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Recrystallization dynamics derived from grain boundary networks

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The evolution of the microstructure in polar ice sheets is believed to follow a three-stage model. In this model, normal grain growth is the exclusive driving force of glacial microstructure in the upper part of ice sheets. Polygonization, the process of grain splitting, counterbalances this normal grain growth. In the deepest layers, where temperature is high enough, dynamic recrystallization effects also occur. Recently, it has been shown that this model is an oversimplification [1].

In our contribution we introduce a new image processing framework developed to automatically extract the complete grain boundary network. From the grain boundary network parameters are derived by advanced digital image processing techniques to characterize the predominant recrystallization mode in an ice core section. Besides the grain area the basic element of our analysis is a single grain boundary, its geometric properties and shape.

Images of the grain boundaries on polished ice core sections taken in microscopic resolution enable us to characterize the properties of a single boundary, e.g. its length, curvature, shape or the dihedral angles at triple junctions. Using this and further information about the presence of subgrain boundaries we try to derive the direction a grain boundary migrates and decide whether its migration is surface tension driven or by the gradient in stored strain energy. From the curvature of a grain boundary we try to estimate the dislocation density, its distribution within a section and a mean dislocation density.

Furthermore, our approach includes the standard analysis of the grain size. For each grain the grain area and parameters describing its shape are determined. Of special interest are the small grains generally neglected. The small and smallest grains indicate the nucleation and formation of new grains if they can be identified with high confidence. Together with subgrain boundaries or irregularly shaped grain boundaries they are primary evidence of dynamic recrystallization. Because the grain boundaries are imaged directly the smallest grain sizes are in principle only limited by the width of a grain boundary. Our method provides firm data about the small grains which are now included in the grain size distribution. The behavior of the grain size distribution characterizes independently the recrystallization regime. In our poster first results are presented and discussed.

[1] Faria et al., 2009, Multiscale Structure of Antarctica Part I: Inland Ice, Physics of Ice Core Records, Vol. 2, Kyoto