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Multiple magma pathways from distinct reservoirs fed the 1975-1984 Krafla Fires eruptions

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We present a detailed petrologic and geochemical study of all nine basaltic eruptions of the 1975-1984 Krafla Fires rifting episode in northeast Iceland. New whole-rock, matrix glass and mineral analyses from scoria and lava flow-top samples collected during or shortly after each eruption show a clear compositional bimodality, with evolved quartz tholeiite (MgO = 5.8 ± 0.2 wt.%) erupted inside the caldera and more primitive olivine tholeiite (MgO = 7.3 ± 0.8 wt.%) erupted north of the caldera margin. Olivine-plagioclase-augite-melt (OPAM) and clinopyroxene-liquid geobarometric calculations indicate tapping of these magmas from distinct reservoirs: a primitive lower-crustal reservoir at ~15 km depth and a more evolved, shallower reservoir at ~7-9 km depth beneath the caldera, consistent with geophysical evidence for involvement of multiple magma reservoirs [e.g., 1]. Crucially, however, our data show that these reservoirs were often tapped simultaneously and without significant mixing or mingling of the two magma types. Diffusion modelling of Fe-Mg in clinopyroxene indicates that the primitive magma erupted in 1984, the final and largest eruption, rose from lower-crustal depths over just several months – well within the duration of the decade-long rifting event. These observations are not consistent with the widely accepted model that all eruptions were fed by lateral magma outflow from a single upper-crustal reservoir that was fed from deeper levels [e.g., 2], and instead require discrete magma supply pathways from the two reservoirs. Comparison of the Krafla Fires with other Icelandic rifting events and eruptions highlights the complexity and diversity of magma transport during plate boundary rifting events, which is not captured by any single generalizable model. Integration of petrologic, geochemical and geophysical data is crucial to provide a holistic view of future rifting events and processes of crustal accretion in Iceland and at other spreading centres.

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