The making of monogenetic lava shields: a case study of the mid-Holocene Trölladyngja eruption, 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. Shield eruptions differ in several significant ways from the more frequent, and more extensively studied fissure eruptions. Lava shields are thought to form by lower intensity, but longer duration effusive eruptions than fissure eruptions, and tend to be compositionally more primitive (higher MgO) and variable (Sinton et al. 2005). Moreover, many of Iceland's lava shields formed in the early Holocene, suggesting a causal link to deglaciation and associated increase in magma production rates. These differences appear to require fundamentally different geodynamic conditions and magmatic supply chains governing lava shields and fissure eruptions (Eason & Sinton 2009). However, the details of how and why lava shield eruptions occur remain poorly understood due to the scarcity of geochemically well-characterized eruptions.

In this ongoing work, we investigate the formation of monogenetic lava shields by carrying out a detailed geochemical case study of the mid-Holocene ~15 km^3 Trölladyngja lava shield in the Northern Rift Zone of Iceland and its nearest neighbouring fissure eruption Fjallsendahraun (~1362 CE). We present a dataset comprising whole-rock major, trace element and Pb isotope data from 44 samples as which cover much of the spatial extent of Trölladyngja, as well as whole-rock and glass major and trace element data from tephras (n = 10) from the Fjallsendahraun craters. 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 (from primitive to moderately evolved basalts; MgO $\approx$ 7–12 wt.%). Similarly, the observed range in trace element (e.g., La/Sm, Nb/Zr) and Pb isotope ratios—that preserve signatures of mantle source, melting degree and magma mixing—suggest variable contributions from geochemically enriched and depleted mantle sources. Together, these observations indicate that the Trölladyngja eruption was not fed from a single well-homogenized magma reservoir—a conventional model for fissure eruptions—but rather, appears to involve variably evolved melts from a dynamic plumbing system that experiences recharge of mantle-derived primitive melts during the course of the eruption.

References

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