Comparison between natural and experimental plastic deformation of plagioclase: Preliminary result

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Most of the inland large earthquakes occur in the brittle-plastic transition zone. The deformation process in the brittle-plastic transition is, therefore, important. Plastic deformation of fine-grained feldspar in the brittle-plastic transition zone has recently been reported, which accompanies dislocation activity (e.g., Shigematsu, 1999). On the other hand, mechanical behavior of such deformation of feldspar is poorly understood, although several studies have revealed the plastic deformation of fine-grained feldspar which accompanies dislocation activity (e.g., Tullis and Yund, 1985). In this study, preliminary deformation experiments of fine-grained plagioclase were carried out to reveal the mechanical behavior and their deformation mechanism.

The following has been revealed from the analysis of naturally deformed fine-grained feldspar. (1) The grain size of fine-grained feldspar is approximately 1 micrometer and dislocation substructure and microstructures of dynamic recrystallization are well developed. (2) They do not have any crystallographic preferred orientation (CPO). (3) There is a microstructure which suggests fine-grained feldspar is weaker than quartz. (4) Microvoids along grain boundaries are developed along crushed deformation localized zones where dynamic recrystallization was ceased.

The starting materials for the experiments were fine-grained sintered albitite which were sintered at 1000 degree in Celsius and 200 MPa for 16 hours in a hot isotropic pressing machine (HIP). The sintered albitite samples were deformed under the condition of 800 degree in Celsius and 200 MPa with the strain rate of 5E-6 s-1 and 1.5E-5 s-1 in a gas-medium deformation apparatus at the Geological Survey of Japan, AIST. Other conditions will be a future subject.

The stress-strain curves were obtained which show the flow stress of 70 MPa at the strain rate of 5E-6 s-1 s-1 and the flow stress of 210 MPa at the strain rate of 1.5E-5 s-1. Microstructure, CPO, and dislocation substructure analyses will be carried out.

The flow stress at the strain rate of 1.5E-5 s-1 is just three times of that at the strain rate of 5E-6 s-1, i.e., Newtonian viscous flow. Although we have not yet analyzed the microstructure and dislocation substructure, well developed dislocation substructure and microstructure of dynamic recrystallization has been reported for the experimentally deformed fine-grained plagioclase at almost the same condition (Tullis and Yund, 1987). If the Newtonian viscous behavior and weak CPO is true, there will be a possibility that the deformation mechanism is not dislocation creep even they have well developed dislocation substructure and microstructure of dynamic recrystallization. Recently superplasticity of ceramics has been reported where the grain boundary sliding is accommodated by dislocation glide (Kim et al., 2001; Ruaon et al., 2003). The deformation mechanism of fine-grained feldspar in the brittle-plastic transition may be this superplastic deformation. In superplastic materials, if grain growth occurs actively during deformation, stress necessary for grain-boundary sliding will increase, which result in the formation of intergranular cavities that leads to premature failure. This hypothesis may also account for the relationship between microvoids formation along grain boundary and crushed deformation localized zones.