Dynamic fluctuations of an East Antarctic outlet glacier since the Pliocene

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Abstract

Understanding past changes in the Antarctic ice sheets provides insight into how they might respond to future climate warming. The degree to which Antarctic ice sheets expanded and contracted under past climates remains uncertain, especially prior to the Last Glacial Maximum. During Pliocene and Pleistocene glacial-interglacial cycles, the East Antarctic Ice Sheet remained relatively stable in its interior (e.g. Yamane et al., 2015) and oscillated at its marine-based margin (e.g. Naish et al., 2009; Pollard & DeConto, 2009). It is currently not clear how outlet glaciers, which connect the ice sheet interior to its margin, responded to these orbitally-paced climate cycles.

We show new ice surface constraints from Skelton Glacier, an outlet of the East Antarctic ice sheet, which drains into the Ross Ice Shelf and over the AND-1B drill site (Talarico et al., 2012). Our multiple-isotope (^{10}Be and ^{26}Al) data indicate that currently ice-free areas adjacent to the glacier underwent substantial periods of ice cover and exposure in the past. We determine the probable ice surface history implied by our data by adopting a burial-exposure modelling approach (Bierman et al., 1999), driven by orbitally-paced oscillations of the ice margin (as recorded at AND-1B; Naish et al., 2009) over the period from the Pliocene to the present day. This analysis shows that: 1) the glacier surface has likely fluctuated since at least the Pliocene; 2) the ice surface was >200 m higher than today during glacial periods, and the glacier has been thicker than present for ~75–90% of each glacial-interglacial cycle; and 3) ice cover at higher elevations possibly occurred for a relatively shorter time per Pliocene cycle than Pleistocene cycle. While it is hard to determine the magnitude of surface lowering during interglacial periods, our data shows that the duration of deglaciation, relative to glacial expansion, was similar in both the Pliocene and Pleistocene.

These outcomes are consistent with evidence from the edge of the East Antarctic plateau that indicate a higher ice sheet surface existed during the Pliocene (e.g. Balco et al., 2014; Di Nicola et al., 2012; Yamane et al., 2015), as well as other data collected from sites at lower altitudes and nearer to the coast, suggesting that glacier surface elevations fluctuated substantially since the Pliocene (e.g. Balco et al., 2014; Di Nicola et al., 2009; Lilly et al., 2010). Large glacial-interglacial fluctuations in ice extent occurred at the marine-based ice margin of the East Antarctic Ice Sheet, in response to the evolving climate and bed topography since at least the Pliocene (e.g. Levy et al., 2012, Pollard & DeConto, 2009). Over this time, our data and analysis demonstrate that such dynamic changes extended upstream to outlet glaciers that connect the ice sheet interior to the ice margin.

Keywords: cosmogenic nuclides, Pliocene, Pleistocene, EAIS

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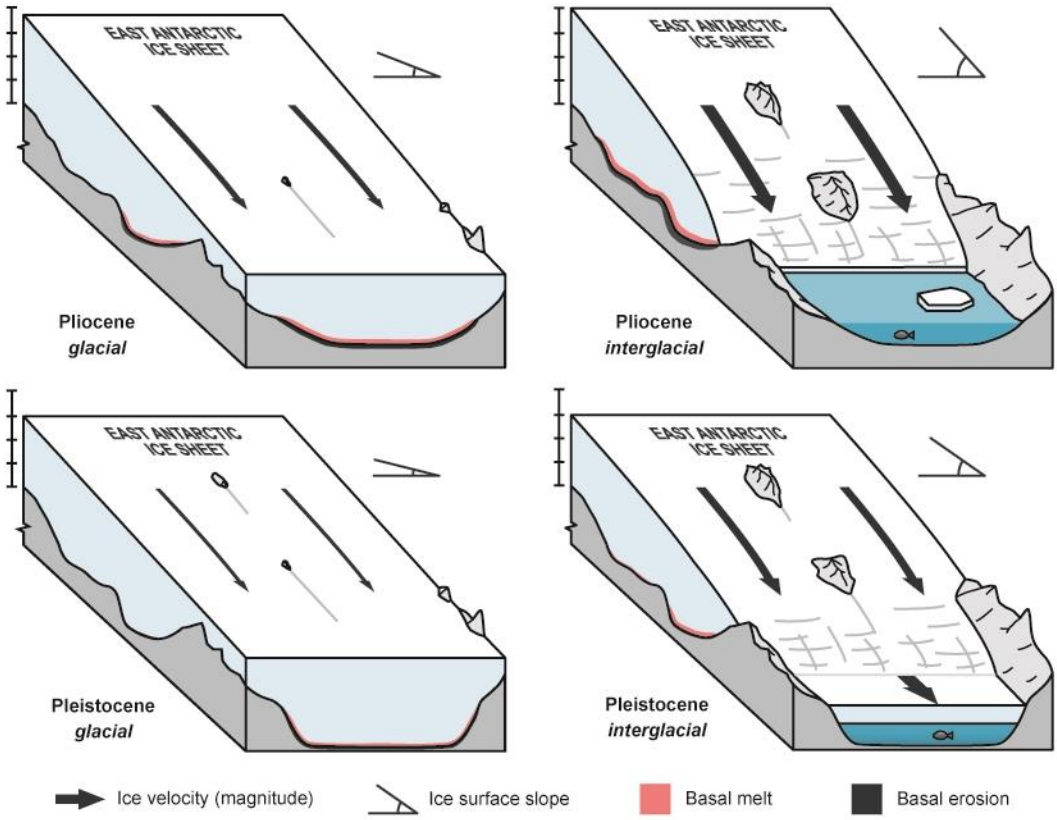
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Pleistocene
glacial
EAST ANTARCTIC ICE SHEET
Pleistocene
interglacial
Ice velocity (magnitude)
Ice surface slope
Basal melt
Basal erosion