Geophysical Research Abstracts
Vol. 20, EGU2018-153-2, 2018
EGU General Assembly 2018

The influence of micron-scale second phase particles on creep behaviour and microstructural evolution of experimentally deformed ice

Sheng Fan and David Prior

University of Otago, Department of Geology, New Zealand (fansh405@student.otago.ac.nz)

Naturally deformed ice may contain impurity particles including atmospheric dust and rock fragments. Studies in other materials suggest that particles interact with grain boundaries, controlling grain boundary mobility and affecting dynamic recrystallization processes and creep dynamics. We explore the influence of graphite particles on ice creep behaviour and microstructural evolution from creep tests on two-phase and pure water ice samples. The two-phase ice is fabricated from pure water ice with 1 vol.% of 1 micrometre graphite particles. Uniaxial compression creep tests were conducted under constant load of 60 kg (initial stress of 1.03 MPa) at -3.8˚C. We present results of the tests on ice samples reached 1, 4, 8 and 12% axial shortening.

Undeformed pure water ice exhibits a homogeneous foam-like structure with a mean grain size of ~520 μm. The two-phase ice exhibits a smaller ice grain size (~460 μm) and widely-developed zig-zagged grain boundaries where the graphite particles aggregate. The creep rate of two-phase ice is lower than that of pure water ice before 8% strain but it reaches the same tertiary creep rate after ~10% strain. The CPO of two-phase ice is weaker compared to pure water ice before 8% strain. After 12% strain, there is a significant strengthening of two-phase ice CPO, with the J-index surpasses that of pure water ice. We have used cryo-EBSD to analyse the internal microstructures of the grains with high distortion in all the samples. For two-phase ice, the orientation of these lattice bending axes change between low (< 8%) and high (> 12%) strain. The change suggests a switch in dislocation systems contributing to the lattice distortion. In contrast, in pure water ice, the bending axes do not change orientation across the whole range of strains. At high strain, the microstructure and mechanical behaviour of two-phase and pure water ice are similar and many previous studies have shown that grain boundary migration (GBM) is the main parameter controlling microstructural and mechanical evolution in pure ice at these warm conditions. The CPO, mechanical data and internal distortions indicate the graphite particles affect the early strain history (< 8% strain) of ice much more than the later part. It is likely that grain boundary sliding (GBS) will have different kinetics for boundaries with and without graphite particles. Then the differences in the fraction of strain accommodated by GBS could influence CPO, mechanical behaviour and intragranular deformation in the early strain history. At high strain, all samples are dominated by GBM. A running hypothesis is that the driving force needed to instigate GBM for ice with grain boundary particles is not achieved until later in the strain history, compared to pure ice. Once migration has started, grain boundary particle distributions are sparser and GBM rates become similar in the two sample types. The creep tests discussed above were conducted at very high homologous temperature. Some pilot experiments show there may be a greater difference of behaviour between two-phase and pure water ice at lower temperatures and this will be investigated in the future.