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Magnetic fabrics in basal ice as an indicator of the dynamics of a surge-type glacier

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In many glaciers, a debris rich basal ice zone lies between the bulk of the glacier ice and the bed. This basal ice zone is strongly affected by the motion of the glacier and its interaction with the bed. Anisotropy of magnetic susceptibility (AMS) has been shown to provide specific useful information regarding the kinematics of deformation within subglacially deformed sediments. In this study, we present the first (to our knowledge) AMS study from basal ice to investigate deformation within a glacier.

Basal ice samples, field descriptions and structural measurements were collected from north-eastern and south-western exposures at the tidewater margin of Tunabreen, a surging glacier in Svalbard. Thermomagnetic, low temperature susceptibility, varying field susceptibly and IRM acquisition reveal that the debris-rich basal ice samples have a mineralogy dominated by paramagnetic phases within the detrital sediment. AMS data reveal that the magnetic lineations (k1) are aligned parallel or sub-parallel to the flow direction seen from aerial photographs and parallel to the direction of extension and shear revealed from structural observations at the ice outcrop (folds, lineations, macrofabric). The magnetic foliation, given by the K1/K2 plane, dips gently up glacier, generally parallel to visible foliations within the ice.

We hypothesise that as the glacier flowed, simple shear affected the basal ice causing stretching and extension. As such, detrital minerals in the spaces between ice crystals rotated into a preferred alignment during progressive deformation associated with the surge and flow of the glacier. On the north-western section, the imbrications of magnetic lineations away from the glacier margins suggest that, as well as longitudinal extension, there is a component of lateral shear. In contrast, at the south-eastern margin, the divergence of the magnetic lineation away from flow reveals lateral spreading and counter-clockwise rotation due to interactions between the advancing surge front and the irregular calving margin of the neighbouring glacier. The results suggest that AMS can be used as a petrofabric indicator within basal glacier ice and subsequently could be a useful new tool for investigations of glacier deformation and interactions with the bed.