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Dynamic behaviour of ice streams: the North East Greenland Ice Stream

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The flow of ice towards the margins of ice sheets is far from homogeneous. Ice streams show much higher flow velocities than their surroundings and may extend, for example the North East Greenland Ice Stream (NEGIS), towards the centre of the sheet. The elevated flow velocity inside an ice stream causes marginal shearing and convergent flow, which in turn leads to folding of ice layers. Such folding was documented in the Petermann Glacier in northern Greenland (Bons et al., 2016).

3-dimensional structural modelling using radargrams shows that folding is more intense adjacent to NEGIS than inside it, despite the strong flow perturbation at NEGIS. Analysis of fold amplitude as a function of stratigraphic level indicates that folding adjacent to NEGIS ceased in the early Holocene, while it is currently active inside NEGIS.

The presence of folds adjacent of NEGIS, but also at other sites far in the interior of the Greenland Ice Sheet with no direct connection to the present-day surface velocity field, indicates that ice flow is not only heterogeneous in space (as the present-day flow velocity field shows), but also in time. The observations suggest that ice streams are dynamic, ephemeral structures that emerge and die out, and may possibly shift during their existence, but leave traces within the stratigraphic layering of the ice.

The dynamic nature of ice streams such as NEGIS speaks against deterministic models for their accelerated flow rates, such as bedrock topography or thermal perturbations at their base. Instead, we suggest that ice streams can also result from strain localisation induced inside the ice sheet by the complex coupling of rheology, anisotropy, grain-size changes and possibly shear heating.

Bons, P.D., Jansen, D., Mundel, F., Bauer, C.C., Binder, T., Eisen, O., Jessell, M.W., Llorens, M.-G, Steinbach, F., Steinhage, D. & Weikusat, I. 2016. Converging flow and anisotropy cause large-scale folding in Greenland's ice sheet. Nature Communications 7:11427, DOI: 10.1038/ncomms11427.