

How old is the Laki magma?

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Timescales of magmatic processes and, in favourable cases, the age of magma can be assessed from U-series disequilibria in young volcanic rocks. Such information is needed in order to better constrain the longevity of magma chambers or reservoirs, and elucidate if magma chambers are only a transient features or longer-lived geological objects.

The 1783-4 AD fissure eruption of Laki (Iceland) produced 15km³ of homogeneous basalt that is characterized by extreme (3‰) ¹⁸O-depletion relative to normal mantle. Basaltic tephra erupted over the last 8 centuries from the Grímsvötn central volcano, which together with Laki are a part of a single volcanic system, are indistinguishable in δ¹⁸O from Laki whole-rock and glass samples. This suggests that all tap a homogeneous and long-lived low-δ¹⁸O magma reservoir. In contrast, extreme oxygen isotope heterogeneity (2.2 – 5.2‰) is observed in minerals extracted from Laki lavas and tephra, and disequilibrium mineral-glass oxygen-isotope fractionations. Such low-δ¹⁸O_{glass} values, and extreme 3‰ range in δ¹⁸O_{olivine} have not been described in any other unaltered basalt.

The (²²⁶Ra /²³⁰Th) activity ratio in Laki lavas and 20th century Grímsvötn tephra is 13% in-excess of secular equilibrium, whereas the latter have equilibrium (²¹⁰Pb/²²⁶Ra). Modelling of oxygen isotope disequilibria in phenocrysts, and these short-lived U-series nuclides yields a coherent age for the Laki-Grímsvötn magma reservoir between 100 and a few 1000 years. Moreover, the oxygen diffusive timescales in phenocrysts, and U-series disequilibria for the melt, indicate that the age of the crystals and the melt is comparable. Taken together, these results suggest the existence of uniquely fingerprinted, low-δ¹⁸O, homogeneous, large volume, and long-lived basaltic reservoir beneath the Laki-Grímsvötn volcanic system that has been kept alive in its position above the centre of the Icelandic mantle plume. Melt generation, crustal assimilation, magma storage and homogenisation all took place in only a few thousands of years at most.