The Effects of H2SO4 on the Flow and Fabric of Polycrystalline Ice

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It is well established that the Earth’ s large continental ice sheets contain a variety of naturally occurring impurities, both soluble and insoluble. Understanding how these impurities affect the rheology, intrinsic thermodynamic properties, and ultimate fate of these ice sheets is much less understood. Previous work has shown that H_2SO_4 dramatically reduces the strength and increases the ductility of single crystal ice, but its effects on polycrystalline ice are unknown. In order to investigate the effects that trace amounts of H_2SO_4 have on the flow and ductility of polycrystalline ice a series of mechanical tests were conducted at -6°C, -10°C, -12°C, and -20°C using laboratory-prepared ice with a mean grain diameter of 1 mm and doped with 1-10 ppm of H_2SO_4. Parallel tests were performed on identical, but undoped polycrystalline ice. Mechanical testing included uniaxial tensile creep tests at a constant load of 38 kg (0.75 MPa initial stress) and uniaxial compression tests at constant strain rates ranging from $1 \times 10^{-6}\ s^{-1}$ to $1 \times 10^{-4}\ s^{-1}$. The tensile tests showed that H_2SO_4-doped specimens exhibited faster creep rates than undoped ice, while the compression tests demonstrated that H_2SO_4-doped specimens exhibit a significantly lower peak stress than undoped ice. Post-mortem microstructural analyses were performed using cross-polarized light thin section imaging, X-ray computed microtomography, Raman spectroscopy, and electron backscatter diffraction. These analyses showed that H_2SO_4-doped specimens had a much larger grain size at strains 15%, and an earlier onset of micro-cracking at lower strain rates than the undoped ice. Further, a liquid-like phase containing H_2SO_4 appears to be present at the grain boundaries of the H_2SO_4 doped ice.

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