

SPECULATIONS ON THE OCCURRENCE OF THE LATE MIOCENE SPECIES, *MINYLITHA CONVALLIS*, IN ANTARCTIC MARGIN SEDIMENTS

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Abstract: Rare to few specimens of the Late Miocene nannolith, *Minylitha convallis*, were noted in continental rise drift deposits recovered during Ocean Drilling Program Leg 188, Prydz Bay, Antarctica, at 64°S latitude. This nannofossil species has not been previously reported at such an extremely high latitude, and this occurrence extends its known geographic range to the margin of Antarctica. Although its ecologic constraints are not well known, its presence in one sample, along with even more-rare specimens of *Discoaster* spp. and *Sphenolithus abies*, possibly indicates a very brief warming of sea-surface temperatures near the Antarctic margin during the Late Miocene (~10.3-9.0Ma).

Introduction

Few calcareous nannofossil-bearing sections of Neogene age have been recovered from the extreme high-latitudes of the Southern Ocean, particularly along the Antarctic margin. Haq (1976, 1980) was one of the first to report on the occurrence and biogeographic implications of coccoliths of this age from high austral latitudes and near the Antarctic margin. More recently, Miocene nannofossils have been retrieved during Legs 113, 119, 120 and 178 (Wise, 1983; Wei & Wise, 1990; Wei & Thierstein, 1991; Wei & Wise, 1992a, b; Barker, Camerlenghi, Acton *et al.*, 1999). The paucity of nannofossils in deposits of this

age generally reflects cooling, associated with the increased thermal isolation of the Southern Ocean around the Antarctic continent, consequent to the establishment of the Antarctic Circumpolar Current (*e.g.* Kennett, 1977).

Ocean Drilling Program (ODP) Leg 188 recovered piston and rotary cores at three southern Indian Ocean sites on the continental margin in Prydz Bay, Antarctica (Figure 1). The sites were cored along a shelf-slope-rise transect in order to obtain a detailed sedimentary record reflecting Cenozoic Antarctic glacial history and palaeoenvironments. Calcareous nannofossils were most common, although sporadic, at continental rise Site 1165 (water-depth = 3537m; 64°2'S). Here, a thick Neogene section, comprising predominantly fine-grained terrigenous and diatom-bearing hemipelagic sediments (sediment-drift deposits), was collected (O'Brien, Cooper, Richter *et al.*, 2001). In addition to nannofossils, diatoms, radiolaria and planktonic foraminifera indicate a relatively continuous, nearly 1000m, Lower Miocene to Upper Pliocene section that underlies a thin Quaternary cover. The presence of nannofossils at Site 1165, although intermittent, does indicate that sea-surface conditions near the Antarctic margin were favourable for nannoplankton productivity at various times during the Neogene and Quaternary. This

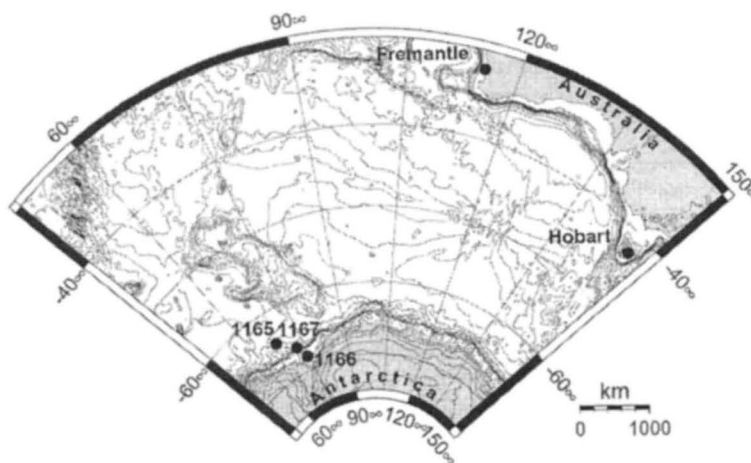


Figure 1: Location map of ODP Leg 188 Sites 1165, 1166 and 1167

brief report summarises the occurrence of nannofossils, most notably the Late Miocene species, *Minylitha convallis*, in a single sample from Site 1165 (Plate 1).

Biostratigraphy

As expected, mid- and low-latitude, age-diagnostic nannofossil marker-species are absent from, and a detailed nannofossil biostratigraphy could not be achieved at, Site 1165. Diatoms and radiolaria provide the comprehensive biostratigraphic framework for much of the section and indicate a nearly continuous Quaternary to Lower Miocene section (O'Brien, Cooper, Richter *et al.*, 2001). Within this framework, only generalised, combined nannofossil zones could be applied. Nannofossil assemblages were key, however, in determining the Early Miocene age for the lower 400m of the section down to the bottom of the hole at ~1000m below sea floor (11bsf).

The focus of this report is core-catcher sample 1165B-14H-CC (124.5mbsf). This sample contains few *M. convallis*, whose known range is confined to Nannofossil Zones CN7b-CN9a (NN9-NN11a) (Gartner, 1992; Young, 1998). The nannofossil zones approximately correlate with the top of magnetic Chron 5 to near the top of Chron 4, and can be assigned an age-range of 11.2-7.2Ma (Berggren *et*

al., 1995). There are no other markers present in the sample to further resolve this nannofossil zonal assignment. In regard to other microfossils, the sample is placed in the *Asteromorphalus kennetti* Diatom Zone, which has an age of 10.3-9.0Ma, and in the *Acrosphaera australis* Radiolarian Zone, with an age of 10.36-9.2Ma (O'Brien, Cooper, Richter *et al.*, 2001; Whalen & Lazarus, 2001).

Nannofossil Observations

For Leg 188 drill and piston core samples, smear-slides were prepared for calcareous nannofossil study using standard techniques. Slides were examined using a light-microscope, under crossed-polarisers, transmitted light, and phase-contrast light, at 1000x and 1200x magnification. At Site 1165, calcareous nannofossils are sporadic but occur somewhat more regularly below ~500mbsf, within the Lower Miocene. Overall, preservation is moderate and abundance high in only a few discrete samples. In the Middle and Upper Miocene section, assemblages are characterised by low diversity, with one or two dominant taxa, notably *Reticulofenestra perplexa* with fewer *Reticulofenestra producta*, *Reticulofenestra* spp. (*R. haqii*, *R. minuta* and *R. minutula*), and *Coccolithus pelagicus*. Lower Miocene nannofossil assemblages lack *R. perplexa*, but contain rare sporadic *Cyclicargolithus floridanus* and even more rare *Cyclicargolithus abisectus*. *Reticulofenestra* spp. is the dominant group throughout the section.

Sample 1165B-14H-CC (124.5mbsf) lies within an ~200m interval barren of nannofossils, except for this sample which contains common to abundant, moderately-preserved specimens. This single, relatively nannofossil-rich sample (3-5 specimens/field of view (fov)) revealed the unexpected presence of rare to few specimens (~1 specimen/50 fov) of the Late Miocene nannolith, *M. convallis*. Also present are very rare *Discoaster* spp. and a single observed specimen of *Sphenolithus abies*. The assemblage is dominated by *R. perplexa* and *R. producta*, with few to common *C. pelagicus*, and small- and medium-sized *Reticulofenestra* spp. Very rare *Reticulofenestra pseudumbilica* is also present.

Discussion

M. convallis has not been previously observed in Upper Miocene sediments from the high austral latitudes and, in particular, the Antarctic margin, thus this discovery considerably extends its known geographic range. This occurrence could possibly indicate a brief warming of Antarctic sea-surface temperatures during Late Miocene times. Warming is supported by the presence of, albeit very rare, *Discoaster* spp. and *S. abies*. The remaining assemblage can be classified as a cold-water end-member, dominated by *R. perplexa*, as previously described from the southern Indian Ocean and other Southern Ocean drill-sites (Haq, 1976; Wise, 1983; Wei & Wise, 1990; Wei & Thierstein, 1991; Wei & Wise, 1992a, b).

The nannofossil assemblage in sample 1165B-14H-CC was likely to have been transported downslope, as suggested by the presence of a well-developed fauna of neritic benthic foraminifers (O'Brien, Cooper, Richter *et al.*, 2001). Although most likely redeposited, the age of the

nannofossil assemblage, based on the known range of *M. convallis* (CN7b-CN9a), is in good agreement with diatom and radiolarian stratigraphy. In fact, the original deposition in shallower water, and subsequent rapid transport, deposition and burial downslope, may have aided nannofossil preservation. Site 1165 is located in fairly deep water (3537m), with the sea-floor presently below the carbonate compensation depth (CCD) (Quilty, 1985). This may also have been the case at the time of deposition during the Late Miocene. Rapid burial within a debris- or mud-flow would facilitate preservation.

Leg 188 shipboard sedimentologists interpreted several carbonate-rich intervals throughout the section at Site 1165 as distal mud-flow deposits, although not specifically the core-catcher sample in question (O'Brien, Cooper, Richter *et al.*, 2001). Moreover, the lack of nannofossils throughout much of the Middle to Upper Miocene section may be due to dissolution below the CCD. Nannofossils are more prevalent at age- and latitude-equivalent, but shallower, sites on Maud Rise, and age-equivalent, shallower sections of the Kerguelen Plateau (Wei & Wise, 1990; Wei & Thierstein, 1991). At deeper-water Site 1165, the few intervals that do contain nannofossils may have been deposited during times of much higher nannofloral productivity, which may have suppressed the CCD and permitted the deposition of coccoliths (see discussion in Wei & Wise, 1992b). It is possible that this higher productivity coincided with warmer sea-surface temperatures.

Wei & Wise (1992b) noted large fluctuations in the abundance of *R. perplexa* relative to *C. pelagicus* in sediments of 8-10Ma from Kerguelen Plateau Sites 744, 747, 748, and 751. They attributed the sharp decrease in relative abundance of *R. perplexa* to warmer sea-surface temperatures, but did not note any *M. convallis* in their samples, which encompass the age of the sample studied here. Two brief, warmer intervals are implied in the Kerguelen Plateau nannofossil data for this time period.

The specific ecologic preferences of *M. convallis* are not well known. Gartner (1992) speculated that *M. convallis* is an analog of the Pleistocene-Holocene taxon, *Florisphaera profunda*, which is known to thrive in nutrient-rich, lower photic zone waters, in well-stratified, oligotrophic oceans (Okada & Honjo, 1973). Its presence in Antarctic waters may reflect this as well, however, importantly, it perhaps denotes a broader temperature tolerance.

Overall, the mere presence of *M. convallis*, along with extremely rare *Discoaster* sp. and *S. abies*, most likely indicates that, for at least a very brief period during the Late Miocene, sea-surface temperatures along the Antarctic margin warmed. Although the ecologic limits of *M. convallis* remain largely speculative, its presence at Site 1165 extends its known geographic range to the extreme high-southern latitudes and indicates its tolerance for lower sea-surface temperatures.

Acknowledgements

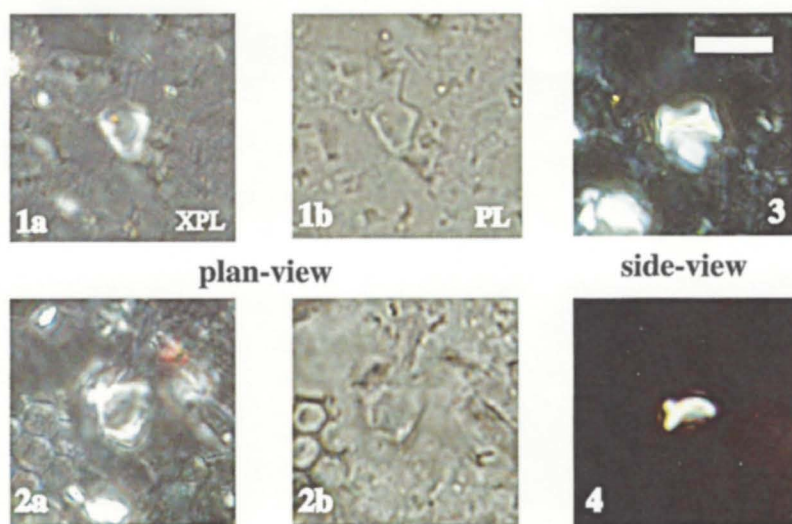
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Plate 1



Minylitha convallis



Discoaster sp.



Reticulofenestra
perplexa

Cross-polarised (XPL) and plain-light (PL) micrographs of plan-views of *Minylitha convallis* (Figs 1-2) and side-views (Figs 3-4). Fig. 5: *Discoaster* sp. (PL). Fig. 6: *R. perplexa* (XPL). All specimens from ODP sample 1165B-14H-CC. Scale bar = 3µm