Polar frontal migration in the warm Pliocene: Diatom and geochemical evidence from the Wilkes Land margin, East Antarctica

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Abstract

The mid-Pliocene is the most recent interval in Earth's history to sustain global temperatures within the range of warming predicted for the 21st century, providing an appealing analog for the changes we might encounter in the coming century. Diatom-based Southern Ocean reconstructions by the USGS Pliocene Research Interpretations and Synoptic Mapping (PRISM) Group suggest an average +2° summer SST anomaly during the 3.3-3.0 Ma interval relative to modern. Here, we present a reconstruction of Pliocene sea surface conditions from a marine sediment core collected at IODP Site U1361, on the Wilkes Land margin continental rise. U1361 biogenic silica concentrations document the alternation of diatom-rich and diatom-poor lithologies; we interpret 8 diatom-rich mudstones within this sequence to record interglacial conditions between 3.8 and 2.8 Ma. Our wt % BSi trends suggest that Pliocene glacial / interglacial cycles featured slow development of interglacial conditions followed by rapid transitions to glacial conditions.

Our diatom data indicate little change in assemblage within each interglacial interval, but significant differences between interglacials. We find that the open-ocean conditions that characterized Site U1361 in the mid-Pliocene became increasingly influenced by sea ice around 3.3 Ma, when northerly latitudes were still experiencing warm conditions (Dowsett et al., 2012). The same timing of glacial intensification has previously been documented from West Antarctica (McKay et al., 2012; Riesselman and Dunbar, 2013), suggesting that late Pliocene cooling was synchronous in both West and East Antarctica and that southern hemisphere cooling led the rest of the planet. We have also identified *Fragilariopsis weaveri*, an extinct diatom that is an established marker of a subantarctic environment situated north of the polar front, in single interglacial interval, marine isotope stage KM3 (3.17-3.15 Ma), which is coincident with the most recent time when atmospheric CO_2 was elevated to our modern, post-industrial level of 400 ppm. This warm interglacial interval follows the onset of Pliocene Antarctic cooling, suggesting that a temporary elevation in atmospheric CO_2 was sufficient to trigger a substantial climate response, including the migration of warm subpolar surface waters within 270 km of the modern marine margin of the East Antarctic Ice Sheet (EAIS).

Building on the identification of a single outlier interglacial within the PRISM interval, we have revisited the reconstructions of Dowsett et al. (1994) and Barron (1996a; 1996b) to explore the response of the Southern Ocean/cryosphere system to peak late Pliocene warmth. By applying a modern chronostratigraphic framework to those low-resolution "mean interglacial" reconstructions, we have determined that the *F. weaveri* peak identified in U1361 is also present in KM3 sediments from 5 other cores in the Pacific sector of the Southern Ocean, constraining a major migration of the subantarctic front during a key interval of warm climate.

Keywords: Pliocene, East Antarctica, diatom micropaleontology, geochemistry

References

Barron, J.A., 1996a. Diatom constraints on the position of the Antarctic Polar Front in the middle part of the Pliocene. Marine Micropaleontology 27, 195-213.

Barron, J.A., 1996b. Diatom constraints on sea surface temperatures and sea ice distribution during the middle part of the Pliocene. USGS Open File Report 96-713.

Dowsett, H., R. Thompson, J. Barron, T. Cronin, F. Fleming, S. Ishman, R. Poore, D. Willard, and T. Holtz Jr., 1994. Joint investigations of the Middle Pliocene climate I: PRISM paleoenvironmental reconstructions. Global and Planetary Change 9, 169-195.

Dowsett, H.J., M.M. Robinson, A.M. Haywood, D.J. Hill, A.M. Dolan, D.K. Stoll, W.-L. Chan, A. Abe-Ouchi, M.A. Chandler, N.A. Rosenbloom, B.L. Otto-Bliesner, F.J. Bragg, D.J. Lunt, K.M. Foley, and C.R. Riesselman, 2012. Assessing confidence in Pliocene sea surface temperatures to evaluate predictive models. Nature Climate Change 2, 365–371.

McKay, R., T. Naish, L. Carter, C. Riesselman, R. Dunbar, C. Sjunneskog, D. Winter, F. Sangiorgi, C. Warren, M Pagani, S. Schouten, V. Willmott, R. Levy, R, DeConto, and R.D. Powell, 2012. Antarctic and Southern Ocean influences on Late Pliocene global cooling. Proceedings of the National Academy of Sciences 109, no. 17, 6423-6428.

Riesselman, C.R. and R.B. Dunbar, 2013. Diatom evidence for the onset of Pliocene cooling from AND-1B, McMurdo Sound, Antarctica, Palaeogeography, Palaeoclimatology, Palaeoecology 369, 136-153.