Microdynamical simulations of polyphase deformation and recrystallisation processes in polar ice and firn

F. Steinbach (1), I. Weikusat (1,2), P.D. Bons (1), A. Griera (3), M.G. Llorens (1), J. Roessiger (1)

(1) Department of Geosciences, Eberhard Karls University of Tübingen, Germany,
(2) Alfred-Wegener-Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany.
(3) Departament de Geologia, Universitat Autònoma de Barcelona, Spain.
(florian.steinbach@uni-tuebingen.de / Phone: +49-7071-2973150)

The Antarctic and Greenland ice sheets store a significant amount of air within their upper, approximately thousand meters. Research shows how the presence of air inclusions can influence the microdynamical processes that affect the flow of ice (Azuma et al., 2012, Roessiger et al., 2014). The microdynamics of pure ice were successfully modelled by e.g. Montagnat et al. (2014) or Llorens et al. (2015), but studies taking into account second phases are scarce. Therefore, polyphase modelling was performed to focus on the implications of bubbles on recrystallisation and deformation.

The full-field theory crystal plasticity code (FFT) of Lebensohn (2001), was coupled to the 2D multi-process modelling platform Elle (Bons et al., 2008), following the approach by Griera et al. (2013). FFT calculates the viscoplastic response of polycrystalline materials deforming by dislocation glide, taking into account mechanical anisotropy. Our models further incorporate surface- and strain-energy driven grain boundary migration and intracrystalline recovery. Sequential operation of each process for small time steps enables multi-process modelling of deformation and concurrent recrystallisation.

Results show that air inclusions lead to increased strain localization and hence locally enhanced dynamic recrystallisation. This is in accordance with Faria et al. (2014), who theoretically predicted such localization, based on firn data from the EPICA Dronning Maud Land (EDML) deep ice core. Our results confirm that strain-induced grain boundary migration already occurs in the uppermost levels of ice sheets, as observed by Kipfstuhl et al. (2009) and Weikusat et al. (2009) in the EDML core.

References

Azuma, N., et al. (2012) Journal of Structural Geology, 42, 184-193

Bons, P.D., et al. (2008) Lecture Notes in Earth Sciences, 106

Faria, S.H., et al. (2014) Journal of Structural Geology, 61, 21-49

Griera, A., et al. (2013) Tectonophysics, 587, 4-29

Kipfstuhl, S., et al. (2009) Journal of Geophysical Research, 114, B05204

Lebensohn, R.A. (2001) Acta Materialia, 49, 2723-2737

Llorens, M.G., et al. (2015) submitted to Journal of Glaciology

Montagnat, M., et al. (2014) Journal of Structural Geology, 61, 78-108

Roessiger, J., et al. (2014) Journal of Structural Geology, 61, 123-132

Weikusat, I., et al. (2009) Journal of Glaciology, 55, 461-472