Deglaciation of the Amundsen Sea Embayment - the Prelude to Recent, Rapid Ice Retreat

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Research into the history, present-day dynamics and future stability of the West Antarctic Ice Sheet (WAIS) has concentrated strongly on the Ross and Weddell Sea sectors of the ice sheet. This research has revealed complex ice-stream dynamics and evidence of unsteady flow, but no sign of a strong negative mass balance or imminent collapse in either region. The Amundsen Sea Embayment Project (ASEP) is motivated by recent satellite and airborne studies of the much less accessible Amundsen Sea area; these have revealed rapid thinning and grounding-line retreat on Pine Island, Thwaites, Smith and Kohler Glaciers resulting in an annual loss of 85 +/- 20 GT of ice [1]. The changes underway in this region are much greater than observed in other sectors of the ice sheet, and are likely to dominate the mass balance of the WAIS in the near future. The purpose of the proposed ASEP Glacial Geology program is to provide long-term context for these changes – on timescales from hundreds to thousands of years.

The existing photographic, instrumental and remote-sensing record for the Amundsen Sea region extends back to 1947 [2]. This makes it difficult to determine whether the present pace of deglaciation represents unsteady ice-stream flow, a response to a recent change in boundary conditions, such as loss of buttressing ice shelves, or is the continuation of conditions that have prevailed steadily for hundreds, or thousands of years. Geologic records of the ice-sheet's thickness and behavior over the past few thousand years will greatly extend the time-base of glaciological studies, complement marine geophysical and geochronological records from the Amundsen Sea, and provide an important addition to the observational and instrumental record to be obtained by other ASEP research groups.

We have proposed an intensive, ground-based glacial-geologic study of Pine Island, Pope, Smith and Kohler Glaciers (Unfortunately there are no bedrock outcrops along Thwaites Glacier, so there is no geologic record of its past thickness). Our plan is to:

(1) Reconstruct ice levels at sites bordering Pope, Smith and Kohler Glaciers, ranging from Mt Murphy and Toney Mountain, large volcanoes at the upstream ends of the glaciers to outcrops close to and beyond their grounding lines. Exposure dates on moraines and glacial erratics, and C-14 dates on ice-marginal sediments stranded above glacier level should provide thinning histories at these sites. We expect to be able to derive past ice elevations, determine if thinning has been steady or episodic, and obtain thinning and retreat rates that can be compared to those derived from remote sensing.

(2) Search for evidence of former glaciation and/or isostatic emergence on islands in Pine Island Bay. Dates on exposed bedrock, glacial debris and uplifted marine sediment will provide constraints on the former extent and retreat rate of Pine Island Glacier, which can be compared to existing marine records (e.g. [3]).

(3) Integrate our results with those of the British Antarctic Survey GRADES Program (Glacial Retreat in Antarctica and Deglaciation of the Earth System; [4]). Researchers participating in the QWAD (Quaternary West Antarctic Deglaciation) program, a sub-component of GRADES, visited Pine Island Bay and the Hudson Mts during the 2005-06 field season, working from R.V. Polarstern. Their geological and chronologic work on samples collected form these areas will complement our proposed work.

(4) Integrate our results with those of the broader Amundsen Sea Embayment Project. We expect both to provide background to ASEP glaciological studies, and to incorporate ASEP findings into our own interpretations, with the overarching goal of determining whether the ongoing, rapid retreat of Amundsen Sea glaciers part of a long-term trend or a recent anomaly.

References: [1] Thomas R. et al., Science, 306, 255-258 (2004). [2] Rignot E., J. Glaciol. 48, 247-256 (2002). [3] Lowe A.L. and Anderson, J.B., Quat. Sci. Revs 21, 1879-1897 (2002). [4] http://www.antarctica.ac.uk/BAS_Science/programmes2005-2010/GRADES/