Diffusion of hydrogen in ringwoodite

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Water plays important roles on evolution of the earth such as the mantle dynamics and magmatism of the earth, since it affects the physical properties of the constituent minerals of the Earth's interior such as the electrical conductivity, melting temperature, and viscosity. Therefore, it is important to understand the distribution and circulation of water in the Earth's interior. The hydrogen diffusion in mantle minerals is essential to discuss the problem.

The diffusion rate of hydrogen has been measured for the upper mantle minerals, such as olivine and diopside, however no data exist for ringwoodite which is a major constituent minerals in the mantle transition zone, despite the transition zone is the main water reservoir of the mantle (ringwoodite can contain up to 2.8 wt% H2O). Therefore, we performed the diffusion experiments of hydrogen in polycrystalline ringwoodite with the composition of Mg2SiO4.

Anhydrous polycrystalline ringwoodite were synthesized from forsterite powder first for the diffusion experiments. The synthesized cylindrical sample was cut into a rectangular shape. It was surrounded by NaCl + Mg(OH)2 powder which was used as the hydrogen source and enclosed in a platinum capsule. The diffusion experiments were performed at 18GPa and 900-1100C. NaCl was used for the purpose of minimizing differential stress. A 1000-ton multi-anvil high-pressure apparatus was used for operation of the Kawai type apparatus. The water content was determined by a Fourier Transform infrared spectrometer (FTIR). After the diffusion experiment, recovered sample was cut into three slices and the central slice was used for the FTIR analysis. The diffusion coefficients were determined by the least-squares fitting of the solution of the Fick's second law into concentration profiles for the one-dimensional diffusion from an infinite diffusion source into semi-infinite medium.

A magnitude of diffusion coefficients and activation energy obtained in our research implies that hydrogen diffusion distance is about 9.5 km in 10^8 years and water is still heterogeneously distributed in the mantle transition zone(in the case of 1873K). Therefore, it is thought that physical properties, such as the electrical conductivity and melting temperature, could vary in the transition zone depending on the geological settings.

We are currently performing hydrogen diffusion experiment in ringwoodite with the composition of (Mg,Fe)2SiO4. We will report the proceedings of the experiments.