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Coccolithophores in modern oceans

Observations on *Syracosphaera rhombica* sp. nov.

Observations sur Syracosphaera rhombica sp. nov.

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Abstract

A spherical coccosphere and two collapsed coccospheres composed of monomorphic rhombic coccoliths were encountered in 2005 in the Java upwelling system of the SE Indian Ocean, while a further two specimens with elongate coccospheres were recently found in the Gulf of Mexico. All of the specimens were collected from the lower photic zone (75–160 m). The coccoliths possess a proximal flange, a slightly flared wall with a serrated distal margin, and a relatively plain central area structure comprised only of overlapping laths. The taxon appears to be an undescribed species of the *Syracosphaera nodosa* group, so we describe it herein as *Syracosphaera rhombica* sp. nov.

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Keywords: Coccolithophorid; Gulf of Mexico; Indian Ocean; Lower photic zone; *Syracosphaera*

Résumé

Une coccosphère sphérique (ainsi que deux coccosphères effondrées) composée de coccolithes rhombiques monomorphiques a été rencontrée en 2005 dans le système de remontée d'eaux profondes de Java dans l'océan Indien du Sud-Est, tandis que deux autres spécimens avec coccosphères allongées ont été récemment trouvées dans le golfe du Mexique. Tous les échantillons ont été prélevés dans la zone photique inférieure (75–160 m). Les coccolithes possèdent une bride proximale, un mur légèrement évasé avec un bord distal serré, et une structure de zone centrale relativement plane, composée uniquement de barres recouvrantes. Il nous semble que ce taxon est une nouvelle espèce du groupe *Syracosphaera nodosa*, décrit ainsi ici comme *Syracosphaera rhombica* sp. nov.

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Mots clés : Coccolithophoridé ; Golfe du Mexique ; Océan Indien ; *Syracosphaera* ; Zone photique inférieure

1. Introduction

The so-called 'shade flora' of subtropical/tropical waters is adapted to permanently stratified waters, high nutrient concentrations and low light levels, and is characterised by a highly diverse coccolithophorid assemblage, including common genera like *Florisphaera* Okada & Honjo and *Gladiolithus* Jordan & Chamberlain (Okada and Honjo, 1973; Jordan and Chamberlain,

1993). In addition, a number of species of *Syracosphaera* Lohmann also inhabit the lower photic zone (LPZ), such as *Syracosphaera* (ex *Deutschlandia*) *anthos* (Lohmann) Janin and *S. lamina* Lecal-Schlauder (Malinverno et al., 2003; Dimiza et al., 2016). In contrast, many other *Syracosphaera* species inhabit the upper photic zone (UPZ), including *S. prolongata* Gran ex Lohmann and *S. pirus* Halldal & Markali which often form incredibly elongate coccospheres, as well as the more traditional spherical forms (Okada and McIntyre, 1977; Andruleit et al., 2005). Herein, we report on a new species, *S. rhombica* sp. nov., that also forms both spherical and elongate coccospheres, but inhabits the LPZ.

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2. Material and methods

A water sample was obtained from 100 m water depth using a CTD rosette at station GeoB 10067-2 (9° 8.93'S 119° 17.49'E; sea-bed depth 1135 m) on 6 September 2005 by scientists aboard the German research vessel *Sonne*, during Leg 3 of cruise SO184 to the eastern Indian Ocean off Java (Hebbeln et al., 2005). 3.4 litres of seawater were filtered without further treatment through a polycarbonate filter (0.45 µm porosity) using a vacuum pump (200 mbar), and then dried for several hours at 50 °C. A portion of the filter was then fixed onto an aluminium stub and coated with gold, and observed in a field emission scanning electron microscope (FEI Sirion 200 SEM).

In addition, water samples were collected along the shelf of the Florida Panhandle in the northeastern Gulf of Mexico from 75 m at Station P7 (29.75° N, 87.25° W; sea-bed depth 160 m) on 13 September 2013 and from 100 m at Station P9 (29.42° N, 87.25° W; sea-bed depth 484 m) on 31 May 2014, as part of a four-year sampling programme for the Deep-C project carried out aboard the American research vessel *Bellows*.

The water samples were collected using a CTD rosette with twelve 5-litre Niskin bottles. Immediately after arriving on deck, 2 litres of seawater were filtered through a Millipore (47 mm diameter, 0.45 µm porosity) membrane filter, with a sieve placed on the filter cup to remove any large particles. To prevent mechanical damage to the coccospheres, filtration was carried out using a vacuum of less than 100 mmHg attached to an electrical pump. After filtration, the filters were rinsed with tap water to remove sea salt, placed in labeled plastic petri-dishes, oven-dried at 50 °C for several hours, covered, and stored in a dry place for later analysis.

A piece of each dried filter was cut out, mounted with double-sided adhesive carbon tape onto a 12 × 10 mm aluminium stub, trimmed to fit the stub diameter, sputter-coated with about 20 nm of gold-palladium, and then examined in a JEOL 6480LV digital SEM. Imaging EDS software attached to the SEM was used to acquire and store the photographic images.

3. Results

3.1. Coccolithophorid assemblages

The CTD samples from station GeoB 10067-2 (collected in September) were never enumerated or observed in detail, so the assemblages associated with *S. rhombica* in the Indian Ocean are currently unknown. However, *S. rhombica* was only encountered in one sample from the LPZ (100 m), with a seawater temperature and salinity of 21.71 °C and 34.25 PSU, and nitrate + nitrite, phosphate and silicate concentrations of 10, 0.64 and 12.45 µM, respectively (Hebbeln et al., 2005).

On the other hand, the assemblages from the Gulf of Mexico are reported herein. *Syracosphaera rhombica* constituted < 1% of the total coccolithophorid assemblage, occurring sporadically in the LPZ at stations P7 (75 m) and P9 (100 m), in September and May, respectively. The LPZ assemblage in May was

dominated by *Florisphaera profunda* Okada & Honjo, *Gladiolithus flabellatus* (Halldal & Markali) Jordan & Chamberlain and *Algirosphaera robusta* (Lohmann) Norris, with lesser contributions from *Umbilicosphaera sibogae* (Weber-van Bosse) Gaarder, *Emiliana huxleyi* (Lohmann) Hay & Mohler, *Gephyrocapsa oceanica* Kamptner, *Ophiaster formosus* Gran, *Hayaster perplexus* (Bramlette & Riedel) Bukry, *Syracosphaera anthos*, *Syracosphaera nana* (Kamptner) Okada & McIntyre, *Syracosphaera noroitica* Knappertsbusch, *Rhabdosphaera clavigera* Murray & Blackman and *Alveosphaera bimurata* (Okada & McIntyre) Jordan & Young. The seawater temperature and salinity at the sample depth was 18.75 °C and 36.23 PSU, respectively. The LPZ assemblage in September was dominated by *Emiliana huxleyi*, *Florisphaera profunda* and *Gladiolithus flabellatus*, with minor contributions (< 1%) from *Algirosphaera robusta*, *Gephyrocapsa oceanica*, *Umbellosphaera irregularis* Paasche, *Michaelsarsia elegans* Gran, *Syracosphaera* spp. and *Solisphaera* Bollmann et al. spp. The seawater temperature and salinity at the sample depth was 19.57 °C and 36.46 PSU, respectively.

3.2. Systematic part

Class Prymnesiophyceae Hibberd, 1976 emend. Cavalier-Smith in Cavalier-Smith et al., 1996

Order Syracosphaerales Hay, 1977 emend. Young et al., 2003

Family Syracosphaeraceae (Lohmann, 1902) Lemmermann, 1903

Genus *Syracosphaera* Lohmann, 1902

Syracosphaera rhombica sp. nov.

Figs. 1–8

Description: Coccosphere shape variable (spherical or elongate), consisting of a single layer of about 70–120 abutting monomorphic coccoliths. Exothecal and specialised circum-flagellar coccoliths seemingly absent. Body coccoliths are rhombic, with a proximal flange, and a flaring outer wall of elements (R units) that are corrugated at the distal end. Inner cycle of wall elements (V units) much shorter (about 1/3 of the length of the outer cycle). Radiating laths (T units) converge in central area, with a secondary layer of elements on top forming a somewhat flattened central structure.

Material: 3 specimens from Station GeoB 10067-2, 1 specimen from Station P7 (75 m; 2013) and 1 from Station P9 (100 m; 2014).

Holotype: Fig. 1. Reposited at BGR, Hannover.

Dimensions: Coccosphere approximately 10 µm in diameter (spherical forms) or 25–30 µm × 5–10 µm (elongate forms). Body coccoliths 2.6–3.1 µm × 1.8–2.0 µm and 0.65–0.8 µm in height.

Remarks: Similar to *S. sp. cf. tumularis* (in Young et al., 2003) but differs by having rhombic not oval body coccoliths (also called muroliths or caneoliths).

Etymology: From Greek *rhombos*—rhombic.

Range and occurrence: Recent, Indian Ocean and Gulf of Mexico.

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