

AN UNUSUAL COCCOLITHOPHORID (HAPTOPHYTA) SPECIMEN FROM PUERTO RICO

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Abstract: During routine phytoplankton counting of offshore Puerto Rican samples, an unusual specimen of *Calciosolenia murrayi* Gran was encountered. *C. murrayi* typically has monomorphic body-coccoliths, but the new specimen bore several types of body-coccolith: at least two types of rhombolith, and a narrow, elliptical coccolith new to science. This latter type is not rhombic like the others, but shares several rhombolith features. However, it differs by being longer, relatively flattened, slightly twisted, and with distally-pointed ends. Although it is possible that the single specimen represents a coccosphere composed mainly of malformed coccoliths, it is suggested here that the new coccolith type may be evidence of an alternate phase. As thousands of only rhombolith-bearing coccospheres have been previously observed by coccolithophorid workers, this new coccolith type may be produced for only a short duration.

Introduction

Since the advent of electron microscopy and the improvement of single-cell isolation and culture techniques, our knowledge of algal life-cycles has increased tremendously. This is even true for the coccolithophorids, calcareous haptophytes, which are predominantly restricted to open oceans. However, despite these advances, coccolithophorid life-cycles are still poorly understood and those that are presently known are mainly neritic species (e.g. *Pleurochrysis carterae* (Braarud & Fagerland) Christensen) or species that are easily grown (e.g. *Emiliania huxleyi* (Lohmann) Hay & Mohler) (Billard, 1994). On the other hand, when observing wild material, coccolithophorid workers sometimes encounter convincing examples of coccospheres seemingly bearing different phases of a life-cycle. Considering the paucity of direct observations on axenic cultured material, these records may give useful information on possible species combinations. In this way a number of associations have been witnessed and reported in the literature (Thomsen *et al.*, 1991; Kleijne, 1993; Alcober & Jordan, 1997; Young *et al.*, 1998, this issue; Cros *et al.*, in press). Most of the known coccolithophorid life-cycles involve either a motile holococcolithophorid and non-motile heterococcolithophorid phase (e.g. *Coccolithus pelagicus* (Wallich) Schiller: Parke & Adams, 1960), or a motile scale-bearing and non-motile coccolith-bearing phase (e.g. *E. huxleyi*: Braarud, 1963). These motile and non-motile phases are now known to represent the haploid and diploid stages respectively (Rayns, 1962; Green *et al.*, 1996). The interesting possibility raised by Alcober & Jordan (1997) was of an association between two non-motile phases, *Ceratolithus cristatus* Kamptner and *Neosphaera coccolithomorpha* Lecal-Schlauder. Recently, whilst studying the phytoplankton assemblages on the filters from the La Parguera time-series station in Puerto Rico (Jordan & Winter, in press), further examples of *Ceratolithus-Neosphaera* associations were encountered (Young *et al.*, 1998, this issue), as well as an unusual specimen of *Calciosolenia murrayi*, bearing several coccolith types, one of which has not been reported previously in the literature.

Location and collection

The *RV Pezmar* (belonging to the University of Puerto Rico) was regularly used over a four year period (1992-1995) to collect biweekly samples off the shelf edge of Puerto Rico. The sampling point (~18°N, 67°W) lies west of La Parguera, the site of the university's marine biological station. Water samples were collected systematically from a number of depths using a single five-litre Niskin bottle, which could be closed manually using a messenger system. Sampling depths were calculated by wire out. After each cast, the water from the bottle was transferred to a plastic carboy, and stored until the water could be filtered at the research station. Only samples collected during January to May, 1995 have been analysed for coccolithophorids (see Jordan & Winter, in press, for further details).

Preparation techniques

A known volume of each water-sample was filtered through a Millipore 47mm-diameter, 0.45µm porosity polycarbonate filter, washed with buffered distilled water, air dried, and stored in a plastic Petri dish. A piece of each filter, ~8x8mm, was attached to an Al EM stub using a small amount of glue, and then coated with either Au or Pt/Pd in an Eiko IB-3 ion coater. The filters were then examined in a Hitachi S-2250N SEM. Photographs were taken either directly by a camera attached to the SEM or images were stored on optical disc prior to being sent to the camera.

Calciosolenia murrayi

This species is regularly reported from the middle photic zone (~70-100m water-depth) of subtropical-tropical waters (Winter *et al.*, 1994; Jordan & Winter, in press), where the long, cylindrical shape of its coccosphere possibly enhances its ability to photosynthesise in low light-conditions (Manton, 1986). Manton & Oates (1985) compared the three living members of the *Calciosoleniaceae* (*C. murrayi*, *Anoplosolenia brasiliensis* (Lohmann) Deflandre and *Navisolenia aprilei* Lecal) and concluded that the body-coccoliths of these species were always rhombic, even when they became very narrow at the poles. Thus, these coccoliths are termed rhomboliths in preference

to the other commonly-used term, scapholith, which means boat-shaped (Jordan *et al.*, 1995). Furthermore, it appears that the rhomboliths on an individual coccosphere are monomorphic despite variation in shape and size.

A collapsed specimen of *C. murrayi* was encountered (on the 15m filter of 13th February, 1995) which bore two types of rhomboliths and a second body-coccolith type (Plate 1, Figure 1). *C. murrayi* is normally characterised by monomorphic body-coccoliths, so our specimen may be malformed. However, the nature of the new coccolith type suggests that the specimen is truly exhibiting polymorphic body-coccoliths. The rhomboliths of the new specimen are either constructed of fine, slightly overlapping laths with spaces in between (labelled 'a' in Plate 1, Figure 2), or are seemingly more heavily calcified, with much broader laths with no gaps in between (labelled 'b' in Plate 1, Figure 2). This latter type was figured by Manton & Oates (1985) and tentatively identified as *C. aff. murrayi*. One of their specimens (their pl.4, fig.14) clearly showed that the body-coccoliths were monomorphic. The third type of body-coccolith is typically longer and narrower than most of the rhomboliths, bears more laths, is slightly twisted at the ends, and is not rhombic (Plate 1, Figure 3). Another characteristic of this new coccolith type is the raised, almost pointed, ends which can be clearly seen in side-view. Whilst rhomboliths of *C. murrayi* and *A. brasiliensis* do not possess this feature, the unmineralised rhombic scales of *Navisolenia* Lecal appear to do so (see Leadbeater & Morton, 1973, pl.1, fig.4).

Navisolenia was recorded by Leadbeater & Morton (1973) from the coast of Yugoslavia between 0-10m water-depth. Whether the unmineralised *Navisolenia* or our mineralised new coccolith type represent phases in the *Calciosolenia* life-cycle is not known at present. However, it is true to say that these haptophytes are unlike any other living coccolithophorids, and should be certainly separated at the family level. Interestingly, the rhomboliths of *Calciosolenia* and *Anoplosolenia* (or their ancestors) can be found as far back as the Hauterivian of the Early Cretaceous, and their morphology has remained seemingly unchanged for over a 100m.y. (Perch-Nielsen, 1985). Prior to their first appearance, similar-looking coccoliths occurred. Of these, *Truncatoscapus* Rood *et al.* (Jurassic-Early Cretaceous) of the Stephanolithiacea may be the ancestor of *Calciosolenia*, in particular *T. delftensis* (Stradner & Adamiker) Rood *et al.* (Perch-Nielsen, 1985; Bown & Young, 1997). Given that the lineage of the Calciosoleniaceae, geologically speaking, is very long and its morphology has remained unchanged throughout this time, it may prove to be a very useful genetic marker for the separation of the haptophytes from other algae. Thus, in the future it would be very interesting to compare the genetics of these calciosolenioid species with other extant coccolithophorids.

Acknowledgements

The authors would like to thank Dr. Jeremy Young, for discussions relating to the evolution of rhombolith-bearing coccolithophorids, Mark Reigle, Angie McGeehe, Jackie Bonilla, Brett Stuart and Salvador Rivera Casiano for helping in the collection and filtration of water-samples,

and the crew of the *RV Pezmar* for their cooperation during sampling.

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Plate 1
Scale bars = 1 μ m

Figures 1-3: An unusual specimen of *Calciosolenia murrayi*. 1. The collapsed coccosphere. 2. High magnification of two types of rhomboliths: a = a narrow, lightly calcified rhombolith (note the open laths), and b = a broad, heavily calcified rhombolith. 3. High magnification of the twisted, elongate body-coccoliths. Note the pointed ends.

