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Experimental investigation of hydrogen isotope fractionation during hydration of olivine-hosted melt inclusions: Implications for D/H in Baffin Island picrites

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Hallis et al. [1] reported anomalously light hydrogen isotopes (dD_{VSMOW} = -218 ‰ to -97 ‰) in olivine-hosted melt inclusions from Baffin Island, Canada. Hydrogen isotopic composition anticorrelates with H_2O concentration (H_2O = 576 to 1964 ug/g) in these inclusions. Hallis et al. [1] interpreted this trend as resulting from dehydration during magma ascent and concluded that the lightest H isotopes are indicative of a source region comprising a mixture of protosolar-like deep mantle and mid-ocean ridge basalt type upper mantle. At these low H_2O concentrations, however, ascending magmas degas dominantly CO_2, providing almost no driving force for dehydration [2]. Further, the low H_2O concentrations that characterize these melt inclusions means that they are especially susceptible to modification by diffusive hydration [3]. We conducted experiments designed to investigate the behavior of hydrogen isotopes during the hydration of olivine-hosted melt inclusions. Olivine grains were heated at 1200 °C and 300 MPa in aqueous fluid. Our results demonstrate that H_2O increases rapidly (up to ~4 wt.% within 24 h), consistent with a H^+ lattice diffusivity of $10^{-11.2}$ m^2/s, and that kinetic hydrogen isotope fractionation occurs during hydration. Hydrogen isotopes initially become lighter as hydration proceeds, creating a negative correlation with H_2O concentration. This trend reverses with increasing hydration, however, as the inclusions must eventually equilibrate with the external fluid. This suggests that the low dD_{VSMOW} values reported by Hallis et al. [1] may reflect diffusive equilibration rather than the hydrogen isotopic composition of the mantle. One explanation for the anomalously light hydrogen isotopes is mixing of magmas with different H_2O contents just prior to ascent and eruption. Thus, the low D/H in these olivine-hosted melt inclusions cannot be uniquely interpreted as being representative of their mantle source unless diffusive hydration can be eliminated as a possibility. References: [1] Hallis et al. (2015), *Science* 350, 795-797; [2] Dixon & Stolper (1995), *J Petrol* 36, 1633–1646; [3] Hartley, M. E. (2015), *Earth Planet Sci Lett* 425, 168–178