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A novel method of determining accumulation rates during the last glacial period at Berkner Island, West Antarctica

Ashleigh Massam (1,2), Sharon Sneed (3), Robert Mulvaney (1), Paul Mayewski (3), and Pippa Whitehouse (2)

(1) British Antarctic Survey, United Kingdom (ashsam73@bas.ac.uk), (2) School of Geography, Durham University, Durham, UK , (3) Climate Change Institute, University of Maine, Orono, ME, USA

Current standard laboratory methods offer a relatively coarse resolution for trace element analysis of deep ice cores (around 10mm). Sub-annual measurements, which reveal a seasonal profile of ions trapped within the ice matrix of a core, are principally reserved for the upper depths of ice cores where compaction due to vertical strain has not reduced the annual layer thickness to values smaller than the typical sampling resolution. Recent improvements in the resolution of direct elemental analysis were demonstrated during a pilot experiment undertaken at the WM Keck Laser Ice Facility using a prototype Sayre Cell^{TM} combined with a laser ablation inductively-coupled plasma mass spectrometer (LA ICP-MS), which was used to carry out ultra-high resolution trace element analysis of ice. As part of this study, this technique was used to obtain a sub-annual view of the onset of the current interglacial period, at circa 11.6 ka BP, as recorded in the Greenland Ice Sheet Project II (GISP2) ice core. Results demonstrated the viability of this method as a technique to extract ultra-high resolution, sub-annual signals of multiple trace elements along an ice core with minimal damage.

We have extended the remit of these studies by undertaking ultra-high resolution analysis of ice originally deposited during the Holocene and the last glacial period at the low-accumulation site at Berkner Island, in the Weddell Sea, Antarctica. Sections of ice, taken from two depths (494-498m; 694-696m) from the Berkner Island ice core, were analysed in order to assess the viability of the LA ICP-MS method on ice from a low-accumulation site. A full climate profile has been obtained at sub-annual view for both Holocene and glacial conditions, where layer thickness is estimated to be $\sim$5mm and hence beyond the current limit of standard chemical analysis.

One potential outcome of this development in direct elemental analysis is the ability to directly determine layer thicknesses at greater depths within the ice sheet – a particular issue in Antarctica where accumulation rates can be very low. In addition, this is the only study so far that is able to evaluate the empirical relationships used in modelled reconstructions of glacial conditions, by comparing modelled glaciological profiles with the profiles derived from the ultra-high resolution trace element analysis. The ultimate outcome of this research is the construction of a more robust age-depth profile which will enable better insight and comprehension of past climate conditions including palaeoaccumulation.

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