



D/H diffusion in serpentine

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Interactions between aqueous fluids and ultrabasic rocks are essential processes in a broad range of contexts including hydrothermal alteration on the parent body of carbonaceous chondrites, at mid-oceanic ridge, and in subduction zones. Tracking these processes and understanding reaction kinetics require knowledge of the diffusion of water in rocks, and of isotope fractionation in major minerals forming under hydrous conditions, such as serpentines. We present a study of D/H inter-diffusion in antigorite, a common variety of serpentine. High-temperature (HT) experiments were performed in a belt apparatus at 540°C and 3.0 GPa on natural antigorite powders saturated with interstitial D₂O. A low-temperature (LT) experiment was performed in diamond anvil cell at 350°C and 2.5 GPa on an antigorite single-crystal loaded with pure D₂O. D/(D+H) ratios were mapped using Raman spectroscopy for the HT experiment and NanoSIMS for the LT experiment. As antigorite is a phyllosilicate, diffusion coefficients were obtained for crystallographic directions parallel and perpendicular to the antigorite layers (perpendicular and parallel to the *c**-axis, respectively). The equations of D/H inter-diffusion coefficients were determined to be $D_{D/H} \text{ (m}^2\text{/s)} = 5.04 \times 10^{-5} \times \exp(-170(\pm 53) \text{ (kJ/mol)} / \text{RT})$ and $D_{D/H} \text{ (m}^2\text{/s)} = 1.52 \times 10^{-7} \times \exp(-157(\pm 32) \text{ (kJ/mol)} / \text{RT})$ perpendicular and along the *c**-axis, respectively, and $D_{D/H} \text{ (m}^2\text{/s)} = 7.29 \times 10^{-6} \times \exp(-166(\pm 14) \text{ (kJ/mol)} / \text{RT})$ for the bulk diffusivity. These results are similar to those obtained on chlorite, in agreement with the similar crystallographic structures and atomic bonds in the two minerals. Assuming D/H inter-diffusion coefficients for antigorite are the same for all serpentine species, closure temperature and diffusion durations are applied to hydrothermal fields and in CI, CM and CR chondrites. Closure temperatures lie below 300°C for terrestrial hydrothermal alteration and depend on serpentine variety because they have different typical grain sizes. They lie below 130°C for carbonaceous chondrites, indicating that D/H isotopic exchange may have persisted down to very low temperatures on their parent bodies. D/H isotopic composition may be associated with grain size heterogeneities in carbonaceous chondrites due to protracted alteration of fine-grained material with the lowest closure temperatures (*ca* 50°C).