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Hydrogen isotopic exchange experiments in mantle xenoliths indicate rapid δD equilibrium with magma

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Water in the form of hydrous point defects in the crystal structure of pyroxenes from mantle xenoliths is frequently used to trace the water content in the lithospheric mantle. However, little is known on the mechanism that allows xenoliths to preserve deep hydrogen signatures and avoid complete reset by reaction with the host magma during transport. Especially, it is unknown how grain boundaries can affect hydrogen exchange between the different constitutive minerals and with the surrounding melt. In this study, we report results from hydrogen-deuterium exchange experiments performed in cubic pieces of natural xenolith aggregates between 600 and 900°C in a deuterium (D) enriched gas, at room pressure. The cubes, all from the same xenolith, contain clinopyroxenes, orthopyroxenes and olivine of mm to sub-millimetre size. We used single crystals of orthopyroxenes (opx), as sensors of the progress of the exchange within the polycrystalline aggregate. We compare diffusion profiles measured in single crystals and opx located at the edge of the cubes with diffusion profiles within opx inside the cubes not directly in contact with the deuterium enriched gas. Data are analysed to assess the possible contribution of grain boundary diffusion on the H-D equilibration of xenoliths during their transport to the surface. OH-OD profiles recorded by infrared spectroscopy in opx at the edge of the cubes are only moderately different from the ones recorded in opx inside the cubes. These results indicate that the isotopic diffusion of hydrogen in grain boundaries is fast enough to equilibrate rapidly the opx crystals inside the cube xenoliths. This can be a first evidence that in nature the δD signature of xenoliths is very likely controlled by the equilibrium with the host magma even in the case of xenoliths with large grain size.