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# Deglacial Chronology of the Northern Scott Coast from Relative Sea-Level Curves

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**Final Report for Period:** 09/2000 - 08/2004

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**Principal Investigator:** Hall, Brenda L.

**Award ID:** 9909104

**Organization:** University of Maine

**Title:**

Deglacial Chronology of the Northern Scott Coast from Relative Sea-Level Curves

### Project Participants

#### Senior Personnel

**Name:** Hall, Brenda

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

**Contribution to Project:**

**Name:** Baroni, Carlo

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

**Contribution to Project:**

This person is a collaborator. He worked with us in the field and has participated in writing abstracts and analyzing data.

#### Post-doc

#### Graduate Student

**Name:** Gardner, Nathan

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

**Contribution to Project:**

This person is the principal graduate student involved in the project. He deployed into the field, carried out a mapping and sampling program at Cape Ross and Inexpressible Island, and is now analyzing samples in the lab. This work will lead to a M.S. thesis.

#### Undergraduate Student

**Name:** Smith, Colby

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

**Contribution to Project:**

Colby Smith was an undergraduate field assistant during the 2000-2001 season. He also is carrying out a senior thesis on material he collected in the field.

**Name:** Marcotte, Peter

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

**Contribution to Project:**

Peter Marcotte was an undergraduate field assistant during the 2000-2001 season. He also is carrying out a senior thesis on material he collected in the field.

**Name:** Roy, Alex

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

**Contribution to Project:**

Alex served as an assistant in the field.

#### Technician, Programmer

**Other Participant****Research Experience for Undergraduates****Organizational Partners****University of Pisa**

Carlo Baroni at the University of Pisa is a full partner in this project. He and I are analyzing the data and writing the papers. Through Dr. Baroni, we were able to obtain key support and hospitality from the Italian Antarctic Program.

**Italian Antarctic Program**

The Italian Antarctic Program provided lodging and meals at Terra Nova Station, as well as a lab for us to use, some field equipment, and computers. Through an arrangement with NSF, they also provided us helicopter support.

**University of Durham**

Rus Hoelzel at the University of Durham analyzed some of the seal skin that we found in the beaches for mtDNA. He determined that the skin was indeed from southern elephant seals and that the seals belong to the Macquarie Island lineage. This is an important determination, because such seals do not live along the Scott Coast today.

**University of Delaware College of Marine Studies**

John Wehmiller at the University of Delaware has been examining the anomalously old shells we found at Cape Ross. He hopes to be able to make at least a gross determination of age (Pleistocene vs Pliocene) based on amino acid racemization. This will help us to determine the age of the oldest beach deposits yet discovered along the Scott Coast.

**University of Oxford**

Gideon Henderson and I have used some solitary corals collected from beaches near the Hell's Gate Ice Shelf to obtain paired U/Th and <sup>14</sup>C dates. These dates will allow us to calculate the marine reservoir effect at times during the past. I used Dr. Henderson's isotope geochemistry lab at Oxford University to analyze the samples.

**Other Collaborators or Contacts**

David Lambert of Massey U. has been analyzing the penguin bones we found for DNA.

Michael Bryden (retired, U. Sydney) examined some photographs of seal bones for us.

Burney LeBeouf (Santa Cruz) is undertaking a study of the elephant seal skin and is arranging DNA and isotope analyses

The British, Smithsonian, and Canterbury Museums have supplied samples from historic expeditions for analysis of the marine reservoir effect.

Paul Koch, (Santa Cruz) is examining the stable isotopes of the elephant seal skin for paleoceanographic and paleodiet information.

Austin Hendy (Cincinnati) identified the Cape Ross shells

These collaborations have led to three new projects on 1) the paleoclimatic significance of the elephant seals (pending NSF), 2) determination of changes in the Holocene marine reservoir effect from solitary corals (NOSAMS lab WHOI and NERC), and 3) calculation of the marine reservoir effect from historical samples (funded primarily through the Italian program).

**Activities and Findings****Research and Education Activities:**

After two seasons of field work (2000/01, 2001/02) we have spent most of our time analyzing radiocarbon and sedimentologic data and constructing relative sea-level curves. A large part of our time has been spent writing papers. Dr. Baroni visited Maine in 2003 for this purpose. We have presented the results of this work at several national and international meetings, as well as to school children in Maine and New Hampshire. We also have been making a concerted effort to determine the past marine reservoir effect, both through dating of museum specimens and through paired radiocarbon and uranium-thorium dating of Antarctic corals. Finally, Nate Gardner, the M.S. student on this project, defended his thesis on the age and formation of beaches along the Scott Coast. A paper with him as the lead author is now in progress.

**Findings:**

This work has yielded some important findings.

## 1) New relative sea-level curve for Terra Nova Bay

We now have a new relative sea-level curve for Terra Nova Bay. This curve is well-constrained by over 80 dates and suggests that deglaciation of the area could not have occurred much earlier than 7000 years ago. This is in contrast to dates of total organic carbon in marine sediment cores taken just offshore that indicate a much older age for deglaciation. This discrepancy remains to be resolved, but we suspect that the offshore dates require re-examination. The current practice of correcting marine downcore dates with the age of the surface material is not well-grounded.

## 2) There is widespread, pre-LGM beach material along the Scott Coast

At Cape Ross, Depot Island, Inexpressible Island, and Spike Cape, we have found that the present raised beaches are composite features, composed of sediments of many different ages. Our most detailed work is at Cape Ross, where there are at least 2-3 beach units. Shells (a kind not now found along the coast today) yield infinite radiocarbon dates, whereas penguin bones are ~30,000 years old. We have determined that much of the beach sediments, as well as many of the beach landforms predate the LGM. This has several important implications. First, undated beaches in the Antarctic can no longer be assumed to be Holocene in age, which has implications for constructing relative sea-level curves in areas where dates are scarce. Fresh-looking beaches can predate the LGM. Second, beaches along the Scott Coast can survive intact overriding by glacial ice. A final result of this research is that the old penguin bones have been analyzed for DNA by David Lambert (Massey U.), and the results confirm his hypotheses of Adelie penguin mutation rates and lineage divergence.

## 3) Southern elephant seals were abundant along the Scott Coast

Our work has confirmed and expanded the former widespread abundance of elephant seals in the Ross Sea. Our previous work had placed them as far south as Marble Point. Now, we have mapped their abandoned rookeries as far north as Edmonson Point. Their former presence in the Ross Sea is believed to have been due to warmer-than-present environments, something that apparently came to an end 500-1000 years ago.

## 4) Beaches along the Scott Coast are wave-formed

We have continued our work on the processes that form beaches in the Ross Sea region. We were curious if we could identify changes in sea ice extent and wave intensity from differences in the size and roundness of boulders on the beaches. These data are still being reduced. However, it appears that there are indeed significant changes in grain size and, in particular, roundness. We also examined beach morphology, made profiles with surveying equipment, and took beach face and backslope angle measurements. We wanted to see if all of the beaches formed by waves during storms (implying open water), or if some were ice-push features. We found very little evidence of ice push (all of it along the modern shore) and conclude that all of the raised beaches we examined are wave-formed storm beaches. The absence of ice-push features among the raised beaches is striking, considering the current fast ice conditions along the coast today.

## 5) The marine reservoir effect may have remained constant at 1300 years in the late Holocene

We conducted a pilot project to see if good U/Th dates could be obtained from solitary corals collected along the Hell's Gate Ice Shelf. The project was successful. These dates were paired with  $^{14}\text{C}$  dates of the same corals to yield the marine radiocarbon reservoir effect. Our preliminary results indicate little (if any) change in the reservoir effect during the late Holocene. If true, this has important implications not only for dating marine organisms in the Ross Sea (improves our confidence in the raised-beach chronology), but also for paleoceanography and ocean ventilation. We are now beginning a more ambitious, full-scale project funded by a grant from NOSAMS and from NERC.

**Training and Development:**

This project has afforded research experience for 1 graduate student and 3 undergraduates. All four participated in the field work. The graduate student and two undergraduates have completed some aspect of the work as a thesis.

**Outreach Activities:**

I regularly visit elementary school classrooms in Maine and correspond with students from the field, when possible. I was the key speaker at the Northern Maine Museum of Science 'Science Day' event. I gave interviews to two local television stations about my work in Antarctica and participated in the Orono Middle School Career Day. I also attended the weather-shortened Maryland Science Center 'Shackleton Event.' Nate Gardner, principal graduate student on this project, talked about his research at elementary schools in New Hampshire.

**Journal Publications**

B. Hall and C. Baroni, "Deglaciation of the Victoria Land Coast, Antarctica", AGU Abstract, Spring Meeting, p. x, vol. , (2002). Published

B. Hall, "Deglaciation of the Western Ross Sea: Part 1, the Southern Scott Coast", West Antarctic Ice Sheet Initiative Annual Meeting, p. x, vol. , (2001). Published

N. Gardner and B. Hall, "Deglaciation of the Western Ross Sea: Part 2, the Northern Scott Coast", West Antarctic Ice Sheet Initiative Annual Meeting, p. x, vol. , (2001). Published

Baroni, C., and Hall, B.L., "A new relative sea-level curve for Terra Nova Bay, Victoria Land, Antarctica", Journal of Quaternary Science, p. 377, vol. 19, (2004). Published

Hall, B., "Late Quaternary ice fluctuations in southern Victoria Land", INQUA Congress, p. 0, vol. , (2003). Published

Hall, B.L., Baroni, C., and Denton, G.H., "Holocene relative sea-level history of the southern Victoria Land coast, Antarctica", Global and Planetary Change, p. 241, vol. 42, (2004). Published

Staubwasser, M., Henderson, G.M., Berkman, P.A., and Hall, B.L., "Ba, Ra, Th, and U in marine mollusc shells and the potential of  $^{226}\text{Ra}/\text{Ba}$  dating of Holocene marine carbonate shells", Geochimica et Cosmochimica Acta, p. 89, vol. 68, (2003). Published

Hall, B.L., and Baroni, C., "Relative sea-level change and deglaciation of Terra Nova Bay, Antarctica", 9th Annual WAIS meeting, p. 0, vol. , (2002). Published

Hall, B.L., and Denton, G.H., "Holocene history of the Wilson Piedmont Glacier", The Holocene, p. 619, vol. 12, (2002). Published

Hall, BL, Baroni, C, "Holocene deglaciation of Terra Nova Bay", 10th Annual WAIS meeting, Sterling, VA, p. 0, vol. , (2003). Published

Hall, BL, Denton, GH, "Relative sea-level changes along the Scott Coast, Antarctica", ANTEC Meeting, Siena, Italy, p. 0, vol. , (2001). Published

Gardner, N., and Hall, B., "Pre-Holocene raised beaches at Cape Ross, Antarctica", Marine Geology, p. , vol. , (2004). submission this September

### **Books or Other One-time Publications**

#### **Web/Internet Site**

##### **URL(s):**

<http://gcmd.nasa.gov/getdif.htm?entry id=Northern Scott Coast Radiocarbon Data>

##### **Description:**

Metadata file in Antarctic Master Directory

### **Other Specific Products**

#### **Contributions**

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

Our findings have produced a relative sea-level curve that will be of use in determining the timing of deglaciation in the northern Ross Sea. This has wide implications for the history and future behavior of the West Antarctic Ice Sheet. Our discovery of pre-Holocene beaches also is an exciting development. It shows that undated raised beaches cannot be assumed to be Holocene in age and cannot be used to reconstruct Holocene marine limits.

This work has also led to avenues of future research, such as the history of elephant seal occupation which will lead to new insights into paleoclimate of the Ross Sea region, as well as genetic information concerning species divergence, mutation rates, and genetic diversity as species numbers decline. The pilot study with the corals has shown that we can accurately determine the marine radiocarbon reservoir effect through time, which will greatly improve the accuracy of our raised-beach data, as well as providing information on ocean ventilation rates and circulation.

**Contributions to Other Disciplines:**

Our new relative sea-level curve will be an important piece of data for global sea-level modellers, such as Dick Peltier. The widespread presence of elephant seals in the Ross Sea documented by our data is biogeographical and genetic interest and we are pursuing this currently. Penguin bones recovered in this study are the oldest ever found in the Ross Sea and have been of great interest to people studying penguin DNA evolution. Corals obtained during this work may provide information on paleoceanography.

**Contributions to Human Resource Development:**

This project has afforded three undergraduate students and one graduate student a chance to participate in a research project in the Antarctic. It has formed the basis for an M.S. thesis and two Capstone Projects. Data gathered in this project are used in GES 441 - Glacial Geology.

**Contributions to Resources for Research and Education:****Contributions Beyond Science and Engineering:**

Our work contributes to the West Antarctic Ice Sheet initiative, whose goal is to understand the behavior of the ice sheet so as to be able to educate the public and politicians about its potential effect on future sea-level rise.

**Categories for which nothing is reported:**

Any Book

Any Product

Contributions: To Any Resources for Research and Education