Doping effect on high-temperature creep of olivine aggregates

*Kosuke Yabe[1], Takehiko Hiraga[1]

1.Earthquake Research Institute, The University of Tokyo

It is very important to examine the flow properties of the upper mantle for understanding the mantle flow and the origin of asthenosphere. Previous studies on creep properties of polycrystalline olivine prepared from naturally derived olivine have shown the effects of temperature, grain size, stress, and the amount of water and melt, which help to construct an applicable flow law to the natural condition (Karato et al 1986, Hirth and Kohlstedt 1995, Mei and Kohlstedt 2000). However, Faul and Jackson (2007) showed that olivine aggregates prepared from reagents using sol-gel technique had about 2 orders of magnitude larger strength compared to the naturally derived olivine aggregates. Later Hansen et al. (2011) showed that Hirth and Kohlstedt (1995) had overestimated the grain sizes of the specimens, but even if it is considered, there remains difference in the strength by about one order of magnitude under diffusion creep regime.

The inconsistency in strength can be resulted from a small difference in chemical composition because it has been observed that a small amount of impurities such as CaO, Al_2O_3, TiO_2 were segregated at grain boundaries in naturally derived olivine aggregates (Hiraga et al. 2003), and because such impurities segregated at grain boundaries have been found to have a large effect on the strength of polycrystalline oxides such as alumina and zirconia (Yoshida et al. 1997).

In this study, we synthesized olivine aggregates by using a new technique and conducted high-temperature creep experiment on such synthesized olivine aggregates. Also we introduced small amount of impurities on such aggregates to investigate the effect of chemical composition on the creep properties of olivine aggregates.

The aggregates were prepared by applying vacuum sintering to nano-sized olivine powder synthesized from highly pure and fine-grained (<100 nm) raw powders (Koizumi et al 2010). Olivine aggregates with and without dopants of <1 wt% Al_2O_3, CaO, TiO_2 were prepared. Deformation tests on these samples showed that non-doped samples were deformed under grain boundary diffusion creep and that there was no major difference in strength between non-doped and impurity-doped samples. Further, the strength was essentially identical to the aggregates by Faul and Jackson (2007). The similar strength of synthesized olivine aggregates used in our study and Faul and Jackson (2007) strongly suggested the presence of unknown chemicals that control creep properties of polycrystalline olivine.

Keywords: olivine aggregates, rheology, doping effect

