Mid-crustal storage and crystallization of Eyjafjallajökull ankaramites, South Iceland

Paavo Nikkola[1,2,*], Enikő Bali[2,3], Maren Kahl[4], Quinten H. A. van der Meer[2], O. Tapani Rämö[1], Guðmundur H. Guðfinnsson[2], and Thorvaldur Thordarson[3]

[1]*Department of Geosciences and Geography, Geology and Geophysics Research Group, P.O. Box 64, FI-00014 University of Helsinki, Finland*

[2]*Nordic Volcanological Center, Institute of Earth Sciences, University of Iceland, Sturlugata 7, 101 Reykjavík, Iceland*

[3]*Faculty of Earth Sciences, University of Iceland, Sturlugata 7, 101 Reykjavík, Iceland*

[4]*Institut für Geowissenschaften, Universität Heidelberg, Im Neuenheimer Feld 234-236, 69120 Heidelberg, Germany*

[*]*Correspondence: paavo.nikkola@helsinki.fi* https://doi.org/10.33799/jokull2019.69.083

Abstract — *Our understanding of the long-term intrusive and eruptive behaviour of volcanic systems is hampered by a relatively short period of direct observation. To probe the conditions of crustal magma storage below South Iceland, we have analysed compositions of minerals, mineral zoning patterns, and melt inclusions from two Eyjafjallajökull ankaramites located at Brattaskjól and Hvammsmúli. These two units are rich in compositionally diverse macrocrysts, including the most magnesian olivine (Fo_{88-90}) and clinopyroxene ($Mg\#_{cpx}$ 89.8) known from Eyjafjallajökull. Olivine-hosted spinel inclusions have high $Cr\#_{spl}$ (52–80) and TiO_2 (1–3 wt%) and low Al_2O_3 (8–22 wt%) compared to typical Icelandic chromian spinel. The spinel-olivine oxybarometer implies a moderate oxygen fugacity of ΔlogFMQ 0–0.5 at the time of crystallization, and clinopyroxene-liquid thermobarometry crystallization at mid-crustal pressures (1.7–4.2 kbar, 3.0$\pm$1.4 kbar on average) at 1120–1195°C. Liquid-only thermometry for melt inclusions with $Mg\#_{melt}$ 56.1–68.5 and olivine-liquid thermometry for olivine macrocrysts with $Fo_{80.7-88.9}$ yield crystallization temperatures of 1155–1222°C and 1136–1213°C, respectively. Diffusion modelling of compositional zonations in the Brattaskjól olivine grains imply that the Brattaskjól macrocrysts were mobilized and transported to the surface from their mid-crustal storage within a few weeks (at most in 9–37 days). Trends in clinopyroxene macrocryst compositions and the scarcity of plagioclase indicate that the mid-crustal cotectic assemblage was olivine and clinopyroxene, with plagioclase joining the fractionating mineral assemblage later. In all, the crystal cargoes in the Brattaskjól and Hvammsmúli ankaramites are composed of agitated wehrlitic or plagioclase wehrlitic crystal mushes that crystallized over a large temperature interval at mid-crustal depths.*

INTRODUCTION

In South Iceland, at the southern tip of the Eastern Volcanic Zone (SEVZ), magmatism occurs outside the main zone of plate spreading in three volcanic systems: Eyjafjallajökull, Katla, and Vestmannaeyjar. The SEVZ is the most recently activated volcanic zone in Iceland (younger than 3 Ma; Martin *et al.*, 2011), where mantle-derived magmas intrude relatively cold oceanic crust (Flóvenz and Saemundsson, 1993). Magma batches fractionate comparatively fast under these conditions, as indicated by U-series disequilibria (Sigmarsson, 1996) and the absence of equilibrium phenocryst assemblages (Mattsson and Oskarsson, 2005) in erupted lavas. In Vestmannaeyjar, the mantle-derived melts have been envisioned to evolve in the crust in isolated, small magma reservoirs over a large depth range (Furman *et al.*, 1991; Mattsson and Oskarsson, 2005). Seismic, geodetic and petrogenetic studies of the Eyjafjallajökull 2010 eruption have highlighted a multi-tier volcanic plumb-