. 1-5.

DISOLENIA SP A. **Takahashi, 1981**

Pl. 2, Fig. 8

Disolenia sp. A Takahashi, 1981, p. 157, pl. 5, fig. 6.

Genus ACROSPHAERA Haeckel, 1881

ACROSPHAERA SPINOSA (Haeckel) LONGICULISPINA **Takahashi**

Pl. 2, Fig. 9.

Collosphaera spinosa Haeckel, 1962, p. 536, pl. 34, figs. 12,13.

Acrosphaera spinosa (Haeckel) Popofsky, 1917, p. 253, text fig, 16; Strelkov & Reshetnyak, 1971, p. 340, pl. 6, figs. 39-41 (partim).

Polysolenia flammabunda (Haeckel) Nigrini, 1967, p. 15, pl. 1, fig. 2; Nigrini & Moore, 1979, p. S13, pl. 2, fig. 2.

Acrosphaera flammabunda (Haeckel) Johnson & Nigrini, 1980, p. 116, pl. 1, fig. 1.

Acrosphaera spinosa longiculispina (Haeckel) Takahashi, 1981, p. 141, pl. 1, figs. 1-4.

ACROSPHAERA SPINOSA (Haeckel) CONICULISPINA **Takahashi**

Pl. 2, Fig. 10.

Collosphaera spinosa Haeckel, 1860b, p. 845; 1862, p. 536, pl. 34, figs. 12,13.

Acrosphaera spinosa (Haeckel) - Brandt, 1885, p. 263, pl. 2, fig. 4; Strelkov & Reshetnyak, 1971, p. 340, pl. 5, figs. 33-38; Johnson & Nigrini, 1980, p. 119, pl. 1, fig. 3.

Polysolenia spinosa (Haeckel) Nigrini, 1967, p. 14, pl. 1, fig. 1; Nigrini & Moore, 1979, p. S19, pl. 2, fig. 5.

Acrosphaera spinosa coniculispina (Haeckel) Takahashi, 1981, p. 151, pl. 1, fig. 2.

ACROSPHAERA SPINOSA (Haeckel) CORONULA **Takahashi**

Pl. 2, Figs. 11-12.

Choenicosphaera flammabunda Haeckel 1887, p. 103, pl. 8, fig. 5.

Acrosphaera spinosa (Haeckel) Popofsky, 1917, p. 254, text-figs. 14-15 (partim); Strelkov & Reshetnyak, 1971, p. 340, pl. 8, fig. 59 (partim).

Acrosphaera spinosa coronula (Haeckel) Takahashi, 1981, p. 151-152, pl. 1, fig. 5.

ACROSPHAERA SPINOSA LAPPACEA **(Haeckel)**

Pl. 2, Fig. 13.

Xanthiosphaera lappacea Haeckel, 1887, p. 120, pl. 8, figs. 10-11.

Polysolenia lappacea (Haeckel) Nigrini, 1967, p. 16, pl. 1, figs. 3a-b; Nigrini & Moore, 1979, p. S15, pl. 2, figs. 3a, b.

Acrosphaera lappacea (Haeckel) Johnson & Nigrini, 1980, p. 119, pl. 1, fig. 2.

ACROSPHAERA PSEUDOARKTIOS **Caulet**

Pl. 2, Fig. 14.

A. pseudoarktios Caulet, 1986b, p. 226, pl. 1, fig. 8.

ACROSPHAERA MURRAYANA **(Haeckel)**

Pl. 2, Figs. 15-16.

Coenicosphaera murrayana Haeckel, 1887, p. 102, pl. 8, fig. 4; Benson, 1966, p. 120, pl. 2, fig. 3.

Trypanosphaera brachysiphon Cleve, 1900b, p. 13, pl. 6, fig. 3.

Polysolenia murrayana (Haeckel) Nigrini, 1968, p. 52, pl. 1, fig. 1a,b.

Acrosphaera murrayana (Haeckel) Popofsky, 1917, p. 259, text-figs. 22,23; Strelkov & Reshetnyak, 1971, p. 347, text-figs. 25.

ACROSPHAERA CYRTODON **(Haeckel)**

Pl. 2, Figs. 18-21.

Odontosphaera cyrtodon Haeckel, 1887, p. 102, pl. 5, fig. 6.

Acrosphaera cyrtodon (Haeckel) Strelkov & Reshetnyak, 1971, p. 344, pl. 7, fig. 51; pl. 8, fig. 54, text-fig. 24.

ACROSPHAERA COLLINA **Haeckel**

Pl. 2, Figs. 17, 23-24.

Acrosphaera collina Haeckel, 1887, p. 101, pl. 8, fig. 2; Brandt, 1905, p. 334-335, pl. 9, figs. 14-15, pl. 10, figs. 32-33.

Solenosphaera collina (Haeckel) Hilmers, 1906, p. 41-44; Popofsky, 1917, p. 250, pl. 14, fig. 3; Strelkov & Reshetnyak, 1971, p. 362, pl. 8, fig. 52.

Disolenia collina (Haeckel) Takahashi, 1981, p. 156, pl. 3, figs. 1,5-7.

***ACROSPHAERA SPINOSA SPINOSA* (Haeckel)**

Pl. 2, Figs. 25 & 27.

Acrosphaera spinosa Brandt, 1885, p. 263, pl. 4, fig. 33a; Haeckel, 1887, p. 100; Strelkov & Reshetnjak, 1971, p. 340, pl. 5, fig. 6.

A. transformata Hilmers, 1906, p. 57, fig. 1.

Polysolenia spinosa (Haeckel) Nigrini, 1967, p. 14, pl. 1, fig. 1.

A. spinosa spinosa Strelkov & Reshetnyak, 1971, p. 340-342, pl. 5, fig. 5; Björklund & Goll, 1979, p. 1308, pl. 1, figs. 7, 10-13.

Genus OTOSPHAERA Haeckel, 1887, emend. Nigrini, 1967

OTOSPHAERA TENUISSIMA **(Hilmers)**

Pl. 3, Fig. 1.

Solenosphaera tenuissima Hilmers, 1906, p. 48, pl. 1, fig. 2; Popofsky, 1917, p. 252, text fig. 13.

Otosphaeara tenuissima (Hilmers) Takahashi, 1981, p. 158, pl. 3, fig. 11.

OTOSPHAERA POLYMORPHA **Haeckel**

Pl. 3, Fig. 2.

Otosphaera polymorpha Haeckel, 1887, p. 116, pl. 7, fig. 6; Nigrini, 1967, p. 23, pl. 1, fig. 8; Nigrini & Moore, 1979, p. 59, pl. 1, fig. 5.

?Trisolenia megalactis megalactis (Ehrenberg) Bjorklund & Goll, 1979, p. 1321, pl. 5, figs. 1-21.

Otosphaera polymorpha (Haeckel) Takahashi, 1981, p. 158, pl. 3, figs. 12, 14, 15.

OTOSPHAERA AURICULATA **Haeckel**

Pl. 3, Fig. 3.

Otosphaera auriculata Haeckel, 1887, p. 116, pl. 7, fig. 5; Nigrini, 1967, p. 2, pl. 1, fig. 7; Johnson & Nigrini, 1980, p. 119, pl. 1, fig. 11; Takahashi, 1981, p. 158, pl. 3, figs. 10, 13.

Genus SIPHONOSPHAERA Muller, 1858a

SIPHONOSPHAERA MARTENSI **Brandt**

Pl. 3, Figs. 4,7.

SIPHONOSPHAERA martensi Brandt, 1905, p. 339, pl. 9, figs. 9-12; Hilmers, 1906, p. 80; Strelkov & Reshetnyak, 1971, p. 356, fig. 28; Takahashi, 1981, p. 160, pl. 4, figs. 4,5,7,8.

SIPHONOSPHAERA POLYSIPHONIA **Haeckel**

Pl. 3, Figs. 5,6,8, 11-13.

Siphonosphaera polysiphonia Haeckel, 1887, p. 106; Nigrini, 1967, p. 18, pl. 1, figs. 4a,b; Renz, 1976, p. 89, fig. 7; Nigrini & Moore, 1979, p. S21, pl. 1, figs. 6a,b; Johnson & Nigrini, 1980, p. 119, pl. 1, fig. 12; Takahashi, 1981, p. 162.

SIPHONOSPHAERA SP. **Haeckel**

Pl. 3, Fig. 9,

Remark : All these specimens show conspecies variations. Hence could not be assigned to any species level (sensu stricto).

SIPHONOSPHAERA sp. aff S. hippotis (Haeckel) Renz, 1976, p. 89, pl. 1, fig. 1; Takahashi, 1981, p. 162, pl. 4, figs. 13-14.

Remark : Due to paucity of material species level could not be resolved and only affinity to the species is mentioned.

SIPHONOSPHAERA MAGNISPHAERA **Takahashi**

Pl. 3, Fig. 10.

Siphonosphaera magnisphaera Takahashi, 1981, p. 159, pl. 4, figs. 1,3.

Family ETHMOSPHAERIDAE Haeckel, 1862

Genus PLEGMOSPHAERA Haeckel, 1881

PLEGMOSPHAERA PACHYPILA **Haeckel**

Pl. 3, Figs. 16, 17; Pl. 4, Fig. 1.

Plegmosphaera pachypila Haeckel, 1887, p. 88; Takahashi, 1981, p. 163, pl. 5, figs. 7-9.

Styptosphaera sp. Takahashi & Honjo, 1981, p. 146, pl. 1, fig. 13.

Remark : Takahashi and Honjo (1981) is senior report and Takahashi (1981) is junior report. Many of the species assignment of Takahashi and Honjo (1981) were changed in Takahashi (1981).

PLEGMOSPHAERA COELOPILA **Haeckel**

Pl. 3, Figs. 18, 28.

Plegmosphaera coelopila Haeckel, 1887, p. 88.

Plegmosphaera coelopila Haeckel - Takahashi, 1981, p. 163, pl. 5, fig. 10.

PLEGMOSPHAERA ENTODICTYON **Haeckel**

Pl. 3, Fig. 19.

Plegmosphaera entodictyon Haeckel, 1887, p. 88; Holland & Enjumet, 1960, p. 103, pl. 48, fig. 1; Boltovoskoy & Riedel, 1980, p. 106, pl. 1, fig. 16; Takahashi, 1981, p. 164, pl. 6. figs. 8, 10-11.

? *Styptosphaera spongacea* Haeckel - Renz, 1976, p. 116, pl. 1, fig. 13.

PLEGMOSPHAERA SP. B **Takahashi**

Pl. 3, Fig. 14.

Plegmosphaera sp. B Takahashi, 1981, p. 163, pl. 6, fig. 1.

Genus STYPTOSPHAERA Haeckel, 1881

STYPTOSPHAERA SPONGIACEA **Haeckel**

Pl. 3, Fig. 20

Styptosphaera spongiacea Haeckel, 1887, p. 87.

Octodendron nidum Tan & Tchang, 1976, p. 233, text-fig. 10.

Styptosphaera spongiacea Haeckel- Takahashi, 1981, p. 165, pl. 6, figs. 6-7, 9.

STYPTOSPHAERA SP. B **Takahashi**

Pl. 3, Fig. 23.

Styptosphaera sp. B Takahashi, 1981, p. 166, pl. 5, fig. 12.

STYPTOSPHAERA SP.C **Takahashi**

Pl. 4, Fig. 2.

Styptosphaera sp. C Takahashi, 1981, p. 166, pl. 5, fig. 13.

Genus THECOSPHAERA Haeckel, 1881

THECOSPHAERA CAPILLACEA **Haeckel**

Pl. 4, Figs. 4,5.

Theocosphaera capillacea Haeckel, 1887, p. 81; Takahashi, 1981, p. 166, pl. 6, fig. 2.

THECOSPHAERA INERMIS **(Haeckel)**

Pl. 4, Figs. 6,7

Haliomma inerme Haeckel, 1860a, p. 815.

Actinomma inerme Haeckel, 1862, p. 440, pl. 24, fig. 5.

Thecosphaera inermis Haeckel, 1887, p. 80.

Thecosphaera inermis (Haeckel) Boltovoskoy & Riedel, 1980, p. 166-167, pl. 11, fig. 9; Takahashi, 1981, p. 166-167, p. 11, fig. 9.

Genus CARPOSPHAERA Haeckel, 1881

CARPOSPHAERA ACANTHOPHORA **(Popofsky)**

Pl. 4, Figs. 8,9.

Haliomma acanthophora Popofsky, 1913, p. 101-102, fig. 13.

?. *Cenosphaera cristata* Haeckel, 1887, p. 66.

Cenosphaera cristata Haeckel- Riedel, 1958, p. 223, pl. 1, figs. 1,2.

Carposphaera acanthophora (Popofsky) Benson, 1966, p. 127, pl. 2, figs. 8-10.

CARPOSPHAERA SP. AFF. C. CORYPHA **Haeckel**

Pl. 4, Figs. 10,11.

Plegmosphaera antarcticum Haeckel- Keany, 1979, p. 53, pl. 2, fig. 1.

?Carposphaera corypha Haeckel, 1887, p. 75.

Carposphaera sp. aff. C. corypha Haeckel- Takahashi, 1981, p. 167, pl. 9, fig. 12.

Remark : All these specimens show conspecies variations. Hence they could not be assigned to any species level (sensu stricto).

CARPOSPHAERA SP. A

Pl. 4, Figs. 12, 13.

Character : Shell spherical with a very small medullary and large cortical shell. Cortical shell have 10-12 pores of variable sizes from large to very small openings.

Remark : All these specimens show conspecies variations. Hence, they could not be assigned to any species level (sensu stricto).

Family ACTINIMMIDAE Haeckel, 1862, emend. Sanfilippo & Riedel, 1980

Subfamily ACTINIMMINIAE Haeckel, 1862, emend. Takahashi, 1981

Genus CENTROCUBUS Haeckel, 1887

CENTROCUBUS CLADOSTYLUS **Haeckel**

Pl. 4, Fig. 14.

Centrocubus cladostylus Haeckel, 1887, p. 278, pl. 18, fig. 1; Takahashi & Honjo, 1981, p. 148, pl. 4, fig. 1.

CENTROCUBUS OCTASTYLUS **Haeckel**

Pl. 4, Fig. 15.

Centrocubus octastylus Haeckel, 1887, p. 278; Takahashi, 1981, p. 168, pl. 1, fig. 1.

Genus SPONGOSPHAERA Ehrenberg, 1847b

SPONGOSPHAERA POLYCANTHA **Muller**

Pl. 4, Figs. 16, 17.

Spongosphaera polycantha Muller, 1858a, p. 32, pl. 4, figs. 1-4; Haeckel, 1887, p. 282; Hollande & Enjumet, 1960, pl. 46, fig. 1.

?*Spongosphaera streptacantha* Haeckel- Popofsky, 1912, pl. 8, fig. 4.

SPONGOSPHAERA SP. AFF. S. HELIODES **Haeckel**

Pl. 4, Fig. 18.

Spongosphaera heliodes Haeckel, 1862, p. 456, pl. 12, figs. 11-13; 1887, p. 283; Takahashi, 1981, p. 168, pl. 7, figs. 7-8.

Remark : Due to paucity of material species level could not be resolved and only affinity to the species is mentioned.

SPONGOSPHAERA SP A.

Pl. 4, Figs. 19, 20

Spongosphaera sp. B Takahashi, 1981, p. 169, pl. 7, fig. 9.

Remark : All these specimens show conspecies variations. Hence they could not be assigned to any species level (sensu stricto).

Genus LYCHNOSPHAERA Haeckel, 1881

LYCHNOSPHAERA REGINA **Haeckel**

Pl. 4, Figs. 21,22.

Lychnosphaera regina Haeckel, 1887, p. 227, pl. 11, figs. 1-4; Takahashi, 1981, p. 169, pl. 7, fig. 10.

Genus ACTINOMMA Haeckel, 1860a; emend. Nigrini, 1968

ACTINOMMA ARCADOPHORUM **Haeckel**

Pl. 5, Fig. 1.

Actinomma arcadophorum Haeckel, 1887, p. 255, pl. 29, figs. 7,8; Nigrini, 1967, p. 29, pl. 2, fig. 3; Nigrini & Moore, 1979, p. S29, pl. 3, Fig. 4; Johnson

& Nigrini, 1980, pl. 1, figs. 13, 14; Takahashi, 1981, p. 169, pl. 8, figs. 8-9, 11.

ACTINOMMA SP. **(Haeckel)**

Pl. 5, Figs. 2,3.

Actinomma capillaceum Haeckel, 1887, p. 255, pl. 29, fig. 6.

Actinomma medianum Nigrini- Johnson & Nigrini, 1980, pl. 1, fig. 15; Takahashi & Honjo, 1981, p. 147, pl. 2, fig. 4

Remark : Specimens are larger than *Actinomma medianum* but shorter than *A. arcadophorum.* They seems to be the transitional specimens between the two species mentioned.

Genus ACANTHOSPHAERA Ehrenberg, 1858.

ACANTHOSPHAERA ACTINOTA **(Haeckel)**

Pl. 5, Fig. 4.

Heliosphaera actinota Haeckel, 1860a, p. 803; 1862, p. 352, pl. 9, fig. 3; 1887, p. 218; Schroder 1909, p. 20, text-fig. 10.

Acanthosphaera tenuissima (Haeckel) Renz, 1976, p. 99, pl. 2, fig. 11.

Acanthosphaera sp. Hollande & Enjumet, 1960, p. 113, pl. 55, fig. 5.

Acanthosphaera actinota (Haeckel) Boltovoskoy & Riedel, 1980, p. 107, pl. 1, fig. 19,; Takahashi & Honjo, 1981, p. 146, pl. 1, figs. 18-19; Takahashi, 1981, p. 171, pl. 8, fig. 1.

ACANTHOSPHAERA SP. **Haeckel**

Pl. 5, Fig. 5.

Remark : All these specimens show conspecies variations of *Acanthosphaera tunis* Haeckel (Haeckel, 1887, p. 210; Takahashi, 1981, p. 171, pl. 8, fig. 2-3). Hence they could not be assigned to any species level (sensu stricto).

ACANTHOSPHAERA CASTANEA **Haeckel**

Pl. 5, Fig. 6.

Acanthosphaera castanea Haeckel, 1887, p. 211, pl. 26, fig. 3; Takahashi, 1981, pl. 8, figs. 4-5.

ACANTHOSPHAERA SIMPLEX **(Haeckel)**

Pl. 5, Fig. 7.

Cladococcus simplex Haeckel, 1860a, p. 800.

Rhaphidococcus simplex Haeckel, 1862, p. 336, pl. 13, figs. 5-6.

Acanthosphaera simplex Haeckel, 1887, p. 216; Takahashi, 1981, pl. 12, fig. 15.

Genus HELIOSPHAERA Haeckel, 1862

HELIOSPHAERA RADIATA **Popofsky**

Pl. 5, Fig. 8.

Heliosphaera radiata Popofsky, 1912, p. 98, text fig. 10; Benson, 1966, p. 160, pl. 5, figs. 1,2; Takahashi & Honjo, 1981, p. 146, pl. 1, fig. 22 ; Takahashi, 1981, p. 172.

Genus CLADOCOCCUS Muller, 1857

CLADOCOCCUS VIMINALIS **Haeckel**

Pl. 5, Figs. 9,10.

Cladococcus viminalis Haeckel, 1862, pl. 14, figs. 2,3; Bjorklund, 1976a, pl. 1, figs. 10-12; Takahashi, 1981, p. 172, pl. 8, figs. 6-7.

CLADOCOCCUS ABIETINUS **Haeckel**

Pl. 5, Figs. 11-13.

Cladococcus abietinus Haeckel, 1887, p. 226, pl. 27, fig. 3; Takahashi & Honjo, 1981, p. 148, pl. 2, fig. 10; Takahashi, 1981, p. 172, pl. 10, fig. 5.

CLADOCOCCUS SCOPARIUS **Haeckel**

Pl. 5, Fig. 14.

Cladococcus scoparius Haeckel, 1887, p. 225, pl. 27, fig. 2; Takahashi & Honjo, 1981, p. 148, pl. 2, fig. 11; Takahashi, 1981, p. 172, pl. 10, figs. 6-7.

CLADOCOCCUC CERVICORNIS **Haeckel**

Pl. 5, Fig. 15.

Cladococcus cervicornis Haeckel, 1860a, p. 801; 1862, p. 370, pl. 14, figs. 4-5; Boltovoskoy & Riedel, 1980, p. 110, pl. 2, fig. 5; Takahashi, 1981, p. 173, pl. 10, figs. 8-10.

Elaphococcus cervicornis (Haeckel) Benson, 1966, p. 172, pl. 6, fig. 1.

Elaphococcus gaussi Popofsky, 1912, p. 100, pl. 6, fig. II.

Genus ARACHNOSPHAERA Haeckel, 1862

ARACHNOSPHAERA MYRIACANTHA **Haeckel**

Pl. 5, Fig. 16.

Arachnosphaera myriacantha Haeckel, 1862, p. 357, pl. 10, fig. 3, pl. 11, fig. 4; 1887, p. 268,; Tan & Tchang, 1976, p. 232, text-fig. 8; Takahashi, 1981, p. 173, pl. 10, figs. 11-12.

Arachnosphaera hexasphaera Popofsky, 1912, p. 108, text figs. 19-21; Takahashi & Honjo, 1981, p. 147, pl. 2, fig. 13.

Genus ACTINOSPHAERA Hollande & Enjumet, 1960

ACTINOSPHAERA TENELLA **(Haeckel)**

Pl. 5, Fig. 17.

Haliomma tenellum Haeckel, 1862, p. 428.

Haliomma spinulosa Muller , 1858a, p. 40, pl. 4, fig. 7.

Actinosphaera capillaceum (Haeckel) Hollande & Enjumet, 1960, pl. 52, fig. 3.

Actinosphaera tenella (Haeckel) Takahashi, 1981, p. 174, pl. 9, fig. 1.

ACTINOSPHAERA ACANTHOPHORA **(Popofsky)**

Pl. 5, Fig. 18.

Haliomma acanthophora Popofsky, 1912, p. 101, text fig. 13; Dumitrica, 1972, p. 833, pl. 20, figs. 1-2.

Actinosphaera acanthophora (Popofsky) Takahashi, 1981, p. 174, pl. 9, figs. 2,3.

ACTINOSPHAERA CAPILLACEA **(Haeckel)**

Pl. 5, Fig. 19.

Haliomma capillaceum Haeckel, 1862, p. 426, pl. 23, fig. 2; 1887, p. 236.

Haliomma erinaceum Haeckel, 1862, p. 427, pl. 23, figs. 3,4; 1887, p. 236.

Actinosphaera capillaceum (Haeckel) Hollande & Enjumet (partim) 1960, pl. 52, figs. 1,2.

Actinosphaera capillacea (Haeckel) Takahashi, 1981, p. 175, pl. 9, figs. 4-5.

Genus HALIOMMA Ehrenberg, 1838

HALIOMMA SP.

Pl. 5, Fig. 20

Haliomma castanea Haeckel, 1962, p. 428, pl. 24, fig. 4; 1887, p. 232; Takahashi, 1981, p. 175, pl. 9, figs. 7-11.

Remark : All these specimens show conspecies variations. Hence they could not be assigned to species level (sensu stricto).

Genus HELIOSOMA Haeckel, 1881

HELIOSOMA SP. AFF. H. RADIANS **Haeckel**

Pl. 5, Fig. 21.

Remarks : Specimens are similar to *Heliosoma radians* Haeckel (Haeckel, 1887, p. 240, pl. 28, fig. 3; Takahashi, 1981, p. 176, pl. 9, figs. 6,8) but due to paucity of material species name could not be assigned.

Genus ELATOMMA Haeckel, 1881

ELATOMMA PENICILLUS **Haeckel**

Pl. 6, Figs. 1-2 .

Elatomma penicillius Haeckel, 1881, p. 243,; Takahashi, 1981, p. 176, pl. 9, figs. 9-10.

ELATOMMA PINETUM **Haeckel**

Pl. 6, Fig. 3.

Elatomma pinetum Haeckel, 1887, p. 242; Takahashi, 1981, p. 176, pl. 10, figs. 1-4.

Cladococcus stalactites Haeckel, 1887, p. 227, pl. 27, fig. 4; Benson, 1966, p. 173, pl. 6, figs. 2,3.

?Haeckeliella macrodoras (Haeckel) Hollande & Enjumet, 1960, pl. 56, figs. 2-6.

Genus ASTROSPHAERA Haeckel, 1887

ASTROSPHAERA HEXAGONALIS **Haeckel**

Pl. 6, Fig. 7.

Astrosphaera hexagonalis Haeckel, 1887, p. 250, pl. 19, fig. 4; Mast, 1910, p. 174,; Popofsky, 1912, p. 105, text-fig. 16; Takahashi, 1981, p. 176, pl. 11, figs. 1-3.

Genus SPHAEROPYLE Dreyer, 1889

SPHAEROPYLE MESPILUS **Dreyer**

Pl. 6, Fig. 5.

Sphaeropyle mespilus Dreyer, 1889, p. 207, pl. 8, fig. 39; Takahashi, 1981, p. 177, pl. 11, figs. 7-8.

Genus CROMYOMMA Haeckel, 1881

CROMYOMMA VILLOSUM **Haeckel**

Pl. 6, Fig. 6.

Cromyomma villosum Haeckel, 1887, p. 261, pl. 30, fig. 2; Takahashi, 1981, p. 177, pl. 11, figs. 10-11

Genus HEXASTYLUS Haeckel, 1881

HEXASTYLUS TRIAXONIUS **Haeckel**

Pl. 6, Fig. 20.

Hexastylus triaxonius Haeckel, 1887, p. 175, pl. 21, fig. 2; Benson, 1966, p. 140, pl. 3, figs. 6,7; Takahashi, 1981, p. 178, pl. 12, figs. 7,8.

Hexastylus dictyotus Haeckel, 1887, p. 176, pl. 21, figs. 8,9.

Genus HEXACONTIUM Haeckel, 1881

HEXACONTIUM AMPHISIPHON **Haeckel**

Pl. 6, Figs. 14,15.

Hexacontium amphisiphon Haeckel, 1887, p. 182, pl. 25, fig. 2; Takahashi, 1981, p. 180, pl. 12, figs. 13-14.

HEXACONTIUM HOSTILE **Cleve**

Pl. 6, Fig. 12.

Hexacontium hostile Cleve, 1900a, p. 9, pl. 6, fig. 4; Schroder, 1909, p. 14, text fig. 6; Goll & Bjorklund, 1971, p. 449, text fig. 6; Boltovoskoy & Riedel, 1980, p. 112, pl. 2, fig. 13.

Hexacontium pachydermum Jorgensen, 1905, p. 115, pl. 8, figs. 31a,b; Bjorklund, 1976b, pl. 1, figs 4-9; Kling, 1977, pl. 1, fig. 18.

?Hexacontium setosum Haeckel, 1887, p. 198,; Cleve, 1900a, p. 9, pl.5, fig. 6; Schroder, 1909, p. 13, text fig. 5.

HEXACONTIUM SP. AFF. H. HOSTILE **Cleve**

Pl. 6, Fig. 18.

Hexacontium sp. aff. H. hostile Cleve- Takahashi, 1981, p. 180, pl. 13, fig. 6.

Remark : Due to paucity of material species level could not be resolved and only affinity to the species is mentioned.

HEXACONTIUM AXOTRIAS **Haeckel**

Pl. 6, Fig. 17.

Hexacontium axotrias Haeckel, 1887, p. 192, pl. 24, fig. 3; Boltovoskoy & Riedel, 1980, p. 112, pl. 2, fig. 11; Takahashi & Honjo, 1981, p. 148, pl. 3, fig. 14; Takahashi, 1981, p. 181, pl. 13, fig. 3.

HEXACONTIUM HERACLITI **(Haeckel)**

Pl. 6, Fig. 19.

Hexalonche heracliti Haeckel, 1887, p. 187, pl. 22, fig. 7.

Hexacontium cf. H. heracliti (Haeckel) Benson, 1966, p. 158, pl. 4, figs. 8-10.

Hexacontium heracliti (Haeckel) Takahashi, 1981, p. 181, pl. 15, figs. 8,9.

HEXACONTIUM HYSTRICINA **(Haeckel)**

Pl. 7, Fig. 25.

Hexalonche hystricina Haeckel, 1887, p. 187, pl. 25, fig. 6.

Hexacontium hystricina Takahashi & Honjo, 1981, p. 148, pl. 3, fig. 16; Takahashi, 1981, p. 181, pl. 15, fig. 10.

Genus HEXACROMYUM Haeckel, 1881

HEXACROMYUM ELEGANS **Haeckel**

Pl. 6, Figs. 11, 16.

Hexacromyum elegans Haeckel, 1887, p. 201, pl. 24, fig. 9; Takahashi & Honjo, 1981, p. 148, pl. 3, fig. 15; Takahashi, 1981, p. 182, pl. 13, figs. 4,5,7.

Genus HETEROSPHAERA Mast, 1910

HETEROSPHAERA SP.

Pl. 6, Figs. 13 & 21.

Heterosphaera sp. A,B,. Takahashi, 1981, p. 182, pl. 13, figs. 8,9,10.

Remark : Due to paucity of material species level could not be resolved.

Genus CROMYECHNICUS Haeckel, 1881

CROMYECHNICUS SP. **Haeckel**

Pl. 7, figs. 1-4.

Cromyechnicus ?sp. Takahashi, 1981, p. 182, pl. 13, fig. 12.

CROMYECHNICUS SP. AFF. C. BOREALIS **(Cleve)**

Pl. 7, Figs. 5,6.

Actinomma boreale Cleve, 1899, p. 26, pl. 1, fig. 5c.

Cromyomma boreale (Cleve) Jorgensen, 1900, p. 59.

Cromyechnicus borealis (Cleve) Jorgensen , 1905, p. 117, pl. 8, fig. 35, pl. 9, figs, 36-37; Bjorklund, 1974, p. 20, figs. 5-7, 1976a, pl. 2, figs. 7-15; Takahashi & Honjo, 1981, p. 147, pl. 2, fig. 8; Takahashi, 1981, p. 183, pl. 13, fig. 13.

Genus STYLOSPHAERA Ehrenberg, 1847a

STYLOSPHAERA MELPOMENE **Haeckel**

Pl. 7, Figs. 10, 11.

Stylosphaera melpomene Haeckel, 1887, p. 135, pl. 16, fig. 1; Takahashi, 1981, p. 184, pl. 14, figs. 1,2.

STYLOSPHAERA SP.

Pl. 7, fig. 26.

Remark : Due to paucity of material species level could not be resolved.

Genus DRUPPATRACTUS Haeckel, 1887

DRUPPATRACTUS OSTRACION **Haeckel**

Pl. 7, Fig. 12.

?Druppatractus ostracion Haeckel, 1887, p. 326, pl. 16, figs. 9,10; Takahashi, 1981, p. 185, pl. 14, figs. 3,4.

Druppatractus.? sp. Takahashi, 1981, p. 189, pl. 15, fig. 5.

Genus ELLIPSOXIPHIUM Haeckel, 1887

ELLIPSOXIPHIUM PALLIATUM **Haecker**

Pl. 6, Fig. 13.

Ellipsoxiphium palliatum Haecker, 1908a, p. 441, pl. 84, figs. 587; Takahashi, 1981, p. 185.

Druppatractus equilonius Hays- Takahashi & Honjo, 1981, p. 147, pl. 3, fig. 5.

(non) *Ellipsoxiphium elegans var palliatus* Haeckel, 1887, p. 296, pl. 14, fig. 7.

Remark : Takahashi (1981) reassigned *D. equilonius* Hays of Takahashi and Honjo (1981) to *Ellipsoxiphium palliatum* Haeckel.

Genus AMPHISPHAERA Haeckel, 1881

AMPHISPHAERA SP. **Haeckel**

Pl. 7, Fig. 15.

Amphisphaera group Takahashi & Honjo , 1981, p. 147, pl. 3, fig. 3; Takahashi, 1981, pl. 14, figs. 6-7.

Genus AXOPRUNUM Haeckel, 1887

AXOPRUNUM STAURAXONIUM **Haeckel**

Pl. 7, Figs. 14, 20,21.

Axoprunum stauraxonium . Haeckel, 1887, p. 298, pl. 48, fig. 4; Hays, 1965, p. 170, pl. 1, fig. 3; Petrushevskaya & Kozlova, 1972, p. 521, pl. 10, fig. 10; Nigrini & Moore, 1979, p. S57, figs. 2,3; Takahashi, 1981, p. 187, pl. 14, figs. 8-10.

?Cromyatractus elegans Dogeil- Dumitrica, 1972, p. 834, pl. 20, fig. 8.

?Amphisphaera cristata Carnevale- Dumitrica, 1972, p. 833, pl. 20, fig. 10.

AXOPRUNUM SP.

Pl. 7, Fig. 24

Remark : Due to paucity of material species level could not be resolved and only affinity to the species is mentioned.

Genus XIPHATRACTUS Haeckel, 1887

XIPHATRACTUS SP B. **Takahashi**

Pl. 7, Figs. 17,18.

Xiphatractus sp. B Takahashi, 1981, pl. 15, figs. 6,7.

Genus STYLATRACTUS Haeckel, 1887

STYLATRACTUS SP.

Pl. 7, Figs. 9, 22, 23

Stylatractus universus Hays, 1965, p. 167, pl. 1, fig. 6; Sanfilippo, 1988, p. 170, pl. 1, fig. 15.

Axoprunum angelium (Campbell & Clark) Kling, 1973, p. 636, pl. 1, figs. 13-16, pl. 6, figs. 14-18.

Remark : Due to paucity of material species level could not be resolved and only affinity to the species is mentioned. Probably it could be reworked specimen.

Family SATURNALINAE Deflandre, 1953

Genus SATURNALIS Haeckel, 1881. emend. Nigrini, 1967

SATURNALIS CIRCULARIS **Haeckel**

Pl. 8, Figs. 1,2.

Saturnalis circularis Haeckel, 1887 p. 131; Nigrini, 1967, p. 25, pl. 1, fig. 9; Renz, 1976. p. 107, pl. 1, fig. 15; Johnson & Nigrini, 1980, pl. 1, fig. 19; Takahashi, 1981, p. 191, pl. 15, figs. 15-18.

Family COCCODISCIDAE Haeckel, 1962, emend. Sanfilippo & Riedel, 1980

Subfamily ARTISCINAE Haeckel, 1881, emend. Riedel, 1967a

Genus DIDYMOCYRTIS Haeckel, 1881, emend. Riedel, 1971

DIDYMOCYRTIS TETRATHALMUS TETRATHALMUS **(Haeckel)**

Pl. 8, Figs. 3-7.

Panartus tetrathalmus Haeckel, 1887, p. 378, pl. 40, fig. 3; Nigrini, 1967, p. 30, pl. 2, fig. 4 a-d.

Ommatartus tetrathalmus (Haeckel) Renz, 1976, p. 107, pl. 1, fig. 6; McMillen & Casey, 1978, pl. 2, fig. 13 a-b; Boltovoskoy & Riedel, 1980, p. 114, pl. 3, fig. 3; Johnson & Nigrini, 1980, pl. 1, fig. 17; Takahashi & Honjo, 1981, p. 148, pl. 4, figs. 2-6.

Ommatartus tetrathalmus tetrathalmus (Haeckel) Nigrini & Moore, 1979, p. S49, PL. 6, fig. 1 a-d; Johnson & Nigrini, 1980, p. 121, pl. 1, figs. 17.

Didymocyrtis tetrathalmus tetrathalmus (Haeckel) Takahashi, 1981, p. 190, pl. 21, figs. 1-14.

Genus SPONGOLIVA Haeckel, 1887

SPONGOLIVA ELLIPSOIDES **Popofsky**

Pl. 8, Fig. 8.

Spongoliva ellipsoides Popofsky, 1912, p. 117, text fig. 28; Renz, 1976, p. 108, pl. 1, fig. 5; Takahashi, 1981, p. 192, pl. 22, figs. 15-16.

Spongoliva cf. ellipsoides Popofsky- Takahashi & Honjo, 1981, p. 148, pl. 1, fig. 17.

?Spongoliva cf. ellipsoides Popofsky- Benson, 1966, p. 190, pl. 8, fig. 6.

Cypassis irregularis Nigrini- Johnson & Nigrini, 1980, pl. 1, fig. 18.

Family PORODISCIDAE Haeckel, 1881, emend.

Petrushevskaya & Kozlova 1972

Genus EUCHITONIA Ehrenberg, 1860b, emend.

Haeckel, 1887

EUCHITONIA ELEGANS **(Ehrenberg)**

Pl. 8, Figs. 9-10.

Pteractis elegans Ehrenberg, 1872a, p. 319,; 1872b, p. 299, pl. 8, fig. 3.

Euchitonia elegans (Ehrenberg) Haeckel, 1887, p. 535; Nigrini, 1967, p. 39, pl. 4, fig. 2 a-b; Johnson & Nigrini, 1980, p. 127, pl. 2, fig. 7; Takahashi & Honjo, 1981, p. 149, pl. 5, fig. 2; Takahashi, 1981, p. 193, pl. 16, figs. 1-6.

EUCHITONIA FURCATA **Ehrenberg**

Pl. 8, Figs. 11,12.

Euchitonia furcata Ehrenberg, 1860a, p. 767; 1860b, p. 832; 1872a, p. 308; 1872b, p. 289, pl. 6(iii), fig. 6; Haeckel, 1887, p. 532,; Nigrini & Moore , 1979, p. S85, pl. 11, figs. 2a,b; Johnson & Nigrini, 1980, pl. 2, fig. 8; Takahashi & Honjo, 1981, p. 149, pl. 3, fig. 6.

Genus AMPHIRHOPALUM Haeckel, 1881

AMPHIRHOPALUM SP.

Pl. 8, Fig. 13.

Remark : Specimens are not Y-shaped but a straight line.

AMPHIRHOPALUM VIRCHOWII **(Haeckel)**

Pl. 8, Figs. 14,15.

Euchitonia virchosii Haeckel, 1887, p. 503, pl. 30, figs. 1-4.

Amphirhopalum virchowii (Haeckel) Dumitrica, 1972, p. 833, pl. 9, figs. 2,4, pl. 11, fig. 6.

AMPHIRHOPALUM YPSILON **Haeckel**

Pl. 8, Figs. 16-18.

Amphirhopalum ypsilon Haeckel, 1887, p. 522; Nigrini & Moore, 1979, p. S75-77, pl. 10, figs.

1a,e; Johnson & Nigrini, 1980, p. 121, pl. 2, fig. 5; Gupta, 1988, pl. 1, figs. 6,7.

Amphicraspedum wyvilleanum Haeckel, 1887, p. 523, pl. 45, fig. 12.

AMPHIRHOPALUM OMALOCLADUM **Caulet**

Pl. 8, Fig. 19.

Trigonastrum sp. Johnson & Nigrini, 1980, pl. 2, fig. 6, pl. 4, figs. 16,17.

Amphirhopalum omalocladum Caulet, 1986b, p. 226, pl. 2, figs. 4-6.

AMPHIRHOPALUM STAUSSII **(Haeckel)**

Pl. 8, Fig. 20.

Tessarastrum staussii Haeckel, 1887, p. 547, pl. 45, fig. 8,; Renz, 1976, p. 112, pl. 3, fig. 7.

Amphirhopalum cf. tessarastrum stausii Haeckel-Johnson & Nigrini, 1980, p. 121, pl. 2, fig. 4, pl. 5, figs. 1,2.

Amphirhopalum staussii (Haeckel) Takahashi, 1981, p. 195, pl. 17, fig. 4.

Genus STYLODICTYA Ehrenberg, 1847a

STYLODICTYA VALIDISPINA **Jorgensen**

Pl. 9, Fig. 1.

Stylodicta validispina Jorgensen, 1905, p. 119, pl. 10, figs., 40a,b; Nigrini & Moore, 1979, p. S103, pl. 13, fig. 5 a-b; Takahashi, 1981, p. 195, pl. 19, fig. 11.

STYLODICTA MULTISPINA **Haeckel**

Pl. 9, Fig. 3.

Stylodictya multispina Haeckel, 1860b, p. 842; 1862, p. 496, pl. 29, fig. 5; Renz, 1976, p. 111, pl. 3, fig. 13; Takahashi & Honjo, 1981, p. 149, pl. 5, fig. 10; Boltovoskoy & Riedel 1980, p. 338, pl. 1, figs. 1 a-c.

STYLODICTYA ACULEATA **(Jorgensen)**

Pl. 9, Fig. 7.

Stylodicya aculeata (Jorgensen) Petrushevskaya, 1967, p. 33, figs. 17: iv-v.

Staurodictya sp. McMillen & Casey, 1978, pl. 2, fig. 18.

Genus STYLOCHLAMYDIUM Haeckel, 1881

STYLOCHLAMYDIUM ASTERISCUS **Haeckel**

Pl. 9, Fig. 2.

Stylochlamydium asteriscus Haeckel, 1887, p. 514, pl. 41, fig. 10; Renz, 1976, p. 109, pl. 3, fig. 12; Molina Cruz, 1977a, pl. 335, p. 4, fig. 6; McMillen & Casey, 1978, pl. 2, fig. 20; Boltovoskoy & Vrba, 1988, p. 399, pl. 1, fig. 2.

STYLOCHLAMYDIUM VENUSTUM **(Bailey)**

Pl. 9, Figs. 5,6.

Perichlamidium venustum Bailey, 1856, p. 5, pl. 1, figs. 16, 17.

Stylochlamydium venustum (Bailey) Haeckel, 1887, p. 515; Ling *et al*. 1971, p. 711, pl. 1, figs. 7, 8, text-fig. 5; Renz, 1976, p. 110, pl. 3, fig. 11; Boltovoskoy & Riedel, 1980, p. 118, pl. 4, fig. 3.

Stylochlamydium ? venustum (Bailey) Nigrini & Moore, 1979, p. S119, pl. 15, fig. 3 a-b.

Genus CIRCODISCUS Petrushevskaya & Kozlova, 1972

CIRCODISCUS MICROPORUS **(Stohr)**

Pl. 8, Fig. 4.

Trematodiscus microporus Stohr, 1880, p. 108, pl. 4, fig. 17.

Porodiscus microporus (Stohr) Haeckel, 1887, p. 493.

Circodiscus microporus (Stohr) Petrushevskaya & Kozlova, 1972, p. 526, pl. 19, figs. 1-7.

Family SPONGODISCIDAE Haeckel, 1862, emend. Riedel, 1967a; Petrushevskaya & Kozlova, 1972

Genus SPONGOBRACHIUM Haeckel, 1881

SPONGOBRACHIUM SP

Pl. 9, Fig. 10.

Spongobrachium sp. Johnson & Nigrini, 1980, p. 127, text-fig, 8, pl. 2, fig. 12, pl. 5, fig. 3; Takahashi, 1981, p. 197.

Genus DICTYOCORYNE Ehrenberg, 1860b

DICTYOCORYNE PROFUNDA **Ehrenberg**

Pl. 8, Fig. 21, Pl. 9, Figs. 9 & 11.

Dictyocoryne profunda Ehrenberg, 1860a, p. 767; 1872a, p. 307; 1872b, p. 288, pl. 7, fig. 23; Haeckel, 1887, p. 592; Nigrini & Moore, 1979, p. S87, pl. 3, fig. 10; Johnson & Nigrini, 1980, p. 127, pl. 2, fig. 9; Takahashi, 1981, p. 197, pl. 16, figs. 10, 12, 13, 15.

DICTYOCORYNE TRUNCATUM **(Ehrenberg)**

Pl. 9, Fig. 13.

Rhopalodictyum truncatum Ehrenberg, 1861, p. 301; Haeckel, 1887, p. 589.

Dictyocoryne cf truncatum (Ehrenberg) Benson , 1966, p. 235, pl. 15, fig. 1.

Dictyocoryne truncatum (Ehrenberg) Nigrini & Moore, 1979, p. S89, pl. 12, fig. 2 a-b; Johnson & Nigrini, 1980, p. 127, pl. 2, fig. 10.

Genus HYMINIASTRUM Haeckel, 1887

HYMINIASTRUM EUCLIDIS **Haeckel**

Pl. 9, Fig. 12.

Hyminiastrum euclidis Haeckel, 1887, p. 531, pl. 43, fig. 13; Benson, 1966, p. 222, pl. 12, figs. 1-3; Nigrini & Moore, 1979, p. S91, pl. 12, fig. 3; Johnson & Nigrini, 1980, p. 127, pl. 2, fig. 11; Takahashi & Honjo, 1981, p. 149, pl. 5, figs. 3-5.

Genus SPONGODISCUS Ehrenberg, 1854a

SPONGODISCUS RESURGENS **Ehrenberg**

Pl. 9, Fig. 14.

Spongodiscus resurgens Ehrenberg, 1854a, p. 21, pl. 35b, fig.16; Petrushevskaya & Kozlova, 1972, p.

5528, pl. 21, fig. 5; Takahashi & Honjo, 1981, p. 149, pl. 4, fig. 11.

Spongodiscus resurgense resurgense Ehrenberg - Petrushevskaya & Bjorklund, 1974, p. 40, text-fig. 6.

SPONGODISCUS BICONCAVUS **Haeckel**

Pl. 9, Fig. 15.

Spongodiscus biconcavus Haeckel, 1887, p. 577; Popofsky, 1912, p. 143, pl. 6, fig. 2; Tan & Tchang, 1976, p. 255, text-fig. 25; Boltovoskoy & Riedel, 1980; Takahashi, 1981, p. 199-200, pl. 19, figs. 2,3.

Spongaster disymmetricus (Dogeil) Petrushevskaya & Kozlova, 1972, p. 528, pl. 21, fig. 14.

Elliptical spongodiscids McMillen & Casey, 1978, pl. 3, fig. 13.

Genus SPONGOTROCHUS Haeckel, 1860 b

SPONGOTROCHUS GLACIALIS Popofsky

Pl. 10, Fig. 14.

Spongotrochus glacialis Popofsky, 1908, p. 228, pl. 26, fig. 8; pl. 27, fig. 1; Boltovoskoy & Riedel, 1980, p. 117, pl. 3, fig. 15; Takahashi & Honjo, 1981, p. 149, pl. 4, fig. 17; Takahashi, 1981, p. 200, pl. 19, fig. 10.

Spongotrochus arachnius Haeckel- Popofsky, 1908, p. 227, pl. 26, figs. 5, 6a, 7, pl. 28, fig. 1.

Spongotrochus multispinus (Haeckel) Renz, 1976, p. 97, pl. 3, fig. 9.

SPONGOTROCHUS SP..

Pl. 9, Figs. 17-20.

All specimen similar to *Spongotrochus* genus are illustrated as *Spongotrochus sp.* in the plate.

Genus SPONGURUS

SPONGURUS CF. ELLIPTICA **(Ehrenberg)**

Pl. 9, Fig. 21

?Acanthosphaera elliptica Ehrenberg, 1872a, p. 301; 1872b, pl. 7, fig. 4.

Spongurus cf. elliptica (Ehrenberg) Benson, 1966, p. 189, p. 8, figs. 4,5.

Spogurus elliptica (Ehrenberg) Johnson & Nigrini, 1980, pl. 1, fig. 20.

SPONGURUS POLYMATICUS **Riedel**

Pl. 9, Fig. 22.

Spongurus polymaticus Riedel, 1958, p. 226, pl. 1, figs. 10,11; Petrushevskaya, 1967, p. 32, figs. 16 I-II; Ling *et al.*, 1971, p. 711, pl. 1, fig. 5; Johnson & Nigrini, 1980, pl. 1, fig. 21.

Spongurus (?) polymaticus Riedel - Petrushevskaya, 1975, p. 577, pl. 7, fig. 4, pl. 37, fig. 7.

Genus SPONGOCORE Haeckel, 1887

SPONGOCORE CYLINDRICA **(Haeckel)**

Pl. 9, Figs. 23,24.

Spongurus cylindricus Haeckel, 1860b, p. 845; 1862, p. 465, pl. 27, fig. 1; 1887, p. 334.

Sponocore diplocylindrica Haeckel, 1887, p. 346; Renz, 1976, p. 95, pl. 3, fig. 8.

Spongocore puella Haeckel, 1887, p. 347, pl. 48, fig. 6; Benson, 1966, p. 187, pl. 8, figs. 1-3; Nigrini, 1970, p. 168, pl. 2, fig. 3; Nigrini & Moore, 1979, P. S69, pl. 8, figs. 5a-c; Johnson & Nigrini, 1980, pl. 1, fig. 22; Takahashi & Honjo, 1981, p. 149, pl. 4, fig. 20.

Spongocore cylindrica (Haeckel) Boltovoskoy & Riedel, 1980, p. 116, pl. 3, fig. 12.

Genus SPONGOPYLE Dreyer, 1889

SPONGOPYLE OSCULOSA **Dreyer**

Pl. 10. Fig. 1.

Spongopyle osculosa Dreyer, 1889, p. 42, pl. 11, figs. 99-100; Riedel, 1958, p. 226, pl. 1, fig. 12; Nigrini & Moore, 1979, p. S115, pl. 15, fig. 1.

Genus SPONGASTER Ehrenberg, 1860 b

SPONGASTER TETRAS TETRAS **Ehrenberg**

PL. 10, Figs. 2-3.

Spongaster tetras Ehrenberg, 1860b, p. 833; 1872b, p. 299, pl. 6, fig. 8; Haeckel, 1887, p. 597; Casey, 1971b, p. 341, pl. 23.3, figs. 18-19; Boltovoskoy & Riedel, 1980, p. 116, pl. 3, fig. 11.

Spongaster tetras tetras Ehrenberg- Nigrini, 1967, p. 41, pl. 5, figs. 1a,b; 1970, p.169, pl. 2, fig. 7; Renz, 1976, p. 94, pl. 3, fig. 4; Nigrini & Moore, 1979, p. S93, pl. 13, fig. 1; Johnson & Nigrini, 1980, p. 127, pl. 2, fig. 13.

SPONGASTER TETRAS IRREGULARIS **Nigrini**

Pl. 10, Fig. 4.

Spongaster tetras irregularis Nigrini, 1967, p. 42, pl. 5, fig. 2; Johnson & Nigrini, 1980, pl. 2, fig. 14.

Family PHACODISCIDAE Haeckel, 1881, emend. Campbell, 1954

Genus HELIODISCUS Haeckel, 1862

HELIODISCUS ASTERISCUS **Haeckel**

Pl. 10, Figs. 6-13.

Heliodiscus asteriscus Haeckel, 1887, p. 445, pl. 33, fig. 8; Nigrini, 1967, p. 32, pl. 3, figs. 1a,b; 1970, pl. 2, fig. 1; Renz, 1976, p. 92, pl. 2, fig. 1, Nigrini & Moore, 1979, p. S73, pl. 9, figs. 1,2; Boltovoskoy & Riedel, 1980, p. 115, pl. 3, fig. 6; Johnson & Nigrini, 1980, pl. 2, Fig. 2.

HELIODISCUS ECHINISCUS **Haeckel**

Pl. 10, Fig. 5.

Heliodiscus echiniscus Haeckel, 1887, p. 448, pl. 34, fig. 5; Nigrini, 1967, p. 34, pl. 3, fig. 2 a-b; Johnson & Nigrini, 1980, p. 121, pl. 2, fig. 3.

Heliodiscus asteroides Haecker, 1907a, p. 122, pl. 7; 1908a, p. 444, pl. 83, figs. 578-580.

Family THOLONIIDAE Haeckel, 1887

Genus THOLOMA Haeckel, 1887

THOLOMA METALLOSSON **Haeckel**

Pl. 6, figs. 8,9.

Tholoma metallosson Haeckel, 1887, p. 672, pl. 10, fig. 13; Takahashi, 1981, p. 208, pl. 11, figs. 12-13.

Cubotholus regularis Haeckel- Renz, 1976, p. 110, pl. 1, fig. 18.

Family PYLONIIDAE Haeckel, emend. Campbell, 1954

Genus HEXAPYLE Haeckel, 1881

HEXAPYLE DODECANTHA **Haeckel**

Pl. 10, Fig. 17.

Hexapyle dodecantha Haeckel, 1887, p. 569, pl. 48, fig. 16; Renz, 1976, p. 113, pl. 1, fig. 11; Takahashi & Honjo, 1981, p. 150, pl. 6, fig. 3.

Hexapyle sp. Takahashi, 1981, p. 208, pl. 23, fig. 7.

Genus OCTAPYLE Haeckel, 1881

OCTAPYLE STENOZONA **Haeckel**

Pl. 10, Figs. 20,21.

Octapyle stenozona Haeckel, 1887, p. 652, pl. 9, fig. 11; Benson, 1966, p. 251, pl. 16, figs. 3,4; Nigrini & Moore, 1979, p. S123, pl. 16, fig. 2 a-b; Takahashi, 1981, p. 208, pl. 23, fig. 8.

Genus TETRAPYLE Muller, 1858b

TETRAPYLE OCTACANTHA **Muller**

Pl. 10, Fig. 18-19.

Tetrapyle octacantha Muller, 1858b, p. 154, p. 33, figs. 1-6; Benson, 1966, p. 245, pl. 15, figs. 7-10; McMillen & Casey, 1978, pl. 3, figs. 2a-b; Nigrini & Moore, 1979, p. S125, p. 16, fig. 3 a-b; Takahashi & Honjo, 1981, p. 150, pl. 6, figs. 5,6; Takahashi, 1981, p. 209, pl. 25, figs. 9-10.

Family LITHELIDAE Haeckel, 1862

Genus LARCOPYLE Dreyer, 1889

LARCOPYLE BUTSCHLII **Dreyer**

Pl. 11, Figs. 1, 2.

Larcopyle butschlii Dreyer, 1889, pl. 10, fig. 10; Benson, 1966, p. 280, pl. 19, figs. 3-5; Nigrini &

Moore, 1979, p. S131, pl. 17, fig. 1 a-b; Takahashi & Honjo, 1981, p. 150, pl. 5, fig. 15.

Genus DISCOPYLE Haeckel, 1887

DISCOPYLE ELLIPTICA **Haeckel**

Pl. 11, Fig. 3.

Discopyle elliptica Haeckel, 1887, p. 573, pl. 48, fig. 20; Takahashi & Honjo, 1981, p. 150, pl. 5, fig. 14; Takahashi, 1981, p. 210.

Genus THOLOSPIRA Haeckel, 1887

THOLOSPIRA CERVICORNIS **Haeckel**

Pl. 11, Fig. 8.

Tholospira cervicornis Haeckel, 1887, p. 700, pl. 49, fig. 5; Takahashi & Honjo, 1981, p. 150, pl. 5, figs. 16-18; Takahashi, 1981, p. 210, pl. 22, figs. 7-9, 12.

Genus LITHELIUS Haeckel, 1862

LITHELIUS MINOR. **Jorgensen**

Pl. 11, Fig. 5

Lithelius minor Jorgensen, 1899, p. 65-66, pl. 5, fig. 24; Benson, 1966, p. 262, pl. 17, figs. 9,10, pl. 18, figs. 1-4; Takahashi, 1981, p. 211, pl. 22, fig. 10..

LITHELIUS NAUTILOIDES **Popofsky**

Pl. 11, Figs. 6-7.

Lithelius nautiloides Popofsky, 1908, p. 230, fig. 4 (only); Riedel, 1958, p. 228, pl. 2, fig. 3 (only), text-fig. 2; Petrushevskaya, 1967, p. 53, figs. 27, 28, I, 29, I.

Genus LARCOSPIRA Haeckel, 1887

LARCOSPIRA QUADRANGULA **Haeckel**

Pl. 11, Figs. 9-11.

Larcospira quadrangula Haeckel, 1887, p. 696, pl. 49, fig. 3; Benson, 1966, p. 266, pl. 16, figs. 7,8; Nigrini & Moore, 1979, p. S133, pl. 17, fig. 2; Johnson & Nigrini, 1980, pl. 2, fig. 15; Takahashi &

Honjo, 1981, p. 150, pl. 6, fig. 2; Takahashi, 1981. p. 211, pl. 23, figs. 11,12.

LITHELID GEN. INDET. SP. INDET.

Pl. 11, Fig. 12.

Specimen illustrated is not identifiable and tentatively assigned to *Lithelid gen. indet. sp. indet.*

Suborder NASSELLARIA Ehrenberg, 1875

Family PLAGIACANTHIDAE Hertwig, 1879, emend. Petrushevskaya, 1971d

Subfamily PLAGIACANTHINAE Hertwig, 1879, emend. Petrushevskaya, 1971d

Genus CLATHROMITRA Haeckel, 1881, emend. Takahashi, 1981

CLATHROMITRA PTEROPHORMIS **Haeckel**

Pl. 12, Fig. 1

Clathromitra pterophormis Haeckel, 1887, p. 1219, pl. 57, fig. 8; Takahashi & Honjo, 1981, p. 150, pl. 6, fig. 16; Takahashi, 1981, p. 214, pl. 24, fig. 8.

Genus GONOSPHAERA Jorgensen, 1905

GONOSPHAERA PRIMORDIALIS **Jorgensen**

Pl. 12, Figs. 2,3.

Gonosphaera primordialis Jorgensen, 1905, p. 133, pl. 14, figs. 64-68; Bjorklund, 1976a, pl. 9, figs. 7,-10

Gonosphaera primordialis? Jorgensen- Takahashi, 1981, p. 216, pl. 26, fig. 2.

Genus PHORMACANTHA Jorgensen , 1905

PHORMACANTHA HYSTRIX **(Jorgensen)**

Pl. 12, Fig. 4

Peridium hystrix Jorgensen, 1900, p. 76.

Phormacantha hystrix (Jorgensen) Jorgensen, 1905, p. 132, pl. 14, figs. 59-63; Takahashi & Honjo, 1981, p. 150, pl. 6, figs. 17-19; Takahashi, 1981, p. 216, pl. 26, fig. 3.

Subfamily LOPHOPHAENINAE Haeckel, 1881, emend.

Petrushevskaya, 1971d

Genus LOPHOPHAENA Ehrenberg, 1847b

LOPHOPHAENA CYLINDRICA **(Cleve)**

Pl. 12, Figs. 6.

Acanthocorys variabilis Popofsky, 1913, p. 360, text-figs. 74-77 (only); Benson, 1966, p. 373, pl. 24, fig. 19.

Lophophaena cylindrica (Cleve) Petrushevskaya, 1971c, p. 117, fig. 61, iv-vi; Renz, 1976, p. 159, pl. 6, fig. 21; Takahashi & Honjo, 1981, p. 151, pl. 7, fig. 2; Takahashi, 1981, p. 217, pl. 25, figs. 3-5.

***LOPHOPHAENA CF. CAPITO* Ehrenberg**

Pl. 12, Figs. 7,8.

?Lophophaena capito Ehrenberg, 1873, p. 242; 1875, pl. 8, fig. 6.

Lophophaena cf. capito Ehrenberg- Benson , 1966, p. 378, pl. 24, figs. 22,23; pl. 25, fig. 1; Takahashi & Honjo, 1981, p. 151, pl. 6, fig. 22; Takahashi, 1981, p. 218, pl. 25, figs. 6-9.

Remark : Due to paucity of material species level could not be resolved and only affinity to the species is mentioned.

LOPHOPHAENA DECACANTHA **(Haeckel)**

Pl. 12, Fig. 9.

Lithomelissa decacantha Haeckel, 1887, p. 1208, pl. 56, fig. 2.

Lophophaena decacantha (Haeckel) Takahashi, 1981, p. 218, pl. 25, figs. 2,8, 10.

Genus HELOTHOLUS Jorgensen , 1905

HELOTHOLUS SP.

Pl. 12, Figs. 12, 13.

Helotholus histricosa Jorgensen, 1905, p. 137, pl. 16, figs. 86-88; Benson, 1966, p. 459, pl. 31, figs. 4-8; Takahashi & Honjo, 1981, p. 151, pl. 7, figs. 6,7; Takahashi, 1981, p. 218.

Genus PEROMELISSA Haeckel, 1881

PEROMELISSA PHALACRA **Haeckel**

Pl. 12, Fig. 10.

Peromelissa phalacra Haeckel, 1887, p. 1236, pl. 57, fiq. 11; McMillen & Casey, 1978, pl. 4, fig.20; Boltovoskoy & Riedel, 1980, p. 122, pl. 5, fig. 3; Takahashi & Honjo, 1981, p. 151, pl. 7, figs. 3-5; Takahashi, 1981, p. 219, pl. 25, figs. 11-15.

Psilomelissa longispina Cleve, 1900a, p. 10, pl. 4, fig. 4.

Psilomelissa phalacra (Haeckel) Popofsky, 1908, p. 283, pl. 32, fig. 4.

Psilomelissa tricuspidata Popofsky, 1908, pl. 32, fig. 9.

Psilomelissa tricuspidata abdominalis Popofsky, 1908, pl. 33, fig. 4.

Lithomelissa monoceras Popofsky, 1913, p. 335, text-fig. 43, pl. 32, fig. 7; Renz, 1976, p. 158, pl. 6, fig. 12.

Peromelissa phalacra Haeckel- Takahashi & Honjo, 1981, p. 151, pl. 7, figs. 3-5; Takahashi, 1981, p. 219, pl. 25, figs. 11-15.

Genus LITHOMELISSA Jorgensen,1900

LITHOMELISSA SETOSA **Jorgensen**

Pl. 12, Fig. 11.

Lithomelissa setosa Jorgensen, 1900, p. 81, pl. 4, fig. 21; 1905, p. 135, pl. 16, figs. 81-83, pl. 18, fig. 108 a-b; Bjorklund, 1976a, pl. 8, figs. 1-13, pl. 11, figs. 19-23; Kling, 1977, p. 217, pl. 1, figs. 2; Boltovoskoy & Riedel, 1980, p. 121, pl. 5, fig. 1; Takahashi, 1981, p. 219, pl. 25, figs. 16-22.

Genus PERIDIUM Haeckel, 1887

PERIDIUM SPINIPES **Haeckel**

Pl. 12, Fig. 5.

Peridium spinipes Haeckel, 1887, p. 1154, pl. 53, fig. 9; Takahashi & Honjo, 1981, p. 151, pl. 6, fig. 20; Takahashi, 1981, p. 220, pl. 26, fig. 4-6.

Peridium longispinum Jorgensen, 1905, p. 135, pl. 15, figs. 75-79, pl. 16, fig. 80; Benson, 1966, p. 359, pl. 23, fig. 27, pl. 24, figs. 1, 2 (only) partim.

Psilomelissa calvata Haeckel, 1887, p. 1209, pl. 56, fig. 3; Renz, 1976, p. 160, pl. 6, fig. 15.

Subfamily SETHOPERININAE Haeckel, 1881 emend. Petrushevskaya, 1971d.

Genus CLATHROCANIUM Ehrenberg, 1860a

CLATHROCANIUM COARCTATUM **Ehrenberg**

Pl. 12, Figs. 14, 16.

Lychnocanium fenestratum Ehrenberg , 1860a, p. 767.

Clathrocanium coarctatum Ehrenberg, 1872a, p. 303; 1872b, p. 287, pl. 7, fig. 6; Haeckel, 1887, p. 1211; Popofsky, 1913, p. 341, text-fig. 50; Takahashi, 1981, p. 221, pl. 26, figs. 11-13.

Clathrocanium triomma Haeckel, 1887, p. 211 , pl. 64, fig. 3.

Clathrocanium coronatum Popofsky, 1913, p. 342, pl. 33, fig. 1.

Clathrocanium cf. coronatum Popofsky- Benson, 1966, p. 394, pl. 26, figs. 1-2.

Clathrocanium ornatum Popofsky, 1913, p. 343, pl. 33, fig. 2.

CLATHROCANIUM DIADEMA **(Haeckel)**

Pl. 12, Figs. 15.

Clathrocorona didema Haeckel, 1881, p. 431.

Clathrocanium diadema Haeckel, 1887, p. 1212, pl. 64, fig. 2; Popofsky, 1913, pl. 32, fig. 4; McMillen & Casey, 1978, pl. 5, fig. 5; Takahashi & Honjo, 1981, p. 151, pl. 7, fig. 8.

Genus CALLIMITRA Haeckel, 1881

CALLIMITRA EMMAE **Haeckel**

Pl. 12, Fig. 18.

Callimitra emmae Haeckel, 1887, p. 1218, pl. 63, figs. 3,4; Benson, 1966, p. 390, pl. 25, fig. 12; Takahashi & Honjo, 1981, p. 151, pl. 7, fig. 11; Takahashi, 1981, p. 222, pl. 26, fig. 14.

CALLIMITRA ANNAE **Haeckel**

Pl. 12, Fig. 17.

Callimitra annae Haeckel, 1887, p. 1217, pl. 63, fig. 2; Takahashi, 1981, p. 223, pl. 26, fig. 15.

Callimitra agnesae Haeckel, 1887, p. 1217, pl. 63, fig. 5.

Callimitra elisabethae Haeckel, 1887, p. 1218, pl. 67, fig. 6; Takahashi & Honjo, 1981, p. 151, pl. 7, figs. 9-10.

Calimitra sp. - Renz, 1976, p. 162, pl. 7, fig. 1.

Genus CLATHROCORYS Haeckel, 1881

CLATHROCORYS GILTSCHII **Haeckel**

Pl. 12, Fig. 19.

Clathrocorys giltschii Haeckel, 1887, p. 1220, pl. 64, fig. 9; Takahashi, 1981, p. 224, pl. 27, figs. 1,3, 9.

Clathrocorys teuscheri Haeckel, 1887, p. 1220, pl. 64, fig. 10.

Family ACANTHODESMIIDAE Haeckel, 1862, emend. Riedel, 1971

Genus ZYGOCIRCUS Butschli, 1882

ZYGOCIRCUS CAPULOSUS **Popofsky**

Pl. 12, Fig. 21.

Zygocircus capulosus Popofsky, 1913, p. 287, pl. 28, fig. 4; Renz, 1976, p. 169, pl. 8, fig. 6; Takahashi & Honjo, 1981, p. 151, pl. 7, fig. 12.

ZYGOCIRCUS PRODUCTUS **(Hertwig)**

Pl. 12, Fig. 20.

Lithocircus productus Hertwig, 1879, p. 197, pl. 12 (7), fig. 4.

Zygocircus productus (Hertwig) Petrushevskaya, 1971c, p. 281, fig. 16; 10; Boltovoskoy & Riedel, 1980, p. 121, pl. 4, fig. 17; Takahashi & Honjo, 1981, p. 151, pl. 7, figs. 13-14; Takahashi, 1981, p. 225, pl. 27, figs. 13-14.

ZYGOCIRCUS SP. CF. Z. PISCICAUDATUS **Popofsky**

Pl. 12, Fig. 23.

Zygocircus piscicaudatus Popofsky, 1913, p. 287, pl.. 28, fig. 3.

Zygocircus sp. cf. Z. piscicaudatus Popofsky- Renz, 1976, p. 171, pl. 8, fig. 3; Takahashi & Honjo, 1981, p. 151, pl. 7, fig. 15; Takahashi , 1981, p. 226, pl. 27, fig. 18.

Genus NEOSEMANTIS Popofsky 1913

NEOSEMANTIS DISTAPHANUS **Popofsky**

Pl. 12, Fig. 22.

Neosemantis distaphanus Popofsky, 1913, p. 299, pl. 29, fig. 2; Petrushevskaya, 1971c, p. 152, figs. 77 i-iii; Kling, 1979, p. 309, pl. 1, figs. 15,16; Boltovoskoy & Riedel, 1980, pl. 4, fig. 14; Takahashi & Honjo, 1981, p. 151, pl. 7, fig. 17; Takahashi, 1981, p. 216, pl. 27, fig. 12.

Genus : ACANTHODESMIA Muller, 1857

ACANTHODESMIA VINCULATUS **(Muller)**

Pl. 12, Figs. 24, 25.

Lithocircus viniculata Muller, 1857, p. 484.

Acanthodesmia vinculata Muller, 1858a, p. 30, pl. 1, figs. 4-7; Petrushevskaya, 1971c, p. 278, fig. 143, I-III; 144, I- VI; Ling, 1972, p. 169, pl. 1, fig. 6; Boltovoskoy & Riedel, 1980, p. 120, pl. 4, fig. 12; Takahashi & Honjo, 1981, p. 151, pl. 7, figs. 18, 19; Takahashi, 1981, p. 226, pl. 29, figs. 6-8.

Eucoronis nephrospyris Haeckel, 1887, p. 977, pl. 82, fig. 5; Benson, 1966, p. 304, pl. 21, figs. 6-8.

Eucoronis angulata Haeckel, 1887, p. 978, pl. 82, fig. 3.

Eucoronis challangeri Haeckel, 1887, p. 978, pl. 82, fig. 4.

Giraffospyris angulata (Haeckel)- Goll, 1969, p. 331, pl. 59, figs. 4,6,7,9, text-fig. 2; Renz, 1976, p. 167, pl. 8, fig. 5, Nigrini & Moore, 1979, p. N11, pl. 19, figs. 2a-d, 3a-b.

Genus LOPHOSPYRIS Haeckel, 1881, emend. Goll, 1977

***LOPHOSPYRIS PENTAGONA PENTAGONA* (Ehrenberg) emend. Goll, 1977**

Pl. 12, Fig. 26, Pl. 13, Fig. 1.

Ceratospyris pentagona Ehrenberg, 1872a, p. 303; 1872b, p. 302, pl. 15, fig. 15.

Ceratospyris allmersii Haeckel, 1887, p. 1067, pl. 86, fig. 3.

Ceratospyris strasbergeri Haeckel, 1887, p. 1067, pl. 86, fig. 2.

Ceratospyris polygona Haeckel- Benson, 1966, p. 321-324, pl. 22, figs. 15-16 (partim).

Ceratospyris sp. Nigrini, 1967, p. 48-49, pl. 5, fig. 6; Renz, p. 172, pl. 8, fig. 8.

Darcadospyris pentagona (Ehrenberg) Goll, 1969, p. 338-339, pl. 59, figs. 1-3, 5; Ling, 1972, p. 168, pl. 2, fig. 5.

Lophospyris pentagona pentagona (Ehrenberg) Goll, 1977, p. 384, 398, pl. 10, figs. 1-7; pl. 11, figs. 1-3,5; Nigrini & Moore, 1979, p. N15, pl.19, fig. 5; Takahashi & Honjo, 1981, p. 151, pl. 7, figs. 20-21; Takahashi, 1981, p. 227, pl. 28, figs. 9-14.

***LOPHOSPYRIS PENTAGONA HYPERBOREA* (Jorgensen) emend. Goll, 1977**

Pl. 13, Fig 2.

Ceratospyris hyperborea Jorgensen, 1905, p. 130-131, pl. 13, fig. 49; Goll & Bjorklund, 1971, p. 449, text-fig. 7.

Ceratospyris polygona Haeckel- Popofsky, 1913, p. 305-308; pl. 30, fig. 1 (partim); Benson, 1966, p. 321-324, pl. 22, figs 17-18 (partim).

Ceratospyris sp. A Renz, 1976, p. 173, pl. 8, fig. 9.

Lophospyris pentagona hyperborea (Jorgensen) Goll, 1977, p. 400, pl. 14, figs. 4-6, 8-9, 11-12; pl. 15, figs. 1-12; Takahashi & Honjo, 1981, p. 152, pl. 7, figs. 22-26; Takahashi, 1981, p. 228, pl. 29, figs. 1-3, 5-10.

LOPHOSPYRIS CHENI **Goll**

Pl. 13, Fig. 3.

Lophospyris cheni Goll, 1977, p. 402, pl. 11, fig. 4, pl. 12, figs. 1-7, Takahashi , 1981, p. 228, pl. 29, fig. 4.

Genus PHORMOSPYRIS Haeckel, 1881, emend. Goll, 1977

***PHORMOSPYRIS STABILIS* (Goll) *SCAPHIPES* (Haeckel)**

Pl. 13, Figs. 4,5.

Tristylospyris scaphipes Haeckel- Benson, 1966, p. 316- 321, pl. 22, figs. 7,9-10.

Tholospyris scaphipes (Haeckel) Goll, 1969, p. 328-329, pl. 58, figs. 1-6 (partim).

Phormospyris stabilis scaphipes (Haeckel)- Goll, 1977, p. 394, pl. 8, figs. 1-15, pl. 9, figs 1-5; Nigrini & Moore, p. N19, pl. 29, fig. 2 a-d; Takahashi, 1981, p. 229, pl. 29, figs. 11, 12, 14.

***PHORMOSPYRIS STABILIS* (Goll) *CAPOI* Goll**

Pl. 13, Figs., 6,7.

Rhodospyris sp. Benson, 1966, p. 329-331, pl. 23, figs. 3-5.

Phormospyris stabilis capoi Goll, 1977, p. 392, pl. 5, figs. 1-2, pl. 6, figs. 1-13, pl. 7, figs. 1-9; Takahashi, 1981, p. 229-230, pl. 29, figs. 15-18.

PHORMOSPYRIS STABILIS STABILIS **(Goll)**
Pl. 13, Fig. 8.

Desmospyris anthocyrtoides (Butschli) Benson, 1966, p. 324-334, pl. 23, figs. 6-8.

Dendrospyris stabilis Goll, 1968, p. 1422-1423, pl. 173, figs. 16-18, 20.

Phormospyris stabilis stabilis Goll, 1977, p. 390, pl. 1, figs. 1-13, pl. 2, figs. 7-14; Kling, 1979, p. 309, pl. 1, fig. 18; Takahashi, 1981, p. 230, pl. 30, figs. 2-5.

Genus DICTYOSPYRIS Ehrenberg, 1847b

DICTYOSPYRIS SP. **Ehrenberg**
Pl. 13, Fig. 9.

Dictyospyris sp. group **B** Ehrenberg- Takahashi & Honjo, p. 152, pl. 7, Fig. 29.

Dictyospyris sp. group Takahashi, 1981, p. 230, pl. 30, fig. 1.

Genus NEPHROSPYRIS Haeckel, 1881

NEPHROSPYRIS RENILLA RENILLA **Haeckel**
Pl. 13, Figs, 10,11.

Nephrospyris renilla Haeckel, 1887, p. 1101, pl. 90, figs. 9, 10; Renz, 1976, p. 179, pl. 8, fig. 18.

Nephrodityum renilla (Haeckel) Benson, 1966, p. 302-304, pl. 21, fig. 5.

Nephrospyris renilla renilla (Haeckel) Goll, 1980, p. 437, pl. 5, fig. 2; Takahashi, 1981, p. 230-231, pl. 30, figs. 7,9; Gupta, 1988, pl. 2, fig. 11.

NEPHROSPYRIS RENILLA LANA **Goll**

Nephrospyris renilla lana Goll, 1980, p. 438, pl. 5, fig. 1; Takahashi, 1981, p. 231, pl. 30, fig. 10; Gupta, 1988, pl. 2, fig. 7.

Genus ANDROSPYRIS Haeckel, 1887

ANDROSPYRIS RAMOSA **(Haeckel)**

Pl. 13, Fig. 12.

Tholospyris ramosa Haeckel, 1887, p. 1079, pl. 89, fig. 3.

?*Tholospyris cupolsa* Haeckel, 1887, p. 1080, pl. 89, fig. 4.

Tholospyris fornicata Popofsky, 1913, p. 309, pl. 30, fig. 2; -Renz, 1976, p. 177, pl. 8, fig. 15; Takahashi & Honjo, 1981, p. 152, pl. 7, fig. 30.

Androspyris ramosa Haeckel- Goll, 1980.

ANDROSPYRIS ANTHROPISCUS **(Haeckel)**

Androspyris anthropiscus (Haeckel)- Goll, 1980, pl. 4, figs. 2,3; Gupta, 1988, p. 67, pl. 1, fig. 11.

ANDROSPYRIS FENESTRATA **Haeckel**

Androspyris fenestrata Haeckel- Goll, 1980, pl. 4, figs. 4,5; Gupta, 1988, p. 67, pl. 1, fig. 12.

ANDROSPYRIS HUXLEYI **(Haeckel)**

Lamprospyris huxleyi Haeckel, 1887, p. 1094, pl. 89, fig. 14.

Androspyris huxleyi (Haeckel) Haeckel, 1887, p. 1894, pl. 89, fig. 14; Goll, 1980, p. 434, pl. 4, figs. 4,5; Takahashi, 1981, p. 232, pl. 30, figs. 15-16; Gupta, 1988, pl. 1, fig. 13.

Genus THOLOSPYRIS Haeckel, 1881, emend. Goll, 1969

THOLOSPYRIS BACONIANA BACONIANA **(Haeckel)**
Pl. 13, fig. 13

Tricolospyris baconiana Haeckel, 1887, p. 1098, pl. 88, fig. 8.

Tholospyris baconiana baconiana (Haeckel) Goll, 1972a, p. 451, pl. 1, figs. 7-9, pl. 2, figs. 1-8; Takahashi, 1981, p. 234, pl. 31, figs. 6-7.

THOLOSPYRIS BACONIANA **(Haeckel)** *VARIABILIS* **Goll**

Pl. 13, Fig. 14.

Tholospyris baconiana variabilis Goll, 1972a, p. 452, pl. 8, figs. 1-8; Pl. 9, Figs. 1-12; Takahashi, 1981, p. 234, pl. 31, fig. 8.

Tholospyris baconiana baconiana (Haeckel) - Takahashi & Honjo, 1981, p. 151, pl. 8, fig. 9.

Genus : LIRIOSPYRIS Haeckel, 1881, emend. Goll, 1968

LIRIOSPYRIS THORAX THORAX **(Haeckel)**

Pl. 13, fig. 15.

Amphispyris thorax Haeckel, 1887, p. 1096, pl. 88, fig. 4.

Liriospyris thorax thorax (Haeckel) Takahashi, 1981, p. 235, pl. 31, fig. 12.

LIRIOSPYRIS RETICULATA **(Ehrenberg)**

Pl. 13, Fig. 16.

Dictyospyris reticulata Ehrenberg, 1872a, p. 307 ; 1872b, p. 289, pl. 10, fig. 19.

Amphispyris costata Haeckel, 1887, p. 1097, pl. 88, fig. 3; McMillen & Casey, 1978, pl. 5, fig. 9; Takahashi & Honjo, 1981, p. 152, pl. 8, figs. 1-2.

Amphispyris reticulata (Ehrenberg) - Nigrini, 1967, p. 44, pl. 5, fig. 3.

Liriospyris reticulata (Ehrenberg) Goll, 1968, p. 1429, pl. 176, figs. 9, 11,13; 1972b, p. 967, pl. 71, fig. 1; Nigrini & Moore, 1979, p. N13, pl. 19, figs. 4a,b; Johnson & Nigrini, 1980, p. 127, pl. 3, fig. 2.

Family SETHOPHORMIDIDAE Haeckel, 1881, emend. Petrushevskaya, 1971d

Genus TETRAPHORMIS Haeckel, 1881

TETRAPHORMIS DODECASTER **(Haeckel)**

Pl. 13, Fig. 17.

Sethophormis dodecaster Haeckel, 1887, p. 1248, pl. 56, fig. 12.

Sethophormis cf. dodecaster Haeckel- Takahashi & Honjo, 1981, p. 152, pl. 8, fig. 8.

Tetraphormis dodecaster (Haeckel) Takahashi, 1981, p. 237, pl. 32, fig. 7.

TETRAPHORMIS BUTSCHLII **(Haeckel)**

Pl. 13, Fig. 18.

Dictyophimus butschlii Haeckel, 1887, p. 1201, pl. 60, fig. 2; Takahashi & Honjo, 1981, pl. 8, fig. 14.

Tetraphormis butschlii (Haeckel) Takahashi, 1981, p. 237, pl. 32, fig. 6.

Genus THEOPHORMIS Haeckel, 1881

THEOPHORMIS CALLIPILIUM **Haeckel**

Pl. 13, Figs. 19,20.

Theophormis callipilium Haeckel, 1887, p. 1367, pl. 70, figs. 1-3.

Sethophormis umbrella Haeckel, 1887, p. 1248, pl. 70, figs. 4-5.

Sethophormis aurella Haeckel, 1887, p. 1248, pl. 55, fig. 3,; Renz, 1976, p. 165, pl. 7, fig. 16.

Theophormis callipilium Haeckel- Takahashi, 1981, p. 237, pl. 32, figs. 9-12.

Genus LAMPROMITRA Haeckel, 1881

LAMPROMITRA SCHULTZEI **(Haeckel)**

Pl. 13, Fig. 21.

Eucecryphalus schultzei Haeckel, 1862, p. 309, pl. 5, figs. 16-19; 1887, p. 1216.

Lampromitra coronata Haeckel, 1887, p. 1214, pl. 60, fig. 7.

? Sethophormis pentalactis Haeckel, 1887, p. 1244, pl. 56, fig. 5; Renz, 1976, p. 165, pl. 7, fig. 7; Takahashi & Honjo, 1981, p. 152, pl. 8, fig. 5.

(non) Lampromitra coronata Haeckel - Keany, 1979, p. 56, pl. 4, fig. 10, pl. 5, fig. 14.

Lampromitra schultzei (Haeckel) Takahashi, 1981, p. 238, pl. 32, figs. 4-5.

LAMPROMITRA CACHONI **Petrushevskaya**

Pl. 13, Fig. 22.

Lampromitra ? sp Dzinoridze *et al.*, 1976, pl. 33, fig. 10.

Lampromitra cachoni Petrushevskaya & Kozlova, 1979, p. 128, text-figs. 362, 363, 497.

?Lampromitra erosa Cleve, 1900, p. 10, pl. 4, figs. 2,3; Dumitrica, 1972, p. 838, pl. 24, figs. 8,9.

Lampromitra cachoni Petrushevskaya- Takahashi, 1981, p. 239, pl. 33, fig. 23.

LAMPROMITRA SPINOSIRETIS **Takahashi**

Pl. 13, Fig. 26.

Helotholus histricosa Jorgensen- Benson, 1966, p. 459, pl. 31, figs. 6,7 (only) (partim).

Lampromitra spinosiretis Takahashi, 1981, p. 239, pl. 34, figs. 1-2, 7.

Genus EUCECRYPHALUS Haeckel, 1860

EUCECRYPHALUS TRICOSTATUS **(Haeckel)**

Pl. 13, Figs. 23, 24.

Theopilium tricostatum Haeckel, 1887, p. 1322, pl. 70, fig. 6; Popofsky, 1913, p. 375, pl. 37, fig. 6; Benson, 1966, p. 444, pl. 30, figs. 1,2; Takahashi & Honjo, 1981, p. 152, pl. 8, fig. 12.

?Corocalyptra elisabathae Haeckel, 1887, p. 1323, pl. 59, fig. 10.

?Corocalyptra agnesae Haeckel, 1887, p. 1323, pl. 59, fig. 3.

Eucecryphalus tricostatus (Haeckel) Takahashi, 1981, p. 240, pl. 33, figs. 4,6.

EUCECRYPHALUS SESTRODISCUS **(Haeckel)**

Pl. 13, Fig. 25.

Cecryphalium sestrodiscus Haeckel, 1887, p. 1399, pl. 58, fig. 1.

Theocalyptra sp. Renz, 1976, p. 137, pl. 5, fig. 13.

Eucecryphalus sestrodiscus (Haeckel) Takahashi, 1981, p. 241, pl. 33, figs. 5,7, 8.

EUCECRYPHALUS GEGENBAURI **Haeckel**

Pl. 13, Fig. 29.

Eucecryphalus gegenbauri Haeckel, 1860b, p. 836; 1862, p. 308, pl. 5, figs. 12-15; 1887, p. 1222; Hertwig, 1879, p. 76, pl. 8, figs. 5 a-b; Takahashi, 1981, p. 241, pl. 33, figs. 13-15.

Clathrocyclas danaes Haeckel, 1887, p. 1388, pl. 59, figs. 13,14; Takahashi & Honjo, 1981, p . 152, pl. 8, fig. 13.

? *Clathrocyclas alcmenae* Haeckel, 1887, p. 1388, pl. 59, fig. 6.

?*Clathrocyclas latonae* Haeckel, 1887, p. 1389, pl. 59, fig. 7.

Clathrocyclas ionis Haeckel, 1887, p. 1389, pl. 59, fig. 9.

Corocalyptra gegenbauri (Haeckel) Popofsky, 1913, p. 384, pl. 34, figs. 1,2.

Theocalyptra gegenbauri - Boltovoskoy & Riedel, 1980, p. 126, pl. 5, fig. 18 (partim).

EUCECRYPHALUS EUROPAE **(Haeckel)**

Pl. 13, Fig. 30.

Clathrocyclas europae Haeckel, 1887, p. 1388, pl. 59, figs. 11, 12.

Eucecryphalus europae (Haeckel) Takahashi, 1981, p. 242, pl. 34, figs. 5,6.

Genus COROCALYPTRA Haeckel, 1887

COROCALYPTRA CERVUS **(Ehrenberg)**

Pl. 13, Figs. 27, 28.

Eucyrtidium cervus Ehrenberg, 1872b, p. 291, pl. 9, fig. 21.

Corocalyptra cervus (Ehrenberg) Popofsky, 1913, p. 383, pl. 34, fig. 3; Benson, 1966, p. 447, pl. 30, figs. 3, 5; Renz, 1976, p. 129, pl. 5, fig. 2; Takahashi, 1981, p. 242-43, p. 33, figs. 9-12.

Genus CLATHROCYCLAS Haeckel, 1881

CLATHROCYCLAS MONUMENTUM **(Haeckel)**

Pl. 14, Fig. 1.

Calocyclas monumentum Haeckel, 1887, p. 1385, pl. 73, fig. 9; Renz, 1976, p. 128, pl. 5, fig. 1; Takahashi, 1981, p. 243-44, pl. 34, figs. 9-11.

Clathrocyclas ? sp. Benson, 1966, p. 457, pl. 31, figs. 2,3.

CLATHROCYCLAS CASSIOPEJAE **Haeckel**

Pl. 14, Figs. 2,3.

Clathrocyclas cassiopejae Haeckel, 1887, p. 1390, pl. 59, fig. 5; Takahashi, 1981, p. 244, pl. 34, figs. 12-14.

CLATHROCYCLAS CF. C. CASSIOPEJAE **Haeckel**

Pl. 14, Fig. 4.

Clathrocyclas sp. Takahashi, 1981, p. 243, pl. 34, fig. 8.

Clathrocyclas cf. C. cassiopejae

CHARACTER : Cephalis cap shaped with small apical spine and fine pores. Thorax conical, dilated and made of very thick skeleton. Pores of thorax circular and smaller than interporous bars adjacent to cephalis and increasing their size and become elliptical towards the dilated opening (Takahashi, 1981). It has a close affinity with *C. Cassiopejae* but differ in very wide tent shaped abdomen.

Remark : All the specimens show conspecies variations. Hence they could not be assigned to any species level (sensu stricto).

Family THEOPERIDAE Haeckel, 1881, emend. Riedel, 1967a

Subfamily PLECTOPYRAMIDINAE Haecker, 1908a, emend. Petrushevskaya, 1971d

Genus PLECTOPYRAMIS Haeckel, 1887

PLECTOPYRAMIS DODECOMMA **Haeckel**

Pl. 14, Fig. 5.

Plectopyramis dodecomma Haeckel, 1887, p. 1258, pl. 54, fig. 6; Benson, 1966, p. 424, pl. 29, fig. 3 ; Nigrini & Moore, 1979, p. N31, pl. 21, fig. 5.

Genus CORNUTELLA Ehrenberg, 1838

CORNUTELLA PROFUNDA **Ehrenberg**

Pl. 14, Fig. 6.

Cornutella profunda Ehrenberg, 1858, p. 31; Nigrini, 1967, p. 60, pl. 6, fig. 5 a-c; Renz, 1976, p. 149, pl. 7, fig. 11; Kling, 1979, p. 309, pl. 1, fig. 21; Boltovoskoy & Riedel, 1980, p. 123, pl. 5, fig. 6; Johnson & Nigrini, 1980, pl. 3, fig. 7; Takahashi, & Honjo, 1981, p. 152, pl. 8, fig. 9; Takahashi, 1981, p. 245, pl. 35, figs. 3-9.

Genus PERIPYRAMIS Haeckel, 1887, emend. Riedel, 1958

PERIPYRAMIS CIRCUMTEXTA **Haeckel**

Pl. 14, Figs. 7, 10.

Peripyramis circumtexta Haeckel, 1887, p. 1162, pl. 54, fig. 5; Riedel, 1958, p. 231, pl. 2, figs. 8,9 ; Benson, 1966, p. 426, pl. 29, fig. 4; Nigrini & Moore, 1979, p. N29, pl. 21, figs. 4a,b; Takahashi & Honjo, 1981, p. 152, pl. 8, figs. 10-11; Takahashi, & Honjo, 1981, p. 245, pl. 35, figs. 10-13.

Genus BATHROPYRAMIS Haeckel, 1887

BATHROPYRAMIS RAMOSA **Haeckel**

Pl. 14, Figs. 8-9.

Bathropyramis ramosa Haeckel, 1887, p. 1161, pl. 54, fig. 4; Renz, 1974, p. 789, pl. 17, fig. 27.

Genus LITHARACHNIUM Haeckel, 1860b

LITHARACHNIUM TENTORIUM Haeckel

Pl. Fig. 12.

Litharachnium tentorium Haeckel, 1860b, p. 836 ; 1862, p. 281, pl. 4, figs. 7-10; Casey, 1971b, p. 341, pl. 23.3, fig. 11; Renz, 1976, p. 150, pl. 7, fig. 6; Boltovoskoy & Riedel, 1980, p. 125, pl. 5, fig. 14; Takahashi, 1981, p. 245, pl. 35, figs. 14-18.

LITHARACHNIUM EUPILIUM **(Haeckel)**

Pl. 14, Fig. 13.

Sethophormis eupilium Haeckel, 1887, p. 1247, pl. 56, fig. 9.

Litharachnium eupilium (Haeckel) Takahashi, 1981, p. 245-246, pl. 36, figs. 1-4.

Subfamily EUCYRTIDIINAE Ehrenberg, 1847b, emend. Petrushevskaya, 1971d

Genus ARCHIPILIUM Haeckel, 1881

ARCHIPILIUM SP. **(Haeckel)**

Pl. 14, Fig. 14.

Sethopilium macropus Haeckel, 1887, p. 1203, pl. 97, fig. 9.

Archipilium spp. aff. A. macropus Petrushevskaya & Kozlova, 1972, p. 553 (partim), pl. 29, figs. 13, 14; Takahashi, 1981, p. 246, pl. 36, fig. 6.

Remark : Due to paucity of material species level could not be resolved and only affinity to the species is mentioned.

Genus PTEROCANIUM Ehrenberg, 1847a

PTEROCANIUM TRILOBUM **(Haeckel)**

Pl. 14, Fig. 15.

Dictyopodium trilobum Haeckel, 1860b, p. 839.

Pterocanium trilobum (Haeckel) Nigrini, 1967, p. 71, pl. 7, fig. 3 a-b; Kling, 1979, p. 311, pl. 2, fig. 13; Nigrini & Moore, 1979 p. N45, pl. 23, figs. 4a-c; Boltovoskoy & Riedel, 1980, p. 126, pl. 5, fig. 15; Johnson & Nigrini, 1980, p. 129, pl. 3, fig. 12; (non) Renz, 1976, p. 135, pl. 5, fig. 17; Takahashi, 1981, p. 247, pl. 36, figs. 10-11.

***PTEROCANIUM PRAETEXTUM PRAETEXTUM* (Ehrenberg)**
Pl. 14, Figs. 17, 18.

Lychnocanium praetextum Ehrenberg, 1872a, p. 316; 1872b, p. 297, pl. X, fig. 2.

Pterocanium praetextum (Ehrenberg) Haeckel, 1887, p. 1330; Takahashi & Honjo, 1981, p. 153, pl. 9, figs. 5, 6.

Pterocanium praetextum praetextum (Ehrenberg) Nigrini, 1967, p. 68, pl. 7, fig. 1; Nigrini & Moore, 1979, p. N41, pl. 23, fig. 2; Johnson & Nigrini, 1980, p. 127, pl. 3, fig. 10.

PTEROCANIUM PRAETEXTUM **(Ehrenberg)** *EUCOLPUM* **Haeckel**

Pl. 14, Fig. 19.

Pterocanium eucolpum Haeckel, 1887, p. 1322, pl. 73, fig. 4.

Pterocanium praetextum eucolpum Haeckel- Nigrini, 1967, p. 70, pl. 7, fig. 2; Kling, 1979, p. 311, pl. 2, figs. 14-16; Nigrini & Moore, 1979, p. N43, pl. 23, fig. 3; Johnson & Nigrini, 1980, p. 127, pl. 3, fig. 11.

Pterocanium praetextum (Ehrenberg) *aff. eucolpum* Haeckel - Takahashi, 1981, p. 248, pl. 36, figs. 14.

PTEROCANIUM BICORNE **Haeckel**

Pl. 14, Figs. 20,21.

Pterocanium bicorne Haeckel, 1887, pl. 73, fig. 15.

Pterocanium sp. Nigrini & Moore, 1979, p. N49, pl. 23, figs. 6a,b.

PTEROCANIUM SP.

Pl. 14, Figs. 16,22

Remark : It is similar to *P. trilobum* in feet but differ in shape of the thorax which is similar to *P. praetextum praetextum*.

Genus DICTYOPHIMUS Ehrenberg, 1847a

DICTYOPHIMUS CRISIAE **Ehrenberg**

Pl. 14, Figs. 23, 24.

Dictyophimus crisiae Ehrenberg, 1854a, p. 241, Nigrini, 1967, p. 66, pl. 6, figs. 7a,b; Nigrini & Moore, 1979, p. N33, pl. 22, figs. 1a,b; Johnson & Nigrini, 1980, p. 127, pl. 3, fig. 9; Takahashi, 1981, p. 249, pl. 37, fig. 2.

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Pterocorys hirundo Haeckel, 1887, p. 1318, pl. 71, fig. 4; Ling *et al*., 1971, p. 715, pl. 2, figs. 8,9.

?Pterocorys sp. Benson, 1966, p. 412, pl. 28, fig. 4 (partim).

DICTYOPHIMUS SP.

Pl. 14, Figs. 25-27.

Dictyophimus infabricatus Nigrini, 1968, p. 56, pl. 1, fig. 6; Nigrini & Moore, 1979, p. N37, pl. 22, fig. 5; Takahashi, 1981, p. 249, pl. 37, figs. 3-5.

CHARACTER : Shell is similar to specimens of *Dictyophimus* sp.

Remark : Due to paucity of material species level could not be resolved and only affinity to the species is mentioned.

Genus DICTYOCODON Haeckel, 1881

DICTYOCODON ELEGANS **(Haeckel)**

Pl. 14, Fig. 28.

Artopilium elegans Haeckel, 1887, p. 1440, pl. 75, fig. 1.

Pterocanium cf. elegans (Haeckel) Benson, 1966, p. 403, pl. 27, figs. 1,2.

Dictyocodon elegans (Haeckel) Takahashi, 1981, p. 250, 251, pl. 37, figs. 6,7,9.

Genus SETHOCONUS Haeckel,1881

SETHOCONUS MYXOBRANCHIA **Strelkov & Reschetnyak**

Pl. 15, Fig. 4.

Sethoconus myxobranchia Strelkov & Reshetnyak, 1971; Renz, 1976, p. 136, pl. 5, fig. 4; Takahashi, 1981, p. 252-253, pl. 38, figs. 7-8.

SETHOCONUS SP. AFF. S. MYXOBRANCHIA **Strelkov & Reschetnyak**

Pl. 15, Fig. 5.

Sethoconus myxobranchia Strelkov & Reschetnyak, 1971.

Character : Very delicate large conical funnel shaped shell similar to *Sethoconus myxobranchia* but differ in its acutely conical mouth compared to the *S. myxobranchia*.

Remark : All the specimens show conspecies variations. Hence, they could not be assigned to any species level (sensu stricto).

Genus CONARACHNIUM Haeckel, 1881

CONARACHNIUM POLYACANTHUM **(Popofsky)**

Pl. 15, Fig. 2.

Lophocorys polyacantha Popofsky, 1913, p. 400, text fig. 122; Benson, 1966, p. 494, (partim), pl. 34, fig.3 (only); Kling, 1979, p. 309, pl. 1, fig. 27.

Conarachnium polyacanthum (Popofsky) Takahashi, 1981, p. 253, pl. 39, figs. 1-4.

CONARACHNIUM PARABOLICUM **(Popofsky)**

Pl. 15, Fig. 6.

? *Sethoconus anthocyrtis* Haeckel, 1887, p. 1296, pl. 62, fig. 21.

? *Periarachnium periplectum* Haeckel, 1887, p. 1297, pl. 55, fig. 11.

Lampromitra parabolica Popofsky, 1913, p. 348, text fig. 54; Renz, 1976, p. 122, pl. 4, fig. 14.

Conarachnium parabolicum (Popofsky) Takahashi, 1981, p. 253, pl. 39, figs. 5,6.

Genus STICHOPILIUM Haeckel, 1881

STICHOPILIUM BICORNE **Haeckel**

Pl. 15, Fig. 7.

Stichopilium bicorne Haeckel, 1887, p. 1437, pl. 77, fig. 9; Benson, 1966, p. 422, pl. 29, figs. 1,2; Renz, 1976, p. 125, pl. 4, fig. 9; Nigrini & Moore, 1979, p. N91, pl. 26, figs. 1a,b; Takahashi, & Honjo, 1981, p. 153, pl. 9, fig. 11; Takahashi, 1981, p. 254, pl. 39, figs. 13-19.

Genus LITHOPERA Ehrenberg, 1847a

LITHOPERA BACCA **Ehrenberg, emend. Nigrini, 1967**

Lithopera bacca Ehrenberg, 1872a, p. 374; Nigrini, 1967, p. 54, pl. 6, fig. 2; Renz, 1976, p. 133, pl. 5, fig. 12; Kling, 1979, p. 309, pl. 2, figs. 4-7; Johnson & Nigrini, 1980, p. 127, pl. 3, fig. 8; Takahashi & Honjo, 1981, p. 153, pl. 9, fig. 13; Takahashi, 1981, p. 254, pl. 40, figs. 1-2; Gupta, 1988, pl. 2, figs. 3,4.

LITHOPERA RENZAE **Sanfilippo and Riedel**

Pl. 15, Fig. 9.

Lithopera renzae Sanfilippo & Riedel, 1970, p. 454, pl. 1, figs. 21-23, 27; Riedel & Sanfilippo, 1971, pl. 2E, figs. 17, 18, pl. 7, fig. 14.

Genus CYRTOPERA Haeckel, 1881

CYRTOPERA LANGUNCULA **Haeckel**

Pl. 15, Figs. 10,11.

Cyrtopera languncula Haeckel, 1887, p. 1451, pl. 75, fig. 10; Benson, 1966, p. 510, pl. 35, figs. 3,4; Casey, 1971b, pl. 23.1, fig. 10; Takahashi & Honjo, 1981, p. 153, pl. 9, fig. 14; Takahashi, 1981, p. 254, pl. 40, figs. 3-6.

CYRTOPERA AGLAOMPA **Takahashi**

Pl. 15, Fig. 12.

Cyrtopera aglaompa Takahashi, 1981, p. 255, pl. 40, figs. 7-8.

Genus THEOCORYS Haeckel, 1881

THEOCORYS SP. **Haeckel**

Pl. 15, Fig. 15.

Theocorys veneris Haeckel, 1887, p. 1415, pl. 69, fig. 5; Benson, 1966, p. 492, pl. 33, figs. 12,13; Renz, 1976, p. 137, pl. 5, fig. 11; Takahashi & Honjo, 1981, p. 153, pl. 9, fig. 17; Takahashi, 1981, p. 256, pl. 40, figs. 11-14.

CHARACTER : Test small but similar to *Theocorys veneris* Haeckel.

Genus THEOCORYTHIUM Haeckel, 1887

THEOCORYTHIUM TRACHELIUM TRACHELIUM **(Ehrenberg)**

Pl. 15. Figs. 13, 14.

Eucyrtidium trachelium Ehrenberg, 1872a, p. 312; 1872b, p. 293, pl. 7, fig. 8.

Calocyclas amicae Haeckel, 1887, p. 1382, pl. 74, fig. 2.

Calocyclas vestalis Haeckel, 1887, p. 1382, pl. 74, fig. 3.

Theocoyrtis trachelium (Ehrenberg) Haeckel, 1887, p. 1405.

Theocorythium trachelium (Ehrenberg) Renz, 1976, p. 147, pl. 6, fig. 13; Riedel & Sanfilippo, 1978, p. 76, pl. 9, fig. 17.

Theocorythium trachelium trachelium (Ehrenberg) Nigrini, 1967, p. 79, pl. 8, fig. 2, pl. 9, fig. 2; Johnson & Nigrini, 1980, p. 135, text-fig. 13e, pl. 4, fig. 3; Takahashi, 1981, p. 257, pl. 40, figs. 15-16.

***THEOCORYTHIUM TRACHELIUM DIANAE* (Haeckel)**

Theocorys dianae Haeckel, 1887, p. 1416, pl. 69, fig. 11.

Theocorythium trachelium dianae (Haeckel) Nigrini, 1967, p. 77, pl. 8, figs. 1a,b, pl. 9, figs. 1a,b; Nigrini & Moore, 1979, p. N97, pl. 26, figs. 3a,b; Johnson & Nigrini, 1980, pl. 4, fig. 4.

THEOCORYTHIUM VETULUM **Nigrini**

Pl. 15, Fig. 16.

Theocorythium vetulum Nigrini, 1971, p. 447, pl. 34.1, fig . 6 a-b.

Remark : It is a early Pliestocene species and only a single specimen was found in one sample and therefore it is considered as reworked species in the material.

Genus LIPMANELLA Loeblich & Tappan, 1961

LIPMANELLA DICTYOCERAS **(Haeckel)**

Pl. 15, Figs. 17-19.

Lithornithium dictyoceras Haeckel, 1860b, p.840.

Dictyoceras acanthicum Jorgensen, 1900, p. 84; 1905, p. 140, pl. 17, fig. 101a; pl. 18, fig. 101b; Benson, 1966, p. 417, pl. 28, figs. 8-10.

Dictyoceras xiphephorum Jorgensen, 1900, p. 84, pl. 5, fig. 22; 1905, p. 140.

Lithopilium sphaerocephalum Popofsky, 1913, p. 380, pl. 35, figs. 2,3; Renz, 1976, p. 123, pl. 4, fig. 8.

Lipmanella dictyoceras (Haeckel) Kling,1973, p. 636, pl. 4, figs. 24-26; 1977, p. 217, pl. 2, fig.2; 1979, p. 309, pl. 2, fig. 8; Petrushevskaya & Kozlova, 1979, p. 137, Takahashi, 1981, p. 257-58, pl. 40, fig. 17.

LIPMANELLA PYRAMIDALE **(Popofsky)**
Pl. 15, Fig. 20.

Theopilium pyramidale Popofsky, 1913, p. 376, pl. 37, fig. 1; Renz, 1976, p. 126, pl. 4, fig. 13.

Dictyoceras pyramidale (Popofsky)- Takahashi & Honjo, 1981, p. 153, pl. 9, fig. 9.

Lipmanella pyramidale (Popofsky) Takahashi, 1981, p. 258, pl. 40, fig. 18.

LIPMANELLA VIRCHOWII **(Haeckel)**
Pl. 15, Fig. 21.

Dictyoceras virchowii Haeckel, 1862, p. 333, pl. 8, figs. 1-5; Tan & Tchang, 1976, p. 285, text fig. 63; Takahashi & Honjo, 1981, p. 153, pl. 9, figs. 7,8.

Dictyoceras neglectum Cleve, 1900a, p. 7, pl. 4, fig. 5; Popofsky, 1913, pl. 34, fig. 4; Renz, 1976, p. 121, pl. 4, fig. 10.

Dictyoceras prismaticum Tan & Tchang, 1976, p. 285 (partim), text figs. 64, 65a,c (only).

Lipmanella virchowii (Haeckel) Takahashi, 1981, p. 258, pl. 40, figs. 19-21.

Genus LITHOSTROBUS Butschli, 1882

LITHOSTROBUS HEXAGONALIS **Haeckel**

Pl. 15, Fig. 22.

Lithostrobus hexagonalis Haeckel, 1887, p. 1475, pl. 79, fig. 20; Renz, 1976, p. 123, pl. 5, fig. 15; Takahashi & Honjo, 1981, p. 153, pl. 9, fig. 10; Takahashi, 1981, p. 259, pl. 41, figs. 1-3.

Lithostrobus cf. hexagonalis Haeckel- Benson, 1966, p. 508, pl. 35, figs. 1,2 ; Nigrini, 1968, p. 58, pl. 1, fig. 10.

Genus CYCLADOPHORA Ehrenberg, 1872b, emend. Lombari & Lazarus, 1988

CYCLADOPHORA BICORNIS **(Popofsky)**

Pl. 15, Fig. 23.

Pterocorys bicornis Popofsky, 1908, p. 288, pl. 34, figs. 7-8.

Theocalyptra bicornis (Popofsky) Riedel, 1958, p. 240, pl. 4, fig. 4; Nigrini & Moore, 1979, p. N53, pl. 24, fig. 1; Ling, 1980, p. 369, pl. 2, fig. 3; Johnson & Nigrini, 1980, pl. 3, fig. 14.

Theocalyptra davisiana davisiana (Ehrenberg)- Takahashi & Honjo, 1981, p. 153, pl. 9, figs. 19,20.

Theocalyptra bicornis (Popofsky) Takahashi, 1981, p. 259, pl. 41, figs. 4-6, 8-11.

Cycladophora bicornis bicornis Lombari & Lazarus, 1988, p. 106, pl. 5, fig. 9-12.

CYCLADOPHORA DAVISIANA DAVISIANA **Ehrenberg**

Pl. 15, Figs. 24, 25.

Cycladophora ? davisiana Ehrenberg, 1861, p. 297; 1872b, pl. 2, fig. 11.

Theocalyptra davisiana (Ehrenberg) Riedel, 1958, p. 239, pl. 4, figs. 2,3 , text fig. 10; Benson, 1966, p. 441, (partim), pl. 29, figs. 14,15 (only); Nigrini & Moore, 1979, p. N59, pl. 24, figs. 2a,b.

Cycladophora davisiana davisiana Ehrenberg- Morley, 1980, p. 206, pl. 1, figs. 1-5.

Theocalyptra davisiana davisiana (Ehrenberg)-Takahashi, 1981, p. 259-260, pl. 47, fig. 7.

CYCLADOPHORA DAVISIANA CORNUTOIDES **(Petrushevskaya)**

Pl. 15, Fig. 28.

Halicaliptra ? cornuta Bailey, 1856, p. 5, pl. 1, figs. 13, 14 (nomen oblitum).

? *Cycladophora davisiana semeloides* Petrushevskaya-Morley, 1980, p. 206, pl. 1, figs. 11-14.

Theocalyptra davisiana cornutoides (Petrushevskaya) - ~~Takahashi & Honjo, 1981, p. 153, pl. 9, fig. 18;~~ Takahashi, 1981, p. 260, pl. 41, figs. 12-16.

CYCLADOPHORA BICORNIS KLINGI **Lombari and Lazarus**

Pl. 15, Fig. 26.

Clathrocyclas spp. Kling, 1973, pl. 9, figs. 26, 27, 29,-31.

Cycladophora bicornis klingi Lombari and Lazarus, 1988, p. 110, pl. 4, figs. 6-12.

Family PTEROCORYTHIDAE Haeckel, 1881, emend. Riedel, 1967a

Genus TETRACORETHRA Haeckel, 1881, emend. Petrushevskaya, 1971c

TETRACORETHRA TETRACORETHRA **(Haeckel)**

Pl. 15, Fig. 29.

Tetraspyris tetracorethra Haeckel, 1887, p. 1044, pl. 53, fig. 19.

Tetracorethra tetracorethra (Haeckel) Renz, 1976, p. 145, pl. 6, fig. 23; Takahashi, 1981, p. 261, pl. 41, figs. 17-18.

Genus PTEROCORYS Haeckel, 1881, emend. Caulet & Nigrini, 1988

PTEROCORYS ZANCLEUS **(Muller)**

Pl. 15, Fig. 32.

Eucyrtidium zanclaeum Muller, 1858a, p. 41, pl. 6, figs. 1-3.

Eucyrtidium carinatum Haeckel, 1862, pl. 7, figs. 4-7.

Theoconus zancleus (Muller) Benson, 1966, p. 482, pl. 33, fig. 4 (not fig. 5).

Pterocorys zancleus (Muller) Nigrini & Moore, 1979, p. N89, pl. 25, figs. 11a,b; Caulet & Nigrini, 1988, p. 232, pl . 2, figs. 10-11.

PTEROCORYS HERTWIGII **(Haeckel)**

Pl. 15, Figs. 33,34.

Eucyrtidium hertwigii Haeckel, 1887, p. 1491, pl. 80, fig. 12.

Theoconus hertwigii (Haeckel) Nigrini, 1967, p. 73, pl. 7, figs. 4a,b; Renz, 1974, pl. 19, fig. 16; Molina-Cruz, 1977a, p. 338, pl. 8, figs. 7,8.

Phormocyrtis fatuosa (Ehrenberg) Benson, 1966, p. 485, pl. 33, figs. 6,7.

Pterocorys hertwigii (Haeckel) Nigrini & Moore, 1979, p. N85, pl. 25, figs. 9; Johnson & Nigrini, 1980, pl. 4, fig. 1; Caulet & Nigrini, 1988, p. 229, pl. 1, figs. 11, 12.

PTEROCORYS SABAE **(Ehrenberg)**

Pl. 16, Figs 1,2.

Pterocanium sabae Ehrenberg, 1872a, p. 319; 1872b, p. 299, pl. 10, fig. 17.

Pterocorys sabae (Ehrenberg) Haeckel, 1887, p. 1367; Petrushevskaya, 1971a, pl. 1, fig. 11; Johnson & Nigrini, 1980, p. 150, pl. 4, fig. 2, pl. 5, figs. 4,5; Caulet & Nigrini, 1988, p. 231, pl. 2, figs. 7-8.

Theoconus junonis Haeckel- Renz, 1974, p. 798, pl. 19, fig. 27.

Pterocorys zancleus (Muller) McMillen & Casey, 1978, pl. 4, fig. 9.

PTEROCORYS SP.

Pl. 15, Figs. 35-39, Pl. 16, Figs. 4-6

Ptrrocorys sp. Haeckel, 1881, p. 435.

Remark : Due to paucity of material species level could not be resolved. All the un-identified species of Pterocorys genera are illustrated in it.

PTEROCORYS MACROCERAS **(Popofsky)**

Pl. 16, Fig. 3.

Lithopilium macroceras Popofsky, 1913, p. 377, text-figs. 91-93 (non text-fig. 94).

Lithopilium clausum Popofsky, 1913, p. 393, text-figs. 112-114 (non fig. 111).

Pterocorys sp. Petrushevskaya, 1967, p. 1305, fig. 2, XII.

Pterocorys macroceras (Popofsky) Petrushevskaya, 1971a, p. 234, fig. 120.

Lamprocyclas cranoides (Haeckel), McMillen & Casey, 1978, pl. IV, figs. 13,14.

Pterocorys zancleus (Muller) Takahashi, 1981, pl. 42, figs. 1-4.

PTEROCORYS LONGICOLLIS **Caulet**

Pl. 16, Fig. 7.

Pterocorys longicollis Caulet, 1986a, p. 850, pl. 4, figs. 4,5; Caulet & Nigrini, 1988, p. 230, pl. 1, fig. 13.

Genus EUCYRTIDIUM Ehrenberg, 1847a

EUCYRTIDIUM ACUMINATUM **(Ehrenberg)**

Pl. 16, Fig. 7.

Lithocampe acuminatum Ehrenberg, 1844, p. 84.

Eucyrtidium acuminatum (Ehrenberg) Ehrenberg, 1854b, p. 43, pl. 22, fig. 27; Popofsky, 1913, p. 406, text-fig. 127; Nigrini, 1967, p. 81, pl. 8, figs. 3a,b; Renz, 1976, p. 130, pl. 5, fig. 5 ; Nigrini & Moore, 1979, p. N61, pl. 24, figs. 3a,b; Johnson & Nigrini, 1980, p. 129, text-fig. 11d, pl. 3, figs. 15.

Eusyringium siphonostoma Haeckel, 1987, p. 1499, pl. 80, fig. 14; Benson, 1966, p. 498, pl. 34, figs. 6-9.

? *Eusyringium cannostoma* Haeckel, 1887, p. 1499, pl. 80, fig. 13.

Stichopilium rapaeformis Popofsky, 1913, p. 404, text-fig. 126.

EUCYRTIDIUM HEXAGONATUM **Haeckel**

Pl. 16, Figs. 12, 19.

Eucyrtidium hexagonatum Haeckel, 1887, p. 1489, pl. 80, fig. 11; Nigrini, 1967, p. 83, pl. 8, figs. 4a,b; Renz, 1976, p. 132. pl. 5, fig. 6; Nigrini & Moore, 1979, p. N63, pl. 24, figs. 4a,b; Johnson & Nigrini, 1980, p. 129, text-fig. 11e, pl. 3, fig. 16; Takahashi, 1981, p. 263, pl. 42, figs. 18-19.

Eucyrtidium cienkowskii Haeckel, 1887, p. 1493, pl. 80, fig. 9.

Eusyringium siphanostoma Haeckel- Takahashi & Honjo, 1981, p. 154, pl. 10, fig. 7.

EUCYRTIDIUM SP. AFF. E. ANOMALUM **(Haeckel)**

Pl. 16, Fig. 14.

Eucyrtidium sp. aff. E. anomalum (Haeckel) Takahashi, 1981, p. 263, pl. 42, fig. 15.

Remark : The specimen shows conspecies variation. Hence, it could not be assigned to any species level (sensu stricto).

EUCYRTIDIUM DICTYOPODIUM **(Haeckel)**

Pl. 16, Fig. 10.

Stichopodium dictyopodium Haeckel, 1887, p. 1447, pl. 75, fig. 6.

Eucyrtidium dictyopodium (Haeckel) Takahashi, 1981, p. 263, pl. 42, fig. 21.

EUCYRTIDIUM PUNCTATUM **(Ehrenberg)**

Pl. 16, Fig. 18.

Lithocampe punctatum Ehrenberg, 1844, p. 84.

Eucyrtidium puncatatum (Ehrenberg) Ehrenberg, 1847b, p. 43; Ehrenberg, 1854c, pl. 22, fig. 24.

Eucyrtidium puncatatum Caulet, 1986a, pl. 5, Fig.9.

EUCYRTIDIUM SP.

Pl. 16, Figs. 9,11,13,15-17,20-25.

Remark : All these specimens show variations in species. Due to paucity of material species level could not be resolved.

Genus ANTHOCYRTIDIUM Haeckel, 1881

ANTHOCYRTIDIUM OPHIRENSE **(Ehrenberg)**

Pl. 16, Figs. 26-30; Pl.. 17, Fig. 14.

Anthocyrtis ophirense Ehrenberg, 1872a, p. 301; 1872b, p. 285, pl. 9, fig. 13.

Anthocyrtidium cineraria Haeckel, 1887, p. 1278, pl. 62, fig. 16.

Anthocyrtidium ophirense (Ehrenberg) Nigrini, 1967, p. 56, pl. 6, fig. 3; Renz, 1976, p. 143, pl. 6, fig. 25; Nigrini & Moore, 1979, p. N67, pl. 25, fig. 1; Kling, 1979, p. 309, pl. 2, fig. 21; Johnson & Nigrini, 1980, p. 129, text-fig. 12a, pl. 3, fig. 18; Takahashi & Honjo, 1981, p. 154, pl. 9, fig. 22; Takahashi, 1981, p. 263, pl. 43, figs. 1-7.

ANTHOCYRTIDIUM ZANGUEBARICUM **(Ehrenberg)**

Pl. 16, Fig. 31; Pl. 17, Fig. 4.

Anthocyrtis zanguebarica Ehrenberg, 1872a, p. 301, ; 1872b, p. 285, pl. 9, fig. 12.

Anthocyrtidium zanguebaricum (Ehrenberg) Haeckel, 1887, p. 1277; Nigrini, 1967, p. 58, pl. 6, fig. 4; Renz, 1976, p. 143, pl. 6, fig. 18; Nigrini & Moore, 1979, p. N69, pl. 25, fig. 2, Johnson & Nigrini, 1980, p. 129, text-fig. 12b, pl. 3, fig. 19; Takahashi & Honjo, 1981, p. 153, pl. 9, fig. 21; Takahashi, 1981, p. 265, pl. 41, figs. 19-22.

Anthocyrtis ovata Haeckel, 1887, p. 1272, pl. 62, fig. 13.

Sethocyrtis oxycephalis Haeckel, 1887, p. 1299, pl. 62, fig. 9.

Anthocyrtium oxycephalis (Haeckel) Benson, 1966, p. 468, pl. 32, figs. 3-5.

ANTHOCYRTIDIUM ANGULARE **Nigrini**

Pl. 16, Figs. 32-34.

Anthocyrtidium angulare Nigrini, 1971, p. 445, pl. 34.1, figs. 3 a-b.

Remark : These are found occasionally in traces (1 or 2 specimens) in few samples and are considered as reworked specimens.

ANTHOCYRTIDIUM EURYCLATHRUM **Nigrini & Caulet**

Pl. 16, Figs. 35-37, Pl. 17, fig. 1.

Anthocyrtidium euryclathrum Nigrini & Caulet, 1988, p. 349, pl. 1, figs. 5-7.

ANTHOCYRTIDIUM NOSICAAE **Caulet**

Pl. 17, Fig. 5.

Anthocyrtidium sp. Dumitrica, 1972, p. 839, pl. 14, fig. 2.

Anthocyrtidium sp. Petrushevskaya, 1974, p. 85, figs. 2,3.

Anthocyrtidium nosicaae Caulet, 1979, p. 132, pl. 2, fig. 6; Nigrini & Caulet , 1988, p. 351, pl. 1, figs. 15-17.

Anthocyrtidium zanguebaricum (Ehrenberg) Molina Cruz, 1982, p. 996, pl. 4, fig. 2.

Remark : It is rarely occurring reworked species.

ANTHOICYRTIDIUM JENGHISI **(Streeter)**

Pl. 17, Fig. 28.

Anthocyrtitum jenghisi (Streeter) Nigrini & Caulet, 1988, p. 350, pl. 1, figs. 9-12.

Remark : It's again a reworked specimen.

ANTHOCYRTITIUM SP.

Pl. 17. Figs. 2,3, 6-13,15-27.

Remark : All these specimens not assigned to any species are illustrated as *Anthocyrtidium* sp. Due to paucity of material the species level could not be resolved.

Genus LAMPROCYCLAS Haeckel, 1881

LAMPROCYCLAS MARITALIS **(Haeckel)** *POLYPORA* **Nigrini**

Pl. 17, Figs. 29-31.

Lamprocyclas maritalis **(Haeckel)** *polypora* Nigrini, 1967, p. 76, pl. 7, fig. 6; Kling, 1979, p. 309, pl. 2, fig. 25; Johnson & Nigrini , 1980, p. 129, text-fig. 12e, pl. 3, fig. 22; Takahashi, 1981, p. 266, pl. 43, figs. 12, 15.

LAMPROCYCLAS MARITALIS VENTRICOSA **Nigrini**

Pl. 17, Figs. 32-34.

Lamprocyclas maritalis ventricosa Nigrini, 1968, p. 57, pl. I, fig. 9; Nigrini & Moore, 1979, p. N79, pl. 25, fig. 6.

Genus LAMPROCYRTIS Kling, 1973

LAMPROCYRTIS HETEROPOROS **(Hays)**

Pl. 18, Fig. 1.

Lamprocyclas heteroporos Hays, 1965, p. 179, pl. 3, fig. 1.

Lamprocyrtis heteroporos (Hays)- Goll, 1980, pl. 3, figs. 12,13; Gupta, 1988, p. 67, pl. 3, figs. 12,13.

LAMPROCYRTIS NEOHETEROPOROS **Kling**

Pl. 18, Fig. 2.

Lamprocyrtis neoheteroporos Kling, 1973, p. 639, pl. 5, figs. 17-19; Sanfilippo & Riedel, 1974, pl. 3, fig. 11; Gupta, 1988, p. 67, pl. 2, fig. 14.

LAMPROCYRTIS NIGRINIAE **(Caulet)**

Pl. 17, Figs. 36-37.

Conarachnium ? sp. Nigrini, 1968, p. 56 (partim) pl. 1, fig. 5a (only).

Conarachnium nigriniae Caulet, 1971, p. 3, pl. 3, figs. 1-4, pl. 4, figs. 1-4.

Lamprocyrtis haysi Kling , 1973, p. 639, pl. 5, figs. 15,16, pl. 15, figs. 1-3; Sanfilippo & Riedel, 1974, p. 1022, pl. 3, figs. 9,10; Riedel & Sanfilippo, 1978, p. 69, pl. 5, fig. 9.

Lamprocyrtis nigriniae (Caulet) Nigrini & Moore, 1979, p. N81, pl. 25, fig. 7; Kling, 1979, p. 309, pl. 2, fig. 26; Johnson & Nigrini, 1980, p. 129, text-fig. 13a, pl. 3, fig. 24, Takahashi, 1981, p. 267, pl. 43, figs. 17-19; Gupta, 1988, pl. 2, fig. 15.

LAMPROCYRTIS HANNAI **(Campbell & Clark)**

Pl. 17, Fig. 38.; Pl. 18, Figs. 8-9.

Theoconus junonis Haeckel, 1887, p. 1401, pl. 69, fig. 7.

? *Lamprocyclas junonis* (Haeckel) Petrushevskaya & Kozlova , 1972, p. 545, pl. 36, fig. 8.

Calocyclas hannai Campbell & Clark, 1944, p. 48, pl. 6, figs. 21, 22.

Lamprocyrtis ? hannai (Campbell & Clark) Kling, 1973, p. 638, pl. 5, figs. 12-14, pl. 12, figs. 10-14; Nigrini & Moore, 1979, p. N83, pl. 25, fig. 8; Johnson & Nigrini, 1979, p. N83, pl. 25, fig. 8; Takahashi, 1981, p. 266.

Lamprocyclas ?. hannai (Campbell & Clark) - Takahashi & Honjo, 1981, p. 154, pl. 9, fig. 25.

Lamprocyclas hannai (Campbell & Clark) - Johnson & Nigrini, 1980, pl. 3, fig. 25.

Family ARTOSTROBIIDIAE Riedel, 1967b, emend. Foreman, 1973

Genus SPIROCYRTIS Haeckel, 1881, emend. Nigrini, 1977

SPIROCYRTIS SCALARIS **Haeckel**

Pl. 18, Figs. 10-12.

Spirocyrtis scalaris Haeckel, 1887, p. 1509, pl. 76, fig. 14; Renz, 1976, p. 142, pl. 6, fig. 1; Nigrini, 1977, pl. 2, fig. 12; Johnson & Nigrini, 1980, p. 135, text-fig. 14e, pl. 4, fig. 9; Takahashi & Honjo, 1981, p. 154, pl. 10, fig. 15; Takahashi, 1981, p. 268, pl. 44, figs. 1-2.

SPIROCYRTIS SP. AFF. S. SERIATA **Jorgensen**

Pl. 18, Fig. 14.

Spirocyrtis seriata Jorgensen, 1905, p. 140, pl. 18, figs. 102, 104; Bjorklund, 1976a, pl. 10, figs. 7-12.

Spirocyrtis subscaleris Nigrini, 1977, p. 259, pl. 3, figs. 1,2.

Spirocyrtis sp. aff. S. seriata Jorgensen- Takahashi, 1981, p. 154, pl. 10, fig. 16; Takahashi, 1981, p. 268, pl. 44, figs. 3-6.

Remark : Due to paucity of material species level could not be resolved and only affinity to the species is mentioned.

SPIROCYRTIS GYROSCALARIS **Nigrini**

Pl. 18, Fig. 15.

Spirocyrtis sp. aff S. scalaris Haeckel- Riedel & Sanfilippo, 1971, p. 1601, pl. 1G, figs. 21-23.

Spirocyrtis sp. Petrushevskaya & Kozlova, 1972, p. 540, figs. 27, 28.

Spirocyrtis gyroscalaris. Nigrini, 1977, p. 259, pl. 2, figs. 10-11.

Genus BOTRYOSTROBUS Haeckel, 1887 emend. Nigrini, 1977

BOTRYOSTROBUS AURITUS / AUSTRALIS **(Ehrenberg)**

Pl. 18, Figs. 16-18.

Lithocampe aurita Ehrenberg, 1844a, p. 84.

Lithocampe australe Ehrenberg, 1844b, p. 187.

Lithostrobus seriatus Haeckel, 1887, p. 1474, pl. 79, fig. 15; Petrushevskaya, 1967, p. 145, pl. 82, figs. I-IV; pl. 24, figs. 6-8.

Botryostrobus auritus / australis (Ehrenberg) Nigrini, 1977, p. 246, pl. 1, figs. 2-5; Johnson & Nigrini, 1980, pl. 4, fig. 6.

BOTRYOSTROBUS AQUILONARIS **(Bailey)**

Pl. 18, Fig. 19.

Eucyrtidium aquilonaris Bailey, 1856, p. 4, pl. 1, fig. 9.

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

Botryostrobus aquilonaris (Bailey) Nigrini, 1977, p. 246, pl. 1, fig. 1; Nigrini & Moore, 1979, p. N99, pl. 27, fig. 1; Kling. 1979 p. 309, pl. 2, fig. 18; Johnson & Nigrini, 1980, p. 135, text-fig. 14a, pl. 4, fig. 5; Takahashi & Honjo, 1981, p. 154, pl. 10, figs. 9,10; Takahashi, 1981, p. 269, pl. 44, figs. 9-13.

Genus PHORMOSTICOARTUS Campbell, 1951, emend. Nigrini, 1977

PHORMOSTICHOARTUS CORBULA **(Harting)**

Pl. 18, Figs. 20-22.

Lithocampe corbula Harting, 1863, p. 12, pl. 1, fig. 21.

Siphocampe corbula (Harting) Nigrini, 1967, p. 85, pl. 8, fig. 5; Riedel & Sanfilippo , 1971, p. 1601, pl. 1H, figs. 18-25; Riedel & Sanfilippo, 1978, p. 73, pl. 9, fig. 7; Renz, 1976, p. 141, pl. 6, fig. 8.

Phormostichoartus corbula (Harting) Nigrini, 1977, p. 252, pl. 1, fig. 10; Johnson & Nigrini, 1980, p. 135, text-fig. 14 c, pl. 4, fig. 7; Takahashi & Honjo, 1981, p. 154, pl. 10, figs. 13,14.

Genus SIPHOCAMPE Haeckel, 1887 emend. Nigrini, 1977

SIPHOCAMPE LINEATA **(Ehrenberg)**

Pl. 18, Figs. 25-31.

Lithocampe lineata Ehrenberg, 1838, p. 130 (partim).

Eucyrtidium lineatum (Ehrenberg) Ehrenberg, 1847b, p. 43 (partim); 1854a, pl. 22, fig. 26.

Tricolocampe cylindrica Haeckel, 1887, p. 1412, pl. 66, fig. 21.

Siphocampe lineata group (Ehrenberg) - Nigrini, 1977, p. 256, pl. 3, figs. 9,10; Johnson & Nigrini, 1980, P. 135, text-fig. 14d, pl. 4, fig. 8; Takahashi, 1981, p. 271, pl. 44, figs. 17-20.

***SIPHOCAMPE ARACHNEA* (Ehrenberg)**

Pl. 18, Fig. 33.

Eucyrtidium lineatum arachneum Ehrenberg, 1861, p. 299.

Lithomitra vanhoffeni Popofsky, 1908a, p. 296, pl. 36, fig.9.

Lithomitra arachnea (Ehrenberg) Riedel, 1958, p. 242, pl. 4, figs. 7,8; Petrushevskaya, 1966, p. 232, text-fig. 7(4); 1971b, text fig. 22.4 b; 1975, p. 586, pl. 10, figs. 13-17.

Siphocampe arachnea (Ehrenberg) Takahashi, 1981, p. 271, pl. 44, figs. 21-23.

SIPHOCAMPE NODOSARIA **(Haeckel)**

Pl. 18, Fig. 32.

Lithomitra nodosaria Haeckel, 1887, p. 1484, p. 79, fig. 1; Petrushevskaya & Kozlova, 1972, pl. 24, figs.29,30.

Lithomitra eruca Haeckel, 1887, p. 1485, pl. 79, fig. 3; Petrushevskaya & Kozlova, 1972, p. 539, pl. 24, figs. 32,33.

Siphocampe nodosaria (Haeckel) Nigrini, 1977, p. 256, pl. 3, fig. 11; Takahashi & Honjo, 1981, p. 154, pl. 10, fig. 11, 12.

Family CANNOBOTRYIDAE Haeckel, 1881, emend Riedel, 1967a

Genus BOTRYOCYRTIS Ehrenberg, 1860b, sensu. Riedel & Sanfilippo, 1977

BOTRYOCYRTIS SCUTUM **(Harting)**

Pl. 18, Figs. 34,35.

Haliomma scutum Harting, 1863, p. 11, pl. 1, fig. 18.

Botryocyrtis caput-serpentis Ehrenberg, 1872a, p. 301; 1872b, p. 287, pl. 10, fig. 21.

?Lithobotrys homunculus Popofsky, 1913, p. 317, pl. 31, figs. 5,6.

Botryopyle erinaceus Popofsky, 1913, p. 319, text-fig. 28a.

Botryocyrtis scutum (Harting) Nigrini, 1967, p. 52, pl 6, fig. 1 a-c; Nigrini & Moore, 1979, p. N105, pl. 28, figs. 1 a-b; Johnson & Nigrini, 1980, pl. 4, fig. 10; Takahashi & Honjo, 1981, p. 155, pl. 10, figs. 23-24; Takahashi, 1981, p. 279-80, pl. 46, figs. 6-7.

BOTRYCYRTIS SP.

Pl. 18, Fig. 36.

Botryocyrtis sp. A Takahashi, 1981, p. 279, pl. 46, figs. 4,5.

Remark : Due to paucity of material species level could not be resolved and only affinity to the species is mentioned.

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

Genus CARPOCANISTRUM Haeckel, 1887

CARPOCANISTRUM FLOSCULUM **Haeckel**

Pl. 18, Figs 43, 45.

Carpocanistrum flosculum Haeckel, 1887, p. 1171, pl. 52, fig. 9; Takahashi, 1981, p. 272, pl. 45, figs. 6-7.

Carpocanium verecundum Haeckel, 1887, p. 1284, pl. 52, figs. 12, 13.

Carpocanium petalospyris Haeckel - Benson, 1966, p. 434 (partim), text fig. 25, pl. 29, fig. 10 (only).

Capocanium spp. Nigrini, 1970, p. 171 (partim), pl. 4, figs. 5,6.

Carpocanistrum spp. - Dumitrica, 1972, p. 838, pl. 14, fig. 4, pl. 15, figs. 11,12, pl. 24, fig. 1,3,6

; Renz, 1976, p. 151, pl. 6, fig. 4; Nigrini & Moore, 1979, p. N23 (partim), pl. 21, figs. 1b,c; Johnson & Nigrini, 1980, p. 127 (partim), text-fig. 9, pl. 3, fig. 5; Takahashi & Honjo, 1981, p. 155, pl. 10, figs. 21, 22.

CARPOCANISTRUM CEPHALUM **Haeckel**

Pl. 18, Figs 38, 44.

Carpocanistrum cephalum Haeckel, 1887, p. 1171, pl. 52, fig. 10; Takahashi, 1981, p. 272-273, pl. 45, figs. 5, 12.

Carpocanistrum evacuatum Haeckel, 1887, p. 1172, pl. 52, fig. 11.

Carpocanistrum petalospyris Haeckel- Benson, 1966, p. 434 (partim) pl. 29, fig. 9 (only).

Carpocanium sp. Benson, 1966, p. 438, pl. 29, figs. 11,12.

Carpocanium sp. A. Nigrini, 1968, p. 55, pl. 1, fig. 4; Nigrini & Moore, 1979, p. N25, pl. 21, fig. 2.

CARPOCANISTRUM FAVOSUM **(Haeckel)**

Pl. 18, Fig. 41.

Sethamphora favosa Haeckel, 1887, p. 1252, pl. 57, fig. 4.

Carpocanistrum ? odysseus Haeckel- Dumitrica, 1972, p. 838, pl. 15, fig. 10, pl. 24, fig. 2.

Carpocanistrum favosum (Haeckel) Takahashi, 1981, p. 273, pl. 45, fig. 8.

CARPOCANISTRUM CORONATUM **(Ehrenberg)**

Pl. 18, Fig. 46.

Carpocanium coronatum Ehrenberg, 1875, p. 66, pl. 5, figs. 7.

Carpocanistrum sp D. Ling, 1975, p. 730, pl. 12, fig. 6.

Carpocanistrum spp. Nigrini, 1970, p. 171, (partim) pl. 4, fig. 4; Nigrini & Moore, 1979, p. N23 (partim), pl. 21, fig. 1a (only).

Carpocanistrum coronatum (Ehrenberg) Takahashi, 1981, p. 273-274, pl. 45, fig. 10.

CARPOCANISTRUM ACUTIDENTATUM **Takahashi**

Pl. 18, Figs. 39,40.

Carpocanistrum acutidentatum Takahashi, 1981, p. 274, pl. 45, figs. 9, 13-15.

Genus CARPOCANARIUM Haeckel, 1887, emend. Nigrini & Moore, 1979

CARPOCANARIUM PAPILLOSUM **(Ehrenberg)**

Pl. 18, Fig. 37.

Eucyrtidium papillosum Ehrenberg, 1872a, p. 310; 1872b, p. 293, pl. 7, fig. 10.

Dictyocryphalus papillosum (Ehrenberg) Haeckel, 1887, p. 1307,; Riedel, 1958, p. 236, pl. 3, fig. 10, text-fig. 8; Nigrini, 1967, p. 63, pl. 16, fig. 6; Ling, 1975, p. 731, pl. 13, fig. 10,; Renz, 1976, p. 139, pl. 6, fig. 9.

Carpocanarium papillosum (Ehrenberg) group - Nigrini & Moore, 1979, p. N27, pl. 21, fig. 3; Johnson & Nigrini, 1980, p. 127, text-fig. 10a, pl. 3, fig. 6; Takahashi & Honjo, 1981, p. 155, pl. 10, fig. 17; Takahashi, 1981, p. 275, pl. 45, figs. 16-17.

5.2 TAXONOMIC FRAMEWORK FOR GROUP COUNTS

The basic philosophy adopted in the paleoceanographic study of radiolarians, is that the latitudinal and vertical (depthwise) distribution of modern fauna can be used to interpret the composition of the fossilized fauna by assuming that coarser taxonomic groups (broadly defined taxa) ranging from late Miocene to Recent had approximately constant environmental affinities. Since the use of radiolarians for environmental study is seriously hampered by con-species variations, difference of opinion in taxonomic placement by the taxonomists, and above all the intergradation of species and genera, it is appropriate to count them in a coarser taxonomic groups in order to use the entire assemblage in environmental analysis rather than one or two species (Kruglikova, 1979; Riedel *et al.* 1985, Westberg-Smith and Riedel, 1985; Mullineaux and Westberg-Smith, 1986; Boltovoskoy, 1987; Sanfilippo, 1988). Although, counting of taxa at species level has the advantage of higher resolution in paleoceanographic changes, but the disadvantage results into relation between species and environment, which cannot be applied beyond the stratigraphic and geographic limits of the narrowly defined taxa (Mullineaux and Westberg-Smith, 1986). The coarser taxonomic framework used by these authors have revealed temporal changes in the oceanographic parameters in geological past especially in Neogene.

Sachs (1973a,b,c), Robertson (1975), Moore (1978), Riedel *et al.* (1985), Romine (1982, 1985), Mullineaux and Westberg-Smith (1986) and Sanfilippo (1988) opined the coarser taxonomic framework for counting the radiolarian population in the paleoenvironmental studies and concluded that generic groups contain better paleoenvironmental informations, though some of them certainly be lost by lumping of species, genera and in some cases even subfamilies into larger taxonomic groups. Mullineaux and Westberg-Smith (1986) discussed the reasoning behind the coarser grouping in paleoceanographic studies. They categorized mid Miocene radiolarian taxa into fifty species/groups and found that even then the signals were strongly reflected in the abundance changes. Gupta *et al.* (1988) and Gupta and Srinivasan (in press) used the coarser taxonomic grouping of late Miocene radiolarian taxa from the Neill Island, Andamans and used the group-wise abundance for the paleomonsoonal upwelling. Recently Takahashi (1987) found that the closer is the morphology of radiolaria *(Pterocanium)* with a generic pair, the lesser the niches in temporal seasonal fluxes are developed. Boltovoskoy (1987) observed that family and suborder level census data yielded similar results to the one based on species and suggested that distribution of high level (coarser) radiolarian categories (morphogroups) is meaningful in the ecological terms.

Since the radiolarian species in present study are highly divergent, accounting more than 250 species, it became difficult to ascertain the composition at species level. Therefore, similar logic has been applied in this work and some of the groups counted are coined considering at least few common morphological features at generic-pair group. In some cases, although the group contained several genera, it is named after two dominant genera as generic pair-name of the group. In certain cases, all the specimens having characteristics of a subfamily are counted together and such groups are named after these subfamilies. Adopting this criterion, a total of 47 morpho-groups are counted in present work in all the randomly settled slides of surface sediment from the basin.

5.2.1 MORPHOGROUPS COUNTED

Followings are the morphogroups counted in present study :

Suborder **SPUMELLARIA** Ehrenberg, 1875

Family **COLLOSPHAERIDAE** Muller, 1858b

Genus *COLLOSPHAERA* Muller, 1855

Collosphaera group

Pl. 1, Figs. 1-26, Pl. 2, Figs. 1-3.

Collosphaera group Gupta & Srinivasan (in press), pl. 1, figs. 7-13.

Group includes all the specimens belonging to the genus *Collosphaera like C. invaginata, C. tuberosa, C. huxleyi, C. sp. cf. C. huxleyi, C. polygona, C. armata* and other unidentified specimens similar to any species of *Collosphaera*.

Genus *DISOLENIA* Ehrenberg, 1860a

Genus *SIPHONOSPHAERA* Muller, 1858a

Genus *OTOSPHAERA* Haeckel, 1887, emend. Nigrini, 1967

Disolenia-Siphonosphaera group

Pl. 2, Figs. 4-8, Pl. 3, Fig. 14.

Disolenia group Gupta & Srinivasan (in press), pl. 1, fig. 14.

Johnson and Nigrini (1980,1982) found that species of the *Disolenia, Siphonosphaera* and *Otosphaera* form exclusively tropical group. Lombari and Boden (1985) mapped and contoured the *Disolenia zanguebarica, D. quadrata* together and found that they dominate the tropical region of the world ocean. All the genera mentioned above in this group have a common feature of protruding tubules or siphons apart from their similar biogeography in Indian Ocean. Therefore, all these genera are counted together in this group. Species counted in this group are *D. quadrata, D. zanguebarica, D. sp., S. socialis, S. polysiphonia, S. martensi, S. sp. aff. S. hippotis, S. magnisphaera, Otosphaera polymorpha, O. auriculata* etc.

Genus *ACROSPHAERA* Haeckel, 1881

Acrosphaera group

Pl. 2, Figs. 9-27.

Acrosphaera group Gupta & Srinivasan (in press), pl. 1, figs. 1-6.

Group includes all **Collosphaerids** with external spines like *A. spinosa, A. spinosa longispina, A. spinosa coniculispina, A. coronula, A. murrayana, A. cyrtodon, A. lappacea, A. arktios/ pseudoarktios, A. spinosa echinoides* etc.

Family **ETHMOSPHAERIDAE** Haeckel, 1862

Genus *PLEGMOSPHAERA* Haeckel, 1881

Plegmosphaera group

Pl. 3, Figs. 15-19, Pl. 4, Figs. 1,3.

Group includes specimens having spherical, delicate, spongy meshwork without radiating spines from the spherical shell, like *Plegmosphaera pachypila, P. coelipila, P. sp. aff. P. lapticali, P. sp.* and *carposphaera sp. aff C. corypha* in its counts.

Genus *STYPTOSPHAERA* Haeckel, 1881

Styptosphaera group

Pl. 3, Figs. 20-28.

All the specimens having spongy meshwork in spherical to ellipsoidal sphere with tiny to pronounced radiating spines are counted together in this group. Species included in counts are *S. spongiacea, S. spumacea, S. Sp. A,B,C.* etc.

Family **ACTINOMMIDAE** Haeckel, 1862, emend. Riedel, 1971; Sanfilippo & Riedel, 1980

Subfamily **ACTINOMMINAE**, Haeckel, 1862, emend. Takahashi, 1981

Genus *ACTINOMMA* Haeckel, 1860a, emend. Nigrini, 1968

Genus *ACANTHOSPHAERA* Ehrenberg, 1858

Actinomma group

Pl. 4, Figs. 4-13, Pl. 5, Figs. 1-8, Pl. 6, Figs. 4-6.

Other Actinommids group Westberg-Smith *et al.* 1986, p. 772.

Actinomma group Gupta & Srinivasan (in press), pl. 1, figs. 35-37.

Specimens having smooth or fine haired cortical shell without any prominent protruding spines are grouped together and counts include *A. arcadophorum, A. medianum, A. sp., A. castanea, A. simplex* and other specimens having similar characteristics of a smoother cortical shell.

Genus *CLADOCOCCUS* Muller, 1857

Cladococcus group

Pl. 5, Figs. 9-15, Pl. 6, Fig. 3.

All actinommins having spherical cortical shell with numerous branched, anotomously branched or unbranched slender to robust, straight to gently curved spines all over the cortical shell are counted together. Group includes *C. viminalis, C. abietinus, C scoparius, C. cervicornis* etc.

Genus *ELATOMMA* Haeckel, 1881

Genus *HALIOMMA* Ehrenberg, 1838

Genus *CROMYOMMA* Haeckel , 1881

Genus *SPHAEROPYLE* Dreyer, 1889

Elatomma-Haliomma group

Pl. 5, Figs. 20-21, Pl. 6, Figs. 1-2, 4-6.

All actinommins having smooth surfaced cortical shell with small and medium size pores, without any spines protruding out of the cortical shell are counted together in this group. Group count includes *H. castanea, H. sp. aff. H. radians?, E. penicillus, Cromyomma villosum, Sphaeropyle mespilius* and other unidentifiable forms having similar characteristics.

Genus *HEXACONTIUM* Haeckel, 1881

Genus *HEXALONCHE* Haeckel, 1881

Genus *HEXASTYLUS* Haeckel, 1881

Genus *HEXACROMYUM* Haeckel, 1881

Genus *HETEROSPHAERA* Mast, 1910

Hexacontium group

Pl. 6, Figs. 11-21

Hexacontium group Westberg-Smith and Riedel, 1985, p. 486, pl. 1, figs. 4a,b, 5; -Riedel *et al*. 1985, pl.1, figs. 6a-c, 7a-c;- Westberg-Smith *et al*. 1986, p. 771; -Mullineaux & Westberg-Smith, 1986, p. 64, pl. 1, fig. 1a,b; Gupta & Srinivasan (in press), pl. 2, figs. 1-4.

Actinommins with six or more piercing radial spines from cortical shell are counted together under this group. Species included in counts are *H. amphisiphon, H. axotrias, H. sp. aff. H. hostile, H. heracliti, H. triaxonius and Heterosphaera sp. A,B* of Takahashi (1981), and *Cromychnius sp.* and *Cromyechnius sp. aff. C. borealis* etc.

Genus *STYLOSPHAERA* Ehrenberg, 1847a

Genus *AXOPRUNUM* Haeckel, 1887

Genus *AMPHISPHAERA* Haeckel, 1881

Genus *DRUPPATRACTUS* Haeckel, 1887

Genus *XIPHATRACTUS* Haeckel, 1887

Genus *ELLIPSOXIPHON* Haeckel, 1887

Stylosphaera group

Pl. 7, Figs. 10-21 & 23-26.

Stylosphaera group Westberg-Smith *et al.* 1986, p. 772; -Westberg-Smith & Riedel , 1985; - Riedel *et al.* 1985; Gupta & Srinivasan (in press), pl. 1, figs. 38-42.

All actinimmins having prominent bipolar spines and smaller thin secondary spines, which may or may not present on cortical shell, are counted together under this group. Species included in the counts are *S. melpomene, D. ostracion, E. palliatum, A. uranus, A. stauraxonium, A. sp?. monostylum* etc.

Family **COCCODISCIDAE** Haeckel, 1862, emend.

Sanfilippo & Riedel, 1980

Subfamily **ARTISCINIAE** Haeckel, 1881, emend.

Riedel, 1967a

Genus *DIDYMOCYRTIS* Haeckel, 1881, emend.

Riedel, 1971

Genus *SPONGOLIVA* Haeckel, 1887

Artiscins (Didymocyrtis) group

Pl. 8, Figs. 3-8

Artiscins group Westberg-Smith *et al.* 1986; - *Didymocyrtis* group Riedel *et al.* 1985, p. 505, pl. 1, figs. 11a-c; -Mullineaux & Westberg-Smith, 1986, p. 64, pl. 2, fig. 1.

Group includes members of the subfamily **Artiscinae** like *D.tetrathalmus tetrathalmus, D. tetrathalmus coronata* and stray specimens of *Spongoliva ellipsoides* in counts. Members of the subfamily **Artiscinae** are found thriving in 25-50 m surface water in the Pacific and Atlantic Oceans (McMillen and Casey, 1978; Kling, 1979).

Family **PORODISCIDAE** Haeckel, 1881, emend.

Petrushevskaya & Kozlova, 1972.

Genus *EUCHITONIA* Ehrenberg, 1860b, emend. Haeckel, 1887

Genus *DICTYOCORYNE* Ehrenberg, 1860b

Genus *HYMENIASTRUM* Haeckel, 1887

Euchitoniids group

Pl. 8, Figs. 9-12.

Dictyocoryne group Westberg-Smith & Riedel, 1985, p. 489, pl. 3, Fig. 1;-*Hymeniastrum* group Riedel *et al*.. 1985, p. 505, pl. 2, figs. 2a,b; *Echitonnia* group Gupta & Srinivasan (in press), pl. 1, figs. 15-18.

Johnson and Nigrini (1980, 1982) found that *Dictyocoryne truncata, D. profunda, Euchitonia furcata, E. elegans, Euchitonia sp.* have a similar distribution in the tropical Indian Ocean. Apart from their similar biogeography, all these have morphological similarity in their three armed discoidal spongy skeleton with or without a patagium. Kling (1979) found that these species are abundant in subsurface water between 100-200 m depth in northeast Pacific. Therefore all these species are counted together in a morphogroup in order to avoid duplication of the same specimen during counting in two different groups. Group includes y-shaped specimens of *Euchitonia elegans, E. furcata, E. sp.,* *Dictyocoryne truncata, D. profunda, Hymeniastrum euclidis* in its counts.

Genus *AMPHIRHOPALUM* Haeckel, 1881

Amphirhopalum group

Pl. 8, Figs. 13-20.

Specimens of *A. ypsilon, A. omalocladum, A. straussi,* are counted together in this group.

Genus *STYLODICTYA* Ehrenberg, 1847a

Genus *STYLOCHLAMYDIUM* Haeckel, 1881

Genus *PORODISCUS* Haeckel, 1881

Stylodictya-Stylochlamydium group

Pl. 9, Figs. 1-7.

Stylodictya spp. Westberg-Smith & Riedel, 1985, p. 489, pl. 2, fig. 6; - *Stylodictya* group Westberg-Smith *et al.* 1986, p. 772; — *Stylodictya-Stylochlamydium* group Gupta & Srinivasan (in press), pl. 1, figs. 19-24.

Group described to count all circular, discoidal, flattened **Porodiscids** with or without radiating spines together. Specimens included in counts are *S. validispina, S. asteriscus, S. aculeata, S. venustum,* and *Porodiscus micromma*.

Family **SPONGODISCIDAE** Haeckel, 1862, emend.

Riedel, 1967a, Petrushevskaya & Kozlova, 1972

Genus *SPONGODISCUS* Ehrenberg, 1854a

Genus *SPONGOTROCHUS* Haeckel, 1860b

Genus *Spongurus* Haeckel, 1881

Genus *SPONGOBRACHIUM* Haeckel, 1881

Genus *SPONGOPYLE* Dreyer, 1889

Spongodiscids group

Pl. 8, Fig. 21; Pl. 9, Figs. 8-22, Pl. 10, Fig. 1.

Spongodiscus group Westberg-Smith & Riedel, 1985, p. 489, pl. 2, figs. 7a, b; -Westberg-Smith *et al*. 1986, p. 772; -Mullineaux & Westberg-Smith, 1986, p. 65, pl. 1, fig. 12; *Spongopyle* group Mullineaux & Westberg-Smith, 1986, p. 66, pl. 1, figs. 7a,b.

Group counts all spherical, subspherical, discoidal to globose spongodiscids together. Species included in counts are *Spongodiscus resurgens, S. biconcavus, Spongotrochus glacialis, Spongotrochus polymaticus, Spongotrochus sp., Spongurus sp., S. setosa* and *Spongopyle osculosa*. Group is named after the family **Spongodiscidae**.

Genus *SPONGASTER* Ehrenberg, 1860b

Genus *SPONGOCORE* Haeckel, 1887

Spongaster-Spongocore group

Pl. 9, Figs. 23-24, Pl. 10, Figs. 2-4

Spongocore group - Westberg-Smith & Riedel, 1985, p. 489, pl. 3, fig. 2; -Mullineaux & Westberg-Smith, 1986, p. 65, pl. 1, fig. 13

Group includes spongy rectangular to cylindrical spongodiscids in counts. Species included in counts are *S. tetras tetras, S. tetras irregularis, S. sp.* and *Spongocore puella*. Group is name after two genera counted together.

Family **PHACODISCIDAE** Haeckel, 1881, emend.
Campbell, 1954

Genus *HELIODISCUS* Haeckel, 1862

Heliodiscus group

Pl. 10, Figs. 5-13.

Phacodiscids group Westberg-Smith & Riedel, 1985, p. 487.-Riedel *et al.*, 1985, p. 505, pl. 1, figs. 10a,b; - Westberg-Smith *et al.*, 1986, p. 772; Gupta & Srinivasan (in press), pl. 2, figs. 7,8.

Group described to count **Phacodiscids** like *H. asteriscus* and *H. echiniscus* together.

Family **PYLONIIDAE** Haeckel, 1881, emend. Campbell, 1954

Genus *TETRAPYLE* Muller, 1858b

Genus *OCTOPYLE* Haeckel, 1881

Genus *HEXAPYLE* Haeckel, 1881

Pyloniids group

Pl. 10, Figs. 15-21.

Pyloniids group Riedel *et al*. 1985, p. 506, pl. 2, figs. 9a,b; -Mullineaux & Westberg-Smith, 1986, p. 66, pl. 2, fig. 2;- Gupta & Srinivasan (in press), pl. 2, figs. 15-16.

All the specimens belonging to family **Pyloniidae** are counted together in this group. The count includes *Tetrapyle octacantha, Octapyle stenozona,* and *Hexapyle dodecantha*. **Pyloniids** are reported to have abundance maxima in surface water of the Pacific and Atlantic Oceans.

Family **LITHELIIDAE** Haeckel, 1862, emend. Campbell, 1954

Genus *LARCOPYLE* Dreyer, 1889

Genus *LITHELIUS* Haeckel, 1862

Litheliids group

Pl. 11, Figs. 1-8.

Lithelius group Westberg-Smith & Riedel, 1985, p. 490, pl. 3, fig. 5; -Mullineaux & Westberg-Smith, 1986, p. 66, pl. 2, figs. 4a, b; -Gupta & Srinivasan (in press), pl. 2, figs. 20-21.

Group described to count all planispirally coiled specimens excluding *Larcospira quadrangula*, like i.e. *L. butschlii, Dictyopyle elliptica, L. minor,* and *L. nautiloides*. Group is named after the family **Lithelidae.**

Genus *LARCOSPIRA* Haeckel, 1887

Larcospira quadrangula group

Pl. 11, Figs. 9-11.

Larcospira group Riedel *et al.* 1985, p. 506, pl. 2, fig. 12;-Mullineaux and Westberg-Smith, 1986, p. 66, pl. 2, fig. 7; - Gupta & Srinivasan (in press), pl. 2, figs. 17-18.

Group includes specimens of *Larcospira quadrangula* only.

Suborder **NASSELLARIA** Ehrenberg, 1875

Family **PLAGIACANTHIDAE** Hertwig, 1879, emend. Petrushevskaya, 1971d

Subfamily **PLAGIACANTHINAE** Hertwig, 1879, emend. Petrushevskaya, 1971d

Plagiacanthins group

Pl. 12, Figs. 1-5.

Group described herein to include all the species of subfamily, with loosely adhered latticed structure over the basic skeletal elements i.e. apical, lateral-apical, vertically directed, primary and secondary lateral spines and median bar and axial rods. Genera counted together in this group are *Archiscenium, Plectanium, Protoscenium, Semantis, Neosemantis, Phormacantha, Cladoscenium* and *Arachnocorallium* with a common feature of a indistinct thorax from rudimentary to poorly developed cephalis.

Subfamily **LOPHOPHAENINAE** Haeckel, 1881, emend. Petrushevskaya, 1971d

Lophophaenins group

Pl. 12, Figs. 6-13.

Lophophaena group Westberg-Smith & Riedel, 1985, p. 492, pl. 4, fig. 4a-e; -Mullineaux & Westberg-Smith, 1986, p. 67, pl. 2, figs. 13 a-c; **Lophophaenids** group Gupta & Srinivasan (in press), pl. 2, figs. 28-31.

Group described to count all the members of subfamily **Lophophaeninae**, with two distinct segments i.e. cephalis and thorax with a well defined latticed structure. Genera included in counts are *Acanthocorys, Lophophaena, Helotholus, Peromelissa, Lithomelissa, Peridium* and *Trisulcus* etc.

Subfamily **SETHOPERININAE** Haeckel, 1881, emend.
Petrushevskaya, 1971d

Sethoperinins group

Pl. 12, Figs. 14-19.

Sethoperinins group Gupta & Srinivasan (in press), pl. 2, figs. 33-36.

Group described to include specimens with a pyramidal cephalis with eucephalic and antecephalic lobe surrounded by latticed plates built by branches of spines. Genera counted together in group are *Lithopilium, Clathrocanium, Clathrocorys* and *Callimitra*.

Family **ACANTHODESMIIDAE** Haeckel, 1862, emend.
Riedel, 1971

Genus *ZYGOCIRCUS* Butschli, 1882

Zygocircus group

Pl. 12, Figs. 20-23.

Group described to count simple **Acanthodesmiids** like *Zygocircus capulosus, Z. productus, Z. cf. piscicaudatus* together in a group.

Genus *LOPHOSPYRIS* Haeckel, 1881, emend. Goll, 1977

Genus *PHORMOSPYRIS* Haeckel, 1881, emend. Goll, 1977

Lophosyris-Phormospyris group

Pl. 12, Figs. 24-26, Pl. 13, Figs. 1-9.

Phormospyris group Gupta & Srinivasan (in press), pl. 2, figs. 23-25.

Group described to count specimens of *Giraffospyris angulata, Lophospyris pentagona, L. pentagona pentagona, L. pentagona hyperborea, L. cheni, L. borealis* and *Phormospyris stabilis stabilis, P. stabilis scaphipes, P. s. capoi, P. stabilis* etc. and named after dominant genera *Lophospyris* and *Phormospyris*.

Genus *ANDROSPYRIS* Haeckel, 1887

Androspyris group

Pl. 13, Fig. 12.

Group described to count together the specimens of *Androspyris ramosa, A. fenestrata, A. huxleyi* etc.

Genus *LIRIOSPYRIS* Haeckel, 1881, emend. Goll, 1968

Liriospyris group

Pl. 13, Figs. 13-16.

Group described to count specimens of *L. thorax thorax, L. t. laticapsa, L. reticulata* together as a group.

Genus *NEPHROSPYRIS* Haeckel, 1881

Nephrospyris group

Pl. 13, Figs. 10-11.

Nephrospyris group Mullineaux & Westberg-Smith, 1986, p. 67, pl. 2, figs. 10a a-g; - Gupta & Srinivasan (in press), pl. 2, fig. 26.

Group described to count specimens of *N. renilla renilla* and *N. renilla lana* together in group count.

Family **SETHOPHORMIDIDAE** Haeckel, 1881, emend. Petrushevskaya, 1971d

Sethophormin group

Pl. 13, Figs. 17-20.

Sethophormin group A,B. Westberg-Smith & Riedel, 1985, p. 492, pl. 4, figs. 6,7; -Riedel *et al.* 1985,

p. 508, pl. 4, figs. 2 a, b; -Mullineaux & Westberg-Smith, 1986, p. 67, Pl., fig. 17.

Group emended to include the specimens with flat cephalis and an umbrella shaped flattened thorax like *Sethophormis rotula, S. dodecaster, Tetraphormis butschlii, Theophormis callipilium* in group counts.

Genus *EUCECRYPHALUS* Haeckel, 1860

Genus *LAMPROMITRA* Haeckel, 1881

Genus *COROCALYPTRA* Haeckel, 1887

Genus *CLATHROCYCLAS* Haeckel, 1881

Eucecryphalus group

Pl. 13, Figs. 21-30, Pl. 14, Figs.. 1-4.

Eucecryphalus group Riedel *et al. 1985*, p. 509; Mullineaux & Westberg-Smith, 1986, p. 67; -Gupta & Srinivasan (in press), pl. 2, figs. 39-41.

Group emended to include all three segmented shells forming a wide conical skeleton with flattened-conical abdomen like *Eucecryphalus tricostatus, E. sestrodiscus, E. europae, E. gegenbauri, E. clinatus, Lampromitra schultzei, L. coronata, L. cachoni, L. spinosiretis, Corocalyptra cervus, Clathrocyclas monumentum* and *C. cassiopejae* in group counts.

Family **EUCYRTIDIIDAE** Petrushevskaya, 1971d

(=**THEOPERIDAE** Haeckel, 1881, emend. Riedel, 1967a)

Subfamily **PLECTOPYRAMIDINAE** Haecker, 1808a, emend. Petrushevskaya, 1971d

Genus *PLECTOPYRAMIS* Haecke, 1887

Genus *CORNUTELLA* Ehrenberg, emend. Nigrini, 1967

Genus *BATHROPYRAMIS* Haeckel

Genus *PERIPYRAMIS* Haeckel, emend. Riedel, 1958

Genus *LITHARACHNIUM* Haeckel

Plectopyramidin group

Pl. 14, Figs. 5-13.

Cornutella group Riedel *et al,* 1985, p. 509, pl. 4, fig. 4;- Mullineaux & Westberg-Smith ,1986, pl. 3, fig. 1.; - *Bathropyramis* spp. Westberg-Smith *et al.* 1986, p. 773; - *Litharachnium* group Westberg-Smith *et al.* 1989, p. 774; - **Plectopyramids** group Gupta & Srinivasan (in press), pl. 2, figs. 42,43, pl. 3, fig. 1

Group described herein to count all the members of subfamily *Plectopyramidinae* with very small thorax, an apical horn, a very large conical-cylindrical to campanulate or wide mouthed funnel shaped thorax , with subangular to quadrangular or rectangular pores, smaller proximally and larger to giagantic distally, are counted together. Species included in group counts are *Plectopyramis dodecomma, Cornutella profunda, Peripyramis circumtexta, Bathropyramis ramosa, Litharachnium tentorium and L. eupilium* etc.

Subfamily **EUCYRTIDIINIAE** Ehrenberg, 1847b, emend. Petrushevskaya, 1971d

Genus *LITHOPERA* Ehrenberg, 1847a

Genus *CYRTOPERA* Haeckel, 1881

Lithpera-Cyrtopera group

Pl. 15, Figs. 9-12.

Lithopera group Westberg-Smith *et al*. 1986, p. 774; - Mullineaux & Westberg-Smith, 1986, p. 67, pl. 3, fig. 2; *Lithopera-Cyrtopera* group Gupta & Srinivasan (in press), pl. 3, figs. 2,3.

Group include *Lithopera bacca* & *Cyrtopera laguncula* in counts as both the genera have a small apical horn and a huge closed abdomen as common feature.

Genus *CYCLADOPHORA* Ehrenberg, 1861

Cycladophora group

Pl. 15, Figs. 23-28.

Cycladophora group Westberg-Smith *et al*. 1986, p. 773. - Gupta & Srinivasan (in press), pl. 3, figs. 4-7.

Group emended to include *Cycladophora bicornis, C. b. bicornis, C. davisiana davisiana, C. d. cornutoides* in group count.

Genus *EUCYRTIDIUM* Ehrenberg, 1847a

Eucyrtidium group

Pl. 16, Figs. 8-25.

Eucyrtidium group Westberhg-Smith *et al*. 1986, p.774; -Mullineaux & Westberg-Smith *et al*. 1986, p. 67, pl. 3, fig. 4; - Gupta & Srinivasan (in press), pl. 3, figs. 8-11.

Group include all species of genus *Eucyrtidium i.e. Eucyrtidium hexagonatum, E. acuminatum, E. hexastichum, E. anomalum,* and *Eucyrtidium sp. (=Lithocampe sp.)* in group count.

Genus *PTEROCANIUM* Ehrenberg, 1847a

Pterocanium group

Pl. 14, Figs. 15-21.

Pterocanium group- Westberg-Smith & Riedel, 1985, p. 493, pl. 5, fig. 6; -Westberg-Smith *et al*. 1986, p. 774; -Mullineaux & Westberg-Smith, 1986, p. 67, pl. 3, figs. 6 a-c; - Gupta & Srinivasan (in press), pl. 3, figs. 12-14.

Group emended to include all the species of genus i.e. *Pterocanium praetextum, P. p. praetextum, P. p. eucolpum, P. trilobum, P. grandiporus, Pteroscenium pinnatum* etc. in group counts.

Genus *DICTYOPHIMUS* Ehrenberg, 1847a,

Genus *PSEUDODICTYOPHIMUS* Petrushevskaya, 1971c

Dictyo-Pseudodictyophimus group

Pl. 14, Figs. 23-27.

Dictyophimus group Westberg-Smith *et al*. 1986, p. 773;- *Pseudodictyophimus* group Westberg-Smith & Riedel, 1985, p. 492, pl. 4, fig. 5a,b; -Riedel *et al*. 1985, p. 508, pl. 3, figs. 17 a, b; -Mullineaux & Westberg-Smith, 1986, Pl., fig. 14; -Gupta & Srinivasan (in press), pl.2, fig. 32.

Group described herein to count species of *Dictyophimus* and *Pseudodictyophimus* together in this group i.e. *Dictyophimus crisiae, D. macroporus,* *D.spp., D. palladius, D. elegans* and *Pseudodictyophims gracilipes* etc. in group counts.

Family **PTEROCORYTHIDAE** Haeckel, 1881, emend. Riedel, 1967a

Genus *PTEROCORYS* Haeckel, 1881

Pterocorys group

Pl. 14, Figs. 30-39, Pl. 15, Figs. 1-7.

Pterocorys Westberg-Smith *et al.* 1986, p.775.

Group emended to count all the species of genus i.e. *Pterocorys campanula, P. claussus, P. hertwigii, P. mynithorax* etc. in group count.

Genus *THEOCORYTHIUM* Haeckel, 1887

Theocorythium group

Pl. 15, Figs. 13-16.

Theocorythium trachelium group Westberg-Smith *et al.* 1986, p. 775.

Group emended to include *Theocorythium trachelium trachelium, T. t. dianae, T. veneris* etc. in group counts.

Genus *ANTHOCYRTIDIUM* Haeckel, 1881

Anthocyrtidium group

Pl. 16, Figs. 26-31.

Anthocyrtidium group Westberg-Smith & Riedel, 1985, p. 494, pl. 5, fig. 15; -Riedel *et al.* 1985, p. 510, pl. 5, fig. 5; -Mullineaux & Westberg-Smith, 1986, pl. 3, figs. 11 a, b; -Gupta & Srinivasan (in press), pl. 3, figs. 26-28, & 52.

Group emended to include specimens of *Anthocyrtidium ophirense, A. zanguebaricum, A. euryclathrum* in group counts.

Genus *LAMPROCYCLAS* Haeckel, 1881

Genus *LAMPROCYRTIS* Kling, 1973

Lamprocyclas-Lamprocyrtis group

Pl. 17, Figs. 29-38, Pl. 18, Figs. 1-9

Lamprocyclas group Riedel *et al.* 1985, p. 510, pl. 5, figs. 6 a, b; -Mullineaux & Westberg-Smith, 1986, pl. 3, figs. 13 a , b; -Gupta & Srinivasan (in press), pl. 3, fig. 29.

Group emended to include specimens having two or three segments in these genera i.e. *Lamprocyclas maritalis maritalis, L. m. ventricosa, L. m.*

polypora, Lamprocyrtis hannai, L. nigriniae etc. in group counts.

Family **ARTOSTROBIIDIAE** Haeckel, 1887, Riedel, 1967b

Genus *SPIROCYRTIS* Haeckel, 1881

Spirocyrtis group

Pl. 18, Figs. 10-15.

Spirocyrtis group Riedel *et al*. 1985, p. 511; Mullineaux & Westberg-Smith, 1986, pl. 3, fig. 16; -Gupta & Srinivasan (in press), pl. 3, fig. 35.

Group emended to include *Spirocyrtis scalaris, S. subscalaris, S. ?platycephala* and *Artostrobus annulatus* in group counts.

Genus *BOTRYOSTROBUS* Haeckel, 1887

Botryostrobus group

Pl. 18, Figs. 16-19.

Botryostrobus group Riedel *et al*, 1985, p. 510, pl. 5, fig. 7; -Mullineaux & Westberg-Smith, 1986, pl. 3, figs. 11 a, b; -Gupta & Srinivasan (in press), pl. 3, figs. 30-34.

Group counts include *Botryostrobus aquilonaris, B. auritus/ australis* species.

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

Phormostichoartus group

Pl. 18, Figs. 20-22.

Phormostichoartus group Westberg-Smith & Riedel, 1985, p. 494, pl. 6, fig. 2a,b; - Riedel *et al*. 1985, p. 510, pl. 5, figs. 10 a,b; - Mullineaux & Westberg-Smith, 1986, pl. 3, figs. 14 a,b; -Gupta & Srinivasan (in press), pl. 3, figs. 36-42.

Group count includes *Phormostichoartus corbula* only.

Genus *SIPHOCAMPE* Haeckel, 1887

Siphocampe group

Pl. 18, Figs. 25-33.

Siphocampe group Westberg-Smith & Riedel, 1985, p. 494, pl. 6, fig. 3; -Riedel *et al*. 1985, p. 510, pl. 5, figs. 8 a-b; - Mullineaux & Westberg-Smith, 1986, pl. 3, fig. 15; -Gupta & Srinivasan (in press), pl. 3, figs. 43-46.

Group counts include *Siphocampe nodosaria, S. lineata,S. arachnea* species.

Family **CANNOBOTRYIDAE** Haeckel, 1881, emend. Riedel, 1967a

Cannobotryids group

Pl. 18. Figs. 34-36.

Cannobotryid group Riedel *et al.* 1985, p. 511, pl. 5, figs. 11 a,b; -Westberg-Smith *et al.* 1986, p. 775; - Mullineaux & Westberg-Smith, 1986, pl. 3, fig. 17; - Gupta & Srinivasan (in press), pl. 3, figs. 47-49.

Group counts include specimens with cephalis having 2 or more unpaired lobes i.e. *Acrobotrys sp., Botryocyrtis sp. Centrobotrys sp.*.

Family **CARPOCANIIDIAE** Haeckel, 1881, emend. Riedel, 1967a

Genus *CARPOCANARIUM* Haeckel, 1887, emend. Nigrini & Moore, 1979

Carpocanarium group

Pl. 18, Fig. 37.

Carpocanarium group Riedel *et al.* 1985, p. 511, pl. 5, figs. 4 a,b; -Mullineaux & Westberg-Smith, 1986, PL. 3, FIG. 18; -Gupta & Srinivasan (in press), pl. 3, fig. 50.

Group count includes *Carpocanarium papillosum* only.

Genus *CARPOCANISTRUM* Haeckel, 1887

Carpocanistrum group

Pl. 18, Figs. 38-46.

Carpocanistrum group A,B. Westberg-Smith & Riedel, 1985, p. 493, pl. 5, fig. 11a,b, 12; -Riedel *et al.* 1985, p. 510, pl. 5, figs. 2,3; - Mullineaux & Westberg-Smith, 1986, p. 68, pl. 3, figs. 10 & 18; - Gupta & Srinivasan (in press), pl. 3, fig. 51.

Group emended herein to include *Carpocanistrum flosculum, C. cephalum, C. favosum, C. coronatum, C. acutidentulum* in count.

CHAPTER 6

6.0 RESULTS AND DISCUSSION

Radiolarian numbers per gram dry sediment (Rads/g) and nassellarian / spumellarian ratio (N/S) are determined in all the sediment samples. A total of two hundred and fifty radiolarian species are identified and they are grouped into forty-seven morphogroups (see section 5.2.1). Percentage data of the morphogroups resulted into 3 clusters and 4 radiolarian factors which are interpreted in term of the seasonal watermasses within the basin. In this chapter all these results are described in detail.

6.1 RADIOLARIANS PER GRAM DRY SEDIMENT

Number of radiolarian tests in unit dry weight sediment was obtained by the method described in section 4.2 and is presented in Table 2. These numbers to their nearest thousands are plotted on map and contoured at 100,000 interval (Fig. 17). In general Rads/g is highest in the central part, where depth is >5,000 m and it reduces rapidly with decrease in depth towards the peripheral flanks of the basin.

Northern part of the basin is characterized by poor radiolarian numbers, ranging from 2,000 to 22,000 Rads/g dry sediment. This region shows the dilution

Table 2

Radiolarian numbers/gram (Rads/g), N/S ratio, opal, $CaCO_3$, total carbon and nitrogen in the surface sediment samples collected from the Central Indian Basin.

SN.	Stn. NO.	Lats. (+=N,-=S)	Longs. (E)	Depth (m)	Rads/g	N/S ratio	Opal* %	$CaCO_3$$ %	C* %	N* %
1.	2483	-02.050	82.079	4590	0,11,642	0.21	16.39	49.5	6.00	0.05
2.	2486	-05.000	82.090	4990	0,12,488	0.19	NA	NA	NA	NA
3.	2494	-04.000	83.190	3750	0,04,492	0.31	NA	NA	NA	NA
4.	2501	-04.000	84.000	4860	0,15,316	0.28	7.15	NA	NA	NA
5.	2513	-01.080	85.000	4600	0,02,434	0.23	6.77	NA	NA	NA
6.	2520	-01.125	87.020	4600	0,14,043	0.16	8.28	NA	NA	NA
7.	2528	-08.070	86.109	5200	1,10,792	0.56	21.83	NA	NA	NA
8.	2531	-07.012	88.155	5080	0,08,716	3.60	NA	NA	NA	NA
9.	2532	-06.001	88.090	5150	1,33,906	0.76	18.07	NA	NA	NA
10.	2533	-05.075	88.180	5030	1,14,682	0.50	NA	NA	NA	NA
11.	2535	-03.062	88.065	4820	0,22,205	0.53	11.29	NA	NA	NA
12.	2237	-01.059	88.095	4620	0,03,387	0.32	17.31	NA	NA	NA
13.	37	-13.500	73.999	5150	1,62,327	0.25	NA	NA	NA	NA
14.	56	-14.002	73.001	4389	0,59,708	0.37	18.07	3.0	NA	NA
15.	81	-12.490	77.011	5486	1,46,480	0.30	35.76	0.5	NA	NA
16.	99	-05.000	75.992	4920	0,09,821	0.22	6.02	2.0	0.19	0.05
17.	101	-07.027	76.002	5290	1,11,617	0.34	16.56	0.5	0.41	0.08
18.	150	-07.444	78.954	NA	1,01,227	0.43	15.5	2.0	0.29	0.07
19.	151	-07.489	78.014	NA	1,00,542	0.45	NA	1.0	0.35	0.08
20.	152	-07.021	76.980	NA	1,10,607	0.36	20.70	1.0	0.39	0.08
21.	153	-08.024	76.967	NA	1,35,943	0.22	22.98	3.0	0.39	0.08
22.	154	-07.067	79.500	NA	1,24,352	0.23	16.18	1.5	0.23	0.06
23 .	155	-07.004	78.495	NA	1,30,068	0.24	16.91	NA	0.41	0.07
24.	156	-07.067	79.500	NA	1,06,258	0.54	11.29	1.5	0.25	0.05
25.	157	-06.468	77.439	NA	1,23,820	0.31	12.68	2.0	0.36	0.07
26.	158	-06.506	78.945	NA	1,17,230	0.24	15.43	2.0	0.32	0.07
27.	199	-12.007	76.477	5450	1,30,800	0.52	26.08	11.5	1.33	0.07
28.	379	+01.089	74.670	2475	0,12,386	0.48	NA	NA	NA	NA
29.	105	-11.010	74.985	5022	2,44,943	0.38	NA	NA	NA	NA
30.	120	-13.006	72.984	4300	1,45,104	0.28	NA	32.5	5.44	0.04
31.	121	-12.007	73.003	5075	0,45,104	0.16	13.55	46.5	6.97	0.04
32.	124	-12.017	73.003	NA	0,27,810	0.36	12.04	61.5	7.42	0.04
33.	126	-12.017	72.016	NA	0,12,486	0.34	NA	NA	NA	NA
34.	127	-11.999	70.990	4750	0,08,486	0.26	3.01	87.0	10.6	0.02
35.	128	-11.969	75.465	5007	2,15,340	0.30	35.01	0.5	0.34	0.06
36.	129	-12.006	76.452	5100	2,32,706	0.20	33.5	3.0	0.37	0.07
37.	139	-11.514	81.490	NA	2,27,675	0.24	26.72	0.5	0.41	0.07
38.	183	-13.510	78.979	5388	0,28,926	0.42	NA	1.1	0.27	0.05
39.	206	-15.487	82.950	NA	0,18,061	0.38	15.15	24.0	3.16	0.05
40.	210	-15.487	82.950	5040	0,24,601	0.45	7.15	1.0	NA	NA
41.	231	-14.890	73.530	4900	0,48,070	0.42	22.21	11.5	2.06	0.05
42.	241	-15.500	72.991	4650	0,37,500	0.26	18.07	1.0	0.29	0.06

ND = Data not Available. * = Data after pattan *et al.* (m/s). $ = Data after Nath *et al.* (1989). #= Data on total carbon and @= data on total Nitrogen (after Jauhri, unpublished).

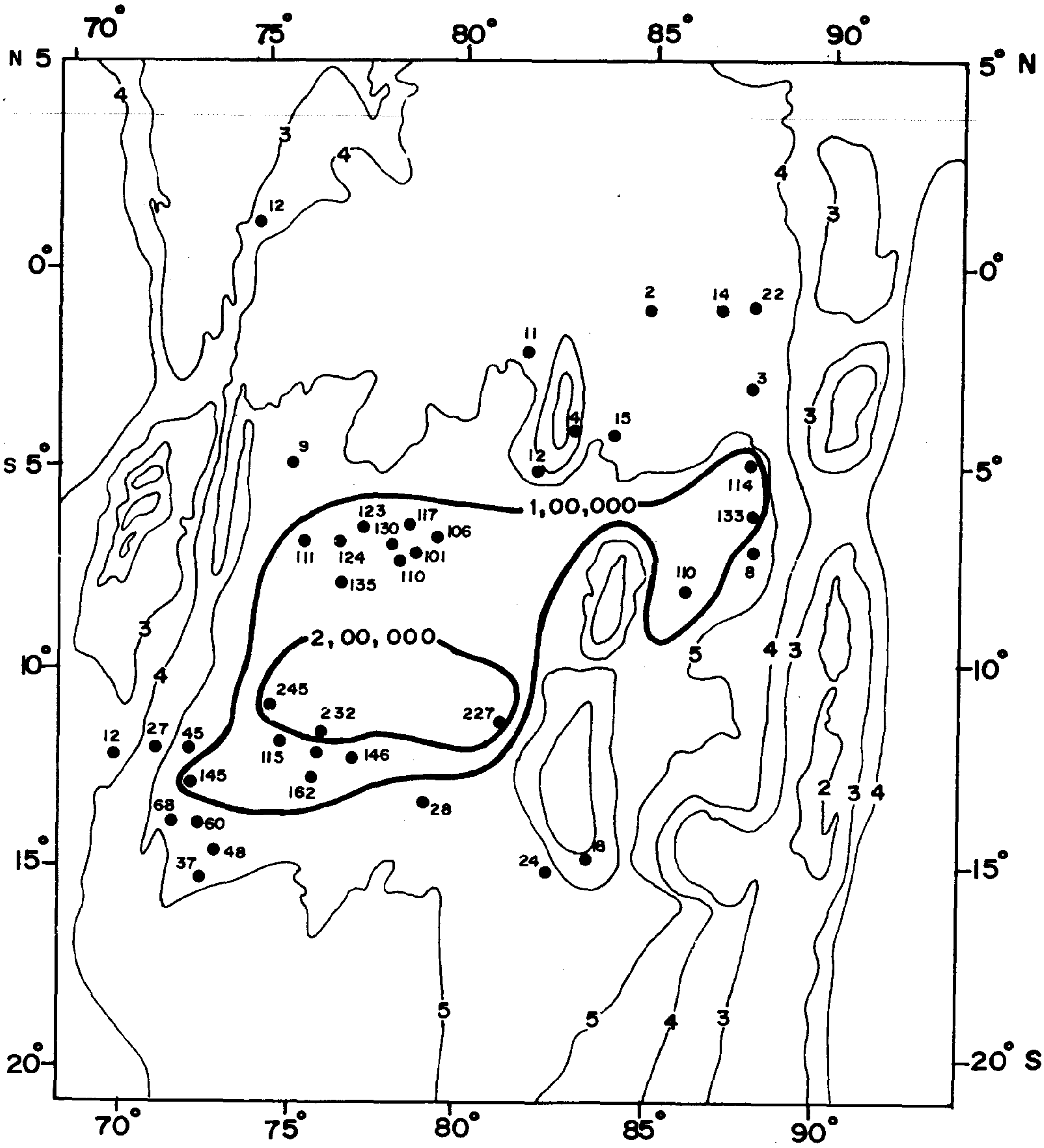

Figure 17. Distribution of radiolarians per gram of dry sediment (Rads/g) in the Basin. Contour interval at 1,00,000 numbers of Rads/g.

of radiolarians in the sediment due to the presence of dissolution resistant foraminifers like *Globorotalia menardi menardi, Globogerinid dutertrie* and their partially dissolved tests and keels contributing major weight in dry sediment (in present study). These locations fall within the depth range (3800-4800 m) of critical carbonate compensation depth (CCrD, Bramlette, 1961) and foraminiferal lysocline (Fl, the depth which separates well preserved foraminifera from noticeably dissolved foraminifera on the sea floor; Parker and Berger, 1971). Similarly, poor Rads/g is also observed at few locations in the western flank of the basin near 12^{0}S. In the eastern equatorial Indian Ocean region, especially in Wharton and Central Indian Basin, whole foraminiferal tests are absent in sediment below 4600 m and this level has been termed as foraminiferal compensation level (FCL, Adelseck, 1978; Cullen and Prell, 1984). FCL is somewhat shallower than the critical carbonate depth (CCrD), the depth at which <10% carbonate is present in surface sediment (Lisitzin and Peletin, 1967; Kolla *et al.* 1976a; Cullen and Prell, 1984). It is clear that lysocline, foraminiferal compensation level (FCL), critical carbonate compensation depth (CCrD), and carbonate compensation depth (CCD) seems to be responsible for the poor Rads/g values in the northern part of the basin.

Numbers of Rads/g sharply increases from 25,000 to more than 1,00,000 at near 7^0S and continues to increase up to 11^0S reaching at a maxima of 2,00,000 Rads/g. It decreases southward and values are lower than 50,000 Rads/g near 14^0S. Higher Rads/g between 7 to 14^0S could be related to the enrichment of radiolarians in unit weight sediment as foraminifers get dissolved below the CCD, as all the locations falling in this band are below CCD (>4800 m). Further decrease in rads/g sediment beyond 14^0S may be due to the fact that, though all the location between this band are also well below the CCD, the drastic decrease in rads/g may be either due to the poor primary productivity in surface water beyond the hydrographic front at 10^0S (as described in sections 3.2.4 and 3.2.6), or due to the influence of silica poor bottom water near mid-oceanic ridges, resulting into the dissolution of radiolarian tests in pelagic clay domain. For example beyond 14^0S Rads/g are lower than 50,000 Rads/g, though all the locations falling below 14^0S are at depth greater than CCD (>4800 m). Therefore, these locations should have greater number of Rads/g, as in case of the band between 7-11^0S. But on the contrary, Rads/g are very low. As SE Indian

Ocean Ridge and Chagos Ridge are considerably far off from these locations, possibility of silica deficient bottom water from these ridges causing dissolution of radiolarian tests could not be an appropriate reason for the poor numbers of Rads/g. The only option left and seems convincing is the poor primary productivity of surface water beyond hydrographic front at $10^{0}S$ (Figs. 12 g & h), causing lesser Rads/g in southern most part of the basin.

Nath *et al.* (1989) analyzed $CaCO_3$ content and Pattan *et al.* (mss.) analyzed biogenic silica in some of samples from the basin (Table 2). The data on $CaCO_3$ and biogenic silica from the common samples was plotted against the Rads/g. Interrelationships between Rads/g and $CaCO_3$ and biogenic silica are significant at 0.1 (90%) level of significance (Figs. 18 a, b, & c). Correlation coefficient of Rads/g dry sediment and water depth of the sample locations (r= 0.35) is moderately significant at 80 % (Fig. 18 d) level. It shows that the radiolarians are abundant and their preservation is better in greater depth especially below the carbonate compensation level. It also indicates that the depth of deposition is the main dominating factor for the richness of radiolarians in the pelagic sediment and radiolaria

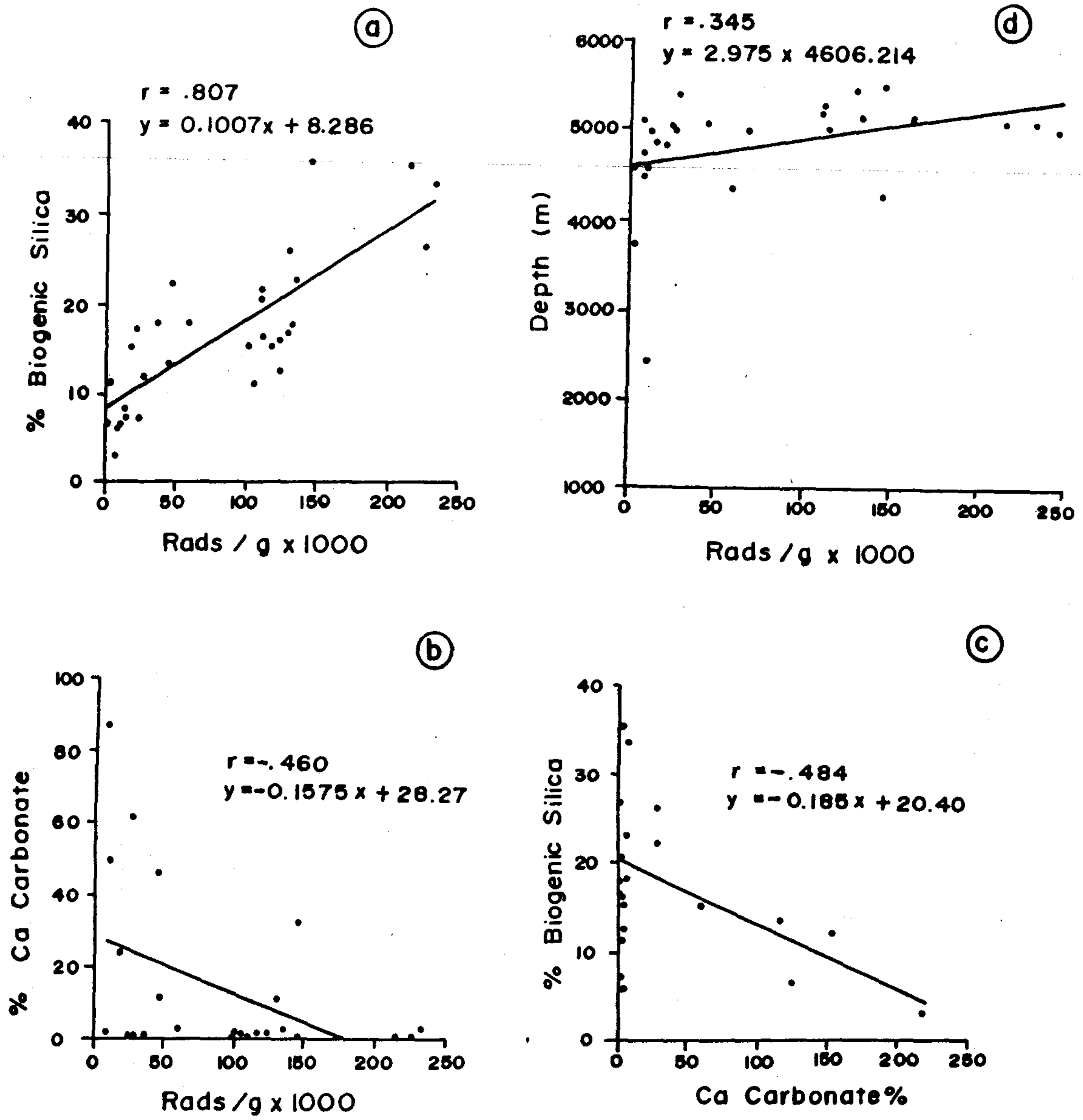

Figure 18. Interrelationships between (a) Rads/g vs biogenic silica, (b) Rads/g vs $CaCO_3$ (c) biogenic silica vs $CaCO_3$, and (d) Rads/g vs water depth in the Basin.

are chief contributor of biogenic silica in the basin.

In order to understand the post depositional effect on radiolarian test within the basin, total carbon and nitrogen contents (P. Jauhri, unpublished data) from these samples are plotted against Rads/g. The Rads/g shows directly proportional relationship (Fig. 19 a) with total nitrogen (r= 0.565) whereas relation is inverse with total carbon (Fig. 19 b; r= -.487). Total carbon and nitrogen (Fig. 19 c) are inversely related (r= -0.795) to each other. Correlation coefficient values are significant at 0.1 (99%) level of significance (Figs. 19 a, b, & c). Poor total carbon in the basin indicates that the basin is oxygenated and sedimentary organic carbon is oxidized. In what way total carbon and nitrogen are affecting on radiolarian test is not yet known. Nevertheless, it can be surmised that differential values of $CaCO_3$, total carbon and nitrogen may be resulting in differential dissolution in the basin (Pattan *et al.*, mss.). However, it is certain that they have a relationship which could be dealt separately in future.

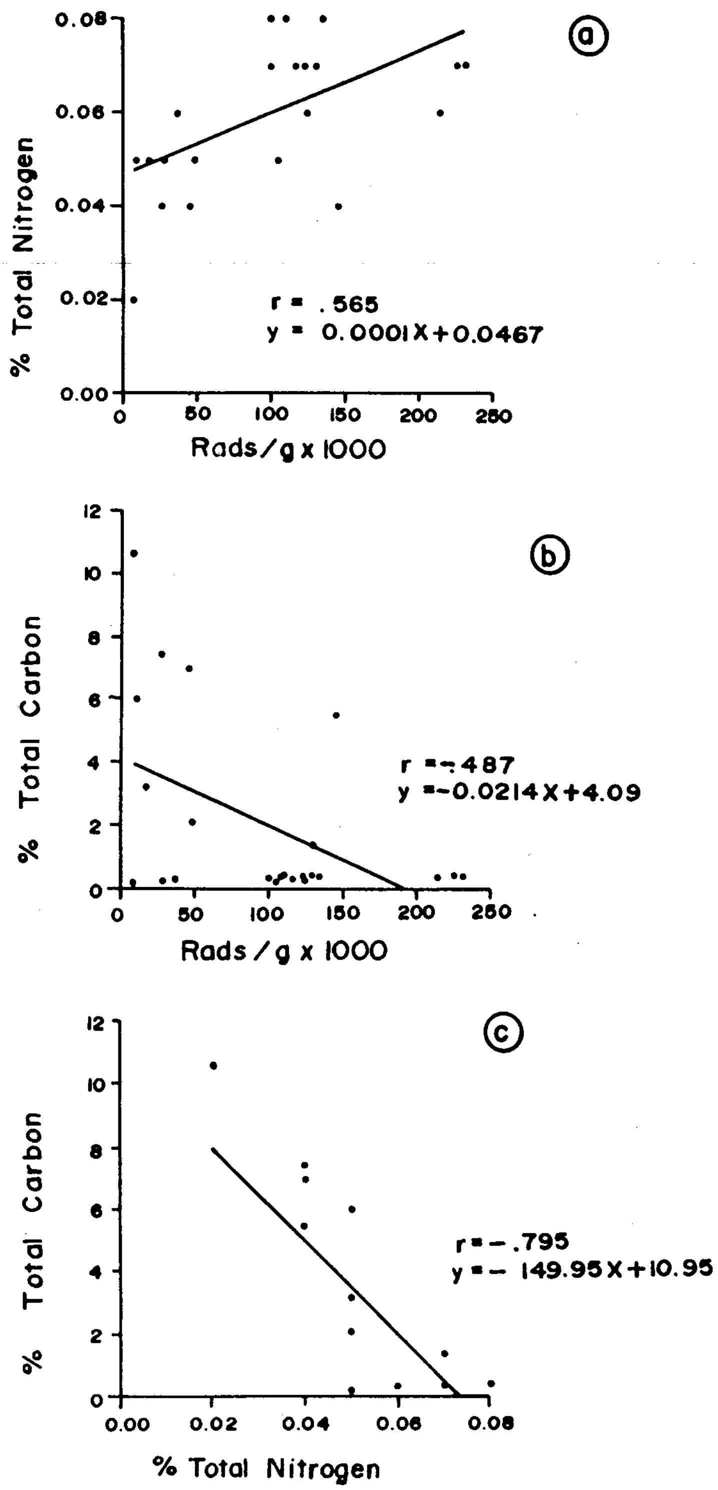

Figure 19. Interrelationships between (a) Rads/g vs total nitrogen, (b) Rads/g vs total carbon, and (c) total nitrogen and total carbon in the basin.

6.2 NASSELLARIAN VERSUS SPUMELLARIAN RATIO

Nassellarian versus Spumellarian (N/S) ratios are presented in Table 2. N/S ratio found in present study ranges from 0.1-0.7 (exception at sample no. 8 with 3.6 value) and is plotted as contour map and three dimensional views using SURFER program (Figs. 20 a, b, & c). Nassellarian and Spumellarian counts were plotted on X-Y plot (Fig. 21) and show high level of significance at 0.01 (99%; r= 0.8091). Takahashi (1981) found higher ratios in his sediment traps study (N/s ratio >1.0 to as high as 4.0). Takahashi compared higher N/S ratios with the ratios of Berger (1968a), Petrushevskaya (1971b), Berger and Sauter (1970), Kowsmann (1973), McMillen (1979) and found that the N/S ratio from radiolarian flux in the sediment traps is many fold higher than reported from the sediments. He attributed this anomaly to the poorer preservation of Nassellarians in the sediments than Spumellarians. Berger and Sauter (1970) found N/S ratio between 0.4-1.1 in their study of sediments off California and attributed to anaerobic environment of the California Basin. Takahashi's (1987) sediment trap data from PAPA site in the arctic region of northeast Pacific indicates similarly very high values of N/S ratio (average N/S 7.31). Blueford *et al.* (1990) also found high ratio (1.0-14.8) in the planktons from northeast Pacific.

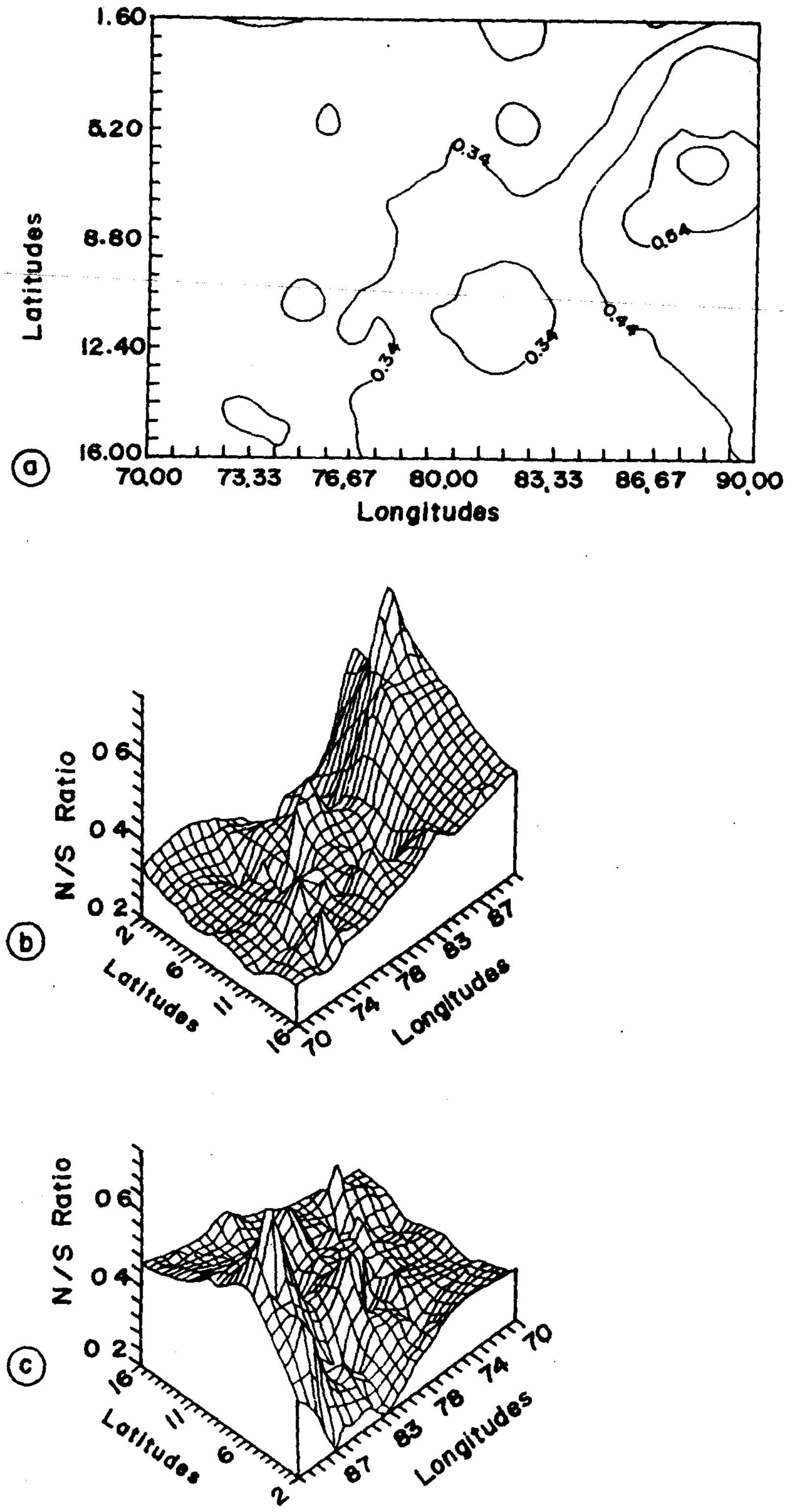

Figure 20. Computer generated (a) contour map of N/S ratio using SURFER and its three dimensional perspective at (b) 225/45^0, and (c) 45/45^0 rotation. Note high ratios in central eastern part of the basin.

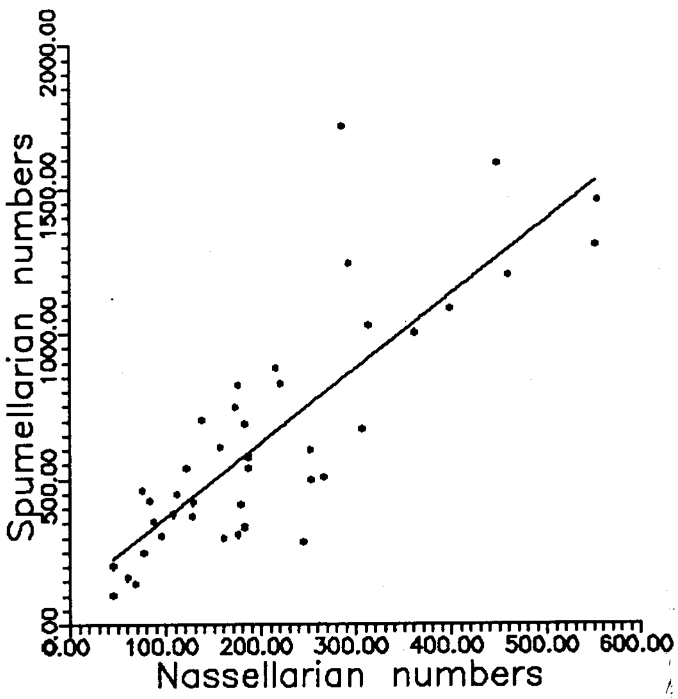

Figure 21. X-Y correlation plot of numbers of Nassellarian and Spumellarians in the samples showing positive correlation (r value 0.8091).

It seems the plankton production of Nassellarians is many fold higher than their preservation in the sediment. No such studies are conducted from the Indian Ocean so far. Future studies on sediment trap and plankton tows may give better insight on this matter. Nevertheless, lower N/S ratios in present study may be related to the oxygenated sea floor as the basin receives oxygen rich (4 ml/l) antarctic bottom water as discussed in section 3.2.3. The differential ratio within the basin may be due to the differential values of total carbon, nitrogen, $CaCO_3$, silica and oxygen contents in the sediment within the basin.

6.3 RADIOLARIAN DIVERSITY IN THE SURFACE SEDIMENTS

All the radiolarian species encountered in present study are identified according to their recent species concept. Besides, a number of species which were hither to unreported from this region were also identified and illustrated, irrespective of their relative abundance, to form a comprehensive report of radiolarian occurrences from this region. Therefore, it will be appropriate to mention here the radiolarian species encountered from the surface sediments by the earlier researchers from the Indian Ocean. First of all Nigrini (1967) identified 45 species in 32 surface sediment samples from the

Indian and Atlantic Oceans, out of which only four samples were from the Central Indian Basin. Petrushevskaya (1967) identified 75 radiolarian species mainly from the Antarctic sector of the Indian Ocean. Lozano and Hays (1976) identified twenty-seven species from the southern Indian Ocean. Dow (1978) recognized 49 species in southeastern Indian Ocean. Johnson and Nigrini (1980, 1982) identified and documented the presence of 74 radiolarian species from the surface sediment of the Indian Ocean. Morley (1989a) quantified the data of 42 radiolarian species for developing the transfer function. Recently Sharma and Mahapatra (1990) have reported 92 species from 22 sediment samples from the Indian Ocean, out of which only eight samples were from the Central Indian Basin. All the species reported from the Indian Ocean are alphabetically listed below along with first letters of the earlier workers [N= Nigrini, (1967), LH= Lozano and Hays (1976), D= Dow (1978), JN= Johnson and Nigrini (1980,1982), Morley (1989a), SM= Sharma and Mahapatra (1990)].

List of species earlier reported from the Indian Ocean. Asterisk marked species (24 species) are not found in present study.

1. *Acanthosphaera tenuissima* Haeckel D.

2. *Acrosphaera flammabunda* (Haeckel) N., JN.

3. *Acrosphaera lappacea* (Haeckel) N., JN., M.

4. *Acrosphaera murrayana* (Haeckel) SM.

5. *Acrosphaera spinosa* (Haeckel) N., JN., M., SM.

6. **Acrosphaera spinosa echinoides* (Haeckel) SM.

7. *Acrosphaera transformata* (Hilmers) SM.

8. *Actinomma spp.* D.

9. *Actinomma arcadophorum* Haeckel N., JN., SM.

10. **Actinomma antarcticum* (Haeckel) N., D., JN., M., SM.

11. **Actinomma leptodermum* (Jorgensen) SM.

12. **Actinomma medianum* Nigrini N., JN., M., SM.

13. *Amphirhopalum cf. Tessarastrum straussii* (Haeckel) JN.

14. *Amphirhopalum ypsilon* Haeckel N., JN., G., SM.

15. *Amphipyris costata* Haeckel N.

16. *Anomalocantha dentata* (Mast) D., JN., M.

17. **Androcyclas gamphonycha* (Jorgensen) LH, D., JN., M.

18. **Antarctissa denticulata* (Ehrenberg) LH, D., M.

19. **Antarctissa strelkovi* Petrushevskaya LH, D., M.

20. **Antartissa spp.* JN.

21. *Anthocyrtidium ophirense* (Ehrenberg) N., LH, D., JN., M., SM.

22. *Anthocyrtidium zangebaricum* (Ehrenberg) N., JN., SM.

23. *Axoprunum stauraxonium* Haeckel SM.

24. *Botryocyrtis scutum* (Harting) N., JN., SM.

25. *Botryopyle sp.* D.

26. *Botryostrobus aquilonarius* (Bailey) D, JN., M., SM.

27. *Botryostrobus auritus /australis* (Ehrenberg) JN., SM.

28. *Buccinosphaera invaginata (=C. invaginata)* (Haeckel) JN.

29. *Carpocanistrum spp.* JN., M.

30. *Carpocanarium sp.* D., SM.

31. *Carpocanarium papillosum* (Ehrenberg) group JN., SM.

32. *Cenosphaera sp.* SM.

33. *Cenosphaera coronata* Haeckel D.

34. *Cenosphaera cristata* Haeckel D., SM.

35. **Centrobotrys thermophila* Petrushevskaya N, JN.

36. *Centrolonche cf. C. hexalonche* Popofsky SM.

37. *Ceratospyris sp.* N.,

38. *Ceratospyris borealis* Bailey SM.

39. *Cladococus abietinus* Haeckel SM.

40. *Clathrocanium diadema* Haeckel SM.

41. *Collosphaera sp. aff. C. huxleyi* Muller SM.

42. *Collosphaera sp. cf. C. huxleyi* Muller JN.

43. *Collosphaera huxleyi* Muller JN., SM.

44. *Collosphaera macropora* Popofsky JN., SM.

45. *Collosphaera tuberosa* (Haeckel) JN., M., SM.

46. *Cornutella profunda* Ehrenberg N., JN., SM.

47. **Cubotholus sp.* SM.

48. *Cycladophora davisiana* Ehrenberg D., LH.

49. *Cypassis irregularis* (Haeckel) JN.

50. *Dictyocryphalus papillosus* (Ehrenberg) N.

51. *Dictyocoryne profunda* Ehrenberg JN.

52. *Dictyocoryne truncatum* (Ehrenberg) JN., SM.

53. *Dictyophimus crisae* Ehrenberg N., JN.

54. **Dictyophimus infabricatus* Nigrini D.

55. *Disolenia quadrata* (Ehrenberg) N., JN., M.

56. *Disolenia zanguebarica* (Ehrenberg) N., JN., M.

57. *Didymocyrtis tetrathalmus* (Haeckel) N., LH, D.
JN. M.

58. **Echinomma leptodermum* D.

59. **Echinomma delicatulum* D.

60. **Ellipsostylus sp.* SM.

61. *Euchitonia sp.* N., D.

62. *Euchitonia elegans* (Ehrenberg) N., JN., M.

33. *Euchitonia furcata* (Ehrenberg) N., JN., M., SM.

64. *Eucyrtidium acuminatum* (Ehrenberg) N., LH,D.,
JN., M.

65. **Eucyrtidium calvertense* D.

66. *Eucyrtidium hexagonatum* Haeckel N., JN.

67. *Giraffospyris angulata* (Haeckel) SM.

68. *Heliodiscus asteriscus* Haeckel N., LH, D., JN., M., SM.

69. *Heliodiscus echiniscus* Haeckel N., JN., SM.

70. *Helotholus histricosa* Jorgensen D.

71. *Hexacontium sp.* SM.

72. *Hexacontium cf. heteracantha* (Popofsky) LH

73. *Hexacontium laevigatum* Haeckel D.

74. *Hexapyle sp.* SM.

75. *Hymeniastrum euclidis* Haeckel JN., SM.

76. *Lamprocyclas maritalis maritalis* Haeckel N., LH, D., JN., M., SM.

77. *Lamprocyclas maritalis polypora* Nigrini N., LH, JN., M.

78. *Lamprocyclas maritalis ventricosa* Nigrini N., JN.

79. *Lamprocyrtis (?) hannai* (Campbell and Clark) JN.

80. *Lamprocyrtis nigriniae* (Caulet) JN., G., SM.

81. *Larcopyle butschlii* Dreyer D., SM.

82. *Larcospira quadrangula* Haeckel JN., M., SM.

83. *Liriospyris reticulata* (Ehrenberg) N., JN., M., SM.

84. *Lithelius minor* (Jorgensen) LH, D., M., SM.

85. *Lithelius nautiloides* Popofsky LH, D., M., SM.

86. *Lithocampe spp.* N., LH, JN., M.

87. *Lithopera bacca* Ehrenberg N., JN., G., M., SM.

88. **Lithostrobus seriatus* D.,

89. *Lophophaena cf. L. capito* Ehrenberg SM.

90. *Lophophaena cylindrica* (Cleve) SM.

91. *Lophospyris pentagona pentagona* (Ehrenberg) JN., SM.

92. *Octopyle stenozona* Haeckel SM.

93. *Ommatodiscus spp.* LH, D., M.

94. *Otosphaera auriculata* N., JN.

95. *Otosphaera polymorpha* N.

96. *Peridium spinipes* Haeckel SM.

97. *Peripyramis circumtexta* Haeckel SM.

98. *Peromelissa phalacra* Haeckel SM.

99. **Phormospyris stabilis antarctica* (Haecker) JN., SM.

100. *Phormospyris stabilis scaphipes* (Haeckel) SM.

101. *Phormostichoartus corbula* (Harting) N., JN., SM.

102. *Phorticium pylonium* (Haeckel) D., LH.

103. *Phorticium clevei* D.

104. *Porodiscus sp. A, B* SM.

105. *Pseudodictyophimus gracilipes* (Bailey) SM.

106. *Pterocanium sp.* JN.

107. *Pterocanium praetextum eucolpum* Haeckel N., JN., M., SM.

108. *Pterocanium praetextum praetextum* (Ehrenberg) N., LH, D. JN., M., SM.

109. *Pterocanium trilobum* (Haeckel) N., D., JN., SM.

110. *Pteocorys hirundo* D.

111. *Pterocorys hertwigii* (Haeckel) JN.

112. *Pterocorys sabae* (Ehrenberg) JN., SM.

113. *Pylospira cf. p. octapyle* Haeckel SM.

114. **Saccospyris conithorax* Haecker JN.,

115. *Saturnalis circularis* Haeckel N., JN., SM.

116. *Siphocampe sp.* LH.

117. *Siphocampe lineata* group (Ehrenberg) JN., SM.

118. *Siphonosphaera polysiphonia* Haeckel N., JN., M.,SM.

119.**Spirema melonia* D.

120. *Spirocyrtis scaleris* Haeckel N., JN.

121. *Spongaster tetras irregularis* Nigrini N., JN., SM.

122. *Spongaster tetras tetras* Ehrenberg N., JN., M., SM.

123. *Spongobrachium sp.* Haeckel JN., SM.

124. *Spongocore puella (=cylindrica)* Haeckel JN., M., SM.

125.**Spongoplegma antarcticum* Haeckel LH.

126. *Spongopyle osculosa* Dreyer LH, D., M.

127. *Spongotrochus glacialis* Popofsky LH, D., M., SM.

128. *Spongotrochus (?) venustrum* (Bailey) SM.

129. *Spongurus (?) sp.* SM.

130. *Spongurus cf. elliptica* (Ehrenberg) JN.

131. *Spongurus polymaticus* Riedel LH, D., JN., M.

132. *Staurolonch sp.* SM.

133. *Stylatractus sp.* D., SM.

134. *Stylochlamydium asteriscus* Haeckel D., SM.

135. *Stylodictya validispina* Jorgensen D., SM.

136. *Styptosphaera (?) spumacea* JN.

137. *Tetrapyle octacantha* Muller LH, D., SM.

138. *Thecosphaera inermis* (?) (Haeckel) SM.

139. *Theocalyptra bicornis* (Popofsky) D., JN., M.

140. *Theocalyptra cf. T. bicornis* (Popofsky) SM.

141. *Theocalyptra (?) bicornis* (Popofsky) LH.

142. *Theocorythium trachelium dianae* (Haeckel) N., JN., M., SM.

143. *Theocorythium trachelium trachelium* (Ehrenberg) N., LH, D., JN., M., SM.

144. *Theoconus hertwigii* (Haeckel) N., LH.

145. *Theoconus zancleus* (Muller) D., M.

146.**Theopilium tricoastratum* Haeckel SM.

147. *Tholospyris sp.* SM.

148. *Tholospira cervicornis* Haeckel SM.

149. *Tholospyris fornicata (=A. ramosa)* Popofsky SM.

150.**Tholospyris procera* Goll SM.

151.**Triceraspyris antarctica* (Haecker) D., LH, M.

152.**Triceraspyris damaecornis* Haeckel N.

153. *Trigonastrum sp.* JN.

154. *Trisolenia megalactis megalactis* (Ehrenberg) SM.

155. *Zygocircus capulosus* Popofsky SM.

156. *Zygocircus productus* (Hertwig) SM.

Out of the above 156 species, reported by earlier workers, only 132 are found in present study which are dealt in the Chapter 5 for the synonyms. Following are the species **encountered for the first time from the Indian Ocean** during present study **from the Central Indian Basin.**

133. *Acanthosphaera castanea* Haeckel
134. *Acanthosphaera simplex* (Haeckel)
135. *Acrosphaera collina* Haeckel
136. *Acrosphaera cyrtodon* (Haeckel)
137. *Acrosphaera spinosa pseudoarktios* Caulet
138. *Actinosphaera acanthophora* (Popofsky)
139. *Actinosphaera capillacea* (Haeckel)
140. *Actinosphaera tenella* (Haeckel)
141. *Amphisphaera* sp. Haeckel
142. *Arachnosphaera myriacantha* Haeckel
143. *Archipilium sp.* (Haeckel)
144. *Astrosphaera hexagonalis* Haeckel
145. *Bathropyramis ramosa* Haeckel
146. *Callimitra annae* Haeckel
147. *Callimitra emmae* Haeckel

148. *Carpocaniastrum acutidentatum* Takahashi

149. *Carpocaniastrum cephalum* Haeckel

150. *Carpocaniastrum coronatum* (Ehrenberg)

151. *Carpocaniastrum favosum* (Haeckel)

152. *Centrocubus cladostylus* Haeckel

153 *Centrocubus octastylus* Haeckel

154. *Circodiscus microporus* (Stohr)

155. *Cladococcus cervicornis* Haeckel

156. *Cladococcus viminalis* Haeckel

157. *Cladococcus scoparius* Haeckel

158. *Clathrocanium coarctatum* Ehrenberg

159. *Clathrocorys giltschii* Haeckel

160. *Clathrocyclas cassiopejae* Haeckel

161. *Clathrocyclas cf. C. cassiopejae* Haeckel

162. *Clathrocyclas monumentum* (Haeckel)

163. *Clathromitra pterophormis* Haeckel

164. *Collosphaera armata* Brandt

165. *Collosphaera confossa* Takahashi

166. *Collosphaera desaii* Sp. Nov.

167 *Conarachnium polycanthum* (Popofsky)

168. *Conarachnium parabolicum* (Popofsky)

169. *Corocalyptra cervus* (Ehrenberg)

170. *Cromyomma villosum* Haeckel

171. *Cromyechinus sp.* Haeckel

172. *Cromyechinus sp. aff. C. borealis* (Cleve)

173. *Cycladophora bicornis klingi* Lobmari and Lazarus

174. *Cyrtopera aglaolampa* Takahashi

175. *Cyrtopera languncula* Haeckel

176. *Dictyocodon elegans* (Haeckel)

177. *Dictyospyris sp.* Ehrenberg

178. *Disolenia sp* A. Takahashi.

179. *Discopyle elliptica* Haeckel

180. *Druppatractus ostracion* Haeckel

181. *Elatomma penicillus* Haeckel

182. *Elatomma pinetum* Haeckel

183. *Ellipsoxiphium palliatum* Haecker

184. *Eucecryphalus europae* (Haeckel)

185. *Eucecryphalus gegenbauri* Haeckel

186. *Eucecryphalus sestrodiscus* (Haeckel)

187. *Eucecryphalus tricostatus* (Haeckel)

188. *Eucyrtidium dictyopodium* (Haeckel)

189. *Eucyrtidium punctatum* (Ehrenberg)

190. *Eucyrtidium sp. aff. E. anomalum* (Haeckel)

191. *Gonosphaera primordialis* Jorgensen

192. *Haliomma sp.* Haeckel

193. *Heliosoma sp. aff. H. radians* Haeckel

194. *Heliosphaera radiata* Popofsky

195. *Hexacontium amphisiphon* Haeckel

196. *Hexacontium axotrias* Haeckel

197. *Hexacontium heracliti* (Haeckel)

198. *Hexacontium hostile* Cleve

199. *Hexacontium sp. aff. H. hostile* Cleve

200. *Hexacontium hystricina* (Haeckel)

201. *Hexacromyum elegans* Haeckel

202. *Lampromitra schultzei* (Haeckel)

203. *Lampromitra cachoni* Petrushevskaya

204. *Lipmanella dictyoceras* (Haeckel)

205. *Lipmanella pyramidale* (Popofsky)

206. *Lipmanella virchowii* (Haeckel)

207. *Litharachnium eupilium* (Haeckel)

208. *Litharachnium tentorium* Haeckel

209. *Lithomelissa setosa* Jorgensen

210. *Lophophaena decacantha* (Haeckel)

211. *Lophospyris pentagona hyperborea* (Jorgensen)

212. *Lophospyris cheni* Goll

213. *Lychnosphaera regina* Haeckel

214. *Nephrospyris renilla renilla* Haeckel

215. *Nephrospyris renilla lana* Goll

216. *Neosemantis distaphanus* Popofsky

217. *Plegmosphaera sp.* Haeckel

218. *Plegmosphaera coelipila* Haeckel

219. *Plegmosphaera entodictyon* Haeckel

220. *Plegmosphaera pachypila* Haeckel

221. *Phormacantha hystrix* Jorgensen

222. *Phormospyris stabilis capoi* Goll

223. *Plectopyramis dodecoma* Haeckel

224. *Pterocorys macroceras* (Popofsky)

225. *Pterocorys longicollis* Caulet

226. *Siphonosphaera magnisphaera* Takahashi

227. *Spongosphaera polycantha* Muller

228. *Spongosphaera sp. aff S. heliodes* Haeckel

229. *Sphaeropyle mespilus* Dreyer

230. *Stylosphaera melpomene* Haeckel

231. *Stylodictya multispina* Haeckel

232. *Spongodiscus resurgense* Ehrenberg

233. *Spongodiscus biconcavus* Haeckel

234. *Sethoconus myxobranchia* Strelkov and Reschetnyak

235. *Sethoconus sp. aff. S. myxobranchia* Strelkov and Reschetnyak

236. *Sphaeropyle meslipus* Dreyer

237. *Spirocyrtis gyroscalaris* Nigrini

238. *Siphocampe nodosaria* (Haeckel)

239. *Siphocampe arachnea* (Ehrenberg)

240. *Stichopilium bicorne* Haeckel

241. *Thecosphaera capillacea* Haeckel

242. *Tholoma metallasson* Haeckel

243. *Tholospyris baconiana baconiana* (Haeckel)

244. *Tholospyris baconiana variabilis* Goll

245. *Tetraphormis dodecaster* (Haeckel)

246. *Tetraphormis butschlii* (Haeckel)

247. *Theophormis callipilium* Haeckel

248. *Tetracorethra tetracorethra* (Haeckel)

249. *Xiphatractus sp. B* Takahashi

250. *Zygocircus sp. cf. Z. piscicaudatus* Popofsky

6.4 RELATIVE ABUNDANCE (%) OF MORPHO-GROUPS

As a total of 250 radiolarian species with a diversity in their morphology are encountered in present study, it was very difficult to generate census data of each and every individual species from 42 samples in the limited time. Therefore 47 morphogroups having morphological similarities at generic, generic-pair group, and subfamily level are frame worked using coarser taxonomy (as described in section 5.2) for the counting in the randomly settled slides. The percentage of forty-seven coarser morphogroups are presented in Table 3 along with total specimen counted in each sample in the last column.

TABLE 3

Percentage of 47 radiolarian morphogroups in 42 surface sediment samples from the Central Indian Basin. tab. cont.

SN	Sample	1	2	3	4	5	6	7	8	9	10	11	12
		RADIOLARIAN MORPHO-GROUPS											
1	2483	7.22	2.71	3.11	5.52	1.40	0.30	16.20	0.70	3.70	3.60	3.90	0.00
2	2486	3.30	2.76	1.57	1.37	0.39	0.18	08.34	0.00	3.73	3.92	2.55	0.00
3	2494	2.76	4.29	1.22	1.84	0.61	0.00	06.13	0.00	1.84	2.45	0.00	0.00
4	2501	2.66	0.81	1.23	2.45	1.64	1.02	26.60	1.02	5.12	4.09	6.15	0.00
5	2513	2.28	0.87	1.73	1.73	0.21	1.19	23.34	1.52	5.86	3.04	1.41	0.00
6	2520	6.69	2.04	1.67	0.18	0.00	0.00	31.59	2.23	4.83	1.67	2.60	0.56
7	2528	6.80	5.97	1.44	0.82	0.20	0.00	04.94	0.41	1.03	0.41	0.61	0.00
8	2531	9.57	4.21	1.14	0.00	1.14	0.38	07.66	0.00	3.06	1.91	0.00	0.38
9	2532	3.32	2.45	0.87	0.52	0.87	0.00	05.95	0.00	1.57	3.15	1.57	0.00
10	2533	6.00	1.60	2.40	1.33	0.66	0.92	14.93	1.86	4.13	4.80	1.46	0.00
11	2535	4.39	4.81	1.96	0.65	1.53	0.21	09.40	0.00	2.18	0.43	0.43	0.00
12	2537	5.24	1.31	3.28	1.18	1.04	0.54	14.43	0.13	6.56	2.49	0.65	0.00
13	37	7.17	4.95	2.34	0.91	0.00	0.26	05.73	0.00	2.86	2.99	3.52	0.00
14	59	6.27	0.89	2.69	0.89	0.00	0.45	06.72	0.00	2.24	3.13	4.03	0.00
15	81	5.82	5.64	2.91	0.36	0.00	0.36	05.82	0.54	1.45	1.63	0.54	0.00
16	99	3.22	0.80	1.61	0.40	0.00	0.00	17.79	0.40	4.00	2.82	6.85	0.00
17	101	6.00	1.60	2.20	0.40	0.60	1.00	00.80	0.60	1.00	4.80	8.40	0.00
18	150	4.06	2.03	3.21	0.84	0.84	0.38	07.78	0.17	2.53	3.38	2.53	0.00
19	151	3.88	3.77	4.49	1.32	0.00	0.00	10.21	0.51	3.88	2.96	3.98	0.00
20	152	7.69	3.37	3.29	1.24	0.58	0.29	09.60	0.36	2.78	1.68	1.90	0.29
21	153	8.77	6.05	4.23	2.72	2.42	0.90	03.93	0.00	0.75	2.11	2.72	0.15
22	154	3.39	1.10	2.28	0.85	2.41	0.45	08.34	0.78	3.39	5.91	4.24	0.45
23	155	7.82	1.77	3.38	0.35	1.24	0.53	06.93	0.71	0.71	1.24	2.84	0.17
24	156	5.98	3.86	3.28	0.57	1.54	0.77	09.82	0.19	1.35	1.93	3.47	0.19
25	157	3.73	3.23	2.48	0.49	1.24	0.74	10.69	0.00	2.48	2.23	3.48	0.00
26	158	2.92	2.25	2.02	0.67	2.70	0.45	09.90	0.22	3.60	2.02	4.50	0.00
27	199	6.99	5.56	3.86	0.90	2.20	0.51	02.20	0.00	0.26	0.26	2.33	0.00
28	379	2.85	2.38	1.42	0.00	0.95	0.00	03.80	2.85	2.38	2.38	0.48	0.00
29	105	6.90	3.62	4.46	1.68	1.43	0.45	03.02	0.99	1.88	2.68	4.46	0.84
30	120	4.17	3.33	3.92	0.83	1.47	0.34	05.25	0.02	2.16	1.81	2.30	0.14
31	121	6.84	1.74	2.64	1.54	2.34	0.89	05.34	0.14	3.29	3.14	2.69	0.00
32	124	3.91	2.76	1.88	0.40	0.20	0.47	05.66	0.00	1.61	0.94	1.21	0.06
33	126	0.55	0.41	0.55	0.00	0.13	0.55	16.41	0.00	2.34	2.48	3.03	0.00
34	127	4.67	2.95	1.81	0.76	1.24	0.09	09.92	0.09	2.95	2.19	3.05	0.28
35	128	6.11	4.47	2.38	1.64	1.71	0.74	05.14	0.22	2.16	1.93	2.01	0.00
36	129	3.69	2.26	1.78	1.19	3.21	0.95	01.30	0.11	1.78	3.33	4.16	0.00
37	139	5.01	1.91	2.64	1.18	2.18	0.54	03.73	0.45	1.73	2.00	4.64	0.18
38	183	2.34	1.29	1.17	0.94	2.46	0.58	04.69	0.70	1.87	0.93	3.28	0.11
39	206	4.87	1.98	2.88	1.14	2.34	0.12	02.64	0.18	1.08	0.90	2.04	0.00
40	210	0.00	0.00	1.36	0.68	0.00	0.00	04.79	0.00	0.68	1.36	2.05	0.00
41	231	2.64	1.45	2.10	0.64	0.80	0.16	05.01	0.10	1.77	0.91	2.04	0.00
42	241	1.72	0.68	1.26	0.68	1.37	0.22	05.97	0.22	3.21	2.98	4.13	0.00

Morphogroups

1. Collosphaera
2. Desolenia-Siphonosphaera
3. Acrosphaera
4. Actinomma
5. Plegmosphaera
6. Styptosphaera
7. Spongodiscids
8. Cladococcus
9. Spongaster-Spongocore
10. Elatomma-Haliomma
11. Hexacontium
12. Amphirhopalum

Table 3 Contd. ....

SN	Sample	13	14	15	16	17	18	19	20	21	22	23
		RADIOLARIAN MORPHO-GROUPS										
1	2483	12.50	05.70	04.80	1.00	1.20	05.50	01.40	1.90	0.40	0.60	0.20
2	2486	17.68	12.77	3.92	1.18	4.32	11.79	00.78	2.35	0.39	0.78	0.00
3	2494	18.71	13.50	02.76	0.61	2.76	13.80	00.00	3.06	0.00	0.92	0.00
4	2501	02.46	09.42	02.46	2.46	0.00	03.07	02.25	3.07	0.40	0.61	0.00
5	2513	07.49	09.01	08.79	2.28	1.08	04.99	02.39	2.06	0.21	0.32	0.00
6	2520	07.99	10.22	05.01	1.30	0.18	03.16	00.92	3.15	0.18	0.18	0.18
7	2528	12.16	10.92	03.30	0.20	1.23	10.10	02.26	1.03	1.65	3.30	1.03
8	2531	21.07	13.79	06.89	1.91	1.53	01.91	01.53	0.76	0.00	0.76	0.76
9	2532	02.62	07.18	08.75	0.35	0.87	11.90	01.92	3.15	1.22	0.52	0.70
10	2533	05.20	06.93	04.13	2.00	1.06	03.33	01.06	3.33	0.30	1.86	0.80
11	2535	08.75	07.87	08.31	1.09	1.53	08.31	01.75	1.31	1.09	2.18	0.65
12	2537	09.18	11.67	05.90	1.96	2.62	03.41	01.04	2.88	0.52	0.91	0.39
13	37	05.34	02.60	12.12	1.04	2.73	18.90	05.35	0.78	0.65	1.30	0.78
14	59	01.79	04.93	16.59	0.89	4.93	02.69	12.55	1.34	0.00	1.79	0.00
15	81	05.28	03.46	08.19	1.63	3.46	22.95	05.82	0.72	0.36	1.82	1.09
16	99	05.64	09.67	05.24	0.00	6.45	12.09	00.80	4.03	0.00	1.61	0.80
17	101	02.40	02.00	09.00	1.00	2.40	24.68	03.80	2.00	0.00	1.20	0.20
18	150	03.89	04.56	09.64	1.01	2.03	15.23	04.23	1.52	0.50	1.86	1.86
19	151	06.74	06.84	08.17	1.63	2.45	05.00	01.12	1.73	0.20	0.71	1.22
20	152	09.16	08.35	07.33	0.80	3.22	09.16	02.05	0.29	0.73	2.63	0.14
21	153	03.47	03.78	16.03	0.90	1.81	17.09	03.47	0.30	0.45	1.21	0.00
22	154	07.37	07.69	11.61	1.95	3.19	12.13	02.02	1.82	0.06	0.52	0.06
23	155	11.74	09.25	13.35	1.60	3.55	09.78	02.66	0.53	0.17	1.06	0.35
24	156	03.66	03.47	13.70	0.77	2.89	10.03	01.73	0.57	0.19	0.77	0.19
25	157	06.96	09.20	08.20	1.49	2.98	11.69	04.47	0.49	0.49	0.99	1.24
26	158	11.93	12.83	09.23	1.12	3.60	08.55	01.57	0.22	0.00	0.00	0.22
27	199	07.64	04.79	07.51	1.16	1.42	11.91	04.01	1.94	0.12	1.29	0.26
28	379	09.52	10.47	11.90	0.00	1.90	11.90	02.38	0.00	1.90	0.00	0.47
29	105	05.61	04.61	14.51	2.08	2.97	07.05	02.38	0.74	0.09	0.84	0.01
30	120	05.89	04.76	13.75	1.91	2.79	19.54	02.45	0.78	0.24	1.27	0.09
31	121	09.39	09.14	14.68	1.99	3.99	11.88	03.59	0.39	0.64	1.09	0.25
32	124	10.45	10.85	12.33	1.95	3.77	12.67	01.28	0.67	0.60	1.68	0.20
33	126	03.86	09.37	10.89	0.68	0.96	16.96	03.31	1.79	0.27	0.82	0.00
34	127	07.63	08.20	11.35	1.90	1.33	15.26	02.67	0.57	0.00	0.19	0.19
35	128	08.79	06.26	13.79	0.89	2.01	14.16	01.41	0.74	0.44	1.11	0.14
36	129	08.92	04.76	19.52	1.90	2.02	18.09	03.92	0.71	0.11	0.11	0.00
37	139	06.01	06.92	16.77	0.91	1.36	17.77	02.82	1.54	0.09	0.72	0.00
38	183	06.22	09.85	15.25	1.87	1.17	12.44	02.34	0.82	0.23	0.58	0.35
39	206	07.28	09.33	15.95	0.96	2.58	12.34	01.86	1.80	0.54	1.38	0.18
40	210	06.16	08.90	19.17	0.68	1.36	08.90	04.10	4.79	0.00	1.36	0.68
41	231	06.63	08.24	15.25	1.61	3.39	13.80	02.10	1.50	0.37	2.15	0.26
42	241	04.24	07.69	18.14	1.49	4.82	17.22	02.52	0.45	0.34	0.57	0.00

Morpho-groups :

13. Euchitoniids
14. Stylodicta-Stylochlamydium
15. Artiscins (Didymocyrtis)
16. Heliodiscus
17. Litheliids
18. Pyloniids (Tetra, Octa, Hexapyle)
19. Larcospira
20. Stylosphaera
21. Plagiacnthins
22. Lophophaenins
23. Sethoperinids

Table 3 Contd. .....

SN	Sample	24	25	26	27	28	29	30	31	32	33	34	35
		RADIOLARIA MORPHO-GROUPS											
1	2483	1.20	4.00	0.30	0.70	0.00	0.40	0.10	0.00	2.60	0.30	0.00	0.10
2	2486	2.35	5.50	0.39	0.98	0.00	0.00	0.00	0.19	0.59	0.39	0.19	0.39
3	2494	3.68	5.83	0.30	2.14	0.92	0.30	0.00	0.30	1.84	0.00	0.61	0.00
4	2501	2.86	6.76	0.61	1.02	0.40	0.00	0.00	0.40	1.64	0.00	0.40	0.4
5	2513	3.25	6.50	0.10	0.86	0.43	0.10	0.00	0.10	0.76	0.00	0.30	0.20
6	2520	1.67	2.78	0.00	0.18	0.18	0.18	0.00	0.93	1.85	0.00	0.37	0.55
7	2528	4.53	5.77	0.00	0.41	0.20	0.00	0.00	1.44	1.65	0.00	0.00	0.41
8	2531	1.91	4.21	0.00	0.38	0.73	0.00	0.00	0.38	3.44	0.00	0.38	0.00
9	2532	2.10	6.30	0.52	1.22	0.87	0.52	0.00	0.52	3.85	0.00	0.35	0.87
10	2533	0.93	4.26	0.13	1.33	0.26	1.73	0.40	0.66	5.06	0.40	0.80	0.93
11	2535	2.18	4.37	0.00	1.09	0.21	2.40	0.65	1.96	3.50	1.53	0.21	0.00
12	2537	3.54	2.75	0.26	1.44	0.13	0.78	0.78	0.39	3.01	0.52	0.26	0.65
13	37	0.52	4.12	0.00	0.78	0.00	0.63	0.13	0.39	2.73	0.39	0.26	0.26
14	59	0.89	2.24	0.00	0.89	0.00	0.00	0.00	0.45	0.00	0.00	0.89	1.79
15	81	3.64	5.46	0.36	0.72	0.36	1.27	0.54	0.36	2.18	0.18	0.00	0.36
16	99	2.82	4.03	0.00	1.20	0.00	0.80	0.00	0.00	1.61	0.40	0.00	0.00
17	101	3.00	5.00	0.00	1.80	0.80	1.40	0.40	0.40	2.60	0.40	0.20	0.00
18	150	1.69	6.26	0.00	1.01	0.16	2.03	0.16	0.33	2.70	0.50	0.33	0.00
19	151	1.83	5.10	0.10	1.43	0.40	1.32	0.51	0.40	0.33	0.81	0.81	0.20
20	152	2.93	4.10	0.07	0.73	0.21	1.31	0.29	0.43	2.71	0.29	0.36	0.43
21	153	2.72	2.26	0.00	1.05	0.15	1.21	0.15	0.60	2.26	0.75	0.00	0.15
22	154	0.97	2.54	0.06	0.78	0.06	0.71	0.13	0.58	0.91	0.00	0.32	0.13
23	155	0.98	2.31	0.00	0.35	0.35	1.06	0.00	0.35	1.95	0.00	0.17	0.35
24	156	3.08	6.17	0.00	1.73	0.77	1.35	0.57	0.57	1.93	0.38	0.96	0.38
25	157	1.99	4.97	0.00	0.74	0.24	0.74	0.24	0.24	3.73	0.00	0.24	0.24
26	158	0.90	2.92	0.00	1.12	0.00	0.90	0.00	0.22	3.15	0.00	1.12	0.22
27	199	2.33	6.60	0.38	0.90	0.52	1.16	0.12	0.38	3.75	0.52	0.65	0.13
28	379	2.89	3.33	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.00
29	105	2.08	5.46	0.00	1.14	0.01	1.39	0.44	0.29	2.48	0.34	0.44	0.24
30	120	2.46	4.66	0.09	0.73	0.14	1.03	0.14	0.49	2.25	0.04	0.29	0.14
31	121	1.74	1.54	0.09	0.54	0.14	0.39	0.15	0.29	1.09	0.19	0.49	0.09
32	124	3.03	5.52	0.13	0.94	0.20	0.47	0.13	0.26	2.42	1.13	0.67	1.01
33	126	5.51	4.82	0.13	2.34	0.13	0.96	0.27	0.27	2.48	0.00	0.55	0.13
34	127	1.43	5.62	0.00	0.76	0.19	0.85	0.28	0.09	1.90	0.28	0.57	0.19
35	128	1.64	2.98	0.14	0.89	0.00	0.29	0.23	0.89	2.16	0.23	0.59	0.23
36	129	2.50	3.80	0.00	0.59	0.23	0.11	0.23	0.11	1.42	0.23	0.59	0.00
37	139	1.73	4.46	0.00	1.09	0.36	0.54	0.00	0.27	2.55	0.09	0.18	0.18
38	183	0.93	5.63	0.11	0.82	0.35	1.40	0.23	0.00	3.05	0.23	0.11	0.00
39	206	3.61	6.62	0.36	1.38	0.30	0.78	0.42	6.62	2.34	0.18	0.30	0.20
40	210	2.73	1.36	0.00	1.36	0.00	0.68	0.00	0.00	6.16	0.68	0.68	0.00
41	231	3.77	6.46	0.43	1.83	0.32	0.37	0.26	0.37	2.10	0.16	0.80	0.21
42	241	2.52	4.36	0.00	0.91	0.34	0.57	0.57	0.34	2.06	0.34	0.34	0.46

Morpho-groups

24. Zygocircus
25. Lophospyris-Phormospyris
26. Androspyris
27. Liriospyris
28. Nephrospyris
29. Sethophormins
30. Eucecryphalus
31. Plectopyramidins
32. Pterocanium
33. Dictyophimus-Pseudodictyophimus
34. Lithopera-Cyrtopera
35. Cycladophora

Table 3 Contd. ....

SN	Sample	36	37	38	39	40	41	42	43	44	45	46	47	Total counts
		RADIOLARIAN MORPHO-GROUPS												
1	2483	1.20	1.50	0.70	0.20	0.10	0.30	0.10	0.30	0.10	0.00	0.00	0.00	0996
2	2486	0.59	0.98	0.78	0.59	0.39	0.00	0.39	0.00	0.00	0.39	0.00	0.00	0509
3	2494	1.84	1.22	0.92	1.53	0.92	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0326
4	2501	0.40	1.84	0.82	1.63	1.02	0.00	0.00	0.20	0.00	0.00	0.40	0.00	0488
5	2513	0.54	0.97	0.87	1.41	0.87	0.00	0.20	0.30	0.00	0.00	0.20	0.00	0921
6	2520	1.11	0.18	0.74	0.74	0.55	0.00	0.18	0.37	0.00	0.18	0.55	0.00	0538
7	2528	1.44	0.61	1.23	1.85	0.41	0.61	2.06	2.68	2.88	0.82	1.03	0.00	0485
8	2531	0.73	0.00	1.14	0.38	0.00	0.73	1.14	1.53	0.73	1.14	0.38	0.00	0261
9	2532	0.70	3.85	3.15	6.83	3.50	0.52	1.22	1.57	0.70	0.35	0.70	0.17	0571
10	2533	1.21	2.40	2.26	4.26	1.46	0.00	0.53	0.66	0.13	0.13	0.53	1.33	0750
11	2535	0.43	3.28	1.96	2.84	1.75	0.21	0.65	0.87	0.43	0.00	0.43	0.00	0457
12	2537	1.04	1.57	1.31	1.57	1.18	0.00	0.26	0.39	0.00	0.13	0.52	0.00	0762
13	37	0.91	1.43	1.30	1.30	1.43	0.00	0.39	0.26	0.00	0.00	0.26	0.00	0767
14	59	0.89	2.24	4.48	4.48	2.24	0.00	0.45	0.89	0.45	0.00	1.34	0.45	0223
15	81	0.54	0.91	0.72	1.09	0.18	0.18	0.18	0.00	0.00	0.00	0.72	0.00	0549
16	99	0.00	1.20	0.80	1.20	0.40	0.00	0.00	0.80	0.00	0.00	0.40	0.00	0248
17	101	1.00	2.00	0.60	3.00	1.00	0.20	0.00	0.00	0.00	0.00	0.20	0.00	0500
18	150	0.84	3.04	1.01	3.72	1.35	0.16	0.00	0.16	0.00	0.00	0.33	0.00	0594
19	151	1.53	4.08	1.22	3.47	1.83	0.10	0.10	0.40	0.00	0.00	0.10	0.00	0979
20	152	1.09	1.46	0.73	1.61	0.29	0.00	0.80	1.17	0.95	0.21	0.58	0.07	1364
21	153	0.30	1.51	0.45	1.96	0.30	0.00	0.30	0.15	0.00	0.00	0.30	0.00	0661
22	154	0.97	2.60	0.97	3.13	2.47	0.00	0.19	0.32	0.13	0.00	0.26	0.06	1533
23	155	1.60	4.03	0.71	2.13	1.06	0.17	0.00	0.35	0.00	0.00	0.00	0.17	0562
24	156	2.50	5.01	0.96	4.82	1.35	0.19	0.00	0.57	0.19	0.19	0.19	0.00	0518
25	157	0.24	3.73	0.24	2.23	0.24	0.48	0.00	0.00	0.00	0.00	0.24	0.00	0402
26	158	1.35	3.82	0.45	2.22	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0444
27	199	0.90	5.18	2.59	3.75	1.16	0.26	0.26	0.13	0.39	0.13	0.52	0.00	0772
28	379	1.42	3.33	1.42	4.28	1.90	0.95	1.42	0.95	1.42	1.42	3.80	0.95	0210
29	105	0.99	2.23	1.48	3.22	1.88	0.24	0.14	0.84	0.00	0.00	0.74	0.09	2014
30	120	1.47	1.81	1.12	1.91	0.73	0.09	0.09	0.39	0.24	0.00	0.19	0.00	2034
31	121	0.49	1.59	0.74	1.44	0.39	0.09	0.09	0.39	0.24	0.00	0.19	0.00	2002
32	124	1.61	2.15	1.07	2.69	0.53	0.13	0.06	0.13	0.06	0.26	0.40	0.20	1483
33	126	0.27	0.96	1.37	2.48	0.96	0.00	0.00	0.27	0.00	0.00	0.41	0.13	0725
34	127	0.47	2.86	1.33	3.04	0.47	0.00	0.00	0.09	0.00	0.00	0.09	0.00	1048
35	128	1.71	1.04	1.78	3.05	0.52	0.00	0.37	0.67	0.74	0.14	1.11	0.14	1341
36	129	0.23	1.09	1.19	1.78	0.71	0.00	0.00	0.23	0.11	0.00	0.71	0.11	0840
37	139	0.27	1.91	0.91	2.37	0.91	0.18	0.18	0.00	0.00	0.09	0.45	0.00	1097
38	183	0.23	3.63	1.40	3.52	3.87	0.00	0.35	0.46	0.00	0.00	0.00	0.00	0852
39	206	1.20	0.60	1.56	2.76	0.54	0.00	0.48	0.72	0.54	0.12	0.42	0.12	1661
40	210	1.36	4.10	1.36	1.36	6.16	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0146
41	231	1.29	1.34	0.86	2.31	2.15	0.05	0.37	0.26	0.26	0.10	0.70	0.05	1855
42	241	0.11	1.49	1.03	3.32	0.23	0.34	0.11	0.11	0.00	0.11	0.23	0.00	0871

Morpho-groups :

36. Eucyrtidium
37. Pterocorys
38. Theocorythium
39. Anthocyrtidium
40. Lamprocyclas-Lamprocyrtis
41. Spirocyrtis
42. Botryostrobus
43. Phormostichoartus
44. Siphocampe
45. Cannobotryids
46. Carpocanistrum
47. Carpocanarium

6.5 STATISTICAL ANALYSES

In order to study the inter-group relationship between the morphogroups counted, Spearman rank difference correlation coefficient were obtained by regression analysis and same is presented in a correlation matrix and r-mode clusters. The data is also analyzed for the factor score matrix and statistically meaningful radiolarian assemblages are recognized in the basin.

6.5.1 R-MODE CLUSTER ANALYSIS

The percentage data of 47 morphogroups in 42 samples (Table 3) was subjected to regression analysis using Spearman rank correlations and result are resultant matrix (Table 4). Weighted pair-group average clustering method (Davis, 1973) was employed and result is presented in Fig. 22 in the form of dendrogram. There are three main clusters i.e. cluster A, B and C, at -0.03 level of similarity.

Cluster A. Cluster A is characterized by *Pyloniids, Articsins, Larcospira* and *Litheliids* groups. Members of these morphogroups *(Tetrapyle octacantha, Octapyle stenozona, Didymocyrtis tetrathalmus, Larcospira quadrangula)* are found in abundance in the surface water (abundance maxima at 25-50 m) of the Pacific

TABLE 4

Spearman rank correlation coefficient of 47 radiolarian morphogroups in 42 surface sediments from the Basin.

MORPHOGROUPS		COLLOSF	DISOL	ACROSF	ACTINOM	PLEGMOSF	STYLOSF	SPNGODIS	CLADOCOC	SPONGAST	ETATOM
1	COLLOSF	1.0000	.5739	.5268	.2067	.0952	.1546	-.1228	-.0001	-.1376	-.1037
2	DISOL	.5739	1.0000	.3742	.1011	.0486	-.1233	-.3272	-.2173	-.3760	-.3912
3	ACROSF	.5268	.3742	1.0000	.2995	.1845	.1540	-.2241	-.0826	-.1353	-.0652
4	ACTINOM	.2067	.1011	.2995	1.0000	.2361	.2170	.1642	.0097	.2112	.2623
5	PLEGMOSF	.0952	.0486	.1845	.2361	1.0000	.3857	-.3180	-.1338	-.1766	-.0151
6	STYLOSF	.1546	-.1233	.1540	.2170	.3857	1.0000	.0908	.0570	.1248	.3258
7	SPNGODIS	-.1228	-.3272	-.2241	.1642	-.3180	.0908	1.0000	.4311	.7574	.2147
8	CLADOCOC	-.0001	-.2173	-.0826	.0097	-.1338	.0570	.4311	1.0000	.3511	.2286
9	SPONGAST	-.1376	-.3760	-.1353	.2112	-.1766	.1248	.7574	.3511	1.0000	.4498
10	ETATOM	-.1037	-.3912	-.0652	.2623	-.0151	.3258	.2147	.2286	.4498	1.0000
11	HEXACONT	-.0923	-.3829	.0920	.1257	.1669	.2869	.0919	-.0090	.0603	.4736
12	AMPHIRHO	.3636	.0851	.2454	-.0674	.1061	-.0726	.1023	.2556	.0247	.0218
13	EUCHITON	.1854	.2679	-.1939	.0938	.0265	-.2619	-.0487	-.0666	.0997	-.1830
14	STYLODIC	-.2828	-.2287	-.5302	-.1631	-.0763	-.3014	.2855	.0806	.3496	-.1948
15	ARTISCIN	-.1309	-.2127	.1474	-.1582	.3837	.1327	-.5500	-.2231	-.4640	-.1729
16	HELIODIS	.0411	-.1682	.1790	.1218	.2524	.4955	.1951	.0634	.3865	.2036
17	LITHELID	-.0158	-.1077	.1745	-.1924	-.1086	-.1522	-.2747	-.3108	-.0301	.0777
18	PYLONIID	-.1362	.1843	-.0081	-.2092	.1341	.0366	-.5505	-.3101	-.5260	-.0160
19	LARCOSPI	.1223	-.0423	.1361	-.1252	-.1153	.1749	-.2550	-.2001	-.2798	.0446
20	STYLOSF	-.3499	-.4069	-.2842	.0859	-.3794	-.1947	.4332	.1019	.2805	.2461
21	PLAGIACAN	.0318	.2821	-.1611	-.0664	-.1083	-.2640	-.1246	.2341	-.0858	-.2160
22	LOPOFININ	.2628	.3085	.1784	-.0870	-.3539	-.1561	-.2200	-.2814	-.3207	-.3343
23	SETHOPERIN	.0412	.2242	.0779	-.2496	-.3486	-.2666	-.0327	-.0311	-.0293	-.0748
24	ZYGOCIRC	-.3460	.0023	-.2699	-.1686	-.2067	-.0504	-.0065	-.0971	-.1582	-.3385
25	LOFOSPYR	-.1967	.1806	-.0829	-.0117	-.0961	-.0336	.0173	-.0791	-.0933	-.1325
26	ANDROSPY	-.1780	-.0100	-.1068	.2995	-.0014	-.0459	.1366	-.0939	.0999	.0372
27	LIRIOSPY	-.3905	-.1898	-.0398	.0088	-.1427	.0494	-.0389	-.3680	-.0925	.1051
28	NEFROSPY	.0569	.1496	-.1424	-.1544	.0071	.1164	-.0925	-.1124	-.2219	-.0335
29	SETHOFOR	.0901	.1743	.4529	-.1033	.0914	.0766	-.1551	-.1116	-.2197	-.0936
30	EUCECRYF	.0415	.1174	.3499	-.0611	.0686	.1077	-.1216	-.1317	.0609	-.0430
31	PLCTOPYR	.1125	.0975	.0953	-.0272	.1898	-.1666	-.1190	-.0748	-.1913	-.2699
32	PTEROCAN	-.0182	.0252	-.0698	-.0752	.0432	-.0051	-.1006	-.1951	-.2332	-.2381
33	DICTOFIM	.0254	.2414	.2600	.0631	-.0676	-.0629	-.1556	-.2581	-.1155	-.2075
34	LITHOPER	-.1775	-.1563	.0401	-.1528	.0416	.0980	-.0076	-.2016	.0003	.0003
35	CYCLADOF	.1447	-.1384	.0220	-.0738	-.3350	.0217	.1419	.0125	.1311	.0921
36	EUCYRTID	.1673	.2156	.2722	.0050	-.1620	-.1900	-.1257	.1039	-.1956	-.1800
37	PTEROCOR	-.1733	-.0065	.2495	-.1581	.1930	-.0018	-.2195	-.0461	-.2968	-.1132
38	THEOCORY	.0352	-.0351	-.0375	-.1236	-.1141	-.1323	-.1761	-.0792	-.1609	-.0298
39	ANTHOCYR	-.1532	-.0687	.0573	-.2797	.1180	.0015	-.3027	.0592	-.3028	.0747
40	LAMPROCY	-.4451	-.3464	-.1635	-.1719	-.0801	-.2029	-.1800	.0313	-.2161	-.0189
41	SPIROCYR	.1677	.2739	-.1486	-.2001	-.0459	-.2360	-.2410	.2274	-.2195	-.1529
42	BOTRYOST	.2488	.3413	-.2426	-.1649	-.1490	-.3372	-.1841	.1951	-.1317	-.2334
43	FORMOSTI	.3137	.2780	-.1555	-.1249	-.1663	-.3062	-.0687	.0882	-.0959	-.2164
44	SIPHOCAM	.2337	.3619	-.1588	-.1283	-.0917	-.2910	-.2211	.1218	-.2387	-.3175
45	CANNOBOT	.1665	.2084	-.3062	-.2800	-.1325	-.2970	-.1304	.3402	-.0446	-.1618
46	CRPCNSTR	-.0425	.0229	-.1347	-.2367	-.1294	-.2010	-.1673	.5045	-.1181	-.0931
47	CRPCNRUM	.0148	-.1691	-.0737	-.1027	-.1205	.0788	-.0090	.5623	.0468	.2403

Table 4 contd.

	MORPHOGROUPS	HEXACONT	AMPHIRHO	EUCHITON	STYLODIC	ARTISCIN	HELIODIS	LITHELID	PYLONIID	LARCOSPI	STYLOSF
1	COLLOSF	-.0923	.3636	.1854	-.2828	-.1309	.0411	-.0158	-.1362	.1223	-.3499
2	DISOL	-.3829	.0851	.2679	-.2287	-.2127	-.1682	-.1077	.1843	-.0423	-.4069
3	ACROSF	.0920	.2454	-.1939	-.5302	.1474	.1790	.1745	-.0081	.1361	-.2842
4	ACTINOM	.1257	-.0674	.0938	-.1631	-.1582	.1218	-.1924	-.2092	-.1252	.0859
5	PLEGMOSF	.1669	.1061	.0265	-.0763	.3837	.2524	-.1086	.1341	-.1153	-.3794
6	STYLOSF	.2869	-.0726	-.2619	-.3014	.1327	.4955	-.1522	.0366	.1749	-.1947
7	SPNGODIS	.0919	.1023	-.0487	.2855	-.5500	.1951	-.2747	-.5505	-.2550	.4332
8	CLADOCOC	-.0090	.2556	-.0666	.0806	-.2231	.0634	-.3108	-.3101	-.2001	.1019
9	SPONGAST	.0603	.0247	.0997	.3496	-.4640	.3865	-.0301	-.5260	-.2798	.2805
10	ETATOM	.4736	.0218	-.1830	-.1948	-.1729	.2036	.0777	-.0160	.0446	.2461
11	HEXACONT	1.0000	.0720	-.466	-.3701	.1405	.0341	.2249	.1980	.1685	.0885
12	AMPHIRHO	.0720	1.0000	.0732	-.0250	.0740	.2709	-.0891	-.2110	-.1545	-.1494
13	EUCHITON	-.4669	.0732	1.0000	.6792	-.3631	.0138	.0549	-.2526	-.4450	-.0821
14	STYLODIC	-.3701	-.0250	.6792	1.0000	-.3633	.0045	.0190	-.4445	-.4822	.1854
15	ARTISCIN	.1405	.0740	-.3631	-.3633	1.0000	.0615	.1909	.3693	.3982	-.3739
16	HELIODIS	.0341	.2709	.0138	.0045	.0615	1.0000	-.1016	-.2007	-.0479	-.1421
17	LITHELID	.2249	-.0891	.0549	.0190	.1909	-.1016	1.0000	.1872	.1900	-.1910
18	PYLONIID	.1980	-.2110	-.2526	-.4445	.3693	-.2007	.1872	1.0000	.1555	-.2989
19	LARCOSPI	.1685	-.1545	-.4450	-.4822	.3982	-.0479	.1900	.1555	1.0000	-.2030
20	STYLOSF	.0885	-.1494	-.0821	.1854	-.3739	-.1421	-.1910	-.2989	-.2030	1.0000
21	PLAGIACAN	-.4508	-.2557	.0316	.1179	-.1598	-.3884	-.1815	.0001	-.100	-.2170
22	LOFOFININ	-.2520	-.1894	-.0683	-.1378	-.1367	-.2417	.1955	.0601	.1922	.0173
23	SETHOPERIN	-.1993	-.2381	-.0540	-.0673	-.2755	-.1701	-.0321	-.0251	.0724	.0803
24	ZYGOCIRC	-.2332	-.2213	-.0192	.2102	-.0830	-.2034	-.0956	.2283	-.1806	.1135
25	LOFOSPYR	-.0435	-.1083	-.0769	-.0534	-.2927	.0808	-.2112	.1352	-.2054	.0400
26	ANDROSPY	-.1535	-.3048	.0315	.1274	-.3518	.1227	-.1689	-.0752	-.1879	.3652
27	LIRIOSPY	.1684	-.2380	-.2339	-.0682	-.0160	-.1447	.0455	.1610	-.1288	.3894
28	NEFROSPY	-.0794	-.0590	.0601	-.0086	-.1917	.0174	-.2343	.0878	-.1816	.1148
29	SETHOFOR	.0666	.0785	-.3602	-.4192	.0273	.0334	-.0184	.1795	-.0399	-.0808
30	EUCECRYF	-.0409	.0020	-.2841	-.3118	.1076	.2398	.0971	.1100	-.0812	-.1685
31	PLCTOPYR	-.1678	-.0518	-.0193	.0465	.0910	-.1231	-.0618	-.0238	-.0894	.0193
32	PTEROCAN	-.1730	-.0398	-.0679	-.0243	-.0052	-.0413	-.3382	-.0245	-.1172	.2996
33	DICTOFIM	-.0864	-.1342	-.0873	-.1959	.0617	.0128	.0608	.0134	-.1208	.0505
34	LITHOPER	.0284	-.0248	-.0566	.0228	.1812	.1747	.0674	-.2614	.0906	.0382
35	CYCLADOF	-.0881	-.0362	-.2357	-.0328	-.0307	.0617	.1883	-.3537	.4061	.0745
36	EUCYRTID	-.2774	.0620	.2297	.0173	-.0660	-.1676	-.0035	-.1901	-.2269	-.0278
37	PTEROCOR	.1136	-.0883	-.2682	-.1936	.1579	-.0749	-.0457	-.0759	.0961	-.0475
38	THEOCORY	-.1683	-.1170	-.2681	-.1909	.1382	-.1642	-.0630	.2536	.4810	.1702
39	ANTHOCYR	.0377	-.0565	-.5139	-.3145	.2534	-.1841	-.0661	.0446	.176	-.0842
40	LAMPROCY	-.0207	-.0152	-.3015	-.0568	.3295	-.1058	-.1975	-.1332	.1663	.4011
41	SPIROCYR	-.2740	.0229	.2239	.1218	-.1232	-.2885	-.1391	-.0485	-.0346	-.2841
42	BOTRYOST	-.4957	-.0247	.2429	.2343	-.2195	-.3848	-.2246	-.1961	-.0529	-.1250
43	FORMOSTI	-.3506	.1302	.1893	.2016	-.2377	-.3491	-.1200	-.3339	-.0864	-.0466
44	SIPHOCAM	-.3954	-.0730	.2235	.1840	-.1676	-.4403	-.1538	-.1144	-.0196	-.2051
45	CANNOBOT	-.4453	.0573	.4398	.3975	-.1892	-.3025	-.1455	-.1948	-.1849	-.1846
46	CRPCNSTR	-.2651	-.0531	-.0809	.0101	.1237	-.3873	-.0710	-.0498	.2058	-.1345
47	CRPCNRUM	-.2077	-.1067	-.1020	.0014	-.0315	-.0690	-.0763	-.2225	.0683	.0482

Table 4 contd.

MORPHOGROUPS	PLAGIACAN	LOFOFININ	SETHOPERIN	ZYGOCIRC	LOFOSPYR	ANDROSPY	LIRIOSPY	NEFROSPY	SETHOFOR	EUCECRYF
1 COLLOSF	.0318	.2628	.0412	-.3460	-.1967	-.1780	-.3905	.0569	.0901	.0415
2 DISOL	.2821	.3085	.2242	.0023	.1806	-.0100	-.1898	.1496	.1743	.1174
3 ACROSF	-.1611	.1784	.0779	-.2699	-.0829	-.1068	-.0398	-.1424	.4529	.3499
4 ACTINOM	-.0664	-.0870	-.2496	-.1686	-.0117	.2995	.0088	-.1544	-.1033	-.0611
5 PLEGMOSF	-.1083	-.3539	-.3486	-.2067	-.0961	-.0014	-.1427	.0071	.0914	.0686
6 STYLOSF	-.2640	-.1561	-.2666	-.0504	-.0336	-.0459	.0494	.1164	.076	.1077
7 SPNGODIS	-.1246	-.2200	-.0327	-.0065	.0173	.1366	-.0389	-.0925	-.1551	-.1216
8 CLADOCOC	.2341	-.2814	-.0311	-.0971	-.0791	-.0939	-.3680	-.1124	-.1116	-.1317
9 SPONGAST	-.0858	-.3207	-.0293	-.1582	-.0933	.0999	-.0925	-.2219	-.2197	.0609
10 ETATOM	-.2160	-.3343	-.0748	-.3385	-.1325	.0372	.1051	-.0335	-.0936	-.0430
11 HEXACONT	-.4508	-.2520	-.1993	-.2332	-.0435	-.1535	.1684	-.0794	.0666	-.0409
12 AMPHIRHO	-.2557	-.1894	-.2381	-.2213	-.1083	-.3048	-.2380	-.0590	.0785	.0020
13 EUCHITON	.0316	-.0683	-.0540	-.0192	-.0769	.0315	-.2339	.0601	-.3602	-.2841
14 STYLODIC	.1179	-.1378	-.0673	.2102	-.0534	.1274	-.0682	-.0086	-.4192	-.3118
15 ARTISCIN	-.1598	-.1367	-.2755	-.0830	-.2927	-.3518	-.0160	-.1917	.0273	.1076
16 HELIODIS	-.3884	-.2417	-.1701	-.2034	.0808	.1227	-.1447	.0174	.0334	.2398
17 LITHELID	-.1815	.1955	-.0321	-.0956	-.2112	-.1689	.0455	-.2343	-.0184	.0971
18 PYLONIID	.0001	.0601	-.0251	.2283	.1352	-.0752	.1610	.0878	.1795	.1100
19 LARCOSPI	-.1000	.1922	.0724	-.1806	-.2054	-.1879	-.1288	-.1816	-.0399	-.0812
20 STYLOSF	-.2170	.0173	.0803	.1135	.0400	.3652	.3894	.1148	-.0808	-.1685
21 PLAGIACAN	1.0000	.2951	.2843	.2310	.0858	.0978	-.3212	-.1122	-.0893	.0012
22 LOFOFININ	.2951	1.0000	.3681	.2559	.1126	.0067	.0957	-.0790	.2889	.1447
23 SETHOPERIN	.2843	.3681	1.0000	-.0938	.1284	-.1255	-.1207	.0125	.3532	.1047
24 ZYGOCIRC	.2310	.2559	-.0938	1.0000	.4071	.2781	.4319	.2464	-.0724	.2016
25 LOFOSPYR	.0858	.1126	.1284	.4071	1.0000	.4920	.3087	.5001	.1109	.1307
26 ANDROSPY	.0978	.0067	-.1255	.2781	.4920	1.0000	.2725	.2835	-.2093	-.0163
27 LIRIOSPY	-.3212	.0957	-.120	.4319	.3087	.2725	1.0000	.3322	.2917	.3399
28 NEFROSPY	-.1122	-.0790	.0125	.2464	.5001	.2835	.3322	1.0000	.0610	.0854
29 SETHOFOR	-.0893	.2889	.3532	-.0724	.1109	-.2093	.2917	.0610	1.0000	.5809
30 EUCECRYF	.0012	.1447	.1047	.2016	.1307	-.0163	.3399	.0854	.5809	1.0000
31 PLCTOPYR	.1923	.2345	-.0176	.1758	.2017	.1787	.0944	.0403	.0975	.2415
32 PTEROCAN	-.0674	.1882	.2846	-.0430	-.0232	.0210	.2016	.1204	.4076	.1288
33 DICTOFIM	.0838	.3056	.1913	-.0188	-.0169	-.1239	.1821	-.1208	.5472	.4626
34 LITHOPER	-.3955	-.1018	-.1540	-.1674	-.0005	.0056	.3972	.1089	.0169	.0764
35 CYCLADOF	.0596	.2100	-.0991	-.1807	-.0767	.1332	-.0343	-.0559	-.1871	.0020
36 EUCYRTID	.0813	.1351	-.0044	-.0230	-.0077	.0074	.1355	.1474	.0001	.0234
37 PTEROCOR	-.0041	-.1446	.2277	-.2860	.0326	-.0877	.0802	.1417	.4526	.0911
38 THEOCORY	.1145	.1517	-.0176	-.1766	.0092	.1363	.0478	.0271	-.0127	-.0075
39 ANTHOCYR	.2247	-.0433	.0989	-.1075	.2279	.0188	.1996	.2716	.3112	.2032
40 LAMPROCY	-.0046	-.0384	.1160	-.0508	-.1296	.0242	.2081	-.0069	.1445	-.0750
41 SPIROCYR	.5840	-.0144	.3379	.0618	.1162	-.1025	-.3946	.2282	-.1772	-.1148
42 BOTRYOST	.7546	.3539	.2262	.1662	.0775	.0288	-.3536	.0625	-.2379	-.1680
43 FORMOSTI	.5651	.4184	.2150	.1671	.0770	-.0641	-.2412	.1088	-.1553	-.1124
44 SIPHOCAM	.7181	.4529	.1796	.2608	.0636	-.0541	-.3421	-.0125	-.2681	-.1773
45 CANNOBOT	.5868	.0006	.1468	.1591	.0209	-.0597	-.4102	.0887	-.4000	-.2478
46 CRPCNSTR	.5996	.0222	.0573	.1271	-.1635	-.0822	-.3209	-.2361	-.2798	-.1240
47 CRPCNRUM	.2856	.0456	.0583	-.1739	-.1485	-.0513	-.0970	-.1361	.0199	-.0169

Table 4 contd.

MORPHOGROUPS		PLCTOPYR	PTEROCAN	DICTOFIM	LITHOPER	CYCLADOF	EUCYRTID	PTEROCOR	THEOCORY	ANTHOCYR	LAMPROCY
1	COLLOSF	.1125	-.0182	.0254	-.1775	.1447	.1673	-.1733	.0352	-.1532	-.4451
2	DISOL	.0975	.0252	.2414	-.1563	-.1384	.2156	-.0065	-.0351	-.0687	-.3464
3	ACROSF	.0953	-.0698	.2600	.0401	.0220	.2722	.2495	-.0375	.0573	-.1635
4	ACTINOM	-.0272	-.0752	.0631	-.1528	-.0738	.0050	-.1581	-.1236	-.2797	-.1719
5	PLEGMOSF	.1898	.0432	-.0676	.0416	-.3350	-.1620	.1930	-.1141	.1180	-.0801
6	STYLOSF	-.1666	-.0051	-.0629	.0980	.0217	-.1900	-.0018	-.1323	.0015	-.2029
7	SPNGODIS	-.1190	-.1006	-.1556	-.0076	.1419	-.1257	-.2195	-.1761	-.3027	-.1800
8	CLADOCOC	-.0748	-.1951	-.2581	-.2016	.0125	.1039	-.0461	-.0792	.0592	.0313
9	SPONGAST	-.1913	-.2332	-.1155	.0003	.1311	-.1956	-.2968	-.1609	-.3028	-.2161
10	ETATOM	-.2699	-.2381	-.2075	.0003	.0921	-.1800	-.1132	-.0298	.0747	-.0189
11	HEXACONT	-.1678	-.1730	-.0864	.0284	-.0881	-.2774	.1136	-.1683	.0377	-.0207
12	AMPHIRHO	-.0518	-.0398	-.1342	-.0248	-.0362	.0620	-.0883	-.1170	-.0565	-.0152
13	EUCHITON	-.0193	-.0679	-.0873	-.0566	-.2357	.2297	-.2682	-.2681	-.5139	-.3015
14	STYLODIC	.0465	-.0243	-.1959	.0228	-.0328	.0173	-.1936	-.1909	-.3145	-.0568
15	ARTISCIN	.0910	-.0052	.0617	.1812	-.0307	-.0660	.1579	.1382	.2534	.3295
16	HELIODIS	-.1231	-.0413	.0128	.1747	.0617	-.1676	-.0749	-.1642	-.1841	-.1058
17	LITHELID	-.0618	-.3382	.0608	.0674	.1883	-.0035	-.0457	-.0630	-.0661	-.1975
18	PYLONIID	-.0238	-.0245	.0134	-.2614	-.3537	-.1901	-.0759	-.2536	.0446	-.1332
19	LARCOSPI	-.0894	-.1172	-.1208	.0906	.4061	-.2269	.0961	.4810	.1762	.1663
20	STYLOSF	.0193	.2996	.0505	.0382	.0745	-.0278	-.0475	.1702	-.0842	.4011
21	PLAGIACAN	.1923	-.0674	.0838	-.3955	.0596	.0813	-.0041	.1145	.2247	-.0046
22	LOFOFININ	.2345	.1882	.3056	-.1018	.2100	.1351	-.1446	.1517	-.0433	-.0384
23	SETHOPERIN	-.0176	.2846	.1913	-.1540	-.0991	-.0044	.2277	-.0176	.0989	.1160
24	ZYGOCIRC	.1758	-.0430	-.0188	.1674	-.1807	-.0230	-.2860	-.1766	-.1075	-.0508
25	LOFOSPYR	.2017	-.0232	-.016	-.0005	-.0767	-.0077	.0326	.0092	.2279	-.1290
26	ANDROSPY	.1787	.0210	-.1239	.0056	.1332	.0074	-.0877	.1363	.0188	.0242
27	LIRIOSPY	.0944	.2016	.1821	.3972	-.0343	.1355	.0802	.0478	.1996	.2081
28	NEFROSPY	.0403	.1204	-.1208	.1089	-.0559	.1474	.1417	.0271	.2716	-.0069
29	SETHOFOR	.0975	.4076	.5472	.0169	-.1871	.0001	.4526	-.0127	.3112	.1445
30	EUCECRYF	.2415	.1288	.4626	.0764	.0020	.0234	.0911	-.0075	.2032	-.0750
31	PLCTOPYR	1.0000	.0281	.0671	-.0698	.0110	.1276	-.2048	.1377	.0749	-.1177
32	PTEROCAN	.0281	1.0000	.2587	.0996	-.0982	-.0021	.2836	.0634	.0626	.3705
33	DICTOFIM	.0671	.2587	1.0000	.0410	-.0413	.0076	.2501	.0455	.0586	.1274
34	LITHOPER	-.0698	.0996	.0410	1.0000	.3122	.4150	.3286	.3032	.3194	.2212
35	CYCLADOF	.0110	-.0982	-.0413	.3122	1.0000	.1369	-.0062	.6051	.3482	.0381
36	EUCYRTID	.1276	-.0021	.0076	.4150	.1369	1.0000	.2416	.0365	.1659	.1248
37	PTEROCOR	-.2048	.2836	.2501	.3286	-.0062	.2416	1.0000	.2198	.6034	.5185
38	THEOCORY	.1377	.0634	.0455	.3032	.6051	.0365	.2198	1.0000	.6147	.3938
39	ANTHOCYR	.0749	.0626	.0586	.3194	.3482	.1659	.6034	.6147	1.0000	.4056
40	LAMPROCY	-.1177	.3705	.1274	.2212	.0381	.1248	.5185	.3938	.4056	1.0000
41	SPIROCYR	-.0653	.0439	-.1562	-.3262	-.0925	.0577	.1339	.0612	.2161	-.0637
42	BOTRYOST	.2072	-.0058	-.1368	-.2896	.1545	.1018	-.1561	.3196	.1841	.0422
43	FORMOSTI	.2376	-.0359	-.1558	-.1716	.1960	.1721	-.1712	.3591	.1935	.0104
44	SIPHOCAM	.2405	-.1048	-.1812	-.2024	.0827	.2497	-.1372	.2266	.1322	-.0640
45	CANNOBOT	.0185	-.1011	-.1943	-.2151	-.0085	.1900	-.1292	.0763	.0601	-.0806
46	CRPCNSTR	-.0053	-.1880	-.1448	-.1247	.1270	.1381	.0118	.3312	.2954	.1664
47	CRPCNRUM	.0110	.0732	-.0718	.1516	.3921	.1823	.1018	.4145	.4201	.1302

Table 4 contd

MORPHOGROUPS		SPIRCCYR	BOTRYOST	FORMOSTI	SIPHOCAM	CANNOBOT	CRPCNSTR	CRPCNRUM
1	COLLOSF	.1677	.2488	.3137	.2337	.1665	-.0425	.0148
2	DISOL	.2739	.3413	.2780	.3619	.2084	.0229	-.1691
3	ACROSF	-.1486	-.2426	-.1555	-.1588	-.3062	-.1347	-.0737
4	ACTINOM	-.2001	-.1649	-.1249	-.1283	-.2800	-.2367	-.1027
5	PLEGMOSF	-.0459	-.1490	-.1663	-.0917	-.1325	-.1294	-.1205
6	STYLOSF	-.2360	-.3372	-.3062	-.2910	-.2970	-.2010	.0788
7	SPNGODIS	-.2410	-.1841	-.0687	-.2211	-.1304	-.1673	-.0090
8	CLADOCOC	.2274	.1951	.0882	.1218	.3402	.5045	.5623
9	SPONGAST	-.2195	-.1317	-.0959	-.2387	-.0446	-.1181	.0468
10	ETATOM	-.1529	-.2334	-.2164	-.3175	-.1618	-.0931	.2403
11	HEXACONT	-.2740	-.4957	-.3506	-.3954	-.4453	-.2651	-.2077
12	AMPHIRHO	.0229	-.0247	.1302	-.0730	.0573	-.0531	-.1067
13	EUCHITON	.2239	.2429	.1893	.2235	.4398	-.0809	-.1020
14	STYLODIC	.1218	.2343	.2016	.1840	.3975	.0101	.0014
15	ARTISCIN	-.1232	-.2195	-.2377	-.1676	-.1892	.1237	-.0315
16	HELIODIS	-.2885	-.3848	-.3491	-.4403	-.3025	-.3873	-.0690
17	LITHELID	-.1391	-.2246	-.1200	-.1538	-.1455	-.0710	-.0763
18	PYLONIID	-.0485	-.1961	-.3339	-.1144	-.1948	-.0498	-.2225
19	LARCOSPI	-.0346	-.0529	-.0864	-.0196	-.1849	.2058	.0683
20	STYLOSF	-.2841	-.1250	-.0466	-.2051	-.1846	-.1345	.0482
21	PLAGIACAN	.5840	.7546	.5651	.7181	.5868	.5996	.2856
22	LOFOFININ	-.0144	.3539	.4184	.4529	.0006	.0222	.0456
23	SETHOPERIN	.3379	.2262	.2150	.1796	.1468	.0573	.0583
24	ZYGOCIRC	.0618	.1662	.1671	.2608	.1591	.1271	-.1739
25	LOFOSPYR	.1162	.0775	.0770	.0636	.0209	-.1635	-.1485
26	ANDROSPY	-.1025	.0288	-.0641	-.0541	-.0597	-.0822	-.0513
27	LIRIOSPY	-.3946	-.3536	-.2412	-.3421	-.4102	-.3209	-.0970
28	NEFROSPY	.2282	.0625	.1088	-.0125	.0887	-.2361	-.1361
29	SETHOFOR	-.1772	-.2379	-.1553	-.2681	-.4000	-.2798	.0199
30	EUCECRYF	-.1148	-.1680	-.1124	-.1773	-.2478	-.1240	-.0169
31	PLCTOPYR	-.0653	.2072	.2376	.2405	.0185	-.0053	.0110
32	PTEROCAN	.0439	-.0058	-.0359	-.1048	-.1011	-.1880	.0732
33	DICTOFIM	-.1562	-.1368	-.1558	-.1812	-.1943	-.1448	-.0718
34	LITHOPER	-.3262	-.2896	-.1716	-.2024	-.2151	-.1247	.1516
35	CYCLADOF	-.0925	.1545	.1960	.0827	-.0085	.1270	.3921
36	EUCYRTID	.0577	.1018	.1721	.2497	.1900	.1381	.1823
37	PTEROCOR	.1339	-.1561	-.1712	-.1372	-.1292	.0118	.1018
38	THEOCORY	.0612	.3196	.3591	.2266	.0763	.3312	.4145
39	ANTHOCYR	.2161	.1841	.1935	.1322	.0601	.2954	.4201
40	LAMPROCY	-.0637	.0422	.0104	-.0640	-.0806	.1664	.1302
41	SPIROCYR	1.0000	.6435	.5073	.5799	.7869	.5349	.2052
42	BOTRYOST	.6435	1.0000	.8644	.8959	.7860	.5509	.3104
43	FORMOSTI	.5073	.8644	1.0000	.8529	.5953	.3600	.1913
44	SIPHOCAM	.5799	.8959	.8529	1.0000	.6919	.5423	.2007
45	CANNOBOT	.7869	.7860	.5953	.6919	1.0000	.6603	.3549
46	CRPCNSTR	.5349	.5509	.3600	.5423	.6603	1.0000	.5750
47	CRPCNRUM	.2052	.3104	.1913	.2007	.3549	.5750	1.0000

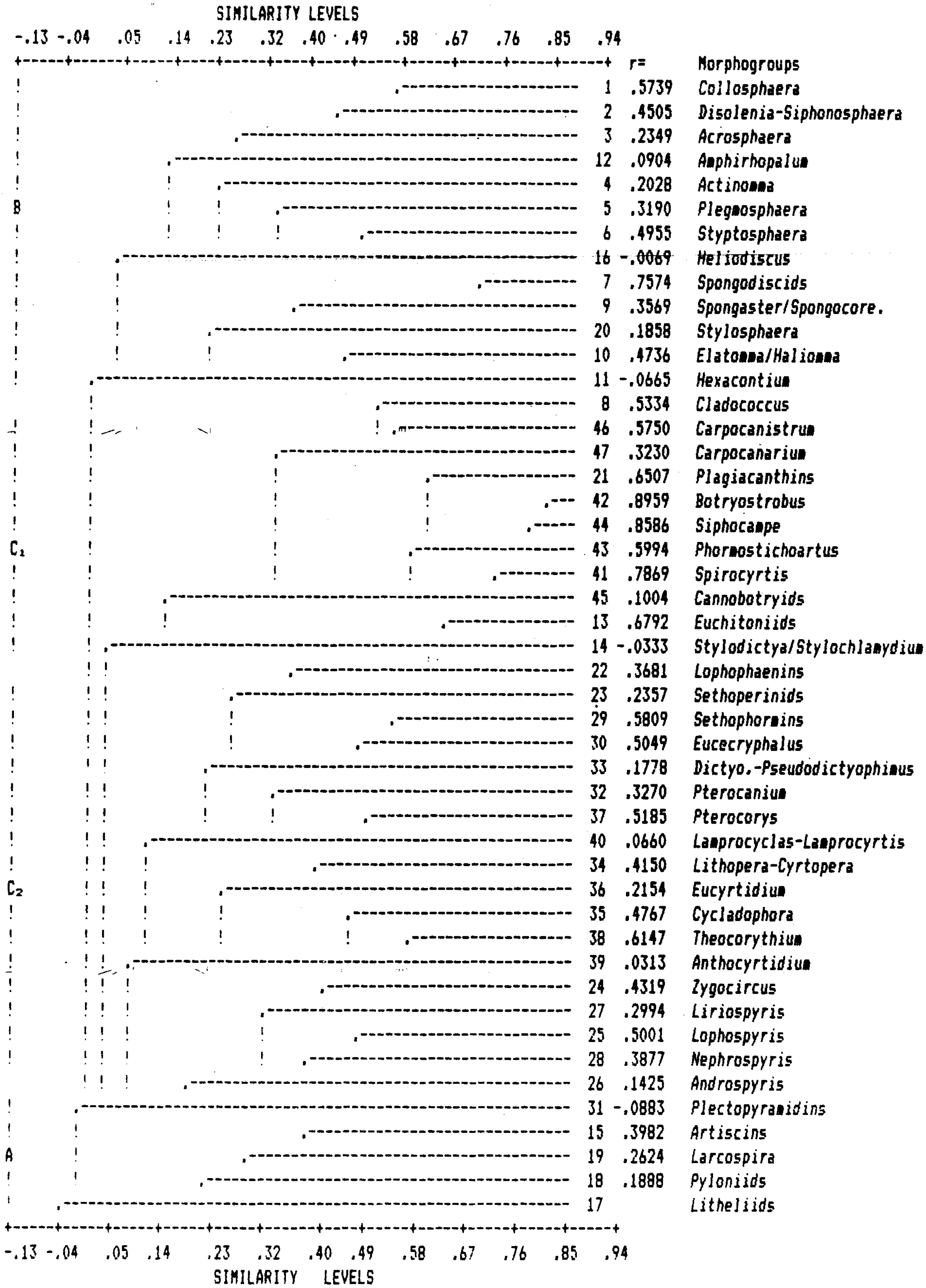

Figure 22 Weighted pair-group average dendrogram of 47 radiolarian morphogroups (r-mode cluster) in present study.

and Atlantic Ocean (Renz, 1976; McMillen and Casey, 1978; Kling, 1979).

Cluster B is characterized by 13 morphogroups. The morphogroups *Collosphaera*, *Acrosphaera*, and *Disolenia-Siphonosphaera* represent colonial radiolarians having preference to the 0-50 m of surface water (McMillen and Casey, 1978; Kling, 1979). The morphogroups like *Heliodiscus*, *Spongodiscids*, *Spongaster-Spongocore*, *Stylosphaera* and *Hexaconitum* are represented by *Heliodiscus echinischus*, *Spongotrochus longispinus*, *Spongotrochus multispinus*, *Spongaster tetras*, *Duppatractus pyriformis*, *Hexastyle phaenaxonius* in 50-100 m of surface water (McMillen and Casey, 1978). Other morphogroups like *Actinomma*, *Elatomma-Haliomma*, *Plegmosphaera*, *Styptosphaera*, *and Amphirhopalum* are also associated with cluster B. Hence, cluster B may be interpreted as surface water fauna (up to 0-100 m) in present study.

Cluster C can be divided into subcluster C_1 and C_2 at 0.03 level of similarity. Subcluster C_1 is comprised of 11 morphogroups i. e. *Euchitoniids*, *Stylodictya-Stylochlamydium*, *Cladococcus*, *Carpocanistrum*, *Carpocanarium*, *Plagiacanthins*, *Botryostrobus*, *Siphocampe*, *Phormostichoartus*, *Spirocyrtis*, and

Cannobotryids etc. Kling (1979) reported upper subsurface maxima of *Botryostrobus auritus/australis*, *Phormostichoartus corbula*, *Hymeniastrum euclidis*, and *Stylodictya validispina* at 100 m watermass (upper subsurface) in northeast Pacific. McMillen and Casey (1978) reported association of *Spirocyrtis scaleris*, *Stylodictya multispina*, *Euchitonia furcata* in 50-100 m upper subsurface watermass in Gulf of Mexico.

Subcluster C_2 is comprised of 19 morphogroups and is chiefly characterized by *Eucecryphalus*, *Dictyo-Pseudodictyophimus*, *Pterocorys*, *Lamprocyclas-Lamprocyrtis*, *Cycladophora*, *Anthocyrtidium*, *Lophospyris-Phormospyris* and *Plectopyramidins* morphogroups. Kling (1979) reported *Eucecryphalus sestrodiscus*, *Dictyophimus crisae*, *Pseudodictyophimus gracilipse*, *Pterocorys zancleus*, *Lamprocyclas maritalis*, *Cycladophora davisiana*, *Anthocyrtidium zanguebaricum*, and *Phormospyris sp.* with abundance maxima at 100-200 m constituting lower subsurface watermass of northeast Pacific. *Lophophaenaeninds*, *Sethoperinids*, *Sethophormins*, *Pterocanium*, *Lithopeera-Cyrtopera*, *Eucyrtidium*, *Zygocircus*, *Nephrospyris*, *Androspyris* are other morphogroups associated with subcluster C_2. *Plectopyramidins* morphogroup, represented by *Cornutella profunda*, *Plectopyramis*, *Bathropyramis* etc., is a representative of deeper dwellers (>700-2000 m) in this cluster (McMillen and Casey, 1978, Kling, 1979). As majority of the morphogroups in subclusters C_1 and C_2 are representing upper and lower subsurface dwelling taxa, cluster C may be by and large safely correlated to the subsurface watermass (depth > 100 m) in present study. As no data on vertical distribution of living radiolarians within the water column of the Indian Ocean is available, one can rely on the informations from the other two oceans. However, it is inferred that faunal depth stratification of the water column in the Indian Ocean, especially the Central Indian Basin, is similar to the Atlantic and Pacific Oceans.

6.5.2 Q-MODE FACTOR ANALYSIS

Q-mode factor analysis has been widely used to obtain statistically sound faunal assemblages out of huge census data of numerous species, species groups. It has been effectively used in radiolarian (Sachs, 1971a,b & c; Dow, 1976; Lozano and Hays, 1976; Moore, 1978; Molina Cruz,1982; Morley, 1989a), and diatom (Burckle, 1989) studies from the surficial sediments. Similar approach has been adopted in present study also in order to obtain meaningful pattern of radiolarian assemblages which can be correlated with the physical, chemical and hydrographical parameters of the overlying water column.

Percentage of 47 morphogroups were subjected to Q-mode factor analysis. Four distinct factors representing a cumulative variance of 93.56% were obtained. Variance and cumulative variance of each factor is presented in Table 5, whereas varimax factor score matrix of each morphogroup is presented in Table 6. All four factors considered to be significant and are named after the most dominant morphogroup. Radiolarian factors and their dominant morphogroups are plotted as factor and morphogroup contour maps and factors are viewed in three dimensional perspectives at $45/45^0$ and $225/45^0$ of rotation of the axis of perspective by using SURFER program.

FACTOR 1 : (Pyloniids assemblages)

Factor 1 accounted for 45.3% of the total variance (Table 5) and is characterized by *Pyloniids* group (Table 6). Percentage of *Pyloniids* group and values of factor one are contoured (Figs. 23 a and b respectively), both of them show highest loading in the area shown by hatches. Dominance of the factor one is also presented three dimensionally (Figs. 23 c & d) for the better perspective.

TABLE 5

Factor loading matrix after varimax rotation of 47 morphogroups in 42 surface sediment samples from the Central Indian Basin

S.N.	Latitude	Longitude	Comunality	Factor 1	Factor 2	Factor 3	Factor 4
1.	02.050 S	82.079 E	.96417	-.33074	.75952	-.47357	-.15435
2.	05.000 S	82.090 E	.98321	-.44299	.48260	-.72975	.06697
3.	04.000 S	83.190 E	.98306	-.45163	.38042	-.77786	.13422
4.	04.000 S	84.000 E	.97953	-.16364	.96638	-.10573	-.03779
5.	01.080 S	85.000 E	.97724	-.29901	.88298	-.25600	-.13992
6.	01.125 S	87.020 E	.97999	-.13187	.93938	-.23299	-.10505
7.	08.070 S	86.109 E	.97149	-.48895	.37279	-.73248	-.02139
8.	07.012 S	88.155 E	.98066	-.21314	.41868	-.82914	-.26598
9.	06.001 S	88.090 E	.97339	-.73979	.43940	-.26749	-.09615
10.	05.075 S	88.180 E	.95940	-.30023	.83050	-.30679	-.19944
11.	03.062 S	88.065 E	.97052	-.56788	.55693	-.51481	-.19053
12.	01.059 S	88.095 E	.96668	-.27787	.76643	-.49774	-.20155
13.	13.500 S	73.999 E	.98263	-.89214	.32416	-.24803	-.08292
14.	14.002 S	73.001 E	.89576	-.57786	.39183	-.07227	-.62890
15.	12.490 S	77.011 E	.98488	-.87482	.29748	-.28187	.10865
16.	05.000 S	75.992 E	.95479	-.49783	.78485	-.27495	.06609
17.	07.027 S	76.002 E	.97326	-.93929	.16947	-.13843	.13418
18.	07.444 S	78.954 E	.98367	-.82948	.46980	-.22978	-.05718
19.	07.550 S	78.467 E	.96623	-.50244	.66418	-.39080	-.27111
20.	07.489 S	78.014 E	.98558	-.57343	.57404	-.53888	-.1722
21.	08.024 S	76.967 E	.97302	-.89724	.23760	-.23057	-.22008
22.	07.021 S	76.980 E	.98239	-.72319	.51096	-.35494	-.15560
23.	07.004 S	78.495 E	.97362	-.64359	.40442	-.53645	-.31144
24.	07.067 S	79.500 E	.96608	-.80213	.34496	-.24210	-.32016
25.	06.468 S	77.439 E	.96848	-.65751	.59981	-.39864	-.09091
26.	06.500 S	78.945 E	.97431	-.50593	.55982	-.57016	-.15528
27.	12.007 S	76.477 E	.97537	-.75415	.25926	-.46887	-.16392
28.	01.089 N	74.670 E	.93561	-.68751	.30856	-.52673	-.16690
29.	11.010 S	74.985 E	.97740	-.73943	.30653	-.33173	-.44945
30.	13.006 S	72.984 E	.98898	-.89968	.30122	-.29025	-.04941
31.	12.007 S	73.003 E	.98811	-.73272	.36232	-.46156	-.28109
32.	12.017 S	73.003 E	.98469	-.69811	.37401	-.54918	-.14188
33.	14.017 S	72.016 E	.99004	-.67724	.65790	-.19100	.05486
34.	11.999 S	70.990 E	.98583	-.75313	.51448	-.37586	-.07621
35.	11.969 S	75.465 E	.97977	-.79922	.32670	-.44026	-.19596
36.	12.006 S	76.452 E	.98311	-.88846	.15793	-.31565	-.19066
37.	11.514 S	81.490 E	.98899	-.88920	.26651	-.29363	-.15163
38.	13.510 S	78.979 E	.98242	-.76997	.34149	-.35672	-.21220
39.	15.090 S	83.560 E	.93188	-.76285	.25040	-.42365	-.25073
40.	15.487 S	82.950 E	.93023	-.67610	.30262	-.26838	-.35501
41.	14.890 S	73.530 E	.98154	-.80421	.33681	-.36563	-.16967
42.	15.500 S	72.991 E	.98729	-.86284	.33533	-.21633	-.13996
% Variace				45.29	25.99	17.77	04.45
% Cumulative variance				45.29	71.28	89.05	93.51

TABLE 6

Factor score matrix after varimax rotation.

S.N.	Morphogroups	Factor 1	Factor 2	Factor 3	Factor 4
1.	Collosphaera	-.11938	.06622	-.18115	-.3359
2.	Desolenia-Siphonosphaera	-.08504	-.01688	-.17025	-.0628
3.	Acrosphaera	-.07907	.04339	-.02394	-.1535
4.	Actinomma	-.01605	.05010	-.01930	-.0525
5.	Plegmosphaera	-.04295	-.00856	-.03119	-.0464
6.	Styptosphaera	-.01732	.01810	.01034	-.0195
7.	Spongodiscids	.06957	.91690**	.13188	.0300
8.	Cladococcus	.00454	.03725	.00450	-.0154
9.	Spongaster-Spongocore	.00102	.19101	-.01688	-.0211
10.	Elatomma-Haliomma	-.07312	.12595	.03420	.0092
11.	Hexacontium	-.14444	.12885	.11469	-.0043
12.	Amphirhopalum	-.00128	.00108	-.00208	-.0161
13.	Euchitoniids	-.04020	.02870	-.80286**	-.0313
14.	Stylodictya-clamydium	-.01822	.20066	-.46019*	.0071
15.	Artiscins (Didymocyrtis)	-.50850*	-.02526	.07491	.6389**
16.	Heliodiscus	-.02620	.04724	-.01078	-.0495
17.	Litheliids	-.08554	.02957	-.05589	-.0527
18.	Pyloniids (Tetra,Octapyle)	-.78207**	.00731	-.05595	.5620*
19.	Larcospira quadrangula	-.14655	.03881	.09429	-.2549
20.	Stylosphaera-Axoprunum	-.00432	.10106	.01014	.0353
21.	Plagiacanthins	-.00444	-.00006	-.02681	.0015
22.	Lophophaenins	-.02949	.01374	-.03829	-.0361
23.	Sethoperinids	-.00753	.01408	-.00800	.0073
24.	Zygocircus	-.06454	.04548	-.06482	.0509
25.	Lophospyris-Phormospyris	-.12661	.11068	-.08112	.0603
26.	Androspyris	-.00070	.00547	-.00377	.0090
27.	Liriospyris	-.03072	.03071	.00118	.0114
28.	Nephrospyris	-.00682	.00232	-.00863	.0087
29.	Sethophormins	-.03303	.02166	.01137	-.0145
30.	Eucecryphalus	-.00781	.00579	.00282	-.0090
31.	Plectopyramidins	-.00901	-.00899	-.02884	-.0426
32.	Pterocanium	-.04948	.04989	-.04073	-.0323
33.	Dictyoph.-Pseudodictyo.	-.00707	.00405	-.00571	-.0134
34.	Lithopera-Cyrtopera	-.00519	.00910	-.00197	-.0287
35.	Cycladophora	-.00036	.01508	.00700	-.0411
36.	Eucyrtidium	-.01137	.00493	-.04518	-.0453
37.	Pterocorythids	-.05549	.02994	-.00407	-.0900
38.	Theocorythium	-.02714	.02187	.00097	-.1092
39.	Anthocyrtidium	-.08229	.04109	.03168	-.1005
40.	Lamprocyclas-Lamprocyrtis	-.02187	.01582	.02844	-.0772
41.	Spirocyrtis	-.00061	-.00570	-.01632	-.0025
42.	Botryostrobus	.00626	-.00784	-.04019	-.0166
43.	Phormostichoartus	.00861	.00051	-.04200	-.0398
44.	Siphocampe	.00687	-.01588	-.04779	-.0182
45.	Cannobotryids	.00666	-.00857	-.03060	-.0035
46.	Carpocanistrum	-.00896	-.00445	-.01566	-.0367
47.	Carpocanarium	.00365	.00536	.00107	-.0148

** Values considered to be most significant contributor (morphogroup) in the factor. * Values considered to be secondary contributor (morphogroup) in the Factor.

The factor 1 is primarily characterized by **Pyloniids** (*Tetrapyle octacantha, Octopyle stenozona, and Hexapyle dodecantha)* morphogroup, whereas **Artiscins** (*Didymocyrtis tetrathalmus*) morphogroup is the secondary contributor (Table 6). The factor assemblage is named after the primary contributor **Pyloniids.** Representatives of this morphogroup *Tetrapyle octacantha* lives in depth range of 50-100 m in the water column of the Gulf of Mexico (McMillen and Casey, 1978). Similarly Kling (1979) found abundance maxima of *Tetrapyle octacantha* and *Octapyle stenozona* at 50 m of the water column in the north west Pacific Ocean. Though the distribution of the **Pyloniids** in water column of the Indian Ocean is not known due to the lack of the plankton tow study of the radiolarians, yet it could be reasonably sound to assume that **Pyloniids** may represent the surface water (0-50 m) characteristics in the Indian Ocean as well.

The basin generally witnesses south equatorial current throughout the year up to 10^0S, but influence of this current extends up to 7^0S during southwest monsoon (Fig. 4 b). The intensity of this current increases from $40X10^6m^3/s$ during northeast monsoon to $54X10^6m^3/s$ during southeast monsoon (Tchernia, 1980).

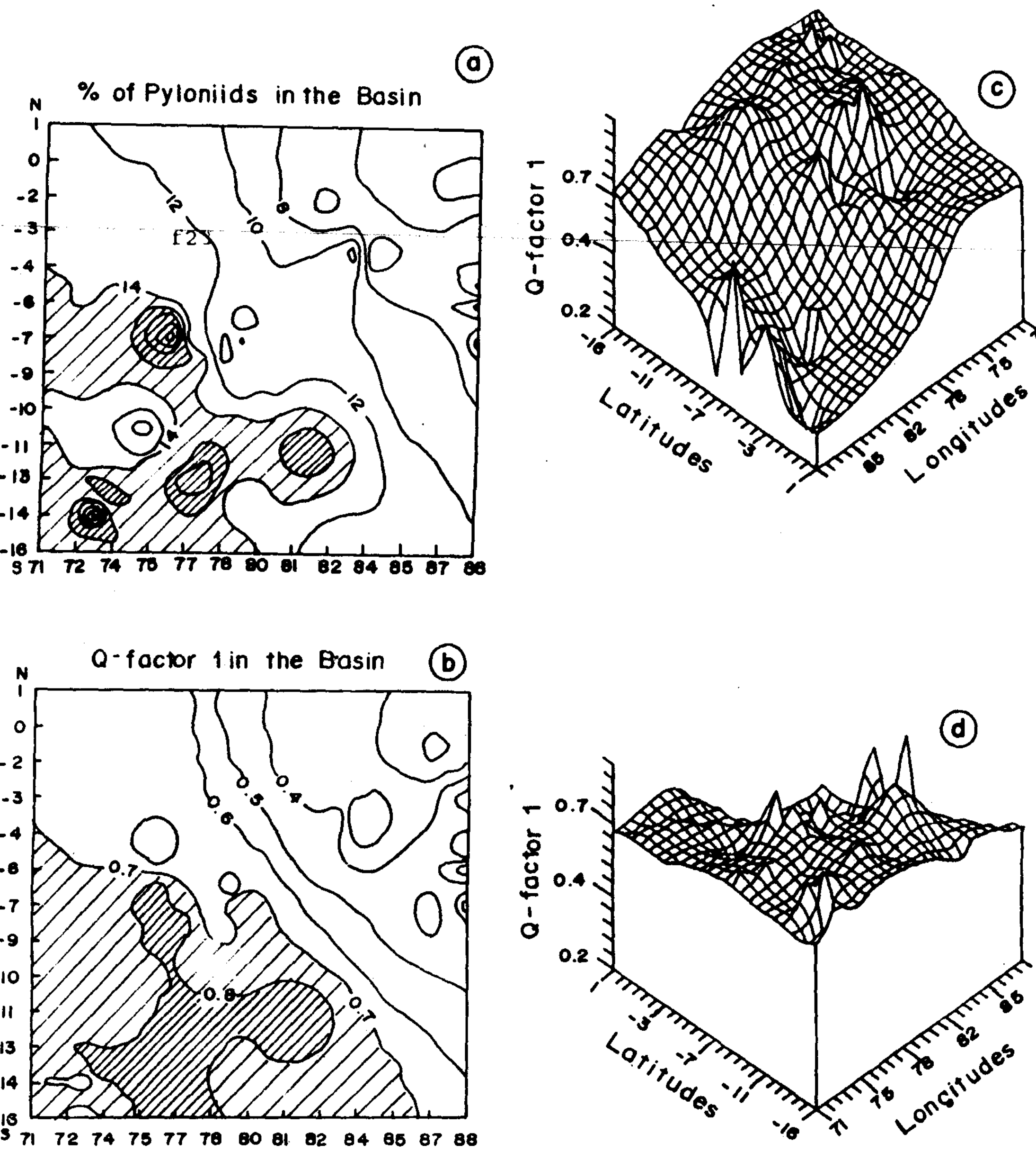

Figure 23. Computer generated contour maps [(a) percentage distribution of *Pyloniids* group; (b) loading of factor 1, higher loading shown with hatches] and three dimensional views [(c) at 45/45^{o} and (d) 225/45^{o} rotation of perspective axis] of factor 1 in the basin.

Another characteristic feature of this area is the presence of hydrographic front at 10^0S (Fig. 8) which separates monsoonal gyre in the north from the subtropical gyre in the south (Wyrtki, 1971). The influence of this front is evident between 7-16^0S on physicochemical characteristics of the watermass present in the basin. Distribution of chlorophyll-a in the surface water (Figs. 12 g, & h) is higher during southwest monsoon (0.2-0.3 µg-atom/l) than it is during northeast monsoon (<0.02 µg-atom/l). It is not out of place to mention here that the potential primary productivity of the surface water in this area is also higher in southwest monsoon period (0.2-0.5 MGC/m^3/h, Fig. 13 a) than it is during northeast monsoon (0.05-0.2 MGC/m^3/h, Fig. 13 b). Considering the dominance of all these parameters (south equatorial current, primary productivity, and 10^0S hydrographic front) in this part of the basin, this factor may be correlated with southwest monsoon associated with the south equatorial current. Another remarkable coincidence is that this transect broadly fall below 7-16^0S latitudes and may be reflecting the influence of hydrographic front at 10^0S as described earlier.

FACTOR 2 : (Spongodiscids assemblages)

Second factor accounted for 25.99 % of total variance (Table 5) and is characterized by *Spongodiscids* group (Table 6). Percentage of *Spongodiscids* group and values of factor 2 are contoured (Figs. 24 a & b respectively), both of them show highest loading in the area shown by hatches. Dominance of the factor 2 is also presented three dimensionally (Figs. 24 c & d) for the better perspective. Factor 2 has highest loading on northern part of the basin north of 6-7^{0}S latitude. **Spongodiscids** group includes *Spongotrochus glacialis, Spongodiscus resurgense, Spongodiscus biconcavus* and *Spongopyle osculosa* in its counts. The reported depth of preference of *Spongotrochus longispinus, Spongotrochus multispinus* and *Spongopyle streptacantha* is 50-100 m water column in the Gulf of Mexico (McMillen and Casey, 1978). The area of dominance of this factor in the basin is influenced by equatorial counter current (Fig. 4 a). In general there seems to be a marked boundary between factor 1 and 2 near 6-7^{0}S in the basin, which can be attributed to the beginning of the influence of hydrographic front at 10^{0}S in the basin.

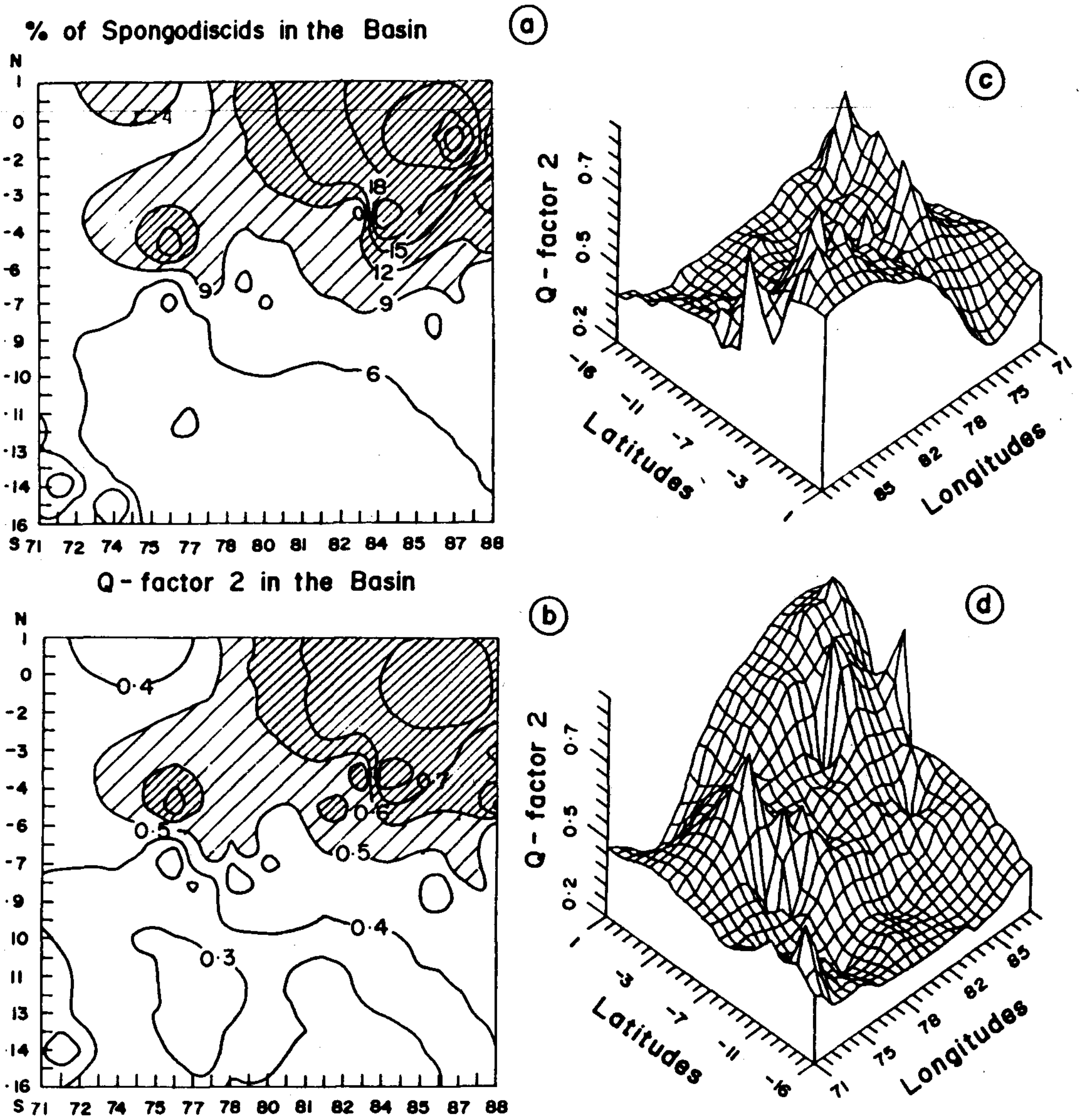

Figure 24. Computer generated contour maps [(a) percentage distribution of *Spongodiscids* group; (b) loading of factor 2, higher loading shown with hatches] and three dimensional views [(c) at 45/45^{o} (d) 225/45^{o} rotation of perspective axis] of factor 2 in the basin.

FACTOR 3 : (Euchitoniids assemblage)

Third factor accounted for 17.77% of total variance (Table 5) and is characterized by *Euchitoniids* group (Table 6). Percentage of *Euchitoniids* group and values of factor 3 àre contoured (Figs. 25 a & b respectively), both of them show highest loading in the area shown by hatches. Dominance of the factor 3 is also presented three dimensionally (Figs. 25 c & d) for the better perspective. **Euchitoniids** group comprises of *Euchitonia elegans, E. furcata, Euchitonia sp. Dictyocoryne truncata, Dictyocoryne profunda, Hymeniastrum euclidis. Euchitonia furcata, Euchtonia elegans Rhopalastrum profundum* prefer 50-100 m of the water column in the Gulf of Mexico (McMillen and Casey, 1978). The depth dominance of this morphogroup in this part of the basin needs more critical assessment in term of subsurface water hydrography. The seasonal variation in surface water primary productivity, temperature, and nutrient (Fig. 12) do not show any correlation with distribution of this factor. Seasonal variation in surface salinity (Fig. 6) has only minor changes and also does not show clear relationship. Therefore, subsurface hydrographic characteristics are taken into consideration. Seasonal variation in subsurface salinity and oxygen content is evident along the

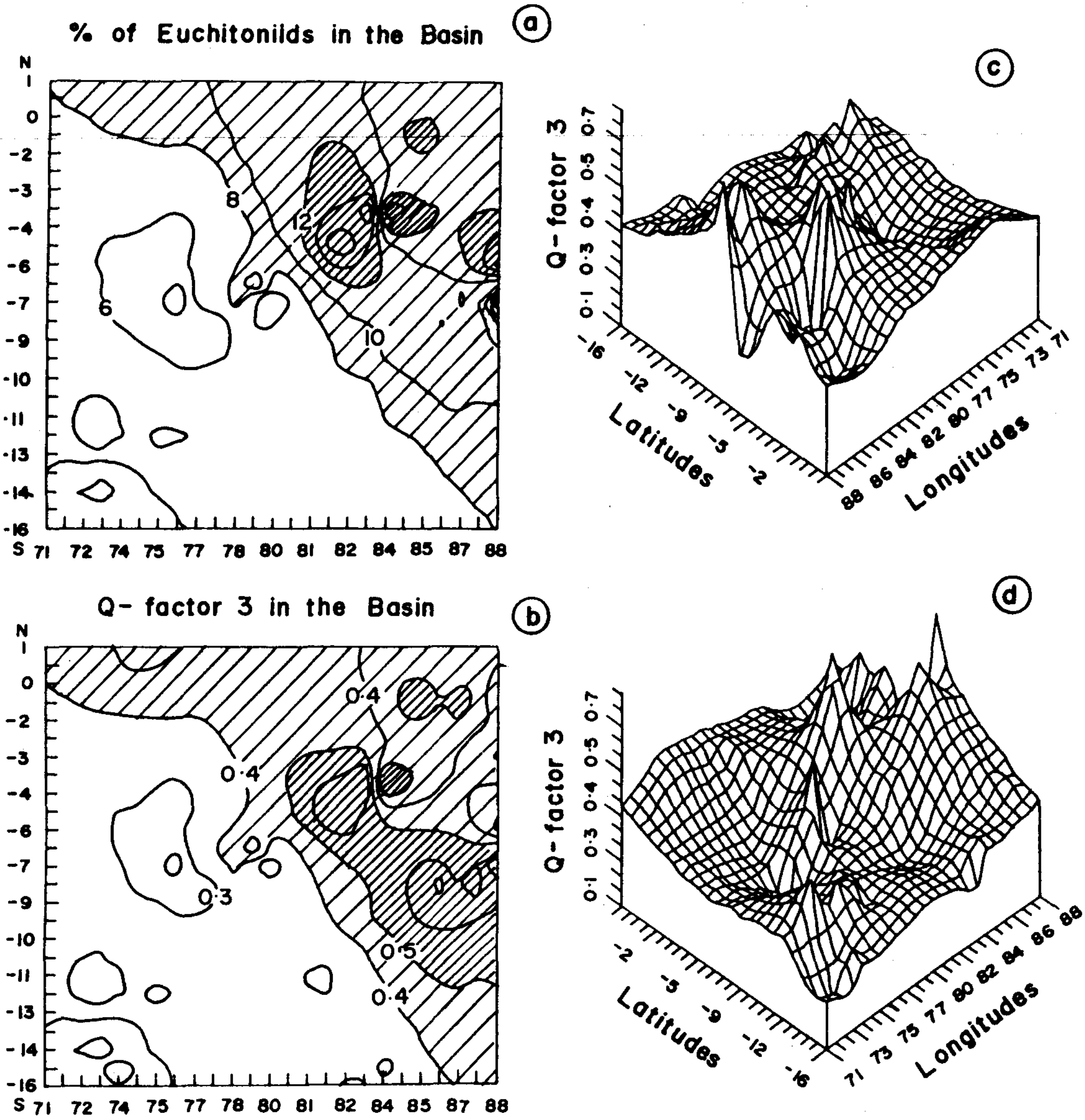

Figure 25. Computer generated contour maps [(a) percentage distribution of *Euchitoniids* group; (b) loading of factor 3, higher loading shown with hatches] and three dimensional views [(c) at 45/45^{o} and (d) 225/45^{o} rotation of perspective axis] of factor 3 in the basin.

equator (IIOE profiles 36 & 37, Figs. 14 a-d) and also from north to south along 75^0E and 92^0E (Figs. 14 e & h) within the basin. Subsurface potential temperature, salinity, silicate and phosphate distribution in a vertical profile from the Central Indian Basin (GEOSECS observations, Fig. 15) are illustrated in order to compare them with the third factor. Seasonal changes in subsurface hydrography seems to be controlling the third factor within the basin. Kling (1976) has reported the relationship of radiolarian distribution with subsurface hydrography. The ecology of radiolarian species constituting this factor also show preference to subsurface watermass.

FACTOR 4 : (Artiscins assemblage)

Factor four is a minor one, accounted for 4.45 % of the total variance (Table 5), and is characterized by *Artiscins* group (Table 6). Percentage of *Artiscins* group and values of factor 4 are contoured (Figs. 26 a & b respectively), both of them show highest loading in the area shown by hatches. Dominance of the factor 4 is also presented three dimensionally (Figs. 26 c & d) for the better perspective. Factor loading of this assemblage show prominence in southern part of the basin, though contour loading for the same is at 0.2 only (Fig. 26 b). This entire area is primarily dominated by factor 1. Factor four

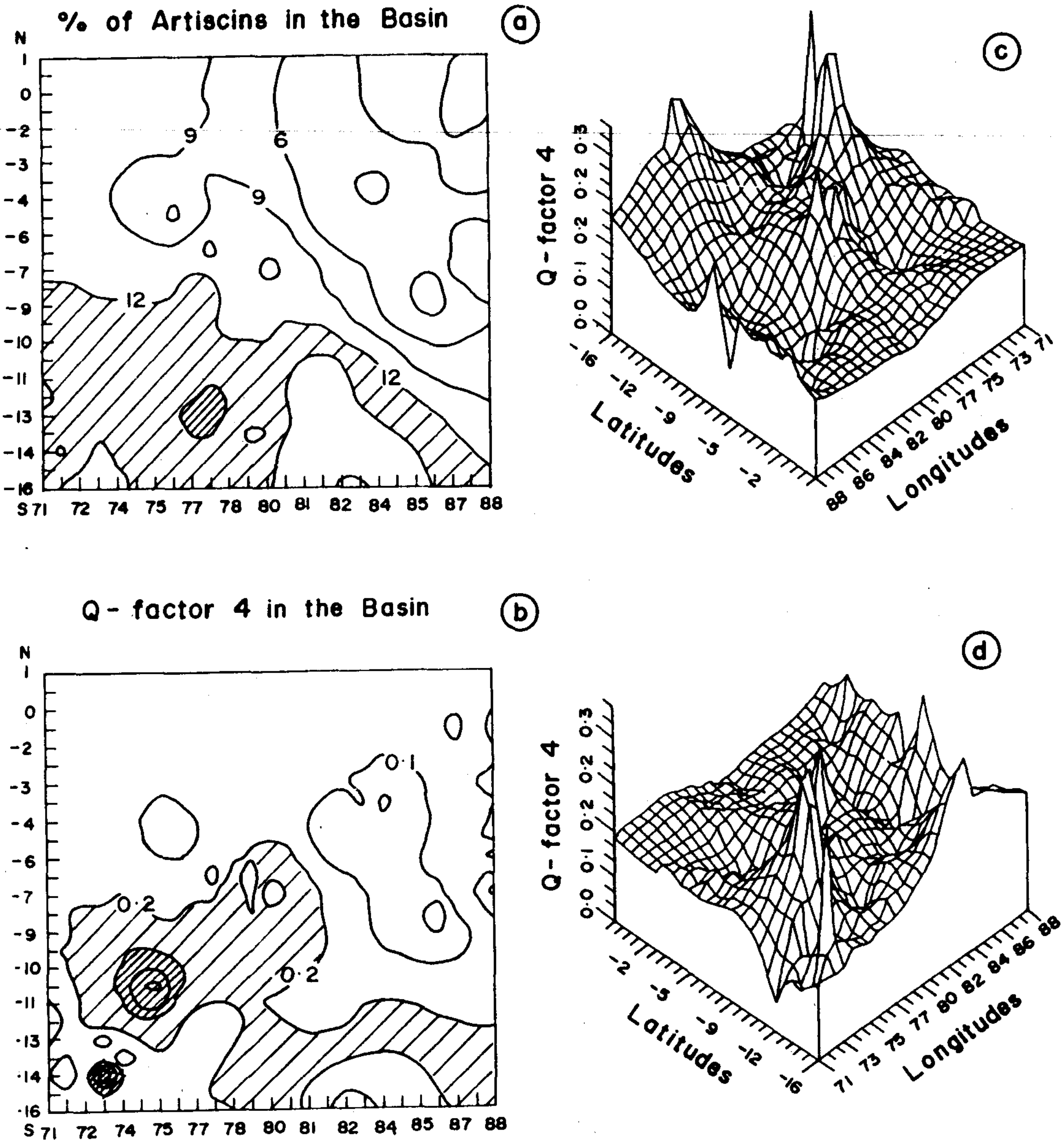

Figure 26. Computer generated contour maps [(a) percentage distribution of *Artiscins* group; (b) loading of factor 1, higher loading shown with hatches] and three dimensional views [(c) at 45/45^{o} and (d) 225/45^{o} rotation of perspective axis] of factor 4 in the basin.

is primarily characterized by *Artiscins (Didymocyrtis tetrathalmus tetrathalmus*) [Fig. 26 a, Table 6].

Pyloniids group (*Tetrapyle, Octopyle, Hexapyle*) is second most dominant group (Fig. 23 a, Table 6). Here it should be recalled that both of these morphogroups (**Artiscins** and **Pyloniids**) also characterize the factor one, but order of their dominance are reverse (Table 6). McMillen and Casey (1978) and Kling (1979) found the abundance maxima of *Didymocyrtis tetrathalmus* at 0-50 m surface water in their studies. It is again confirmed that *Didymocyrtis tetrathalmus* **(Artiscins)** and *Tetrapyle octacantha* **(Pyloniids)** are characterizing not only the same watermass and the water column (0-50 m) but also the same area in the basin. Therefore, factor four also indicates the characteristics of south equatorial currents as well as hydrographic front at 10^{0}S of equator, as in the case of factors one. Hence, factors one and four may be attributed as complimentary and indicators of south equatorial current and hydrographic front in the basin.

CHAPTER 7

7.0 PALEOCEANOGRAPHIC SIGNIFICANCE

Although radiolarian clusters and factors indicate preference to the surface and subsurface watermasses and geographically distinct faunal assemblages within the Central Indian Basin respectively, yet it will be beneficial to compare these results with distribution of other siliceous microfossils like diatoms in the northern Indian Ocean for a better understanding. In present chapter radiolarian factors (present study) and diatom factors (Burckle, 1989) are compared and potential of radiolarians as the indicator of monsoonal variation in geological past is discussed.

7.1 COMPARISON OF RADIOLARIAN AND DIATOM FACTORS

Radiolarian factors obtained in present study, when compared with diatom factors of Burckle (1989) in the Indian Ocean, show somewhat similar trend in the dominance of distinct geographical areas within the basin (Fig. 27).

Burckle (1989) studied the distribution of diatom species in the surface sediment of northern Indian Ocean. He analyzed percentage data of twenty-one diatom species using Q-mode factor and obtained three diatom factors (cumulative variance 93.08%) in the

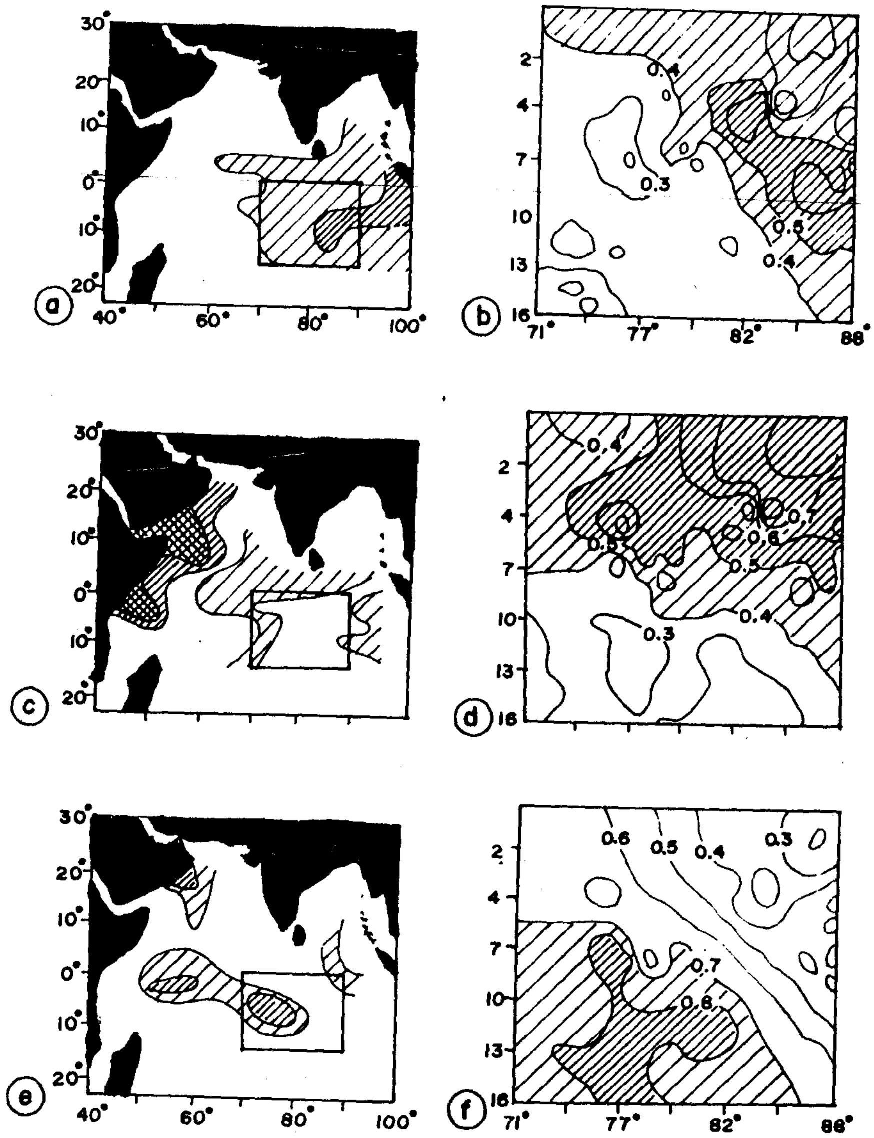

Figure 27. Comparison of diatom factors in the equatorial Indian Ocean (Burckle, 1989) and radiolarian factors in the Central Indian Basin. Rectangle within figures a,c, and e indicate area of Central Indian Basin. a = Diatom factor 1 with high loading off Sumatra and its extension into central Indian Basin. b = Radiolarian factor 3 with higher factor loading in southeastern part of the basin. c = Diatom factor 2 with poor loading in the equatorial region. d = Radiolarian factor 2 with higher loading in northern part of the basin. e = Diatom factor 3 with equatorial dominance (swell and pitch). f = Radiolarian factor 1 with higher loading in southwestern part of the basin. Note the similarity in the dominance of diatom and radiolarian factors in the region.

northern Indian Ocean. His first factor accounted for 44% variance and is characterized by *Nitzschia marina, Thalassionema nitzscioides, T. nitzschiodes var. parva, T. nitzschioides var. obtusum* and *Pseudoeunotia doliolus* species. Maximum dominance (>0.9) of diatom factor one is located off Sumatra with a protruding tongue into the Central Indian Basin (Fig. 27 a). Radiolarian factor 3 characterized by *Euchitoniids* in present study has almost same area of occupancy as the diatom factor 1 (Fig. 27 b). Burckle (1989) attributed his first factor representing the northeast monsoon in the Indian Ocean. Since distribution of radiolarian factor 3 and diatom factor 1 are in general agreement, radiolarian factor 3 can be considered as indicator of the northeastern monsoon in the basin.

Burckle's second diatom factor (variance 44.29%) is characterized by *Azpeitia nodulifer* species. This factor is abundant in equatorial region and shows dominance around Arabian and Somalian upwelling region. The second factor of Burckle though does not match with any of the radiolarian factor in toto, yet can be considered to be reflected in the equatorial dominance of radiolarian factor two (Figs. 27 c & d).

He attributed his second diatom factor related to southwest monsoon in the Indian Ocean.

His third diatom factor (variance 4.87%) is characterized by *Rhizosolenia bergonii* and dominates the western (especially the equatorial one) Indian Ocean. Its dominance in the equatorial Indian Ocean is a swell and pitch outlined area, whose eastern end is located in the western part of the Central Indian Basin (Fig. 27 e). According to Burckle (1989) this factor is related to the southwest monsoon since it has highest loading along the western equatorial region dominated by east-west flowing southwest monsoon current (Defant, 1961; Prell *et al.*, 1980). Radiolarian factors one and four characterized by *Pyloniids* and *Artiscins* morphogroups are dominating in the southwestern part of the Central Indian Basin (Fig. 27 f).

Comparison of Figures 27 e and 27 f shows that area of dominance of diatom factor 3 and cumulative dominance of radiolarian factors one and four are same. The dominance of the diatom factor 3 in this area shows influence of southwest monsoon. Therefore it is safe to infer that radiolarian factors 1 and 4 represented by **Pyloniids** and **Artiscins** morphogroups indicate effect of southwest monsoon.

7.2 *PALEOCEANOGRAPHIC SIGNIFICANCE*

Radiolaria represent the physical and hydrographic conditions of the watermasses in which they inhabit and thrive. Though majority of them are cosmopolitan and can occur in a broader geographical area, which may cover major part of the globe, it is their relative abundance which ascertains their dominance over the other species or morphogroups. For example *Cycladophora davisiana davisiana* is an abundant species in subtropical and subpolar waters (Morley 1977, Morley and Hays, 1979; Lombari and Boden, 1985) and characterizes cold polar subpolar watermass, but the same species is also occurring in the equatorial Central Indian Basin in present study in traces. So it is the dominance of the species or morphogroup which characterizes the watermass and not their sheer occurrence. Therefore morphogroups studied in this work may serve as potential indices for paleoceanographic changes.

Surface distribution of the radiolarian factors in present study clearly indicates well defined wateramsses overlying the Central Indian Basin; (i) Counter equatorial current, (ii) South equatorial current (Fig. 4 a) and are well reflected in two prominent areas, representing the counter equatorial current and south equatorial current hydrographic front at 10^0S. Comparisons of diatom factors in previous pages indicate that the basin also witnesses SW and NE monsoonal effects, which are reflected in factors 1 & 4 and 3 respectively (Figs. 27 a-f). As the region is equatorial hence oceanographic variations in geological past may not be as strong in term of glacial and interglacial as in the variation of SW and NE monsoonal intensities. This view is supported with the paleomonsoonal studies of Prell *et al*. (1980), Prell and Streeter (1981), Prell (1984), Prell and Van Campo (1986) and Prell and Kutzbath (1987) that during the glacial periods the monsoon was weaker and climate was drier than the interglacial one in the Indian Ocean. The monsoonal variations can be studied by counting *Pyloniids* and *Artiscins* together and *Euchitoniids* morphogroup in subsamples of the core. It can be plotted and monsoonal fluctuation in geological past may be ascertained clearly whether SW or NE monsoon were intense at certain geological period.

CHAPTER 8

8.0 CONCLUSIONS

Surficial distribution of radiolarians in the Central Indian Basin reveals the following points :

I. Northern part of the basin is characterized by poor radiolarian yield due to their dilution by dissolution resistant foraminifers like *G. menardi, G. duetritie* in unit weight as this part is shallower than the carbonate compensation depth (CCD) and within critical carbonate depth (CrCD.) and foraminiferal level (FL), i.e. lysocline. Region around 10-12^{0}S has highest number of rads/g and south of it radiolarian yield further decreases due to the poor primary productivity of the surface water beyond the hydrochemical front at 10^{0}S in the basin.

II. Nassellarians versus spumellarians (N/S) ratio indicates selective differential dissolution of nassellarians within the basin.

III. Two hundred and fifty radiolarian species are identified and illustrated (in eighteen plates). Hundred and eighteen species were hither to unreported and are being reported for the first time from the surface sediment samples from the Indian Ocean.

IV. R-mode cluster analysis indicates inter-relationship of 47 morphogroups. Cluster A and B represent the surface watermass whereas cluster C indicates subsurface watermasss within the basin. However, these faunal associations are from the surface sediment and they must be confirmed from the plankton tow or the time series traps at different water depth in the basin.

V. Q-mode factor analysis of forty-seven morphogroups in the surface sediment revealed 4 recognizable factors which can be grouped into three dominant factors i.e. (i) factor 1 & 4; (ii) factor 2 and (iii) factor 3, characterized by *Pyloniids, Artiscins; Spongodiscids* and *Euchitoniids* morphogroups respectively. Factors 1 & 4 can be correlated with diatom factor 3 of Burckle (1989) which represent a equatorial watermass complementary to SW monsoon. Factor 2 is correlated to equatorial counter current in the basin. Whereas factor 3 is comparable to diatom factor 1 of Burckle (1989) and characterizes NE monsoon in the basin.

VI Comparison of diatom factors of Burckle (1989) and radiolarian factors of present study clearly indicates that radiolarian are also influenced by the monsoonal seasonality in the Indian Ocean. Fluctuations in the monsoon in geological past can be studied by down core variation of radiolarian factors 1 & 4 and 3. Ratio of *Pyloniids* + *Artiscins* versus *Euchitoniids* morphogroups can be used to decipher the intensities of southwest and northeast monsoons in geological past.

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EXPLANATION TO THE PLATES

Radiolarian taxa are illustrated in 18 Plates. They are arranged in suborders, families and subfamilies as they appear in the taxonomy. Illustrations are transmitted light or scanning electron micrographs along with the magnification followed by corresponding reference number (J/18 and so on) for the future studies. All the specimens and the slides are housed at Geological Oceanography Division , National Institute of Oceanography, Dona Paula, Goa.

EXPLANATION OF PLATE -1 Family COLLOSPHAERIDAE

Scale bar is for 300 X magnification of LM only.

1.	*Collosphaera invaginata* (Haeckel)	LM	300	J/18
2.	*C. invaginata* (Haeckel)	LM	300	J/19
3.	*C. tuberosa* Haeckel	SEM	300	7/18
4.	*C. tuberosa* Haeckel	SEM	600	3/17
5.	*C. tuberosa* Haeckel	SEM	800	7/11
6.	*C. orthoconus* (Haeckel)	LM	300	B/7
7.	*C. desaii* Sp. Nov. (Holotype)	LM	300	J/8
8.	*C. desaii* Sp. Nov. (Paratype)	LM	300	J/9
9.	*C. polygona* Haeckel	LM	300	L/10
10.	*C. polygona* Haeckel	SEM	800	7/21
11.	*C. huxleyi* Muller	SEM	800	4/1
12.	*C. huxleyi* Muller	LM	300	F/25
13.	*Collosphaera sp.*	LM	300	S/18
14.	*Collosphaera sp. aff. C. huxleyi* Muller	LM	300	F/8
15.	*C. sp. aff. C . huxleyi* Muller	LM	300	L/22
16.	*C. sp. aff. C. huxleyi* Muller	LM	300	---
17.	*C. sp. cf. C. huxleyi* Muller	SEM	800	3/26
18.	*C. sp. aff. C. huxleyi* Muller	LM	300	J/31
19.	*C. armata* Brandt	SEM	500	7/2
20.	*C. confossa* Takahashi	SEM	800	4/35
21.	*C. confossa* Takahashi	LM	300	F/15
22.	*C. armata* Brandt	LM	120	F/22
23.	*Collosphaera sp.* Muller	LM	300	R/19

24.	*Collosphaera sp.*	SEM	800	6/28
25.	*C. polygona* Haeckel	LM	120	F/27
26.	*C. polygona* Haeckel	LM	120	F/27
27.	*C. polygona* Haeckel	LM	120	----
28.	*Collosphaera tuberosa* Haeckel			
29.	*Collosphaera sp.*	SEM	1040	5/1
30.	*Collosphaera sp.*	SEM	800	3/34
31.	*Collosphaera sp.*	LM	300	----
32.	*Collosphaera sp.*	SEM	400	2/18
33.	*Collosphaera sp.*	LM	300	O/4

PLATE-I

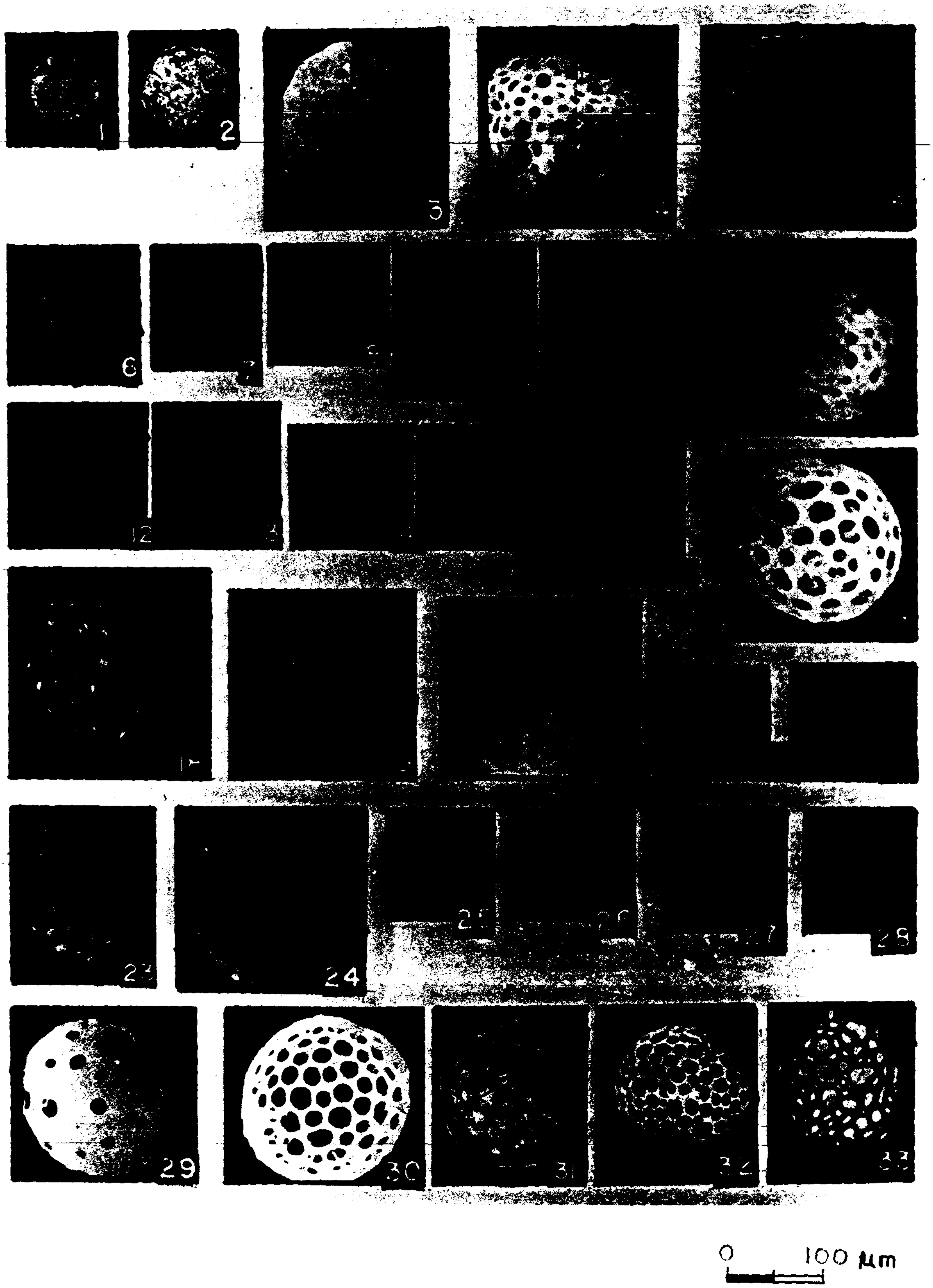

PLATE 2 Family COLLOSPHAERIDAE (Contd.)

Scale bar is for 300 X magnification of Lm only.

1.	*Collosphaera sp.*	LM	300	H/29
2.	*Collosphaera sp.* (focussed on equator)	LM	300	H/28
3.	*Collosphaera sp.*	LM	300	O/6
4.	*Disolenia zanguebarica* (Ehrenberg)	SEM	600	5/24
5.	*D. quadrata* (Ehrenberg)	SEM	400	6/18
6.	*D. quadrata* (Ehrenberg)	SEM	800	5/17
7.	*D. zanguebarica* (Ehrenberg)	LM	300	H/15
8.	*D. Sp. A.* Takahashi	LM	120	F/23
9.	*Acrosphaera spinosa longiculispina* Takahashi	LM	300	J/14
10.	*A. spinosa coniculispina* Takahashi	SEM	800	6/21
11.	*A. spinosa coronula* Takahashi	LM	300	J/13
12.	*A. spinosa coronula* Takahashi	SEM	500	3/22
13.	*A. lappacea* (Haeckel)	SEM	800	7/8
14.	*A. spinosa pseudoarktios* Caulet	LM	300	H/24
15.	*A. murrayana* (Haeckel)	LM	300	G/21
16.	*A. murrayana* (Haeckel)	SEM	500	6/13
17.	*A. collina* Haeckel	LM	120	G/1-2
18.	*A. cyrtodon* (Haeckel)	LM	300	J/18
19.	*A. cyrtodon* (Haeckel)	LM	300	L/4
20.	*A. cyrtodon* (Haeckel)	SEM	800	---
21.	*A. cyrtodon* (Haeckel)	LM	300	---
22.	*Acrosphaera sp. A*	LM	300	J/16
23.	*A. collina* Haeckel	LM	300	J/3

24.	*A. collina* Haeckel	LM	120	G/38
25.	*A. spinosa spinosa* (Haeckel)	LM	300	G/34
26.	*A. spinosa coniculispina* Takahashi	SEM	800	3/28
27.	*A. spinosa spinosa* (Haeckel)	SEM	600	4/6

PLATE-2

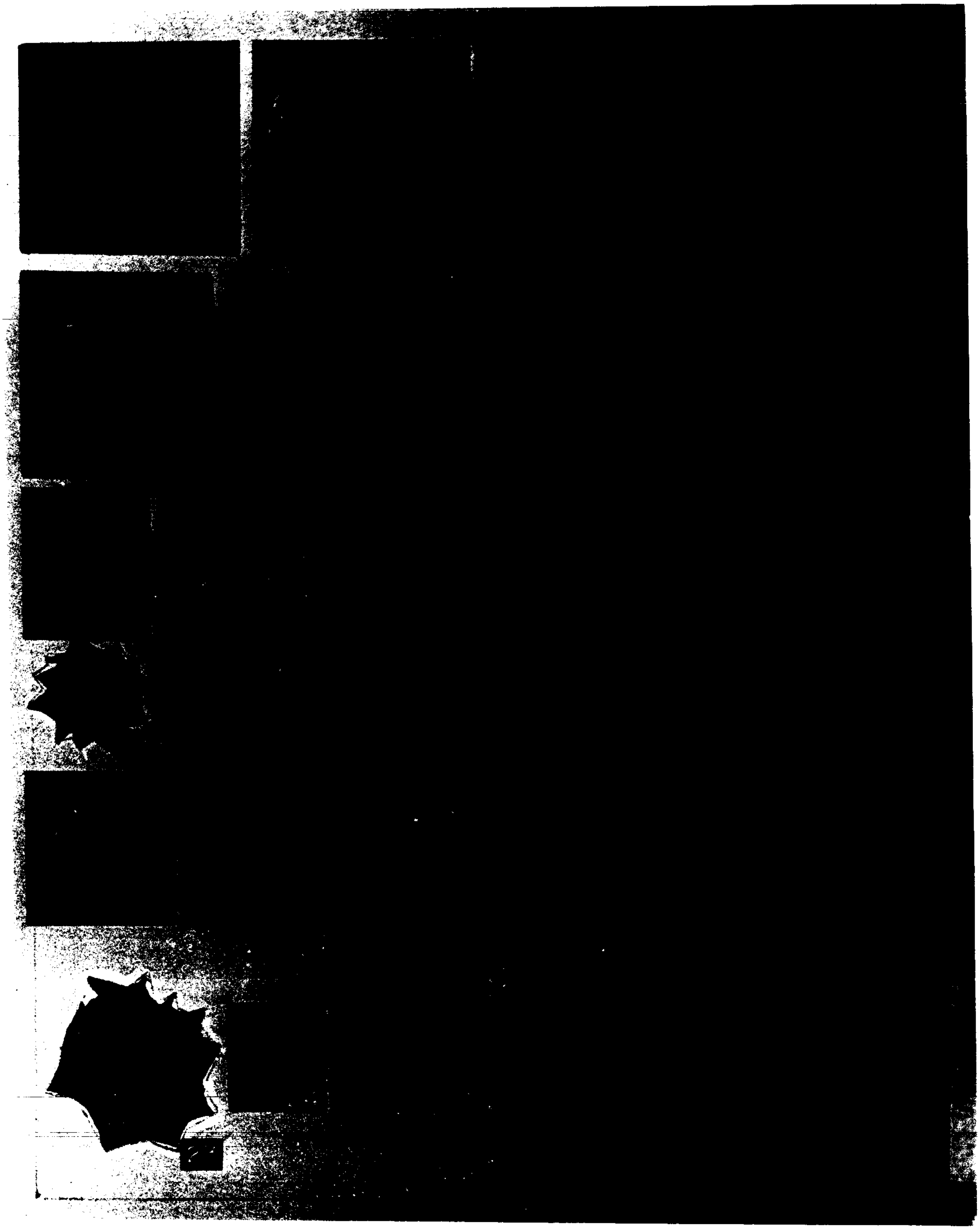

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Plate 3 Family COLLOSPHAERIDAE (Contd.) and ETHMOSPHAERIDAE

Scale bar is for 300 X magnification of LM only.

1.	*Otosphaera tenuissima* (Hilmers)	SEM	800	T/8
2.	*O. polymorpha* Haeckel	LM	300	F/29
3.	*O. auriculata* Haeckel	SEM	800	5/31
4.	*Siphonosphaera martensi* Brandt	SEM	800	6/9
5.	*S. polysiphonia* Haeckel	LM	300	G/35
6.	*S. polysiphonia* Haeckel	SEM	800	7/27
7.	*S. martensi* Brandt	SEM	500	5/15
8.	*S. polysiphonia* Haeckel	LM	300	Q/8-9
9.	*Siphonosphaera sp.*	LM	300	J/32
10.	*S. magnisphaera* Takahashi	LM	300	E/38
11-12.	*S. polysiphonia* Haeckel	LM	300	G/32,F/31
13.	*S. polysiphonia* Haeckel	LM	300	D/13
14.	*Plegmosphaera sp. B.* Takahashi	LM	300	----
15.	*Plegmosphaera sp.* Haeckel	LM	80	A/29
16.	*Plegmosphaera pachypila* Haeckel	LM	300	E/29
17.	*P. pachypila* Haeckel	SEM	800	4/2
18.	*P. coelipila* Haeckel	SEM	800	1/22
19.	*P. entodictyon* Haeckel	LM	300	A/5
20.	*Styptosphaera spongiacea* Haeckel	LM	300	J/11
21.	*Styptosphaera sp.* Haeckel	LM	300	E/9
22.	*Styptosphaera sp.* Haeckel	LM	300	J/9
23.	*Styptosphaera sp.* B Takahashi	SEM	540	2/33
24.	*Styptosphaera sp.* Haeckel	LM	300	I/18
25.	*Styptosphaera sp.* Haeckel	SEM	800	7/2

26.	*Styptosphaera sp.β*..	Takahashi	SEM	450	4/36
27.	*Styptosphaera sp.B*	Takahashi	SEM	800	2/22
28.	*Plegmosphaera coelipila*	Haeckel	SEM	800	1/3

PLATE - 3

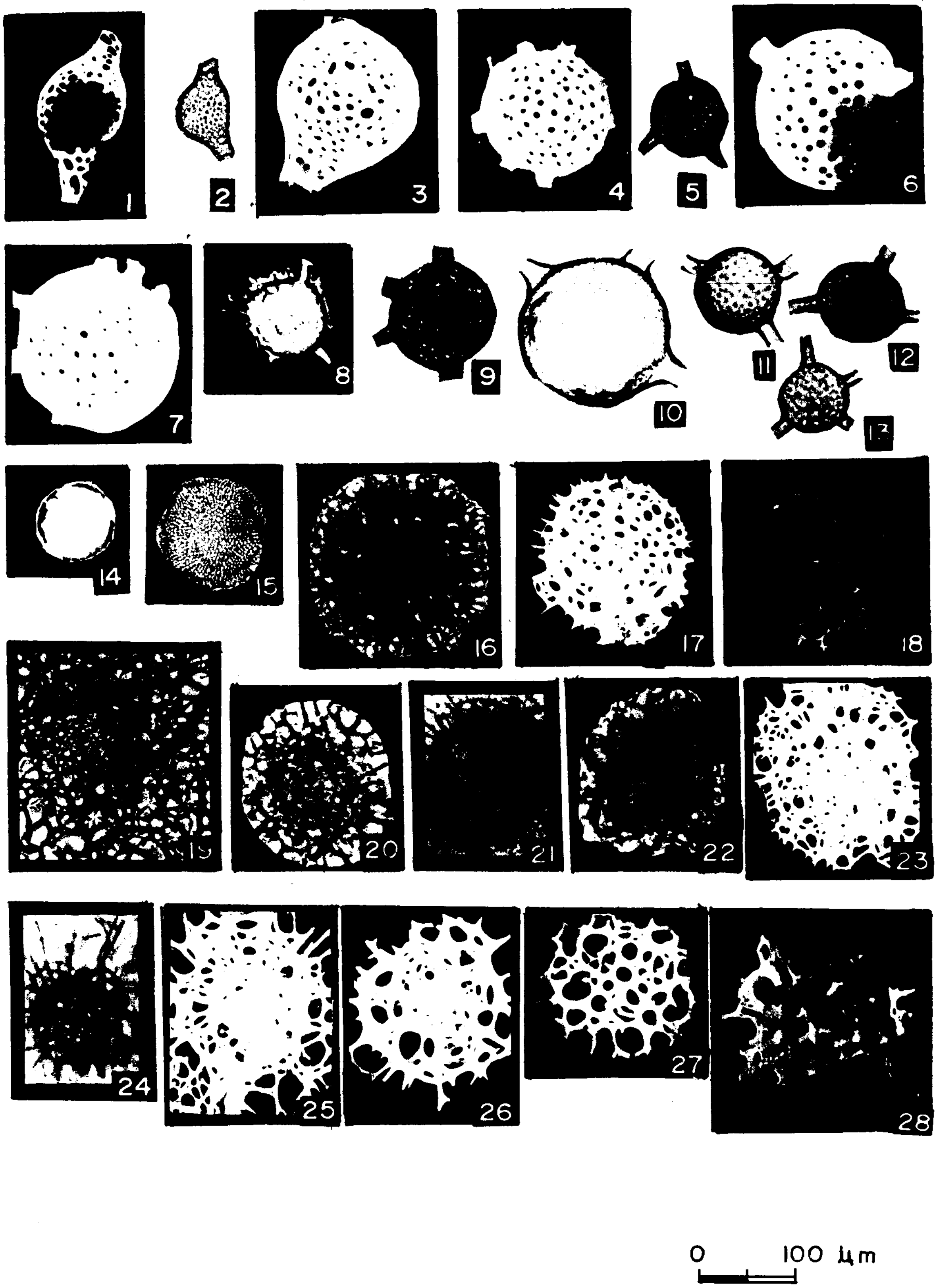


PLATE 4 Family ETHMOSPHAERIDAE (contd.) and ACTINOMMIDAE

Scale bar for 300 X magnification of LM only.

1.	*Plegmosphaera pachypila* Haeckel	LM	300	A/3
2.	*Styptosphaera sp.*C Takahashi	LM	300	A/6
3.	*Styptosphaera sp* (a part enlarged)	SEM	2000	7/1
4.	*Thecosphaera capillacea* Haeckel	SEM	400	5/34
5.	*T. capillacea* Haeckel	LM	300	E/29
6.	*T. inermis* (Haeckel)	SEM	800	4/9
7.	*T. inermis* (Haeckel)	SEM	1050	4/18
8.	*Carposphaera acanthophora* (Popofsky)	LM	300	J/7
9.	*C. acanthosphaera* (Poposky)	SEM	800	7/2
10.	*C. sp. aff. C. corypha* Haeckel	LM	300	S/38
11.	*C. sp. aff. C. corypha* Haeckel	SEM	600	1/25-26
12.	*Carposphaera sp. A*	SEM	450	4/34
13.	*Carposphaera sp. A*	SEM	120	K/22
14.	*Centrocubus cladostylus* Haeckel	LM	80	S/16
15.	*Centrocubus octostylus* Haeckel	LM	80	D/21
16.	*Spongosphaera polycantha* Muller	LM	80	D/22
17.	*S. polycantha* Muller	LM	80	H/13
18.	*Spongosphaera sp. aff S. heliodes* Haeckel	LM	80	A/27
19.	*Spongosphaera sp. A*	LM	120	G/28
20.	*Spongosphaera sp. A*	LM	120	G/26
21.	*Lychnosphaera regina* Haeckel	LM	80	D/20
22.	*L. regina* Haeckel	LM	80	D/8

PLATE - 4

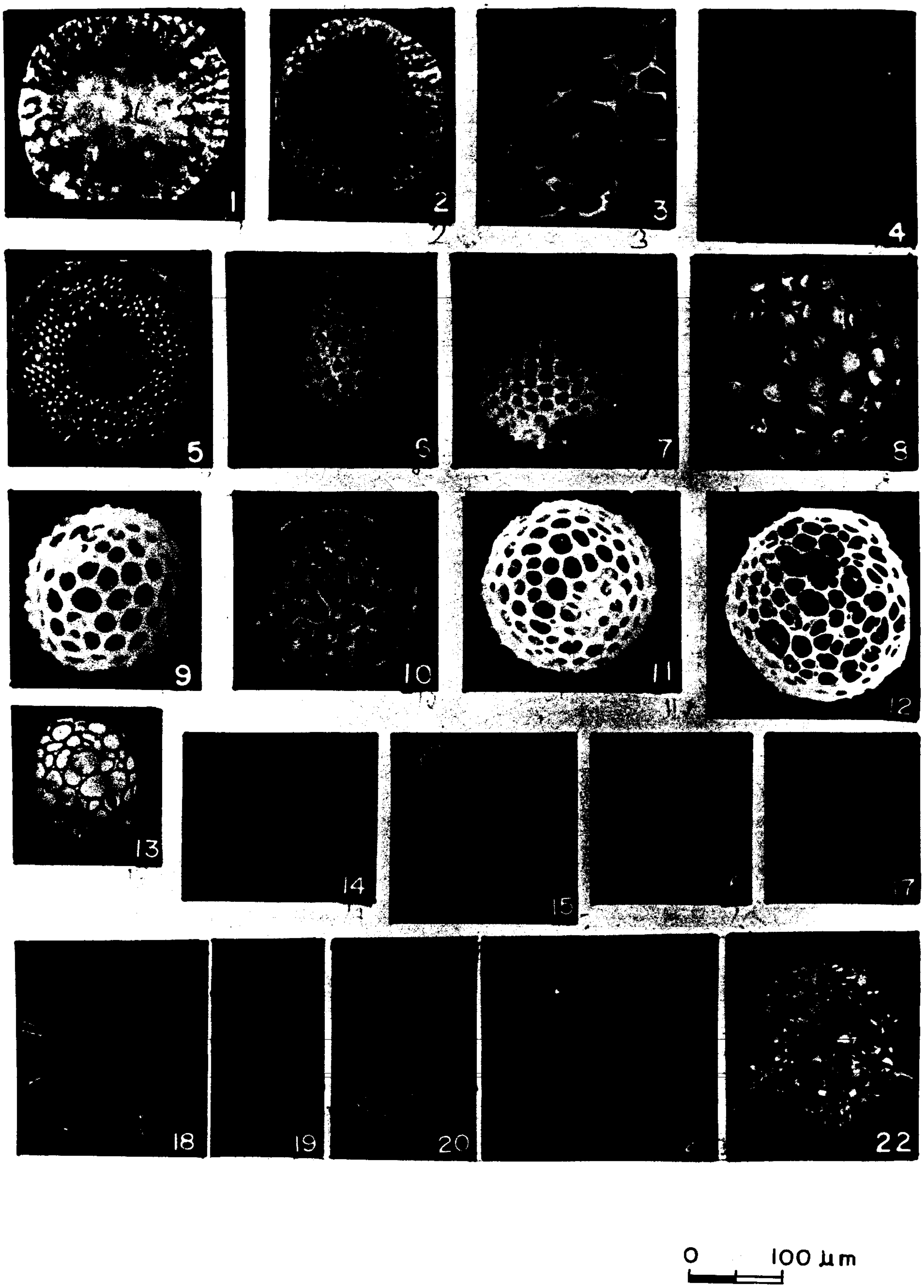


PLATE 5 Family ACTINOMMIDAE (contd.)

Scale bar for 300 X magnification of LM only.

1.	*Actinomma arcadophorum* Haeckel	LM	300	G/18
2.	*Actinomma sp.* Haeckel	SEM	450	3/9
3.	*Actinomma sp.* Haeckel	SEM	600	7/14
4.	*Acanthosphaera actinota* (Haeckel)	SEM	600	4/13
5.	*Acanthosphaera sp.* Haeckel	SEM	600	1/6
6.	*Acanthosphaera castanea* Haeckel	SEM	800	4/3
7.	*Acanthosphaera simplex* (Haeckel)	SEM	800	6/1
8.	*Heliosphaera radiata* Popofsky	SEM	1000	6/17
9.	*Cladococcus viminalis* Haeckel	LM	300	H/26
10.	*Cladococcus viminalis* Haeckel	LM	120	G/15
11.	*Cladococcus abietinus* Haeckel	LM	120	E/30
12.	*Cladococcus abietinus* Haeckel	LM	80	A/28
13.	*Cladococcus abietinus* Haeckel	LM	300	A/1
14.	*Cladococcus scoparius* Haeckel	LM	300	E/36
15.	*Cladococcus cervicornis* Haeckel	LM	300	A/17
16.	*Arachnosphaera myriacantha* Haeckel	LM	300	N/18
17.	*Actinosphaera tenella* (Haeckel)	SEM	500	3/7
18.	*Actinosphaera acanthophora* (Popofsky)	SEM	800	3/6
19.	*Actinosphaera capillacea* (Haeckel)	SEM	800	2/21
20.	*Haliomma sp.* Haeckel	SEM	600	3/18
21.	*Heliosoma sp. aff. H. radians* Haeckel	SEM	800	6/2

PLATE- 5

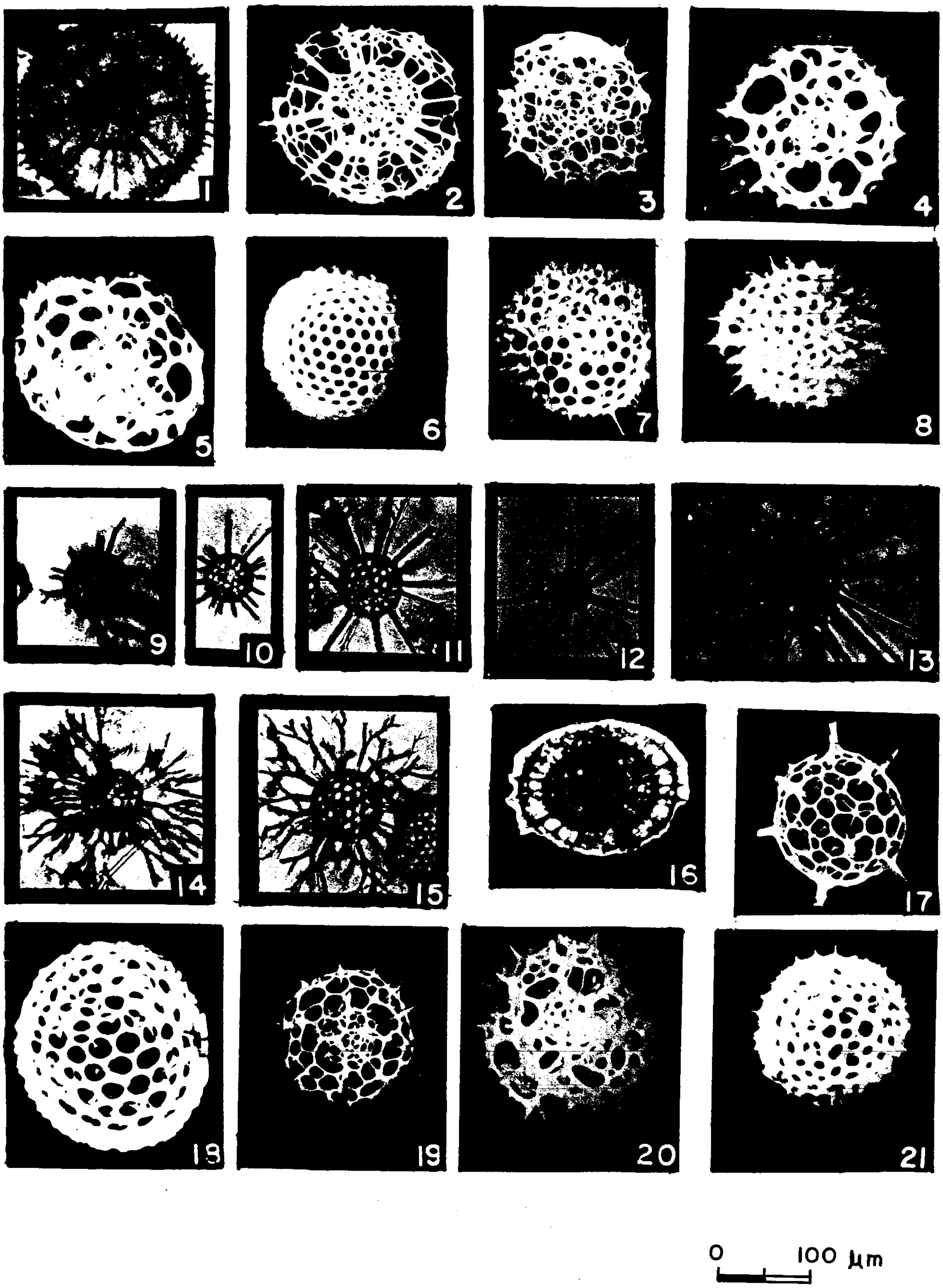


PLATE 6 Family ACTINOMMIDAE (contd.)

Scale bar is for 300 X magnification of LM only.

1.	*Elatomma penicillus* Haeckel	LM	300	E/33
2.	*E. penicillus* Haeckel (focussed before equator)	LM	300	E/34
3.	*E. pinetum* Haeckel	LM	80	E/28
4.	*Stylosphaera sp. A* Takahashi	SEM	850	2/30
5.	*Sphaeropyle mespilus* Dreyer	SEM	400	1/8
6.	*Cromyomma villosum* Haeckel	SEM	800	1/19
7.	*Astrosphaera hexagonalis* Haeckel	LM	80	J/27
8.	*Tholoma metallasson* Haeckel	SEM	600	7/23
9.	*Tholoma metallasson* Haeckel	SEM	500	3/14
10.	*Actinommid* gen. indet. sp. indet	SEM	1000	5/3
11.	*Hexacromyum elegans* Haeckel	SEM	600	4/7
12.	*Hexacontium hostile* Cleve	SEM	600	2/1
13.	*Heterosphaera sp. A* Takahashi	SEM	400	2/9
14.	*Hexacontium amphisiphon* Haeckel	SEM	400	2/9
15.	*H. amphisiphon* (pores of cortical shell)	SEM	2000	2/10
16.	*Hexacromyum elegans* Haeckel	SEM	1000	---
17.	*Hexacontium axotrias* Haeckel	SEM	400	2/11
18.	*Hexacontium sp. aff. H. hostile* Cleve	SEM	400	1/17
19.	*Hexacontium heracliti* (Haeckel)	SEM	600	2/13
20.	*Hexastylus triaxonius* Haeckel	SEM	600	1/32
21.	*Heterosphaera sp. B* Takahashi	SEM	400	2/26

PLATE- 6

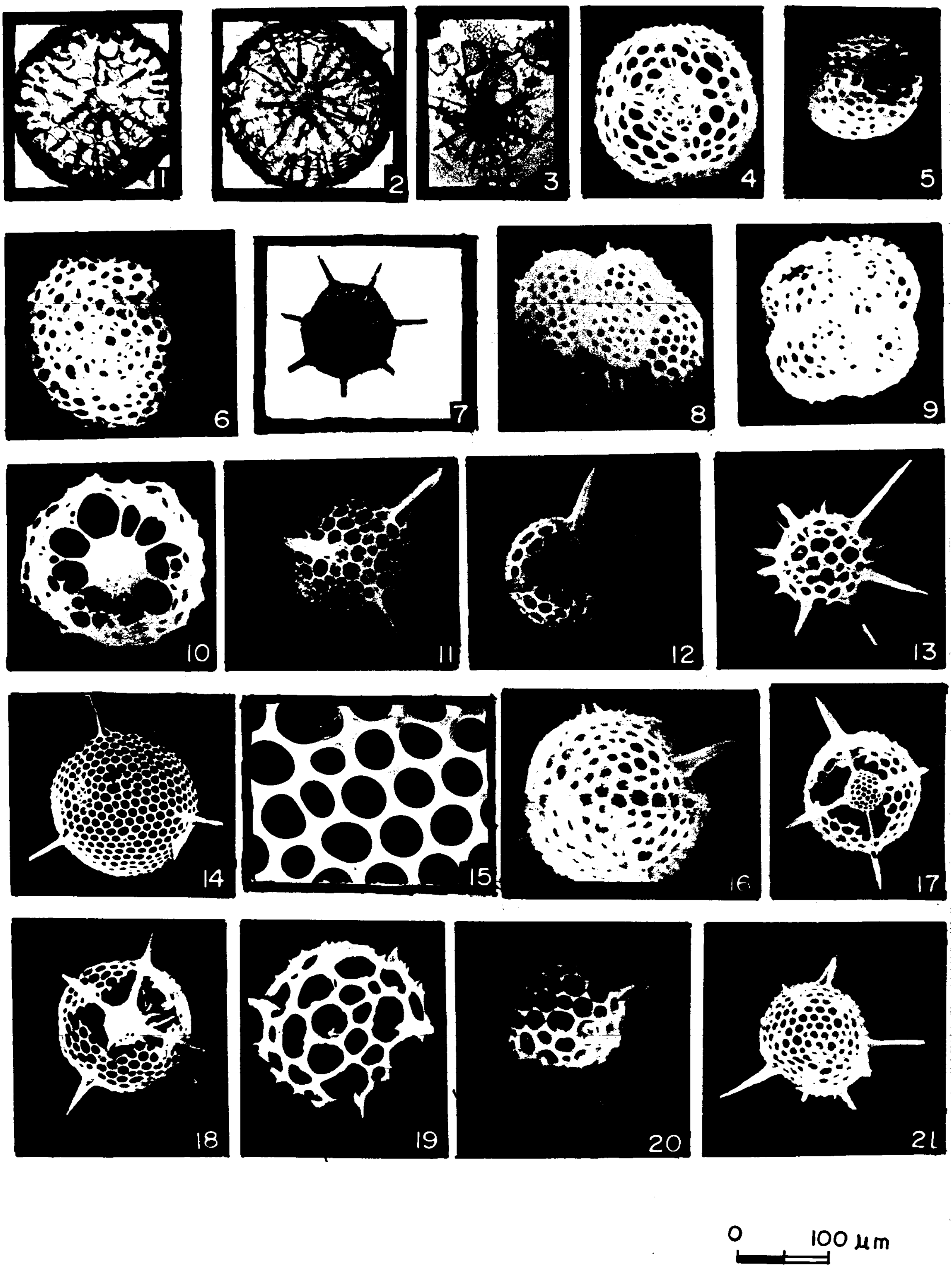
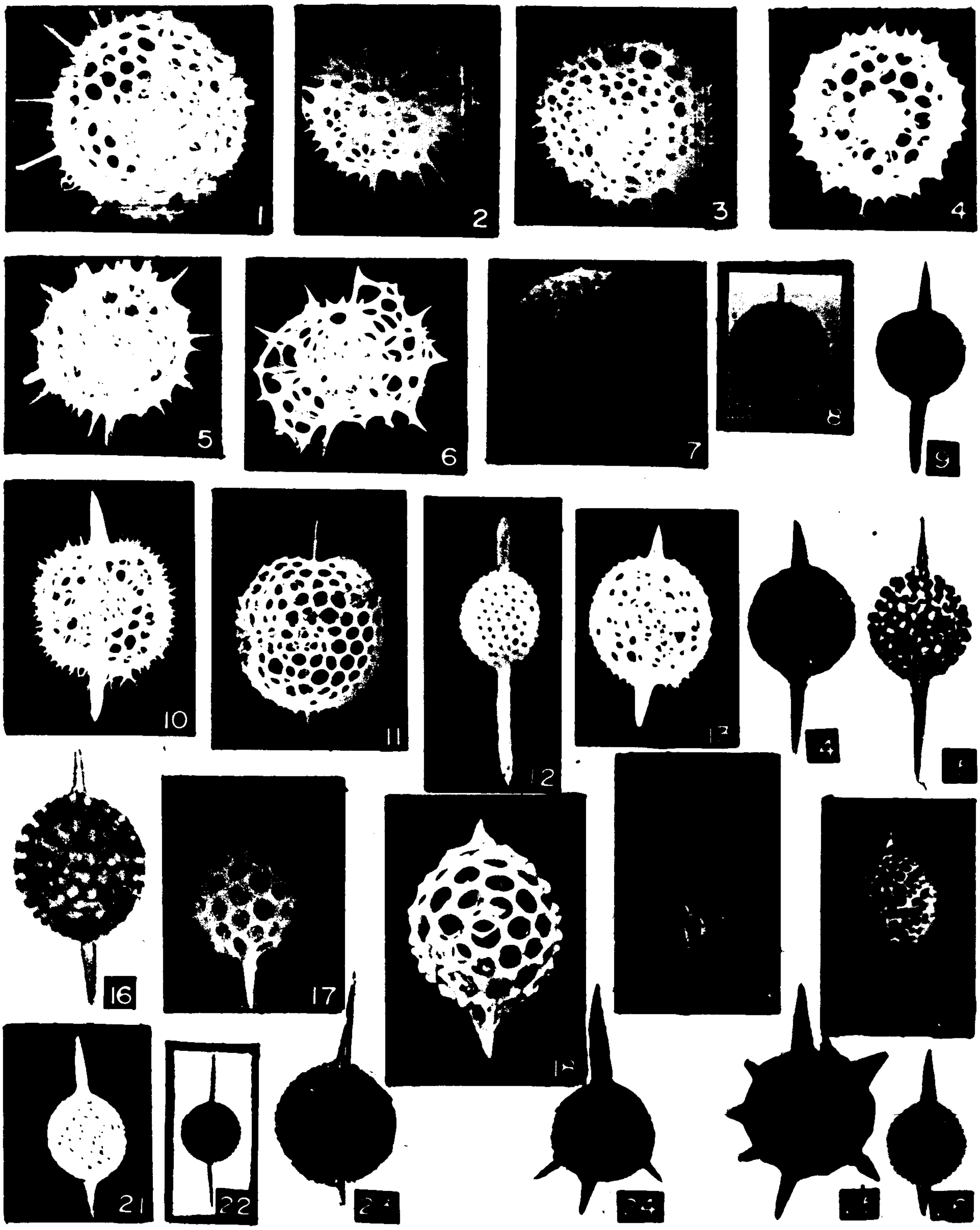


PLATE 7 Family ACTINOMMIDAE (contd.)
Scale bar is for 300 X magnification of LM only.

1.	*Cromyechinus sp.* Haeckel	SEM	960	7/11
2.	*Cromyechinus sp* Haeckel	SEM	600	7/13
3.	*Cromyechinus sp.* Haeckel	SEM	800	7/20
4.	*Cromyechinus sp.* Haeckel	SEM	800	1/29
5.	*Cromyechinus sp. aff. C. borealis* (Cleve)	SEM	800	3/23
6.	*Cromyechinus sp aff. C. borealis* (Cleve)	SEM	800	1/24
7.	*Actinomma sp.* Haeckel	SEM	600	4/9
8.	*Actinommaid sp. A.*	LM	300	H/25
9.	*Stylatractus sp.*	LM	300	C/32
10.	*Stylosphaera melpomene* Haeckel	SEM	600	3/31
11.	*Stylosphaera melpomene* Haeckel	SEM	600	4/5
12.	*Druppatractus ostracion* Haeckel	SEM	400	3/5
13.	*Ellipsoxiphium palliatum* Haeckel	SEM	600	3/32
14.	*Axoprunum stauraxonium* Haeckel	LM	300	D/13
15.	*Amphisphaera sp.* Haeckel	LM	300	C/16
16..	*Ellipsoxiphium palliatum* Haecker	LM	300	B/30
17.	*Xiphatractus sp. B* Takahashi	SEM	800	4/30
18.	*Xiphatractus sp. B* Takahashi	SEM	600	1/23
19.	*Druppatractus ? sp.* Takahashi	SEM	500	1/2
20.	*Axoprunum stauroxonium* Haeckel	SEM	400	3/23
21.	*Axoprunum stauroxonium* Haeckel	SEM	250	2/25
22.	*Stylatractus sp.*	LM	120	----
23.	*Stylatractus sp.*	LM	300	B/16
24.	*Axoprunum sp.*	LM	300	S/23
25.	*Hexacontium hystricina* (Haeckel)	LM	300	J/20
26.	*Stylosphaera sp.*	LM	300	C/6

PLATE- 7



0 100 μm

PLATE 8 Subfamilies Saturnalinae, Artiscinae;

Family PORODISCIDAE

Scale bar is for 300 X magnification of LM only.

1.	*Saturnalis circularis* Haeckel (oblique view)		300	B/15
2.	*Saturnalis circularis* Haeckel	LM	300	E/10
3.	*Didymocyrtis tetrathalmus* (Haeckel)	LM	300	A/34
4.	*Didymocyrtis tetrathalmus* (Haeckel)	SEM	600	7/4
5.	*Didymocyrtis tetrathalmus* (Haeckel) (internal of cortical twin-shell)	SEM	800	7/9-10
6.	*D. tetrathalmus tetrathalmus* (Haeckel)	SEM	400	7/22
7.	*D. tetrathalmus tetrathalmus* (Haeckel)	SEM	400	7/31
8.	*Spongoliva ellipsoides* Popofsky	LM	300	I/41
9.	*Euchitonia elegans* (Ehrenberg)	LM	120	I/11
10.	*Euchitonia elegans* (Ehrenberg)	LM	300	I/13
11.	*Euchitonia furcata* Ehrenberg	SEM	400	6/4
12.	*Euchitonia furcata* Ehrenberg	LM	210	I/16
13.	*Amphirhopalum sp.*	LM	300	H/4
14.	*Amphirhopalum virchowii* (Haeckel)	LM	300	C/19
15.	*Amphirhopalum virchowii* (Haeckel)	LM	300	C/3
16.	*Amphirhopalum ypsilon* Haeckel	LM	300	---
17.	*Amphirhopalum ypsilon* Haeckel	LM	300	B/11
18.	*Amphirhopalum ypsilon* Haeckel	LM	120	---
19.	*Amphirhopalum omalocladum* Caulet	LM	300	S/21
20.	*Amphirhopalum straussi* (Haeckel)	LM	600	---
21.	*Dictyocoryne profunda* Ehrenberg	LM	80	L/4

PLATE - 8

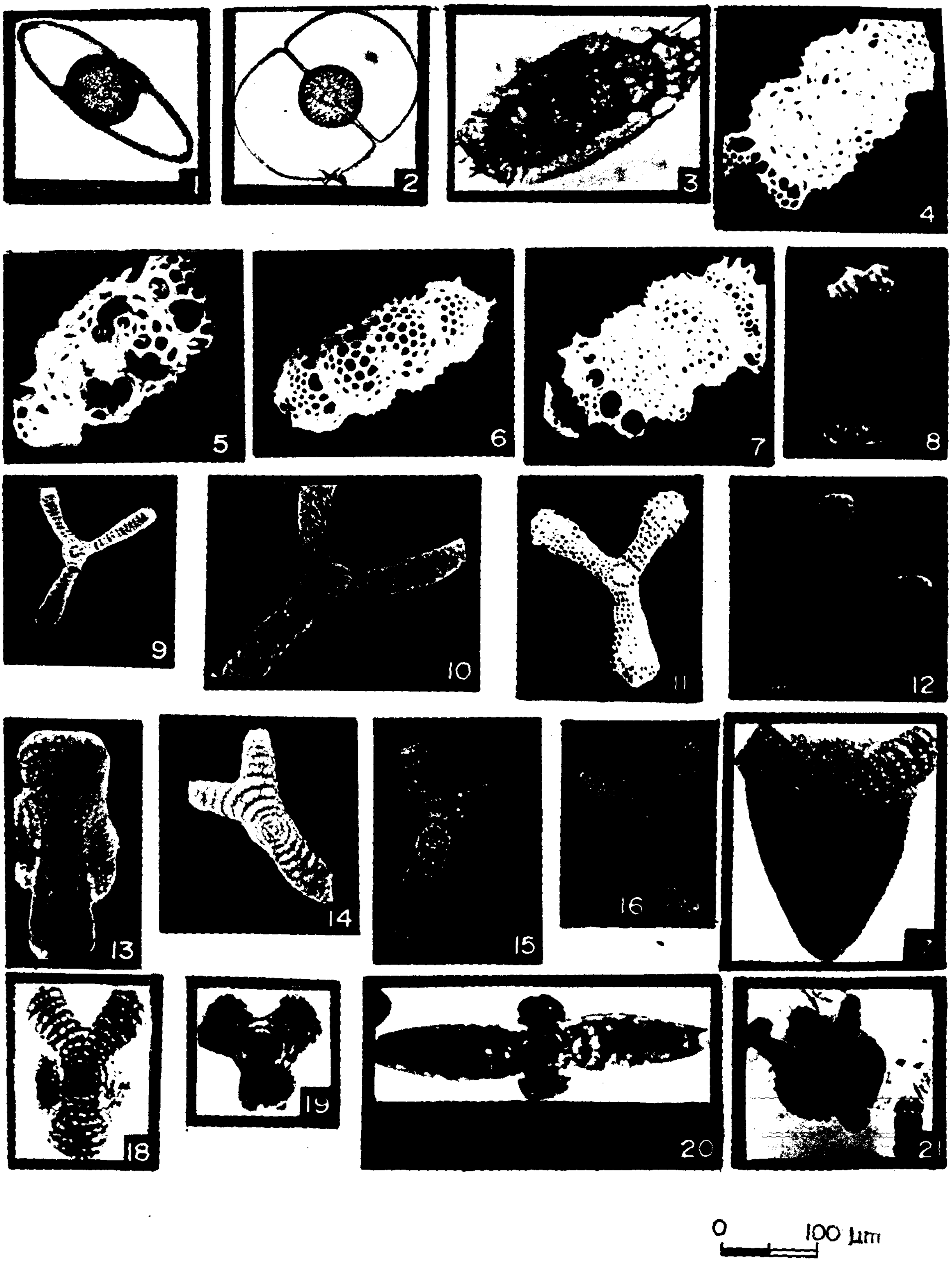
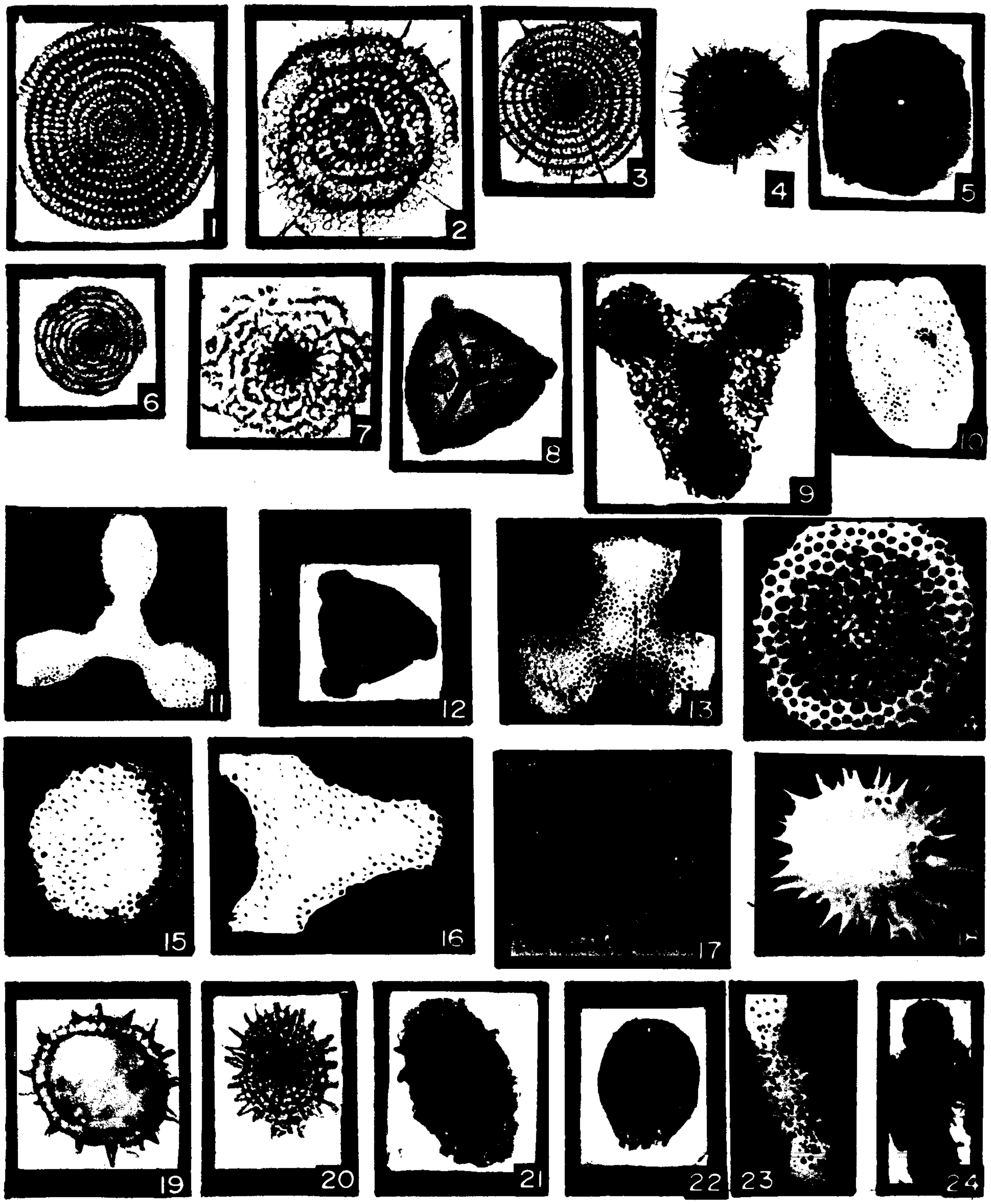


PLATE 9 Family PORODISCIDAE and SPONGODISCIDAE

Scale is for 300 X magnification of LM only.

1.	*Stylodictya validispina* Jorgensen	LM	300	S/24
2.	*Stylochlamydium asteriscus* Haeckel	LM	300	N/1
3.	*Stylodictya multispina* Haeckel	LM	300	S/17
4.	*Circodiscus microporus* (Stohr)	LM	300	H/1
5.	*Stylochlamydium venustum* (Bailey)	LM	300	H/2
6.	*Stylochlamydium venustum* (Bailey)	LM	300	H/3
7.	*Stylodictya aculeata* (Jorgensen)	LM	300	---
8.	*Rhopalastrum sp.*	LM	80	S/30
9.	*Dictyocoryne profunda* Ehrenberg	LM	300	---
10.	*Spongobrachium sp.* Haeckel	SEM	300	5/5
11.	*Dictyocoryne profunda* Ehrenberg	LM	300	3/21
12.	*Hymeniastrum euclidis* Haeckel	LM	80	S/2
13.	*Dictyocoryne truncatum* (Ehrenberg)	SEM	400	6/24
14.	*Spongodiscus resurgens* Ehrenberg	SEM	800	6/29
15.	*Spongodiscus biconcavus* Haeckel	SEM	800	2/17
16.	*Dictyocoryne sp. A*	SEM	600	1/27
17.	*Spongotrochus sp.*	LM	300	E/32
18.	*Spongotrochus sp.*	SEM	400	7/17
19.	*Spongotrochus sp.*	LM	300	K/25
20.	*Spongotrochus sp*	LM	300	G/36
21.	*Spongurus cf. elliptica* (Ehrenberg)	LM	300	G/23
22.	*Spongurus pylomaticus* Riedel	LM	300	G/31
23.	*Spongocore cylindrica* (Haeckel)	SEM	400	G/22
24.	*Spongocore cylindrica* (Haeckel)	LM	300	---

PLATE- 9



0 100 µm

PLATE 10 Family SPONGODISCIDAE, PHACCODISCIDAE and PYLONIIDAE

Scale bar is for 300 X magnification for LM only.

1.	*Spongopyle osculosa* Dreyer	LM	300	---
2.	*Spongaster tetras tetras* Ehrenberg	LM	300	Q/36
3.	*Spongaster tetras tetras* Ehrenberg	SEM	400	5/10
4.	*Spongaster tetras irregularis* Nigrini	LM	300	R/31
5.	*Heliodiscus echinicus* Haeckel	SEM	800	7/29
6.	*Heliodiscus asteriscus* Haeckel	LM	300	B/22
7.	*Heliodiscus asteriscus* Haeckel	LM	120	K/10
8.	*Heliodiscus asteriscus* Haeckel	LM	300	H/34
9.	*H. asteriscus* Haeckel	SEM	400	3/4
10.	*H. asteriscus* Haeckel	SEM	600	2/29
11.	*H. echiniscus* Haeckel	SEM	400	1/31
12.	*H. asteriscus* Haeckel	SEM	400	2/19
13.	*H. asteriscus* Haeckel	SEM	400	2/20
14.	*Spongotrochus glacialis* Popofsky	SEM	400	5/33
15.	*Hexapyle sp.*	LM	300	E/1
16.	*Hexapyle sp.*	LM	300	E/16
17.	*Hexapyle dodecantha* Haeckel	LM	300	J/28
18.	*Tetrapyle octacantha* Muller	LM	300	H/7
19.	*Tetrapyle octacantha* Muller	SEM	800	4/11
20.	*Octapyle stenozona* Haeckel	LM	300	I/33
21.	*Octapyle stenozona* Haeckel	SEM	400	2/4

PLATE - 10

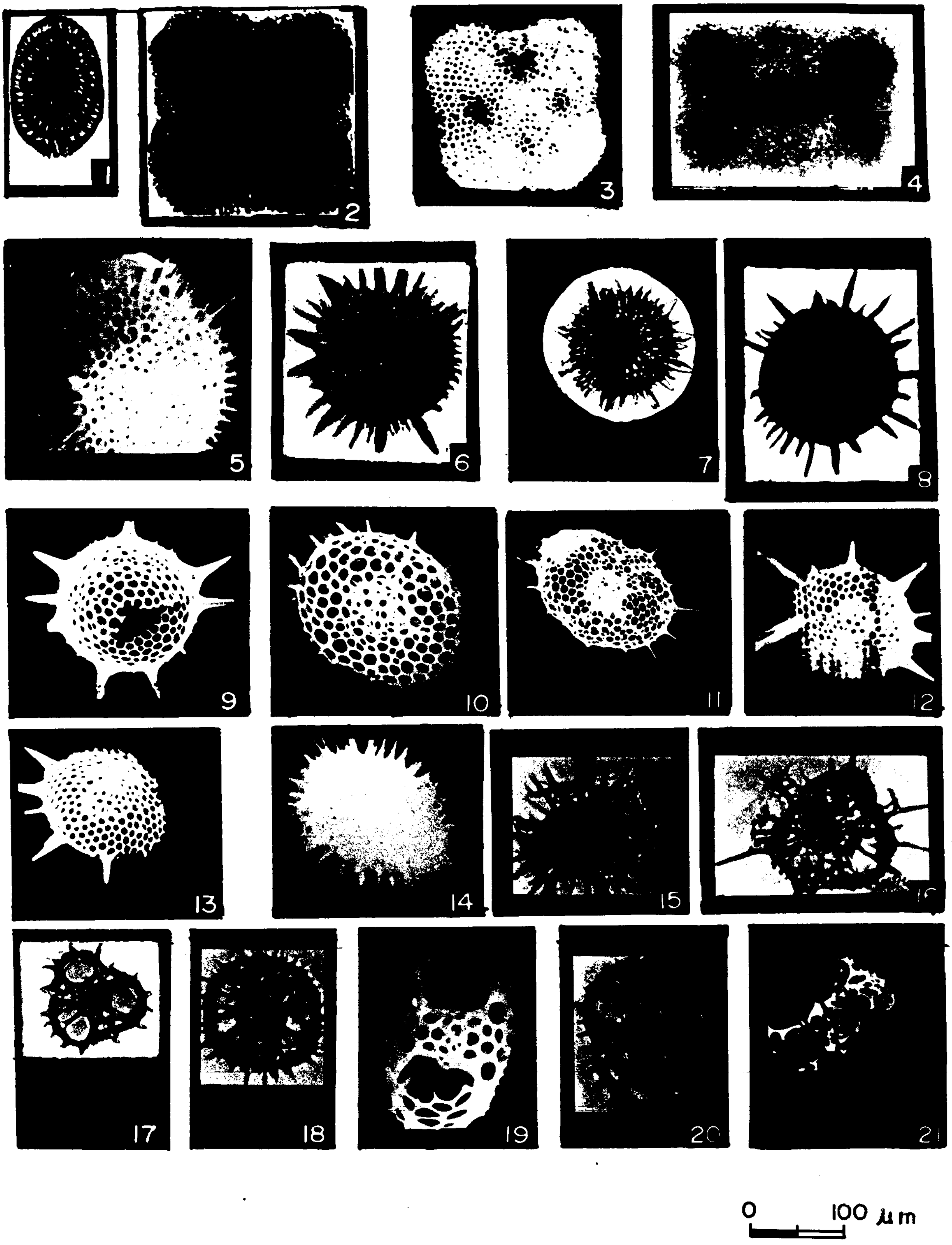
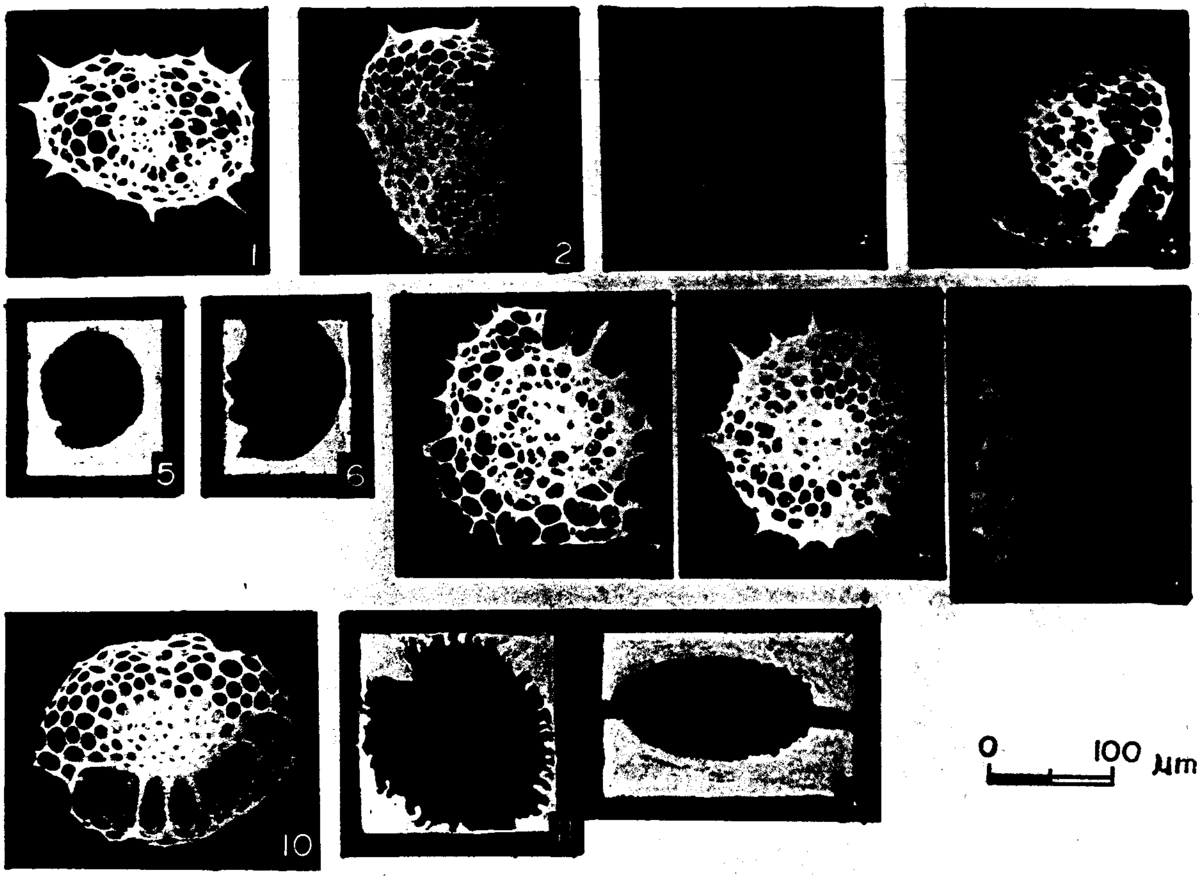


PLATE 11 Family LITHELIDAE

Scale bar is for 300 X magnification of LM only.

1.	*Larcopyle butschlii* Dreyer	SEM	450	3/11
2.	*Larcopyle butschlii* Dreyer	SEM	400	2/11
3.	*Discopyle elliptica* Haeckel	SEM	450	2/27
4.	*Lithelius sp.*	SEM	600	4/26
5.	*Lithelius minor* Jorgensen	LM	300	---
6.	*Lithelius nautiloides* Popofsky	LM	300	I/30
7.	*Lithelius nautiloides* Popofsky	SEM	400	1/34
8.	*Tholospira cervicornis* Haeckel	SEM	450	3/12
9.	*Larcospira quadrangula* Haeckel	SEM	450	3/13
10.	*Larcospira quadrangula* Haeckel	SEM	450	3/3
11.	*Larcospira quadrangula* Haeckel	SEM	300	H/9
12.	*Lithelid* gen. indet. sp. indet.	LM	300	G/11

PLATE - II



0 100 μm

PLATE 12 Suborder **NASSELLARIA**

Family **PLAGIACANTHIDAE** and **ACANTHODESMIDAE**

Sclae bar is for 300 X magnification of LM only.

1.	*Clathromitra pterophormis* Haeckel	LM	300	H/11
2.	*Gonosphaera primordialis* Jorgensen	SEM	800	2/11
3.	*Gonosphaera primordialis* Jorgensen	SEM	2000	2/5
4.	*Phormacantha hystrix* (Jorgensen)	SEM	1050	4/18
5.	*Peridium spinips* Haeckel	LM	210	J/1
6.	*Lophophaena cylindrica* (Cleve)	SEM	800	5/25
7.	*Lophophaena cf. capito* Ehrenberg	SEM	600	1/15
8.	*Lophophaena cf. capito* Ehrenberg	SEM	800	2/8
9.	*Lophophaena decacantha* (Haeckel)	SEM	800	1/14
10.	*Peromelissa phalacra* Haeckel	SEM	800	5/7
11.	*Lithomelissa setosa* Jorgensen	SEM	800	5/26
12.	*Helotholus sp.*	LM	300	J/4
13.	*Helotholus sp.*	LM	210	J/6
14.	*Clathrocanium coarctatum* Ehrenberg	SEM	800	7/1
15.	*Clathrocanium diadema* (Haeckel)	SEM	800	4/21
16.	*Clathrocanium coronatum* Ehrenbrg	LM	120	---
17.	*Callimitra annae* Haeckel	LM	300	J/1
18.	*Callimitra emmae* Haeckel	LM	300	B/21
19.	*Clathrocorys giltschii* Haeckel	LM	300	---
20.	*Zygocircus productus* (Hertwig)	LM	300	J/3
21.	*Zygocircus capulosus* Popofsky	LM	120	R/24
22.	*Neosemantis distaphanus* Popofsky	LM	120	O/1
23.	*Zygocircus sp. cf. Z. piscicaudatus* Popofsky		800	5/27
24.	*Acanthodesmia viniculata* (Muller)	SEM	800	7/6

25.	*Acanthodesmia viniculata* (Muller)	SEM	500	4/17
26.	*Lophospyris pentagona* (Ehrenberg)	SEM	600	7/26

PLATE-12

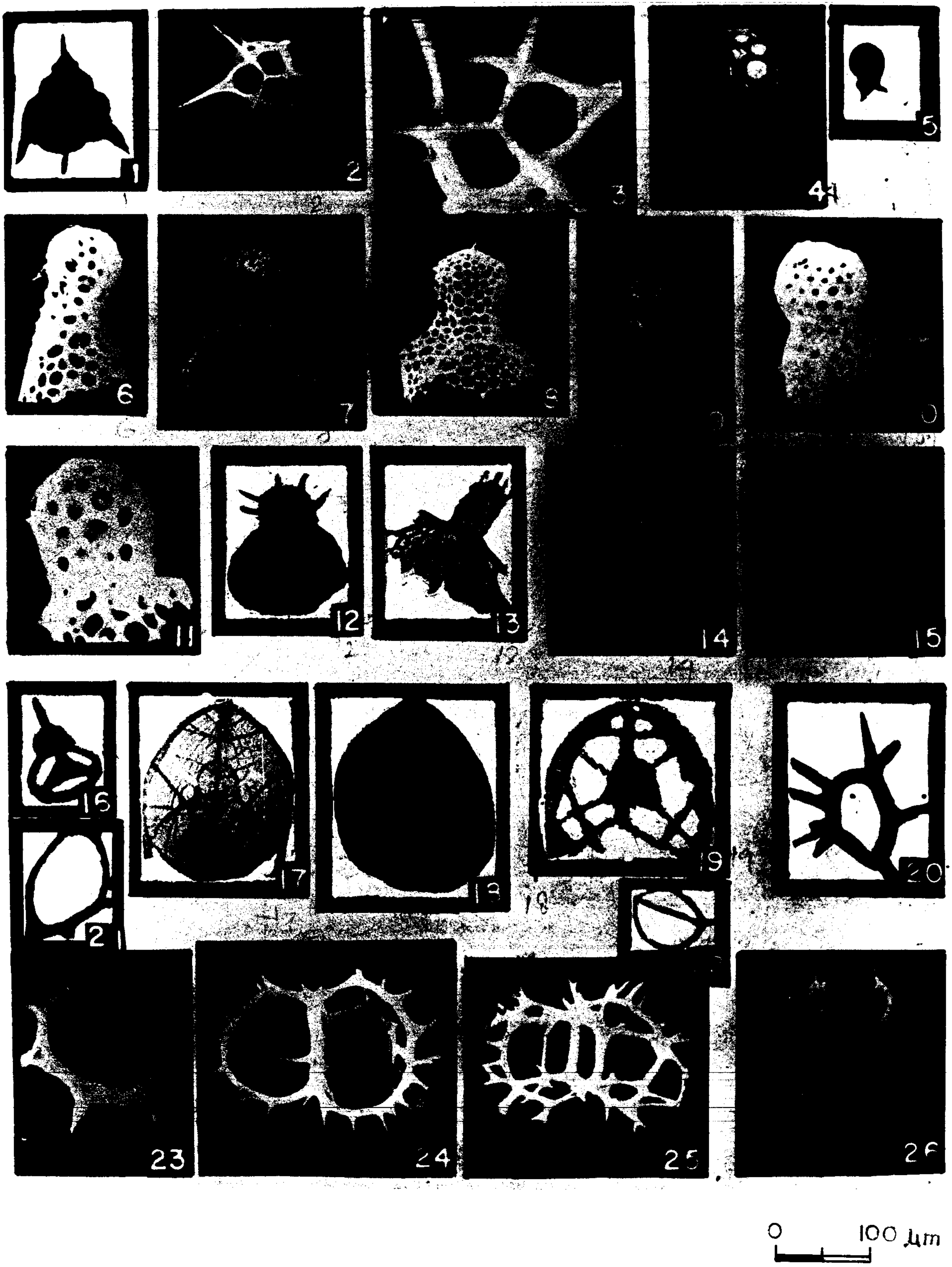


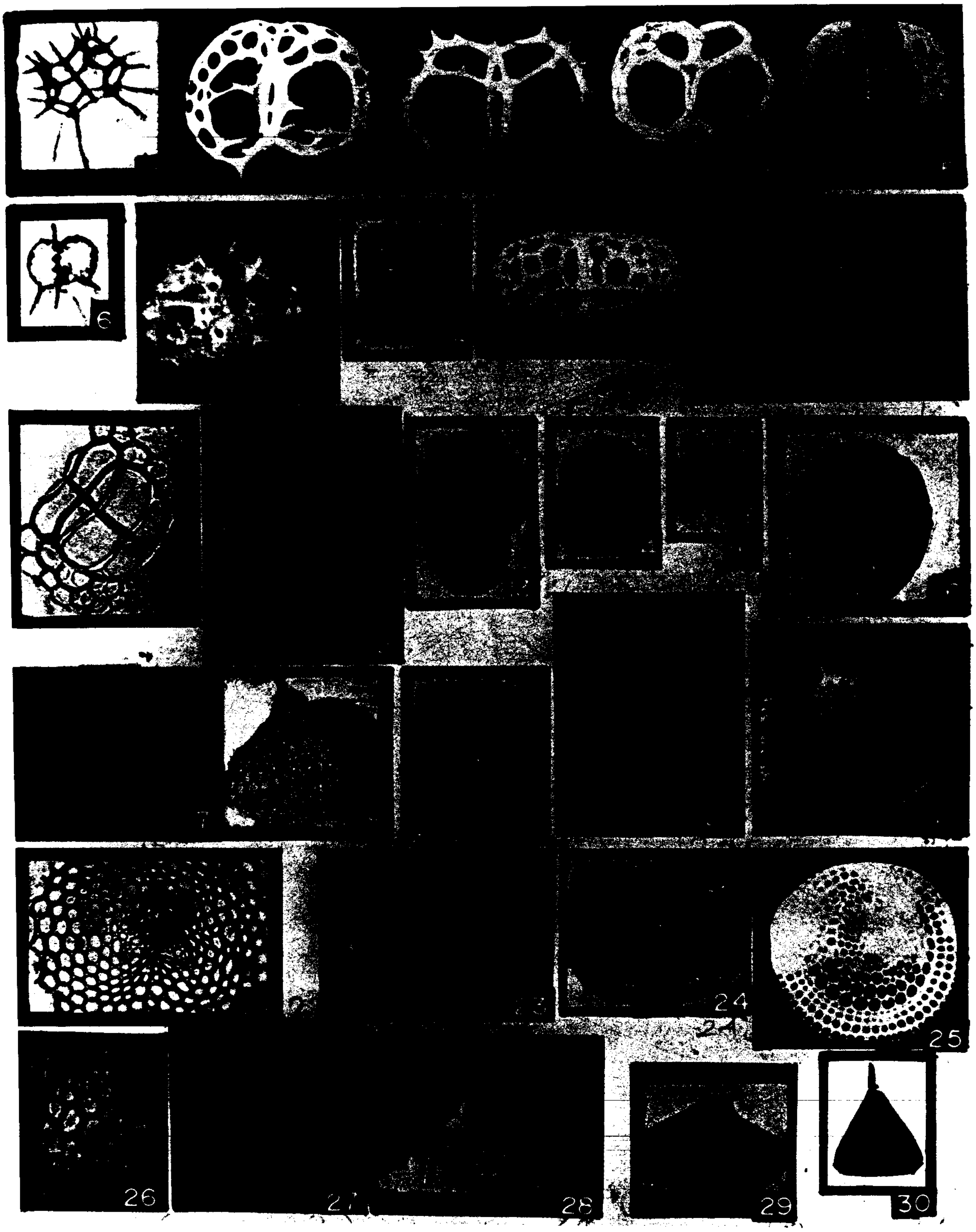
PLATE 13 Family ACANTHODESMIDAE (contd.) and SETHOPHORMIDAE

Scale bar is for 300 X magnification of LM only.

1.	*Lophospyris pentagona pentagona* (Ehrenberg)		300	E/4-6
2.	*Lophospyris pentagona hyperborea* (Jorgensen)		600	2/32
3.	*Lophospyris cheni* Goll	SEM	500	2/15
4.	*Phormospyris stabilis scaphipes* (Haeckel)	SEM	800	2/16
5.	*Phormospyris stabilis scaphipes* (Haeckel)	SEM	800	5/11
6.	*Phormospyris stabilis capoi* Goll	LM	120	---
7.	*Phormospyris stabilis capoi* Goll	SEM	600	1/13
8.	*Phormospyris stabilis stabilis* (Goll)	LM	120	----
9.	*Dictyospyris sp.*	SEM	600	1/16
10.	*Nephrospyris renilla renilla* Haeckel	LM	120	J/33
11.	*Nephrospyris renilla renilla* Haeckel	LM	300	---
12.	*Androspyris ramosa* (Haeckel)	SEM	400	7/16
13.	*Tholospyris baconiana baconiana* (Haeckel)	LM	120	J/36
14.	*Tholospyris baconiana variabilis* Goll	LM	120	---
15.	*Liriospyris thorax thorax* (Haeckel)	LM	120	---
16.	*Liriospyris reticulata* (Ehrenberg)	LM	300	R/33
17.	*Tetraphormis dodecaster* (Haeckel)	SEM	800	4/22
18.	*Tetraphormis butschlii* (Haeckel)	LM	300	
19.	*Theophormis callipilium* Haeckel	LM	300	A/14
20.	*Theophormis callipilium* Haeckel	LM	300	E/24-25
21.	*Lampromitra schultzei* (Haeckel)	SEM	600	4/29
22.	*Lampromitra cachoni* Petrushevskaya	LM	300	N/23
23.	*Eucecryphalus tricostatus* (Haeckel)	SEM	600	4/28
24.	*Eucecryphalus tricostatus* (Haeckel)	LM	300	---

25.	*Eucecryphalus sestrodiscus* (Haeckel)	SEM	500	5/19
26.	*Lampromitra spinosiretis* Takahashi	LM	300	S/3
27.	*Corocalyptra cervus* (Ehrenberg)	LM	300	M/7
28.	*Corocalyptra cervus* (Ehrenberg)	SEM	600	5/9
29.	*Eucecryphalus gegenbauri* Haeckel	LM	300	S/34
30.	*Eucecryphalus europae* (Haeckel)	LM	300	S/10

PLATE-13



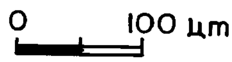


PLATE 14 Family SETHOPHORMIDAE

Subfamily Plectopyramidinae

Scale bar is for 300 X magnification of LM only.

1.	*Clathrocyclas monumentum* (Haeckel)	LM	300	---
2-3.	*Clathrocyclas cassiopejae* Haeckel	LM	300	R/25,Q/6
4.	*Clathrocyclas cf. C. cassiopejae* Haeckel	LM	300	A/9
5.	*Plectopyramis dodecoma* Haeckel	LM	300	---
6.	*Cornultella profunda* Ehrenberg	LM	300	---
7.	*Peripyramis circumtexta* Haeckel	LM	300	---
8.	*Bathropyramis ramosa* Haeckel	LM	300	D/15
9.	*Bathropyramis ramosa* Haeckel	LM	300	---
10.	*Peripyramis circumtexta* Haeckel	LM	120	A/6
11.	*Bathropyramis sp* Haeckel	LM	210	D/14
12.	*Litharachnium tentorium* Haeckel	LM	300	J/10
13.	*Litharachnium eupilium* (Haeckel)	LM	120	A/15
14.	*Archipilium sp.* (Haeckel)	LM	300	A/10
15.	*Pterocanium trilobum* (Haeckel)	SEM	400	4/16
16.	*Pterocanium sp.*	SEM	400	3/21
17.	*P. praetextum praetextum* (Ehrenberg)	SEM	450	4/14
18.	*P. praetextum* Haeckel	SEM	480	3/2
19.	*Pterocanium eucolpum* Haeckel	SEM	500	5/23
20	*Pterocanium bicorne* Haeckel	LM	300	B/8
21.	*Pterocanium bicorne* Haeckel	LM	120	S/35
22.	*Pterocanium sp.*	LM	300	B/ 26
23.	*Dictyophimus crisiae* Ehrenberg	LM	300	E/26
24.	*Dictyophimus crisiae* Ehrenberg	SEM	400	3/20
25.	*Dictyophimus sp.*	LM	300	R/17

26.	*Dictyophimus sp.*	LM	300	L/25
27.	*Dictyophimus sp.*	SEM	500	6/25
28.	*Dictyocodon elegans* (Haeckel)	LM	300	K/7

PLATE – 14

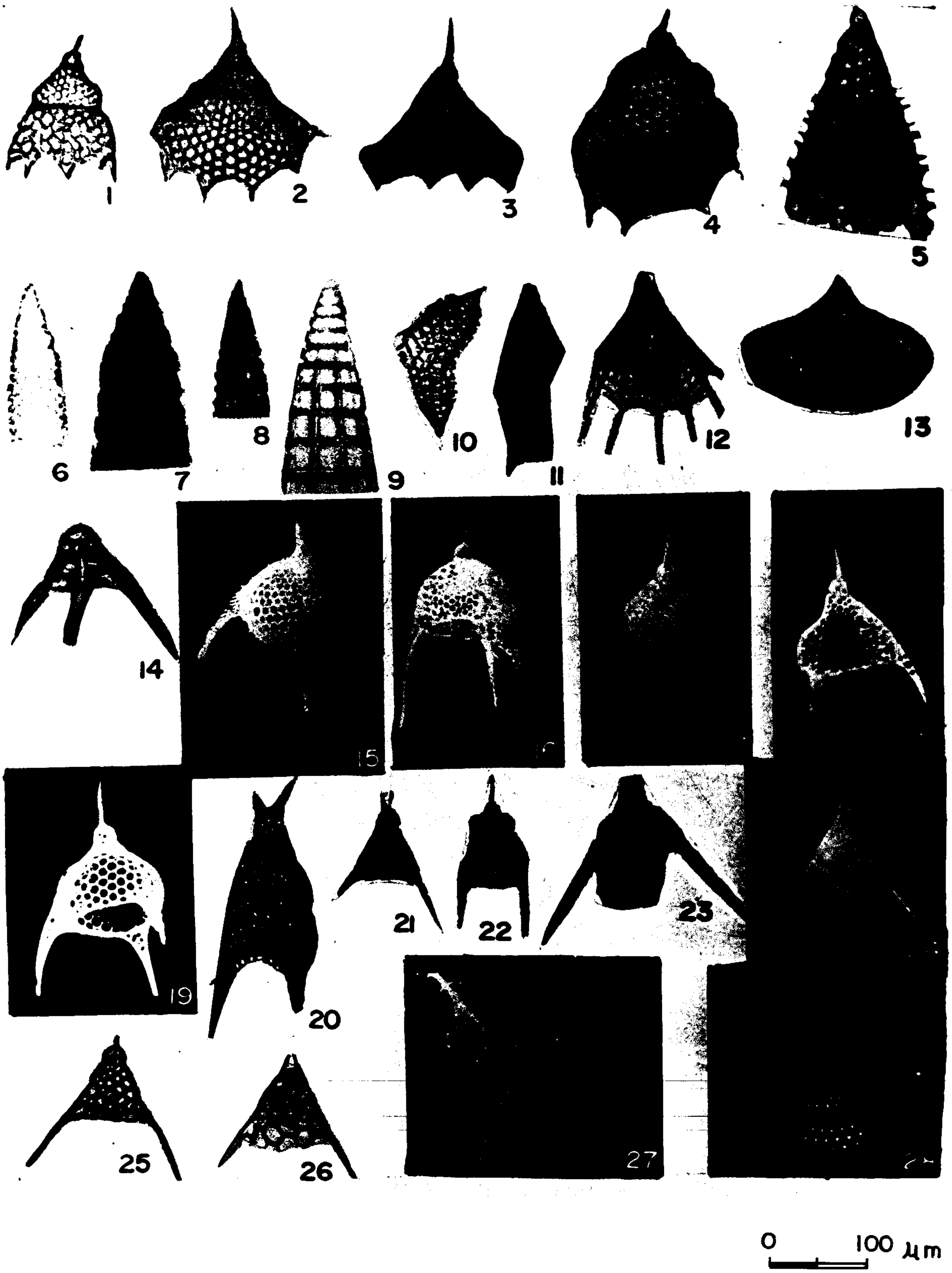


PLATE 15 Family THEOPERIDAE

Scale bar is for 300 X magnification of LM only.

1.	*Pterocanium*	LM	120	M/14
2.	*Conarachnium polycanthum* (Popofsky)	LM	300	E/17
3.	*Conarachnium sp. A*	LM	300	S/13
4.	*Sethoconus myxobranchia* Strelkov & Reschetnyak		300	E/21
5.	*Sethoconus sp. aff. S. mixobranchia* Strelkov & Reschetnyak		55	1/12
6.	*Conarachnium parabolicum* (Popofsky)	LM	300	A/2
7.	*Stichopilium bicorne* Haeckel	LM	300	D/4
8.	*Cyclampterium neatum* Sanfilippo & Riedel	LM	120	B/31
9.	*Lithopera renzae* Sanfilippo & Riedel	LM	300	A/25
10.	*Cyrtopera languncula* Haeckel	LM	300	A/25
11.	*Cyrtopera languncula* Haeckel	LM	120	D/17
12.	*Cyrtopera aglaolampa* Takahashi	LM	120	D/16
13.	*Theocorythium trachelium trachelium* (Ehrenberg)	SEM	400	3/33
14.	*Theocorythium trachelium trachelium*	LM	300	A/36
15.	*Theocorys sp.* Haeckel	LM	300	R/18
16.	*Theocorythium vetulum* Nigrini	LM	300	B/33-34
17.	*Lipmanella dictyoceras* (Haeckel)	LM	300	E/19
18.	*Lipmanella dictyoceras* (Haeckel)	LM	300	A/32
19.	*Lipmanella dictyoceras* (Haeckel)	LM	300	A/35
20.	*Lipmanella pyramidale* (Popofsky)	LM	300	J/2
21.	*Lipmanella virchowii* (Haeckel)	LM	300	E/27
22.	*Lithostrobus hexagonalis* Haeckel	LM	300	A/24
23.	*Cycladophora bicornis* (Popofsky)	LM	600	---

24. *Cycladophora davisiana davisiana* Ehrenberg SEM 640 1/20

25. *Cycladophora davisiana davisiana* Ehrenberg SEM 800 3/25

26. *Cycladophora bicornis klingi* Lobmari and Lazarus LM 300 Q/21

27. *Cycladophora davisiana semeles* (Petrushevskaya) LM 300 E/18

28. *Cycladophora davisiana cornutoides* (Petrushevskaya) LM 300 E/15

29. *Tetracorethra tetracorethra* (Haeckel) LM 300 6/30

30. *Pterocorys sp.* LM 300 E/11

31. *Pterocorys sp.* LM 300 C/25

32. *Pterocorys zancleus* (Muller) SEM 600 7/19

33. *Pterocorys hertwigii* (Haeckel) LM 300 S/33

34. *Pterocorys hertwigii* (Haeckel) LM 300 E/14

35. *Pterocorys sp.* LM 300 D/9

36. *Pterocorys sp.* LM 300 E/27

37. *Pterocorys sp.* LM 300 R/5

38. *Pterocorys sp.* LM 300 R/27

39. *Pterocorys sp.* LM 300 K/19

PLATE - 15

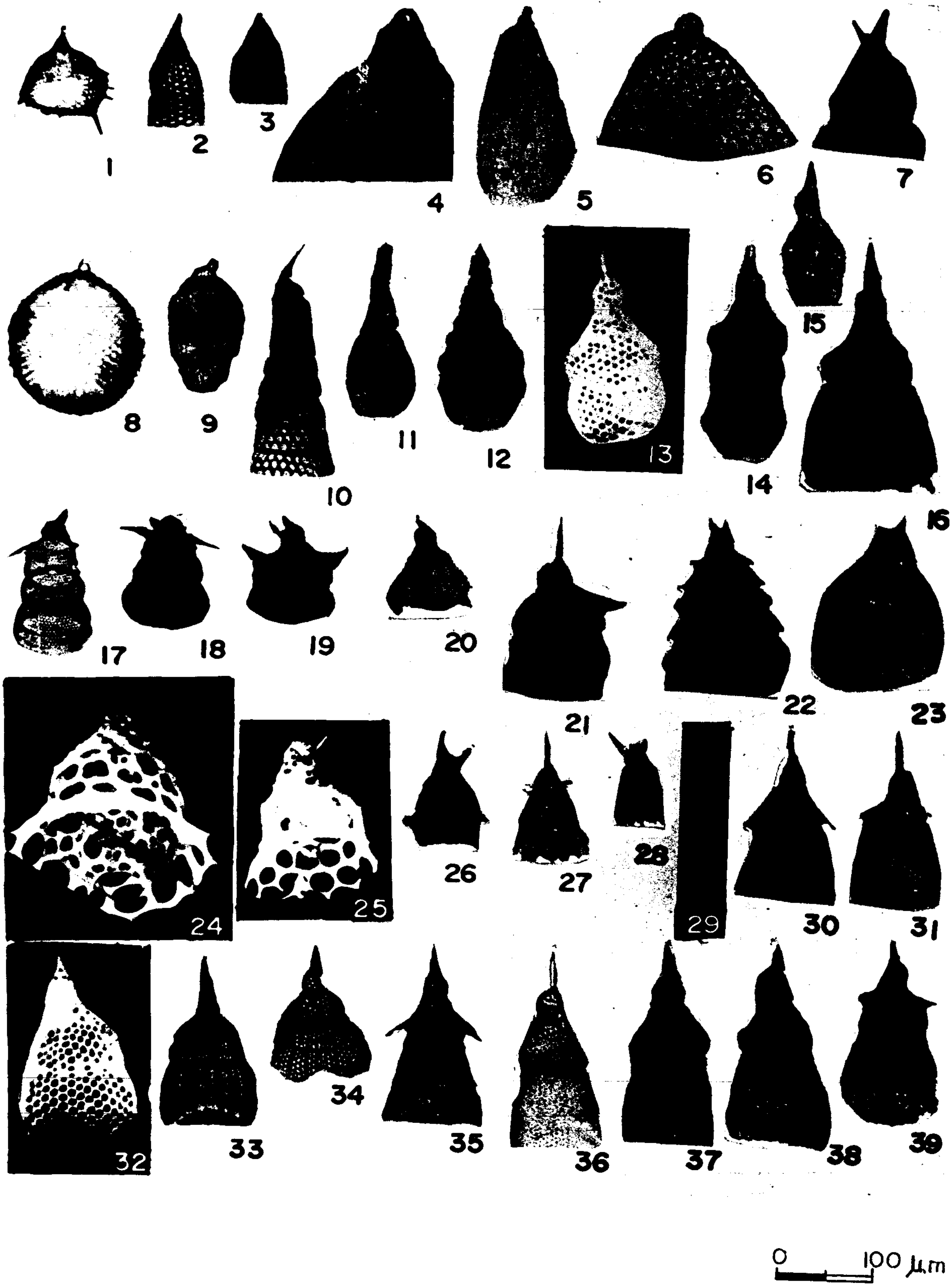


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PLATE 16 Family : THEOPERIDAE (contd.)

Scale bar is for 300 X magnification of LM only.

1.	*Pterocorys sabae* (Ehrenberg)	SEM	460	3/30
2.	*Pterocorys sabae* (Ehrenberg)	SEM	400	7/6
3.	*Pterocorys macroceras* (Popofsky)	LM	300	A/26
4.	*Pterocorys sp.*	LM	300	D/37
5.	*Pterocorys sp.*	LM	300	C/29
6.	*Pterocorys sp.*	LM	300	R/4
7.	*Pterocorys longicollis* Caulet	LM	300	R/3
8.	*Eucyrtidium acuminatum* (Ehrenberg)	SEM	800	4/5
9.	*Eucyrtidium sp.*	SEM	600	7/32
10.	*Eucyrtidium dictyopodium* (Haeckel)	SEM	450	4/8
11.	*Eucyrtidium sp.*	LM	300	Q/34
12.	*Eucyrtidium hexagonatum* Haeckel	LM	300	D/7
13.	*Eucyrtidium sp.*	LM	300	R/2
14.	*Eucyrtidium sp. aff. E. anomalum* (Haeckel)	LM	300	C/34
15.	*Eucyrtidium sp.*	LM	300	Q/5
16.	*Eucyrtidium sp.*	LM	300	R/8
17.	*Eucyrtidium sp.*	LM	300	R/9
18.	*Eucyrtidium punctatum* (Ehrenberg)	LM	300	R/20
19.	*Eucyrtidium hexagonatum* Haeckel	LM	300	B/9
20.	*Eucyrtidium sp.*	LM	300	C/33
21.	*Eucyrtidium sp.*	LM	300	E/2
22.	*Eucyrtidium sp.*	LM	300	R/29
23.	*Eucyrtidium sp.*	LM	300	A/4
24.	*Eucyrtidium sp.*	LM	300	E/22
25.	*Eucyrtidium sp.*	LM	300	Q/27

26.	*Anthocyrtidium ophirense* (Ehrenberg)	LM	300	D/28
27.	*Anthocyrtidium ophirense* (Ehrenberg)	SEM	500	7/5
28.	*Anthocyrtidium ophirense* (Ehrenberg)	SEM	500	2/31
29.	*Anthocyrtidium ophirense* (Ehrenberg)	SEM	450	5/28
30.	*Anthocyrtidium ophirense* (Ehrenberg)	SEM	640	4/23
31.	*Anthocyrtidium zanguebaricum* (Ehrenberg)	SEM	600	7/12
32.	*Anthocyrtidium angulare* Nigrini	SEM	800	1/33
33.	*Anthocyrtidium angulare* Nigrini	SEM	800	4/25
34.	*Anthocyrtidium angulare* Nigrini	LM	300	D/25
35.	*Anthocyrtidium euryclathrum* Nigrini & Caulet	LM	300	C/22
36.	*Anthocyrtidium euryclathrum* Nigrini & Caulet	LM	300	C/21
37.	*Anthocyrtidium euryclathrum* Nigrini & Caulet	LM	300	B/2
38.	*Anthocyrtidium sp.*	SEM	600	4/33

PLATE- 16

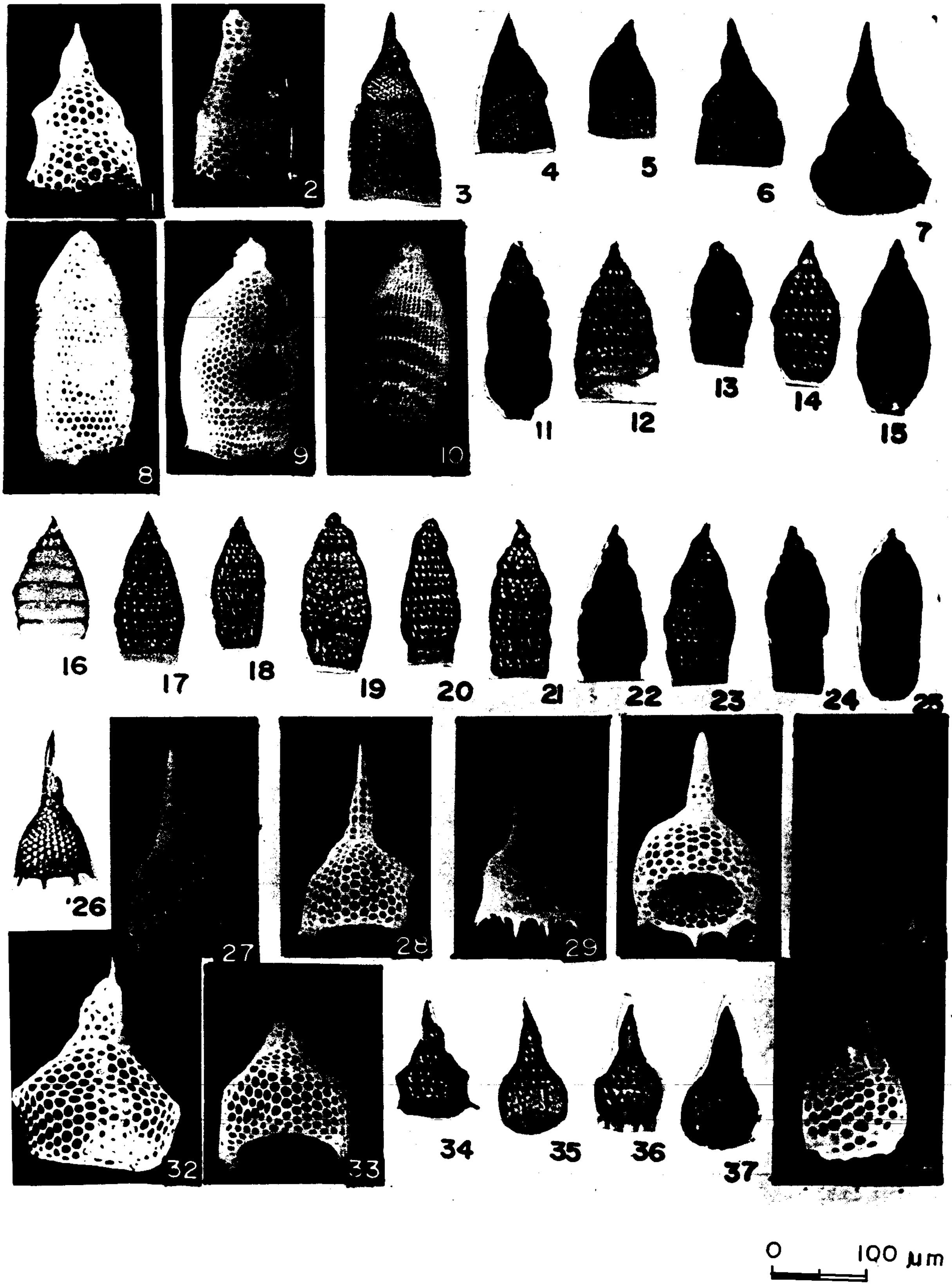


PLATE 17 **Family : THEOPERIDAE (contd.)**

Scale bar is for 300 X magnification of LM only.

1.	*Anthocyrtidium euryclathrum* Nigrini & Caulet	LM	300	C/11
2.	*Anthocyrtidium sp.* Caulet	LM	300	D/36
3.	*Anthocyrtidium sp.* Caulet	LM	300	C/10
4.	*Anthocyrtidium zanguebaricum* (Ehrenberg)	LM	300	C/27
5.	*Anthocyrtidium nosicaae* Caulet	LM	300	C/28
6.	*Anthocyrtidium sp.*	LM	300	D/36
7.	*Anthocyrtidium sp.*	LM	300	C/13
8.	*Anthocyrtidium sp.*	LM	300	B/6
9.	*Anthocyrtidium sp.*	LM	300	C/15
10.	*Anthocyrtidium sp.*	LM	300	D/35
11.	*Anthocyrtidium sp.*	LM	300	C/24
12.	*Anthocyrtidium sp.*	LM	300	C/12
13.	*Anthocyrtidium sp.*	LM	300	C/11
14.	*Anthocyrtidium ophirense* (Ehrenberg)	LM	300	C/23
15.	*Anthocyrtidium sp.*	LM	300	D/34
16.	*Anthocyrtidium sp.*	LM	300	D/37
17.	*Anthocyrtidium sp.*	LM	300	C/14
18.	*Anthocyrtidium sp.*	LM	300	R/13
19.	*Anthocyrtidium ?*	LM	300	---
20.	*Anthocyrtidium sp.*	LM	300	B/13
21.	*Anthocyrtidium sp.*	LM	300	B/44
22.	*Anthocyrtidium sp?.*	LM	300	B/14
23.	*Anthocyrtidium sp.*	LM	300	A/18
24.	*Anthocyrtidium sp.*	LM	300	B/36
25.	*Anthocyrtidium ?.*	SEM	800	2/35

26.	*Anthocyrtidium ?.*	SEM	500	7/4
27.	*Anthocyrtidium sp.*	SEM	500	6/11
28.	*Anthocyrtidium jenghisi* (Streeter)	SEM	400	4/12
29.	*Lamprocyclas maritalis polypora* Nigrini	SEM	400	6/8
30.	_*Lamprocyclas maritalis polypora* Nigrini	SEM	400	6/1
31.	*Lamprocyclas maritalis polypora* Nigrini	SEM	400	1/30
32.	*Lamprocyclas maritalis ventricosa* Nigrini	SEM	400	1/11
33.	*Lamprocyclas maritalis ventricosa* Nigrini	LM	300	R/6
34.	*Lamprocyclas maritalis ventricosa* Nigrini	LM	300	R/15
35.	*Lamprocyclas sp.*	SEM	450	3/15
36.	*Lamprocyrtis nigriniae* (Caulet)	SEM	800	7/20
37.	*Lamprocyrtis nigriniae* (Caulet)	SEM	500	3/19
38.	*Lamprocyrtis hannai* (Campbell & Clark)	SEM	500	6/19

PLATE - 17

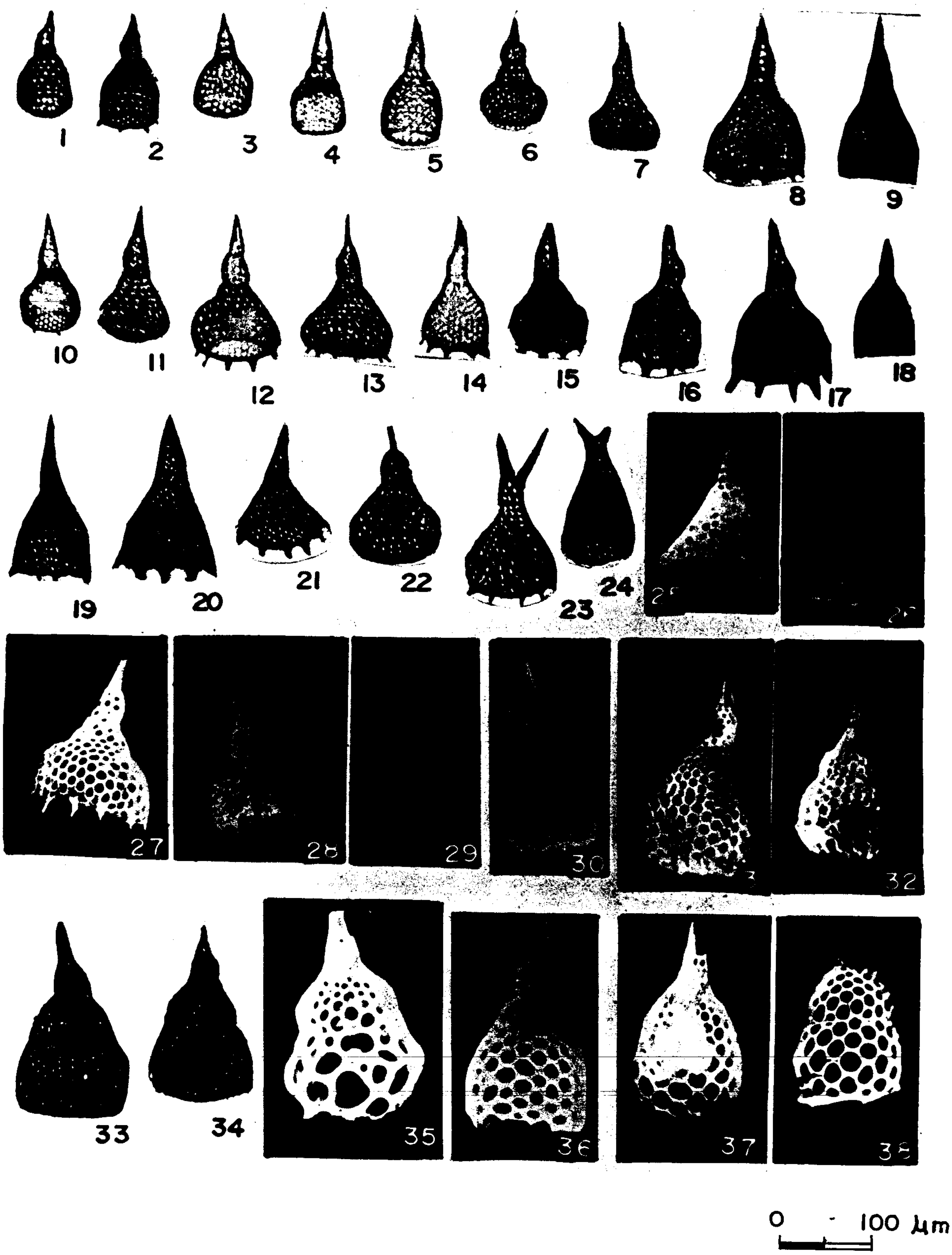


PLATE 18

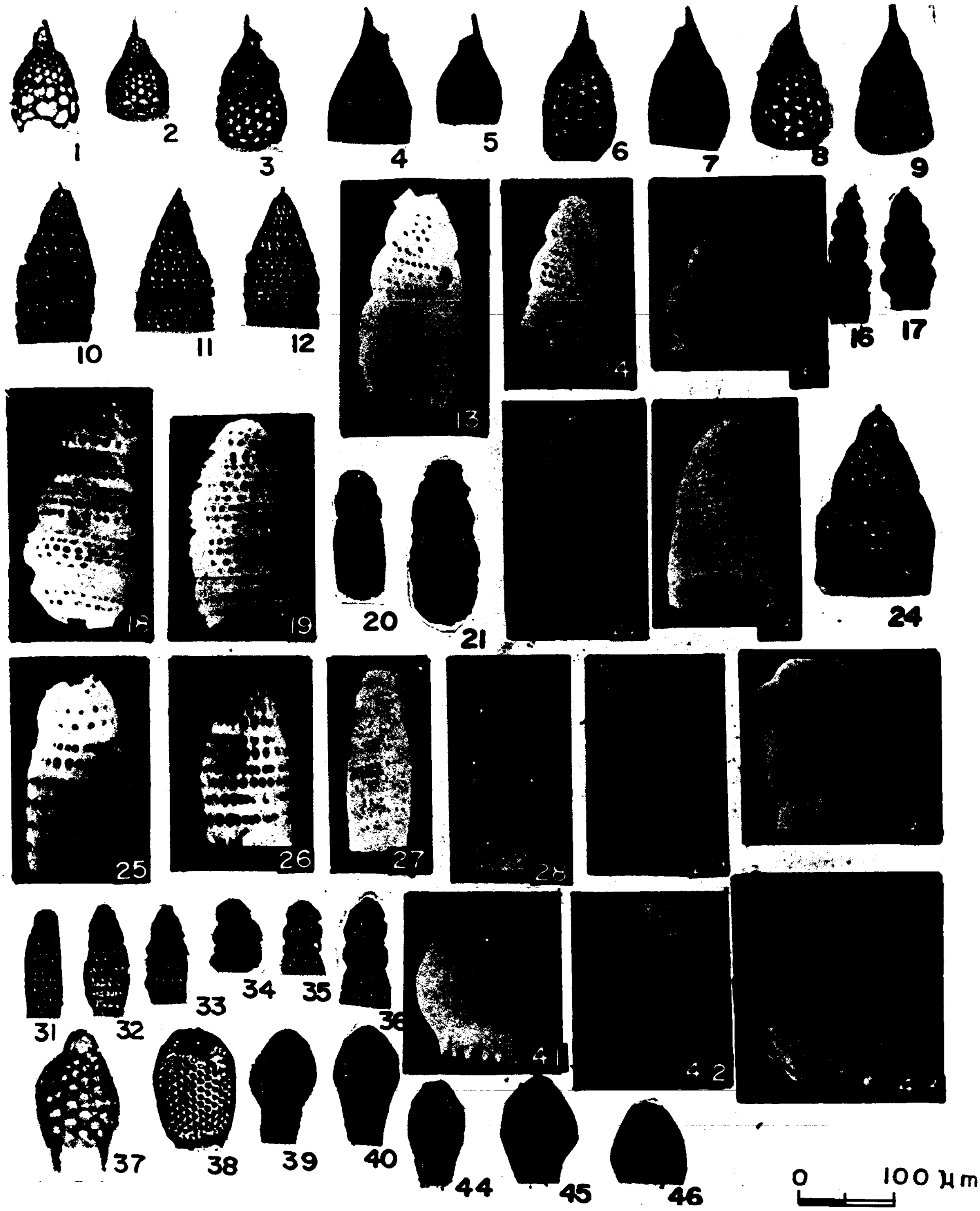
Family : **THEOPERIDAE (contd.), ARTOSTROBIIDAE, CANNOBOTRYIIDAE and CARPOCANIIDAE**

Scale bar is for 300 X magnification of LM only.

1.	*Lamprocyrtis heteroporos* (Hays)	LM	120	D/31
2.	*Lamprocyrtis neoheteroporos* Kling	LM	120	D/30
3.	*Lamprocyrtis sp.*	LM	300	S/5
4.	*Lamprocyrtis nigriniae* (Caulet)	LM	300	B/4
5.	*Lamprocyrtis nigriniae* (Caulet)	LM	120	J/30
6.	*Lamprocyrtis sp.*	LM	300	A/8
7.	*Lamprocyrtis sp.*	LM	300	J/20
8.	*Lamprocyrtis hannai* (Campbell & Clark)	LM	300	C/1
9.	*Lamprocyrtis hannai* (Campbell & Clark)	LM	300	C/7
10.	*Spirocyrtis scalaris* Haeckel	LM	300	D/6
11.	*Spirocyrtis scalaris* Haeckel	LM	300	E/31
12.	*Spirocyrtis scalaris* Haeckel	LM	300	A/30
13.	*Spirocyrtis sp.*	SEM	800	6/12
14.	*Spirocyrtis sp. aff. S. seriata* Jorgensen	SEM	800	5/22
15.	*Spirocyrtis gyroscalaris* Nigrini	SEM	800	7/10
16.	*Botryostrobus auritus/ australis* (Ehrenberg)	LM	300	D/11
17.	*Botryostrobus auritus/ australis* (Ehrenberg)	LM	300	Q/4
18.	*Botryostrobus auritus/ australis* (Ehrenberg)	SEM	800	6/5
19.	*Botryostrobus aquilonaris* (Bailey)	SEM	800	6/16
20.	*Phormostichoartus corbula* (Harting)	LM	300	E/2
21.	*Phormostichoartus corbula* (Harting)	LM	300	A/7
22.	*Phormostichoartus corbula* (Harting)	SEM	800	6/23
23.	*Phormostichoartus sp.*	SEM	800	5/18

24.	*Phormostichoartus sp.*	LM	300	O/2
25.	*Siphocampe lineata* (Ehrenberg)	SEM	800	7/9
26.	*Siphocampe lineata* (Ehrenberg)	SEM	800	6/14
27.	*Siphocampe lineata* (Ehrenberg)	SEM	800	5/4
28.	*Siphocampe lineata* (Ehrenberg)	SEM	800	5/20
29.	*Siphocampe lineata*	SEM	800	7/24
30.	*Siphocampe lineata* (cephalis)	SEM	2000	7/25
31.	*Siphocampe lineata* (Ehrenberg)	LM	300	---
32.	*Siphocampe nodosaria* (Haeckel)	LM	300	Q/7
33.	*Siphocampe arachnea* (Ehrenberg)	LM	300	S/8
34.	*Botryocyrtis scutum* (Harting)	LM	300	Q/28
35.	*Botryocyrtis scutum* (Harting)	LM	300	Q/37
36.	*Botryocyrtis sp.*	LM	300	S/32
37.	*Carpocanarium papillosum* (Ehrenberg)	LM	300	---
38.	*Carpocaniastrum cephalum* Haeckel	LM	300	---
39.	*Carpocaniastrum acutidentatum* Takahashi	LM	300	Q/35
40.	*Carpocaniastrum acutidentatum* Takahashi	LM	300	S/29
41.	*Carpocaniastrum favosum* (Haeckel)	SEM	800	7/7
42.	*Carpocaniastrum acutidentatum* Takahashi	SEM	800	6/29
43.	*Carpocaniastrum flosculum* Haeckel	SEM	800	6/26
44.	*Carpocaniastrum cephalum* Haeckel	LM	300	S/2
45.	*Carpocaniastrum flosculum* Haeckel	LM	300	Q/24
46.	*Carpocaniastrum coronatum* (Ehrenberg)	LM	300	Q/32

PLATE - 18



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