Introduction

Subglacial rhyolitic edifices have a wide spectrum of sizes, morphologies and interfaces (Figs. 1-3), reflecting various eruptive styles and degrees of explosivity. However, a subglacial rhyolitic eruption has never been observed and so the controlling factors on eruptive behaviour are poorly understood. During subaerial eruptions, volcanoes are thought to be a key factor in determining eruptive style with (a) a pre-explosive H2O and CO2 content and (b) closed system degassing, leading to more explosive volcanoes. During subglacial eruptions, explosivity is at least partly determined by the degree of magma-water interaction. Lab-based studies suggest that the presence of bubbles may hinder phreatomagmatic explosions. This would imply that, contrary to subaerial eruptions, subglacial eruptions favour volatile-poor magma for explosive activity.

Dalvikví (mixed behaviour)

Geological background

All of our samples were collected from the Torfajökull central volcano in South-Iceland (Fig. 4). We sampled from three edifices: Bláhnúkur (Fig. 1), Dalvíkví (Fig. 2) and SE Rauðfossafjöll (Fig. 3) that erupted with effusive, mixed and explosive behaviour respectively. They all have similar major element chemistry and erupted under similar interval thicknesses (20-40 km). See paper on reprocessing palaeo-ice thicknesses (XL56: Edinger et al. 2016). Do volcanoes provide an explanation for their contrasting styles?

Method

Volcanic concentrations were measured using the Ion Microprobe Facility at the University of Edinburgh. We probed matrix glass, as well as melt inclusions to determine the pre- and pre-explosive volatile contents respectively. We applied formulae to model open and closed system degassing and also looked at vesicle and microlite textures as these also shed light on degassing paths.

Results: Pre-explosive volatile content

Ion probe data indicates that explosively produced samples have a higher pre-explosive water content (Fig 5a, 5b) than effusively produced samples (Fig. 5a, 5b). These values (up to 5.4 wt%) are significantly higher than the expected values for Icelandic rhyolite, which is discussed in the literature as being 1-2 wt%.

Water-poor matrix glass (Fig. 5) suggests that the water-richness of melt inclusion is not due to hydration.

Our results show that as well as being water-rich, explosive samples are also Cl-poor. Whereas the opposite is true for effusive samples (Fig. 6). This could reflect differences in degassing paths.

Discussion: Degassing paths

Modelled open and closed system degassing paths have been compared with H2O-Cl relationships but no significant distinction was found (Fig. 6). However, effusive samples require a much higher (900 ppm) Cl distribution coefficient (DCl) than explosive samples (350).

Increases in DCl can occur due to melt growth. Geochemical data shows that for the effusively erupted Bláhnúkur, there is a significant difference between melt inclusion and matrix glass data (Fig. 7), which could be attributed to melt growth, but for the more explosively erupted Dalvíkví, there has been little change in chemistry.

Conclusion

Our data suggests that explosive subglacial rhyolitic eruptions are associated with high pre-explosive water contents and closed system degassing whereas effusive eruptions have low pre-explosive water contents and open system degassing.

Thus it seems that during subglacial rhyolitic eruptions, volcanoes play a similar role as they do in subaerial eruptions i.e. the presence of ice has little effect on the role of volcanoes.

Our data shows that Icelandic rhyolite may be significantly more water-rich than previously thought, and this provides a recipe for highly explosive activity.

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References


Bláhnúkur (effusive)

Dalvíkví (mixed behaviour)

SE Rauðfossafjöll (explosive)