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The Antarctic record of Pliocene warmth and its expression in the AND-1B drillcore

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The potential for comparison of the now well-accepted Pliocene warmth to the current effects of modern climate change has made the topic of the extent and global expression of this warmth one of great interest. This time period is uniquely recorded in the ANDRILL McMurdo Ice Shelf Project AND-1B drillcore by a stratigraphic interval representing extended depositional conditions characterized by a highly-productive open-marine environment. Nearly 100-m of diatomite and diatom-rich sediments preserve three distinct time intervals, which chronostratigraphic controls suggest represent deposition during 3.33-3.6 Ma, 4.3-4.5 Ma and ∼4.6 Ma. This record is extraordinary both in its extent as well as its proximity to the Antarctic continent.

The diatom assemblages preserving these time intervals record a marine environment quite different than occurs today in the Ross Sea. Species such as Shionodiscus tetraoestrupii, Stellarima stellaris and Thalassionema nitzschioides are common throughout this 100m interval while they currently are observed only in waters closer to and north of the modern Polar Frontal Zone. Sea surface temperature estimates from these species suggest conditions 3-5°C warmer than present in southern McMurdo Sound. Additionally, often low numbers of clasts within the diatomite and diatom-rich sediments corroborate a decrease in glacial and seasonal ice at the AND-1B site during this interval.

Other drillcore records containing sediments from this time exist in locations both proximal to and on the Antarctic continent as well as within the Southern Ocean. Several sites in close proximity to AND-1B within McMurdo Sound (DVDP-10, DVDP-11 and CIROS-2) contain diatom-rich sediments correlative to these three intervals. The assemblages within samples from these three cores record a fjordal setting indicative of increased sea level associated with warmer marine conditions at these sites. The middle diatomite interval in AND-1B, 4.3-4.5 Ma, contains abundant species recording what is interpreted as the warmest part of this record. Proximal marine sediments of the Sørsdal Formation (Vestfold Hills, East Antarctica) contain a similar assemblage as well as evidence of marine mammels, further supporting the idea of warm marine temperatures and extending the record to the other side of the continent.

The diatom assemblages present and the high biogenic opal productivity indicated at Site 1165, as well as two sites on the Antarctic Peninsula (ODP Sites 1095 and 1096), also reflect warmer-than-present marine conditions between 3.5-3.7 Ma. The diatom-rich sediments in both locations likely reflect a continent-wise productivity interval producing the upper-most of the three, and thickest diatomite unit in AND-1B.

Species of another siliceous microfossil group, silicoflagellates, from ODP Site 1165 in Prydz Bay record these three diatomite intervals through changes in Dictyocha/Distephanus ratios and offer additional evidence that continent-wide open-marine coastal environments with reduced sea ice were prevalent during interglacial periods of this time. Estimates of sea surface temperatures based on silicoflagellate data from this site suggest that conditions could have been as much as 5°C warmer than present.

Early to mid-Pliocene warm intervals represented by diatomite deposition in the AND-1B drillcore indicate persistent and continent-wide marine conditions significantly warmer today. Interglacial periods during this time were represented by a greatly reduced sea-ice presence and proximal marine conditions conducive to high

biosiliceous productivity. These warm intervals were regular features of the global climate during this time period.