An early Pliocene short-lived disruption of Antarctic ice-sheet ocean systems with consequences for marine ice-sheet stability

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Abstract

Today the Wilkes Subglacial basin is protected from ocean incursion by a bedrock ledge that prevents warm currents from reaching the grounding line of the East Antarctic Ice Sheet. The change in bedrock elevation originated in the mid-Pliocene through mantle flow or dynamic topography (Austermann et al., 2015). The early Pliocene record off Wilkes Land, however, is predating the bedrock elevation changes and provides insights into the interactions of oceanographic processes and marine ice-sheet dynamics that are applicable to other West and East Antarctic margins susceptible to ocean forcing. Here I interpret high-resolution records of ice-rafted debris mass accumulation rates (IRD MAR) and bulk geochemical records from (Integrated) Ocean Drilling Program Sites and Dry Valley Drilling Project 11 (DVDP-11) to assess the spatial extent of a disruption in early Pliocene high-latitude ocean circulation.

IRD MAR records from Site U1359 off Wilkes Land show a significant increase in ice dynamics in the early Pliocene (Hansen et al., 2015). Mn and Ba enrichment and calcium carbonate percent data from Wilkes Land Sites U1358, U1359, and DVDP-11, suggest that the western Pacific sector of Antarctica was affected by widespread oceanographic changes at ~4.6-4.5 Ma (Orejola et al., 2014; Hansen and Passchier, 2016; Verhagen and Passchier, 2016). These changes mark intervals that are lithologically and geochemically distinct at Sites U1358, U1359 and DVDP-11 and are dominated by fine grained sediments with diatomaceous laminae or elevated marine carbonate content. In DVDP-11, however, major element geochemical analyses show that the chemical index of alteration (CIA) was below 60 in the early Pliocene, indicating a dominant physical weathering regime with limited atmospheric moisture, similar to the present (Verhagen and Passchier, 2016). The oceanographic changes were short-lived, but were followed by a change in orbital cyclicity of IRD-MAR at Site U1359 for several glacial-interglacial cycles between ~4.5 and 3.6 Ma (Hansen et al., 2015).

The interval between 4.5 and 4.0 Ma constitutes a Pliocene climatic optimum (Federov et al., 2013). Short-lived disruptions of the high-latitude Pacific ocean circulation, perhaps related to the expansion of the Pacific equatorial warm pool in the early Pliocene, were associated with southward migration of atmospheric and oceanic fronts. Enhanced wind-driven circulation may have resulted in the short-lived southward penetration of warm water at shallow depth in the Pacific Antarctic sector resulting in the retreat of marine-based ice sheets that lasted several glacial-interglacial cycles. Work on cores from upcoming IODP expeditions around the Pacific margin of Antarctica could extend this work and investigate the possible connection between changes in the Pacific circulation and Antarctic ice dynamics during the early Pliocene climatic optimum.

Keywords: Pliocene, IRD MAR, geochemistry, IODP

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