Source versus process: Peridotite constraints on magma genesis

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Abyssal peridotites, the residues of basalt crustal genesis, preserve lithologic, elemental, and isotopic evidence for source- and process-induced heterogeneities. For example, the larger isotopic range of abyssal peridotites relative to mid-ocean ridge basalts requires the presence of long-lived source heterogeneities that are smoothed out by melting and melt mixing.

Here, we demonstrate that peridotites also record a greater range of oxygen fugacity (fO_2) than their basalt counterparts. We have determined the fO_2 of basalts and peridotites from the same ridge segment using μ-XANES and spinel oxybarometry, respectively [1]. Both lithologies reflect source mantle very near the quartz-fayalite-magnetite (QFM) buffer, and basalt fO_2 is within error of the global basalt average. While basalt fO_2 spans less than one log unit, peridotite fO_2 spans almost three log units, from <QFM-1.5 to ~QFM+1. Some peridotite dredges vary by over two log units, indicating relatively small length-scale (<1 km) variability. The peridotites record a diversity of features, including evidence of melt addition and a subset that suggest an ancient refractory component.

Constraining the relative contributions of source and process requires an understanding of the thermodynamic and petrologic controls on the chemical evolution of melts and residues during melting and reactive melt transport. We explore the use of numerical models for identifying which elements can serve as tracers of different parts of the system, through the incorporation of trace element transport into reactive melt transport models [2]. Source heterogeneity is not preserved in the melt when it occurs at small length-scales, but is preserved in the residue for elements that are moderately incompatible (D~0.1). These elements – such as heavy rare earth elements – may be key to tracing source variability in peridotites, whereas highly incompatible elements are more process influenced.

[1]Birner *et al*. (2018) *EPSL*. [2]Keller & Katz (2016) *J. Pet*.