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Collaborative Research: West Antarctic Ice Sheet Stability: The Glacial Geologic Record from the Ohio Range of the Horlick Mountains in the Bottleneck

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Organization: University of Maine

Title:

Collaborative Research: West Antarctic Ice Sheet Stability: The Glacial Geologic Record from the Ohio Range of the Horlick Mountains in the Bottleneck

Project Participants

Senior Personnel

Name: Borns, Harold

Worked for more than 160 Hours: Yes

Contribution to Project:

Project Director

Post-doc

Graduate Student

Name: Putnam, Aaron

Worked for more than 160 Hours: Yes

Contribution to Project:

Undergraduate Student

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Harvard University

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities:

A field party comprising Robert Ackert, Aaron Putnam, Sujoy Mukhopadhyay, and Peter Braddock(Harold Borns was prevented from fieldwork by an unexpected medical condition), occupied two field camps in the Ohio Range between Dec. 31, 2004 and Jan. 26, 2005. All of the primary field objectives of the project were realized. These consisted of 1) Establishing the height of the WAIS in the Ohio Range during the LGM. 2) Collection of samples for exposure dating to constrain the timing of the ice sheet high stand and the subsequent down draw to the present ice elevation. One hundred and four samples were collected from glacial erratics on spurs and nunataks, and from boulders on ice-cored moraines fringing the WAIS. 3) Mapping of alpine glacier moraines on Mercer Ridge and collection of samples for exposure dating from moraine boulders. In addition, exposure samples from an older alpine moraine that likely predates the LGM were collected. For each

exposure sample, documentation includes precise location and elevation determined by GPS and barometric altimeters, sketches, photographs, boulder dimensions and topographic shielding. Differential GPS was used to construct moraine profiles and reference datum for the altimeter measurements.
During the course of the project we successfully established measurements protocols for cosmogenic 3He and 21 Ne and both these isotopes were measured in our laboratory. Measurements of 10Be in the glacial erratics and bedrocks have also been completed.

The presentations resulting from our work include:
Robert P. Ackert Jr., Sujoy Mukhopadhyay. Glacial Geology of the Ohio Range, Antarctica: Constraints on Ice Sheet Elevation During the Last Glaciation, AGU, Fall 2005.

Robert P. Ackert, Jr., Sujoy Mukhopadhyay, Aaron Putnam and Harold Borns, Surface exposure ages from the LGM trimline in the Ohio Range, Horlick Mountains, WAIS, Fall 2006.

Robert P. Ackert jr., Sujoy Mukhopadhyay, Bryon Parizek, and Harold Borns. Surface exposure ages of glacial erratics at the Ohio Range, Horlick Mountains, 10th International Symposium on Antarctic Earth Science (ISAES), Santa Barbara, CA, Aug. 2007

Ackert, J., R.P. Mukhopadhyay, S. Parizek, B.R., and Borns, H.W., Constraints on Ice Elevation near the West Antarctic Ice Sheet Divide during the Last Glaciation: Geophysical Research Letters. In press.
Putnam, A., 2007, An Independent Alpine Glacier Chronology, Ohio Range, Antarctica: M.S. thesis, University of Maine

Findings:

We report past ice elevation data from the Ohio Range, located near the WAIS divide and the onset region of the Mercer Ice Stream. Cosmogenic exposure ages of glacial erratics record a WAIS highstand of !125 m above the present surface date to ~11.5 ka. This suggest that ice elevation changes during the last glaciation in intereior WAIS were typically quite modest and limited to at most a couple hundred meters. Further, the results indicate that the deglaciation history in interior WAIS, on either side of the Ross Embayment was similar. Specifically, maximum ice elevations occurred or persisted until 10 to 11.5 ka, ~3000 years after the periphery of the ice sheet in the Ross Sea had begun to retreat (Licht et al. 1996; Stone et al., 2003). Hence, our observational data from the Ohio Range strongly support inferences drawn from ice-sheet models (Steig et al. 2001) that maximum interior ice elevations occurred in the early Holocene in response to increasing accumulation rates and that during deglaciation a wave of thinning propagated upstream from the coast reaching the head of the ice streams in ~3000 years The deglacial chronology also prohibits an interior WAIS contribution to meltwater pulse 1A.

Our observational data of ice elevation changes compare well with predictions of a thermomechanical ice-sheet model (Parizek and Alley, 2004) that incorporates very low basal shear stress downstream of the present day grounding line. We conclude that ice streams in the Ross Sea Embayment had thin, low-slope profiles during the last glaciation and interior WAIS ice elevations during this period were several hundred meters lower than previous reconstructions (e.g. Denton and Hughes, 2002). This conclusion implies that the WAIS ice volume was smaller than has been proposed, which has important implications for interpretation of bed-rock uplift rates in the Ross Embayment that typically assume thicker ice loads during the LGM, and for the contribution of the WAIS to post LGM sea-level rise.

Training and Development:

Two undergraduate work study students assisted Putnam and Borns on preparing samples for both 21Ne and 10Be analysis.

Outreach Activities:

Public style lecture by Borns at University of Maine on the proposed goals of the research, the fieldwork, and on our findings based on fieldwork and surface exposure dating of moraines.

Journal Publications

Books or Other One-time Publications

Robert P. Ackert,Sujoy Mukhopadhyay, Bryon P. Parizek, and Harold Borns, "Ice elevation near the West Antarctic Ice Sheet divide during the Last Glaciation", (2007). paper, Accepted
Collection: Geophysical Research Letters, p.,vol., (2007).
Bibliography: Pending Publication

Web/Internet Site

URL(s):

URL(s):http://gcmd.nasa.gov/getdif.htm?Mukhopadhyay_0338271

Description:

The entire dataset of surface exposure ages of erratics and bedrock samples at the Ohio Range generated during the course of this project can be accessed through this site.

Other Specific Products

Contributions

Contributions within Discipline:

We established that maximum ice elevations in the Ohio Range were ~125 m above the present ice surface and occurred 10.5-12.5 ka. These elevations and those obtained in the Executive Committee Range are the only field constraints on interior WAIS elevation outside of Marie Byrd Land. We compare our results with model predictions of the Mercer Ice Stream and show that the WAIS had very low surface slopes in the Ross Embayment due to very low basal shear stress seaward of the present grounding line. Our observational date will serve as benchmark for ice sheet models that try to predict the future behavior of the WAIS.

Contributions to Other Disciplines:

The magnitude and timing of maximum interior WAIS elevations are a key constraint for ice sheet models. Our results support similar inferences about past WAIS elevations in the Ross Embayment based on the Siple Dome Ice Core. Hence this paper will be of particular interest to the ice-sheet modeling community. Our new constraints suggest that the WAIS was several hundred meters thinner than traditional ice sheet reconstructions at its maximum extent. The smaller ice volume limits the contribution of the WAIS to Holocene sea level rise. Knowledge of the ice load history in West Antarctica is necessary for studies involving glacial isostasy thus, will be of interest to those studying crustal motion in Antarctica.

Contributions to Human Resource Development:

Contributions to Resources for Research and Education:

The equipment and techniques used in the Surface Exposure Dating Laboratory of the University of Maine for the preparation of samples were refined and improved to produce more accurate measurements for 3He and 10Be.

Aaron Putnam has complied his MS thesis and is now in a PhD program at University of Maine in with added training at Lamont-Doherty Geological Observatory, Columbia University. His focus is on the chronology of the last glaciation.

Contributions Beyond Science and Engineering:

Categories for which nothing is reported:

Any Journal

Any Product

Contributions: To Any Human Resource Development

Contributions: To Any Beyond Science and Engineering