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Characterisation of rock samples collected on the 1st and 2nd days of the eruption - major elements and mineral chemistry

Petrographic features:

The rock is predominantly composed of vesicular glass formed by the quenching of a basaltic melt. It contains, in order of decreasing abundance, the following minerals: plagioclase > olivine > clinopyroxene > spinel (Sample 001, Fig. 1, spinel is not visible in these pictures). There are three size groups of crystals: larger macrocrysts, smaller microphenocrysts, and tiny microlites. The macrocrysts are generally 2-3 mm in width and 5 mm in length. All macrocrysts are zoned (see an example of plagioclase on Fig. 1c) with primitive cores and relatively more evolved rims. The evolved rims occasionally contain silicate melt inclusions. Microphenocrysts are generally homogeneous and euhedral. Microlites formed upon quenching (Fig. 1f) are finer grained and subhedral to euhedral.

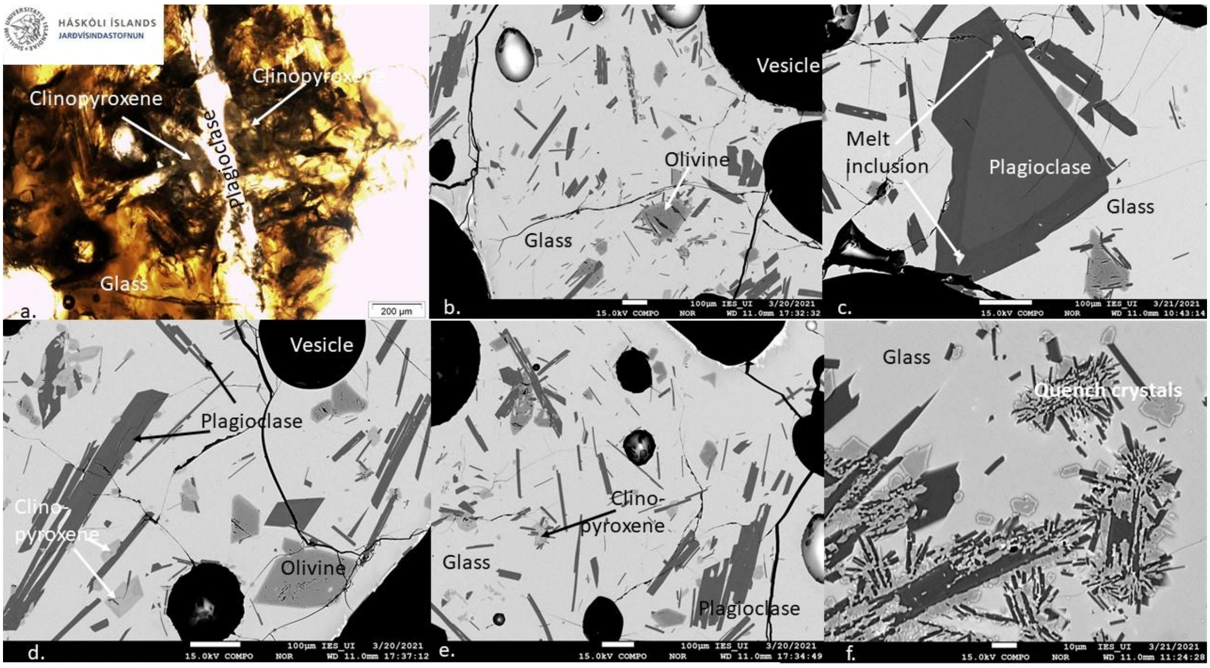

Fig. 1.: *Petrographic features of the quenched lava sample 20210320-001. a) Photomicrograph of a chip of basaltic glass with glomerocrysts of clinopyroxene and plagioclase. B) Back-scattered electron image of basaltic glass with microphenocrysts of olivine and plagioclase and microlites of plagioclase and clinopyroxene. C) Back-scattered electron image of a zoned plagioclase macrocryst with melt inclusions trapped in the outer zone of the crystal. d-e) Back-scattered electron image indicating intergrowth of plagioclase, clinopyroxene and olivine. f) Back-scattered electron image of quench pyroxene and plagioclase.*

Chemical composition:

The ***groundmass glass*** is a primitive tholeiitic basalt with an average mg# of 54. When compared to glass samples from the 9th to the 13th century Reykjanes Fires (comparative data from Caracciolo et al., in prep), this glass is clearly distinct with its low TiO_2 (Fig. 2), K_2O, and P_2O_5 (not shown) contents.

Bulk rock has an olivine tholeiite composition with an average mg# of 60.1 with lower TiO_2 and K_2O contents than the groundmass glass. In comparison with bulk rock samples from historical eruptions on the Reykjanes Peninsula, the new lava clearly reveals lower TiO_2 contents for any given MgO content (Fig. 3), highlighting its primitive nature. Moreover, the bulk rock measurements lie at the primitive end of the spectrum of magmas that have erupted on the Peninsula over the Holocene (Note that cumulative picrites are excluded from this plot).

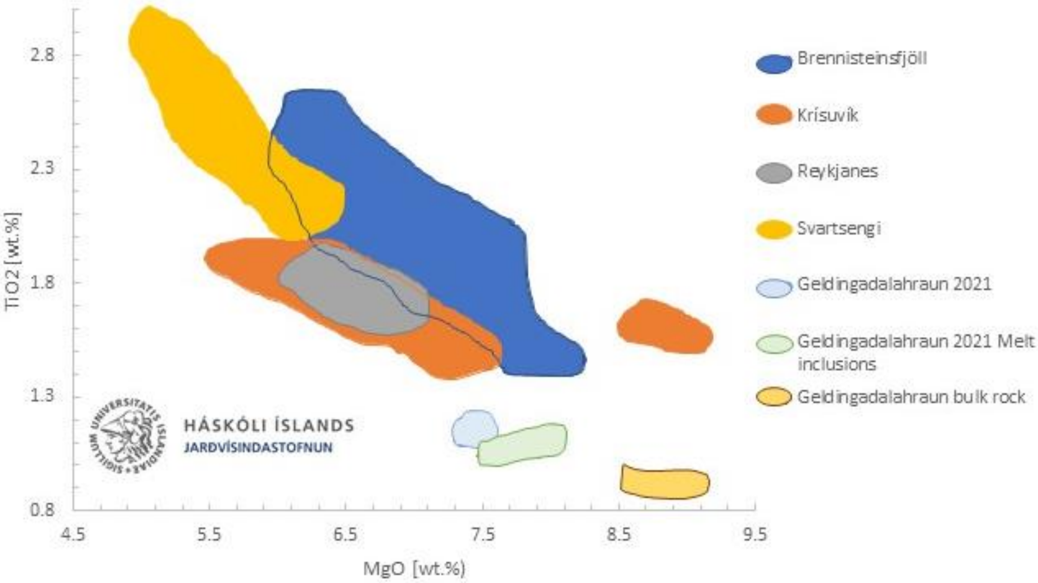

Fig. 2: *Comparison of silicate glass compositions (groundmass glass and melt inclusions) of the quenched lava sample 20210320-001 (Geldingadalahraun 2021) to those erupted during the 9th to 13th century Reykjanes Fires (Caracciolo et al. in prep). Note the distinctly low TiO2 contents of the new lava.*

The chemical composition of the various macrocrysts were also determined. Olivine compositions range between forsterite 85.1 (in the cores) to 81.8 (in the rims). Plagioclase compositions varies in anorthite contents from 86 (analysed in the macrocryst cores) to 77 (in macrocryst rims and microphenocrysts). Clinopyroxene is augitic in composition and has mg#'s up to 87.3 and Cr_2O_3 up to 1.33 wt%.

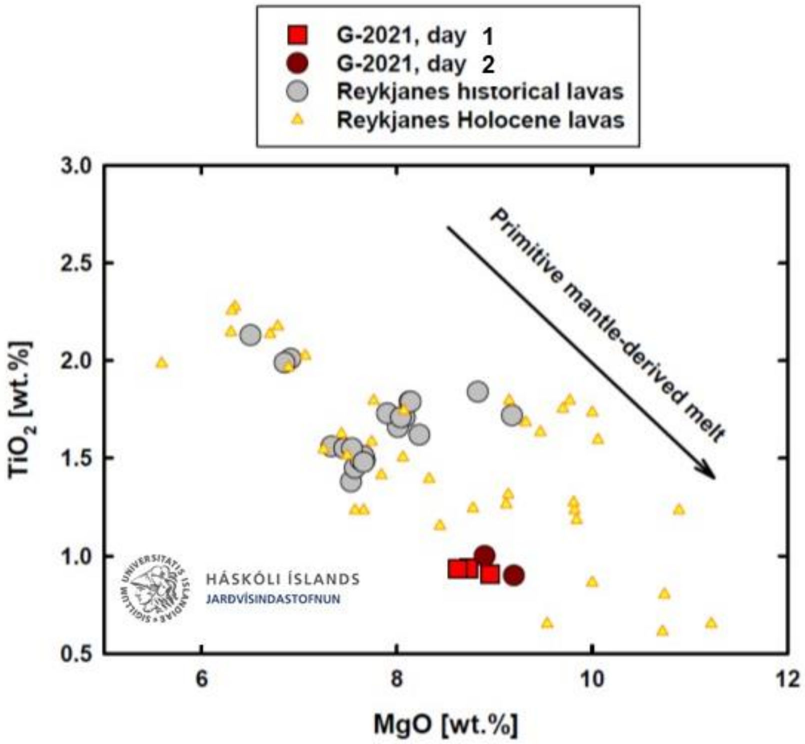

Fig. 3: *Same figure as above but with bulk rock compositions. Historical flows are from Peate et al. (2009) and Holocene flows from Jakobsson et al. (1978) and Gee et al. (1998).*

Preliminary results on thermobarometry

The eruption temperature was calculated based on various liquid and mineral-liquid thermometers (Putirka, 2008). All thermometers give consistent results of a melt temperature between 1180-1190 °C. This is approximately 20 °C hotter than the eruption temperatures found for Holuhraun (Halldórsson et al. 2018). The last equilibration pressure of the magma and its crystal cargo before the eruption can be calculated based on the clinopyroxene-melt (Neave and Putirka, 2017) and olivine-augite-plagioclase-melt (OPAM) (Yang et al. 1991, Hartley et al. 2018) geobarometers. These methods give an equilibration pressure of 0.2 to 0.8 kbar, consistent with the magma being stored in a shallow (0.5 to 2 km depth) dyke before eruption. We note that the calibration uncertainty of both geobarometry methods is ±1.3-1.4 kbar, but we obtained consistent pressures from multiple analyses and our calculations are consistent with the results of ground deformation (https://en.vedur.is/about-imo/news/earthquake-swarm-in-reykjanes-peninsula).

The variation in bulk rock and glass compositions is consistent with the crystallization of the observed mineral phases (at various depths) from the host magma. Hence, we calculated a magma temperature and magma storage depth for the primitive liquid composition represented by the whole rock samples. OPAM (Hartley et al. 2018) calculations indicate that the bulk rock compositions represent a liquid on the 4-phase cotectic (probability fit of 0.97 to 1). The calculated pressures are in the range of 5.2-5.8 kbar, which corresponds to a depth of 14-16 km. This pressure is to be confirmed by other methods, however, it indicates that the shallow dyke is fed by a magma storage horizon close to the crust-mantle boundary which is located at about 15 km underneath the Peninsula (Brandsdóttir, personal communication).

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Volatile contents and implications for volatile outgassing:

S and Cl contents were analysed both in the degassed groundmass glass and in several silicate glass inclusions (e.g.: Fig. 1c). The Cl contents in the groundmass glass and melt inclusions are indistinguishable. Therefore, no significant magmatic Cl is expected in the eruption plume. On the other hand, S content in the melt inclusions is much higher (1140 ppm on average) compared to that of the groundmass glass (250 ppm on average), suggesting a significant S release at the vent and from the lava flow.

References:

Gee et al. (1998) Journal of Petrology, 39/5, 819–839.
Halldórsson et al. (2018) Contributions to Mineralogy and Petrology 173, Article number: 64
Hartley et al. (2018) Contributions to Mineralogy and Petrology 173, Article number: 10
Jakobsson et al. (1978) Journal of Petrology, 19/4, 669–705.
Neave and Putirka (2017) American Mineralogist 102/4, 777-794.
Peate et al. (2009) Contributions to Mineralogy and Petrology, 157, 359–382.
Putirka (2008) Reviews in Mineralogy and Geochemistry 69/1, 61-120.
Yang et al. (1991) Contributions to Mineralogy and Petrology 124, 1–18