Chemical and Textural characterisation of two Phobos regolith simulants

Conference or Workshop Item

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Currently, samples returned from Phobos have a Planetary Protection status of “unrestricted Earth return”. If impact experiments show significant survival of biosignatures, this status may require re-assessment, with implications for future missions, such as MMX! [1]

**Could life, or its signatures, survive the journey from Mars to Phobos?**

- Studies have suggested that impact ejecta from Mars, which would represent Mars’ surface over its geological history, could have accreted onto Phobos [2].
- Mars ejecta could constitute up to 0.05% of Phobos’ regolith, where ~200 ppm was deposited in the last 10 million years [2-4].
- If life existed on Mars during its ancient past, evidence may have been altered or destroyed by subsequent geological processes [5].
- Impact ejecta, which could have contained ancient martian biosignatures, may have been deposited onto Phobos and could still be preserved today [5,6] - lithopanspermia.

**Without direct samples, regolith simulants are vital.**

- Currently, all we know about Phobos comes from remote sensing.
- Future sample return missions (i.e. JAXA’s Martian Moons eXploration mission MMX) are in development.

**Demand for Phobos simulants:**

- Mission tests – landing/take off mechanisms, microgravity sampling techniques and spacecraft exhaust contamination – Planetary Protection.
- Science - *in-situ* resource utilisation potential assessment of Phobos and NEAs [7] and testing the Mars-Phobos lithopanspermia hypothesis.

An ESA concept study funded the design and production of a Phobos regolith simulant. Feasibility dictated that two simulants were needed to meet all the physical and chemical requirements of potential uses [4].

Spectral data suggest Phobos’ surface is similar in composition to D- or T-type asteroids, carbonaceous chondrites and lunar mare regolith [8,9].

Best available analogue is a combination of Tagish Lake and lunar regolith [4,10,11].

**Compositional simulant (Phobos-1C)**

- Inherent density of compositional simulant is comparable to Phobos’ regolith.
- Crushed particles subsequently sieved into three size fractions <425 µm, 1.2-3.3 mm and >5 mm for future experiments.

**Physical simulant (Phobos-1P)**

- Using size distribution power law: \( N(D) = k (D\text{\textsuperscript{3}} + D\text{\textsuperscript{3}}) - \text{\textsuperscript{1/3}} \text{\textsuperscript{1/3}} \)
- Power law index \( x \), turnover index \( D_\text{t} \), cut-off index \( b \) constant \( k \) [12]
- Physical simulant mimics Phobos’ hypothesized average regolith grain size of ~1 mm [13], with <300 µm depletion [14].

**Compositional simulant mineralogy**

- Plagioclase:  Anorthite
- Pyroxene:  Wollastonite
- Olivine:  Fo, Fa
- Quartz and glassy phases

**Physical simulant mineralogy**

- Crushed aggregate concrete Topcrete
- Density 1.67 ± 0.05 g cm\(^{-3}\)
- Compressive strength 3.5 MPa

**Future aims:**

- Further characterisation: XRD (NHM)
- Run impact experiments using the high-velocity All-Axis Light-Gas Gun to test the survival and modification of biosignatures.
- Assess the accuracy and reliability of current biosignature identification and analysis techniques.