matís

EUROPLANET 2024RI

René Groben
Viggó Marteinsson

Skýrsla/Report Matís nr. 2-25

Janúar 2025
ISSN 1670-7192
DOI nr. 10.5281/zenodo.14638699

Skýrsluágrip Matís ohf.
Matvælarannsóknir

matís

Report Summary
Icelandic Food and Biotech R&D

ISSN 1670-7192

Titill / Title	EUROPLANET 2024RI		
Höfundar / Authors	René Groben & Viggó Marteinsson		
Skýrsla / Report no.	2-25	Útgáfudagur / Date:	13. janúar 2025
Verknr. / Project no.	62620		
Styrktaraðilar /Funding:	EU HORIZON2020 – Grant Agreement ID 871149		
Ágrip á íslensku:	ESB verkefnið EUROPLANET 2024RI (2020 – 2024) bauð upp á ferðastyrki fyrir vísindamenn til að sinna vettvangsrannsóknum í jaðarumhverfi fyrir stjörnulíffræði og plánetuarannsóknir. Matís aðstoðaði vísindamenn við rannsóknir þeirra hér á landi en Ísland hefur upp á að bjóða margs konar umhverfi sem líkjast aðstæðum á öðrum hnöttum, þar á meðal vatni undir jökulís, hraunum á mismunandi aldri, eldfjalla- og hversvæði. Starfsmenn Matís nýttu sérþekkingu sína til að aðstoða vísindamenn við að skipuleggja vettvangsrannsóknir, velja viðeigandi staði og skipuleggja vísindaleiðangra. Auk þess gátu vísindamenn fengið aðgang að rannsóknaraðstöðu í samvinnu við Matís. Á meðan verkefnið stóð, komu yfir 16 rannsóknarteymi til Íslands með fjölbreytt úrval af vísindalegum spurningum. Þetta leiddi til nýrrar vísindalegrar þekkingar um íslenskt jaðarumhverfi og um hvernig hugsanlegar aðstæður eru á Mars, auk nýrrar samvinnu sem gætu nýst til nýrra umsókna og skrifum á vísindagreinum.		
Lykilorð á íslensku:	*Ísland, jaðarumhverfi, plánetuarannsóknir, stjörnulíffræði*		
Summary in English:	The EU project EUROPLANET 2024RI (2020 – 2024) offered travel grants for scientists to conduct field work in extreme environments for astrobiological and planetary research. Matís was responsible in assisting researchers with their work in Iceland, which is an ideal place to study these topics, offering a multitude of different environments, including glacial and sub-glacial environments, lava fields of different ages, volcanic areas, and active hydrothermal systems. Matís staff was using their expertise to assist visitors in planning their field research, choosing appropriate sites, and organizing the logistics to assess them. In addition, visitors had access to equipment, biological laboratories, and other research facilities at Matís. During the time of the project, 16 research teams with a broad range of scientific questions were visiting Iceland and were hosted by Matís. This led to new scientific knowledge about Icelandic extreme environments and about potential conditions on Mars and other extraterrestrial bodies, as well as to new collaborations, follow-up proposals, and scientific publications.		
English keywords:	*Astrobiology, extreme environments, Iceland, planetary sciences*		

Table of Contents

1 Introduction

The European H2020 project EUROPLANET 2024RI had the aim to build up and provide a pan-European, and even global, research infrastructure in the fields of planetary science and astrobiology. The consortium of over 50 participants from Europe, Africa, Asia, and South America consisted of partners from academia, research organisations and industry. A key part of the activities of EUROPLANET 2024RI was the provision of Transnational Access (TA) sites in different countries that offered specific environments of interest for researchers in the fields of planetary science and astrobiology. In multiple calls throughout the lifetime of the project (2020 – 2024), scientists from all over the world could apply for access to these sites and obtain a travel grant and assistance by local scientists and experts in conducting their research.

Matís was responsible in assisting researchers with their work in Iceland. Iceland offers a multitude of different environments, including glacial and sub-glacial environments, lava fields of different ages, volcanic areas, and active hydrothermal systems, that can be used for astrobiological and planetary research. Staff at Matís has an extensive track record of conducting field research in Iceland, particularly with respect to surveys of life in extreme environments. This expertise was used to assist visitors in planning their field research, choosing appropriate sites, and organizing the logistics to assess them. In addition, visitors had access to equipment, biological laboratories, and other research facilities at Matís. Matís staff also joined the visitors in the field and assisted them directly with their lab work if this was needed, depending on the specific research project and especially if it aligned with the interests and ongoing research at Matís.

Examples of research that has been carried out and for which Iceland is particularly suited included:

Physical, chemical, and biological analyses and sampling in extreme Mars-analogue environments to understand the capabilities and limits of microorganisms to exist under these conditions (e.g., under extreme heat or cold).

Research into geological and geo-chemical interaction between rocks and microorganisms and how this might influence biosignatures/-markers on other planetary bodies.

Field testing of equipment and methodologies that are supposed to be employed in future Mars Missions, e.g., sampling of putative biological specimens and tracers, remote-controlled vehicles, sensors, and analytical instruments.

2 Research Projects at the Icelandic TA sites

Within the EUROPLANET 2024RI project, Matís welcomed and assisted 16 teams of researchers from Europe and North America, which conducted a wide range of field work and research. The abstracts of the successful visits to Iceland and (where available) links to the full scientific reports can be found at the EUROPLANET 2024RI website (https://www.europlanet.org/europlanet-2024-ri/ta1-pfa/ta1-facility-1-iceland-field-sites-matis/) and are reproduced here.

2.1 20-EPN-003: Production and Early Preservation of Biosignatures in Glaciovolcanic Lakes: A Biogeochemical Analogue for Mars (Erin Gibbons, McGill University, Canada)

The search for extraterrestrial life, either extinct or extant, on Mars is a key objective for several international space exploration programmes. To maximise the likelihood of success for these programmes, we must first study ecosystems on Earth that resemble those on Mars and investigate both the kinds of organisms that can survive there and the processes that control their ultimate preservation/fossilisation in the rock record.

We proposed that the geothermally-heated lake Gengissig, located in the Highlands of Iceland, represented an ideal natural laboratory within which to conduct a Mars-centric taphonomic study. Geologically, this setting provides an excellent analogue for Mars because the basaltic bedrock has a bulk chemical composition that is similar to the rocks measured on Mars by past and current rovers, thereby allowing us to study how signs of life may be preserved by the rock types common on Mars. Furthermore, this remote location is nearly devoid of multicellular life-forms and is isolated from anthropogenic input, providing a pristine ecosystem to study the fossilisation processes expected to be encountered on Mars – those operating on microbial life.

We collected water, rock, and lake sediment samples to investigate the site. We intentwill use a combined genomic, stable isotope, and geochemical approach to investigate the indigenous microbial communities and their ultimate fossilisation in this Mars-like terrain. the results of which will be immediately relevant towards directing current and upcoming Mars rovers towards sites on Mars most likely to retain signs of ancient extraterrestrial life.

2.2 20-EPN-017: LITRASV – Life in TRAvertine-Sinter Veins: a possible key to recognize extra-terrestrial life in tectonically-driven depositional systems (Enrico Capezzuoli, University of Florence, Italy)

Detailed study of travertine and sinter depositional systems and related feeder conduits (veins) in cold desertic setting (Lýsuhóll and Hveravellir sites- Iceland), as possible repository of subsurface life to be observed in extra-terrestrial setting. The performed field activity allows reconstruction of the structural control in these sinter/travertine depositional systems, with stratigraphic-sedimentological characterisation of the travertine-sinter lithofacies. 16 travertine/sinter samples were collected from the two sites, together with the basic physical characterization of the thermal springs (T, pH, Cond). Due to the local conditions, all the collected samples derive from fossil/inactive systems (veins and crusts samples). Among these, one sample derives from a sinter vein recognized in the Lýsuhóll site, while all other derive from fossil vents or close surroundings.

Samples returned to Italy for future petrographic and geochemical characterization in order to detect and define possible organic presence in such an extreme environment.

2.3 20-EPN2-066: From Geitafell volcano (Iceland) to Mars: How hydrothermal alteration of basalt can guide our understanding of habitable environments on Mars (Julia Semprich, Open University, UK)

Hydrothermal systems provide conditions and nutrients for microbial life and thus have the potential to create subsurface habitats on Mars. Characteristic minerals associated with these hydrothermal systems have been detected on Mars' surface by spectral observations from orbit, but their formation conditions and spatial distribution remain unknown. The aim of this study was a detailed characterisation of the spatial distribution and mineral chemistry of the low-grade metamorphic/hydrothermal alteration mineralogy in an extinct hydrothermal system.

Field work was conducted at the Geitafell central volcano near Hoffell in the south-eastern part of Iceland, an ideal analogue for Mars. The focus of this research was to record spatial relationships between the basaltic host rocks and the hydrothermal alteration in the field and to sample characteristic low-grade metamorphic minerals, which have also been detected on Mars.

We collected 19 samples from different alteration zones within the hydrothermal system including veins and vesicular basalt showing a range of alteration minerals such as carbonates, quartz, zeolites, chlorite, prehnite, epidote, andradite, and actinolite. We will now be able to conduct a detailed study

of the samples including petrography, mineral chemistry, and spectroscopy, which can then be used to further constrain our models of hydrothermal alteration on Mars.

We expect this research to be highly relevant to the study of hydrothermal systems on Mars and particularly for sample return once the Perseverance Rover reaches the rim of Jezero Crater, which likely exposed hydrothermally altered rocks.

2.4 20-EPN2-071: Deposition of organic matter as a factor controlling microbial colonisation of analogue terrestrial surfaces (Tina Santl-Temkiv, Aarhus University, Denmark)

This project was designed to improve the understanding of biosignatures in analogue terrestrial surfaces, volcanic rocks, that result as a consequence of microbial colonisation and weathering. During the visit, the automatic medium-volume sampling system PNS DM — modified to run on batteries charged with solar panels — was assembled, tested, and calibrated in the laboratory of Matis.

Due to a delay in shipment of the solar panels, the installation of the system at the field site could not be performed but will be finalised by the host institution in the near future. As a part of the visit, the area of the Fagradalsfjall volcano was visited and the location where the sampling system will be installed was discussed. Once the sampler system will be installed in proximity of the Fagradalsfjall volcano crater, aerosol samples will be collected continuously for a year along with replicate rock samples in order to investigate the impact of aerosol deposition on rock microbial community assembly, using microbial, chemical and physical analysis. This will be performed in collaboration between the team of Prof. Viggó Þór Marteinsson and the team of Assoc. Prof. Tina Santl-Temkiv and will result in greatly improved understanding of colonisation, community assembly, and biosignature emergence in analogue terrestrial surfaces.

2.5 20-EPN2-099: Bioaerosol generation at geothermal systems: Implications for the detection of biosignatures in cryovolcanic plumes at the ocean worlds (Mark Fox-Powell, Open University, UK)

The aim of our project was to capture and study microscopic aerosols ejected from bubbling or geysering geothermal springs in Iceland. Our primary motivation was to understand the potential for biosignatures to become entrained within cryovolcanic plumes at icy moons, such as Saturn's moon Enceladus, where similar bubbling of hydrothermal gases is thought to drive the formation of aerosols

that are then accelerated into space. Fieldwork was conducted at geothermal systems in Iceland in July and August 2022 by a team from the Open University (UK).

We focused our aerosol sampling efforts on two locations that exhibit contrasting aerosolisation regimes: Olkelduhals hot springs, Hverageroi, which exhibit constant, moderate bubbling of geothermal gases, and Strokkur, Geysir, which experiences regular energetic geyser eruptions. Our aerosol flux monitoring showed that geothermal springs are prolific local sources of aerosols, producing fluxes orders of magnitude above background levels. We also found that aerosol production is tightly controlled by bubbling and/or eruption activity.

Successful replicate sample sets were taken at upwind locations to characterise the background aerosol environment, and at multiple downwind locations to capture geothermal aerosols. We also took samples of spring fluids, as the assumed local aerosol sources, and geothermal gases, which are responsible for driving bubbling activity. Ongoing work is investigating the chemical composition, biomass content and microbial diversity of aerosols, and the volatile profiles of geothermal gases. Our data will provide the first insights from natural analogues into the formation of aerosols within cryovolcanic plumes.

2.6 20-EPN2-105: Uncrewed Aerial System (UAS) and LiDAR Survey of Relict and Active Periglacial Patterned Ground as Analogues for Mars (Paul Knightly, Northern Arizona University, USA)

Uncrewed aerial system (UAS) and LiDAR surveys were performed at periglacial patterned ground sites, including polygons terrain and stone circles, in the Westfjords and Central Highlands, Iceland during the 2022 site field season. Shallow trenches (up to 1 m depth) were excavated to gather in-situ measurements and observations to determine the presence or absence of permafrost and substrate characteristics. No permafrost was observed at either site suggesting the features may be periglacially relict. The processed UAS and LiDAR data will be used to perform morphometric evaluations of patterned ground at each site and compared to previously collected and analyzed morphometric evaluations of periglacially active patterned ground in the Canadian Arctic. The objective of this work is to develop a set of morphometric criteria for distinguishing between active and relict patterned ground. The developed criteria may help inform on the current level (or absence of) periglacial activity and ice content of patterned ground on Mars.

2.7 20-EPN2-117: To the Root of a Problem – Exploring Mars's Rootless Cones Based on the Geomorphometry of Icelandic Analogues (Sebastiaan de Vet, TU Delft, Netherlands)

Rootless cones are created by steam explosions when lava flows interact with local water sources. Consequently, these landscape features offer a unique palaeo-environmental insight into the conditions at the time of the eruption. Rootless cones have also been identified on planet Mars. The aim of this project was to identify geomorphological and morphometric characteristics of Icelandic rootless cones and use these insights to infer the formation conditions and palaeo-environmental significance of rootless cones on the planet Mars. While features on Mars can only be studied remotely through satellite data, this project leverages the accessibility of Icelandic analogues to study their morphologies and properties in fine details. The rootless cone groups in the Younger Laxa Lava are uniquely and specifically suited for this purpose; they offer a morphological variety along various gradients of lava-water interactions.

During the field project the team intended to map representative rootless cones in the Younger Laxa Lava in high-resolution during a drone-assisted photogrammetric survey and analyse high-resolution Digital Terrain Models to quantitatively compare rootless cones on Iceland and Mars. However, logistical issues arising in the aviation industry during Summer 2022 resulted in a temporary loss of fieldwork gear. The project was thus refocussed to carry out a field campaign to collect representative pilot-dataset to meet parts of the initial goals and prepare for a future follow-up campaign.

2.8 20-EPN2-120: A Molecular Toolkit to Hunt and Resolve Fungal Dark Matter (FDM) in Extreme Planetary Environments (Ali Nawaz, TU Munich, Germany)

Fungi are amazing but largely enigmatic creatures with huge diversity and biological potential in any conceivable ecosystem known so far. This holds for our planet, but this also seems true for outer space and other planetary bodies. However, we do not know what kind of extremophile fungi are or have been growing on other planets.

To have a clue, we need to explore extreme analogue sites on our planet using novel and advanced methods. Therefore, we here propose to collect and study samples from various extreme habitats of Iceland using a unique combination of Laser-microdissection of single cells and long-read sequencing to fully resolve the Fungal Dark Matter of Mars-analogue extreme sites in Iceland.

We believe that the outputs of this project will bring novel fungal species into scientific arena and the findings of this proposal will help the broader general scientific community dealing with AstroMycology

in specific, and Astrobiology in general, to rightly speculate on the capabilities and limitations of microbial life in extreme environments and correlate it with the conditions of other planets.

2.9 20-EPN2-122: IceSCOPE – Iceland Subsurface Classification of Organics, PAHs, and Elements (Pablo Sobron, Impossible Sensing, USA)

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 colonise 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 ruggedised, 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 colonisation of fresh basalt.

2.10 22-EPN3-007: SeisChem – The influence of seismic events on fluid and gas chemistry at the Icelandic planetary field site (John Edgar, Newcastle University, UK)

Measurable H2 can be generated during active seismicity through the reaction of water with freshly created rock surfaces. Field measurements have shown that rock-water reactions during seismic

events can also lead to significant changes in the pH and increase the concentration of H2O2 in geological fluids. Whilst prior studies have investigated locations representing felsic crust, a large proportion of the deep biosphere resides in basaltic terrains. H2O2 generated through rock-water reactions is greater in basaltic rocks and enhanced when temperatures exceed ~80 °C. Importantly, these elevated temperatures overlap the growth ranges of some hyperthermophilic microorganisms. The generation of H2O2 in these environments represents an understudied energetic window of opportunity for extant microbial life, and possibly for the origins of life on Earth.

This project sampled a seismically active hydrothermal area in Iceland where elevated temperatures were anticipated to lead to enhanced H2O2 generation from rock-water reactions.

The SeisChem team investigated the relationship between seismicity and the products of rock – water reactions in a geologically active hydrothermal system. The central objective of SeisChem was to bridge a knowledge gap between laboratory studies and field measurements by:

- Sample fluid and gas in time series, recording in-situ H2O2 and ancillary geochemical data
- Store and return samples to the laboratory for H2 (g) and major ion (aq) analyses
- Compare and contrast field and laboratory data with local seismic activity.

2.11 22-EPN3-011: Phototrophic Microorganisms in Cold Deserts of Iceland – Ecology and Diversity of Potential Analogues (Daniel Remias, University of Salzburg, Austria)

Geology and climate of inland regions at Iceland are ideal prerequisites for exploring microbial adaptation to cold and dry habitats. Bare terrestrial ground surfaces and high-altitude melting snowfields represent niches at the edge of life on Earth. Soil samples were harvested at altitudes from almost at sea level up to more than 1000 m. Additionally, red snow caused by cryoflora (snow algae) from permanent snow packs in the Kerlingarfjoll Mountains were collected, and photosynthetic uptake rates were measured in situ with labelled carbon (13C). Red snow was transported to the lab and the pigments extracted and the UV-protecting pigments characterized by HPLC.

The main aim of the project was the molecular characterisation of the phototrophic microbial community for evaluation of abundance and diversity of terrestrial and frozen habitats. Barren, desert-like sites were compared with vegetated ones. Microalgae marker DNA were extracted with dedicated kits for environmental soil samples.

This study aims to shed light on how photoautotrophic microbial life could work at Earth analogues with similar or even worse climatical or soil conditions. Finally, Icelandic terrestrial microalgae will be tested as potential analogues compared to other worlds like Mars or icy moons.

2.12 22-EPN3-061: Analogue Studies to Test the Scientific Potential of the First SERS Prototype Analysis (Marco Veneranda, University of Valladolid, Spain)

Iceland provides access to a great variety of environments that are widely considered potential analogues of hydrothermal processes on Mars). Previous investigation revealed a wide variety of microbial communities proliferating at the water side of Krysuvik and Hveradalir hydrothermal systems. Although providing crucial information on the dynamics of extremophilic life, the lack of low altered mineralogical samples prevented from: 1) fully comprehend the hydrothermal weathering dynamics of the primary rock (extrusive Fe-rich basaltic lava), and 2) determine the relation between microbial proliferation and the degree of hydrothermal alteration of the hosting mineral substrate.

As these two aspects are of key importance to understand the habitability potential of the ancient hydrothermal systems found on Mars, Marco Veneranda and Guillermo Lopez Reyes performed a new campaign of analysis to address these two topics. On one hand, the two researchers investigated the mineralogical composition of the two analogue sites by using a portable emulator of the RLS Raman spectrometer onboard the ESA/ExoMars rover. Afterwards, a novel device for the automated synthesis of SERS nanoemulsions was used to investigate the organic content of the hydrothermal waters. The obtained results were then used to select optimal geological and biological samples to be returned in the laboratory for further investigation. As a whole, this research project aims at supporting the RLS team in defining and optimizing the potential scientific outcome of the RLS instrument once it will be operated on the surface of Mars.

2.13 22-EPN3-116: Fault Scaling at Southwest Iceland (Işık Su Yazıcı, German Aerospace Center DLR, Germany)

Fault population studies reveal the lithospheric stress and strength conditions. Geometric fault properties provide insights into mechanical and temporal evolution of fault systems, as well as past and future potential for seismic energy release. Understanding the displacement-length relationship of faults can also help to estimate the current seismicity level. Improved constraints on the current seismicity of Mars based on lnSight mission results, are the motivation for a renewed and detailed analysis of martian fault systems. Partly due to the limited number of reliable datasets, data on the

relationships between fault displacement and length of extraterrestrial bodies are scarce. Using Digital Elevation Models (OEM) and corresponding orthoimages derived from High Resolution Stereo Camera (HRSC) data, we previously obtained information on the displacement distribution along faults and the maximum displacement (Dmax) at the Memnonia Fossae (MF) fault system on Mars.

The volcanic rifting zone in SW Iceland displays similar characteristics as MF. Specifically, the availability of airborne HRSC data (HRSC-AX) of an area characterized by widespread normal faults in the rift zone at Thingvellir, and well-exposed faults in Reykjanes, are exceptionally well-suited sites as analogues for the MF. Considering the scarcity of terrestrial analogue work complementing the analysis of planetary fault scaling, this field work helps to improve our understanding of fault scaling relationships: Our goal is to combine terrestrial remote sensing data (HRSC-AX) with ground truth to obtain a better basis for evaluating planetary fault scaling (which relies on remote sensing only).

2.14 22-EPN3-126: In-Situ observations in support for VERITAS Venus analogue airborne radar campaign at Holuhraun and Djyngasandur, Iceland (Solmaz Adeli, German Aerospace Center (DLR), Germany)

The composition of lava fields on Venus and their alteration state is poorly understood. The Venus Emissivity Mapper (VEM)/VERITAS will observe the surface of Venus in the NIR range, which will allow studying the spectral characteristics of the Venusian surface, as well as the type of lava and likely alteration processes. To prepare for this mission, VERITAS organised a field campaign in Iceland in early August, 2023, which included in-situ NIR data acquisition by the DLR-Berlin team, enabled through this Europlanet funding. The main goals have been 1) to understand the in-situ NIR reflectance spectral response of Venus analogue material, 2) to acquire in-situ emittance of an active volcano in the NIR spectral range, 3) to collect samples to be analysed in the Planetary Spectroscopy Laboratory (PSL-DLR-Berlin) using reflectance and emittance spectroscopy methods, to create an emissivity spectral library, and 4) to compare the laboratory data with field measurements.

In order to collect a wide range of textures (from pahoehoe to a'a) and compositional variations of basaltic lava fields, in addition to different fumarolic deposits, the team visited and imaged the Holuhraun lava field, Askja lava field, and Fagradalsfjall area. These sites offer an age range from the altered 1960 Askja lava field to the 2023 eruption in Fagradalsfjall. The Askja and Holuhraun sites also offered variation in grain sizes and tefra and sand coverage, which affects the spectral behavior of the surface material in NIR. the team also collected about 60 kg of samples to be analysed in the Venus chamber of the PSL-DLR-Berlin.

2.15 22-EPN3-129: In-situ and laboratory spectroscopic characterisation of Icelandic lava flows; an analogue of Venus – VERITAS mission preparation (Nils Mueller, German Aerospace Center (DLR), Germany)

As part of collaborative field work of the VERITAS science team, Nils Mueller and Akin Domac visited several locations with partially sediment covered lava flows in the vicinity of Askja, Vatnajokull National Park, Iceland. This was done simultaneously with an airborne radar campaign by the German Aerospace Center {DLR. e.V.) acquiring synthetic aperture radar images at X- and S-band, the wavelengths of the radar instruments on the Venus orbiters VERITAS and Magellan, respectively. The objective of the field-work was to document the nature and extend of sediment cover on lava flows and how it affects scattering and roughness at radar wavelengths. This will improve the combined Magellan/VERITAS SAR image interpretation by providing in-situ data that can be tied to specific S and X band backscatter values. Another aspect is change detection as the same airborne radar collected data of the near pristine Holuhraun lava flow in 2015.

The field work data collected includes photos, notes, LIDAR scans of SxS m2 patches, and clast and sediment samples from the the surface and, if possible, from 20 cm depth. The initial observations show that parts of the Holuhraun lava flow have been significantly modified by aeolian sediments in the 8 years since the end of the eruption. These sediments affect the roughness on radar wavelengths but also radar backscatter via changes in composition, density, clast size, and water content. Whether the changes are notable in the radar images remains to be seen, as the interpretation is ongoing.

2.16 22-EPN3-130: Biosignatures in Icelandic geothermal aerosols (Mark Fox-Powell, Open University, UK)

The aim of our project was to capture and study microscopic aerosols ejected from bubbling geothermal springs in Iceland, as an analogue for the formation of cryovolcanic plumes at icy moons such as Enceladus. This project built on a successful Europlanet-funded field campaign in 2022. Our objectives in 2023 were to (i) comprehensively map size-dependent aerosol fluxes with increasing distance and elevation from the springs; and (ii) to collect simultaneous samples for microbiological and elemental analyses at multiple downwind locations.

We focused our investigations on Olkelduhals hot springs, near Hverageroi, where a pool with circum-neutral pH supporting thick microbial streamers experiences constant moderate gas flux. Our data from 2022 showed that this spring is a prolific and constant source of aerosols. We found that downwind aerosol size distributions changed with distance and with elevation from the spring. Four

complete aerosol sample sets were taken downwind of the spring; each requiring a full field day. A background (upwind) air sample was also taken. Comprehensive samples for geochemical and microbiological analyses were taken from the spring, along with the collection of volatile and semi-volatile organic compounds using thermal desorption tubes. The sample set will form the basis of a new PhD studentship, beginning in October 2023 at the Open University, which will investigate the chemical composition, biomass content and microbial diversity of aerosols, and the volatile profiles of geothermal gases. Our data will provide the first insights from natural analogues into the formation of aerosols within cryovolcanic plumes.

3 Outcome & Impact

EUROPLANET 2024RI was a huge success, especially for the Icelandic TA site, where, due to high demand, nearly 2,5 times the number of visits were granted than anticipated and planned at the start of the project. This success came despite the problematic situation of the Covid-19 pandemic that occurred during the first two years of EUROPLANET 2024RI, leading to travel restrictions and cancellations of visits to Iceland. Nevertheless, most projects could be conducted in the end despite delays.

First and foremost, the outcome of the various successful research projects fulfilled the purpose of the international visitors and allowed them to answer a broad range of scientific questions related to astrobiology and planetary sciences. Without the possibility to visit extreme environments that can serve as Mars- or other extraterrestrial analogues, like for example Iceland, this kind of research would otherwise not be able to be conducted.

In addition, the samples and measurements taken within the EUROPLANET 2024RI visits also add to the scientific knowledge about the extreme environments of Iceland, benefiting the country and its scientific community directly. Matís staff used the opportunities of collaborating with many of the visitors, e.g., taking additional samples that would add value to ongoing research projects, like AirMicrome (Rannís - 174425-051). These collaborations also led to common publications and follow-up proposals. As it takes time to analyse the results that came out of the visits, and often even integrate them with other experiments and field campaigns, publications that derive from EUROPLANET 2024RI visits to Iceland are yet sparse. However, as the example of the predecessor EU project, EUROPLANET 2020-RI, showed, scientific papers based on the research visits to Iceland can and will be published even many years after the project ended, and therefore the number can be expected to still rise over time.

4 Acknowledgements

We would like to thank the coordinator and colleagues at the EUROPLANET2024RI project office for the constructive, helpful, and friendly atmosphere while managing the project. We would also like to thank all our visitors for the great collaboration, and the interesting research projects we were able to experience and being part of.

5 Publications

Publications deriving from research visits to Iceland within EUROPLANET 2020-RI and EUROPLANET 2024RI (status: end of 2024). Matís co-authors are marked in **bold**.

1. Brogi, A., Israde, I., Árnadóttir, S., & Capezzuoli, E. (2023). Tectonic control on travertine and silica sinter deposition in oceanic transform-fault setting: the case of the Lýsuskarð volcano-geothermal area, Snæfellsnes Peninsula, Iceland. International Geology Review, 65, 3287–3310. doi.org/10.1080/00206814.2023.2180779.
2. **Daussin, A.**, Mater, É., Santl-Temkiv, T., Cockell, C., **Marteinsson, V.**, & **Vannier, P**. (2022). Survival of Potential Land Colonizers' Bioaerosols Towards Simulated Atmospheric Stress Factors. SSRN Electronic Journal. doi: 10.2139/ssrn.4308052.
3. **Daussin, A.**, **Vannier, P.**, Daboussy, L., Santl-Temkiv, T., Cockell, C., & **Marteinsson, V**. (2024). Atmospheric dispersal shapes rapid bacterial colonization of Icelandic Lava Rocks. FEMS Microbes, 5, doi: 10.1093/femsmc/xtae016.
4. **Daussin, A.**, **Vannier, P.**, Mater, É., Santl-Temkiv, T., Cockell, C., & **Marteinsson, V**. (2023). Survival of Icelandic airborne microbes towards simulated atmospheric stress factors. Extremophiles. doi: 27. 10.1007/s00792-023-01302-6.
5. **Daussin, A.**, **Vannier, P.**, Ménager, M., Daboussy, L., Santl-Temkiv, T., Cockell, C., & **Marteinsson, V**. (2023). Comparison of Atmospheric and Lithospheric Culturable Bacterial Communities from Two Dissimilar Active Volcanic Sites, Surtsey Island and Fimmvörðuháls Mountain in Iceland. Microorganisms, 11. doi: 665. 10.3390/microorganisms11030665.
6. Qu, Z., **Groben, R.**, **Marteinsson, V.**, Agatha, S, Filker, S., & Stoeck, T. (2018). Redescription of Dexiotricha colpidiopsis (Kahl, 1926) Jankowski, 1964 (Ciliophora, Oligohymenophorea) from a hot spring in Iceland with identification key for Dexiotricha species. Acta Protozoologica, 57, 95 - 106. doi: 10.4467/16890027AP.18.009.8983.

7. Moreras-Marti, A., Fox-Powell, M., Stueeken, E., Di Rocco, T., Galloway, T., Osinski, G.R., Cousins, C.R., & Zerkle, A.L. (2021). Quadruple sulfur isotope biosignatures from terrestrial Mars analogue systems. Geochimica et Cosmochimica Acta, 308, 157-172. doi: 10.1016/j.gca.2021.06.007.
8. Moreras-Marti, A., Fox-Powell, M., Zerkle, A.L., Stueeken, E., Gazquez, F., Brand, H.E.A., Galloway, T., Purkamo, L., & Cousins, C.R. (2021). Geobiology, 19, 489-509. doi: 10.1111/gbi.12459.
9. Muñoz-Iglesias, V., Sánchez-García, L., Carrizo, D., Molina, A., Fernández-Sampedro, M., & Prieto-Ballesteros, O. (2022). Raman spectroscopic peculiarities of Icelandic poorly crystalline minerals and their implications for Mars exploration. Scientific Reports, 12. doi: 10.1038/s41598-022-09684-x.
10. Sánchez-García, L., Carrizo, D., Molina, A., Muñoz-Iglesias, V., Lezcano, M.A., Fernández-Sampedro, M., Parro, V., & Prieto-Ballesteros, O. (2020). Fingerprinting molecular and isotopic biosignatures on different hydrothermal scenarios of Iceland, an acidic and sulfur-rich Mars analog. Scientific Reports, 10. doi: 10.1038/s41598-020-78240-2.
11. Simon, K., Sobron, P., Barros, R., Stasi, G., & **Daussin, A.** (2022). In-Situ Multispectral Investigation of the Biogeochemistry of the Geldingadalir Lava Field. Conference Paper, SciX 2022, October 2022.