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Using centrifuge modelling to investigate glacier crevassing

Brice Rea (1), Andrew Brennan (2), and Doug Benn (3)

(1) University of Aberdeen, School of Geosciences, Aberdeen, United Kingdom (b.rea@abdn.ac.uk), (2) Division of Civil Engineering, University of Dundee, UK, (3) The University Centre in Svalbard (UNIS), P.O. Box 156 N-9171, Longyearbyen, Svalbard.

Realisation of the importance of calving margins and supraglacial meltwater routing to the bed of glaciers and ice sheets has raised interest in crevassing processes. Advances have been made in, theoretical treatments of crevasse formation and propagation, the development of physically-based calving models with subsequent implementation in ice sheet/glacier flow models utilising a number of different approaches. To-date only one study has tested crevassing propagation theory against empirical data and this dealt only with shallow water-free crevasses. There is a need for more such studies where where key parameters are well constrained, for example crevasse water depths, crevasse depth, stress/strain regime, temperature. The challenges for a field-based study are great due in part to the difficulty in determining crevasse and water depths and with the general working environment in which crevasses generally form. An alternative solution is to utilise physical modelling and here we report on the preliminary stages of such a project using a geotechnical beam centrifuge. The centrifuge creates real-world (prototype) stress conditions in scaled models, by testing in an enhanced 'gravity' field, and is ideal for problems governed by self-weight stresses. Scaling factors, for model to prototype, have to be confirmed. Following the Linear Elastic Fracture Mechanics (LEFM) approach crevasses propagate instantaneously when KI, (the stress intensity at the crack tip) exceeds KIC (the fracture toughness). KI is determined from the sum of three stress intensity factors (SIF): KI-1 a positive tensile stress resulting from the resistive stress, KI-2 the lithostatic stress which is negative (compressive) and for a water holding crevasse, KI-3 the hydrostatic stress which is positive. Experiments start with a pre-cast crevasse and as the models are constructed at 1g the elastic strain developed as the centrifuge spins up to 100g provides KI-1 which (due to lateral confinement) is directed perpendicular to the pre-cast crevasse. SIF scaling relationships should be KIp = KIm. (where p is prototype and m is model) but this has to be confirmed for ice fracturing.