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Shear deformation experiment of garnet and its geological implication

ikuo katayama[1]; Shun-ichiro Karato[2]

[1] Geology & Geophysics, Yale Univ; [2] Yale University, Department of Geology and Geophysics

Garnet Garnet and olivine are two important minerals in two geochemically distinct rock types, peridotite and eclogite. Consequently, the relative strength between garnet and olivine is a key factor in understanding the geodynamic behavior of two distinct geochemical reservoirs. Here we investigated rheology of garnet by shear deformation experiments using the Griggs-type solid medium apparatus. Garnet and olivine samples were together sandwiched between alumina pistons in simple shear geometry. We prepared two different composition of garnet, one is Fe-rich (Alm46Prp52Grs2) and the other one is Mg-rich (Alm10Prp85Grs5). Because of uncertainty in reading differential stress from an external load-cell, we used dislocation density of deformed olivine crystals to infer stress level during deformation. Oxygen fugacity was buffered by the Ni/NiO reaction, and the water content was relatively low (200 ppm H/Si) based on infrared spectra and olivine fabric. We performed two experiments at 2GPa and 1473K using different strain-rates, approximately 1x10-3 and 1x10-4 s-1. The Fe-rich garnet has larger strain than olivine, which indicates that garnet is weaker than olivine at the given conditions. Dislocation creep is likely the dominant deformation mechanism according to the stress exponent of 3 based on the stress and strain-rate relation and dynamic recrystallization in deformed garnet. On the other hand, the Mg-rich garnet has significantly smaller strain than olivine, suggesting that garnet is much stronger than olivine. This result indicates that the creep strength of garnet is depending on its chemical composition. The garnet in subducted oceanic crust contains higher Fe content, suggesting that garnet-rich layer is weaker or identical to the surrounding peridotitic upper mantle. Our results provide new insights into the geodynamic behavior of garnet-rich regions including the processes of separation of a garnetite layer at around the 660 km discontinuity.