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Oxygen isotopes in melt inclusions and groundmass glasses from the Askja volcanic system, north Iceland

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Studies of the oxygen isotope geochemistry of mid-ocean ridge basalts (MORBs) show that fresh MORB glasses have an average δ^{18}O of +5.7±0.2‰. Icelandic basalts are typified by low δ^{18}O values, with a mean value of +4.5±0.8‰. Melt inclusions hosted by crystals formed early in a melt's history preserve oxygen isotope ratios inherited from parental mantle-derived melts. However, assimilation of low-δ^{18}O hydrothermally altered crustal material and mixing with magmas held in shallow crustal chambers exerts a strong control on the δ^{18}O signature of groundmass glasses and of melt inclusions trapped during later stages of crystallisation. The measured range in δ^{18}O therefore reflects a combination of mantle variability and crustal processes.

This study focuses on olivine- and plagioclase-hosted melt inclusions and groundmass glasses from tephra samples collected from various sites around the Askja central volcano and Askja volcanic system. Oxygen isotope ratios were measured by SIMS. Independent laser fluorination data was also obtained for a subset of groundmass glasses. The δ^{18}O data, used in conjunction with major, trace and rare earth element chemistry for the melt inclusions and glasses, reveal significant differences in the mechanisms of magma supply between the northern and southern segments of the Askja volcanic system. In addition, crustal assimilation and mixing with rhyolitic melts exert important controls on δ^{18}O, particularly for magmas erupted at the Askja central volcano.

Groundmass glasses from tephras erupted within the Askja caldera almost universally have a low δ^{18}O signature between +3.0 and +3.5‰. The low δ^{18}O of tephras erupted during and following the 1874-76 volcano-tectonic episode is consistent with mixing with a low-δ^{18}O rhyolitic magma in Askja's shallow (3 km) holding chamber. Melt inclusions from two tuff cone sequences located within the Askja caldera are much more primitive than these historic magmas. In both tuff cones, only a small number of melt inclusions preserve mantle-like δ^{18}O signatures. Mixing with a hydrothermally altered rhyolitic contaminant explains the δ^{18}O variations in one of the tuff cones. The δ^{18}O variations in the second tuff cone may indicate post-eruption oxygen isotope exchange with low-δ^{18}O hydrothermal fluids.

Melt inclusions and groundmass glasses from the Holuhraun fissure eruption, ~20 km south of Askja, mostly preserve mantle-like δ^{18}O signatures of +4.1 to +5.4‰. The absence of low-δ^{18}O analyses indicates that the Holuhraun magma was not significantly affected by crustal assimilation and was erupted directly from the melt source region with only a short residence time in the crust.

Melt inclusions and groundmass glasses from the Nyjahraun fissure eruptions, ~60 km north of Askja, have a δ^{18}O range of +3.1 to +4.0‰, with most values at the upper end of this range. An additional δ^{18}O analysis of +5.5‰ is given by Macdonald et al. (1987). These results can be interpreted such that the Nyjahraun parental magma was resident in the shallow plumbing system for some time prior to eruption. There it evolved by mixing with a low-δ^{18}O component or, alternatively, may have been modified by percolating meteoric water. Following the onset of eruption, a pathway was established between the deep magma source and the volcanic vents, allowing melt with unaltered mantle δ^{18}O to be discharged at the surface.

Macdonald, R. et al. (1987), Mineralogical Magazine, 51, 183-202.