Micro-Dynamics of Ice

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By the common definitions of a mineral and a rock, ice is both a mineral and a rock. Contrary to common silicate and carbonate minerals, ice is close to its melting temperature under natural conditions, and can therefore deform by ductile flow at the Earth's surface. Mountain glaciers and polar ice sheets flow at rates that are observable on human time scales, orders of magnitude faster than usually assumed for other rocks. Ice, therefore, provides a unique opportunity to observe and study rock deformation "live".

Ice has many faces, from snowflakes to icebergs, from brittle cracking in crevasses to ductile flow in glaciers and ice sheets. Ice on Earth has a direct impact on human society and is also strongly influenced itself by human activity, from avalanches caused by a careless skier to melting of polar ice sheets that may raise the sea level. With global warming potentially looming, it is of paramount importance to understand how ice behaves and would react to changes in conditions. Furthermore, the polar ice sheets contain a unique climate record, which is now accessed through deep drilling projects that reach layers of ice that are hundreds of thousands of years old.

Microstructure, the arrangement of grains, grain boundaries and any other entities that make up a rock, is important in two ways. First, it controls mechanical properties of rocks. Secondly, its study allows us to deduct the history of the rock, and by induction the processes that took place and boundary conditions acting on the rock. In recognition of this, the European Science Foundation Research Network Programme "Micro-Dynamics of Ice" (Micro-DICE) has encouraged research on microstructures in ice, from snow to ice sheets. This Special Issue contains a collection of papers resulting from a Micro-DICE Workshop on Numerical Modelling of Ice and Other Minerals, held at the School of Geographical and Earth Sciences at the University of Glasgow, UK, in 2011. We thank the Journal of Structural Geology for the invitation to publish these papers in its journal, which will hopefully bridge the growing gap between structural geologists and glaciologists.

The Special Issue starts with a historical overview of the study of ice cores (Faria et al., 2013a) and a review of the state of the art on polar ice microstructure research (Faria et al., 2013b). The review of Wilson et al. (2013) focuses on ice microstructure and fabric evolution and the analogies between ice and other minerals, in particular quartz. Montagnat et al. (2013) review the many numerical approaches employed to simulate ice, from the atomic scale up to the scale of polar ice sheets. This review highlights the importance of the mechanical anisotropy of ice and the challenges this poses to modellers.

The above review papers are followed by three topical papers. Roessiger et al. (2013) modelled the influence of bubbles on grain growth, a study that also has implications on grain growth in two-phase rocks in general.

Peternell et al. (2013) describe a new method to quantify microstructural evolution and apply this to in-situ experiments on ice. Finally, Koehn and Sachau (2013) model shear localization and crevasse development in glacier fronts; a reminder that ice at the Earth's surface is both a ductile and brittle material.

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