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Properties of grain boundary networks in the NEEM ice core

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The microstructure along the entire NEEM ice core (North-West Greenland, 2537 m length) drilled in 2008-2011 has been analyzed based on a large data set of sublimation groove images. The sublimated surface of vertical section series (six consecutive 6 x 9 cm2 sections in steps of 20 m – in total about 800 images) have been scanned by a Large Area Scanning Macroscope. In these cross-section images 10-15 μm wide grain boundary grooves and air bubbles appear dark, whereas the inside of grains appears gray (further developed by [1]).

A dedicated method of automatic image analysis has recently been developed to extract and parameterize the grain boundary networks of this set [2]. In contrast to the microstructure obtained from thin sections between crossed polarizers in transmitted light, sublimation groove images in reflected light allow to include small grains (equivalent radius of 65 μm) in the size distribution. It has become possible to extract continuous curvature values of grain boundaries, an estimate of the lower bound of the stored strain energy and the dislocation density. In this contribution we give an overview on profiles of different calculated parameters related to deformation and recrystallization mechanisms.

In older glaciological studies the value of the lower cut-off for grain sizes considered for calculation of a mean grain size has been arbitrary. We suggest to compare different definitions of the lower cut-off in the size. With respect to the important question which processes are dominating the grain size evolution in the late- to middle-Holocene, high sensitivity to the definition of this cut-off has been found [3].

Between 250 m and 1000 m depth the curvature of grain boundaries steadily increases and grains become more irregularly shaped which correlates with increasing pressure of air bubbles. In the NEEM ice core the depth of the transition from air bubbles to clathrate hydrates clearly can be separated from the depth where the transition from Holocene to the last glacial takes place. In this way, we found that the shape of grains is highly influenced by air bubbles, whereas the size of the grains is more sensitive to climatic transitions.

[1] S. Kipfstuhl et al., 2006, Journal of Glaciology, 52, 398-406
[2] T. Binder et al., 2013, Journal of Microscopy, in review
[3] T. Binder et al., 2013, Proceedings, 5th International Conference on Recrystallization and Grain Growth, in press