Glacial discharge, productivity and oceanic variability from the Antarctic coastal zone: results from a 171 m Holocene sediment core from IODP Expedition 318

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Abstract

Rapid freshening of surface and bottom waters along the Antarctic margin has been observed in recent decades, concomitant with large shifts in other environmental conditions, such as increased melting of West Antarctic Ice Sheet (WAIS) ice shelves and an increase in sea ice extent. Understanding the drivers of such environmental changes is hampered by limited instrumental records from the Antarctic, which are too short, sparse and discontinuous to provide a satisfactory baseline. Palaeo-records from the Antarctic margin can provide an opportunity to extend these records and view such changes from a longer-term perspective.

A 171m core of laminated diatom ooze spanning the Holocene was recovered from the Adélie drift during IODP 318, with eighty-seven radiocarbon dates confirming that this is the most expanded, continuous Holocene sediment sequence yet recovered worldwide. This presents a new opportunity to study Antarctic climatic evolution on a Holocene timescale, from a climatically-sensitive coastal polynya environment. Here we present records of compound-specific C and H isotope analysis of fatty acid biomarkers, grain-size, core image analyses, mass accumulations rates, bulk diatom carbon isotopes, TEX_{86}^{L}, highly-branched isoprenoid alkenes and diatom counts. We reconstruct changes in glacial meltwater and sedimentary inputs, productivity, water masses and sea ice over the past 11,400 years.

Our H isotope record captures large millennial-scale shifts of >50‰ throughout the Holocene, which we interpret as a response to inputs of isotopically depleted glacial meltwater. The Early Holocene period is characterized by large deglacial meltwater inputs, along with evidence for ice-rafted debris and a large volume of poorly sorted, terrigenous material. We suggest this meltwater originates from retreating East Antarctic outlet glaciers until ca. 8.2 ka. Subsequent sedimentary inputs appear to be transported from a more distal source and here we discuss different potential sources of the meltwater. Inputs of meltwater broadly follow the pattern of temperature change recorded in Antarctic ice cores, showing a long-term decline over most of the Holocene. A large mid-Holocene meltwater pulse is evident at ca. 4.5 ka, coincident with shifts in most sedimentary and productivity proxies and evidence for a rapid increase in sea ice.

We suggest this represents a large glacial retreat during the warmer mid-Holocene, leading to greater transport of cool Antarctic Surface Waters along the coast and driving greater sea ice production along the Adélie coast. After 8.2 ka, patterns of meltwater and sedimentation rates closely follow a Holocene record of El Niño from the Galapagos, suggesting a potentially important link with tropical Pacific climate.

Keywords: Holocene, Adélie Land, Glacial discharge, Biomarkers