The generation and destruction of compositional variation in Icelandic magma

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In order to recover information about the properties of the convecting mantle from the composition of MORB it is necessary to understand processes which influence the composition of mantle melt during its ascent from the source regions towards the surface. Two of the most important of these processes are crystallisation and mixing, which are likely to have left their mark on the composition of all MORB. Nevertheless, constraints on the range of mantle melt compositions present under indivdual segments of mid-ocean ridges can be obtained by study of olivine-hosted melt inclusions from picrites and high MgO basalts.

The active rift zones of Iceland contain a number of primtive eruptions with abundant forsteritic olivine phenocrysts. The presence of significant variation in the trace element composition of melt inclusions hosted by these olivines is well known and has been attributed to fractional melting or mantle source variation. New trace element (93 analyses) and Pb-isotope data (36 analyses) from Icelandic olivine-hosted melt inclusions have been acquired on the Cameca 1270f and 4f ion probes at the NERC facility at the University of Edinburgh. The observed relationship between the Pb isotope and trace element composition of these inclusions indicates that compositional variability primarily reflects heterogeneity in the mantle source, with little of the preserved variation resulting from progressive fractional melting of a homogeneous source. Almost 40% of the global range of $^{208}Pb/^{206}Pb$ and $^{207}Pb/^{206}Pb$ for young OIB and MORB is found in melt inclusions from one picrite eruption. High-amplitude, short-lengthscale variation is therefore present in the mantle under ridges.

The destruction of this compositional variability by mixing can be tracked by studying the relationship between the melt inclusions and their host olivines. The coupled drop in the trace element variability of the inclusions and the forsterite content of the olivines indicates that mixing and crystallisation are concurrent. This relationship may be generated by convection in magma bodies. Similar relative rates of mixing, cooling and crystallisation are obtained both from the melt inclusion population of single eruptions and from a dataset including all available olivine-hosted inclusions from Iceland. Thermobarometric results indicate that the mixing of mantle melts occurs in magma bodies within the lower crust, with the extent of mixing progressively increasing between 30 and 15 km depth. These magma bodies may be similar to the series of stacked sills where much of the solidification of the lower crust of ophiolites is thought to occur.