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Scyphosphaera porosa Kamptner, 1967 rediscovered in the plankton

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Abstract *Scyphosphaera porosa* was described by Kamptner (1967) from Late Quaternary sediments obtained by the *Challenger* Expedition, but has not since been recorded. A single coccosphere of this species has been discovered on a filter from the lower photic zone, collected during Atlantic Meridional Transect Cruise 14 from near the type locality. The new specimen proves that this is a distinctive extant species, but possibly with closer affinity to *Pontosphaera multipora* than *Scyphosphaera apsteinii*.

Keywords *Scyphosphaera*, lower photic zone, coccolithophores

1. Introduction

Scyphosphaera is one of the more striking of the extant coccolithophores, producing large dimorphic coccospheres, with plate-like body coccoliths and bowl-like equatorial 'lopadoliths'. Only one extant species of *Scyphosphaera, S. apsteinii,* is recognised in recent syntheses of the extant coccolithophore flora (*e.g.* Young *et al.*, 2003; Jordan *et al.*, 2004), although a high diversity of Neogene species has been described (see reviews by Aubry, 1990; Siesser, 1998; Young, 1998).

Whilst examining a plankton filter-sample from the South Atlantic, collected during Atlantic Meridional Transect (AMT) Cruise 14, a beautiful and very unusual *Scyphosphaera* specimen was observed. Technically, this is not a new species, since a literature review revealed that it had previously been described by Kamptner (1967) from Holocene sediments, but it does not appear to have been observed in the plankton before, and so this note briefly records it as an addition to the known biodiversity of extant coccolithophores.

2. Structure of *Scyphosphaera* coccoliths

As discussed by Romein (1979), Theodoridis (1984) and Aubry (1990), *Pontosphaera*, *Scyphosphaera* and *Helicosphaera* coccoliths all have rather similar structure, and they are all included in the Zygodiscales in recent classifications (Young & Bown, 1997; Young *et al.*, 2003). In each case, they are formed of three main sets of elements: an outer flange, proximal plate and distal blanket. The outer flange is formed of anticlockwise-imbricated elements, and in *Helicosphaera* is modified into a spiral flange. It is formed of crystals with sub-vertical *c*-axes, that is, V-units, which are dark in crossed-polars in plan view. The proximal plate is formed of radial elements and the blanket of a mass of small, apparently discrete, units. Both the blanket and the proximal plate are formed of crystal units with subradial calcite *c*-axes, that is, R-units, and are in fact continuous with each other (Henriksen *et al.*, 2004; Young *et al.*, 2004).

In *Scyphosphaera apsteinii* lopadoliths, the outer flange of V-units forms a narrow layer around the outside of the coccolith, the elements show strong anticlockwise imbrication in the lower third or so of the coccolith, then continue vertically to the top of the coccolith (Pl.1, fig.6). The R-units form the proximal plate of radial elements, which have a much less regular appearance on their distal side, and extend up the inside of the lopadolith wall, usually continuing to the crest of the wall. The wall thus has a two-layered construction (Pl.1 figs 7, 8, and see description of Kamptner, 1967).

3. Material and methods

The specimen was observed by light microscopy (LM) of a filter sample, collected by Timothy Adey (National Oceanography Centre, Southampton), during Atlantic Meridional Transect Cruise 14 from the tropical South Atlantic in early summer, 2004. The sample was from conductivity-temperature-depth cast 26, 120m water-depth, 24.23˚S, 25.00˚W. The sample was collected on a Nucleopore-type polycarbonate filter. Cruise and sample details are documented in Holligan *et al.* (2004).

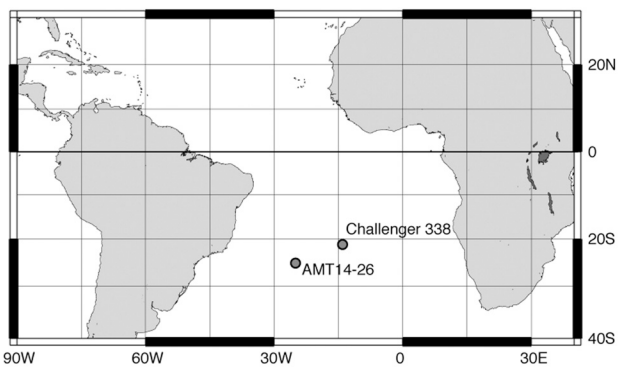


Figure 1: Map of the South Atlantic showing the location of *Challenger* Station 338, type locality of *Scyphosphaera porosa*, 50km and Station AMT14-CTD26, from which the new specimen was collected

For LM, a portion of the filter was permanently mounted on a glass slide using low viscosity Norland Optical Adhesive No.74. Polycarbonate filters are not ideal for LM as they are optically translucent, rather than transparent, and the micropores disrupt images. In practice, this means it is not possible to use bright-field or phase-contrast illumination. In crossed-polars, however, the filters behave as single, low-birefringence crystals. By rotating the stage to the position where the filter goes into extinction, coccolithophores can usefully be studied. The sample was studied on a Zeiss Axioplan transmitting light-microscope, equipped with a Leica Firecam 280 camera for digital imaging. Comparative specimens of *Scyphosphaera apsteinii* were imaged on a Phillips XL-30 FEG scanning electron microscope (SEM).

4. Observations

The AMT sample contains a diverse lower-photic assemblage, including *Florisphaera profunda, Gladiolithus flabellatus*, *Algirosphaera robusta, Hayaster perplexus, Reticulofenestra sessilis, Scyphosphaera apsteinii, Syracosphaera anthos, S. lamina* and *S. bannockii*. The sample has been extensively studied by both SEM and LM. In LM, a single, very unusual *Scyphosphaera* specimen was observed, as illustrated in Plate 1, fig.1. The coccosphere is formed of five equatorial lopadoliths (high-sided muroliths) and *ca*.40 body-coccoliths. Excluding the lopadoliths, the coccosphere is 28μm in diameter. The lopadoliths are straight-sided, flaring distally, 15-20μm high, with a basal width of 6-7μm and distal width of 10-15μm. The body coccoliths are irregularly elliptical in plan view, 5-8μm long and 4-5μm wide, with two or three rings of large (*ca*.0.5μm) pores.

When examined in crossed-polars with a gypsum plate, the lopadoliths can be seen to be constructed of two cycles of units. An outer cycle of elements with *c*-axes oriented parallel to the length of the lopadoliths (V-units) forms most of the wall. An inner cycle with *c*-axes oriented perpendicular to the length of the lopadoliths (R-units) forms the base and an inner layer of the wall, extending a quarter to half the way up the wall.

5. Interpretation

Numerous Cenozoic species of *Scyphosphaera* have been described, particularly from the Late Neogene, but it has generally been thought that there is only one extant species, *Scyphosphaera apsteinii*, possibly with a sub-taxon, *S. apsteinii* f. *dilatata*. My own observations of *Scyphosphaera* specimens, from both plankton samples and culture experiments, fully confirm this. While every *S. apsteinii* coccosphere is different, they share numerous common characteristics, and clearly differ from the specimen observed here. The lopadoliths of *S. apsteinii* are typically broad and distinctly barrel-shaped (Pl.1, figs 4-7). In cross-section, they have thick walls, with the inner cycle of R-units extending to the top of the coccolith (Pl.1, figs 7, 8). This contrasts markedly with the observed specimens in which the lopadoliths are straight-sided, thin-walled and in which the R-units only extend a short distance up the coccolith. Just as strikingly, the *S. apsteinii* coccospheres usually only have 10-15 body coccoliths with an irregular scatter of minute pores in the central-area (Pl.2, figs 4, 5), in contrast to the much more numerous body coccoliths with large pores of the observed specimen.

The illustrated specimen (Pl.1, figs 1, 2) is clearly not *S. apsteinii*. A review of the numerous other species that have been described (see reviews in Aubry, 1990 and Siesser, 1998) revealed that *S. porosa* Kamptner, 1967 is based on essentially identical lopadoliths, as shown by the figures from Kamptner (1967) reproduced here (Pl.1, figs 3, 4). They show the same simple, flaring shape, with large pores in the base, and are similar in size. Kamptner (1967) quotes a size-range of 15-21.7μm high; the lopadoliths on the new specimen are 15-20μm high. Kamptner (1967) also described, in detail, the appearance of the specimens in cross-polarised light and with the gypsum plate and, specifically, the fact that the base and wall show different behaviour. Finally, it is noteworthy that *Challenger* Station 338 was located in the South Atlantic at 21.25˚S, 14.03˚W, and so remarkably close to the site from which this new specimen was collected (Figure 1).

Kamptner (1967) only observed isolated lopadoliths in a sediment-sample, so he did not have any data on the associated body coccoliths. Nonetheless, the similarity of the lopadoliths is so striking that it is clear that the observed specimen is a coccosphere of *S. porosa*, rather than of an undescribed species.

Material from the *Challenger* Expedition is archived in the Natural History Museum, so it was possible to make new smear-slides from the ooze recovered from Station 338. However, no specimens of *S. porosa* were found. This is not entirely surprising, as it is evident that Kamptner (1967) only found a few specimens in the course of his extended study of the sample.

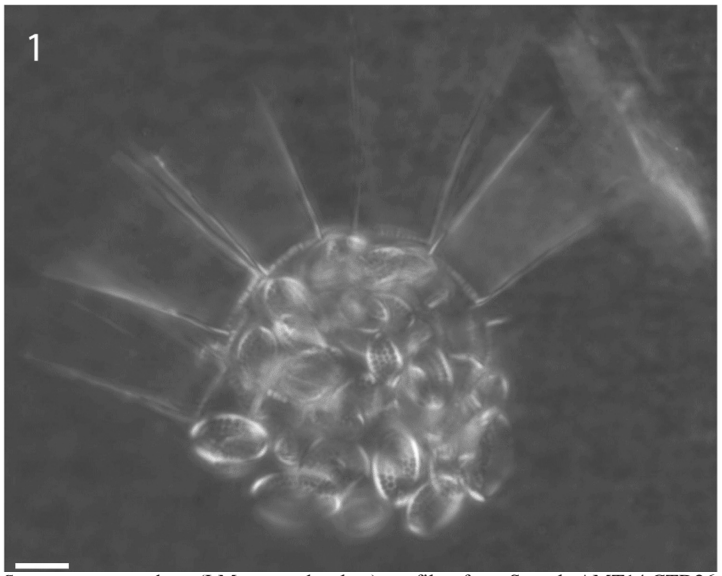
6. Discussion

Given the intensive studies that have been carried out on extant coccolithophores, including South Atlantic samples, it is rather surprising to find a large and very distinctive species in the plankton for the first time. Either *Scyphosphaera porosa* is a very rare species, possibly confined to the South Atlantic or, conceivably, it is not a discrete species, but rather a rarely-expressed life-cycle phase of *Pontosphaera multipora,* which is a rather rare and variable species. This interpretation is suggested by the similarity of the body-coccoliths to those of *P. multipora*. Since I only have LM observations on a single specimen, it is not possible to definitively distinguish between these two possibilities, but in the absence of any positive evidence that it is a life-cycle phase, I suggest *S. porosa* should be regarded as a discrete species.

An unusual aspect of *S. porosa* is that the inner wall-cycle of R-units only extends part of the way up the lopadolith. Not just *S. apsteinii*, but also the diverse range

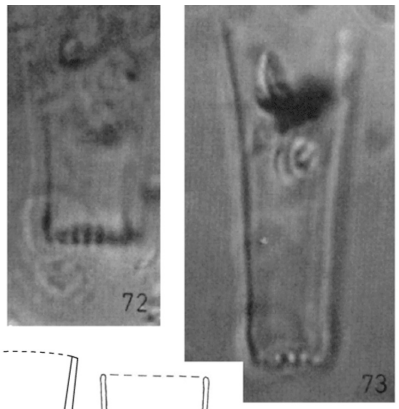
Plate 1

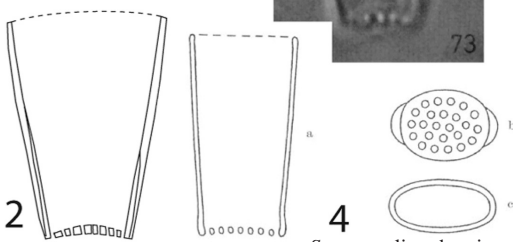
LM and SEM micrographs of *Scyphosphaera* coccoliths. All scale-bars = 5μm



S. porosa coccosphere (LM, crossed-polars), on filter from Sample AMT14 CTD26

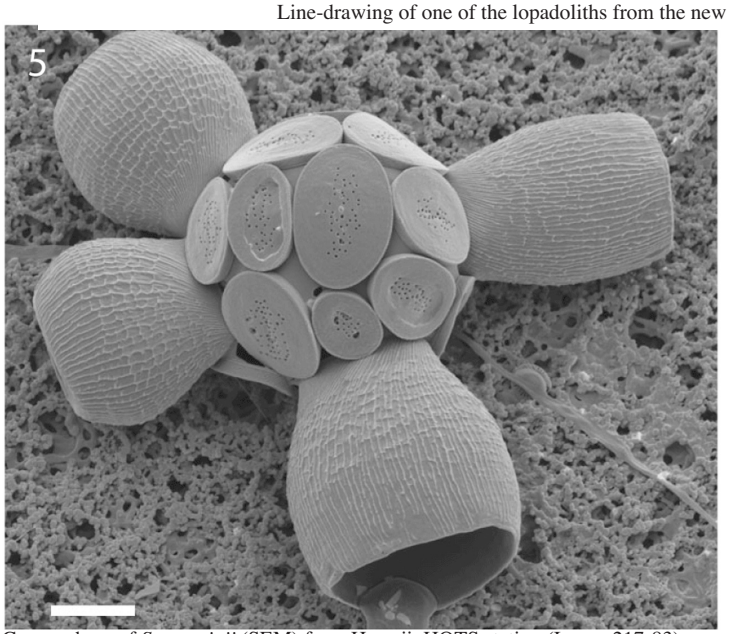
S. porosa (LM) from Kamptner (1967). Specimens from *Challenger* dredging, Station 338



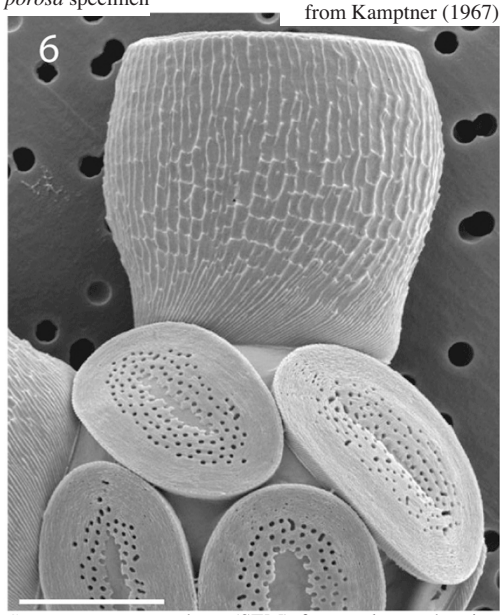


Line-drawing of one of the lopadoliths from the new *S. porosa* specimen

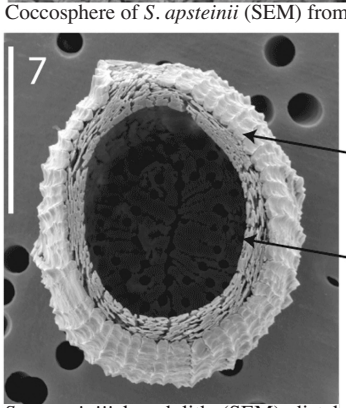
S. porosa line-drawings from Kamptner (1967)



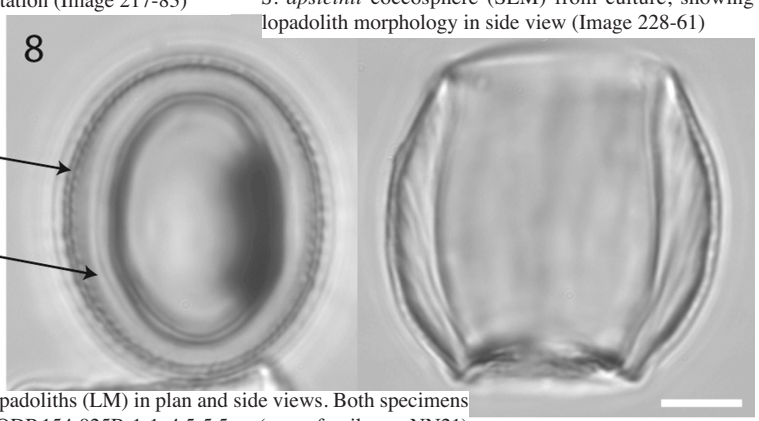
Coccosphere of *S. apsteinii* (SEM) from Hawaii, HOTS station (Image 217-83)



S. apsteinii coccosphere (SEM) from culture, showing lopadolith morphology in side view (Image 228-61)



S. apsteiniii lopadolith (SEM) distal view, from culture (Image 228-46)



S. apsteinii lopadoliths (LM) in plan and side views. Both specimens from Sample ODP 154-925B-1-1, 4.5-5.5cm (nannofossil zone NN21)

of Neogene *Scyphosphaera* species, show the R-units extending to the crest of the coccolith. To verify this, several Neogene samples with high concentrations of *Scyphosphaera* coccoliths were re-examined, and no specimens with restricted R-unit cycles similar to those of *S. porosa* were seen. So, *S. porosa* is a rather anomalous *Scyphosphaera* species, which possibly makes affinity with *Pontosphaera* more likely.

7. Conclusion

A single coccosphere of the large species *Scyphosphaera porosa* has been observed on a plankton filter from the South Atlantic lower photic zone. It is possible that this is an aberrant *Pontosphaera*, rather than a true *Scyphosphaera*, but in either case it provides another example of the continuing trend of new observations of rare, patchily-distributed, lower-photic species, as documented by, for example, Jordan & Chamberlain (1993), Young & Andruleit (2006) and Bollmann *et al*. (2006).

Acknowledgements

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