

CHAPTER 2

Systematic Descriptions

Chapter 2

SYSTEMATIC CLASSIFICATION

2.1 Introduction

Classification of coccolithophores began about a century ago following the phytoplankton studies in the north Atlantic by Murray and Blackman in 1898 and Mediterranean Sea by Lohmann (1902). With the further discovery of new taxa from different regions of the world, the classification schemes became progressively more comprehensive (Kamptner, 1928, 1941; Schiller, 1930; Deflandre, 1952) which were largely based on cell and the shape of the coccolith and associated apparatus (flagella), with the advent of the electron microscope, detailed coccolith morphology could be studied. But, recent studies on taxonomic works have mainly concentrated on separating to families and genus level.

2.2 Morphology of coccolithophore skeletons

Coccoliths are divided into two general groups: *holococcoliths* and *heterococcoliths*. Holococcoliths are made up of tiny submicroscopic calcite crystals, mostly rhomohedra, arranged in regular order, whereas, heterococcoliths are usually larger and built of different tiny microscopic elements such as plates, rods and grains, combined together into a relatively rigid structure. As holococcoliths invariably disintegrate after they are shed, it is the heterococcolith which forms the bulk of the microfossils.

2.3 Coccolith shape classification

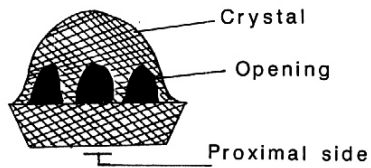
CALYPTROLITH: - holococcolith; basket-shaped, open proximally (Fig. 2.1A).

CANEOLITH: - disc or bowl-shaped; lath-filled central area (Fig. 2.1B).

CERATOLITH: - horse shoe or wishbone -shaped (Fig. 2.1C).

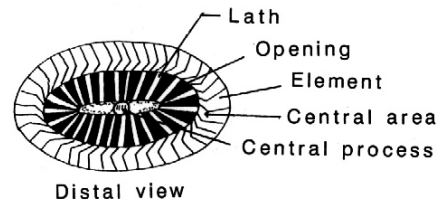
CRIBRILITH: - disc-shaped; numerous central-area perforations (Fig. 2.1D)

A. CALYPTROLITH



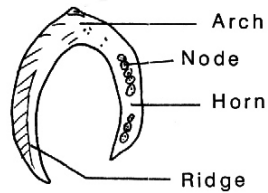
Homozygosphaera triarcha

B. CANEOLITH



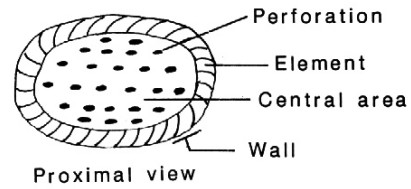
Syracosphaera pulchra

C. CERATOLITH



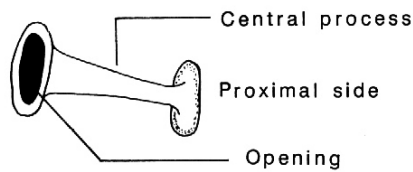
Ceratolithus cristatus

D. CRIBRILITH



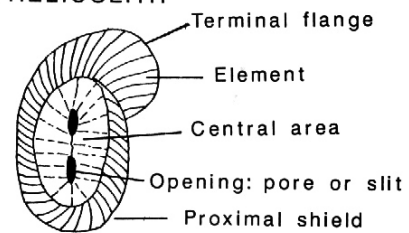
Pontosphaera syracusana

E. CYRTOLITH



Discosphaera tubifer

F. HELICOLITH



Helicosphaera carteri

Fig. 2.1. Sketches of A. calyptrolith; B. caneolith; C. ceratolith; D. cribrilith; E. cyrtolith; F. helicolith shape-forms and their morphologic parts (after Siesser and Winter, 1994)

- CYRTOLITH: - disc-shaped; convex outward, often with a projecting central process (Fig. 2.1E).
- DISCOLITH: - disc-shape; thickened, raised rim. May or may not have central area perforations.
- HELICOLITH: - spiraling, overlapping marginal flange (Fig. 2.1F).
- LOPADOLITH: - basket-, cup- or vase-shaped, with high rim, opening distally (Fig. 2.2G).
- PENTALITH: - five four-sided crystals joined to form a pentagon (Fig. 2.2H).
- PLACOLITH: - two shields joined by a central column (Fig. 2.2I).
- PRISMATOLITH: - solid or perforate polygonal prism (Fig. 2.2J).
- RHABDOLITH: - single shield, surmounted by a club-shaped central process (Fig. 2.2K).
- SCAPHOLITH: - rhombohedral shape, with parallel laths joining in the central area (Fig. 2.2L).

2.4 Taxonomy

- Kingdom : Protista Haeckel (1866)
- Phylum : Prymnesiophyta Hibberd (1976)
- Class : Prymnesiophyceae Hibberd (1976)

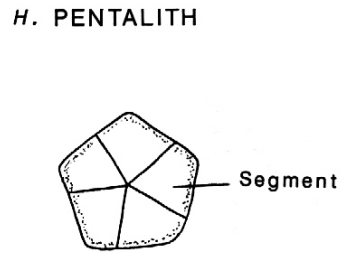
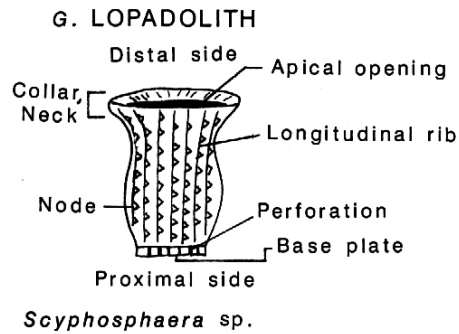
Family: **CALCISOLENIACEAE** Kamptner (1937)

Genus: **ANOPLOSOLENIA** Deflandre (1952)

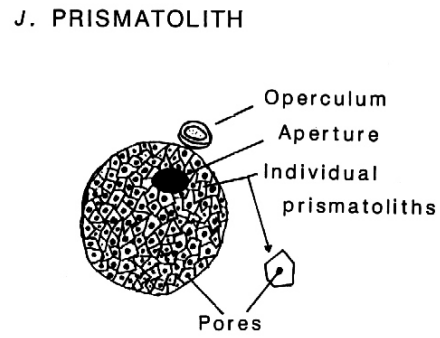
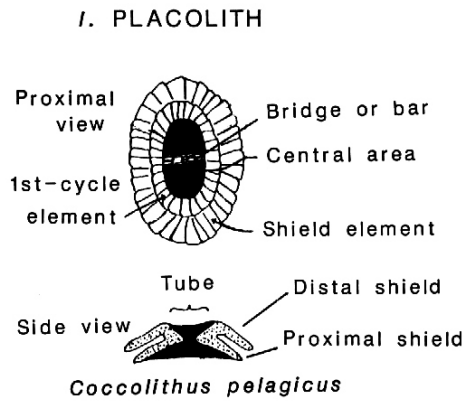
Type species: Anoplosolenia brasiliensis Lohmann (1919)

Description: Cells are covered by scapholiths which are rhombohedral in shape. Unlike *C. murrayi*, *A. brasiliensis* lacks terminal spines at both the ends with a larger cell.

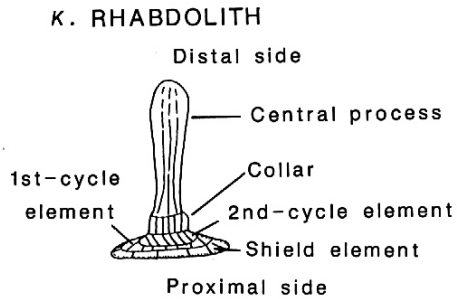
Distribution: It is commonly found in the Arabina Sea, Bay of Bengal, Red Sea and Pacific.



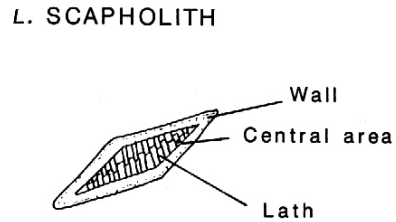
Braarudosphaera bigelowii



Thoracosphaera heimii



Rhabdosphaera claviger



Anoplosolenia brasiliensis

Fig. 2.2. Sketches of G. lopadolith; H. pentalith; I. placolith; J. prismatolith; K. rhabdolith; and L. scapholith shape-forms and their morphologic parts (after Siesser and Winter, 1994).

Genus: **CALCIOSOLENIA** Gran (1912)

Type species: Calciosolenia murrayi Gran (1912)

Description: Spindle-shaped cell covered by scapholiths (rhomboliths). Scapholiths are diamond-shaped and composed of upright wall elements, where each wall element is associated with a lamella which partially spans the short axis of the central area (Jordan and Kleijne, 1994).

Description: It is commonly occurs in the Arabian Sea, Bay of Bengal, Red Sea and Mediterranean Sea.

Family: **CALYPTROSPHAERACEAE** Boudreaux and Hay (1969)

Genus: **CALYPTROLITHINA** Heimdal (1982)

Type species: Calyptrolithina multipora Norris (1985)

Description: Coccolithophores are characterized by holoccoliths bearing; coccoliths built up entirely of calcite rhombohedrons, held together tightly by an organic matrix. Dimorphic coccosphere consisting of calyptroform ordinary and zygoform stomatal holococcoliths.

Description: It is reported from the Arabian Sea, Bay of Bengal, Red Sea and Mediterranean Sea, Atlantic Ocean and Pacific Ocean.

Family: **CERATOLITHACEAE** Norris (1965)

Genus: **CERATOLITHUS** Kamptner (1950)

Type species: Ceratolithus cristatus Kamptner (1950)

Description: Cell is partially covered by a single horseshoe-shaped coccolith and numerous hoop-shaped coccoliths (Jordan and Kleijne, 1994).

Distribution: It is commonly found in the Arabina Sea, Bay of Bengal, Red Sea and Pacific Ocean and Mediterranean Sea.

Family: **COCCOLITHACEAE** Poche (1913)

Genus **CALCIDISCUS** Kamptner (1950)

Type species: Calcidiscus leptopora Murray and Blackman (1898)

Description: Cell is covered by overlapping placoliths. Each placolith consists of two shields of sub-horizontal elements and a connection tube (Jordan and Kleijne, 1994). Placolith, circular in plan view with shields convex distally, concave proximally. Elements petaloid with dextral imbrication in the distal and sinistral in the proximal shield. The suture line on the distal surface of the distal shield is straight for approximately one-half the distance from the central column and then curves sinistrally (McIntyre and Bé, 1967).

Distribution: Very common in the Arabina Sea, Bay of Bengal, Red Sea and Pacific Ocean and Mediterranean Sea.

Genus **NEOSPHAERA** Lecal – Schlauder (1950)

Type species: *Neosphaera coccolithomorpha* Lecal-Schlauder (1950)

Description: Spherical to sub spherical coccosphere consisting of overlapping circular coccoliths that are convexly bent over the cell surface. Coccoliths with proximal large, monocyclic shield of non-imbricate elements and straight sutures, and has a central opening surrounded by a distally extending double-layered tube. Inner and outer tube elements fuse to form a thick collar around the central opening (McIntyre and Bé, 1967). Outer tube elements are distal extension of the proximal shield elements; they may form a narrow band of elements with dextral precession and V-shaped sutures around the lower part of the tube. The inner tube consists of vertical elements, with straight sutures, which protrude beyond the outer tube (Kleijne, 1993). This species is found in deep habitat between 100 and 200 m.

Distribution: Bay of Bengal, Arabian Sea, Atlantic Ocean, Pacific Ocean and Mediterranean Sea.

Genus: **OOLITHOTUS** Reinhardt, in Cohen and Reinhardt (1968)

Type species: *Oolithotus fragilis* Lohmann (1912)

Description: Large spherical to subspherical coccosphere consisting of tightly interlocking circular to subcircular placoliths with a crenulate periphery. Central area is a circular, somewhat eccentric depression without an opening; Placoliths with shields connected by an asymmetrically placed central tube. proximal shield covered by a basal plate. Distal shield consists of 18-20 elements with slight sinistral inbrication; sutures straight and incised, with dextral precession at circular depression (Kleijne, 1983).

Distribution: It is reported from Arabian Sea and Bay of Bengal, Atlantic Ocean, Pacific Ocean and Mediterranean Sea.

Type species: *Oolithotus antillarum* Cohen (1964)

Description: Small coccosphere consisting of 13-20 subcircular placoliths with an eccentric narrow tube and a pore – a narrow, deep depression – in the central area. Proximal side of central area in general entirely covered by a basal plate, consisting of inward growing extensions of proximal shield elements. Distal shield with smooth periphery, consisting of 13 dextrally imbricated elements; sutures laevogyre and somewhat incised in distal view, straight in proximal view. Proximal shield mono – to cyclic sutures in inner half straight, then kinked and S-shaped in counter-clockwise direction, and dextrogyre in outer half of shield (in proximal view) (Kleijne, 1993).

Distribution: It is reported from Bay of Bengal, Arabian Sea and Atlantic Ocean.

Genus: **UMBILICOSPHAERA** Lohmann (1902)

Type species: *Umbilicosphaera sibogae* Kamptner (1963)

Description: Placolith, circular, concave-convex distal shield varying from smaller to larger than the flat proximal shield (McIntyre and Bé, 1967).

Distribution: It is found in the Bay of Bengal, Arabian Sea, Pacific Ocean and Atlantic Ocean.

Family: **HELICOSPHAERACEAE** Black (1971)

Genus: **HELICOSPHAERACEAE** Kamptner (1954)

Type species: *Helicosphaera carteri* Wallich (1877)

Description: Cell covered by helicoliths in a spiral arrangement. Coccosphere may have an apical opening. Helicolith with narrow spiral flange and differentiated central portion. Central opening may be present on the distal side (Jordan and Kleijne, 1994).

Distribution: It is found in the Bay of Bengal, western Arabian Sea, Pacific Ocean, Atlantic Ocean and Mediterranean Sea.

Family: **NOELAE RHABDACEAE** Jerkovic (1970)

Genus: **GEPHYROCAPSA** Kamptner (1943)

Type species: Gephyrocapsa oceanica Kamptner (1943)

Description: Cell covered by overlapping placoliths. Placoliths characterized by a reticulum or grill covering the proximal part of the central area opening (Jordan and Kleijne, 1994). Placolith, is oval in plan view with closely spaced shields convex distally, concave proximally, connected by a short column. A bridge of two elements arches obliquely across the central pore on the distal side. The elements of the shield are slightly imbricate, sinistral in the proximal and dextral on the distal shield. The central pore is covered in the proximal side by a delicate plate of interconnected rods radiating from the central line (McIntyre and Bé, 1967).

Distribution: It is found in the Bay of Bengal, Arabian Sea, Red Sea, Pacific Ocean, Atlantic Ocean and Mediterranean Sea (world wide in warm waters > 18° C)

Genus: **EMILIANIA** Hay and Mohler, in Hay et al. (1967)

Type species: Emiliana huxleyi Lohmann (1902)

Description: Placolith, oval in plan view with shields equal in size, convex distally – concave proximally and a large elliptical central pore covered by a plate. The distal shield is formed of “T” shaped elements, oval to circular in cross section, separated from each other except at the margin where the “T” ends interlock. This arrangement of elements resembles a spoked wheel. The element of the proximal shield vary in shape and development responding to the changing environment. The elements in warm-water forms exactly resemble the ones described above in the distal shield, whereas the cold water forms are represented with a solid shield of flattened elements with blunt or slightly pointed margins. The two shields are connected by a central column formed of elements which are continuations of the shield elements and sinistrally imbricate. A delicate plate of interconnected rods forming a grill cover the proximal side of the central pore in the forms with the open proximal shield (warm). The solid proximal shield type (cold) has a central plate of thin interlocked elements completely closing the pore (McIntyre and Bé, 1967).

Distribution: It is reported from the Bay of Bengal, Arabian Sea, Pacific Ocean and Atlantic Ocean (world wide).

Family: **RHABDOSPHAERACEAE** Ostenfeld (1899)

Genus: **ALGIROSPHAERA** Schlauder (1945)

Type species: *Algirosphaera oryza* Schlauder (1945)

Description: Monathecate, dimorphic coccosphere, consisting of two types of sacculiform (to labiatiform) rhabdoliths. Protrusion, formed by lamellar cycle elements, is long-elliptical at its base; it consists of two thick curved blades that are connected by a thin layer of interlocking elements along their distal and lateral sides. Body rhabdoliths with a low, bulging protrusion; protrusion of circum-flagellar rhabdoliths higher, wider and more laterally flattened – almost petaloid – especially at about half its height (Kleijne, 1993).

Distribution: It is known for its distribution in the Bay of Bengal, Arabian Sea, Pacific Ocean, Atlantic Ocean and Mediterranean Sea.

Genus: **DISCOSPHAERA** Haeckel (1894)

Type species: *Discosphaera tubifera* Murray and Blackman (1898)

Description: Salpingiform cyrtolith with a large trumpet shaped appendix attached to a small, slightly convex, round – to- elliptical basal plate, the largest dimension being the length to the appendix (McIntyre and Bé, 1967).

Distribution: It is reported from Bay of Bengal, Arabian Sea, Red Sea and Mediterranean Sea.

Genus: **RHABDOSPHAERA** Haeckel (1894)

Type species: *Rhabdosphaera clavigera* Murray and Blackman (1898)

Description: Helatoform cyrtolith with an oval base plate, often necked at the short diameter of the oval. Convex distally, it carries a long hollow appendix ending in a short spine. The basal plate is surrounded by a marginal ring of slightly imbricate flattened rhombic elements. The central disc is made up of thin overlapping rhombs that rise toward the center to form a pointed base for the appendix (McIntyre and Bé, 1967).

Distribution: It is reported from Bay of Bengal, Arabian Sea, Red Sea, Pacific Ocean, Atlantic Ocean and Mediterranean Sea.

Family: **SYRACOSPHAERACEAE** Lemmermann (1908)

Genus: **CORONOSPHAERA** Gaarder, in Gaarder and Heimdal (1977)

Type species: *Coronosphaera mediterranea* Lohmann (1902)

Description: Cell is mostly covered by caneloliths. Irrespective of shape, the two coccolith types have a distal arrangement of wall elements, each joined at their bases by lamellae. In trough-shaped coccoliths and rhombolith – like caneloliths these lamellae are arranged across the short axis of the coccolith, whereas in most caneloliths they are radial. Only in caneloliths the lamellae converge in the central area to form an overlapping random arrangement of elements or an organized central structure. This central structure may or may not produce a distally protruding central spine. Cyrtoliths and deviating coccoliths may form a complete or partial layer respectively on top of the canelolith. Pole spines or ring and link coccoliths may also be associated with caneloliths (Jordan and Kleijne, 1994).

Distribution: It is reported from the Bay of Bengal, Arabian Sea, Red Sea, Gulf of Aden, Pacific Ocean, Atlantic Ocean and Mediterranean Sea.

Genus: **SYRACOSPHAERA** Lohmann (1902)

Type species: *Syracosphaera pirus* Halldal and Markali (1955)

Syracosphaera rotula Okada and McIntyre (1977)

Syracosphaera pulchra Lohmann (1902)

Syracosphaera anthos Lohmann (1912)

Syracosphaera lamina Lecal-Schlauder (1951)

Description: Coccosphere monothecate, ditheceate, monomorphic, dimorphic. Cell is mostly covered by caneloliths. Irrespective of shape, the two coccolith types have a distal arrangement of wall elements, each joined at their bases by lamellae. In trough-shaped coccoliths and rhombolith – like caneloliths these lamellae are arranged across the short axis of the coccolith, whereas in most caneloliths they are radial. Only in caneloliths the lamellae converge in the central area to form an overlapping random arrangement of elements or

an organized central structure. This central structure may or may not produce a distally protruding central spine. Cyrtoliths and deviating coccoliths may form a complete or partial layer respectively on top of the canelolith. Pole spines or ring and link coccoliths may also be associated with caneloliths (Jordan and Kleijne, 1994).

Distribution: These species are reported from the Bay of Bengal, Red Sea, Arabian Sea, Atlantic Ocean and Pacific Ocean.

Genus: **FLORISPHAERA** Okada and Honjo (1973)

Type species: *Florisphaera profunda* Okada and Honjo (1973)

Description: The coccoliths of this genus are simple and rather unusual. Coccoliths are thick polygonal plate devoid of surface ornamentation.

Distribution: It is found to occur in the Arabian Sea and Bay of Bengal, Pacific Ocean, Atlantic Ocean and Mediterranean Sea.

Genus: **THOROSPHERA** Ostenfeld (1910)

Type species: *Gladiolithus flabellatus* Halldal and Markali (1955)

Description: The coccolith are thick polygonal elongate plate which are devoid of surface ornamentation.

Distribution: It is known for its occurrence in Indian Ocean, Pacific Ocean, Atlantic Ocean and Mediterranean Sea.

Genus: **UMBELLOSPHAERA** Paasche, in Markali and Paasche (1955)

Type species: *Umbellosphaera irregularis* Paasche, in Markali and Paasche (1955)

Description: Coccosphere has two types of 20 umbelloliths of two types that have a smooth shield. B-umbelloliths and larger A-umbelloliths consists of a high funnel with a crenulate periphery and a flat base with a prominent flange. Elliptical A-Umbelloliths have a long-elliptical base and central area. Circular to sub-circular B-umbelloliths have a circular base of which the flange has an irregular periphery; central area circular in proximal view and sub-circular to normal-elliptical in distal view.

Distribution: They are known to occur in Bay of Bengal, Arabian Sea, Gulf of Aden, Red Sea, Atlantic Ocean and Pacific Ocean.

Type species: Umbellosphaera tenuis Kamptner (1937)

Description: Coccusphere consisting of umbelloliths of two types that have a highly variable pattern of radial ribs on the shields. A-umbelloliths long-elliptical, with long-elliptical base and narrow flange. B-umbelloliths sub-circular, with circular to normal-elliptical base and central area, and narrow or no flange. Central area of B-umbelloliths and large A-umbelloliths may be partly occluded by tooth-like protrusions extending inward from ribs on the funnel. Central area floored by basal plate.

Distribution: They are known to occur in the Bay of Bengal, Arabian Sea, Gulf of Aden, Red Sea, Atlantic Ocean and Pacific Ocean.