Europlanet TA Scientific Report

PROJECT LEADER

Project number: 20-EPN2-122
Name: Pablo Sobron
Home Institution: Impossible Sensing
TA Facility visited: Matís, Iceland

Project Title: **IceSCOPE - Iceland Subsurface Classification of Organics, PAHs, and Elements**

Scientific Report Summary.
(plain text, no figures, maximum 250 words, to be included in database and published)

The recent volcanic eruption at Geldingadalir in 2021 serves as an ideal analog for studying the biogeochemistry of volcanism on other planetary bodies with active (e.g. Io) and/or extinct (e.g. Mars) volcanic systems. Along with this, comparative analog studies between a recently-active volcano like Geldingadalir and old lava fields present throughout Iceland will provide meaningful context in understanding (1) the conditions necessary for microorganisms to colonize lifeless or barren environments and (2) how life transforms the environment, which has implications in the search for extant or extinct life in our solar system.

Our technology demonstration focused on the deployment of ruggedized, handheld spectroscopic tools for surveying the biology and chemistry present in the lava fields. We deployed a gamma ray spectrometer and laser induced breakdown spectroscopy (LIBS) instrument to assess the elemental composition of the natural samples, an ultraviolet (UV) fluorescence imager to investigate organic signatures on the rock surfaces, and a near-infrared (NIR) reflectance spectrometer for determining mineralogy and molecular bonding structures.

We collected co-registered spectroscopic measurements on >5 samples throughout the Geldingadalir lava field and at a control field nearby, and surveyed >10 additional surface and subsurface features throughout the lava field with one or more of the instruments. At the conclusion of the work, we had collected >1000 UV fluorescence images, 10s of NIR reflectance and LIBS spectra, and >10 gamma ray measurements.

Highlights of the project: Demonstration of a scientific payload for astrobiological research in volcanic environments and new understanding of microbial colonization of fresh basalt.

Full Scientific Report on the outcome of your TNA visit

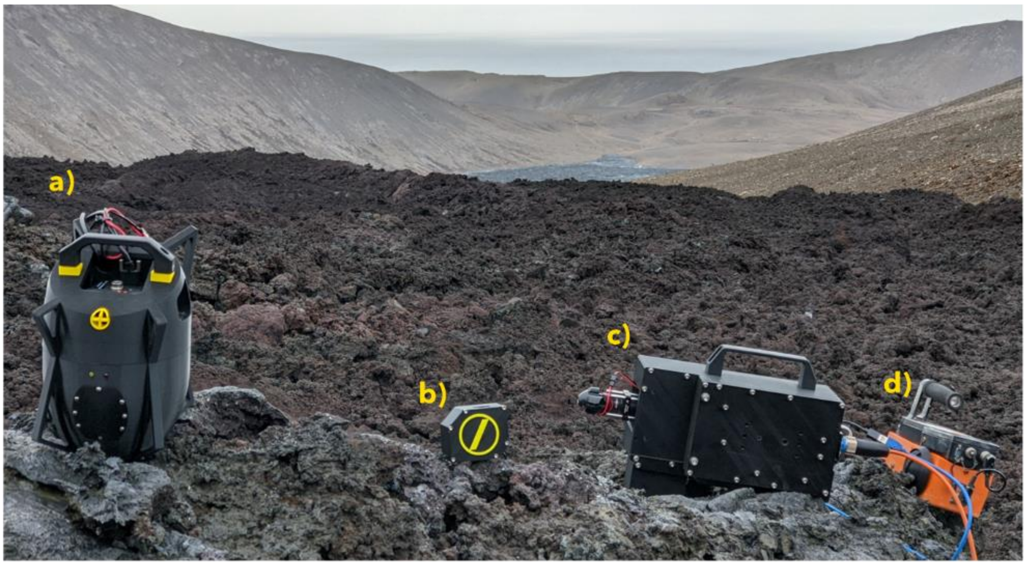

Figure 1. Suite of spectroscopic instruments deployed in the Geldingadalir lava field. Instruments include a UV fluorescence imager for investigating organic compounds and biological species (a), a NIR reflectance spectrometer for investigating mineralogy and molecular bonding, and a LIBS probe (c) and gamma ray spectrometer (d) for analyzing the elemental composition of samples.

The recent volcanic eruption at Geldingadalir is an ideal analog environment for studying the biogeochemistry of volcanism on other planetary bodies, as well as investigating the conditions and mechanisms through which life may arise in lifeless or barren environments. Our team deployed a suite of ruggedized, handheld spectroscopic instruments throughout the field site (Figure 1) to analyze samples in-situ and understand how the composition (elemental, molecular, biological) of the lava field varied (1) within the lava field (i.e. between the top, middle, and bottom of the field and between the surface and subsurface of the field) and (2) between the fresh lava field and an old, control field nearby. These instruments included an ultraviolet (UV) fluorescence imager, near-infrared (NIR) reflectance spectrometer, laser-induced breakdown spectroscopy (LIBS) probe, and a gamma ray spectrometer. We utilized these instruments to simulate various mission operational concepts, including employing these instruments as survey tools to guide sampling efforts of high-priority targets to bring back to the laboratory for analysis.

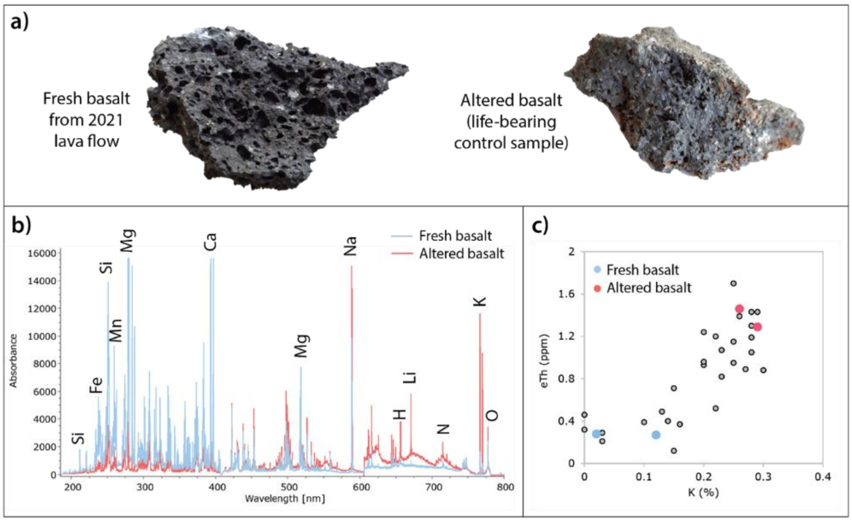

Figure 2. Mineralogical and textural differences between basaltic rocks from the 2021 lava flow and altered older, moss-covered basaltic rocks from the basement (a). Comparison between LIBS spectra of the two rock types showing decrease in some rock-forming elements (e.g. Fe, Si, Mg) and increase in alkali-metals (Na, Li, K) and nonmetals (e.g. N and O) from fresh to altered (life-bearing) basalt (b). Variation of concentrations of Th (as equivalent Th) and K within the lava field showing lower abundance in fresh basalt when compared to altered (life-bearing) basalt (c).

Spectroscopic data indicated several key differences between the fresh lava field and the control field. LIBS and gamma ray analysis (Figure 2) demonstrated differences between the type and distribution of key elements between the sites, including various rock-forming elements, alkali-metals, and nonmetals.

UV fluorescence imaging identified strongly fluorescent features (from sub-mm up to several mm in size) on the control sample indicative of potential organic constituents such as fungi or lichen growing throughout the rock matrix (Figure 3). Fluorescence imaging of various sites and samples throughout the fresh lava field found little-to-no fluorescent features among the sampled surfaces when excited by an assortment of UV light sources, however. This is consistent with the hypothesis that there is likely minimal or no organic colonization of the fresh lava yet as it is a recent eruption and is still minimally active (i.e. hot and emitting volcanic gases in some places).

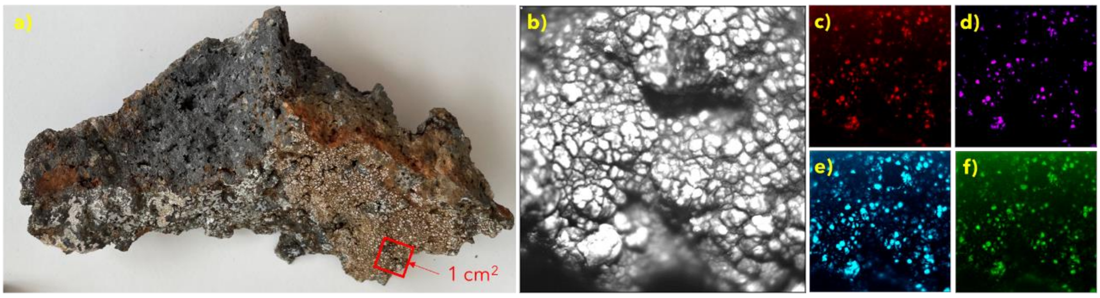

Figure 3. Control sample measured with fluorescence imager (a). Spot under investigation outlined in red. Black and white visible image acquired using broadband LED (b) compared to fluorescence images acquired with 365nm LED excitation. False-color fluorescence images capture emission centered around 388nm (c), 433nm (d), 470nm (e), and 744nm (f), where brighter colors indicate stronger emission intensity.

NIR reflectance data indicates several differences between the physical and chemical properties of the control field and the fresh lava field (Figure 4). The control sample NIR reflectance is an order of magnitude larger than the fresh sample, potentially a result of the lighter-colored features and denser mineral matrix of the control sample compared to the darker, more-porous fresh lava sample. The strong absorption feature around 1450 nm is indicative of the presence of water or hydrated constituents in the control sample, as water has a strong absorption peak at that wavelength with a tailing O-H absorption feature. As this measurement was made on the same location on the control sample as the UV fluorescence measurements above, this result supports the idea that the strongly fluorescent features are moss, fungi, or some other biological constituent as these would require water to stay alive. Aurelian Daussin, PhD student at Matís, joined our team in the field to take complementary samples for microbial diversity studies with the aim of combining the different analyses in a peer-reviewed paper.

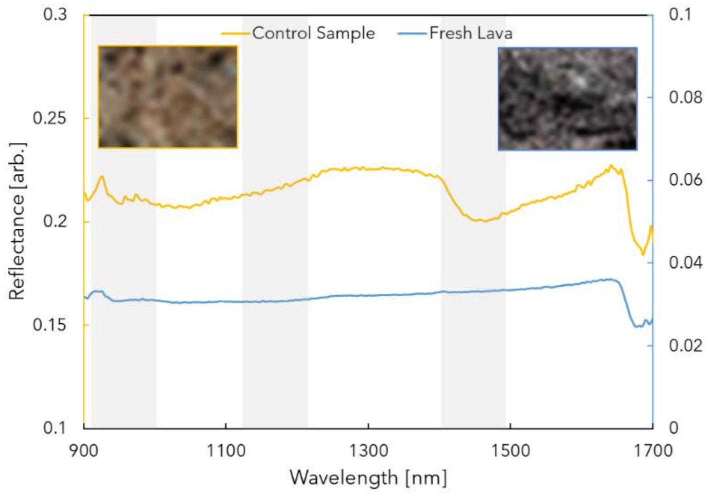

Figure 4. Averaged NIR reflectance spectra acquired on control sample vs fresh lava sample with key O-H absorption bands identified in grey. Higher overall reflectance and presence of key absorption feature around 1450 nm in control sample potentially due to white-colored lichen/fungi on the sample surface compared to the dark, porous, barren lava sample.

Although data analysis is still ongoing, the preliminary results presented here indicate several biogeochemical differences exist between the fresh lava field and the old lava field. Future data analysis will investigate (1) correlations between all of the spectroscopic data types, (2) the chemical diversity of lava field itself (top to bottom and surface to subsurface), and (3) how some spectroscopic measurements could be predictors of different biogeochemical properties of the rocks as confirmed by other spectroscopic measurements.

- Give details of any publications arising/planned (include conference abstracts etc)

We will submit an abstract to the SciX 2022 conference for a poster presentation. Pending laboratory analysis of returned samples, we plan on submitting a manuscript to a peer-review journal (ex: Astrobiology).

- Host confirmation

Please can hosts fill in/check this table confirming the breakdown of time for this TA project:

Dates for travel to accommodation for TA visit (if physical visit by applicant)	Start Date of TA project at facility	Number of lab/field days spent on TA Visit pre-analytical preparation	Number of days in lab/field site for TA Visit	Number of days spent in lab for TA Visit data analysis	End Date of TA project at facility	Dates for travel home (if physical visit by applicant)
Departed: 14-05-22 (Simon) 11-05-22 (Sobron) Arrived: 15-05-22 (Simon) 12-05-22 (Sobron)	16-05-22	0	3	0	18-05-22	Departed: 19-05-22 (Simon and Sobron) Arrived: 19-05-22 (Simon and Sobron)

The host is required to approve the report agreeing it is an accurate account of the research performed.

Host Name	
Host Signature	
Date	

- Project Leader confirmation

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Project Leader Name	**Pablo Sobron**

Project Leader Signature	
Date	**7 June 2022**