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Volcanic systems of Iceland and their magma source

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Several active hot-spot volcanoes produce magma from mantle sources which composition varies on decadal time scale. This is probably best demonstrated by the recent work of Pietruszka and collaborators on Kilauea, Hawaii. In marked contrast, basalt lavas from volcanic system in Iceland located above the presumed centre of the Iceland mantle plume have uniform isotope composition over the last 10 thousand years. Volcanic systems are composed of a central volcano and a fissure swarm, or a combination of both and they represent a fundamental component of the neovolcanic zones in Iceland. Four such systems, those of Askja, Bárðarbunga, Kverkfjöll and Grímsvötn in central Iceland were chosen for investigation. The last three have central volcanoes covered by the Vatnajökull ice-sheet whereas part of their fissure swarms is ice-free. Tephra produced during subglacial eruptions together with lavas from the fissure swarms of Holocene age have been collected and analysed for Sr, Nd and Th isotope ratios. Those volcanic formations that can be univocally correlated to a given volcanic system display uniform isotope ratio but different from one volcanic system to another. An exception to this regularity is that Askja products have isotope ratios indistinguishable from those of Gímsvötn, but since these volcanic systems lies far apart their lava fields do not overlap. A practical aspect of these findings was demonstrated during the rifting event of Bárðarbunga and fissure eruption forming the Holuhraun lava field.

Relatively low, O isotope ratios in these basalts and heterogeneous macrocrystal composition have been ascribed to important metabasaltic crustal contamination with or without crystal mush recycling. In that case a surprisingly efficient magma mixing and melt homogenization must have occurred in the past beneath the volcanic systems. One possibility is that during the rapid deglaciation much mantle melting occurred and melts accumulated at the mantle-crust boundary or within the crust in magma reservoirs that are still feeding the volcanic systems. A second possible explanation for absence of temporal variations of isotope ratios for a given volcanic system during the last 10 thousand years is that the roots of these systems lie at further depths within the mantle. In that case, extensive fertile source rock of recycled origin with distinct isotope composition must feed the volcanic system and that the melt extraction mechanism from these source regions does not alter (or homogenize) the final melt products. The consequences of these two mechanisms and possible discrimination between them will be discussed.