Award Date: June 6, 2018 (extended to 2019)
Lewis & Clark Fund for Exploration & Field Research in Astrobiology
Dhaliwal, Jasmeet Kaur

A field work & geochemical study of Holuhraun volcano as an analog for hydrothermal vents and martian volcanism

Project Report

The focus of this project was to visit the 2014 – 2015 Holuhraun lava flow, with the two objectives of sampling across the lava flow, and sampling along the lava-water interface, where the Holuhraun eruption encountered the Jökulsá á Fjöllum river. This field trip was planned in collaboration with Saemunder Haldorrsson and Eniko Bali at the Nordic Volcanological Institute at the University of Iceland (UI), who acquired the permits necessary for the field team to sample in the Holuhraun lava field (which is part of the Vatnajokull National Park). The team also included UI graduate students, postdoctoral scholars, and visiting scientists, as well as colleagues from the U. of Manchester and UC Santa Barbara. The Icelandic team members ensured that we were able to conduct field work in the Central Highlands (where Holuhraun is located), including driving on 4x4 roads. In addition to the Holuhraun site, this field trip also included visits to Askja, Hrimalda and Kverkfjöll. The major challenge of this trip was the size of the Jökulsá á Fjöllum river at the time of the field work. As the river was too rapid to approach the lava-river interface, we focused on the interface of the lava and the glacial flood plain, which is a more episodic and typically calmer source of water.

Following the main field work, a subset of the team hiked for 5-days across the Rejkjanes peninsula to observe the lavas formed along the western rift. The purpose of this trip was to observe and contrast the western rift zone to the eastern rift zone; both of these volcanic provinces continue to contribute to the ongoing formation of Iceland, and the interactions between lava and water (or ice).

Itinerary: August 2019

Aug 10th: departure for Iceland

Aug 11th: University of Iceland, trip logistics

Aug 12th – 16th: Central Highlands – Holuhraun, Askja, Hrimalda, Kverkfjöll (volcanos)

(stayed at cabins at Dreki & Sigurðarskáli í Kverkfjöllum)

Aug 17th: University of Iceland, organizing samples, trip wrap-up

Aug 18th – 24th: Reykjanesvegur – Fagradalsfjall, Reykjanes, Eldvörp (volcanos); Gunnuhver (mud pots); Reykjanestá Cliffs (peninsula, with expression of Mid-Atlantic ridge)

Aug 25th: return to US

Askja

In approaching the Dreki cabins, we stopped to walk through some of the 1875 lava field of the Askja volcano. Here, we observed the extensive rhyolite layer (above previous basaltic eruptions). This rhyolite ranged from more compact rocks, to vesiculated specimens, to airy, pumice-type rocks. This rhyolite layer is rare among Icelandic eruptions and contrasted strongly with the basaltic surroundings.

A field work & geochemical study of Holuhraun volcano as an analog for hydrothermal vents and martian volcanism

Holuhraun

The field trip spent two full days at the Holuhraun lava field. The objective had been to visit for three additional days along the lava-river interface, but the river was particularly powerful and this was considered dangerous by both the trip leaders and the rangers at Vatnajokull National Park. We therefore focused on two days at the Holuhraun site, and included the original schedule for team members to sample their target locations (Hrimalda and Kverfjoll).

Day 1

We drove from the Dreki huts to the Holuhraun lava flow and drove along the lava flow until the road turned away. At this point, we parked the car, and headed south. We then walked along the route marked "Day 1: walk to vent" in Figure 1.

We started at **A** and walked south through an older, much more eroded lava flow, and then entered the flood plain that runs along Holuhraun (these adjacent lava flows are evident in Figure 1b). The glacial flood plain had little standing water, allowing for a straightforward walk along the Holuhruan lava field, toward the southwest. The reason for walking along the lava field, instead of through it, was because the fresh lava was very difficult and slow to traverse.

We finally reached the edge of the lava at **B**, from where we entered the lava field and headed south toward the eruptive vent. While we were aiming for the central vent, our entry point was too far east (**C**), and so we ended up at the eastern end of the fissure. As the lava flow was increasingly dangerous (rubble, broken pahoehoe and loose scoria nearest the vent), we decided to sample the glassy scoria near the eastern edge of the vent.

During our return traverse across the lava field, we were able to identify and collect several glassy rim samples from the flow. In returning from **B** to **A**, we sought to collect glass from the edge of the lava flow (interface with the glacial flood plain); however, we were unable to identify glass rims along this path. It is possible that the build-up of rubble over the course of the eruption covered such glass, or that the lava had already crystallized prior to interacting with the glacial flood plain, and any water that may have been there. As we turned north from the glacial flood plain toward the car, we observed how the Holuhraun lava had flowed up to the older, adjacent lava flow. This junction led to complete coverage of the glacial flood plain in this area, requiring the water to flow under the two lava flows at this point (see Figure 1b)

Day 2

On this day, we drove from Dreki toward the north-eastern part of the Holuhraun lava flow. We had to stop the car near the edge of the lava field because of the amount of standing water in the glacial flood plain (labeled "Day 2: lava-flood plain interface" in Figure 1). From the car, we walked ~500 m to the lava flow.

As we were unable to approach the Jökulsá á Fjöllum river on the eastern side because of safety considerations, we focused on examining the Holuhraun lava field at the edge of the glacial flood

plain. This activity required wading in the ankle-deep to knee-deep water, along the edge of the lava field (which was relatively sharp). In this location, we moved from west to east along the flow, until the water became too deep; in this way, we were able to sample numerous glassy samples (~25). These samples were less glassy than those at the vent, and those we found on Day 1 while traversing the lava field. This is likely a result of the longer time required for the lava to flow from the vent to the river, leading to a more crystalline (and less glassy) rock. That said, we did find some unique glass samples above the lava-flood plain interface, but it is unclear if they ever interacted with the water. If there is pervasive rapidly-quenched glassy material at the lava-river or lava-flood plain interface, it is likely submerged at this point and difficult (or impossible) to access.

Hrimalda

This volcano is considered to be a sub-glacial eruption, and at present is strongly weathered as a result of subsequent glacial melting. In order to access this site, we walked across a field of low-lying basalts, and then sub-glacially formed pillow-basalts, before ascending the flanks of the volcano. Here we stopped at outcrops, among the weathered scree and gravel, and identified and collected glassy rims.

Kverkfjöll

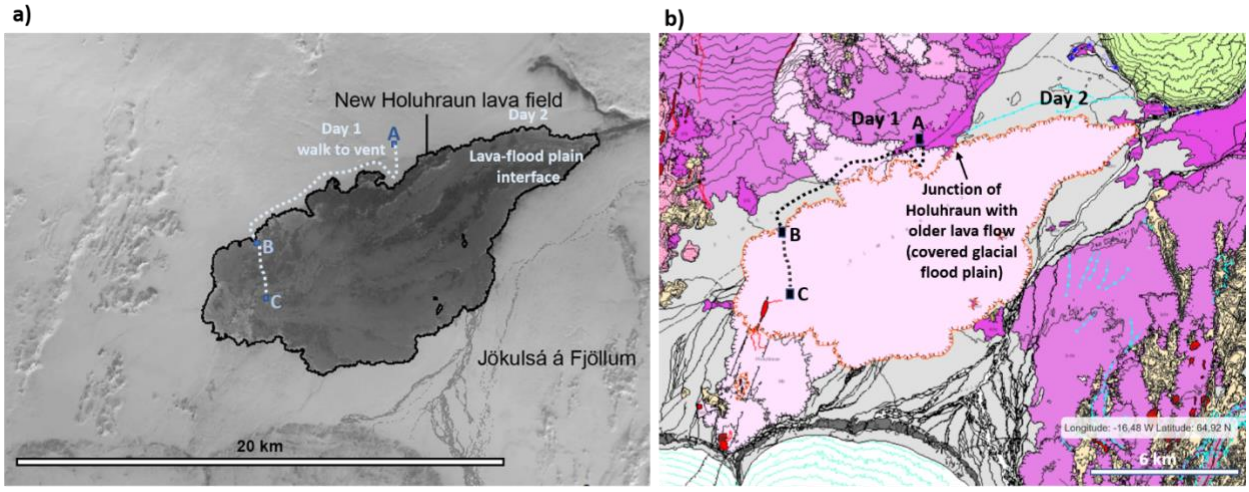
Kverkfjöll is a volatile-rich volcano with extensive geothermal activity in its vicinity. At this site, we sought to collect gas samples of volcanic complex, but it was a difficult task. Based on a prior visit from a team member, who could not access direct gas samples from the actual glacier, we sought to approach from below the glacier, near one of the main glacial melt streams. However, we were unable to locate any distinct gas vents; we were able, however, to collect glacial water samples (with which the gas had presumably mixed).

Reykjanes Peninsula

During the five days on the Reykjanes peninsula, we walked along the Reykjavegur, which is a trail that runs east-to-west along the peninsula. We began in Grindavik and went east toward the Seltun mud-pots. Thereafter, we returned to Grindavik and walked west, along the Blue Lagoon out to Reykjanestá, and then returned to the north into Reykjanesbaer. In contrast to much of the central highlands, the majority of the lava flows that we observed in the Reykjanes Peninsula were post-glacial. In this area, there were multiple and recent lava flows, as well as extensive geothermal activity. In particular, we were able to walk along extinct fissures and cinder cones. Many of the lava formations were more weathered than that of Holuhraun, but less weathered than older, sub-glacial flows in the eastern highlands; this allowed us to safely walk through the lava fields and observe features such as the mixture of pahoehoe and rubbly a'aa flows. In the west, we explored Eldvörp, which is an area of scoria and spatter cones, with pervasive geothermal steam vents. At the tip of the peninsula, we saw the expression of the mid-Atlantic ridge as it rises to meet Iceland. As we hiked from the peninsula back toward the east, we encountered much more weathered (and presumably older) lava flows, with fine wind-blow volcanic sand.

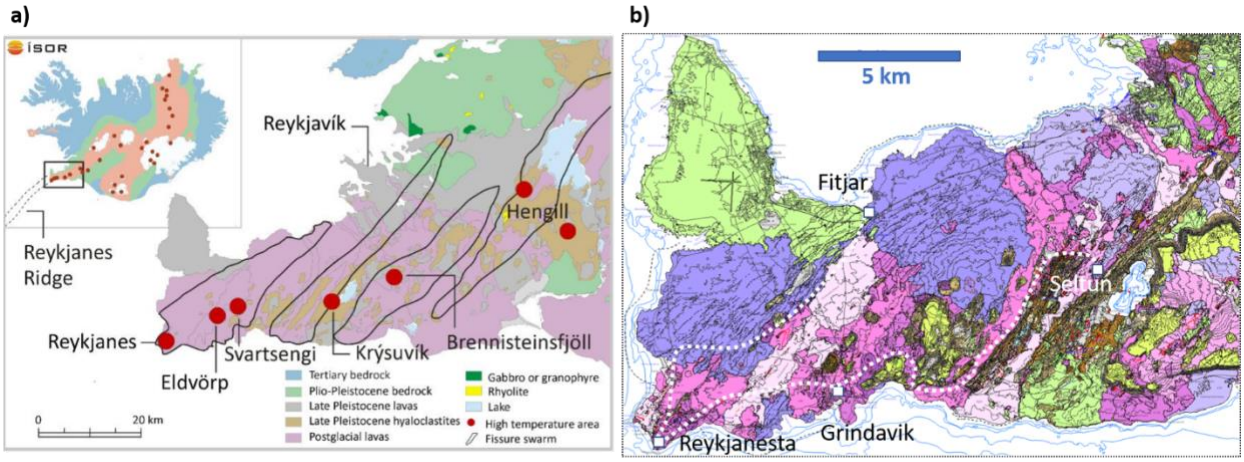
A field work & geochemical study of Holuhraun volcano as an analog for hydrothermal vents and martian volcanism

Figure 1: Holuhraun lava field satellite image (a) and geologic map (b), with Day 1 and Day 2 itineraries labeled.



Halldórsson et al. (2018), Contributions to Min. & Pet. ISOR (Icelandic Geosurvey)

Figure 2: The Reykjanes peninsula with basic geology and fissure swarms (a) and detailed geology and walking route (b). During the trek through the Reykjanes peninsula, we began in the town of Grindavik and set out east along the Reykjavegur toward the lake of Djupavatn, and eventually to the Seltun mudpots. From there, we returned west to return to Grindavik. From there, we head out west along the Reykjavegur, and then took the Arnastigur toward the Reykjanestá cliffs; we then returned east along the Reykjavegur and turned north along the Skipsstigur toward Fitjar, which is near Keflavik.



Guðnason et al. (2015), Proc. World Geothermal Cong. ISOR (Icelandic Geosurvey)