Geophysical Research Abstracts
Vol. 19, EGU2017-15503, 2017
EGU General Assembly 2017

Microshear in the deep EDML ice core analyzed using cryogenic EBSD

Ernst-Jan Kuiper (1,2), Gill Pennock (1), Martyn Drury (1), Sepp Kipfstuhl (2), Sérgio Faria (3,4), and Ilka Weikusat (2)

(1) Faculty of Earth Science, Utrecht University, Postbus 80021, 3508 TA Utrecht, Netherlands, (2) Alfred Wegener Institute for polar and Marine Research, Am Alten Hafen 26, 27568 Bremerhaven, Germany, (3) BC3-Basque centre for Climate Change, Ikerbasque, Bilbao, Spain, (4) NUT-Nagaoka University of Technology Nagaoka, Niigata, Japan

Ice sheets play an important role in sea level evolution by storing large amounts of fresh water on land. The ice in an ice sheet flows from the interior of the ice sheet to the edges where it either melts or calves into the ocean. This flow of ice results from internal deformation of the ice aggregate. Dislocation creep is assumed to be the dominant deformation mechanism for polar ice and is grain size insensitive. Recently, a different deformation mechanism was identified in the deeper part of the EDML ice core (Antarctica) where, at a depth of 2385 meters, the grain size strongly decreases, the grain aspect ratio increase and, the inclination of the grain elongation changes (Faria et al., 2006; Weikusat et al., 2017). At this depth the borehole displacement increases strongly (Weikusat et al., 2017), which indicates a relatively high strain rate.

Part of this EDML ice core section was studied using cryogenic electron backscattered diffraction (cryo-EBSD) (Weikusat et al, 2011). EBSD produces high resolution, full crystallographic (a-axis and c-axis) maps of the ice core samples. EBSD samples were taken from an ice core section at 2392.2 meter depth. This section was chosen for its very small grain size and the strongly aligned grain boundaries.

The EBSD maps show a very low orientation gradient of <0.3° per millimetre inside the grains, which is 5-10 times lower than the orientation gradients found in other parts of the ice core. Furthermore, close to some grain boundaries, a relatively strong orientation gradient of 1°-2° per millimetre was found. The subgrain boundaries developed such that they elongate the sliding boundaries in order to accommodate the incompatibilities and maintain the strongly aligned grain boundary network. We identify the dominant deformation mechanism in this part of the ice core as grain boundary sliding accommodated by localized dislocation creep, which is a process similar to microshear (Drury and Humpreys, 1988). The existence of layers of soft ice has serious implications for ice core dating, related paleoclimate studies and ice flow modelling with respect to ice sheet mass balance and sea level predictions.

References:

- Drury and Humphreys, 1988. Microstructural shear criteria associated with grain boundary sliding during ductile deformation. J. of Struc. Geol. 10, 1, 83-89.
- Faria et al., 2006. Is Antarctica like a birthday cake?, Max Planck Institute of Mathematics and the Sciences
- Weikusat et al., 2011. Cryogenic EBSD on ice: preserving a stable surface in a low pressure SEM. J. Micros. 242, 3, 295-310. (doi: 10.1111/j.1365-2818.2010.03471.x)
- Weikusat et al., 2017. Physical analysis of an Antarctic ice core-towards an integration of micro- and macrodynamics of polar ice. Phil. Trans. R. Soc. A 375, 2015347. (doi:10.1098/rsta.2015.0347)