7-28-2005

Glacial History of the Amundsen Sea Shelf

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Final Report for Period: 08/1999 - 07/2001
Submitted on: 07/28/2005
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Award ID: 9814692
Organization: University of Maine
Title:
Glacial History of the Amundsen Sea Shelf

Project Participants

Senior Personnel

Name: Kellogg, Thomas
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Belknap, Daniel
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Kellogg, Davida
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Hughes, Terence
Worked for more than 160 Hours: Yes
Contribution to Project:
Dr. Hughes served as a field assistant aboard N.B. Palmer during February and March 2000 and served as a scientific advisor during our fieldwork. Support was limited to travel and medical expenses.

Post-doc

Graduate Student

Name: Johnson, Jesse
Worked for more than 160 Hours: Yes
Contribution to Project:
Mr. Johnson served as a field assistant aboard N.B. Palmer during February and March 2000. Support was limited to travel and medical expenses.

Name: Gontz, Allen
Worked for more than 160 Hours: Yes
Contribution to Project:
Mr. Gontz served as a field assistant aboard N.B. Palmer during February and March 2000. Support was limited to travel and medical expenses.

Undergraduate Student

Name: Harper, Melissa
Worked for more than 160 Hours: Yes
Contribution to Project:
Ms. Harper served as a field assistant aboard N.B. Palmer during February and March 2000. Support was limited to travel and medical expenses.

Technician, Programmer

Name: Introne, Douglas

Worked for more than 160 Hours: Yes

Contribution to Project:

Mr. Introne served as a field assistant aboard N.B. Palmer during February and March 2000. Support was limited to travel and medical expenses.

Other Participant

Name: Nabor, Daniel

Worked for more than 160 Hours: Yes

Contribution to Project:

Mr. Nabor served as a field assistant aboard N.B. Palmer during February and March 2000. No support was provided

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

Dr. Stan Jacobs of Lamont-Doherty Earth Observatory served as Chief Scientist on NBP00-1 and offered much assistance and advice for our project.

Dr. Eugene Domack of Hamilton College advised us concerning radiocarbon dating of Amundsen Sea sediments.

Activities and Findings

Research and Education Activities:

Field Accomplishments

During February and march of 2000, we completed fieldwork on the Amundsen Sea continental shelf with the following results:

1. Identified and surveyed the southern ends of 13 of 16 glacial troughs on the Amundsen Sea Shelf (only two of these, Thwaites and Pine Island troughs, were previously known in any detail if at all).
2. Completed swath bathymetric mapping of the continental shelf margin from 122?15ÆW to 102?W, and made 5 additional crossings west of 122?15ÆW. One notable result of this mapping was the discovery of a large re-entrant between 121?W and 118?30'W. Second, the location of this margin, which had previously been know only from a few scattered crossings in now established for most of the Amundsen Sea.
3. Completed 4 seismic profiles, three across glacial troughs and one along a trough, These demonstrate the widespread occurrence of bedrock highs in the glacial troughs and shows that they are unlike troughs in the Ross and Weddell seas where a thick layer of sediments is present.
4. Recorded accurate positions for coastlines and ice shelf margins for over half the Amundsen Sea coastline.
5. Total SeaBeam swath bathymetry = 9062 km
6. Total cores in the Amundsen Sea = 68 (26 Kasten, 42 Piston)
7. Completed the first bathymetric map of the Amundsen Sea shelf.
8. Most field goals were met despite heavy ice cover.

Findings:

The 16 glacial troughs on the Amundsen Sea shelf are linear or curved depressions on the continental shelf. Depths are usually greatest at their southernmost ends immediately adjacent to the calving fronts of ice shelves, or off glaciers. In most cases maximum depths are between 900 and 1500 m and trough sides are steepest on their western margins. We have no information on trough depth, morphology, or southward extent beneath the ice shelves. Depths generally decrease and the walls become less steep as the troughs broaden into shallow depressions on the outer continental shelf. In some cases two or more troughs merge in the mid-shelf region in tributary fashion, similar to the joining of ice streams on the grounded ice sheet (Vaughan et al., 2000) to form a compound-trough. At least two of the compound troughs attain depths nearly as great or greater than those near the southern ends of the individual tributary troughs. Many troughs and compound-troughs turn toward the northwest near their southern ends or in the mid-shelf region. The troughs are not flat-bottomed but display trough-parallel elongated or irregular shaped topographic highs that can rise as much as 500 m above trough floors on either side at their southern ends and to lesser heights further north.

Some of these topographic highs have steep slopes on their stoss sides and gentler slopes on their lee sides; others show the opposite (ôroche moutoneeö) pattern. Seismic profiles oriented parallel to and across three troughs show that these topographic highs are bedrock with little or no sediment cover.

Because most Amundsen Sea troughs emerge from beneath ice shelves in passages between bedrock topographic highs or are directly downstream from known glaciers, they presumably record the former positions of grounded ice streams at times when WAIS ice was more extensive than today. In short, the entire set of troughs defines the flow pattern of glacial ice across the continental shelf. These flowlines almost certainly follow preexisting structural features of the bedrock because they do not extend straight to the shelf break but curve around topographic highs. The inter-trough highs (e.g., Bear Peninsula Bank) may have supported local ice caps or ice domes during deglaciation, and may separate modern flow patterns of near-bottom waters on the continental shelf.

The shoaling and broadening of the troughs toward the continental shelf break is consistent with grounded ice extending to the shelf break during glacials. Overdeepening of the troughs at their southern ends would be a consequence of a grounded ice sheet that thickened to the south away from the shelf break. Thicker (heavier) ice would enhance glacial scour. Along with the considerable depths of the troughs at their southern ends, this attests to the vigor of ice streams in this sector of Antarctica during glacials.

Unlike glacial troughs in the Ross and Weddell seas, the Amundsen Sea troughs are not covered with thick marine sediments but instead have very irregular bedrock floors. The fact that vigorous ice flow occurred here is demonstrated by the great depth of ice-scoured depressions in these rocky beds. This suggests that the presence of a fluidized sediment bed is not a necessary precondition for rapid ice stream flow. Future studies of ice steams around West and East Antarctica may show that rocky beds are more common than sediment-floored beds, in which case ice streams entering the Ross and Weddell seas would be exceptions.

The massive Pine Island and Thwaites troughs and the large number of deep, lightly sedimented troughs fronting the Getz and Dotson ice shelves, indicate that intense glacial activity characterized the entire Amundsen Sea sector during former glaciations. There were more ice streams discharging into the Southern Ocean in this sector than in either the Ross or Weddell sea embayments, important information for glaciologic modeling of the WAIS. Future studies will thus need to incorporate the mechanics of glacier flow in these and other similar bedrock-floored ice troughs.

Training and Development:

Two graduate students (Jesse Johnson and Allen Gontz) and one undergraduate (Melissa Harper) received valuable shipboard training in marine geological and marine geophysical methods (coring, SeaBeam, Seismic).

One field assistant, Larry Reynolds, is a high school teacher and participated in the TEA program. Larry comments: '...out of my participation came lots of e-mails from schools around the country from kids who will form the next generation of Antarctic scientists. Additionally, two promising young students at Liberty... have chosen hard science as a career, and in each case I think it is fair to say that my TEA website played a big role. TEA is a good program, specifically because it is one window for non-scientists to understand the wonder of polar science. It accomplishes what Congress funded it for! I continue to fulfill my duties to TEA, by correspondence with schools, public speaking, teacher mentoring, and construction and use of lesson plans based on my experience.'

Dr. Terry Hughes has a long-standing (over 20 years) interest in glacial dynamics in the Amundsen Sea sector. His participation on this project yielded many useful insights that helped us during the fieldwork and he will benefit from the experience of visiting the area.

Outreach Activities:

I presented a slide show and lecture to the 8th grade class at Ossining, NY highschool on our results. Similar lectures are planned for other highschools in Maine.

See previous section on our TEA participant.

Journal Publications

Books or Other One-time Publications

Web/Internet Site

URL(s):

http://tea.rice.edu/tea_reynoldsfrontpage.html

http://gcmd4.gsfc.nasa.gov:8080/KeywordSearch/servlets/md/getdif.py?entry_id=[GCMD]Amundsen Sea Swath Bathymetry&xsl=full_display.xsl&portal=ceos

Description:

The first URL is the Teachers in Antarctica web page of Larry Reynolds who was a field assistant on this project.

The second URL is the metadata report.

Other Specific Products

Product Type:

Map

Product Description:

We have completed a preliminary version of the first bathymetric map of the Amundsen Sea shelf from 135 degrees west to 100 degrees west based on over 9000 km of Multi-beam swath bathymetry supplemented with digital data from 3 prior cruises. We are still attempting to locate data from two previous cruises to complete this map.

Sharing Information:

We expect to publish in a scientific journal and will offer the data for inclusion on the next update of navigational charts of the area. Basic centerline bathymetry and related geophysical data is also being made available to NGDC to update their merged satellite/bathy files.

Product Type:

Data or databases

Product Description:

68 sediment cores (26 Kasten, 42 Piston) from the Amundsen Sea continental shelf.

Sharing Information:

Cores are stored at the Antarctic Core Facility at Florida State University and will be made available to other investigators upon completion of this project.

Contributions

Contributions within Discipline:

Our field work allowed us to compile the first bathymetric map of the Amundsen Sea continental shelf, showing the positions of all major ice streams. This allows us to define the glacial flow pattern on the shelf during former glaciations.

It is clear that former glaciations extended to the continental shelf break in the Amundsen Sea. Dating the sediment cores (in progress) will allow us to refine the timing of the last glaciation to cover the shelf.

Our results should be of importance to glacial modellers who are attempting to reconstruct the LGM West Antarctic ice sheet.

Our study of Amundsen Sea troughs shows that fast glacial flow in the troughs did not require a soft sediment bed but occurred on a very irregular bedrock base. This will require some revision of current thinking on mechanisms involved in fast glacier flow.

Contributions to Other Disciplines:

See previous section.

Contributions to Human Resource Development:

This project has provided valuable training for two University of Maine graduate students and one undergraduate.

In addition, the participation of Mr. Larry Reynolds in the TEA program while serving as field assistant with us had had a far-reaching impact on high school science students nationwide.

Contributions to Resources for Research and Education:

68 sediment cores housed at Florida State University will be available for other investigators on completion of this project.

Our bathymetric map of the Amundsen Sea will be a valuable resource for other workers interested in this area.

See TEA web site.

Contributions Beyond Science and Engineering:

Categories for which nothing is reported:

Organizational Partners

Any Journal

Any Book

Contributions: To Any Beyond Science and Engineering