Europlanet TA Scientific Report

PROJECT LEADER

Project number: 20-EPN2-099
Name: Mark Fox-Powell
Home Institution: Open University (UK)
TA Facility visited: Iceland Field Sites

Project Title: *Bioaerosol generation at geothermal systems: Implications for the detection of biosignatures in cryovolcanic plumes at the ocean worlds*

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

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: Ölkelduháls hot springs, Hveragerði, 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.

Full Scientific Report on the outcome of your TNA visit

The aim of this work was to determine the chemical composition, biomass content and microbial diversity of microscopic aerosols ejected from bubbling or geysering geothermal springs, in order to understand the formation of cryovolcanic plumes at icy moons, such as Saturn's moon Enceladus, where similar bubbling of hydrothermal gases is thought to drive aerosol formation. Fieldwork was conducted between 26/07/2022 and 10/08/2022 by Mark Fox-Powell, Claire Batty and Ben Stephens from the Open University.

Sampling localities: Aerosol sampling was conducted at the Strokkur geyser at Geysir (N 64.312712 W 020.300761), and a system of three bubbling springs at Ölkelduháls (N 64.056677 W 021.235075), near Hveragerði. These locations encompassed contrasting aerosolisation regimes: periodically erupting geyser plumes (Strokkur) vs. constantly bubbling springs (Ölkelduháls) (Fig.1). The Strokkur discharge had a measured temperature of 73.5 °C and a pH of 8.7. The Ölkelduháls system comprised three pools, designated Springs 1-3 (Fig. 1), with respective temperatures of 59.3, 66.5 and 73.6 °C, and pH levels of 6.5, 3.4 and 4.2. Thick grey microbial streamers were observed in Ölkelduháls Spring 1.

Figure 1. Left: Strokkur eruption, showing sampling and monitoring equipment located in lower right-hand foreground. Right: Ölkelduháls geothermal springs sampling sites.

Sampling: Aerosols were sampled in replicated 30-minute increments using a Bertin Instruments Coriolis µ aerosol sampler at 300 litres air min^{-1} (Fig. 2). Aerosol densities in three size fractions (diameters ≤ 10.0, ≤ 2.5 and ≤ 1.0 µm) were recorded in real time using a Turnkey Osiris Particle Enumerator. Upwind background samples were obtained at each site, and sampling locations downwind were guided by aerosol fluxes recorded by the Osiris. Weather, particularly rain and wind, set strict constraints on sampling, necessitating flexibility in the itinerary and often repeat visits to the same location. Out of 14 days, sampling was possible on approximately 8. Sampling at Geysir was conducted overnight to avoid contamination by high numbers of tourists. Samples of spring fluids, as the assumed local aerosol sources, were also taken for geochemical and microbiological analyses, and geothermal gases were sampled using thermal desorption (TD) tubes (Fig. 2). An oily surface layer at Spring-1 was sampled using the glass plate technique.

Figure 2. Left: Sampling equipment close to Ölkelduháls Spring 3. Right: Field team member Claire Batty collecting gas samples at Ölkelduháls Spring 1.

Preliminary results: Real-time monitoring showed aerosol fluxes in the immediate downwind vicinity of geothermal springs orders of magnitude higher than background levels. Furthermore, the fluxes differed markedly between the two main sampling locations; Ölkelduháls expressed sustained high densities of aerosols throughout sampling periods, while Strokkur fluxes were directly, and strongly, influenced by geyser eruptions, as shown in Fig. 3. Immediately following Strokkur eruptions, aerosol densities sharply increased before rapidly falling to background levels. At Ölkelduháls, aerosol size distributions were strongly

influenced by distance from the spring, with the largest measured droplets (≤ 10.0 µm diameter) decreasing to background levels within 10 m.

Ongoing work: All spring and aerosol samples are currently being analysed for ionic and elemental composition, using chromatography, optical emission spectroscopy and mass spectrometry. Biomass content is being analysed using microscopic techniques. Gas samples in TD tubes are being prepared for analysis via gas chromatography. DNA extraction protocols will be optimised for anticipated low-biomass aerosol samples using dilutions of spring fluids, prior to extracting DNA from aerosols.

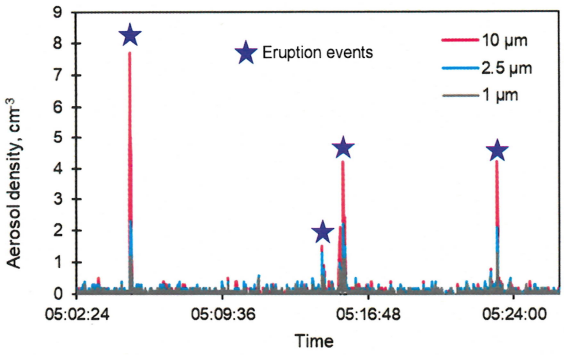

Figure 3. Size-dependent aerosol flux recorded during a 30-minute sampling interval at Strokkur, at a distance of 25 m downwind of the geyser.

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

Results will be submitted to the Lunar and Planetary Science Conference (abstract submission: early January 2023), with a manuscript expected to be prepared for submission by spring 2023.

- 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: 26-07-22 Arrived: 26-07-22	27-07-22	0	8	0	09-08-22	Departed: 10-08-22 Arrived: 10-08-22

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

Host Name	René Groben / Matís ohf.
Host Signature	
Date	28.08.2022

- Project Leader confirmation

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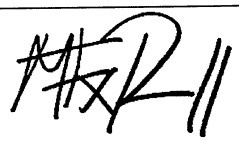
Project Leader Name	Mark Fox-Powell
Project Leader Signature	
Date	25/08/2022