Project: AFI 5/03

TIMING AND RATES OF ICE SHEET THINNING, ELLSWORTH MOUNTAINS: CONSTRAINTS ON WEST ANTARCTIC ICE SHEET DYNAMICS

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Location: Ellsworth Mountains, Weddell Sea embayment

Field Personnel: Dr Mike Bentley, Dr Chris Fogwill
BAS Field Assistants: Rob Smith, Tom Marshall

Aim and rationale:

The overall aim of the project is to establish the timing and rate of thinning of the West Antarctic Ice Sheet (WAIS) from its maximum extent in an area inland of the Weddell Sea embayment. The specific objectives are (a) to date geomorphological evidence of ice sheet thinning in the Ellsworth Mountains using *in situ* cosmogenic nuclides and (b) to infer WAIS dynamics (specifically grounding line and ice volume changes) in the Weddell Sea embayment through high-resolution glaciological modelling, constrained against the geomorphological record of elevation change through time. The importance of the project is that the past dynamics of the WAIS have implications for its future behaviour, and thus global sea level. The past history of the Weddell Sea sector of the WAIS is arguably the least well understood region.

Key questions to be addressed:

1. When did the WAIS start thinning in this sector following the LGM?
2. What was the rate of thinning?
3. Did the WAIS thin relatively early to a close-to-present configuration, or has it been thinning progressively from sometime after the LGM until the present day?
4. What was the timing of pre-LGM glacial expansion(s)?
5. Can we say anything about long-term landscape evolution of the Ellsworth Mountains?

Fieldwork objectives:

Our aim was to map and sample the glacial geomorphology of the Ellsworth Mountains, with a view to understanding the deglacial history. Throughout our emphasis was on taking samples that will allow us to date any changes in ice altitude/extent. We visited a series of sites in turn and at each one we carried out the following activities:

- geomorphological mapping – from satellite imagery and aerial photography, ground truthing, surveying and GPS traverses.
- sample erratics, bedrock and sediment from altitudinal transects: sampling consisted of hammer and chisel, petrol-powered rock saw (in a few instances), and pits dug into glacial sediments.

We worked along a c. 350 km transect, stretching from Pirrit Hills (81º06' S, 85º31' W) in the south, to the ridge between Mt Bentley and Mt Hubley in the north (78º09' S, 86º41' W). Most sites were on the western (West Antarctic Ice Sheet) side of the range but we also worked in the Flowers Hills (78º24' S, 84º31' W) on the east side of the range, adjacent to the Rutford Ice Stream. The sites we worked in included: Pirrit Hills; Flowers Hills; Patriot Hills; Independence Hills; Marble Hills ; Soholt Peaks ; Edson Hills; Epperly Spur; Long Gables;

Mt Hubley ridge. We also made a reconnaissance visit to Liberty Hills in the Heritage Range, and made less detailed observations on other, more limited areas, that we travelled close to along the transect.

Highlights:
We were deployed earlier than planned in mid-November and completed the 350 km transect by early January with little or no logistical hold-ups. This was helped by generally good weather, save for one week-long 'blow' at Patriot Hills. We were able to visit and sample all of our target sites, and in total were able to retrieve 200+ erratic and bedrock samples for cosmogenic isotope analysis, as well as several depth profiles of tills that we were able to excavate. The quality of the samples is excellent as the majority of the lithologies we sampled were quartz-rich sandstones and quartzites. Initial laboratory results have confirmed that these samples contain abundant material for analysis.

Our geomorphological mapping has revealed a much more complex landscape and glacial history than had been previously supposed. From the sediments, moraines and erosional landforms preserved in the Ellsworth Mountains we have now identified a series of ice sheet advances (thickening) and retreats (thinning). Our sampling programme for cosmogenic isotope analysis will allow us to date most, if not all, of these advances. From weathering criteria, and analogy to other Antarctic deposits we have worked on previously we estimate that the age of the preserved glacial deposits encompass the period from pre-Quaternary (e.g. > 2 million years old) to the last few hundred years. Our field season has allowed us to produce one of the most detailed geomorphological studies of any part of the West Antarctic Ice Sheet, as well as the most comprehensive coverage for cosmogenic isotope analysis.

A further highlight was the unexpected discovery of a complex series of blue-ice moraines in many parts of the Ellsworths – these record ice sheet fluctuations. The moraines are unusual features that have not previously been studied in great detail and we believe that in collaboration with glaciologists and ice sheet modellers, we may be able to use them to enhance our understanding of recent changes in the ice sheet.

Thanks to:
Our success was helped immeasurably by the support of our field assistants, Rob and Tom, who remained cheerful no matter how many times we said 'just one last sample'. We are also grateful to the Field Operations team who gave us first-class support in a logistically demanding area.

Field camp in the northern Sentinel Range, Ellsworth Mountains. Mt Vinson is visible in the background.

Chris Fogwill about to sample erratics from a till deposit, Heritage Range.