Geophysical Research Abstracts
Vol. 18, EGU2016-14616, 2016
EGU General Assembly 2016

First Younger Dryas moraines in Greenland

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Over the Greenland ice sheet the Younger Dryas (YD) cold climate oscillation (12.9-11.7 kaBP) began with up to 10°C drop in temperatures and ended with up to 12°C abrupt warming. In the light of the present warming and melting of the ice sheet, and its importance for future climate change, the ice sheet's response to these dramatic changes in the past is of great interest. However, even though much effort has gone into charting YD ice margin behaviour around Greenland in recent years, no clear-cut signal of response to the oscillation has been uncovered. Here we show evidence to suggest that three major outlets from a local ice cap at Greenland's north coast advanced and retreated synchronously during YD. The evidence comprises OSL (optically stimulated luminescence) dates from a marine transgression of the coastal valleys that preceded the advance, and exposure ages from boulders on the moraines, formed by glaciers that overrode the marine sediment. The OSL ages suggest a maximum age of 12.4 ±0.6 kaBP for the marine incursion, and 10 exposure ages on boulders from the three moraines provide an average minimum age of 12.5 ±0.7 kaBP for the moraines, implying that the moraines were formed within the interval 11.8-13.0 kaBP.

Elsewhere in Greenland evidence for readvance has been recorded in two areas. Most notably, in the East Greenland fjord zone outlet glaciers over a stretch of 800 km coast advanced through the fjords. In Scoresby Sund, where the moraines form a wide belt, an extensive 14C and exposure dating programme has shown that the readvance here probably culminated before YD, while cessation of moraine formation and rapid retreat from the moraine belt did not commence until c. 11.5 kaBP, but no moraines have so far been dated to YD. Readvance is also seen in Disko Bugt, the largest ice sheet outlet in West Greenland. However, here the advance and retreat of the ice stream took place in mid YD times, and lasted only a few hundred years, while YD in general was characterised by large scale, more than 200 km, retreat on the shelf. Therefore, although readvance and retreat occurred in both areas, the readvance was apparently not triggered by the initial YD cooling nor was the retreat caused by the abrupt warming at the end. At all other sites with a record that run through or into YD - Southeast Greenland, South Greenland, northern West Greenland - the ice margins were apparently retreating through YD, leaving the north coast as the only area with evidence for a climatically conditioned YD readvance/retreat.

The apparent mismatch between ice core temperatures and ice margin behaviour is generally seen as a function of reduced AMOC (Atlantic Meridional Overturning Circulation), inducing both higher seasonality with very cold winters and warm summers, and also occurrence of warm subsurface water to melt the ice sheet margin along some coasts. Therefore the ice margin response to the cold oscillation was to some extent determined by the nearness to the North Atlantic – with North Greenland being the farthest away. Although this may explain why glaciers advanced in North Greenland, while they melted in more southerly parts, it still leaves the question with a bearing on the future: why don't we see any ice margin response neither to the initial YD cooling, nor to the abrupt warming at the end?