In search of direct evidence of past retreat of the West Antarctic Ice Sheet along eastern Ross Ice Shelf: Prospecting for deep stratigraphic targets by shallow drilling beneath ice rises

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Abstract

Ice sheet simulations assessing Antarctica's impact on future sea level rise imply a possible contribution of more than a meter by 2100 and more than 15 meters by 2500. However, the same model, using a variety of physical parameters produces a large range of change in global mean sea level (+1.07 m to +7.54 m) during the last interglacial (DeConto and Pollard, 2016). These simulations associated with the high-end estimates imply oceanic gateways in the Siple Coast region and a complete collapse of the interior of the marine based WAIS. The lower-end estimates demonstrate only a modest change in WAIS and grounded ice along the Siple Coast. Currently, about 40% of the ice discharge of the entire West Antarctic Ice Sheet occurs from ice streams that feed the southern Ross Ice Shelf along the Siple Coast, and in the region of the Crary and Steershead ice rises (Price et al., 2001). Over short timescales the velocity of these ice streams is highly variable (e.g., Retzlaff and Bentley, 1993; Joughin et al., 2002; Joughin and Tulaczyk, 2002; Horgan and Anandakrishnan, 2006). Thus, ice sheet reconstructions over centennial to millennial time scales along the Siple Coast, particularly during past warm periods, are needed to provide a long-term perspective on the ice sheet's behavior and to assess potential future Antarctic Ice Sheet contributions to global sea level (e.g., DeConto and Pollard, 2016). It is of fundamental interest with the Scientific Community of Antarctic Research Programme: Past Antarctic Ice Sheet Dynamics (PAIS) and the strategic vision for NSF investments in Antarctic and Southern Ocean Research to develop a coordinated science plan between the international Antarctic science communities to carry out an integrated effort to better characterize the ice sheet history along the Siple Coast during the last interglacial period, and other past warm periods during the Neogene and Quaternary. Short term goals include using existing technologies (i.e., Agile Sub-Ice Geological drill system) to carry out shallow drilling of the Crary and Steershead ice rises in order to recover and date sediments directly underlying the ice shelf. The anticipated 10-meter sediment cores recovered will not only have value as Neogene and/or potentially Quaternary paleoenvironmental archives, but may also provide information on till deformation processes downstream of the Whillans and Kamb ice streams. Sediments previously drilled and sampled by the Ross Ice Shelf Project examined by Scherer et al., (1988) identified deposition of reworded lower Miocene sediments from the Crary Ice Rise. We are proposing a programme of site evaluation and survey similar to the successful ANDRILL MIS Project, and current evaluation of sites near the grounding line of the Kamb Ice Stream being led by the New Zealand Ross Ice Shelf Programme (2017-2019). It is intended that deployment of logistics and operations to Crary and Steershead ice rises could be collaborative between NSF, New Zealand and other national programmes. Our proposed surveys of the ice rises will involve: (1) Acquisition of oversnow seismic reflection profiles radiating away from the proposed shallow drill core sites that will allow the deeper geometry of the strata to be evaluated for locating deeper drilling and recovery of long, continuous records. (2) The seabed and ocean cavity at potential coring sites will be accessed with hot water drilling technology. (3)

The flow rate of the ice shelf will be measured with GPS and satellite data. (4) Properties of the water column (currents, salinity, temperature) and sub ice shelf biology examined using oceanographic casts and moorings, probes and camera/ROV. (5) Short sediment cores will allow the nature and age of the youngest sub-sea floor sediments and LGM- Holocene depositional processes to be established.

The potential of past large scale retreat and collapse of the West Antarctic Ice Sheet is implied by the ANDRILL 1B record (Naish et al., 2009), sediments sampled beneath the Whillans ice stream (Scherer et al., 1998), and numerical ice sheet models (Pollard and DeConto, 2009). Direct evidence of past grounding line migration along the Siple Coast of West Antarctica is critically-needed to constrain ice sheet sensitivity and extent, and is a high priority within the research community (Kennicutt et al., 2015)

Keywords: Ice Rises, Siple Coast, WAIS

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