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Syn-eruptive magma plumbing dynamics of monogenetic lava shields in Iceland

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Monogenetic lava shields—gently sloping, conical lava mounds that erupted from a central vent—are some of the grandest expressions of basaltic magmatism in Iceland's volcanic rift zones, with volumes of single eruptions exceeding 10 km^3. Lava shield eruptions differ both compositionally (more variable, higher MgO) and dynamically (longer durations of up to decades, lower intensity) from the more frequent and more extensively studied fissure eruptions [1,2]. Moreover, many of Iceland's lava shields formed in the early Holocene, suggesting a causal link to the increase in magma production rates during deglaciation. The geodynamic conditions and magmatic supply chains that govern lava shield eruptions appear to be fundamentally different from fissure eruptions but remain poorly understood due to the scarcity of geochemically well-characterized eruptions.

We carry out a detailed geochemical case study of the mid-Holocene ~15 km^3 Trölladyngja lava shield in the Northern Rift Zone of Iceland (n = 44), and its nearest neighbouring fissure eruption, Fjallsendahraun (~1362 CE; n = 10). We present a comprehensive dataset comprising whole-rock, groundmass and glass major, trace element and radiogenic isotope data from the two eruptions. Compared to Fjallsendahraun and other Icelandic fissure eruptions, the Trölladyngja lavas show greater variability in terms of both crystal content (from aphyric to plagioclase-olivine-phyric) and major element compositions (MgO ≈ 7–12 wt.%). Similarly, the Trölladyngja lavas display a wider range of trace element (e.g., Nb/Zr) and isotopic (Sr-Nd-Hf-Pb) indicators of mantle source heterogeneity. Compiling regional data, we observe that the degree of major element variability appears to increase with eruption volume for Icelandic monogenetic lava shields, whereas their incompatible trace element variability is higher than fissure eruptions for all eruption sizes.

These observations indicate that Trölladyngja and other large-volume lava shield eruptions in Iceland are not fed from a single well-homogenized magma reservoir—a conventional model for fissure eruptions—but rather, involve variable entrainment of a mush pile and/or crystal cumulates and a dynamic plumbing system that experiences syn-eruptive recharge of mantle-derived melts.

References

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[2] Sinton et al. (2005) *G-cubed 6*, 12.