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Sustained Antarctic contribution to abrupt global sea level rise during Meltwater Pulses 1A and 1B

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Understanding millennial-scale variability of the Earth's ice sheets is key to gaining insights into ice sheet-climate feedbacks, and quantifying their contribution to past and future sea-level rise. Current projections of future global mean sea-level (GMSL) rise cannot truly reflect this variability, as they do not include ice sheet-ocean dynamic feedbacks that may determine rates of future ice-sheet mass loss. Such feedbacks are apparent in the geological record, with periods of rapid continental ice-sheet loss during the deglaciation leading to abrupt GMSL rise, driving regional and global climate change through climate/meltwater feedbacks. The most significant event is Meltwater Pulse-1A (MWP-1A), an abrupt sea-level rise of ∼20 m in less than 500 years defined from the Tahiti and Barbados coral records occurring at ∼14.6 ka, during the Last Glacial Termination (LGT or T1, 21,000-11,000 years ago).

Reconstructing the contribution of the Antarctic ice sheets (AIS) to MWP-1A has proved challenging due to the paucity and fragmentary nature of geological records, and also technical issues in reconstructing past change in such a dynamic setting, where the legacy of past ice-sheet change can have a long-lasting impact on contemporary ice-sheet stability. This has led to contrasting reconstructions, from 'high-end' scenarios suggesting tens of meters (over 50%) of MWP-1A GMSL rise was sourced from Antarctica, to 'low-end' scenarios invoking far lower contributions. Resolving this conflict is critical to defining the role of AIS in ice-ocean-climate feedbacks. Key to this is the contribution to MWP-1A and subsequent meltwater pulses of the extensive Weddell Sea Embayment (WSE), which drains one-fifth of the present-day AIS, with input from the Antarctic Peninsula, West and East Antarctic ice sheets.

Here we present a unique record of Antarctic ice sheet elevation changes derived from the Patriot Hills blue ice area, located close to the modern day grounding line of the Institute Ice Stream in the Weddell Sea Embayment (WSE). Combined isotopic signatures and gas volume analysis from the ice allows us to develop a record of local ice sheet palaeo-altitude that is assessed against independent regional high-resolution ice sheet modeling studies, allowing us to demonstrate that past ice sheet elevations across this sector of the WSE were considerably higher and more dynamic than those suggested by current terrestrial reconstructions.

We argue that the Antarctic ice sheet in the WSE had a significant influence on post LGM sea level rise including MWP-1A (∼14.6-13.6 ka) and during MWP-1B (∼12-11 ka), reconciling past sea-level rise reconstructions and demonstrating for the first time that this sector of the WAIS made a significant and direct contribution to post LGM sea level rise. These findings provide new insights into the role the Antarctic ice sheets take in driving

abrupt climate change, and suggest contemporary ice-sheet stability across the WSE results from Late-Holocene ice-sheet readvance, with implications for future ice-sheet stability.