

# *Syracosphaera noroiticus* sp. nov., and *S. marginaporata* sp. nov., (Syracosphaeraceae, Prymnesiophyta), new coccolithophorids from the Mediterranean Sea and North Atlantic Ocean

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## ABSTRACT

During scanning electron microscope investigations of living coccolithophorids from the Mediterranean Sea and the North Atlantic Ocean, two hitherto undescribed species of the genus *Syracosphaera* Lohmann, 1902 emend. Gaarder (in Gaarder and Heimdal, 1977) were found. The first species, *Syracosphaera noroiticus* sp. nov., was recorded in the Gulf of Lyons (Mediterranean Sea), and the second, *S. marginaporata* sp. nov., was found in the eastern North Atlantic. *J. Micropalaeontol.*, 12 (1): 71-76, August 1993.

## INTRODUCTION

Coccolithophorids are a group of golden-brown, unicellular, planktonic algae, which inhabit the euphotic zone of the oceans. Because some of them have been shown to pass through a motile phase with a flagellar apparatus, a sometimes visible haptonema and with non-mineralized organic scales, they have been included in the class of the Haptophyceae (Parke and Dixon, 1964). The most typical property of coccolithophorids are minute calcite platelets, which cover the cell-surface and which show different morphologies from species to species. These "coccoliths" are formed intracellularly and after completion extruded to surround the cell in form of a coccosphere (Wilbur and Watabe, 1963; van der Wal, 1984; Westbroek et al., 1986). Despite their minute sizes, typical coccosphere diameters range from about 3µm to 30µm, coccolithophorids are an important component of the marine phytoplankton, and are distributed in the surface waters throughout all of the world oceans (McIntyre and Bé, 1967; Okada and McIntyre, 1977 and 1979; Okada and Honjo, 1973 and 1975; Winter et al., 1979; Winter, 1985; Mitchell-Innes et al., 1987; Samtleben and Schröder, 1990; Kleijne, 1990 and 1991; Knappertsbusch, 1993).

Coccoliths also form a major portion of the fine fraction of Mesozoic to Recent deep-sea sediments and therefore have a long tradition as tools for biostratigraphic, biogeographic and paleo-oceanographic studies (Haq, 1983 and 1984; Perch-Nielsen, 1985; Crux and Heck, 1989). More recently, the scientific community became aware of extended blooms of some coccolithophorid species in transitional to subpolar surface waters of the modern oceans (Groom and Holligan, 1987; Balch et al., 1991), which led to the suspicion, that coccoliths play a key role for transferring inorganic carbon from the euphotic zone into the deeper waters and the sediments (Holligan et al., 1983). However, nannopalaeontologists working with modern coccolithophorids are still faced with an incomplete knowledge on the physiology, ecology, biogeography and the taxonomic inventarisation of these organisms. In the framework of two

independent expeditions in the Mediterranean Sea (VICOMED I) and in the Eastern North Atlantic (JGOFS Leg 4), the geographic and vertical distribution of living coccolithophorids have been studied. During these investigations two species have been found in plankton samples, which have been illustrated by several authors in the literature but have remained undescribed. The purpose of the present taxonomical note is to describe these two species.

## MATERIALS AND METHODS

The plankton samples were collected during the French oceanographic expedition VICOMED I (from September 17 to October 10, 1986) and the Dutch JGOFS Leg 4 in the eastern North Atlantic (from June 2 to 29, 1990).

The sampling locations, water depths and dates of collection are listed below.

Sample	Latitude	Longitude	Depth	Day	Area
FB 1	42° 47.1' N	4° 36.9' E	100m	17.9.1986	Mediterranean Sea
FH 34	46° 41.8' N	20° 08.2' W	3m	22.6.1990	North Atlantic
FB 23	53° 02.09' N	20° 46.81' W	10m	8.6.1990	North Atlantic
FB 34	47° 40.10' N	20° 52.26' W	20m	11.6.1990	North Atlantic

Upon recovery with 30 litre Niskin bottles, the water samples were immediately filtered on board of the ship with a Millipore-filtering system. The filters were MF-membrane filters of type HA from Millipore, with a diameter of 47µm and a pore size of 0.45µm. To remove salt the filters were rinsed with a diluted ammonia solution (pH=9). Thereafter, they were air-dried (for about 24 hours), and stored in plastic cases in the dark. For electron microscopy, a filter sector was fixed on a cover glass with scotch tape, mounted on an SEM stub and coated with gold (150 Ångstrom, 40mA, Ar-atmosphere at 0.05 bar) in a Baltzer's sputter coater. Examination was carried out using a JEOL JSM-840 scanning electron microscope.

## SYSTEMATIC DESCRIPTIONS

*Syracosphaera noroiticus* sp. nov.

Pl. 1, figs 1-3

*Syracosphaera* sp., Nishida, 1979, pl. 8, fig. 4a-b.  
 Unidentified heterococcolithophorid "B", Heimdal & Gaarder, 1981, p. 67, pl. 12, figs. 60 and 61.  
*Syracosphaera* sp. type E, Kleijne (1993), p.260-26, pl. 6, fig. 4.

**Derivation of name:** From "Le Noroit", research ship during VICOMED I.

**Diagnosis:** *Coccosphaera subsphaerica*, cum polymorphismo et habens circa 50 caneolithos. Dithecatismus non observatus. Diametrus circa 10.1  $\mu\text{m}$ . Coccolithi caneoliti ellipsoidales sunt. Magnitudo, per axem longiorem, circa 2.5 $\mu\text{m}$ , per axem minorem 1.8 $\mu\text{m}$ . In plurimi coccolithi area centralis formatur 28 ad 30 lamellas radialiter tendentes et regulariter positae, habet structuram centalem elongatam exigue elevatam. Certe coccolithi structura centrale cum lamellis concentricis habent. Coccolithi stomatales caneolithi similes rotulae sunt. Clipea distales et proximales per murum centalem breviorum se iuncta. Area centralis habet ca. 20 lamellas radialiter tendentes et structuram centalem distaliter prominentem angustam. Diametrus ca. 1 $\mu\text{m}$ .

**Description:** Polymorphic coccosphere, subspherical in shape, with about 50 caneoliths and stomatal coccoliths in the polar area. No dithecatium observed. Diameter of coccosphere about 10 $\mu\text{m}$ . Coccoliths are elliptical caneoliths, each measuring about 2.5 $\mu\text{m}$  in length and are about 1.8 $\mu\text{m}$  wide. The central area is formed by 28 to 30 regularly arranged radial elements, in most cases with a centrally raised structure. Some coccoliths contain concentric elliptical rings within the central area. Stomatal coccoliths are circular caneoliths, with a rim consisting of equally sized distal and proximal flanges connected by a short central wall in between. The central area has ca. 20 radial elements and a long, prominent central spine. Diameter of stomatal coccoliths ca. 1 $\mu\text{m}$ , length of the central spine ca. 1 $\mu\text{m}$ .

**Remarks:** The coccoliths consist of a wall of upright and sinistrally imbricated laths on the distal side, and a flange on the proximal side. In some cases the wall appears to be constructed of two cycles of elements: an external cycle with lower elements and an inner cycle, of which the elements raise above those of the external cycle. In coccoliths where no central process was observed, the central area is only formed by a grill of radially arranged elements. Coccoliths with concentric rings in their central areas appear to lack a flange on the proximal side, but are characterized by radial laths, which slightly extend the wall margin.

During VICOMED I water samples were collected at 17 stations along a transect from Toulon to Heraklion and at several depths within the uppermost 200m of the watercolumn (Knappertsbusch, 1993). However, this species was only recorded at one station and in one single sample,

indicating the scarcity of this species. Previously, *S. noroiticus* has been reported as an undetermined syracosphaerid from surface waters of the tropical Pacific (27° 59.8' N/149° 04.2' E) by Nishida (1979), and from the eastern Central Atlantic by Heimdal and Gaarder (1981).

**Holotype:** Plate 1, Figure 1. Type locality: Mediterranean Sea, at station GOL (lat. 42° 47.1' N, long. 4° 36.9' E) during VICOMED I. Deposited at the Geological Institute of the Federal Institute of Technology in Zürich (sample FB 1).

### *Syracosphaera marginaporata* sp. nov.

Pl. 2, Figs 1-3

Unidentified heterococcolithophorid "E", Heimdal and Gaarder, 1981, p. 67, pl. 13, fig. 64.

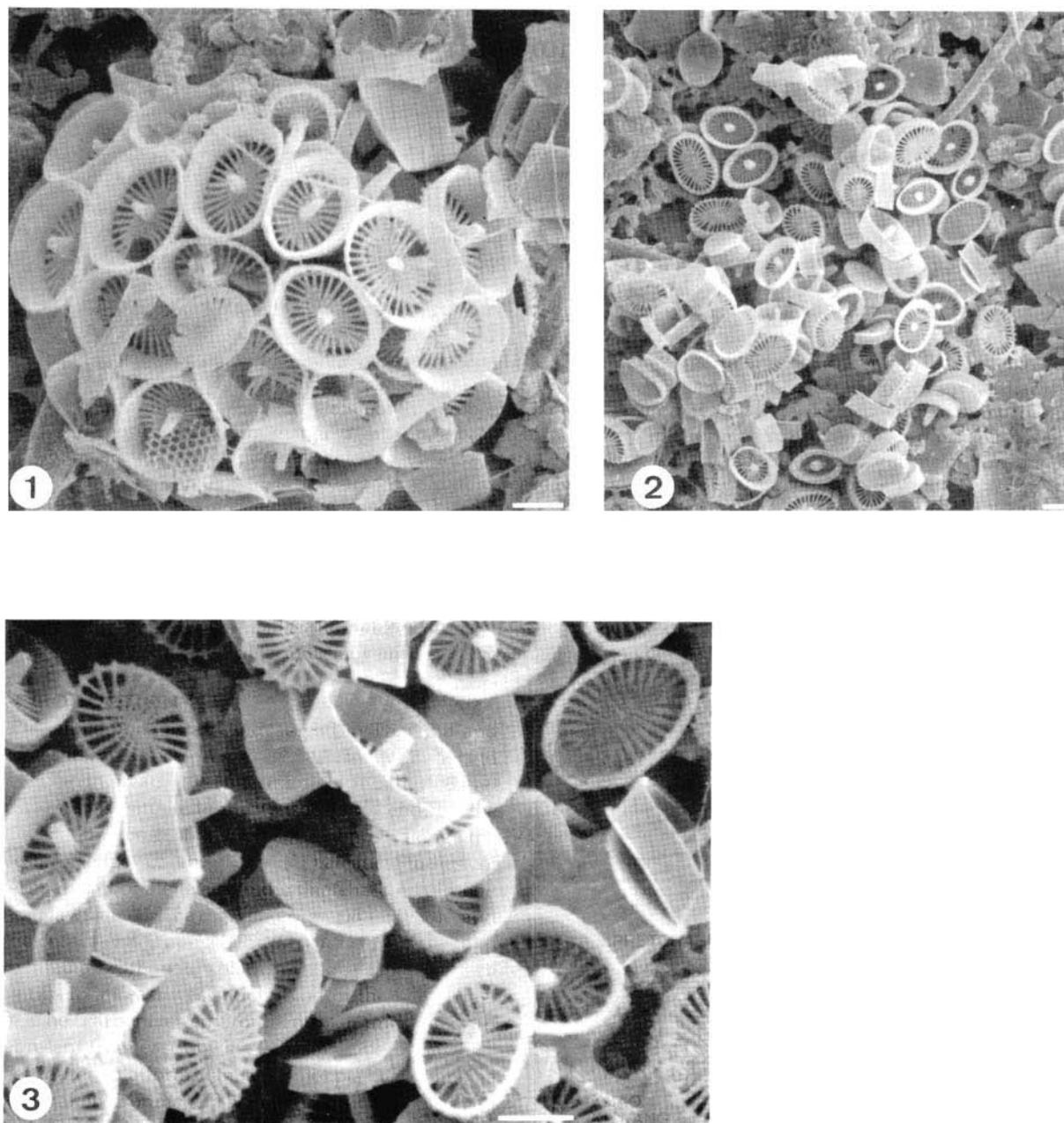
*Syracosphaera* sp. A, Samtleben & Schröder, 1990, pl. 1, fig. 3.

*Syracosphaera* sp. type H, Kleijne (1993), p.258-259, pl. 5, fig. 6.

**Derivation of name:** Marginal pore-like openings in the distal central area.

**Diagnosis:** *Testa coccolithica subglobosa cum dimorphismo*, habens circa 24 caneolithi magni. Circa 5 caneolithi stomatales minori, aream apicalem circumdant. Dithecatismus non observatus. Caneolithi ordinarii ellipsoidales cum peripheria lata. Caneolithi cum clipea distales et proximales se iuncta per murum centalem breviorum. Areae centralea superficies distales corrugatas habent, formatur lamellis regulariter positae. Coccolithi non structurae centralae carent. Margina areae centralis perforatur de 18 ad 25 ordine fenestris similes rotulae. Clipeo distale de 1.3 ad 1.7 $\mu\text{m}$  longitudine, de 1.0 ad 1.2 $\mu\text{m}$  latitudine. Caneolithi helatoformes ellipsoidales multo minori sunt. Area centralis lamellas radialiter tendentes et structuram centalem distaliter prominentem, aliquantulum magnam et cylindricum habet, circa 1 ad 1.5  $\mu\text{m}$  in magnitudo. Magnitudo coccolithorum, per axem longiorem circa 1.1 $\mu\text{m}$ , per axem minorem circa 0.6 $\mu\text{m}$ .

**Description:** Monothecate dimorphic coccosphere, covered with about 24 large caneoliths, and with about 5 modified caneoliths around the flagellar opening. Ordinary caneoliths are elliptical in outline, with a rim consisting of broad distal and proximal flanges with a short wall between them. The central area is wide, flat or slightly corrugated on the distal side, but without any clear central structure. It is filled with straight, radially arranged lath-like elements, which are fused together except along the outer margin of the central area, where 18 to 25 distinct round, pore-like gaps occur between the elements. The coccolith size ranges between 1.3 to 1.7  $\mu\text{m}$  in length and 1.0 to 1.2  $\mu\text{m}$  in width. The circumpolar caneoliths are also elliptical in shape but are somewhat smaller than the ordinary caneoliths. On their



#### Explanation of Plate 1

*Syracosphaera noroiticus* sp.nov., Figs. 1-3.

**Fig. 1:** Coccosphere of *Syracosphaera noroiticus* sp. nov. Note dimorphic coccoliths (circular caneloliths) in apical region of coccosphere. Sample FB 1, Station GOL (42° 47.1' N/04° 36.9' E), 100m, VICOMED I. Film 8-1542. Scale bar 1µm.

**Fig. 2:** Disintegrated coccosphere of *S. noroiticus* sp. nov.. Sample FB 1, Station GOL, 100m, VICOMED I. Film 8-1539. Scale bar 1µm.

**Fig. 3:** Highly magnified coccoliths of *S. noroiticus* sp. nov. from Figure 2. Note circular structures in the central area on the proximal side of some coccoliths. Film 8-1539. Scale bar 1µm.

distal sides the central area is formed by slender radial ribs. A prominent cylindrically shaped process arises from the center on the distal side. The length of the process is about 1 to 1.5  $\mu\text{m}$ . The coccolith measures about 1.1  $\mu\text{m}$  in length and 0.6  $\mu\text{m}$  in width.

**Remarks:** During the present study *S. marginaporata* was observed at 46° 41.8' N/20° 08.2' W at 3m water depth, at station 2 (10m water depth) and at station 3 (20m water depth) during JGOFS Leg 4. Heimdal and Gaarder (1981) reported an individual from the northern Central Atlantic, which may indicate, that this species prefers the upper photic layer at transitional latitudes.

*S. marginaporata* is morphologically closely related to *Syracosphaera ampliorea* Okada and McIntyre (1977). This species has similarly constructed caneloliths, containing also a row of marginal pore-like gaps between the elements in the central area. However, in detail, these structures are different (elongate and 8-shaped, or two separate rows of concentric openings) from those of *S. marginaporata* (single row of circular openings). In both cases, these openings may rather have resulted from incomplete fusion of the radial elements in the central area. In addition, *S. ampliorea* has a monomorphic coccosphere, whilst *S. marginaporata* is dimorphic. Considering the wide morphological variability of coccoliths within several fossil and extant species (Winter et al., 1978; Samtleben, 1980; Matsuoaka and Okada, 1990; Knappertsbusch, 1990; Young and Westbroek, 1991), it cannot be excluded, that the two morphologies of *S. ampliorea* and *S. marginaporata* belong to end-members of a plexus with transitional forms. However, there is only very sparse information available on the morphology and geographic distribution of these two species, and at present it is not possible to give a representative statistical analysis of their morphological variability. For the time being, because of the morphological differences, it is proposed here to continue to treat *S. marginaporata* and *S. ampliorea* as two different species.

**Holotype:** Plate 2, figure 1. Type locality: North Atlantic, (lat. 47° 40.10' N/ 20° 52.30' W, water depth 20m). Deposited at the National Herbarium, Leiden, The Netherlands (Sample FB 34, Film No. 6.1.91/1).

## DISCUSSION AND CONCLUSIONS

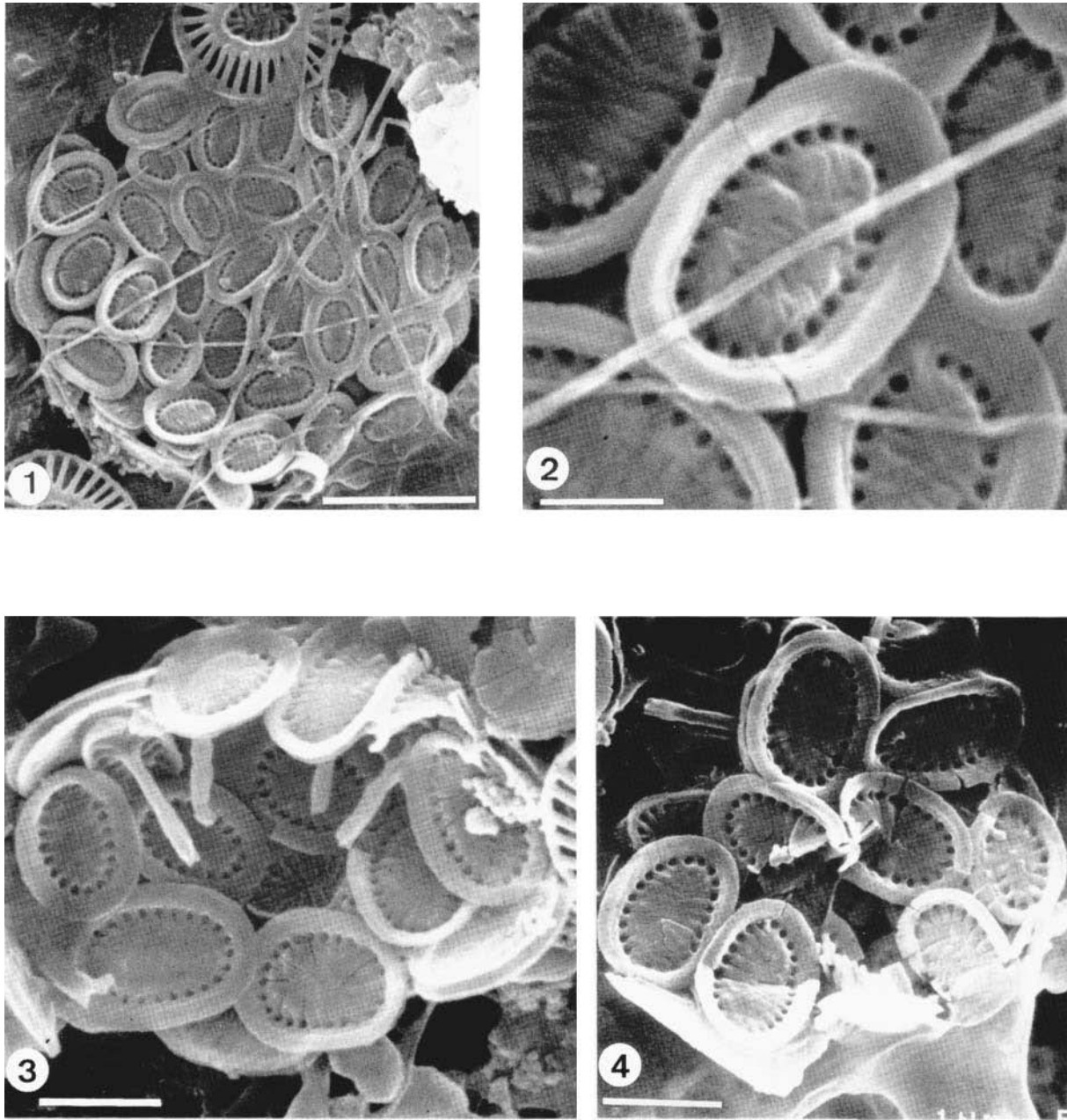
The presence of caneloliths is the common criterion for all individuals of the genus *Syracosphaera*. A canelolith is a basket-shaped coccolith with a central area of radially arranged lamellae, with or without a central structure, with proximal and distal rim elements, which may or may not be

connected by a wall (Halldal and Markali, 1954 and 1955). The two new species presented above clearly exhibit the morphological features of a canelolith, hence, they are regarded as members of the genus *Syracosphaera*. The majority of the syracosphaerids also show di- or polymorphism, often by the presence of stomatal coccoliths in the flagellar area, as was the case in *S. noroiticus* and *S. marginaporata*.

The occurrence of monothecate (a single layer of mono- or polymorphic coccoliths) and dithecate (a double layer of polymorphic coccoliths) cases in syracosphaerids as well as ultrastructural characteristics led Gaarder and Heimdal (1977) to emend the genus *Syracosphaera* Lohmann and to split the group into three different genera, *Syracosphaera* Lohmann emend. Gaarder, *Coronosphaera* Gaarder and *Caneosphaera* Gaarder. The former contained dithecate coccospheres, while the latter two consisted of monothecate cases. If this classification scheme was applied *S. noroiticus* would require the formation of a new genus, because none of the three genera proposed by Gaarder and Heimdal meet the ultrastructural features of *S. noroiticus* properly, while *S. marginaporata* could fit into the genus *Caneosphaera* Gaarder. However, the recent discussion about the classification of the syracosphaerids has shown, that the solution of Gaarder and Heimdal is impractical, because several other species of *Syracosphaera*, illustrated in Okada and McIntyre (1977) could not be fitted into their scheme (Kleijne, personal communication). To by-pass the growing taxonomic difficulties with *Syracosphaera* Jordan and Young (1990) proposed to keep this genus as a group of species with variable morphology, related by the possession of caneloliths, with or without cyrtoliths, but lacking the highly specialized polar coccoliths, found in *Michaelsarsia* and other syracosphaerid genera. To avoid more confusion the relatively open concept of Jordan and Young (1990) is followed to classify *S. noroiticus* and *S. marginaporata*, until a more applicable nomenclatural concept of syracosphaerid genera is elaborated.

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#### Explanation of Plate 2

*Syracosphaera marginaporata* sp.nov. Figs. 1-4.

**Fig. 1:** Disintegrated coccosphere of *Syracosphaera marginaporata* sp. nov. Coccoliths are oval caneoliths with pores at the margin of the central area. Sample FB 23, 10m, station 2 (53° 02.09' N/20° 46.81' W), JGOFS Leg 4. Film 4.1.91/1. Scale bar 2.5µm.

**Fig. 2:** Highly magnified coccoliths of *S. marginaporata* sp. nov. from Figure 1. Film 4.1.91/1. Scale bar 0.5µm.

**Fig. 3:** Collapsed coccosphere of *S. marginaporata* sp. nov. showing dimorphic coccoliths, with large caneoliths as ordinary body coccoliths and smaller helatoform caneoliths with central spine as modified coccoliths. Sample FB 34, station 3 (47° 40.10' N/20° 52.26' W), 20m, JGOFS Leg 4. Film 6.1.91/1. Scale bar 1µm.

**Fig. 4:** Disintegrated coccosphere of *S. marginaporata* sp. nov. Sample FB 34, station 3, 20m, JGOFS Leg 4. Film 13.6.91/1. Scale bar 1µm.

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