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Comparisons of Fabric Strength and Development in Polycrystalline Ice at Atmospheric and Basal Hydrostatic Pressures

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Understanding and predicting the flow of polycrystalline ice is crucial to ice sheet modeling and paleoclimate reconstruction from ice cores. Ice flow rates depend strongly on the fabric (i.e. the distribution of grain sizes and crystallographic orientations) which evolves over time and enhances the flow rate in the direction of applied stress. The mechanisms for fabric evolution in ice have been extensively studied at atmospheric pressures, but little work has been done to observe these processes at the high pressures experienced deep within ice sheets where long-term changes in ice rheology are expected to have significance.

We conducted compressive creep tests to $\sim$10% strain on 917 kg m^{-3}, initially randomly-oriented polycrystalline ice specimens at 0.1 (atmospheric) and 20 MPa (simulating $\sim$2,000 m depth) hydrostatic pressures, performing microstructural analyses on the resulting deformed specimens to characterize the evolution and strength of crystal fabric. Our microstructural analysis technique simultaneously collects grain shape and size data from Scanning Electron Microscope (SEM) micrographs and obtains crystallographic orientation data via Electron BackScatter Diffraction (EBSD). Combining these measurements allows rapid analysis of the ice fabric over large numbers of grains, yielding statistically useful numbers of grain size and orientation data.

We present creep and microstructural data to demonstrate pressure-dependent effects on the mechanical and microstructural evolution of polycrystalline ice and discuss possible mechanisms for the observed differences.