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Calcareous nannofossil evidence for Marine Isotope Stage 31 (1 Ma) in the AND-1B Core, ANDRILL McMurdo Ice Shelf Project (Antarctica).

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During the austral summer 2006 the ANDRILL Program recovered a 1285 m-long succession of cyclic glacimarine sediments from the McMurdo Ice Shelf (MIS). The aim of the MIS Project was to obtain continuous Neogene (c. 0-10 Ma) glacial, glacimarine, volcanic, and biogenic sediments that have accumulated in the region of the McMurdo Ice Shelf (Ross Sea) nourished by ice flowing from East Antarctic Ice Sheet (EAIS) outlet glaciers in the Transantarctic Mountains (TAM).

The MIS AND-1B drill core represents the longest and most complete (98% recovery) geological record from the Antarctic continental margin to date, and will provide a key reference record of climate and ice-sheet variability through the Late Neogene; detailed investigations of this record will contribute for improving our knowledge of Antarctica's influence on global climate.

Preliminary on-ice analysis of the smear slides of the Andrill core revealed calcareous microfossils (dinoflagellates, calciosponge spicula and small foraminifera) occurring with variable concentrations. The presence of thoracosphaerid fragments in the smear slides of the first 600 mbsf (Quaternary), probably belong to the species Thoracosphaera saxea (Stradner 1961), and Thoracosphaera heimi (Kamptner, 1941) and other, potentially undescribed species (Villa & Wise 1998), suggests either a peculiar adaptation to this environment, due to their ability to develop cysts or warmer conditions at the time of their deposition, or a combination of both. However, they represent an additional element to use with the other proxies for inferring palaeoenvironmental conditions of the core.

Subsequent shore-based analyses of 100 samples from 86-96 mbsf revealed for the first time the presence of Pleistocene coccolithophorids at these high southern latitudes (77° S), including: Coccolithus pelagicus, small Gephyrocapsa, Reticulofenestra asanoi, Pseudoemiliania lacunosa, Dictyoccocites productus, Reticulofenestra sp., Reticulofenestra minutula, Thoracosphaera spp.. The presence of several Tertiary reworked species and rare Cretaceous reworked taxa are interpreted in terms of provenance.

As the lower temperature limit for living calcareous nannoplankton is about 2.5°C, the presence of nannofossils from 86 to 96 mbsf, though rare, is an indication of ice-free and sea surface temperatures warmer than today, in the Ross Sea.

The presence of numerous volcaniclastic units and biosiliceous sediments from 86.6 to 92.5 mbsf indicate an extended period of open-water conditions with no sea ice, beyond the calving line.

An 40Ar/39Ar age of 1.014 $\pm$ 0.004 Ma on pumice at 85.50 mbsf confirms the age assignment given by diatom biostratigraphy (1.07 Ma) for this interval. Accordingly, the short normal magnetozone between 84.97 and 91.13 mbsf is correlated with the Jaramillo Subchron (C1r.1n) (Wilson et al., 2007).

The presence of nannofossil in the biogenic interglacial sediments is consistent with warm episode of surface waters and open marine conditions during the Jaramillo subchron, at $\sim$1 Ma, which corresponds with Marine isotope stage (MIS-31) (Naish et al., 2007). The "superinterglacial" associated with MIS 31 was the last significant warm interglacial of the obliquity-dominated world, and may represent a precursor to the high-amplitude eccentricity-dominated cycles that followed the mid-Pleistocene climate shift.

Climate proxies from other studies from the Southern Ocean at ODP Site 1165 (Villa et al., 2008), at ODP Site 1094 (Scherer et al., 2008), and from the Antarctic margin in a shelly carbonate sequence at Cape Roberts 1 (Villa and Wise, 1998; Scherer et al., 2008) also support the idea of a warming event during this time, suggesting that it was extended around the Antarctic Continent.

This in turn implies a total or partial collapse of McMurdo Ice Shelf and a concurrent shift or temporary dissipation

of the Polar Front (Antarctic Convergence) and Antarctic Divergence that currently serve as barriers to the influx of calcareous nannofossils to the margins of Antarctica. The warm interval during the Jaramillo Subchron shows that these areas were more climatically dynamic than previously thought and calls into questions the notion that the EAIS has remained in a stable polar condition since the late Neogene. The warm surface water event reported here is especially significant given its proximal position to the Antarctic ice sheet.

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