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Major West Antarctic Ice Sheet retreat events during the Pliocene: Evidence from the sediment provenance analyses of Amundsen Sea IODP U1532 records

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The stability of the West Antarctic Ice Sheet (WAIS), crucial for preventing major future sea-level rise, is threatened by ocean-forced melting in the Pacific sector, especially in the Amundsen Sea. So far, direct evidence of the extent and rate of WAIS retreat during past warm periods has been lacking. Here, we analyzed detrital Nd, Sr, and Pb isotope data of sediments (<63 μm) recently drilled at International Ocean Discovery Program (IODP) Site U1532 on the Amundsen Sea continental rise to assess WAIS behavior, particularly the extent of its retreats, during glacial–interglacial cycles of the Pliocene (5.33–2.58 million years ago, Ma), a time warmer than present.

The Pliocene sediments of Site U1532 are marked by alternations of thick, gray, predominantly terrigenous laminated silty clays with relatively thin, greenish, biosilica-bearing/rich, bioturbated muds containing dispersed ice rafted debris (IRD), whose abundance usually increases towards the top of the muds. The IRD-bearing greenish mud intervals are typically less than 1.7 m thick and are characterized by a lower natural gamma ray (NGR) signal and negative a*-values. Fourteen prominent greenish mud intervals are identified between 4.65 Ma and 3.33 Ma. The diatom assemblages in the IRD-bearing muds are dominated by open water taxa, heavily silicified *Fragilariopsis* (*F. barronii*, *F. interfrigidariata*, and *F. praeinterfrigidariata*) and *Dactyliozolen antarcticus*, and significant biological productivity is indicated by relatively high diatom concentrations and elevated Ba/Ti ratios, which are a proxy for biogenic barium. The abundance of IRD and the presence of diatom taxa suggest that the IRD-bearing muds formed during interglacial periods, potentially reflecting past retreat events of the WAIS.

At Site U1532, we observe significant variations in Nd, Sr, and Pb isotopes of detrital sediments throughout glacial–interglacial cycles, indicating substantial changes in WAIS extent. A notable provenance signal emerges at the onset of some glacial intervals (3.88 Ma 3.6 Ma, and 3.33 Ma), characterized by high Pb (> 18.93 for $^{206}Pb/^{204}Pb$) and low ε_{Nd} (< –5 ε_{Nd}) values. This distinct isotopic signature suggests long-distance supply of detritus sourced from plutonic rocks located in the continental interior. The presence of this material at Site U1532 indicates major inland retreat of the WAIS during the immediately preceding interglacials, which allowed icebergs to transport and deposit the detritus on the Amundsen Sea shelf. Our Pliocene records reveal multiple major inland retreats of the WAIS, highlighting the extent of possible WAIS response to ongoing global warming.

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