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3D microfabric analysis of progressive, polyphase subglacial deformation beneath the late Weichselian Baltic Ice Stream (Scandinavian Ice Sheet, Europe)

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We present the results of a detailed micro- and macrostructural study on the Late Pleistocene subglacial tills exposed in the sea cliffs at Jasmund on the Island of Rügen, northern Germany. These deposits form part of a major thrust and fold complex which developed as a result of glaciotectonism associated with the highly dynamic Baltic Ice Stream; the latter drained the Scandinavian Ice Sheet during the last glaciation in northern Europe. The island of Rügen is located on the southwestern Baltic Sea coast and was situated at the southern marginal zone of the Scandinavian Ice Sheet during the late Weichselian. Sediment-landform associations and flow-direction criteria derived from a variety of glacial deposits have been used to reconstruct successive glacial advances and retreats of this highly dynamic ice sheet across the Island of Rügen.

The microfabrics developed within the tills laid down by the Scandinavian Ice Sheet have been studied by means of a three-dimensional analysis based on the microstructural mapping methodology [1], enabling the identification and interpretation of the successive generations of fabrics in terms of a progressive, polyphase deformation history. The data sets derived from three perpendicularly oriented thin sections taken from 10 block samples, were used to construct detailed 3D models of the planar and linear microfabrics developed within the tills. The cross-cutting patterns of the microstructural domains which define these fabrics have been used to reconstruct a temporal succession of deformation events which occurred in response to ductile shearing imposed by the overriding ice. Three successive generations of microfabric have been identified: S1 (oldest) is a heterogeneously developed, up-ice-dipping, planar foliation (S fabric); whereas S2 is represented by a locally well-developed, down-ice-dipping linear fabric (L fabric); and S3 (youngest) is an anastomosing, variably developed subvertical fabric which probably formed as a result of the dewatering of the till during final stages of the shear event and the “locking” of the subglacial shear zone.

Shear-sense indicators, including asymmetrical S-C fabrics and C′-type shear bands, present within the tills are used to reconstruct the direction of ice flow responsible for subglacial deformation. This evidence, coupled with the orientation and relative age relationships displayed between the microfabrics have enabled the construction of a detailed 3D model of subglacial deformation beneath the Baltic Ice Stream. This progressive, ductile shearing event records a changing pattern of polyphase deformation which can be directly related to changes in the regional ice-flow direction across the Island of Rügen.

References:

[1] Phillips E et al. (2011) Quaternary Science Reviews 30: 2570-2596