Light lithophile elements and boron isotopes track crustal assimilation in Icelandic basalts

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Primitive melt inclusions trapped during the earliest stages of fractional crystallization are able to preserve the oxygen and boron isotopic signatures inherited from mantle-derived melts. However, the strong O- and B-isotopic contrasts between primitive melts, geothermal and marine fluids, and hydrothermally altered crustal rocks, mean that alteration and crustal assimilation may exert strong control on the $\delta^{18}O$ and $\delta^{11}B$ signatures of melt inclusions trapped at later stages of crystallization. A past study of oxygen isotope variations in olivine- and plagioclase-hosted melt inclusions and matrix glasses from the Askja and Bárðarbunga volcanic systems in North Iceland revealed a positive correlation between $\delta^{18}O$ and MgO, which was suggested to reflect assimilation of low-$\delta^{18}O$ meta-basalt contaminants by melts with initially mantle-like $\delta^{18}O$ of +5.2±0.2‰ [1]. Here, we report volatile (S, F, Cl) and light lithophile element (Li, B) concentrations and boron isotopic ratios measured in the same samples.

The main suite of melt inclusions contain 127-1744 ppm S, 58-587 ppm F, 40-729 ppm Cl, 0.34-2.41 ppm B and 0.45-7.9 ppm Li. Volatile and light lithophile element concentrations are broadly consistent with fractional crystallization trends. A subset of inclusions from two eruptions preserve B and Li enrichments at constant MgO that cannot be explained by crystallization alone. These enrichments do not correlate with other incompatible trace elements, so are unlikely to represent trapped incompatible element-enriched boundary layers surrounding the host crystal. Instead, they may reflect mixing of heterogeneous melts within the magmatic systems. Melt inclusion $\delta^{11}B$ values range from -20.9‰ to +0.4‰. The most primitive inclusions have $\delta^{11}B$ of -10.3±2.0‰, similar to past estimates of the boron isotopic composition of the Icelandic mantle [2]. Coupled $\delta^{11}B$ and $\delta^{18}O$ signatures in melt inclusions from the 1797 AD Holuhraun eruption are consistent with ascending magmas progressively assimilating hydrothermally altered basaltic contaminants in the upper crust.

[1] Hartley et al. (2013) GCA 123:55-73
[2] Gurenko & Chaussidon (1997) Chem Geol 135:21-34