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Using geochemistry to unravel the dynamics of Icelandic volcanoes: results from recent monitoring studies of basaltic fissure eruptions

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The Icelandic rift system represents a key locality to unravel the details of basaltic fissure eruptions, which help develop magma transport models at divergent plate boundaries worldwide. Geochemical data tracking variations at individual volcanoes or even single eruptions in both space and time have become essential in the development of such models. Observations associated with the 2014–2015 Holuhraun eruption, and the 2021-2022 Fagradalsfjall eruptions – the best monitored basaltic fissure eruptions ever recorded – have resulted in two apparent end-member models of magma transport in Iceland.

Despite its long duration and relatively large volume, compositional heterogeneity of the Holuhraun lava was remarkably small over the course of the eruption. These observations suggest tapping from a well-mixed reservoir, inferred to be situated consistently at mid-crustal levels (8±5 km) [1]. In contrast, geochemical analyses of basalts erupted during the 2021 Fagradalsfjall eruption suggested sourcing from a Moho-level magma reservoir (17±3 km). During the first 50 days of the eruption, geochemical proxies, signifying different mantle compositions and melting conditions, changed at a rate unparalleled for basaltic eruptions globally. These results suggested sampling of dynamic melt lens environments close to the Moho [2]. On-going work targeting samples from the remainder of the 2021 and the 2022 eruptions further highlight the dynamics of this Moho-level magma processing zone [3][4].

Finally, our on-going efforts targeting a high-spatial-resolution sample set from the 1975-84 Krafla Fires have resulted in an even more complex, hybrid model that may involve both of the end-members discussed above. The earliest Krafla eruptions suggested that magma was transported laterally from an upper-crustal reservoir beneath the Krafla Caldera into the north/south fissure swarm [5]. However, detailed geochemical studies focusing on lavas from all events have been lacking and we are using lava chemistry to argue for tapping of multiple magma reservoirs situated at different levels throughout the crust [6].

[1] Halldórsson et al., (2018) *CMP* 173:64. [2] Halldórsson et al., (2022) *Nature* 609, 529–534. [3] Bali et al., (2023) this meeting. [4] Marshall et al., (2023) this meeting. [5] Björnsson et al., (1977) *Nature* 266, 318–322. [6] Rooyakkers et al., (2023) this meeting.