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Issues with fracturing ice during an ice drilling project in Greenland (EastGRIP)

Ilka Weikusat[1,2], David Wallis[3], Steven Franke[1], Nicolas Stoll[1], Julien Westhoff[4], Steffen Bo Hansen[4], Trevor James Popp[4], Frank Wilhelms[1], and Dorthe Dahl-Jensen[4,5]
[1]Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Glaciology, Bremerhaven, Germany (ilka.weikusat@awi.de)
[2]Department of Geosciences, Tübingen University, Germany
[3]Department of Earth Sciences, Utrecht University, The Netherlands
[4]Department of Physics of Ice, Climate, and Earth, Niels Bohr Institute, University of Copenhagen, Denmark
[5]Centre for Earth Observation Science, University of Manitoba, Winnipeg, Canada

Drilling an ice core through an ice sheet (typically 2000 to 3000 m thick) is a technical challenge that nonetheless generates valuable and unique information on palaeo-climate and ice dynamics. As technically the drilling cannot be done in one run, the core has to be fractured approximately every 3 m to retrieve core sections from the bore hole. This fracture process is initiated by breaking the core with core-catchers which also clamp the engaged core in the drill head while the whole drill is then pulled up with the winch motor.

This standard procedure is known to become difficult and requires extremely high pulling forces (Wilhelms et al. 2007), in the very deep part of the drill procedure, close to the bedrock of the ice sheet, especially when the ice material becomes warm (approximately -2°C) due to the geothermal heat released from the bedrock. Recently, during the EastGRIP (East Greenland Ice coring Project) drilling we observed a similar issue with breaking off cored sections only with extremely high pulling forces, but started from approximately 1800 m of depth, where the temperature is still very cold (approximately -20°C). This has not been observed at other ice drilling sites. As dependencies of fracture behaviour on crystal orientation and grain size are known (Schulson & Duval 2009) for ice, we thus examined the microstructure in the ice samples close to and at the core breaks.

First preliminary results suggest that these so far unexperienced difficulties are due to the profoundly different c-axes orientation distribution (CPO) in the EastGRIP ice core. In contrast to other deep ice cores which have been drilled on ice domes or ice divides, EastGRIP is located in an ice stream. This location means that the deformation geometry (kinematics) is completely different, resulting in a different CPO (girdle pattern instead of single maximum pattern). Evidence regarding additional grain-size dependence will hopefully help to refine the fracturing procedure,

which is possible due to a rather strong grain size layering observed in natural ice formed by snow precipitation.

Wilhelms, F.; Sheldon, S. G.; Hamann, I. & Kipfstuhl, S. Implications for and findings from deep ice core drillings - An example: The ultimate tensile strength of ice at high strain rates. Physics and Chemistry of Ice (The proceedings of the International Conference on the Physics and Chemistry of Ice held at Bremerhaven, Germany on 23-28 July 2006), **2007**, 635-639

Schulson, E. M. & Duval, P. Creep and Fracture of Ice. Cambridge University Press, **2009**, 401