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Quantifying strain beneath glaciers: fabric analyses at macro and micro-scales

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There has been much discussion in recent years regarding the role and significance of subglacial deformation in the dynamics of contemporary and former ice masses. It has been proposed that the presence of deformable substrates beneath an ice mass exerts fundamental controls over ice dynamics, and may have a critical influence over the stability of ice masses. However, to unravel the clearly complex relationship between ice dynamics and subglacial deformation, an effective means of assessing the magnitude of deformation from field evidence is required.

Particle arrangement (fabric) in sediments is thought to provide evidence of the physical conditions operating at the time of deposition, and has been traditionally considered in glacial sediments to yield information regarding former ice-flow directions and processes of till deposition/deformation, and indications of consequent glacier dynamics. Developments have focused on the application of statistical methods (vector and eigenvector analysis) to develop envelopes of characteristic fabric characteristics as the basis for interpretation. However, the value of traditional vector based approaches for reconstruction of subglacial stress patterns has been questioned in recent years, as a consequence of the ambiguity of fabric shape 'envelopes' indicating specific subglacial conditions.

This study reports the findings from a range of field-based experiments that have investigated the fundamental processes by which subglacial fabrics develop. Studies at macro- and micro-scales of tills recently exposed at two sites in Iceland are used to

develop a model by which patterns of particle orientation as a function of particle size reflect the magnitude and duration of sediment strain during subglacial deformation. We demonstrate that it is possible to identify the relative strain history of subglacial tills from different locations, and identify the presence of accreting till bodies and zones of net erosion of the deforming bed. This model is applied to a multiple till sequence in Central Scotland, to identify three distinctly different glacial dynamics regimes during the last glacial cycle, and to illustrate how such data may be applied to understanding the dynamics of past glaciation.