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High water effect on silicon self-diffusion in wadsleyite

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Water has a strong influence on transport properties in minerals and on the Earth's interior dynamics. However, the small effect of water on upper-mantle rheology was suggested based on Si self-diffusivity because Si is the slowest diffusion species in silicate minerals and believed to control their rheology (Fei et al. 2013). The aim of this study is to examine whether the effect of water on Si self-diffusivity is also small in wadsleyite, which is the major mineral of the upper part of the mantle transition zone. We have experimentally determined Si self-diffusivity as a function of water content and crystallographic orientation Measurement were conducted on single crystals of Fe-free wadsleyite using 29Si enriched thin-film as a diffusing couple. Diffusion profiles were obtained using a NanoSIMS with the depth-profile method. Here, we determined Arrhenius relations for volume diffusion rates parallel to each crystallographic orientation. It was found that water significantly enhances Si self-diffusivity in comparison with previously reported values for wadsleyite and olivine. These results suggest that mantle viscosity significantly decreases across the 410-km discontinuity by assuming high water content in the mantle transition zone.