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Determining intensive parameters through clinopyroxene-liquid equilibrium in Grímsvötn 2011 and Bárðarbunga 2014 basalts.

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Pressure (P) and temperature (T) at which magma is stored before eruption are parameters needed for better understanding of pre-eruptive signals. Putirka (2008) reviewed various igneous geothermobarometers based on crystal-liquid equilibrium. These allow evaluating early melt inclusion (MI) entrapment conditions and final crystal-matrix glass P-T equilibrium conditions. In this study, the former is based on clinopyroxene (cpx)-hosted MI and cpx-host measurements, whereas the latter is estimated from analyses of crystal rims and adjacent matrix glass. Olivine (ol)-liquid equilibrium is rapidly attained and records the last thermal equilibrium before basalt eruptions. In contrast, more sluggish reaction between cpx and liquid makes MI in cpx cores the choice for estimating the deepest (and hottest) crystal-liquid equilibrium. Equilibrium criteria were evaluated from the apparent Fe-Mg exchange and textural relationships.

Tephra erupted at Grímsvötn central volcano 2011 is of quartz tholeiite composition whereas the 2014 tephra from Bárðarbunga volcanic system is a more primitive olivine tholeiite. These two basalt types are the most common in Iceland and form a crust with estimated density of 2800 kg/m3. Both basalts contain approximately 1-5% phenocrysts of plagioclases, cpx and ol with sparse sulphides and, in the Grímsvötn case, ubiquitous FeTi-oxides. The geothermobarometers suggest that cpx crystallized at P from 60 to 620 MPa (depth range: 1.7-17 km) and T between 1030 and 1135 °C before the Grímsvötn 2011 eruption. In marked contrast, the Bárðarbunga ol-tholeiite crystallized at higher P from 410 to 660 MPa (depth range: 11-18 km) at restricted T of 1176 to 1182 °C.

The shallowest recorded crystallization depth at Grímsvötn coincides with geophysical depth estimates of its high-level magma chamber (1.8 km; Hreinsdóttir et al., 2014), whereas the deepest crystallization is within error of the estimated mantle-crust boundary, as also observed for the 2014 Bárðarbunga activity (close to 20 km). However, the shallowest crystallization of the ol-tholeiite occurred at approximately 10 km, an order of magnitude deeper than beneath the Grímsvötn central volcano. Moreover, the T at which this deep crystallization took place is approximately 150 °C higher. The geothermobarometric study strongly suggests that the 2014 basalt did not equilibrate in a high-level magma chamber beneath Bárðarbunga and, thus, was not fed laterally shallow in the crust to the eruption site, but rather stalled at approximately 10 km depth before the eruption.

References:
Putirka K.D. (2008). Thermometers and barometers for volcanic systems. In: Putirka, K. D. & Tepley, F. J. (eds.) Minerals, Inclusions, and Volcanic Processes. Rev. Mineral. Geochem. 69, 61-120.
Hreinsdóttir S. et al. (2014). Volcanic plume height correlated with magma-pressure change at Grímsvötn volcano, Iceland. Nature Geoscience 7, 214-218.