Low D/H in Baffin Island Melt Inclusions: Primordial Water or Diffusive Hydration of Inclusions?

PETER J. MICHAEL[1]

[1]Dept. of Geosciences, University of Tulsa, 800 S. Tucker Dr., Tulsa, OK, 74114 USA pjm@utulsa.edu

The possibility of primordial H inside Earth, and the D/H ratio of the high-^{3}He source of basalts are important problems to address. But caution must be used in drawing conclusions from melt inclusions, especially when Hydrogen is involved. Hallis et al. [1] concluded that Earth accreted with primordial water from the protosolar nebula, based on D/H in olivine-hosted melt inclusions from high ^{3}He/^{4}He lavas of Baffin Island. Here I show that melt inclusion formation can lead to similar [H_2O] and D/H trends, and that their data do not require mixing between MORB and a low-D/H source, but are better explained by diffusive hydration of inclusions.

Melt inclusions may become hydrated when they crystallize during cooling, resulting in decreased internal pressure and decreased hydrogen fugacity [2]. H^+ then diffuses rapidly into the inclusion from the host lava while D^+ diffuses more slowly, increasing [H_2O] and decreasing D/H [3]. For these low-H_2O melt inclusions, even small amounts of [H_2O] increase would significantly influence D/H.

Other possible mechanisms involve hydration of inclusions by inward diffusion of H^+ from a host lava that has higher [H_2O] than the inclusion. For example, an H_2O-saturated lava at equilibrium would have 0.20% dissolved H_2O at 15 meters depth and 0.06% dissolved H_2O near its surface. (A similar range of [H_2O] as Baffin inclusions). If a crystal and melt inclusion (0.06% H_2O) from the surface sank 15 meters, or was entrained by ascending magma, it would be surrounded by magma with 3.3 times greater [H_2O] than in the inclusion. H^+ would diffuse into the inclusion more rapidly than D^+, giving the inclusion high [H_2O] and low D/H. Another possible mechanism is when variably enriched magmas and their crystals mix at crustal depths, as proposed for Icelandic inclusions [4], where olivines with low-[H_2O] inclusions from a depleted magma became part of a mixed magma that had higher [H_2O]. In all such mechanisms, the low H_2O contents of the Baffin inclusions make them very sensitive to H gain and D/H decreases. These hydration events could produce low-D/H inclusions and negative correlations on diagrams of wt.% H_2O *vs*. ∂D that are similar to subsequent dehydration events (Fig. 1A in [1]).

[1] Hallis et al. 2015, *Science* **350**, 795-797. [2] Danyushevsky et al., 2002, *Chem. Geol* **183**, 5-24. [3] Bucholz et al. 2013, *EPSL* **374**, 345-355. [4] Hartley et al., 2015, *EPSL* **425**, 168-178.