KECK Geology Consortium
Learning Science Through Research
Published by Keck Geology Consortium
Short Contributions
30th Annual Symposium Volume
29th April, 2017
ISBN: 1528-7491

EXAMINING THE EMPLACEMENT HISTORY OF A ROOTLESS CONE COMPLEX ASSOCIATED WITH THE LAKI VOLCANIC FIELD

ANNY SAINVIL, Smith College
Research Advisors: Professor Mark Brandriss, Professor Robert Newton

INTRODUCTION

The Laki eruption of 1783-1784 in southern Iceland is responsible for the release of 15.1 ± 1.0 km^3 of magma, consisting of 14.7 km3 of lava and 0.4 km^3 of tephra material. The eruption expanded into a 27-kilometer-long, northeast-trending fissure, creating lava flows that covered 599 km^2 (Thordarson and Self, 1993), making this one of the largest eruptions in history. The eruption occurred on the Eastern volcanic zone of Iceland as part of the Grimsvotn volcanic system and resulted in the opening of 140 vents (Guilbaud et al., 2005). The eruption also led to the formation of several volcanic rootless cone complexes in the area (Guilbaud et al., 2005). Rootless cones are formed by hydromagmatic eruptions caused by explosive interactions between molten lava and water-saturated substrate, and represent volcanic vents that have lateral feeders which are the lava tubes of flows. Typical rootless cones have funnel-shaped conduits and terminate in bowl-shaped craters. Younger cones can overlap and conceal older cones. The most important identifying feature of a rootless cone is the distinctive internal layering that shows that each cone was built from multiple explosions during a period of sustained activity.

The purpose of this project was to examine and map volcanic features such as lava flows and rootless cone complexes to the south of one of the Laki fissure segments, in order to better understand the evolution of the landscape. I used Digital Terrain Models (DTMs), detailed field observations, and field photos to map the various volcanic morphologies of the area and formulate a chronologic interpretation of the volcanic features and processes associated with a large tephra cone structure near Leidolfsfell. My research determined that the large cone is probably an amalgamation of tephra that erupted from a large number of rootless cone vents, which have since been buried by flows or additional tephra and are therefore not visible in the present-day terrain.

METHODS

My fieldwork was done during several days of the four-week Keck Geology Iceland tephrastratigraphy project in the summer of 2016. Field photographs and observations of textures and landscape features were collected in addition to GPS locations of specific focus

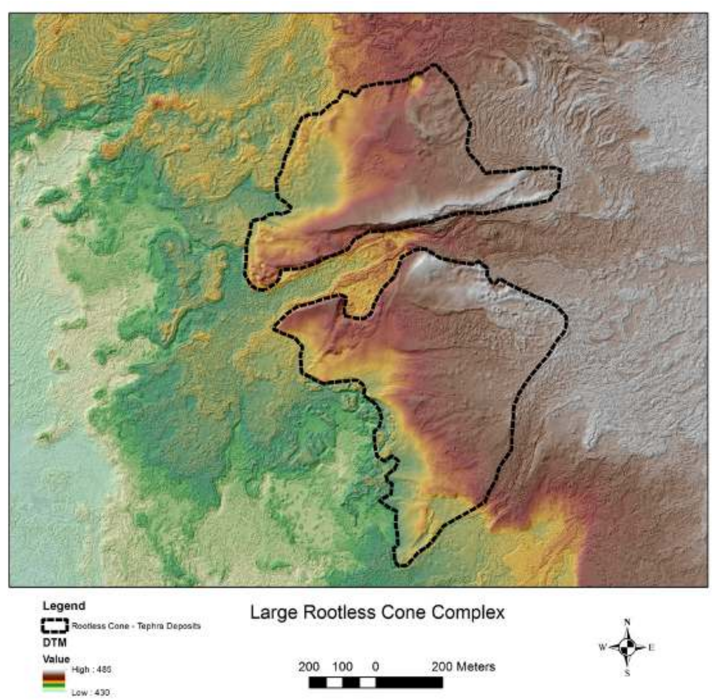

Figure 1: Digital terrain map (DTM) of the field area south of the Laki fissure. The central ridge is outlined with dashed black lines.

Figure 2: Field photographs showing typical examples of the four volcanic features that were mapped (tumuli, lava flows, rootless cone craters, and smooth tephra deposits).

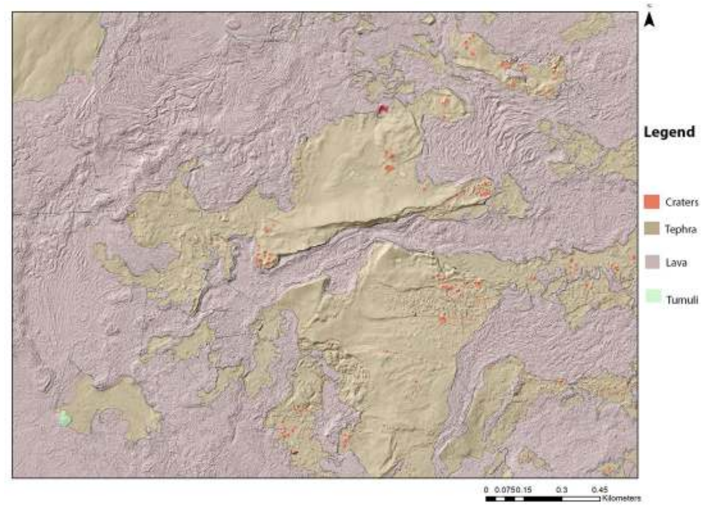

Figure 3: Map of volcanic features, superimposed on the digital terrain map.

areas. A UX5 plane was used to collect elevation data for a digital terrain map of an area of approximately 2 km x 2 km (Fig. 1). I used field observations and field photographs, together with the digital terrain data and ArcGIS software, to formulate key criteria for recognizing various types of volcanic features and to plot them on a terrain map of the area. This map will be a helpful tool for researchers who study this area in the future, as well as for understanding the formation and evolution of the unusually large rootless tephra feature.

RESULTS

The most prominent topographic feature in the area is a ridge about a kilometer long and up to ~30 m high, with a deep valley running down its center (Fig. 1). In the entire area, four distinctive types of volcanic features were selected for mapping: tumuli, rootless cone craters, smooth tephra, and lava flows. Field photographs of typical examples of these features are shown in Figure 2, and their distributions are shown on the map in Figure 3.

DISCUSSION

Much of the mapped area was probably covered by early lavas that are now covered by tephra and later lava flows. On top of these early lavas, 596 rootless cone craters of varying sizes were identified and mapped based on the digital terrain model. These cones range from a few meters to approximately 30 meters in diameter, and are nearly all in areas of smooth tephra deposits. Smooth tephra deposits also cover the main ridge, and other areas of smooth tephra are scattered across the map. The large tephra-covered ridge in the center of the area is cut in two by a valley up to ~30 m deep, with a lava flow in the bottom that flowed through the valley from east to west (Fig. 4). The discontinuity of the individual tephra layers exposed in the walls of the valley (the "tephra cliffs" in Figure 4) suggest that the large ridge is composed of at least several distinct tephra cone deposits that were created by multiple rootless cones, and does not represent the deposits from a single rootless cone eruption. In general, the smooth tephra layers are older than the mapped lava flows, as seen in Figure 4 and also in Figure 5, in which lava is clearly seen to have flowed into an existing rootless cone crater that was previously covered by tephra.

The large amount of tephra on the large central ridge most likely formed by deposition from numerous rootless vents that were formerly located on the lava flow in the main channel, based on the observation that the tephra thickness is greatest along the flow margins. These vents have since been either carried away or buried by the flowing lava. Tephra deposited in association with one major rootless cone explosion typically exhibits radial symmetry, so the more complex morphology of this large feature was likely caused by overlapping tephra deposits from multiple eruptions (Hamilton et al., 2010). It is difficult, however, to explain how the ground surface beneath

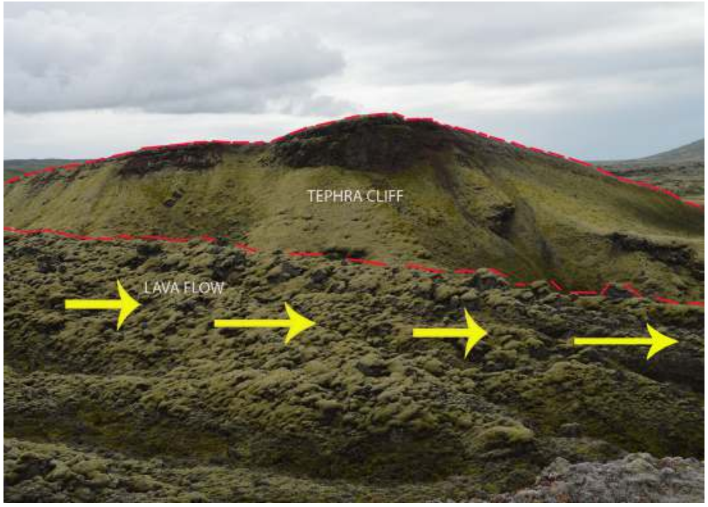

Figure 4: Tephra cliff that forms half of the divided main ridge in the center of the map area; the lava flow that fills the central channel is visible in the foreground. Arrows point in the direction of flow. Note the discontinuous nature of tephra layers exposed in the cliff.

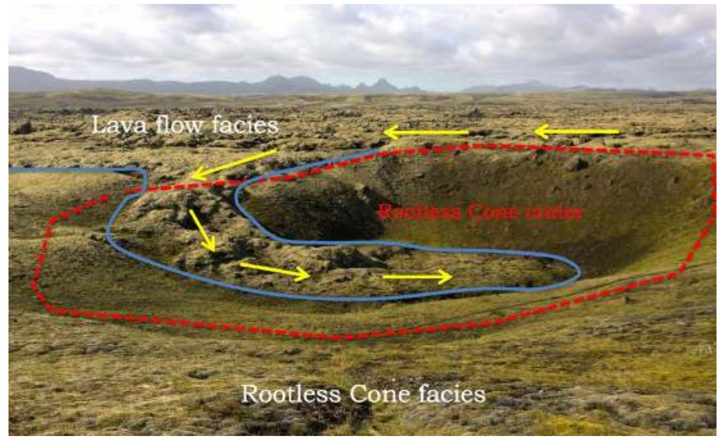

Figure 5: A rootless cone in an area of smooth tephra, with a younger lava flowing into the crater.

this particular lava channel would have maintained a sufficient supply of water to create such a large tephra volume. The smaller clusters of rootless craters show radial symmetry, and are presumably linked to low-lying areas that had less water to drive explosive activity. Examination of tephra stratigraphy in the deposits on the large tephra ridge would help to evaluate the hypothesis that they formed from repeated explosive events in the lava channel. In addition to a general stratigraphic analysis, looking at the dispersal of tephra sizes along the slopes of the tephra ridge could help determine whether the size distribution is consistent with the central flow being the tephra source, and help to evaluate the water to lava ratios associated with creation of this feature.

CONCLUSION

Rootless cones provide important indicators of paleo-environment. Based on detailed examination of the digital terrain model for this map area, the high topographic feature in the center of the area may represent ridges of tephra that were erupted from the lava flow that occupies the central channel. Cross cutting relationships show lavas flowing into rootless cone craters, indicating that the cones formed prior to emplacement of the final flows. In view of the fact that all of the 596 distinct cones that I identified were small, and formed in distinct clusters, it seems unlikely that the large topographic feature represents a massive rootless cone formed by a single eruptive event. Based on the distribution of tephra deposits and smaller craters, I conclude that the large feature is a composite rootless cone complex formed from many associated vents.

In the future, incorporating crustal thickness of the lava to examine the chronology of the various features would be helpful. In previous studies focused on Hawaiian sheet flows, Hon et al. (1994) found that the thickness of the crust is proportional to the square root of the time during which fluid lava is supplied to the center of the flow. Prolonged flow of lava into a continuously wet, low-lying area of the landscape would be necessary in order to produce the large amount of tephra that forms the prominent topographic ridge in my area. At Laki, hundreds of upper crustal thickness measurements were taken through the main channel, which could help to improve our understanding of the emplacement history of flows, rootless cones, and the large central tephra deposit in the mapped area.

ACKNOWLEDGEMENT OF SUPPORT

This report is based upon work supported by the National Science Foundation under Grant No.

(NSF-REU #1358987). Special thanks to Krystina Lincoln and Lucas Zeller for their tremendous help in the field and to my home advisors at Smith College.

REFERENCES CITED

Hamilton, C.W., Thordarson, T., and Fagents, S.A., 2010, Explosive lava-water interactions I: Architecture and emplacement chronology of volcanic rootless cone groups in the 1783-1784 Laki lava flow, Iceland: Bulletin of Volcanology, v. 72, p. 449–467, doi: 10.1007/s00445-009-0330-6.

Guilbaud, M.-N., Self, S., Thordarson, T., and Blake, S., 2005, Morphology, surface structures, and emplacement of lavas produced by Laki, A.D. 1783 – 1784, in Manga, M., and Ventura, G., eds, Kinematics and dynamics of lava flows: GSA Special Papers, v. 396, p. 81–102, doi: 10.1130/2005.2396(07).

Hon, K., Kauahikaua, J., Denlinger, R., and Mackay, K., 1994, Emplacement and inflation of pahoehoe sheet flows: observations and measurements of active lava flows on Kilauea volcano, Hawaii: Geological Society of America Bulletin, v. 106, p. 351–370, doi: 10.1130/0016-7606(1994)106<0351:EAIOPS>2.3.CO;2.

Thordarson, T., and Self, S., 1993, The Laki (Skaftár Fires) and Grímsvötn eruptions in 1783–1785: Bulletin of Volcanology, v. 55, p. 233–263, doi: 10.1007/BF00624353.