

The olivine-hosted melt-inclusion geochemistry of the 2021 and 2022 eruptions of Fagradalsfjall

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In 2021, Fagradalsfjall erupted, marking the end of 800 year volcanic inactivity of the Reykjanes Peninsula Volcanic Zone. The geochemical compositions of volcanic eruptions like these can be used to study melting of the mantle below Iceland, controlled by the mid-Atlantic spreading ridge and the Iceland mantle plume. The mantle is shown to be lithologically heterogeneous, but it is unknown to what spatial extent. The aim of this research is to better constrain the melting conditions, the nature of the source components and their contribution to melt generation below Fagradalsfjall by studying melt inclusions (MI) in high-Fo olivine (Fo₈₄₋₉₀ wt.%). For this purpose, we combine geochemical analyses and an analytical model.

We analysed the combined major- and trace element composition, Sr-Nd isotopes of MIs and Sr-Nd-Hf-Pb isotopes in five lavas from the May and September 2021 and August 2022 eruptions. We find that the olivines are antecrystic, and that their MIs are more mafic and show much larger geochemical variability compared to bulk lavas. The La/Sm and Nb/Zr of melt inclusions vary from depleted to enriched signatures (0.5-4.8 and 0.02-0.31, respectively) whereas our bulk lavas show a limited range (2.74-3.09 and 0.17-0.18) suggesting homogenisation during melt extraction and mixing in magma chambers. Significant differences are observed between the MI of the September 2021 and August 2022 flows, with 0.57-2.19 and 0.94-4.77 for La/Sm, and 0.02-0.14 and 0.12-0.20 for Nb/Zr respectively. Isotopic compositions of MIs match our bulk rocks for ¹⁴³Nd/¹⁴⁴Nd but are more enriched for ⁸⁷Sr/⁸⁶Sr. Compared to older Reykjanes eruptions, the whole rock ¹⁴³Nd/¹⁴⁴Nd are lower (0.512953-0.512989) but the ¹⁷⁶Hf/¹⁷⁷Hf are higher (0.283186-0.283192), suggesting a slightly different source. The melt-inclusions reveal an enriched (E-MORB) component and a D-MORB component melting separately and mixing to generate the lavas. Melt mixing and accumulation during melt extraction is constrained further using a polybaric melting model of a two component peridotite-pyroxenite source. A best fit is observed with a mixture of 97:3 peridotite:pyroxenite, where the peridotite component begins melting around 70km, reaching a degree of melting (DF) of 15%, and the pyroxenite reaches a DF of 25%, with melt initiation at 80km depth.