MISIP-2024 Project-4 – Effect of iron content on the viscosity of ringwoodite: implication on the viscosity of Martian mantle

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Martian meteorites suggests that there is about twice as much iron in Mars' mantle (~18 wt% FeO) as on Earth (~8 wt% FeO)(Dreibus and Wänke, 1985;Wänke and Dreibus, 1988, 1994; Anderson, 1989; Rubie et al., 2004). And the viscosity of martian mantle is estimated to be ~10^{22} Pa· s from the tidal deformation by Phobbs, which is one order of magnitude higher than that of the Earth. The previous results of deformation of olivine show the viscosity of Fo_{90} is one order of magnitude larger than that of Fo_{75}. However, viscosities of high pressure polymorphs, wadslydite and ringwoodite, are not well-known. To discuss viscosity contrast between Earth and Mars, it is needed to determine the effect of iron on viscosity of high pressure mimerals. This study trys to design a series of high pressure experiments to test how iron content effect the viscosity of ringwoodite.

Specifically, this study use Kawai type multianvil apparatus to synthesis well-sintered ringwoodite with different iron content under 20 Gpa and 1200 ° C, and the starting materials as Fo_{60} + 3mol%Px and Fo_{90} + 3mol%Px. Then we make the ringwoodite samples deformed by D111-type high-pressure deformation apparatus which is capable of controlling the d-ram displacement of 300 μm and 600 μm at high pressure and high temperature. Then we measured the length of deformed samples and estimate the viscosity based on the following equations:

$$\epsilon = \frac{l_0 - l}{l_0} \qquad (1)$$

$$\dot{\epsilon} = \frac{A}{\eta}\sigma^n \qquad (2)$$

where ϵ is strain, l_0 is the initial length of sample, l is the length after deformation,$\dot{\epsilon}$ is strain rate, η is viscosity, A is constant, σ is stress, and n is stress exponent.

In conclusion, estimated from the strain rate between samples, viscosity of ringwoodite with Mg# 60 is 1.5 times larger than that with Mg# 90. This iron effect is much smaller than the effect on olivine (Zhao et al., 2009). Deformation mechanism in the present study may be dominated by diffusion creep because 1) no LPO was observed and 2) no recrystallization was observed. By understanding the difference of viscosity composed of different iron content, we can offer implications on the viscosity of Martian mantle.