Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SIT38-06 Room:304 Time:May 23 12:15-12:30

Heterogeneous distribution of water and strain localization of polycrystalline synthetic anorthite

Jun-ichi Fukuda[1*], Jun Muto[1], Hiroyuki Nagahama[1]

[1]Dept. Earth Sci., Tohoku Univ.

Recent tomographic investigations for the crust have observed low seismic velocity zones and high electrical conductivity zones especially beneath the active fault zones in the crust. In these zones, it is assumed that aqueous fluids are introduced through fractures and plastic deformation of surrounding rocks has been enhanced (e.g. Wannamaker et al. 2009).

Previous deformation experiments, which focused on the effect of water for feldspar as a dominant constituent in the lower crust, have been performed under equilibrium water conditions within rocks and minerals. These experiments therefore have not evaluated the process for brittle-plastic transition and enhancement of plastic deformation under non-equilibrium water condition which are related to the above tomographic observations.

In this study, we performed shear deformation experiments on initially dry synthetic polycrystalline anorthite under the condition where water was introduced externally and heterogeneously distributed within the sample. Polycrystalline anorthite used in the experiments is composed of the average grain size of 3 micrometers with Si-rich melt of 5 vol%. The sample column of 6.2 mm phi was cut by 45 degree, and 1 mm thickness was obtained. A Ni strain marker was set within the sample in a direction normal to slip orientation. Then, the sample was sandwiched by 45-degree-cut alumina shear pistons. The shear deformation was conducted using a solid pressure medium (Griggs type) deformation apparatus at 900 degree C, confining pressure of 1.0 GPa, and shear strain rate of $10^{-3.5,\ -4.0,\ -4.5}$/sec up to shear strain of 2. Pyrophyllite powder was added around the ends of two alumina pistons as a source of water by dehydration under the experimental condition.

The stress-strain curves showed significant weakening only for the experiments with 0.5 wt% added water. For example, in an experiment conducted at shear strain rate of $10^{-4.5}$/sec with 0.5 wt% water added, the sample was weakened below the differential stress of 50 MPa. On the other hand, in other experiments of the same shear strain rates and added water less than 0.5 wt%, the differential stress reached 1000 MPa and then weakened. Observations of recovered samples under a polarized optical microscope showed that cataclastic flow dominated in the samples of less added water. Plastic deformation dominated in the samples of 0.5 wt% added water experiments, and the strain marker locally shows shear strain of 5.

We measured water distribution in deformed samples by mapping measurements of infrared spectroscopy. The IR spectra of the sample show broad water absorption bands at 2800-3800 cm-1, indicating that the presence of aqueous fluid at grain boundaries. The maximum water content was 130 ppm H_2O in the samples of 0.1 wt% water added experiments. On the other hand, in the samples with the 0.5 wt% added experiment at the shear strain rate of $10^{-4.0}$/sec, the maximum water content was 550 ppm H_2O in strain-localized areas. This sample also includes cataclastically-deformed area, where the water content was c.a. 250 ppm H_2O. Thus, deformation mechanisms and enhancement of plastic deformation greatly depend on heterogeneity of water content. In this study, we also discuss differences of mechanical and microstructural differences which depend on added water content. Then, we discuss relationship between deformation and heterogeneous distribution of water within the samples.

Keywords: Griggs deformation apparatus, Shear deformation experiment, Water introduction, Enhancement of plastic deformation, IR spectroscopy