

CALCAREOUS NANNOFOSSILS FROM SEDIMENTS OF THE CONTINENTAL SLOPE OFF BOMBAY (INDIA)

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Abstract. About 22 calcareous nannofossils along with a few re-worked coccoliths of Cretaceous and Tertiary, and Discoasters of Neogene are present in a core collected from the continental slope in the Arabian sea. Two biostratigraphic Zones i.e. *Gephyrocapsa oceanica* and *Emiliana huxleyi* were encountered. The re-worked fauna may be attributed to the Indus river which drains a part of the Cretaceous and Tertiary formations in western India, or to derivation from outcrops on the continental slope.

Introduction.

Calcareous nannofossils: coccoliths are microscopic skeletal plates (1-20 microns diameter) constructed by a complex arrangement of calcite crystallites produced by the unicellular, biflagellate golden brown Algae, *Coccolithophyceae* during some phase of their life cycle. The majority of coccoliths occur in marine environment forming an important constituent of pelagic sediments. Coccoliths were first illustrated by Ehrenberg in 1840, subsequently, Huxley in 1858 discovered them in deep-sea sediments. Calcareous nannofossils from the Arabian sea have not been studied till recently; Norris (1965) described live cells of *Ceratolithus* Kamptner, widely distributed in the Arabian sea. Martini and Müller (1972) studied the systematics of coccoliths from the sediments of the Northern Arabian sea. Cepek (1973) reported a new species of coccolith, *Pontosphaera indo-oceanica* n. sp., and Bukry (1974) studied the coccolith stratigraphy from the DSDP cores in the SE part of the Arabian Sea.

Material and methods.

During one of the cruises of I.N.S. Darshak in the year 1970, a number of gravity cores were collected in the Arabian sea. Among the three cores

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have come across *D. perplerus* in Miocene through Holocene sediments and suggested that this species may still be living. But, in the present material *D. perplerus* clearly shows the calcitic overgrowth indicating re-working and may not be living at least in the present study area. Burns (1972) has also reported Discoaster species from Holocene sediments of SW Pacific ocean. Ericson et al. (1963) have marked the extinction of Discoasters as boundary between Pliocene and Pleistocene, hence, its occurrence in the still younger sediments is suggesting re-working of microfossils into the younger sediments.

Coastal erosion of the continents and islands, turbidity currents as well as underwater volcanic activity may lead to re-distribution of older forms into younger sediments at any time (Bramlette & Sullivan, 1961). According to Funnel (1964) most of the Cretaceous samples have been re-worked along the continental margin or on seamounts and contain a considerable number of re-worked fossils.

Indications of possible outcrops of Cretaceous formations on the slope is suggested by the fact that Cutch shows continuous marine sedimentation from the Callovian up to the Aptian after which there is a break followed by the Deccan trap flows, overlain by Lower Eocene. In the Narmada Valley in western India, Cretaceous strata begin with the Cenomanian and continue into the Eocene. The Narmada valley appears to have been occupied by an arm of sea throughout Mesozoic and it may have continued to be deluged during the Tertiary also (Krisnan, 1953). Therefore re-worked microfossils might have been brought by the Indus and Narmada rivers which drain a portion of the Cretaceous and Tertiary formations in western India.

Similarly, the Pleistocene and Holocene sediments of Mississippi cone in the Gulf of Mexico contain many Cretaceous coccoliths clearly re-worked from the drainage area of the Mississippi and other Gulf coast rivers (Bukry, 1971).

It is therefore possible that these re-worked « faunal elements » might have been carried by currents owing to their very minute size, even a mild current would accomplish the transportation from the outcrops of older formations on the outer continental shelf and slope. It is quite possible that the tiny remains of the coccolithophorids were swept into deeper water off the slope where they were deposited (Bramlette, 1957).

The presence of *Braarudosphaera bigelowi*, which is an indicator of littoral environment, at a depth of 2240 m may be an indication of transportation by currents.

Systematics

Genus *Braarudosphaera* DeLandre, 1947*Braarudosphaera bigelowi* (Gran & Braarud) DeLandre, 1947

1947 *Braarudosphaera bigelowi* DeLandre, p. 439, text-fig. 15.

This coccolith belonging to the family *Braarudosphaeraceae* is the only surviving species of this family which has long stratigraphic range from Jurassic to Holocene. Its occurrence in the nearshore area of the Bay of Fundy was noticed by Gran and Braarud (1935). Martini (1965) considers the species of *Braarudosphaeraceae* as characteristic shallow water forms. It is rarely found in the present study.

Genus *Ceratolithus* Kamptner, 1950*Ceratolithus cristatus* Kamptner, 1954

Pl. 60, fig. 1

1954 *Ceratolithus cristatus* Kamptner, p. 43, fig. 44, 45.

1972 *Ceratolithus cristatus* - Martini & Muller, p. 66, pl. 5, fig. 77.

It is tropical to temperate in its range, the arms of horse-shoe are smoothly ornamented with a row of small teeth. The earliest occurrence of these forms is near the Plio-Pleistocene boundary to Recent (Bukry et al., 1968).

Ceratolithus telesmus Norris, 1965

1965 *Ceratolithus telesmus* Norris, p. 21, pl. 11, fig. 57; pl. 12, fig. 13.

The arms of these *Ceratolithus* are quite long with faintly developed teeth like ornamentation. In the present study, it was noticed that both the tips of the horse-shoe shaped ceratoliths are joined in most of the cases. According to Norris (1965) it is strictly a tropical form ranging from Plio-Pleistocene to Recent.

Genus *Coccolithus* Schwartz, 1894*Coccolithus pelagicus* (Wallich) Schiller, 1930

1877 *Coccosphaera pelagica* Wallich, p. 246, pl. 11, fig. 1, 3-7, 10.

1930 *Coccolithus pelagicus* - Schiller, text-fig. 123.

This placolith is commonly regarded as a cold water species by many authors (Hasle, 1960; Mc Intyre & Bé, 1967). Bartolini (1970) considers it

as being environment-sensitive. It is not commonly found in the present material, its first occurrence is in the Paleocene.

Genus *Cyclococcolithus* Kamptner, 1954

Cyclococcolithus leptoporus (Murray & Blackman) Kamptner, 1954

Pl. 60, fig. 2.

1898 *Coccosphaera leptopora* Murray & Blackman, p. 430, pl. 15, fig. 1-17.

1902 *Coccolithophora leptopora* - Lohmann, 100, 23, fig. 20.

This placolith is circular in outline with about 30 petaloid elements showing dextral imbrication on the distal side. Cohen (1964) states that the number of rays varies from 20 in small to 33 in large specimen. Mc Intyre et al. (1967) report in a sample from subantarctic water *C. leptoporus* which is of larger size with a plate count averaging about 40. It has been known from the Miocene to Recent.

Genus *Emiliania* Hay & Mohler, 1967

Emiliania huxleyi (Lohmann) Hay & Mohler, 1967

Pl. 60, fig. 3

1902 *Pontosphaera huxleyi* Lohmann, p. 130, pl. 4, fig. 1; pl. 6, fig. 69.

1967 *Coccolithus huxleyi* - Hay & Mohler, p. 447, pl. 10, fig. 1, 2; pl. 11, fig. 1, 2.

It is a cosmopolitan and dominant coccolithophore in modern oceans; owing to its very minute size it is difficult to identify under light microscope. This is characterized by its "T" shaped elements around the shield with a central grille. The species of *E. huxleyi* in the present material clearly shows the fusion of "T" shaped elements in the outer shield and a distinct central grille.

Genus *Gephyrocapsa* Kamptner, 1943

Gephyrocapsa aperta Kamptner, 1963

1963 *Gephyrocapsa aperta* Kamptner, p. 173, pl. 6, fig. 32, 35.

According to Geitzeñauer (1972), *G. aperta* evolved during the early Pleistocene and probably became extinct during the Late Pleistocene; this species has been identified in the present material particularly in the lower part of the core.

***Gephyrocapsa caribbeana* Boudreaux & Hay, 1969**

1972 *Gephyrocapsa caribbeana* - Geitzenauer, pp. 49-50, fig. 2, no. 2.

It was mostly noticed in the lower parts of the core. Hay et al. (1967) described this species from a Pleistocene core in the Caribbean. It is believed to be the ancestor of *Gephyrocapsa oceanica* Kamptner (Hay et al., 1967).

***Gephyrocapsa oceanica* Kamptner, 1943**

Pl. 60, fig. 4.

1943 *Gephyrocapsa oceanica* Kamptner, p. 45.

1967 *Gephyrocapsa oceanica* - Mc Intyre & Bé, p. 570, pl. 9, fig. A-B.

It has been considered to be characteristic of warm and temperate waters by Kamptner (1956) and Hasle (1960). On the contrary according to Mc Intyre and Bé (1966) the Atlantic cold water fauna is defined by the presence of large number of *G. oceanica*. Martini and Müller (1972) recorded it abundantly in the northern Arabian sea. It is found in abundance in the core under investigation. Its known geological range is Lower Pleistocene.

Genus *Helicopontosphaera* Hay & Mohler, 1967***Helicopontosphaera kamptneri* Hay & Mohler, 1967**

Pl. 60, fig. 5.

1954 *Helicopontosphaera carteri* Kamptner, p. 21, text fig. 17-19.

This species is fairly common in the top levels of the present core. It probably ranges back to the early Pliocene or late Miocene (Hay et al., 1967).

Genus *Pontosphaera* Lohmann, 1902***Pontosphaera alboranensis* Bartolini, 1970**

Pl. 60, fig. 8.

This cribrolith mostly resembles the type specimen of Bartolini (1970). It slightly differs in its somewhat circular outline. A large number of pores in the central area is arranged irregularly, the outer rim is made of more than 200 slender small rods showing clockwise inclination on the distal side.

Pontosphaera aff. pauciforata Kämtner

Pl. 60, fig. 7

The oval shaped coccolith more or less resembles that of Stradner's (1972) *Pontosphaera pauciforata* (pl. 19, fig. 1). It possesses a very thick rim with about 50-55 pores in the central area which are somewhat arranged concentrically. Its known range is Quaternary.

Pontosphaera sp.

Pl. 60, fig. 6

This coccolith exhibits oval outline with a lamellar rim area. The central area is covered by pores of different shape and dimensions and the arrangement of these pores appears to be irregular.

Genus Syracosphaera Lohmann, 1902**Syracosphaera pulchra** Lohmann, 1902

Pl. 60, fig. 9

1902 *Syracosphaera pulchra* Lohmann, p. 134, pl. 4, fig. 33, 36, 36a, 37.1964 *Discolithus histricus* Kämtner, Cohen, p. 236, pl. 1, fig. a-g; pl. 2, fig. 1.

Martini and Müller (1972) have reported that this species is commonly found in the northern Arabian sea. It resembles *S. pulchra* of Halldal and Markali (1955, pl. 11, fig. 1, 3 and 4). The central area is filled with radially arranged ribs. It is living in the present day oceans.

Genus Thoracosphaera Kämtner, 1927**Thoracosphaera heimi** (Lohmann) Kämtner, 1954

Pl. 60, fig. 10

It is globular with an opening. Large number of pores with tetragonal prismatic outline are distributed all over the sphere.

Genus Umbellosphaera Paasche, 1955**Umbellosphaera irregularis** Paasche, 1955

Pl. 60, fig. 11

1955 *Umbellosphaera irregularis* Markali & Paasche, p. 97, pl. 3, fig. a-f; pl. 4, fig. a-b; pl. 5, fig. a-c; pl. 6, fig. a-c.1961 *Discosaster murrayi* Black & Barnes, pl. 24, fig. 2.1967 *Umbellosphaera irregularis* Mc Intyre & Be, p. 567, pl. 2, fig. A-D.

It is a tropical form, frequently noticed in the northern Arabian sea

by Martini and Müller (1972). The micrococcolith of *U. irregularis* has been erroneously described as a new Discoaster, *Discoaster murrayi* Black & Barnes (1961). It is sparsely distributed in the material under study.

***Umbellosphaera tenuis* Kamptner, 1927**

1927 *Umbellosphaera tenuis* Kamptner, pp. 311-312, pl. 17, fig. 41 and 42.

According to Hasle (1960) and Mc Intyre and Be (1966, 67) it is indicative of warm temperate water. It is sparsely seen in the upper layers of the core.

Genus *Umbilicosphaera* Lohmann, 1902

***Umbilicosphaera mirabilis* Lohmann, 1902**

Pl. 60, fig. 12

1902 *Umbilicosphaera mirabilis* Lohmann, p. 149, pl. 5, fig. 26, 26a.

1954 *Cyclcoccolithus mirabilis* Kamptner, p. 24, text-fig. 21-23.

It is a circular placolith with convex distal shield.

The specimens of *Helicopontosphaera wallichi*, *Scyphosphaera apsteinii*, *Syracosphaera histrica* and *Cyclcoccolithus aequiscutum* were rarely seen in the material under investigation.

In addition to the above, the following re-worked fossils were also encountered: *Discoaster brouweri*, *D. variabilis*, *D. perplexus*, *Scapholithus fossilis*, *Arkhangeliskiella cymbiformis*, *Watznaueria barnesae*, *Micula stauriphora* and *Nannoconus* sp.

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PLATE 60

Calcareous nannofossils from the continental slope in the Arabian sea:

- Fig. 1 - *Ceratolithus cristatus* Kamptner; \times 3,500 SEM.
- Fig. 2 - *Cyclcoccolithus leptoporus* (Murray & Blackman) Kamptner; \times 5,000 SEM.
- Fig. 3 - *Emiliania huxleyi* (Lohmann) Hay & Mohler; \times 30,000 TEM.
- Fig. 4 - *Gephyrocapsa oceanica* Kamptner; \times 5,000 SEM.
- Fig. 5 - *Helleopontosphaera kamptneri* Hay & Mohler; \times 3,500 SEM.
- Fig. 6 - *Pontosphaera* sp.; \times 3,500 SEM.
- Fig. 7 - *Pontosphaera* aff. *paucitorata* Kamptner; \times 4,500 SEM.
- Fig. 8 - *Pontosphaera alboranensis* Bartolini; \times 3,500 SEM.
- Fig. 9 - *Syracosphaera pulehra* Lohmann; \times 3,260 TEM.
- Fig. 10 - *Thoracosphaera hermi* (Lohmann) Kamptner; \times 3,000 SEM.
- Fig. 11 - *Umbellosphaera irregularis* Pausche; \times 9,200 SEM.
- Fig. 12 - *Umbellosphaera mirabilis* Lohmann; \times 5,000 SEM.

