

A revision of Quaternary species of the genus *Scyphosphaera*

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The genus *Scyphosphaera* is perhaps one of the most understudied groups of coccolithophores due to its relative scarcity in many stratigraphic sections. Polymorphism is one important feature of the scyphosphaerids as illustrated by Lohmann (1902) in his drawings of the type species *S. apsteinii*. Siesser (1998) indicated that 53 species had been described from lower Eocene to Upper Pleistocene sediments. Many Quaternary *Scyphosphaera* species have been described in the literature, but some may belong to the same coccosphere. To clarify the ranges of Quaternary *Scyphosphaera* and the biostratigraphic value of some of these species, I undertook a detailed analysis of sediments from Ocean Drilling Program (ODP) Leg 154 sites in the tropical Atlantic Ocean. I observed a total of 39 *Scyphosphaera* species in the Leg 154 Quaternary sediments. This degree of variation of forms is similar to that observed in Miocene or Pliocene sediments. I found no decrease in the number of *Scyphosphaera* species for the Late Pliocene (Subzone NN16B) or the Early Pleistocene (Zone NN17 to Subzone NN19A). Based on this assessment, the number of Quaternary *Scyphosphaera* species has so far been underestimated. All 39 species survived the early Quaternary cooling between 2.588 and 1.727 Ma (De Kaenel et al., 2024) and disappeared in the late Early Pleistocene (Calabrian). Only nine species are recorded in the Holocene, and the youngest sample examined (1000 years) contained all nine: *S. antilleana*, *S. apsteinii*, *S. aranta*, *S. cohenii*, *S. elegans*, *S. galeana*, *S. magma*, *S. porosa*, and *S. recurvata*.

I identified a total of nine *Scyphosphaera* groups (GR) in the Quaternary based on morphologic criteria and extinction levels. Species that disappear at the same time are placed in the same group and are thought to represent forms (*formae*) belonging to the same coccosphere and so to one unique species. The extinction of these groups occurs between Subzones NN19B and NN21A with two groups surviving until today: the *S. apsteinii* group (GR1) and the *S. porosa* group (GR2). The *S. hemirana* group (GR3) disappeared at 0.128 Ma (NN21B), the *S. recta* group (GR4) at 0.525 Ma (NN19F), the *S. globulosa* group (GR5) at 0.699 Ma (NN19F), the *S. aequatorialis* (GR6) at 0.731 Ma (NN19F), the *S. pulcherrima* group (GR7) at 0.966 Ma (NN19F), the *S. campanula* group (GR8) at 1.318 Ma (NN19D), and the *S. lagena* group (GR9) at 1.643 Ma (NN19B). Each group of *Scyphosphaera* consists of lopadoliths of the same structure with some morphological variations in the shape of the margin or of the neck. A lopadolith with a neck was never observed in a group of lopadoliths without a neck. GR1 to GR5 include lopadoliths without a neck, and GR6 to GR9 lopadoliths have necks. The highest occurrence of *Scyphosphaera* with a neck (GR6 at 0.731 Ma) occurs at the base of the Middle Pleistocene, just above the Matuyama/Brunhes magnetochron boundary, and divides the Quaternary into two main intervals (Early Pleistocene and Middle–Late Pleistocene). The other six Pleistocene groups provide useful additional biohorizons to subdivide the Quaternary calcareous nannofossil zonation.

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