Reviewed research article

The 1845–46 and 1766–68 eruptions at Hekla volcano: new lava volume estimates, historical accounts and emplacement dynamics

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Abstract — *We use new remote sensing data, historical reports, petrology and estimates of viscosity based on geochemical data to illuminate the lava emplacement flow-lines and vent structure changes of the summit ridge of Hekla during the large eruptions of 1845–46 and 1766–68. Based on the planimetric method we estimate the bulk volumes of these eruptions close to 0.4 km^3 and 0.7 km^3, respectively. However, comparison with volume estimates from the well-recorded 1947–48 eruption, indicates that the planimetric method appears to underestimate the lava bulk volumes by 40–60%. Hence, the true bulk volumes are more likely 0.5–0.6 km^3 and 1.0–1.2 km^3, respectively. Estimated melt viscosity averages for the 1766–68 eruption amount to 2.5 $\times$ 10^2 Pa s (pre-eruptive) and 2.5$\times$10^3 Pa s (degassed), and for the 1845–46 eruption 2.2$\times$10^2 Pa s (pre-eruptive) and 1.9$\times$10^3 Pa s (degassed). Pre-eruptive magmas are about one order of magnitude more fluid than degassed magmas. In the 1845–46 and 1947–48 eruptions, SiO_2 decreased from 58–57 to 55–54 wt% agreeing with a conventional model that Hekla erupts from a large, layered magma chamber with the most evolved (silica-rich) magmas at the top. In contrast, the lava-flows from 1766–68 reveal a more complicated SiO_2 trend. The lava fields emplaced in 1766 to the south have SiO_2 values 54.9–56.5%, while the Hringlandahraun lava-flow that erupted from younger vents on the NE end of the Hekla ridge in March 1767 has higher SiO_2 of 57.8%. This shows that the layered magma chamber model is not suitable for all lava-flows emplaced during Hekla eruptions.*

INTRODUCTION

The Hekla volcano is one of the four most active volcanic systems in Iceland, having erupted about 23 times since the settlement of Iceland in the year 874 (Thórarinsson, 1967; Thordarson and Larsen, 2007; Höskuldsson *et al.*, 2007; Pedersen *et al.*, 2018a,b). Hekla therefore presents one of the major volcanic hazards of Iceland (Einarsson, 2018; Barsotti *et al.*, 2019). So far, the older historical eruptions have mainly been studied from literary sources in combination with tephra chronology, which provides a great record of the explosive activity and its related hazards (Thórarinsson, 1967; Sverrisdottir, 2007; Gudnason *et al.*, 2017, 2018; Janebo *et al.*, 2016a,b, 2018). Hekla eruptions generally start with subplinian to plinian explosive eruption plumes up to 12–36 km high (Thorarinsson, 1967; Höskuldsson *et al.*, 2007), and typically gives no to little warning (Grönvold *et al.*, 1983; Soosalu *et al.*, 2003; Einarsson, 2018). This makes future Hekla eruptions hazardous for air traffic, especially since one of the busiest air traffic corridors in the world runs straight over Hekla (Soosalu *et al.*,