Olivine trace element constraints on the location of melt mixing in Iceland

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Current models of melt generation in Iceland stress the role of mixing between fractional melts in the melting column, with primary evidence coming from large incompatible element and isotopic heterogeneity in melt inclusions (MI) hosted by primitive olivines in single lavas [e.g.1]. We report trace element data for some 2000 olivine phenocrysts from Icelandic lavas, that includes analysis of Zr and Y in the range 3-100ppb, at 5σ detection limits of ~1ppb. Reproducibility is better than 10% 2sd for >10ppb Zr. Rock samples with simple chemistry show systematic Ti, Zr and Y increases with decreasing Fo (e.g. 50% increase from Fo_{87-84}), reflecting increase in either equilibrium melt concentrations and/or the partition coefficents. Zr/Y and Zr/Ti ratios remain constant suggesting that, at least over a limited Fo range, they can be used as indicators of the incompatible element chemistry of the magmas that crystallized the olivines.

Olivines that host highly variable MI are largely restricted to small-volume picrites strongly depleted in LREE, with much lower Zr/Y (1.0-1.3) than more typical mildly LREE-enriched tholeiites (3.0-4.7). Olivines from the former have much lower Zr/Y (0.05-0.15, cf. 0.22-0.37 in LREE-enriched lavas), although a few olivines in each have higher and lower Zr/Y respectively. Two picrites with very heterogeneous MI also have heterogeneous olivines, and in one, known to have variable MI Pb isotopes [1], the olivine chemistry varies sympathetically with MI chemistry. These, and many other, picrites also contain An_{83-88} plagioclase crystals. Some have low La, Ba, Sr in equilibrium with their LREE- and Ba-depleted hosts, but most have La, Ba and Sr similar to plagioclase in the normal LREE-enriched tholeiites. Some show a thin outer zone with near-equilibrium Ba, La, Sr. These plagioclases undoubtedly did not grow in the melting column but represent xenocrysts from normal tholeiites in the Icelandic crust. We suggest that the olivines from depleted lavas that host LREE-enriched MI may also represent crustal xenocrysts. Forsterite contents around 90mol% in these may simply represent diffusive equilibration of Fe/Mg with the host melt, known to be 4 orders of magnitude faster than Ca/Na equilibration in plagioclase. In one picrite that contains gabbro xenoliths, olivine shows decreasing $\delta^{18}O$ with Fo and increasing Zr/Y, supporting a xenocryst origin.

[1] Maclennan 2008. *Geochim Cosmochim Acta* **72**, 4159