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Magma plumbing to the 2014-15 Holuhraun eruption, Iceland

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The 2014-15 Holuhraun fissure eruption on Iceland produced ca. 1.6 km^3 of lava, which ranks it as the largest Icelandic fissure eruption since the 1783 Laki event. The eruption was located within the Askja fissure swarm, but accompanied by caldera collapse in the Bárðarbunga central volcano 45 km to the southeast. Geophysical methods were used to monitor the eruption from the outset, and identified a seismic swarm linking Holuhraun to Bárðarbunga [1][2], implying that magma was transported laterally from beneath Bárðarbunga to the eventual eruption site at Holuhraun. In order to better understand this lateral connection between Bárðarbunga and Holuhraun, we present mineral textures and compositions, mineral-melt-equilibrium calculations, whole rock and trace element data, and oxygen-isotope ratios for selected Holuhraun samples.

Clinopyroxene-melt equilibrium thermobarometry applied to mineral-whole rock couples resulted in crystallization pressures between 26 MPa and 882 MPa, which corresponds to depths of 0.97 to 33 km. In contrast, plagioclase-groundmass equilibrium pairs resulted in crystallization pressures between 103 MPa and 165 MPa, or 3.8 to 6.1 km depth. Main crystallization peaks are found at 17-20 km depth, and 5 km depth, respectively. Major and trace element variation diagrams show that Holuhraun lavas are compositionally similar to lavas from the Bárðarbunga-Veiðivötn system and both are notably different to available data for Askja lavas. In terms of oxygen isotopes, the gabbro fragments range in their $\delta^{18}O$ values from 4.0 to 5.0 ‰ (standard delta notation), whereas the lavas show slightly higher $\delta^{18}O$ values between 4.4 and 5.4 ‰. The lava $\delta^{18}O$ values are relatively low and their observed spread from MORB values down to those typical of the gabbro fragments imply interaction between Holuhraun magmas and low $\delta^{18}O$ crystal mushes and/or partially crystallized chamber walls.

Our results show that the recent Holuhraun lavas are related geochemically to historical lavas from the Bárðarbunga system, and that they crystallized at multiple levels throughout the crust, likely in an inter-connected, multi-tiered magma plumbing system from ca. 29 to 5 km depth. We find evidence for magma mixing and assimilation of low $\delta^{18}O$ Icelandic crustal rocks, both of which would be facilitated by a complex plumbing system beneath a central volcano, such as Bárðarbunga.

References:

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