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CROSSROADS IN EARTH AND PLANETARY MATERIALS

H-D interdiffusion in brucite at pressures up to 15 GPa

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ABSTRACT

Proton diffusion in brucite was investigated by conducting hydrogen-deuterium (H-D) exchange experiments using multi-anvil high-pressure apparatuses at pressures from 3 to 15 GPa and temperatures in the range of 750–1050 K. The diffusion couple was composed of a natural proton-dominated brucite single crystal surrounded by synthesized D-doped brucite polycrystals. Micro-Raman spectroscopy was used to determine the diffusion profiles of the samples. The D/H diffusion profile across the boundary between single crystal and polycrystalline D-doped brucite showed an asymmetric pattern characterized by faster diffusion in aggregates. The D/H interdiffusion rate determined from the analysis of the single crystal side indicates that the interdiffusion rate increases with increasing H/D ratio. The H-D interdiffusion rate in the direction perpendicular to the *c*-axis is about 0.5 orders of magnitude higher than that in the direction parallel to the *c*-axis. At 3 GPa, the H-D interdiffusion coefficients [D(m^2/s)] along and perpendicular to the *c*-axis of brucite at compositions of C_{OD}^{norm} = 0.2 in the single-crystal region were determined to be $3.30(\pm1.77) \times10^{-11}\exp[-48.2(\pm5.8)\ (kJ/mol)/RT]$ and $1.43(\pm1.33) \times10^{-9}\exp[-67.5(\pm23.2)\ (kJ/mol)/RT]$, respectively. The H-D interdiffusion rate perpendicular to and along the *c*-axis increased about one order of magnitude by compression from 3 to 10 GPa, but the pressure enhancement became weaker above 10 GPa. From 10 to 15 GPa, there is almost no pressure dependence of proton diffusion for both directions. As pressure increases up to 10 GPa, enhancement of the proton migration is strongly correlated with the activation of the atomic interaction and decrease of O···O′ distance induced by compression. The positive pressure effect on the proton diffusion in brucite suggests that proton diffusion in higher-pressure hydrous phase becomes faster because of the shorter O···O′ distance.

Keywords: Brucite, H-D interdiffusion, diffusion, high pressure, Raman spectroscopy