Identifying deformation mechanisms in the EDML ice core using EBSD measurements

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Deformation of ice in continental sized ice sheets determines the flow behavior of ice towards the sea. Basal dislocation glide is assumed to be the dominant deformation mechanism in the creep deformation of natural ice, but non-basal glide is active as well. Knowledge of what types of deformation mechanisms are active in polar ice is critical in predicting the response of ice sheets in future warmer climates and its contribution to sea level rise, because the activity of deformation mechanisms depends critically on deformation conditions (such as temperature) as well as on the material properties (such as grain size).

One of the methods used to study the deformation mechanisms in natural materials is electron backscattered diffraction (EBSD).We obtained ca. 200 EBSD maps of nine different depths from a Greenlandic ice core (NEEM) and an Antarctic ice core (EDML). The step size varied between 8 and 25 µm depending on the size of the deformation features. The size of the maps varied from 2000 to 20000 grid points. Indexing rates were up to 95%, partially by saving and reanalyzing the EBSP patterns.

With EBSD we characterize subgrain boundaries and determine the lattice rotation configurations of each individual subgrain. Combining these observations with arrangement/geometry of subgrain boundaries the dislocation types can be determined, which form these boundaries. Three main types of subgrain boundaries have been recognized in the EDML ice core[1,2].

Here, we present more results obtained from EBSD measurements performed on the EDML ice core samples from the last glacial period, focusing on the relevance of dislocation activity of the possible slip systems. We also compare the EBSD maps of the EDML ice core to the EBSD maps of the NEEM ice core.

Preliminary results show that all three subgrain types, recognized in the NEEM ice core, occur in the EDML samples. In addition to the classical boundaries made up of basal dislocations, subgrain boundaries made of non-basal dislocations are also common.

[1] Weikusat, I.; de Winter, D. A. M.; Pennock, G. M.; Hayles, M.; Schneijdenberg, C. T. W. M. Drury, M. R. Cryogenic EBSD on ice: preserving a stable surface in a low pressure SEM. J. Microsc., 2010, doi: 10.1111/j.1365-2818.2010.03471.x

[2] Weikusat, I.; Miyamoto, A.; Faria, S. H.; Kipfstuhl, S.; Azuma, N.; Hondoh. T. Subgrain boundaries in Antarctic ice quantified by X-ray Laue diffraction. J. of Glaciol., 2011, 57, 85-94