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Dust composition changes from Taylor Glacier (East Antarctica) during the last glacial-interglacial transition: A multi-proxy approach

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ABSTRACT

Mineral dust is transported in the atmosphere and deposited in oceans, ice sheets and the terrestrial biosphere. Temporal changes in locations of dust source areas and transport pathways have implications for global climate and biogeochemical cycles. The chemical and physical characterization of the dust record preserved in ice cores is useful for identifying of dust source regions, dust transport, dominant wind direction and storm trajectories. Here, we present a 50,000-year geochemical characterization of mineral dust entrapped in a horizontal ice core from the Taylor Glacier in East Antarctica. Strontium (Sr) and neodymium (Nd) isotopes, grain size distribution, trace and rare earth element (REE) concentrations, and inorganic ion (Cl^- and Na^+) concentrations were measured in 38 samples, corresponding to a time interval from 46 kyr before present (BP) to present. The Sr and Nd isotope compositions of insoluble dust in the Taylor Glacier ice shows distinct changes between the Last Glacial Period (LGP in this study ranging from ~46.7–15.3 kyr BP) the early Holocene (in this study ranging from ~14.5–8.7 kyr BP), and zero-age samples. The $^{87}Sr/^{86}Sr$ isotopic composition of dust in the Taylor Glacier ice ranged from 0.708 to 0.711 during the LGP, while the variability during the early Holocene is higher ranging from 0.707 to 0.714. The ε_{Nd} composition ranges from 0.1 to −3.9 during the LGP, and is more variable from 1.9 to −8.2 during the early Holocene. The increased isotopic variability during the early Holocene suggests a shift in dust provenance coinciding with the major climate transition from the LGP to the Holocene. The isotopic composition and multiple physical and chemical constraints support previous work attributing Southern South America (SSA) as the main dust source to East Antarctica during the LGP, and a combination of both local Ross Sea Sector dust sources and SSA after the transition into the Holocene. This study provides the first high time resolution data showing variations in dust provenance to East Antarctic ice during a major climate regime shift, and we provide evidence of changes in the atmospheric transport pathways of dust following the last deglaciation.

1. Introduction

Ice cores drilled from the Greenland and Antarctic ice sheets are excellent archives of atmospheric composition and climate over hundreds of thousands of years (EPICA community members, 2004; Jouzel et al., 1997; Petit et al., 1999). Climate parameters, such as greenhouse gas (CO_2 and CH_4) concentrations, and climate proxies, such as stable isotope variability in precipitation, are utilized in ice

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cores to reconstruct long-term records of atmospheric change (Loulergue et al., 2008; Lüthi et al., 2008). Variations in dust fluxes to polar ice sheets during glacial-interglacial periods are correlated to proxies for temperature changes (reconstructed from δD and $\delta^{18}O$ records) over long timescales (Basile et al., 1997; Biscaye et al., 1997, and references therein). Physical and chemical characterization of dust particles deposited in Antarctic ice is used to trace fine-grained mineral material (dust) to its origins as sediment generated in potential source areas (PSAs) (Grousset and Biscaye, 2005, and references therein).

The dominant source of dust to East Antarctica during the Last Glacial Period (LGP in this study ranging from ~46.7–15.3 kyr BP) was most likely Southern South America (SSA) (Grousset et al., 1992; Vallelonga et al., 2010, and references therein). Higher amounts of dust were transported to Antarctica during glacial periods, relative to interglacial periods, due to increased dust availability at the source area and windier conditions caused by a more pronounced pole-equator temperature gradient (Hammer et al., 1985; Petit and Delmonte, 2009; Sugden et al., 2009). In contrast, dust transported to Antarctica during the early Holocene (in this study ranging from ~14.5–8.7 kyr BP) and present day is not well characterized from a geochemical perspective due to the extremely small concentrations preserved in Antarctic ice (Delmonte et al., 2010). The observation of larger dust particles in Holocene ice from coastal East Antarctic sites such as Talos Dome (Fig. 1, see inset) indicates a higher input of local (high-elevation ice-free

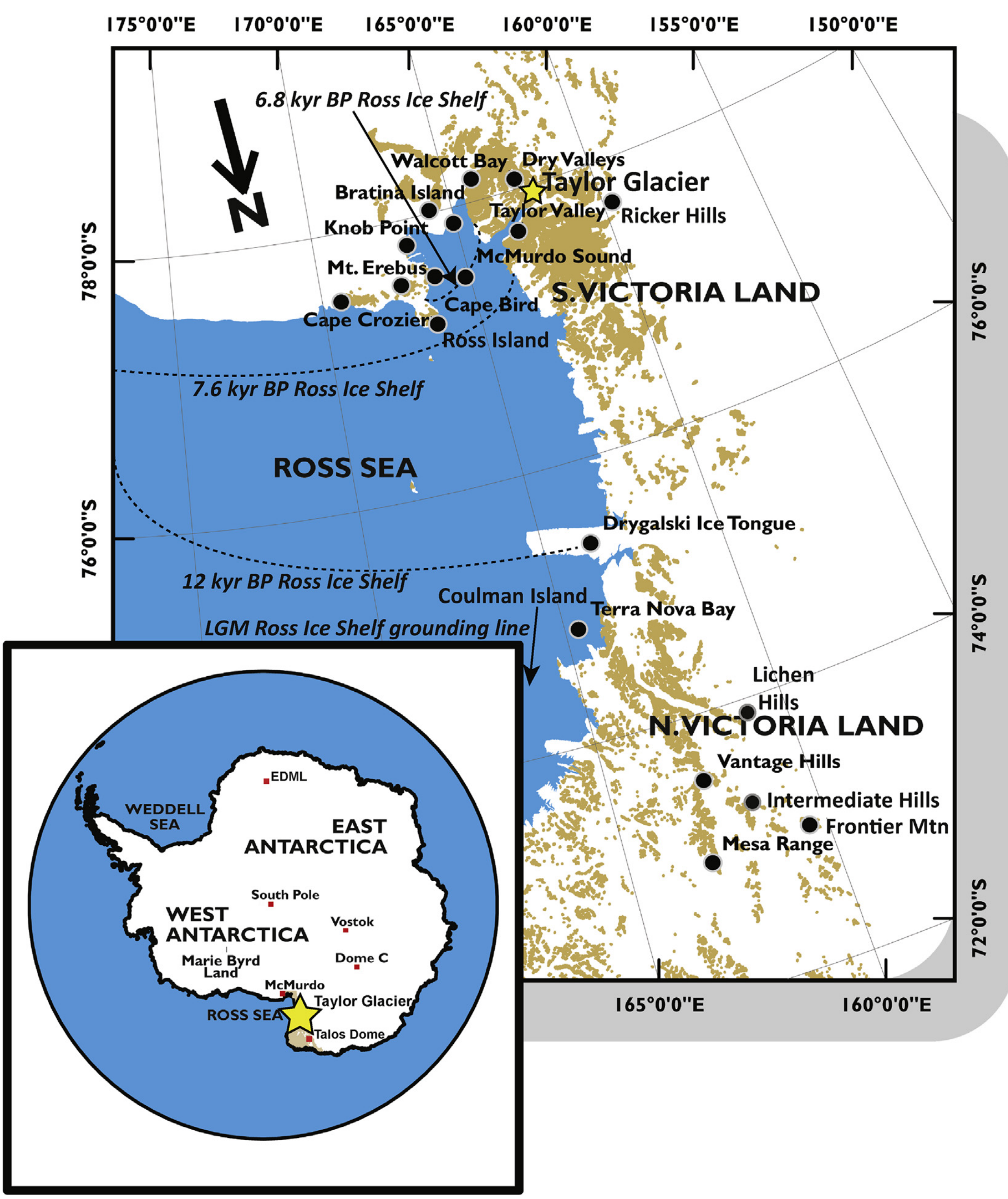

Fig. 1. Location map of Taylor Glacier and surrounding area. The East Antarctic Ice Sheet shaded in white, the Ross Sea in blue, and exposed rock surfaces in brown. Taylor Glacier (yellow star) is shown relative to potential source areas of dust and important landmarks (Drygalski ice tongue, Ross Island, and Coulman Island) discussed here. Dashed lines with age listed show the timing of the Ross Ice Shelf grounding line retreat (Licht et al., 1996; Conway et al., 1999). Inset map shows locations of Antarctic ice core drilling sites EDML, South Pole, Vostok, Dome C, Taylor Dome, and Taylor Glacier (yellow star). Figure adapted from Blakowski et al. (2016). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)