Geochemical variability in mid-ocean ridge basalts: making the link between global and local datasets

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The geochemical variability preserved in mid-ocean ridge basalts (MORB) is a key tracer of the magmatic storage and transport processes they experience during their ascent through the mantle and crust. The effect of these processes is to collapse the huge diversity of melt compositions predicted to form during polybaric fractional melting of a lithologically heterogeneous mantle, into the narrow range we see expressed in most mod-ocean ridge settings. Magma chambers can therefore be seen as contaminating the variance structure of primitive mantle melts, even without wall-rock assimilation contaminating melts by chemical addition.

In portions of the mid-ocean ridge system such as Iceland, by combing the record of magma chemistry archived in melt inclusions with the uniquely large amount of whole-rock data from the region, we have reconstructed a partial history of magma mixing and are able to recover a more primitive spectrum of magma chemical diversity. The key observation is that as crystallisation proceeds, mixing in magma chambers progressively reduces geochemical variability, until by ~5wt% MgO almost all primary chemical diversity has been lost. These chemical systematics allow us to make predictions about how mixing processes should operate in MORB generally and the key factors controlling mixing efficiency: crustal thickness, magma supply rate, and by extension spreading rate, and mantle potential temperature. However, with its low sampling density, the global MORB database does not easily allow testing of these hypotheses.

We have developed a novel geospatial statistical analysis to bridge the gap between observations made on a small scale – in single ridge segments – to the entire global dataset of MORB chemistry. By analysing the geochemical variance in MORB over a range of bandwidths we have captured the ~2000km lengthscale at which the simple relationships between geochemical variability and MgO appear. This result demonstrates that on short lengthscales mantle chemical structure and magmatic processes operate coherently in the creation and destruction of geochemical variability.