Chemical and Textural Characterisation of Two Phobos Regolith Simulants poster

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Chemical and textural characterisation of two Phobos regolith simulants

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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].

<table>
<thead>
<tr>
<th>Component</th>
<th>Wt %</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>JSC-1A</td>
<td>46</td>
<td>Vesicular component accounts for space weathering processes [4,8]</td>
</tr>
<tr>
<td>Antigorite</td>
<td>35</td>
<td>Phyllosilicate component present on Phobos’ surface according to 0.65 and 2.8 µm spectral absorptions [10]</td>
</tr>
<tr>
<td>Gilonite</td>
<td>4</td>
<td>Contributes complex organics seen in Tagish Lake [4]</td>
</tr>
</tbody>
</table>

Compositional simulant mineralogy

Plagioclase: An3.4-7.4Or3.0-6.6Ab6-9.66
Pyroxene: Wo0.48-0.8En27.5-83.8Fe0.8-5.68
Olivine: Fo72.45-84.8Fa15.2-25.5
Quartz and glassy phases

Physical simulant (Phobos-1P)

Using size distribution power law:
\[ N(D) = k (D_b + D_0)^{-s/b} \]

Power law index \( s \) turnover index \( D_0 \)
cut-off index \( b \) constant \( k \) [12]

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 mimics Phobos’ hypothesized average regolith grain size of ~1 mm [13], with <300 µm depletion [14].

Physical simulant mineralogy

Quartz & Calcite, consistent with concrete.

Crushed aggregate concrete Topcrete chosen for the physical simulant because it is physically comparable to Phobos [8] with a density of 1.67 ± 0.05 g cm\(^{-3}\).

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.

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