Transfer of Biomarkers in the Phobos-Mars System: Hyper-Velocity Impact Investigations using a Light Gas Gun

Conference or Workshop Item

TRANSFER OF BIOMARKERS IN THE PHOBOS-MARS SYSTEM: HYPER-VELOCITY IMPACT INVESTIGATIONS USING A LIGHT GAS GUN.

Z. S. Morland (zoe.morland@open.ac.uk), **V. K. Pearson, M. R. Patel, S. F. Green and N. K. Ramkissoon,** *AstrobiologyOU, School of Physical Sciences, Open University, Milton Keynes, MK7 6AA*.

Introduction and Motivation: Planetary Protection (PP) policies are designed to protect all Solar System bodies from forward and backward contamination during space exploration, in order to preserve potential life, as well as its precursors and remnants. Each space mission is individually categorised (I-V) based on experimental and/or theoretical findings by internal and external advisory groups [1].

In 2024, the Japan Aerospace Exploration Agency (JAXA) plans to launch the Martian Moons eXploration (MMX) mission with the main scientific goal of clarifying the origin of the two moons of Mars (Phobos and Deimos). To achieve this goal they plan to land, most likely on the larger moon Phobos, a CNES-DLR rover, for ground-truth analysis of the surface [2]; and the main JAXA lander, equipped with a double sampling system to obtain a soil scoop and >2cm soil core for sample-return in 2029 [3].

As a discrete Solar System body, Phobos is not considered habitable owing to its extreme temperatures, harsh radiation environment and lack of nutrient supply [4]. However, its proximity to Mars and short orbital period led to the hypothesis that Phobos could sweep up particles ejected from large impacts into the martian surface [5]; models suggest that Phobos' regolith could include up to ~250 ppm of martian ejecta material [6,7]. Considering that the surface of Mars has many "Special Regions" that could have been habitable in the past [8], it is not unreasonable to suggest that, if life developed in these areas and subsequently left behind biosignatures, an impact into one of these areas could eject material containing biologically significant material, which could then deposit on the surface of Phobos.

Following this consideration, studies have taken place to investigate the feasibility of unsterilized material being transferred from Mars to Phobos (e.g. ESA's SterLim [9] and JAXA [10,11] teams). Using specific microbes these simulations make assumptions about the life involved in the transfer process and by combining theoretical and practical experiments they may introduce uncertainties.

Experiment plan: This study involves a series of impact and heating experiments that coherently simulate the conditions martian material, containing biomarkers, would experience throughout the transfer process from Mars to Phobos (Fig. 1&2).

Defining biomarkers. Past investigations [9-11] have used Mars-analogue terrain to advise on the biological loading of martian material, however, this makes broad assumptions about the life that exists, or may have existed, on Mars. Therefore, this study will use a solution containing specific organic biomarkers designed to represent the basic level of biosignatures that could exist on the martian surface.

Ejection from Mars. A martian basalt analogue will be doped with the organic solution, which will be subjected to impact using an inert projectile (Fig. 1A). An ejecta capture method currently in development will collect ejected particles for subsequent analysis.

Atmospheric ascent. Collected ejecta particles will be heated to simulate aerodynamic heating during martian atmospheric ascent (Fig. 1B).

Deposition onto Phobos. Processed particles will then be fired into a Phobos regolith simulant and subsequently analysed (Fig. 1C).

Implications: Results from this project will provide insight into the likelihood of martian biosignatures being present within Phobos' regolith and furthermore whether they could be identified in returned samples.

References: [1] Planetary Protection NASA Policy Directive 8020.7G (1999). [2] Bertrand et al. (2019) *15th ASTRA*.[3] Usui et al. (2019) *50th LPSC*. [4] Smith & Detsis (2019) *Nat. Acad. Sci. Eng. & Med.* [5] Murray (2011) *Proc. EPSC-DPS. 6*. 1003. [6] Ramsley and Head (2013) *Planet. & Space Sci. 87*. 115-129. [7] Chappaz et al. (2013) *Astrobiology. 13(10)*. 963-980. [8] Rummel et al. (2014) *Astrobiology*. *14(11)*. 887-968. [9] Patel et al. (2019) *Life Sciences in Space Research*. [10] Fujita et al. (2019) *Life Sciences in Space Research.* [11] Kurosawa et al. (2019) *Life Sciences in Space Research*.

Fig. 1: Conceptual diagram of experiment plan
Fig. 2: AALGG at the Open University

Figure 1

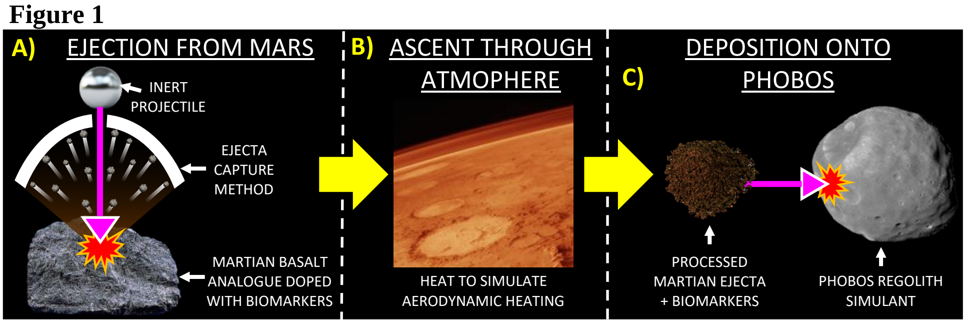

Figure 2