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# The Origin of a Polar Ice Sheet in East Antarctica

George H. Denton

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**Final Report for Period:** 09/1996 - 02/2001

**Submitted on:** 10/04/2001

**Principal Investigator:** Denton, George H.

**Award ID:** 9527047

**Organization:** University of Maine

**Title:**

The Origin of a Polar Ice Sheet in East Antarctica

**Project Participants**

**Senior Personnel**

**Name:** Denton, George

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

**Name:** Sugden, David

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

David Sugden participated in the field work in Beacon Valley and in the western Transantarctic Mountains. He is involved in publishing papers on this work.

**Name:** Shaefer, Jorg

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

Jorg Shaefer analyzed samples for cosmogenic isotopes and published the results.

**Name:** Marchant, David

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

This person carried out field work in Beacon Valley and has been involved in publishing the results of the project.

**Name:** Hall, Brenda

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

Brenda Hall participated in Victoria Valley field work and is involved in publishing the results.

**Post-doc**

**Graduate Student**

**Name:** Kelly, Meredith

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

Meredith Kelly carried out field work in Victoria Valley as her M.S. thesis research. She is involved in publishing the results.

**Name:** Lewis, Adam

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

Adam Lewis participated in Beacon Valley fieldwork as part of his M.S. thesis research. He is involved in publishing the results.

**Name:** Lorrey, Andrew

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

Andrew Lorrey carried out field work in Beacon Valley as part of his M.S. research. He is involved in publishing the results.

**Undergraduate Student**

**Name:** Benoit, Amy

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

Amy Benoit assisted in the Victoria Valley field work.

**Research Experience for Undergraduates****Organizational Partners****ETH Zurich**

Jorg Shaefer of ETH Zurich performed cosmogenic isotope analyses in his laboratory and collaborated with the research.

**University of Edinburgh**

David Sugden collaborated on the research and spent time in Maine to work on the project.

**Boston University**

Personnel from Boston University and the University of Maine used each others facilities and carried out the research together in the field.

**Other Collaborators or Contacts****Activities and Findings****Research and Education Activities:**

Field work was carried out in western Victoria Valley, Beacon Valley, and the western Transantarctic Mountains between the Royal Society Range and Mawson Glacier. Samples collected during this research were analyzed at ETH-Zurich for cosmogenic isotopes and at the University of Maine for sediment grain size and texture. Results of this work form the basis for three theses. This work has been presented at Lamont-Doherty Earth Observatory, Victoria University in Wellington (NZ), Institute of Geological and Nuclear Sciences in Wellington (NZ), INQUA Congress in Durban (South Africa), Wenner-Gren Conference in Malawi, The Pot and Kettle Club in Bar Harbor (Maine), the Southport Yacht Club (Maine), Johns Hopkins University, the NOAA Panel on Abrupt Climate Change in Zermatt (Switzerland), and Lehigh University.

**Findings:**

The results show:

- 1) that a polar ice sheet emerged in East Antarctica in middle Miocene time,
- 2) that this polar ice sheet expanded over the Transantarctic Mountains and to the outer continental shelf, reaching its all-time maximum size, between 13 and 15 million years ago,
- 3) that the polar ice sheet in East Antarctica achieved approximately its present-day size by 13 million years ago, 4) that the East Antarctic Ice Sheet has remained stable under a polar climate for the past 13 million years, and

5) that a polar climate extreme enough to preserve ancient glacier ice has existed for at least 8 million years in the western Dry Valleys alongside the East Antarctic Ice Sheet.

The field work in the western Transantarctic Mountains showed evidence of massive ice-sheet overriding in the form of subglacial channel systems, scabland topography cut by subglacial floods, corrugated bedrock, and striations. Argon-40/argon-39 dates show that this overriding occurred in Miocene time. The field work in western Victoria Valley shows that only polar glaciers were present after the mountain-overriding episode, demonstrating continuously cold climate even on the valley floors relatively close to sea level during the past 13 million years. The field work in Beacon Valley confirms the stunning conclusion that ancient buried ice has been preserved at a relatively high elevation alongside the East Antarctic Ice Sheet. This is the most ancient glacier ice discovered on Earth. Together, these results point to the enormous stability of both the Transantarctic Mountains and the adjacent East Antarctic Ice Sheet.

Many of the data have been reduced and are in press. The information concerning the massive ice-sheet overriding of the Transantarctic Mountains is still being processed and written up. This will be the most important product of the research into the origin of the polar ice sheet in East Antarctica.

#### **Training and Development:**

This project afforded M.S. thesis opportunities for 3 graduate students. It also exposed an undergraduate student to field research. Hillary Tulley, a Teacher Experiencing Antarctica, participated in the field work and gained insight into Antarctic scientific research.

#### **Outreach Activities:**

The results of this work formed the basis for lectures at the Pot and Kettle Club in Bar Harbor, Maine, and at the Southport Yacht Club in Southport, Maine.

#### **Journal Publications**

George Denton, "The history of the Antarctic Ice Sheet", *Science*, p. , vol. , ( ). Accepted

Meredith Kelly, George Denton, Brenda Hall, "Late Cenozoic paleoenvironment in southern Victoria Land, based on a polar form of drift in western Victoria Valley", *GSA Bulletin*, p. , vol. , ( ). in revision for publication

George Denton and David Sugden, "Massive ice-sheet overriding of the Transantarctic Mountains in middle Miocene time", *Geografiska Annaler*, p. , vol. , ( ). in preparation

David Sugden and George Denton, "Landscape evolution of the Convoy Range of the Transantarctic Mountains", *Geomorphology*, p. , vol. , ( ). manuscript completed

Jorg Schafer, Susan Ivy-Ochs, Rainer Wieler, Ingo Leya, Heinrich Baur, George H. Denton, Christian Schluchter, "Cosmogenic noble gas studies in the oldest landscape on earth: Surface exposure ages of the Dry Valleys, Antarctica", *Earth and Planetary Science Letters*, p. 215, vol. 167, (1999). Published

Jorg M. Schafer, Heinrich Baur, George H. Denton, Susan Ivy-Ochs, Dave R. Marchant, Christian Schluchter, and Rainer Wieler, "The oldest ice on Earth in Beacon Valley, Antarctica: New evidence from surface exposure dating", *Earth and Planetary Science Letters*, p. 64, vol. 179, (2000). Published

David R. Marchant, Adam Lewis, Eric Moore, Roland Souchez, George Denton, David Sugden, G. Landis, "Formation of patterned ground and

sublimation till over Miocene  
glacier ice in Beacon Valley, southern Victoria Land, Antarctica", GSA Bulletin, p. , vol. , (2001). Accepted

### Books or Other One-time Publications

Andrew M. Lorrey, "Distribution of patterned  
ground and surface deposits on  
a debris-covered glacier  
surface in Mullins Valley and  
Upper Beacon Valley, Antarctica", (2000). Thesis, Published  
Bibliography: University of Maine, Orono,  
Maine, 126p.

Meredith A. Kelly, "Surficial deposits in western  
Victoria Valley: A record of  
paleoenvironments in southern  
Victoria Land since  
Middle-Miocene time", (1999). Thesis, Published  
Bibliography: University of Maine, Orono,  
Maine, 226p

Adam R. Lewis, "The paleoclimatic significance  
of massive buried glacier ice  
in Beacon Valley, Antarctica", (2000). Thesis, Published  
Bibliography: University of Maine, Orono,  
Maine, 282p.

### Web/Internet Site

### Other Specific Products

### Contributions

#### **Contributions within Discipline:**

This work has afforded knowledge of the fundamental stability of the  
East Antarctic Ice Sheet.

#### **Contributions to Other Disciplines:**

This work places strict limits on future sea-level rise from the East  
Antarctic Ice Sheet. Extensive collapse of the East Antarctic Ice  
Sheet is highly unlikely, and coeval sea-level rise from this factor  
is therefore severely limited.

#### **Contributions to Human Resource Development:**

This project supported three M.S. students and was the basis for their  
theses. An undergraduate student and a high school teacher also gained  
research experience in Antarctica. Data from this project were  
routinely incorporated into undergraduate and graduate courses.

#### **Contributions to Resources for Research and Education:**

#### **Contributions Beyond Science and Engineering:**

Any upcoming change in sea level has significant influence on human  
settlements in coastal areas. The present research shows that it is  
unlikely that the huge East Antarctic Ice Sheet, the largest on the

planet, will contribute in any significant way to future sea-level rise. This is in sharp contrast to the situation in West Antarctica.

**Categories for which nothing is reported:**

Any Web/Internet Site

Any Product

Contributions: To Any Resources for Research and Education