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Lateral variations in flank zone basalts from Iceland and the role of garnet pyroxenites during mantle melting

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Melting of fertile pyroxenites before that of more abundant lherzolites during primitive basalt formation in the mantle is frequently proposed. However, identifying their geochemical signature in the resulting basalts is not always trivial. Such lithological heterogeneity beneath oceanic islands has been inferred from both basaltic bulk lava samples and glass inclusions. Lava samples represent the integrated magma formation processes (melting, mixing, contamination and fractionation) whereas glass inclusions record melts less affected by higher-level processes. Nevertheless, more precise analyses of compositional parameters in bulk samples allow thorough assessment of mantle heterogeneity from the final basalt composition at surface. This is especially true for well characterized sample suites from islands showing important compositional variability in their basalts.

Here, we present new major- and trace element, and Sr-Nd-Hf-Pb isotope results on post-glacial Icelandic basalts from the Snæfellsnes Volcanic Zone (SNVZ), the South Iceland Volcanic Zone (SIVZ) and the Mid-Iceland Belt (MID) that clearly reveal systematic lateral variations. Along the strike of the flank zones (SNVZ and SIVZ), regular decrease is observed for alkalinity, La/Yb, Sm/Yb, HFSE/Y, 87Sr/86Sr and 206-207-208Pb/204Pb towards the centre of Iceland, where olivine-tholeïtes with depleted trace element compositions, low 87Sr/86Sr and 206-207-208Pb/204Pb (and high 143Nd/144Nd and 176Hf/177Hf) are produced. Bulk samples from mature volcanic system have uniform isotope ratios, whereas young systems produce basalts showing significant local compositional range superimposed on the general geographical trend.

The systematic decrease of residual garnet signature (high La/Yb, Sm/Yb, HFSE/Y) and Sr and Pb isotope ratios (and the increase of Nd and Hf isotope ratios) in the flank lavas towards the assumed centre of the plume is consistent with the occurrence of fertile garnet pyroxenites in the mantle source. Basalts from the periphery of the island are probably generated by less total melting and thus sample the more enriched and fusible component(s) of the mantle beneath Iceland. Hence, melts of this fertile mantle dominate the bulk melt composition at the periphery, and are progressively diluted towards the centre. In the Mid-Iceland Belt, basalt compositions are dominated by melts derived principally from the more refractory component(s) of the mantle. The lateral variations of the basalt compositions and the proposed diminishing role of fertile pyroxenites towards the centre of the island is readily explained by increased total melting towards the hotter core of the Iceland mantle plume. In conclusion, despite the ubiquitous contribution of pyroxenite melts in oceanic basalt genesis, their role is most readily identified in basalts formed from relatively cold mantle melting such as beneath off-axis volcanism.