Reviewed research article

Magma degassing in the effusive-explosive subglacial rhyolitic eruption at Dalakvísl, Torfajökull, Iceland: insights into quenching pressures, palaeo-ice thickness, and edifice erosion

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Abstract — *Dissolved volatile contents preserved in the matrix glass of subglacially erupted rocks offer important insights into quenching pressures. With careful interpretation, these data may yield information on eruption conditions. In this paper we present detailed edifice and glacier reconstructions for explosive and effusive subglacial rhyolitic deposits at Dalakvísl, Torfajökull, Iceland. When grouped by lithofacies, Dalakvísl glasses display trends of decreasing H_2O with elevation, consistent with a subglacial setting. A number of solubility pressure curves (SPCs) have been used to model these quenching pressure–elevation trends in order to reconstruct the loading conditions. Effusively erupted glasses (e.g. lava lobes) have higher dissolved water contents than the more explosively produced material (e.g. obsidian sheets), indicating a systematic difference in subglacial pressure and/or degassing behaviour. Best model fits to data are achieved when loading is by a combination of erupted deposits (with a flat-topped morphology) and ice/meltwater. Our best estimate for the original edifice summit elevation is ∼810 m a.s.l., similar to its current elevation; however, as the edifice is now more conical this indicates significant post-eruptive erosion around the margins of the edifice. We propose that during the initial stages of the eruption, meltwater could not escape, thus maintaining high subglacial pressure under which effusive lava bodies were produced intrusively. Our best estimate is that the original palaeo-ice surface was ∼1,020 m a.s.l., suggesting a syn-eruptive glacier thickness of ∼350 m, assuming a similar base level to today (∼670 m a.s.l.). A sudden release of meltwater then led to a pressure drop, driving a transition to more explosive activity with an ice surface over the vent closer to 880 m a.s.l. This study demonstrates the uses of dissolved volatile contents in reconstructing past environments and shows how eruption dynamics can be tracked over the timeline of a pre-historic eruption, offering valuable insight into the complex coupling between pressure and the mechanisms of subglacial eruptions. Keywords; subglacial rhyolite, explosive-effusive transition, water solubility, infra-red spectroscopy, volcano-ice interactions.*

INTRODUCTION

Although eyewitness accounts and monitoring of recent eruptions are perhaps the greatest source of accurate data, capturing such accounts can be difficult to achieve, especially for subglacial settings. Firstly, subglacial volcanoes can be extremely explosive due to violent fuel-coolant interactions and are therefore dangerous to monitor (Duncan *et al.*, 1986; Mastin *et al.*, 2004; Stevenson *et al.*, 2011). Secondly, some, if not all, of the deposits will be obscured by the glacier (Tómasson, 1996; Owen, 2016). Thirdly, a subglacial rhyolite eruption has never been observed (Guðmundsson, 2003; Tuffen *et al.*, 2008). Therefore, in order to understand subglacial rhyolitic volcanism, we need to turn to past eruptions (Owen, 2016).

This paper focuses on an unnamed hill in South Iceland that shows a huge variety of subglacial rhyolitic deposits, some of which are highly unusual.