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Properties of grain boundary networks in the NEEM ice core analyzed by combined transmission and reflection optical microscopy

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Microstructure analysis of ice cores is vital to understand the processes controlling the flow of ice on the microscale. To quantify the microstructural variability (and thus occurring processes) on centimeter, meter and kilometer scale along deep polar ice cores, a large number of sections has to be analyzed. In the last decade, two different methods have been applied: On the one hand, transmission optical microscopy of thin sections between crossed polarizers yields information on the distribution of crystal c-axes. On the other hand, reflection optical microscopy of polished and controlled sublimated section surfaces allows to characterize the high resolution properties of a single grain boundary, e.g. its length, shape or curvature (further developed by [1]).

Along the entire NEEM ice core (North-West Greenland, 2537 m length) drilled in 2008-2011 we applied both methods to the same set of vertical sections. The data set comprises series of six consecutive 6 x 9 cm2 sections in steps of 20 m – in total about 800 images. A dedicated method for automatic processing and matching both image types has recently been developed [2]. The high resolution properties of the grain boundary network are analyzed. Furthermore, the automatic assignment of c-axis misorientations to visible sublimation grooves enables us to quantify the degree of similarity between the microstructure revealed by both analysis techniques. The reliability to extract grain boundaries from both image types as well as the appearance of sublimation groove patterns exhibiting low misorientations is investigated.

X-ray Laue diffraction measurements (yielding full crystallographic orientation) have validated the sensitivity of the surface sublimation method for sub-grain boundaries [3]. We introduce an approach for automatic extraction of sub-grain structures from sublimation grooves. A systematic analysis of sub-grain boundary densities indicates a possible influence of high impurity contents (amongst others visible in ice-penetrating radar measurements) on the generation of sub-grain boundaries.

[1] S. Kipfstuhl et al., 2006, Journal of Glaciology, 52, 398-406
[2] T. Binder et al., 2013, Journal of Microscopy, 250, 130-141
[3] I. Weikusat et al., 2011, Journal of Glaciology, 57, 111-120