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Collaborative Research: Grounding-line Retreat in the Southern Ross Sea - Constraints from Scott Glacier

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Final Report for Period: 08/2009 - 07/2010

Submitted on: 07/13/2010

Principal Investigator: Hall, Brenda L.

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Organization: University of Maine

Submitted By:

Hall, Brenda - Principal Investigator

Title:

Collaborative Research:Grounding-line Retreat in the Southern Ross Sea - Constraints from Scott Glacier

Project Participants

Senior Personnel

Name: Hall, Brenda

Worked for more than 160 Hours: Yes

Contribution to Project:

Brenda Hall is the project PI and has been involved with all planning and scientific aspects of the project. She deployed into the field and is involved with laboratory work.

Post-doc

Graduate Student

Name: Bromley, Gordon

Worked for more than 160 Hours: Yes

Contribution to Project:

Gordon Bromley is the principal graduate student on this project. He has participated in aerial photograph interpretation, field work, and laboratory analyses. He also has given two presentations on this work.

Name: Garhart, Kimberly

Worked for more than 160 Hours: Yes

Contribution to Project:

Kim has participated in the project organization, including organization, location, and procurement of materials, background research, and sample curation.

Name: Garcia, Juan

Worked for more than 160 Hours: Yes

Contribution to Project:

This person participated in lab work and literature review.

Undergraduate Student

Name: Mietkiewicz, Nathan

Worked for more than 160 Hours: Yes

Contribution to Project:

Nathan Mietkiewicz participated in the field work for this project.

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

University of Washington

This is a collaborative project with the University of Washington. In order to avoid duplication, they will provide details of their part of the project in their report. I will focus this report on those aspects of the project that were the responsibility of the University of Maine - glacial geologic mapping, profile reconstruction, and radiocarbon dating.

Other Collaborators or Contacts

In addition to the collaborative work with the University of Washington, we have collected sediment samples for researchers at Massey University in New Zealand related to their Antarctic project looking at springtails.

Activities and Findings

Research and Education Activities:

Our major research activities related to this project include 1) two field seasons at Scott Glacier; 2) glacial geologic mapping of sites along the glacier, including Mt. Verlautz, Mt. Howe, La Gorce Mts., Mt. Walshe, Mt. Gardiner, Cox Peaks, and the Karo Hills; 3) production of glacial geologic maps and glacier profiles; 4) collection and dating of radiocarbon samples from former ice-marginal lakes; 5) collection of exposure-age samples for the Washington group; 6) presentation of results at international meetings; and 7) preparation of manuscripts.

We have been involved in education activities, including the 1) mentoring of graduates and undergraduate students (two students participated in field work), 2) lectures at middle and elementary school class rooms and retirement communities, and 3) participation in an activity designed to attract high school girls to earth science.

Findings:

Our work has resulted in surficial geologic maps of seven sites along Scott Glacier and measurements of former ice elevations from the glacier head (Mt. Howe) to the mouth (Karo Hills). Our mapping, along with elevation measurements, indicate minor thickening near the glacier head (~40 m at Mt. Howe) and significant thickening (>1000 m) at the glacier mouth near the Karo Hills during the last glacial maximum (LGM). All nunataks near the glacier mouth appear to have been overridden during the LGM, even those more than 1000 m above present ice level. A spectacular set of cosmogenic exposure ages (more details on the results in the University of Washington report) from the Karo Hills are consistent with this observation and indicate continued ice thinning, perhaps in pulses, from about 11,000 to 2000 years ago.

LGM-age drift (inferred from its fresh appearance and confirmed by exposure ages) is present alongside the glacier in every ice-free area examined. Commonly, its upper limit is marked by a prominent drift edge. In several locations, we have been able to identify multiple recessional moraines, something that we have not seen before in the southern TAMS (although most locations, i.e., at Reedy Glacier, show one recessional moraine). Ages of these recessional moraines have allowed us to track the pattern and timing of glacier thinning through the Holocene, allowing us to relate the timing of thinning and marginal retreat to grounding-line fluctuations farther to the north and to global climate and sea-level events.

Chronology comes from exposure-age dating (to be detailed in the Washington report) and radiocarbon dating (discussed here). One exciting aspect of our work is that we have been able to assign radiocarbon ages to many of the recessional moraines. As expected, we were able to locate relict algal mats from former ice-dammed lateral lakes. These lakes formed adjacent to the ice margin when the glacier was more extensive than it is now. The Mt. Walshe area was particularly productive in the 2007/08 field season. Dates from this site bracket a recessional moraine there between about 4000-5000 yr B.P. and show a general pattern of ice retreat between ~9000 and 2000 yr B.P. In the second field season, we collected ancient algae in excellent context from La Gorce Mtns., Cox Peaks, and Karo Hills. Most of the date samples are from Cox Peaks, where a series of moraines, each with its own former ice-dammed pond, represents Holocene positions of the Scott Glacier lobe. We can document ice positions at ~5000 yr B.P. (possibly the same moraine as at nearby Mt. Walshe) and at ~3000 yr B.P. Ice has retreated slowly since that time, with algae just above modern pond level, within 20 m horizontally of the ice front, dating to ~1600 yr B.P. These data, along with those from Reedy Glacier (which are of similar age), are the first evidence of dated mid-late Holocene moraines along major outlet glaciers in the southern Transantarctic Mountains. We are now trying to determine if these moraines represent local mechanical adjustment to the Holocene outlet glacier thinning or if they represent regional climate signals. Another important finding from the radiocarbon dates is that they all suggest thinning and marginal retreat slowed substantially or perhaps halted by 1500 years ago. This suggests Scott Glacier has been stable since that time.

At Mt. Walshe and, to some extent, the Karo Hills, we are able to make direct comparisons between radiocarbon and ^{10}Be exposure ages. Our

initial comparisons suggest that ^{10}Be dates may be consistently slightly young, when compared to the radiocarbon. There are several possible reasons why this could be, including the need to alter the ^{10}Be production rate. However, we are still testing to see if this relationship holds for a large number of samples. This represents the first possibility in the Antarctic for making direct comparisons between the two dating methods and may lead to new insights into ^{10}Be systematics.

In summary, our work indicates substantial LGM ice thickening in the interior Ross Embayment. Deglaciation was delayed compared to locations north of Antarctica, apparently commencing about 11,000-12,000 years ago. This is consistent with evidence from farther north in the embayment, such as in the McMurdo Sound region. Thinning occurred throughout the Holocene, probably in pulses that may correlate to periods of grounding-line retreat, particularly at 7000-8000 yr B.P. (see Washington report for details). Very little has happened at Scott Glacier in the last ~2000 years, suggesting first, that the Ross Sea grounding line passed the glacier mouth by this time and second, that the glacier has achieved relative stability.

Training and Development:

This project has afforded excellent research training and experience for graduate and undergraduate students. Two students participated in the 2007-2008 and one in 2008-2009 field work. Two have gained laboratory experience.

Outreach Activities:

We have visited four elementary and middle schools, as well as a senior citizens community, to talk about this research and Antarctica in general. We also participated in 'Expanding your Horizons' an outreach effort designed at attracting girls to earth science. In addition, we participated in a polar regions website put together by Will Steger and his staff. This is associated with one of his recent expeditions and consists of educational materials and resources for teachers. Finally, we also used results from this research in a presentation at the University of Lund (Sweden). This presentation was part of their diversity series and was designed to discuss the role of women in Antarctic research and the challenges they face in science.

Journal Publications

Hall, B., "Holocene glacial history of Antarctica and the subantarctic islands", *Quaternary Science Reviews*, p. 2213, vol. 28, (2009).
Published,

Books or Other One-time Publications

Hall, B.
Stone, J.
Bromley, G.
Todd, C.

Conway, H., "History of the grounded ice sheet in the Ross Sea sector, Antarctica: Implications for ice-sheet behavior at and since the last glacial maximum", (2008). abstract, Accepted
Collection: AMQUA Meeting Abstract (invited)
Bibliography: AMQUA Meeting, State College, PA

Hall, B., Stone, J., Conway, H., Bromley, G., Todd, C., and Cowdery, S., "History of the grounded ice sheet in the Ross Sea sector: New data from Scott and Reedy Glaciers", (2009). abstract, Published
Collection: Past Climates Symposium and Australasian INTIMATE Meeting
Bibliography: Wellington, New Zealand

Bromley, G., Hall, B., Stone, J., and Conway, H., "Late Quaternary fluctuation of Scott Glacier in response to grounding-line retreat in the Ross Sea Embayment", (2008). abstract, Published
Collection: 15th Annual West Antarctic Ice Sheet Meeting
Bibliography: Sterling, VA

Hall, B., Stone, J., Bromley, G., Todd, C., and Conway, H., "History of the grounded ice sheet in the Ross Sea sector, Antarctica at and since

the LGM", (2008). abstract, Published
 Collection: American Quaternary Association Meeting
 Bibliography: State College, PA

Hall, B., Stone, J., Bromley, G., Todd, C., and Conway, H., "History of the grounded ice sheet in the Ross Sea sector, Antarctica, at and since the LGM", (2008). Abstract, Published
 Collection: 15th Annual West Antarctic Ice Sheet meeting
 Bibliography: Sterling, VA

Hall, B., Bromley, G., Mietkiewicz, N., Stone, J., Conway, H., and Cowdery, S., "Reconstructing Holocene ice-marginal fluctuations with relict algal mats at Reedy and Scott Glaciers", (2008). abstract, Published
 Collection: 15th Annual West Antarctic Ice Sheet Meeting
 Bibliography: Sterling, VA

Web/Internet Site

URL(s):

<http://gcmd.nasa.gov/getdif.htm?ScottGlacierRadiocarbonDates>

Description:

This site contains metadata related to our archive of radiocarbon dates associated with this project.

Other Specific Products

Contributions

Contributions within Discipline:

Our work contributes substantially to our knowledge of Antarctic glacial history and, in particular LGM ice thickness in the interior Ross Embayment and the timing of grounding-line retreat. This information has further implications for the behavior of the West Antarctic Ice Sheet; in particular, the mechanisms that may control the extent of its grounding lines.

Contributions to Other Disciplines:

Our work will help address questions, such as the stability of the West Antarctic Ice Sheet, which bear on future sea-level change. In addition, our reconstruction of ice-sheet thinning and grounding-line retreat may contribute to understanding of past sea-level rise.

Contributions to Human Resource Development:

We have mentored four students in earth sciences related to this project. In addition, results from this project are incorporated into undergraduate and graduate courses. Photos, anecdotes, and data from this project also are used in presentations to elementary and middle-school classrooms. In the middle-school classrooms, the focus is especially on science as a viable career option for both males and females.

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

Our work has contributed towards understanding the West Antarctic Ice Sheet, the behavior of which remains one of the largest uncertainties in future sea-level predictions.

Conference Proceedings

Categories for which nothing is reported:

Any Product

Contributions: To Any Resources for Research and Education

Any Conference