Possible cause for rapid deformation of ice from glacial periods, investigated from laboratory-based deformation experiments and microstructural observations

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Deformation mechanism of coarse-grained polycrystalline ice is well investigated by various experiments. However, the deformation of ice-sheet ice is complicated by various factors such as local distributions of impurities and mechanical anisotropies. Detailed analyses of ice cores have revealed that ice from glacial periods (ice-age ice) that has highly-concentrated impurities and small grains deforms rapidly compared with ice from Holocene. Although the causes of the rapid deformation in ice-age ice have been discussed in various studies, the detailed mechanism remains unclear.
The deformation rate in ice sheets is extremely slow; therefore, ice-sheet ice deforms under low dislocation density state. To replicate such deformation mechanism in laboratory experiments, we prepared fine-grained ice which has much grain boundaries. Since grain boundaries can act as sinks of dislocations, a low dislocation density state is kept during deformation like ice sheets.
To investigate the cause of rapid deformation of ice-age ice, we conducted deformation experiments and microstructural observations using artificial ice, with focusing on the influences of microparticles and grain size (grain boundaries). We made pure ice, and silica-dispersed ice with particle diameters of 0.3 μm and mass concentrations of 0.1 and 0.01 %. For the investigation of grain-size-sensitivity of deformation, various-sized ice (mean grain size with 30 μm –2 mm) was prepared.
Our experimental results revealed different trends for softening and hardening effect due to microparticles dispersion, grain-size-sensitivity, and microstructural evolutions during deformation in fine- and coarse-grained ice. Silica-dispersed ice with coarse grains indicated a hardening trend compared with pure ice, while little direct effect on the deformation in fine-grained ice. Grain-size-sensitivity was appeared only in fine-grained ice: the strain rates become larger at finer grains.
In this presentation, we discuss the possible cause for the rapid deformation of ice-age ice based on systematic deformation experiments and microstructural observations.

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