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Taxonomic note: *Sphenolithus pseudoheteromorphus*, a new Miocene calcareous nannofossil species from the equatorial Indian Ocean

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Abstract *Sphenolithus pseudoheteromorphus* sp. nov., first recorded as *S. pseudoheteromorphus* in sediments recovered during ODP Leg 115 in the western equatorial Indian Ocean, is here formally described and illustrated. Its palaeogeographical distribution is reported, encompassing the Ontong Java Plateau (western equatorial Pacific, ODP Leg 130) and the Ceara Rise (western equatorial Atlantic, ODP Leg 154). It is found at the same stratigraphic level in all three locations, and thus could be useful for interregional biostratigraphic correlation.

Keywords Calcareous nannofossils, taxonomy, *Sphenolithus*, ODP, Miocene

1. Introduction

A new species of *Sphenolithus* Deflandre (*in* Grassé, 1952), *S. pseudoheteromorphus*, was found for the first time in 1990, during a detailed study of Miocene calcareous nannofossils from equatorial Indian Ocean sediments (ODP Leg 115; Rio *et al*., 1990; Fornaciari *et al*., 1990). Though Rio *et al*. (1990) recorded and Fornaciari *et al*. (1990) illustrated *S. pseudoheteromorphus*, they never provided a formal description of this new taxon. Later studies recorded the presence of the species in oceanic sediments from different areas (Leg 130, Ontong Java Plateau: Fornaciari *et al*., 1993; Leg 154, western equatorial Atlantic Ocean: Fornaciari, 1996), but a description of this taxon was still not published and it thus remained a *nomen nudum*, that is, a formally undescribed taxon.

This new species appears to have a reproducibly well-defined, short stratigraphic range in the Miocene over a wide geographical area, which is potentially useful for global biostratigraphic correlation, thus we provide a detailed formal description of *S. pseudoheteromorphus*, which we observed from the Mascarene Plateau (ODP Leg 115).

2. Material and methods

Miocene calcareous nannofossil oozes from ODP Legs 115, 130 and 154 were analysed using a Zeiss Ultraphot light microscope (LM), under parallel and cross-polarised light with 1250x magnification. Preparation of smear-slides followed the standard technique described in Bown & Young (1998). Norland 61 optical adhesive was used as a permanent mounting medium. The microphotographs provided have been taken using both light and scanning electron microscopes (SEM).

3. Systematic palaeontology

The higher classification of calcareous nannofossils utilised is that of Young & Bown (1997a, b). The formal definition of this new species complies with the *International Code of Botanical Nomenclature* (*ICBN*; Greuter *et al*., 2000).

Order DISCOASTERALES **Hay, 1977**
Family **SPHENOLITHACEAE** Deflandre *in* Grassé, 1952
Genus *Sphenolithus* Deflandre *in* Grassé, 1952

Sphenolithus pseudoheteromorphus sp. nov.
Pl.1, figs 1-16; Pl.2, figs 1-5, 9, 13

1990 *Sphenolithus pseudoheteromorphus* Fornaciari *et al*.: pl.3, figs 4a, b.

Derivatio nominis: From the Greek '*pseudos*', meaning 'false' *S. heteromorphus*. **Diagnosis**: Medium-sized, conical or pyramidal sphenolith with a prominent apical spine. The base of the sphenolith is constructed of about 10 wedge-shaped elements, oriented obliquely to the length of the axis, which support three cycles of laterally-projecting elements. These are wedge-shaped and encase an apical spine up to 2/3 the length of the entire nannolith. **Description**: Under cross-polarised light (XPL), *S. pseudoheteromorphus* presents a long, weakly birefringent element in the third cycle when the long axis is at 0˚ (*e.g.* Pl.1, figs 5, 9, 11, 13). With the long axis at 45˚ (*e.g.* Pl.1, figs 6, 10, 12, 14), it shows a long, moderately-birefringent spine that is slightly asymmetrical (*i.e.* not parallel to the long axis), because of the presence of this well-developed element in the upper lateral cycle, overlapping onto the apical spine. **Differentiation**: In the LM, this species is very similar to *S. heteromorphus*, from which is distinguished by the presence of the long, bright element in the upper lateral cycle at 0˚. In addition, figured specimens of *S. heteromorphus* (*e.g.* Aubry, 1989; this study: Pl.2, fig.16) have two cycles of lateral elements, while *S. pseudoheteromorphus* has three cycles. **Holotype**: Pl.1, fig.1 (SEM). **Dimensions**: height (H) - 4.5-12μm. Holotype: H - 10μm, base width (W) - 4 μm, base height - 3.5μm. **Paratypes**: Pl.1, figs 2-4, Pl.2, fig.13 (SEM); Pl.1, figs 5-10 (LM). Sample ODP

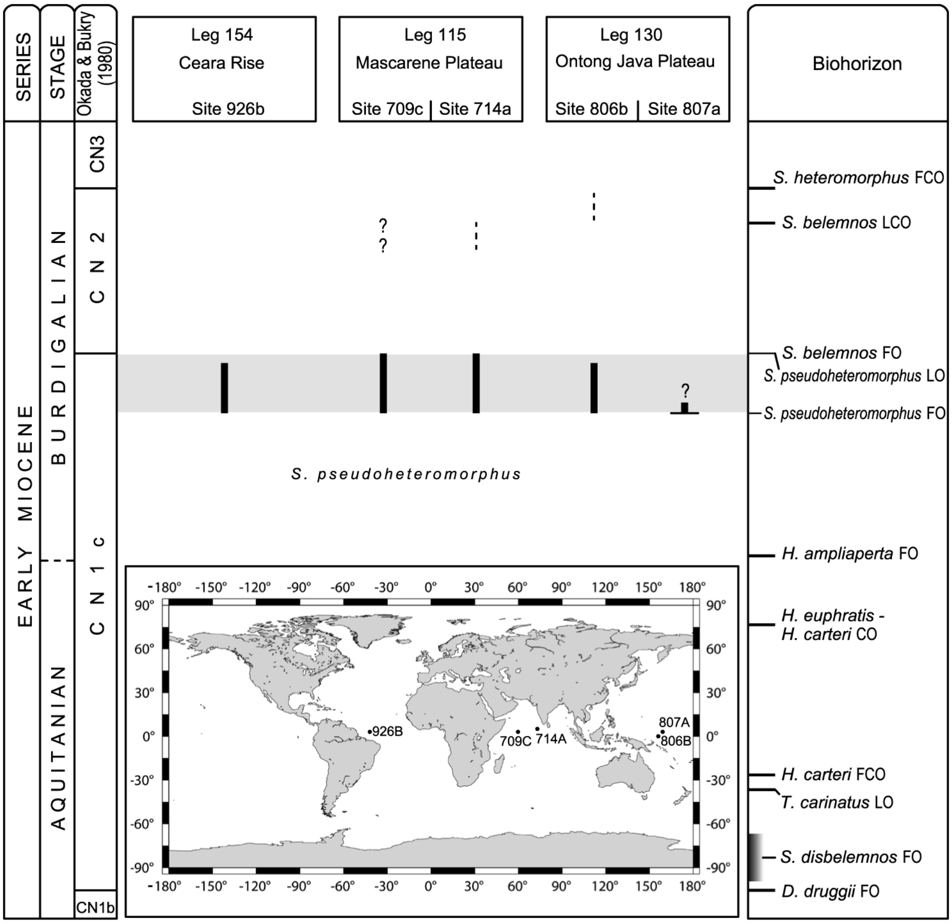

Figure 1: Stratigraphic distribution of *Sphenolithus pseudoheteromorphus* from ODP Holes 709C, 714A, 806B, 807A and 926B (Rio *et al*., 1990; Fornaciari *et al*., 1993; Fornaciari, 1996; Raffi *et al*.; 2006; this study) plotted against the chronostratigraphy (ATNTS: Lourens *et al*., 2004) and the biozonation of Okada & Bukry (1980). FO = first occurrence; LO = last occurrence; CO = crossover. The map projection indicates the locations of the ODP holes considered in the text

115-714A-19X-5, 75cm. **Type locality**: ODP Leg 115, Site 714, Mascarene Plateau, western equatorial Indian Ocean. **Type level**: Sample ODP 115-714A-19X-5, 75cm. **Geographical occurrence**: Western equatorial Indian Ocean (ODP Leg 115, Holes 709C and 714A: Rio *et al*., 1990; Fornaciari *et al*., 1990), western equatorial Pacific Ocean (ODP Leg 130, Holes 806B and 807A: Fornaciari *et al*., 1993) and western equatorial Atlantic Ocean (ODP Leg 154, Hole 926B: Fornaciari, 1996). **Stratigraphical occurrence**: Upper part of CN1c or NN2 (of, respectively, Okada & Bukry, 1980, Martini, 1971). Very rare specimens have been observed stratigraphically higher, in CN2, in Holes 709C, 714A and 806B, whereas it is missing from the equivalent stratigraphic interval in Holes 807A and 926B. This inconsistency in the last occurrence may be explained by the reworking commonly recorded in the Mascarene Plateau material during this interval; reworking may also affect Hole 806B sediments. The stratigraphic distributions available for *S. pseudoheteromorphus* suggest that the stratigraphic range of this species is actually restricted to a very short interval in the uppermost part of CN1c, thus indicating that it has a distinct stratigraphic distribution (Figure 1). **Biochronology**: Age-depth plots from Holes 714A, 806B, 807A and 926B, based on the Astronomical Tuned Neogene Time Scale (ATNTS: Lourens *et al*., 2004), and age estimates derived from magnetostratigraphic data, available for Hole 709C (Schneider & Kent, 1990), provide multiple calibrations for the first occurrence of *S. pseudoheteromorphus*. This biohorizon lies in Chron C6n in all the considered sites, suggesting that the evolutionary first appearance and stratigraphical range of this taxon could be used for interregional correlations. **Repository**: Holotype and paratypes deposited in the permanent collection of the Museo di Geologia e Paleontologia dell'Universitá di Padova (MGPD), Padova, Italy (protocol #MGPD30096).

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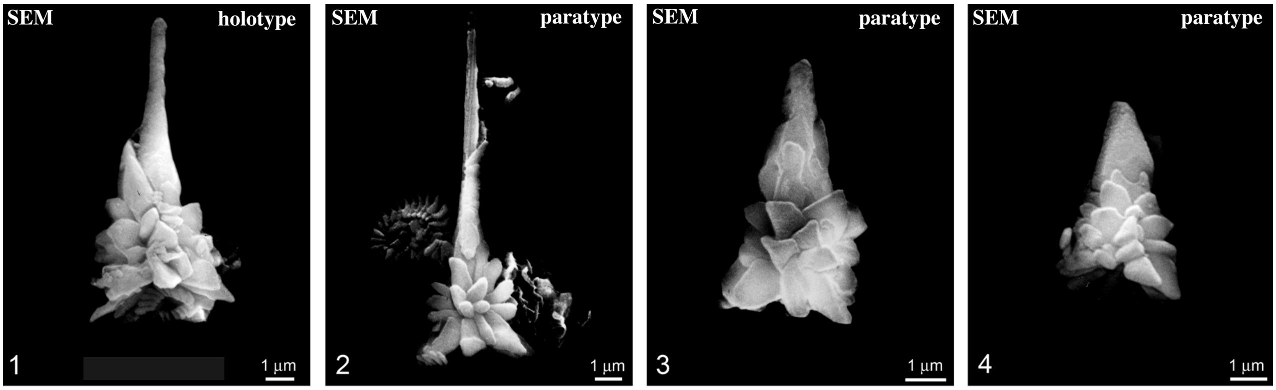
Plate 1

Microphotographs of *S. pseudoheteromorphus*
from ODP Sites 714 (western equatorial Indian Ocean) and 806 (western equatorial Pacific Ocean)

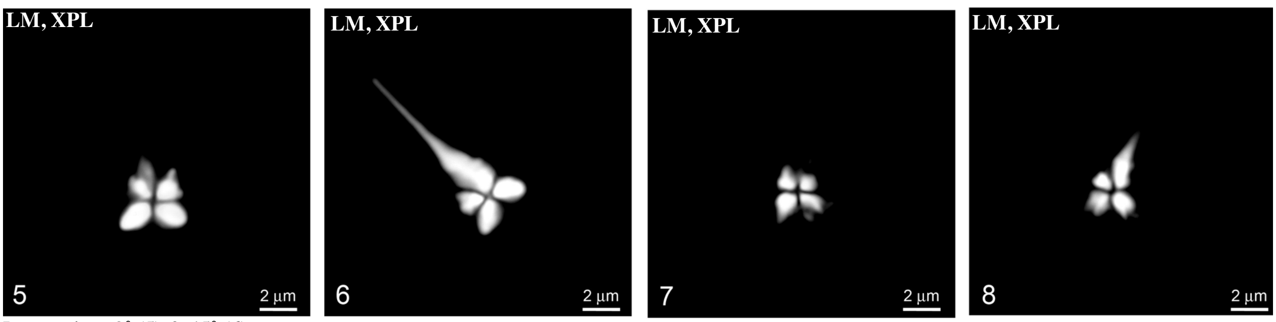


Side view
Sample 115-714A-19X-5, 75cm

Side view
Sample 115-714A-19X-5, 75cm

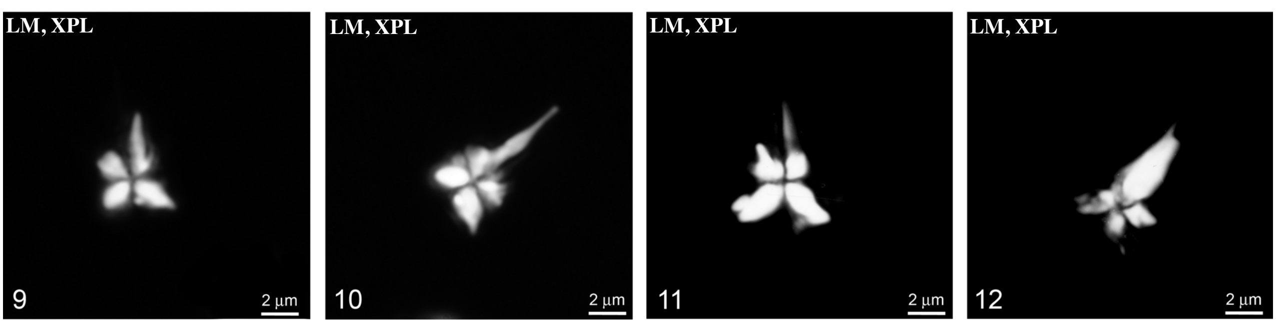
Side view
Sample 115-714A-19X-5, 75cm

Side view
Sample 115-714A-19X-5, 75cm



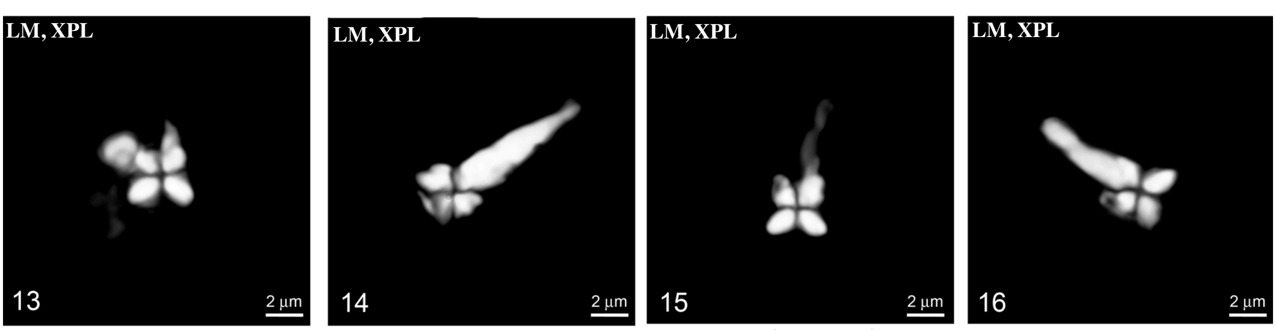
Long axis at 0˚ (5) & 45˚ (6)
Sample 115-714A-19X-5, 75cm

Long axis at 0˚ (7) & 45˚ (8)
Sample 115-714A-19X-5, 75cm



Long axis at 0˚ (9) & 45˚ (10)
Sample 115-714A-19X-5, 75cm

Long axis at 0˚ (11) & 45˚ (12)
Sample 115-714A-19X-5, 116cm

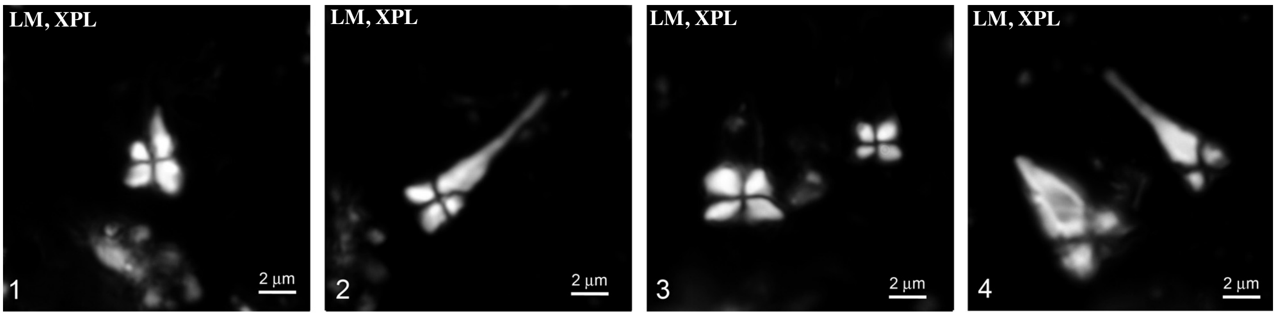


Long axis at 0˚ (13) & 45˚ (14)
Sample 130-806B-66X-3, 69cm

Long axis at 0˚ (15) & 45˚ (16)
Sample 130-806B-66X-3, 69cm

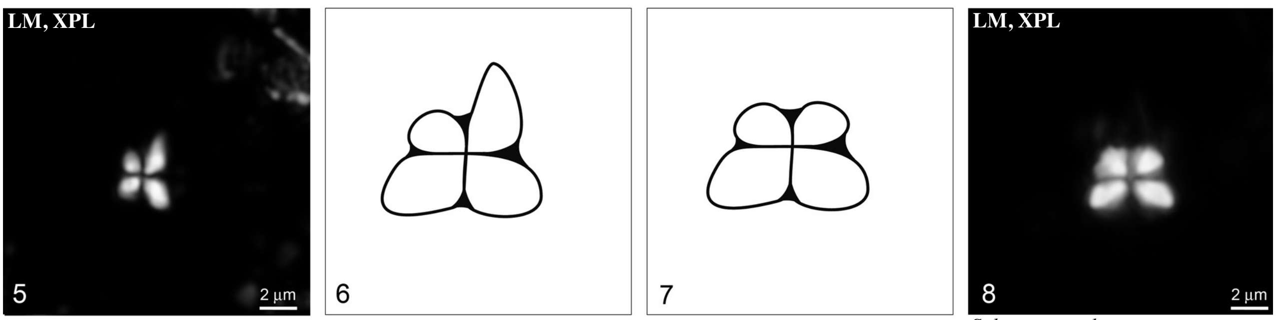
Plate 2

Microphotographs of *S. pseudoheteromorphus* and *S. heteromorphus*
from ODP Sites 926 (western equatorial Atlantic Ocean) and 714 (western equatorial Indian Ocean)



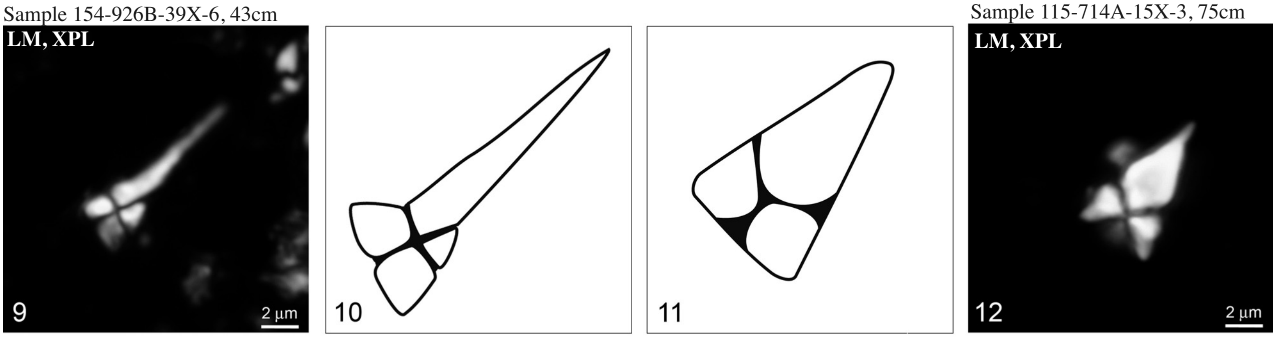
S. pseudoheteromorphus, long axis at 0˚ (1) & 45˚ (2)
Sample 154-926B-39X-6, 43cm

S. heteromorphus, long axis at 0˚ (3) & 45˚ (4)
Sample 154-926B-33X-CC



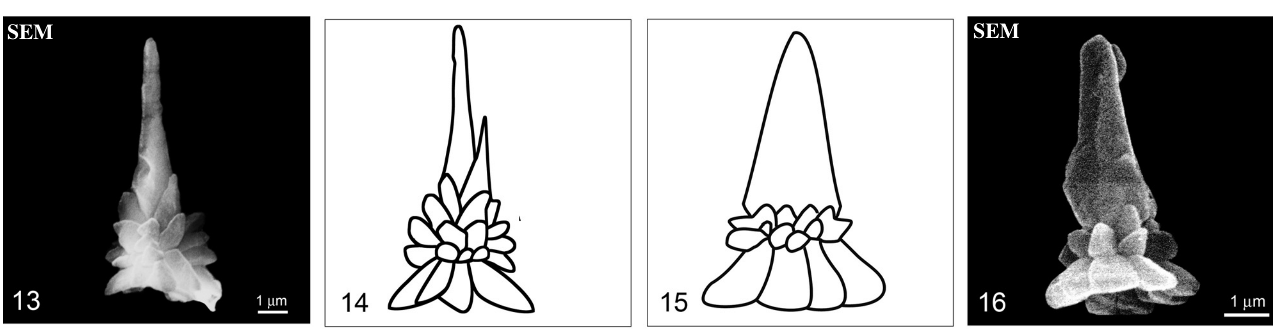
S. pseudoheteromorphus
long axis at 0˚ (5) & 45˚ (9)
Sample 154-926B-39X-6, 43cm

S. heteromorphus
long axis at 0˚ (8) & 45˚ (12)
Sample 115-714A-15X-3, 75cm



Sketch of *S. pseudoheteromorphus*
from LM image at 0˚ (6) & 45˚ (10)

Sketch of *S. heteromorphus*
from LM image at 0˚ (7) & 45˚ (11)



S. pseudoheteromorphus side view
Sample 115-714A-19X-5, 75cm

S. pseudoheteromorphus
Sketch from SEM image

S. heteromorphus
Sketch from SEM image

S. heteromorphus side view
(reproduced from Perch-Nielsen, 1977, pl.34, fig.3)
Sample 39-357-6-5, 70cm