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# Microstructural analysis of the thermal annealing of ice-Ih using EBSD

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Rocks deformed in the middle crust and deeper in the Earth typically remain at high temperature for extended time spans after the cessation of deformation. This results in annealing of the deformation microstructure by a series of thermally activated, diffusion-based processes, namely: recovery and static recrystallization, which may also modify the crystal preferred orientation (CPO) or texture. Understanding the effects of annealing on the microstructure and CPO is therefore of utmost importance for the interpretation of the microstructures and for the estimation of the anisotropy of physical properties of lower crustal and mantle rocks. Ice-Ih –the typical form of water ice on the Earth's surface, with hexagonal crystal symmetry– deforms essentially by glide of dislocations on the basal plane [1], thus it has high viscoplastic anisotropy, which induces strong heterogeneity of stresses and strains at both the intra- and intergranular scales [2-3]. This behavior makes ice-Ih an excellent analog material for silicate minerals that compose the Earth.

In situ observations of the evolution of the microstructures and CPO during annealing enable the study of the interplay between the various physical processes involved in annealing (recovery, nucleation, grain growth). They also allow the analysis of the impact of the preexisting deformation microstructures on the microstructural and CPO evolution during annealing. Here we studied the evolution of the microstructure of ice-Ih during static recrystallization by stepwise annealing experiments. We alternated thermal annealing and electron backscatter diffraction (EBSD) analyses on polycrystalline columnar ice-Ih pre-deformed in uniaxial compression at temperature of -7 °C to strains of 3.0-5.2. Annealing experiments were carried out at -5 °C and -2 °C up to a maximum of 3.25 days, typically in 5-6 steps. EBSD crystal orientation maps obtained after each annealing step permit the description of microstructural changes. Decrease in average intragranular misorientation at the sample scale and modification of the misorientation across subgrain boundaries provide evidence for recovery from the earliest stages of annealing. This evolution is similar for all studied samples irrespective of their initial strain or annealing temperature. After an incubation period up to 2 hours, recovery is accompanied by recrystallization (nucleation and grain boundary migration). Grain growth proceeds at the expense of domains with high intra-granular misorientations and its kinetics fits the parabolic growth law. Deformation-induced microstructures (tilt boundaries and kink bands) are stable features during early stages of static recrystallization and locally slow down grain boundary migration, pinning grain growth.

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