Effect of solid particles and grain boundary on deformation of fine-grained polycrystalline ice

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Behavior of Greenland ice sheet plays a fundamental role in global climate change. Understanding of ice sheet dynamics is important for high-accuracy prediction of sea level rise and ocean circulation variation. Although ice sheet behavior has large spatial-temporal scales, importance of microstructure of polycrystalline ice has been suggested from ice-core analysis (e.g., Faria et al., 2014). Flow law of large-grained polycrystalline ice has been studied by laboratory experiments. However, flow law of ice-sheet ice is complicated by various factors. Cloudy bands, which are localized in the ice sheet cores and contains highly-concentrated impurities, show finer ice grains. Although the interaction between solid particles and ice has been discussed by previous papers (e.g., Rempel and Worster, 1999, Durand et al., 2006), detailed effects in polycrystalline ice and ice core are still uncertain. We have performed mechanical tests and microstructure analysis using artificial ice to investigate the effect of solid particles on flow low of fine-grained polycrystalline ice.

We prepared artificial ice with and without silica-particles (particle size of 0.3 μm and dispersed-amount of 0.1wt%). Powder ice (made by spraying pure water and silica-dispersed water into liquid nitrogen) is compressed for an hour with 70 MPa pressure. Deformation experiments were conducted under constant temperature and pressure with various conditions. Our experimental results clarified the effect of solid particles as follows: 1) grain size of silica-dispersed ice is smaller than that of pure-water ice, 2) strain rate of silica-dispersed ice is larger than that of pure-water ice, 3) minimum strain rate (steady-state creep) was not achieved even with 10%-strain for both pure-water and silica-dispersed ice. Generally, a dislocation creep, which has no dependence on grain-size, dominates the ice deformation, however, our results (grain-size dependence and decreasing strain rate) suggest the possibility of grain boundary effect on the deformation mechanism.

In this presentation, we discuss the deformation mechanism of fine-grained polycrystalline ice from deformation test and microstructure analysis, and the flow of Greenland ice sheet.

Keywords: ice-sheet flow, solid particle

