The 452nd Geodynamics Seminar

H-D inter-diffusion in Fe-bearing wadsleyite and ringwoodite

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Abstract

Water plays an important role in the Earth's interior, such as triggering the volcanism and seismicity, enhancing plastic deformation and electrical conductivity, and reducing melting temperature and seismic velocities. Especially the mantle transition zone has considered to be a large water budget in the Earth's interior, because wadsleyite and ringwoodite, which are the major phases forming the transition zone, can contain considerable amount of water in their crystal structure.

In this study, proton conduction mechanism in wadsleyite and ringwoodite was investigated by high-pressure experiment of H-D inter-diffusion in H- and D-doped single crystal pair to constrain the electrical conductivity of hydrous wadsleyite and ringwoodite. H-D inter-diffusion coefficients were determined at various temperatures between 1000 and 1300 K and pressures of 16 and 21 GPa for wadsleyite with hree principles crystallographic direction and ringwoodite, respectively.
H-D inter-diffusion profiles obtained by secondary ion mass spectroscopy (SIMS) in both Fe-bearing wadsleyite and ringwoodite crystal pairs show symmetrical shape across the interface. Hydrogen self-diffusivities of Fe-bearing wadsleyite and ringwoodite are determined to be $D_{\mathrm{H}} = 10^{-7.15\pm0.46} * \exp(-\frac{106\pm11\ kJ/mol}{2.303*RT})\ m^2/s$ and $D_{\mathrm{H}} = 10^{-7.29\pm0.46} * \exp(-\frac{101\pm10\ kJ/mol}{2.303*RT})\ m^2/s$, respectively. There is small anisotropy of hydrogen self-diffusion in Fe-bearing wadsleyite at the mantle transition zone condition.

Based on the Nernst-Einstein relation, electrical conductivities calculated from present hydrogen self-diffusivities are consistent well with those of *Yoshino et al.* [2008] at the transition zone condition except for ringwoodite at high water content, but are about 1-2 orders of magnitude lower than *Dai et al.* [2009] and *Huang et al.* [2005]. The discrepancies between the conductivity measurements and this study would attribute to varying degrees of dehydration during heating and difference of grain sizes.

Compared to the global average one dimensional conductivity-depth model, water concentration in the mantle transition zone is estimated to be less than 1000 ppmw. In the wedge mantle where the subducted slab stagnates, only hydration of wadsleyite and ringwoodite cannot explain both high conductivity and seismic velocity anomalies in subduction slabs. The characteristic distance for hydrogen self-diffusion in the mantle transition zone is estimated to be ~1.8 km after 100 Myr. The heterogeneity of water distribution in the mantle transition zone detected by geophysics observation could be maintained for geologically long time scale. The supercritical fluids long-term preserved in the top of subducted stagnate slab might be most possible explanation for both high conductivity and seismic velocity anomalies in the wedge mantle.

詳細は当センターホームページ: http://www.grc.ehime-u.ac.jp/をご覧ください
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