Sedimentology, structual glaciology and isotope studies at Storglaciären

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Abstract
During August 2001, a multi-disciplinary study was undertaken at Storglaciären including sedimentological, structural glaciological and isotopic analysis techniques. These data were collected to address two key issues: 1) to elucidate the evolution of supraglacial ice-cored moraine features, or 'debris-charged ridges' in the terminal zone of the glacier, and 2) to determine the character of sediment-landform associations in the proglacial area.

Introduction

Recent research concerning the relationship between ice structure and debris distribution in High-Arctic polythermal glaciers has illustrated the importance of thrusting as a mechanism for elevating subglacial debris from the glacier bed (e.g. Hambrey and Huddart, 1995), and highlights the significance of folding in redistributing entrained supraglacial, glaciofluvial and basal glacial debris (Glasser and Hambrey, 2001). Since these studies are focused on polythermal glaciers at high latitudes, there is a need to establish the applicability of observed relationships to glaciers of similar thermal regime in other geographical settings. Since 1994, a number of small (1–2 m high) transverse debris-charged ridges have emerged in the terminal zone of Storglaciären, providing an excellent opportunity to test these relationships. The characterisation of sediment-landform associations at polythermal glacier margins contributes to a growing body of data important for palaeoenvironmental discrimination and accurate interpretation of the glacial geological record.

Methods

Structural glaciological and sediment facies distribution maps were produced for the glacier and proglacial area respectively using 1:30 000 scale stereo-pair aerial photographs and field mapping. Sediment facies were sampled for particle-size distribution, clast lithological, shape and roundness analyses. These were complimented by field measurement of three-dimensional clast fabric data and striation orientations. Structural measurements were made in the terminal zone of the glacier. Debris-charged ridges were washed to reveal the contact between the sediment and surrounding ice. Ice facies were described according to ice type and overall bubble and debris content (Hubbard and Sharp, 1995; Knight, 1994). Ice samples were collected using a 10 mm diameter ice screw, transferred immediately to sterile Polyethylene vials and transported to the Geophysical Isotope Laboratory of Copenhagen University for stable isotope analysis.

Remarks

The nature and evolution of debris-charged ridges near the glacier snout

Debris-charged ridges emerge from curvilinear fractures in the glacier terminal zone and contain bands of sediment-rich ice up to 0.4 m thick composed of sandy gravel and diamicton facies interpreted as glaciofluvial and basal glacial material respectively. Structural mapping demonstrates that these fractures cannot be traced up-glacier into pre-existing structures such as crevasses or crevasse traces, and are interpreted as new structural features formed near the glacier snout. Field observations show complex folding of glacier ice and associated sediment layers. The isotopic composition ($\delta^{18}O$) of coarse-clear and coarse-bubbly glacier ice facies is similar to that of debris-rich interstitial ice that forms the ridges, implying that none of these facies have undergone isotopic fractionation by the incomplete freezing of available water. The precise mechanism responsible for the formation of the new fractures is unclear, but their morphology and distribution indicates an origin by compressional tectonics near the snout, either at the thermal boundary where active glacier ice is being thrust over stagnant ice, or as a result of large-scale folding in the glacier. Material elevated in this way was probably originally entrained by regelation into the bed, however questions remain as to why there is no significant isotopic fractionation. Further work is therefore required to elucidate the role of each of these mechanisms in elevating basal materials to the ice surface.

Sediment-landform associations in the proglacial area

Mapping and laboratory analysis of ice-marginal facies at Storglaciären reveals six lithofacies and seven sediment-landform associations. Sandy gravel, silty gravel, massive sand and silty sand facies are interpreted as glaciofluvial in origin. A widely distributed pervasively deformed to massive clast-rich sandy diamicton is interpreted as the product of a deformed basal till sheet and shares characteristics with modern till sampled from the glacier bed. Given the relatively widespread distribution of this facies, it is possible that the areal extent of cold-based ice at Storglaciären during the Little Ice Age was similar to that of present day (at approximately 16%; Holmlund *et. al*, 1996), with only a restricted area around the glacier snout. Massive block gravels, comprising two distinctive moraine ridges are thought to reflect supraglacial sedimentation and ice marginal and subglacial reworking of heterogeneous proglacial sediments during the Little Ice Age. Estimates of the relative abundance of these facies suggests that sandy gravels and diamicton are of most volumetric importance, similar to observations made at the margins of polythermal glaciers in Svalbard (e.g. Huddart and Hambrey, 1996). Full results of the sedimentology, structural glaciology and isotope studies will be published in two separate papers in Geografiska Annaler: Series A.

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