I128-P007 **Room: Poster Session Hall** **Time: May 23**

Effect of pressure on grain-growth kinetics of magnesiowüstite

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The Earth's lower mantle is known to consist of (Mg,Fe)SiO_3-perovskite and (Mg.Fe)O-magnesiowustite. Although magnesiowustite occupies only 20 vol% in the lower mantle, rheology of the lower mantle may be dominated by magnesiowustite because magnesiowustite is considered to be significantly softer than (Mg,Fe)SiO_3-perovskite.

Then the dominant deformation mechanism of magnesiowustite at lower mantle conditions is most probably diffusion creep. Diffusion creep rate depends on the grain-size of mineral. Grain-growth kinetics of pure-MgO at 1 atm was investigated by Spriggs et al. (1964). However, grain-growth kinetics of single phase (Mg.Fe)O-magnesiowustite at high-pressure has not been known. Therefore, in this study, we have investigated effect of pressure on grain-growth kinetics of (Mg,Fe)O- magnesiowustite.

magnesiowustite aggregates with a composition of $(Mg_{0.85}Fe_{0.15})O$ have been annealed under dry conditions using multi-anvil apparatus at 10 GPa, 1500 degree C and the oxygen fugacity of Ni-NiO buffer. Starting material is an aggregate sintered by piston-cylinder apparatus with average grain size of 4.0 um. The run products were polished using diamond paste and subsequently with colloidal silica suspension, and etched by acetic aid. Average grain size of sample were measured by linear intercept method (Mendelson, 1969). Grain-growth kinetics is generally represented by G^n - ${G_0}^n$ = kt where G is average grain-size at time t; G_0, initial grain-size; t, annealing time; n, a dimensionless constant; and k, the growth rate constant. Grain growth kinetics of magnesiowustite aggregate at 10 GPa and 1500 degree C was found to be expressed by D^2 - ${D_0}^2$ = kt, with k = 48 um^2/h. The activation volume of grain-growth kinetics was determined to be 3.0 cm^3/mol using present results at 10 GPa and Spriggs et al.'s (1964) results at 1atm. This result shows grain-growth of magnesiowustite in single phase aggregate is much faster than that in two phase mixture of MgSiO3-perovskite and MgO (Yamazaki et al., 1996) at 25 GPa and 1500 degree C.