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Shallow lateral magma migration or not during the Bárðarbunga 2014 activity and preceding the Flæðahraun eruption: the geochemical perspective.

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Basaltic fissure eruptions several tens of km away from central volcanoes in Iceland are interpreted to reflect either lateral magma migration from a shallow magma chamber beneath the central volcano, or vertical dyke propagation from deep magma reservoir underlying large part of the fissure swarm. During the Krafla Fires (1975-1984) basalts emitted within the caldera of the central volcano and far away out on the fissure swarm have different composition. During the subglacial eruption at Gjálp (1996), halfway between Grímsvötn and Bárdarbunga, the erupted magma had identical isotope ratios as that of the former but different from that of the latter, despite earthquake originating at Bárdarbunga and propagation towards the eruption site at Gjálp. These geochemical fingerprints have been taken to indicate that lateral magma migration over tens of km was an unlikely process.

The spectacular lateral migration of seismicity from 16 August to 29 August and associated ground deformation has been interpreted to reflect a lateral dyke injection over 45 km, from a shallow magma chamber beneath the Bárðarbunga central volcano to the eruption site forming the new Flæðahraun (Sigmundsson et al., 2015). The isotope ratio of Sr in Flæðahraun is identical to that of Holocene lavas and tephra produced at the Bárdarbunga Volcanic System confirming uniform Sr isotope ratios at a given volcanic system in Iceland. Thermodynamic equlibrium between mineral and magmatic liquid indicate that the first Flæðahraun olivine tholeiite originated from more than 10 km depth at a temperature of approximately 1180 °C. Basalt this hot is not likely to have been stored in a superficial magma chamber before migrating laterally at shallow depth over 40 km beneath a glacier covered surface.

Basalts crystallizing at variable depth should have different trace element composition caused by evolving crystallizing mineral assemblage, where plagioclase proportions should increase with decreasing depth. Enhanced plagioclase over olivine and clinopyroxene fractionation will decrease, respectively, the ratios Ni/Sr and Sc/Sr in the derived melt. The Flæðahraun parental magma is likely to have similar composition as the Kistufell primitive olivine tholeiite, which is thought to be close to a mantle melt (Breddam, 2002). The Ni/Sr decreases from 1.6-2.7 in Kistufell to 0.36 in Flæðahraun and Sc/Sr remains constant at 0.38, suggesting dominant olivine fractionation.

These results strongly suggest crystal fractionation at depth were plagioclase is not a dominant mineral phase, and thus contradicts the proposition of a shallow magma transfer during the 2014 Bárðarbunga rifting event.

Breddam, K., Kistufell: primitive melt from the Iceland mantle plume. J.Pet. 2002
Sigmundsson, F. et al., Segmented lateral dyke growth in a rifting event at Bárðarbunga volcanic system, Iceland. Nature 2015.