Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SIT039-07 Room:301A Time:May 24 10:00-10:15

The effects of secondary mineral to grain-size sensitive creep

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Natural rocks are generally multiphase, thus the effects of secondary minerals are important and not negligible. Some study suggests that with respect to the volume fraction of secondary minerals (f_2), grain size, viscosity and deformation mechanism could be changed. Especially grain size is one of the important parameters, which could change viscosity and deformation mechanism directory. Hiraga et al. (2010a) determined grain growth law using forsterite (Fo) ? enstatite (En) systems, and they showed the grain size ratio changes with respect to enstatite fruction (f_{en}) can explain Zener relations. They estimate the viscosity changes with respect to f_{en} using Zener relation and grain growth law.

Zener pinning is the effect that one phase blocks grain boundary movement of another phase. Zener pinning can be characterized following equation, $d_1/d_2=b/f_2{}^m$ (eq.1), where d_1 is grain size of first phase, d_2 is grain size of second phase, f_2 is volume fraction of second, b and m is parameter of Zener relation (Smith, 1948).

In this study, we determine grain growth law and conduct deformation experiments using Fo97En3 to Fo4En96 samples. According to the results of grain growth experiments, the grain growth can be characterized by $d^n-d_0{}^n=kt$ (eq.2), where d is grain size of after grain growth, d_0 is initial grain size, n is grain growth exponent, k is grain growth coefficient and t is time. The grain growth coefficient of k show the velocity of grain growth, and it becomes smaller with increasing f_2. It suggests that with increasing f_2, grain growth velocity become slower. This grain growth function of k changes with respect to f_2 can explain the model of grain growth function of K (Takayama et al. 1982; Hiraga et al. 2010a).

In addition, we conduct the deformation experiments and determine the effects of secondary minerals for deformation following, 1) viscosity changes during the deformation can explain grain growth during the deformation (eq.2) and strength difference between forsterite and enstatite. We make the model to consider the viscosity changes and it has good agreement comparing our experimental results. 2) Zener relation (eq.1) is effective not only in the initial samples but also the deformed samples. 3) With increasing f_{en} deformation mechanism also change grain boundary sliding (GBS) accommodated dislocation creep to GBS accommodated diffusion creep.

Consequently, Secondary mineral volume fractions have large effect to rheological changes during grain size sensitive creep.

Keywords: peridotite, forsterite, grain size, deformation mechanism, Zener relation