The West Antarctic Ice Sheet during the Late Pleistocene: Insights from geochemical provenance studies of marine sediments

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Abstract

The West Antarctic Ice Sheet (WAIS) plays a fundamental role in the global climate system. Its complete or even partial disintegration would cause global sea-level rise and perturbation of ocean circulation. Ice sheet models are used to assess future WAIS stability, but their validation relies on geological constraints on the state of the ice sheet, particularly during periods of past warmth.

Here we investigate potential changes of the WAIS over the past 800,000 years by analysing the geochemical provenance of terrigenous components in marine sediments. Each glacial and interglacial stage is studied in two deep water cores recovered offshore from the Amundsen Sea Embayment (ASE). In detail we analysed strontium (Sr) and neodymium (Nd) isotopic compositions and trace element compositions in the fine-grained (<63μm) sediment fraction as well as $^{40}Ar/^{39}Ar$ ages on individual ice-rafted (>150μm) hornblende and biotite grains.

Sediment core PS58/254, located on the continental rise offshore from the eastern ASE, exhibits a radiogenic fingerprint throughout the Late Pleistocene similar to that of modern surface sediments in the area. The Nd isotope signature, however, shows systematic down-core fluctuations in the order of three ε_{Nd} units. They correlate with physical properties of the sediments, such as magnetic susceptibility, and trend towards lower values during interglacials, notably during Marine Isotope Stage (MIS) 5 and MIS 7. A source for this lower ε_{Nd} signature could be detritus shed from Pine Island Bay in the eastern ASE, an area of accelerated ice loss today. Strontium isotope ratios do not co-vary with ε_{Nd} values, but correlate with changes in kaolinite content. Both proxies are elevated during glacial periods, most likely due to the subglacial erosion and reworking of pre-Oligocene sedimentary rocks outcropping either below the WAIS or on the shelf.

Preliminary observations on sediment core PC493, located on the continental slope offshore from the western ASE show a low amplitude of Nd isotope variations, and absolute values point to supply of detritus from the Dotson-Getz drainage area in the western ASE. The most pronounced Nd isotope excursion in the core occurs during MIS 5, one of the warmest interglacials during the Late Pleistocene.

Overall, temporal changes in the fine-grained sediment provenance of both cores indicate regional changes in the configuration of the WAIS. Additional insights on ice covered areas can be deduced from the study of ice-rafted mineral grains. $^{40}Ar/^{39}Ar$ hornblende and biotite ages from core PC493 reveal a persistent glacial and interglacial supply of grains from the Abbott-Cosgrove drainage area in the easternmost ASE, indicating the presence of ice caps there throughout the past 800 kyrs.

We will discuss our new down-core records and their implications in the context of previously suggested dynamical behaviour of the WAIS during the Late Pleistocene.

Keywords: West Antarctic Ice Sheet, geochemistry, sediment provenance, Late Pleistocene