Glacial history of the NE Antarctic Peninsula over centennial to millennial timescales

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1. Rationale

- The northern Antarctic Peninsula region is an area of considerable uncertainty regarding LGM ice sheet dynamics, elevation and extent.
- Evidence from James Ross Island could provide important and detailed information regarding the interaction between the Mount Haddington Ice Cap and the Prince Gustav Ice Stream during the LGM and deglaciation.
- The onshore record is uncertain and chronostratigraphy is poor. There is a need for an independent dating programme.
- A terrestrial chronology of cosmogenic nuclide dates will provide estimates of ice sheet extent, timing of deglaciation, and rates of ice sheet thinning.
- We will obtain deglacial and Holocene chronologies for the eastern margin of the ice sheet, which is currently derived solely from marine geological data.

2. Aims

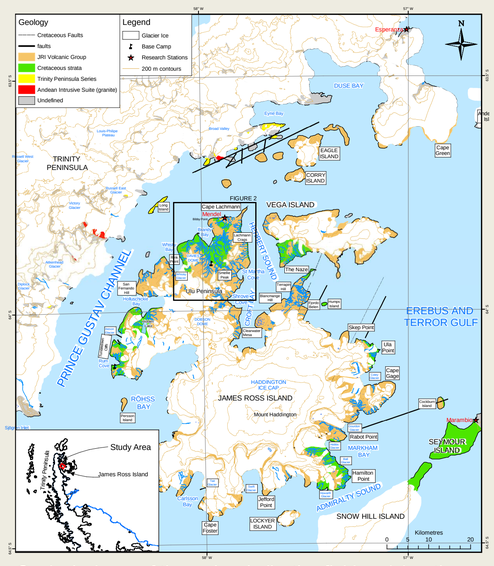
Aim: To reconstruct the glacial history of the NE Antarctic Peninsula over various timescales.

Research Objectives:

1. To determine the timing and style of post-LGM retreat along the eastern margin of the Antarctic Peninsula;
2. To examine the long-term response of tributary glaciers to ice-shelf collapse events;
3. To understand recent changes in Antarctic Peninsula ice shelves and tributary glaciers.

3. Study Area

- Our geographical focus is the Ulu Peninsula, James Ross Island, which has a well-preserved record of glacier fluctuations, but one that is largely unexploited.
- James Ross Island is composed of Cretaceous sedimentary strata, overlain by the Neogene James Ross Island Volcanic Group, which comprises basalt deltas, tuffs, and glacigenic diamictites.
- The Ulu Peninsula is largely ice-free, with several large glaciers draining Dobson Dome.
- Granite erratics from Trinity Peninsula are reported to be distributed across the island.



Geological map of the region, indicating field work location. Source regions of granite erratics are shown in red.

Basecamp by Monolith Lake. Lookalike Peaks and the large ice-cored moraines of Whisky Glacier are in the background.

Neogene tillites are well preserved on the island, and were redistributed as glacial erratics across the surface. Some of these tillites contain granite boulders, which could have been reworked by Quaternary glaciers.

Monolith Lake with San Jose Pass in the distance, looking towards Santa Martha Cove. Note the smoothed and sculpted slopes, across which are distributed rare granite erratics.

4. Methods

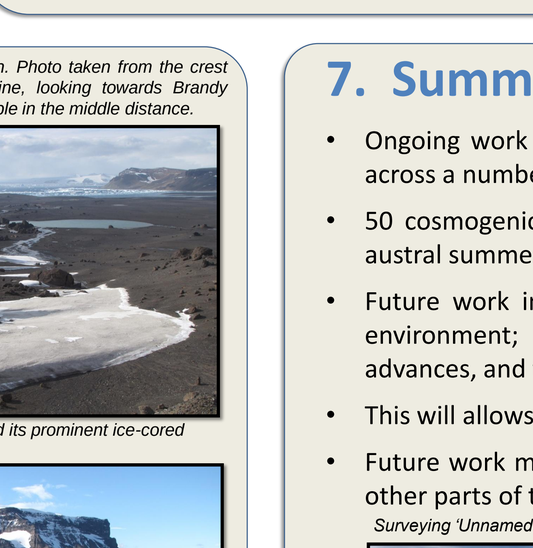
4.1 Field Methods

- 7-week onshore field campaign (January to March 2011) with one field camp at Monolith Lake, Ulu Peninsula, James Ross Island.
- 3 scientists: Neil Glasser, Jonathan Carrivick and Bethan Davies.
- Field techniques included geomorphological mapping, sedimentological analysis, logging of ice-cored facies, and sampling for cosmogenic nuclide dating.
- 50 basalt and granite rock samples were collected. Samples were taken from erratic boulders on moraine ridge crests or glacigenic surfaces.
- Sample preparation will be done in Autumn 2011 at SUERC, East Kilbride.

4.2 Remote-Sensing Methods

- Geomorphological and glaciological maps were created for the whole of the study region.
- Data sources: ASTER and SPOT-5 satellite imagery, BAS aerial photographs, and DEMs created by the SPIRIT programme and by the Czech Geological Survey.
- Identification of features followed standard procedures (Glasser et al, 2008; 2009).
- These maps were 'ground-checked' during the 2011 austral summer field season.

5. Initial Findings: Geomorphological Maps



Geomorphological map of the Ulu Peninsula, Brandy Bay region. Stars indicate location of cosmogenic nuclide samples. Yellow circles are granite boulders. Granite boulders are particularly common in coastal regions.

Note the hyaloclastite boulder train emanating from Whisky Glacier, and its relationship with the large moraine in Brandy Bay.

The small cirque glaciers have large terminal and lateral moraines that are ice-cored, with ice scars and perched lakes.

The basaltic rocks of the James Ross Island Volcanic Group weather to form a landscape of mesas (flat-topped table mountains) with steep cliffs surrounded by scree. Protalus rand pronival ramparts frequently form on these cliffs.

Initial findings indicate that the landsystem is composed of the following land elements:

1. Glacier ice and perennial snow
   a) Cirque glaciers;
   b) Dome/plateau glaciers;
   c) Valley glaciers;
2. Glacial landforms
   a) Smoothed and sculpted cols;
   b) Glacial drift, both with abundant Trinity Peninsula erratics and without;
   c) Ice-cored moraines;
   d) Hyaloclastite boulder trains;
   e) Ice-scoured bedrock;
3. Fluvial landforms;
4. Slope-related landforms
   a) Mesas;
   b) Cliffs;
   c) Scree;
5. Permafrost landforms
   a) Rock glaciers;
   b) Protalus/pronival ramparts;
   c) Perched lakes;
   d) Solifluction and patterned ground.

Blockfield on top of Lachman Mesa.

6. Cosmogenic Nuclide Dating

We have identified three groups of boulders:

Group 1

Trinity Peninsula granite boulders, that can be used to date the incursion of the Antarctic Peninsula Ice Sheet onto James Ross Island, the geometry of the ice sheet and its associated ice streams, and the chronology of deglaciation (red stars on the geomorphological map). The boulders fall into three categories:

- Boulders associated with glacial drifts containing high numbers of Trinity Peninsula erratics in coastal locations;
- Isolated granite boulders on basalt-rich lag surfaces on mesas;
- Isolated granite boulders on basalt lag surfaces on cols and passes in the interior of James Ross Island.

Group 2

Basalt and granite boulders on basalt-lag surfaces on the interior of James Ross Island, associated with mid-Holocene glacier advances (blue stars on the geomorphological map).

Group 3

Basalt boulders on sharp-crested ice-cored moraines on the interior of James Ross Island (green stars on the geomorphological map).

Using cosmogenic isotope dating on 40 of the mapped boulders, we will test **three key hypotheses:**

1. During the LGM, James Ross Island was inundated by a thicker Antarctic Peninsula Ice Sheet. During deglaciation, the Prince Gustav Ice Stream developed, resulting in pre-LGM age glacier erratics at high elevations on the interior of the island, and younger, deglaciation-age erratics in coastal regions.
2. There was a mid-Holocene readvance of Whisky Glacier, resulting in a large moraine flanking Brandy Bay.
3. There was a small readvance of cirque glaciers on the Ulu Peninsula during the Late Holocene, resulting in ice-cored moraines that are at least 200 years old.

Hyaloclastite boulder train. Photo taken from the crest of Whisky Glacier moraine, looking towards Brandy Bay. Monolith Lake is visible in the middle distance.

San José Glacier and its prominent ice-cored moraines.

Cosmogenic nuclide sampling a granite boulder on Cretaceous bedrock. Note the basalt erratics.

7. Summary and further work

- Ongoing work is investigating the glacial history of the NE Antarctic Peninsula across a number of timescales.
- 50 cosmogenic nuclide samples taken during fieldwork during the 2010-2011 austral summer.
- Future work includes the development of a land-system model in this polar environment; reconstruction of mid-Holocene and Late Holocene glacier advances, and the LGM deglacial history.
- This will allows Research Objectives #1 and #2 to be thoroughly addressed.
- Future work may involve a second field season to Terrapin Hill, Vega Island and other parts of the Peninsula.

Surveying 'Unnamed Glacier'

The team. From left: Bethan Davies, Alan Hill (FGA), Neil Glasser and Jonathan Carrivick.

8. Acknowledgements

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