Report:
Mars Returned Sample Quality Workshop

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MEPAG meeting
May 14, 2014
How Important is Sample Quality?

**HYPOTHETICAL:**
*IF MARS SAMPLES WERE RETURNED TO EARTH, WHAT STATE WOULD THEY NEED TO BE IN TO BE SCIENTIFICALLY USEFUL?*
Part 1.

Rock Samples
Approach

Focus Group: Carlton Allen, Lars Borg, Dave Des Marais, Chris Herd, Scott McLennan

Pre-Workshop
• Define science investigations for each potential RSS objective
• Draft assessment of sample quality factors that might impact RSS science investigations
• Define draft requirements (w.r.t. RSS) for quality factors
• Formulate draft requirements for sample quality

LPSC Workshop
March 16th, 2014
• Participants: 30+ sample scientists from universities and NASA centers
• Review and edit the starting materials above
• Input on quantifying potential sample quality requirements
• Prioritize the quality factors

Post-Workshop
• Close out open issues identified at workshop
• Derive sample quality requirements for M-2020

Continuous involvement of scientists (community, M-2020, program) and engineers (project, program)
# Rock Samples: Sample Quality Matrix

## Potential RSS Science Goals

<table>
<thead>
<tr>
<th>Science Investigations in Each Goal</th>
</tr>
</thead>
</table>

## Quality Factors

<table>
<thead>
<tr>
<th>Possible Impact</th>
</tr>
</thead>
</table>

## Color Code in Cells

- High (3)
- Moderate (2)
- Minor (1)
- Unrated (0)

## Potential for Science Damage

- Designation: x

## Sample Preparation

<table>
<thead>
<tr>
<th>Earth-sourced contamination</th>
<th>Magnetic</th>
<th>Mechanical integrity</th>
<th>Thermal</th>
<th>Sample loss</th>
<th>Preserve Mars Chemistry</th>
<th>Radiation</th>
</tr>
</thead>
</table>

## Objective Description

- Working List of Measurements (method)

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**PRE-DECISION DRAFT: For Planning and Discussion Purposes Only**
## Working List of Measurements (method)

<table>
<thead>
<tr>
<th>Working List of Measurements (method)</th>
<th>Purpose</th>
<th>Sample Preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Powder</td>
<td>Minerals</td>
</tr>
<tr>
<td>Morphology (e.g., cells, subcellular structures, cell clusters) (microscopy)</td>
<td>Biosignature</td>
<td></td>
</tr>
<tr>
<td>Rock Fabrics (e.g., stromatolites)</td>
<td>Biosignature</td>
<td></td>
</tr>
<tr>
<td>Mineral/biogenic minerals (e.g., carbonates, sulfates, phyllosilicates, silicate oxides [e.g., biogenic magnetite, permineralization]) (spectroscopy, XRD, etc.)</td>
<td>Biosignature</td>
<td>x</td>
</tr>
<tr>
<td>Organic compounds &amp; Distribution (e.g., lipid biomarkers) (spectroscopy, MS, chromatography, etc.)</td>
<td>Biosignature</td>
<td>x</td>
</tr>
<tr>
<td>Stable isotopic patterns (e.g., indicators of biological redox reactions) (MS, laser spectroscopy)</td>
<td>Biosignature</td>
<td>x</td>
</tr>
<tr>
<td>Identification of minerals and elemental abundances</td>
<td>Habitability-water activities &amp; surface/near-surface processes</td>
<td>x</td>
</tr>
<tr>
<td>Identification of minerals and elemental abundances</td>
<td>Habitability-Chemical building blocks, C, H, P, O, N, S</td>
<td>x</td>
</tr>
<tr>
<td>Minerals and elemental abundances (redox state)</td>
<td>Habitability-Energy source</td>
<td>x</td>
</tr>
<tr>
<td>Identification of minerals and elemental abundances (solvent, T, etc)</td>
<td>Habitability &amp; surface/near-surface processes involving water</td>
<td>x</td>
</tr>
<tr>
<td>Biogenic gas if any</td>
<td>Biosignature</td>
<td></td>
</tr>
</tbody>
</table>
Part II: Sample Quality Factors & Requirement

- Earth Sourced Contamination
- Magnetic History
- Mechanical Properties
- Thermal History
- Radiation History
- Sample Gain/Loss
- Preserve Mars Chemistry: Chemical/Mineral alteration of sample within/outside containers

- Organic/Biological (input from Organic Contamination Panel)
- Inorganic
- Fracturing
- Movement of fragments
- Volatiles
- Cross-Contamination
- Loss of drilled samples

See example next chart
Gain/loss of Volatiles

Draft Requirement

Samples should be acquired, transported, and made available to scientific research in a manner that shall have a greater than 80% confidence that seals for individual samples have a leak rate $<\text{TBD cc}_\text{Mars}$ of He/second.

Input from 03-16-14 Workshop

- Strategy and requirement agreed to limit loss of volatiles to $<1\%$ of original water.
- Additionally, agreement on a non-sealing failure rate (e.g., like 20% of samples can fail to seal).

See complete list in handout table
### Draft Priority of Sample Quality Factors from 2014 LPSC Workshop

<table>
<thead>
<tr>
<th>Potential Magnitude of Impact</th>
<th>Priority of Science Investigations Affected</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H</strong></td>
<td><strong>Inorganic Contamination</strong></td>
</tr>
<tr>
<td></td>
<td>• Organic Contamination</td>
</tr>
<tr>
<td></td>
<td>• Fracturing</td>
</tr>
<tr>
<td></td>
<td>• Movement of Fragment</td>
</tr>
<tr>
<td></td>
<td>• Loss of Drilled Samples</td>
</tr>
<tr>
<td></td>
<td>• Volatile Loss or Gain</td>
</tr>
<tr>
<td></td>
<td>• Thermal History</td>
</tr>
<tr>
<td><strong>M</strong></td>
<td><strong>Chemical/Mineral Alteration of Samples</strong></td>
</tr>
<tr>
<td></td>
<td>within and outside of Containers</td>
</tr>
<tr>
<td></td>
<td><strong>Biological Contamination</strong></td>
</tr>
<tr>
<td><strong>L</strong></td>
<td><strong>Radiation History</strong></td>
</tr>
<tr>
<td></td>
<td>• Cross Contamination</td>
</tr>
<tr>
<td></td>
<td>• Magnetic History</td>
</tr>
</tbody>
</table>

PRE-DECISION DRAFT: For Planning and Discussion Purposes Only
Part 2.

Soil Samples
Physical, structural, chemical, mineralogical properties of soils and their lithic components are important for:

- Climate-soil interactions
- Differentiation and evolution of Martian crust and mantle
- Surface/near-surface processes with or without water
- Habitability
- Future human exploration (hazards, resource, etc.)
Present Knowledge of Martian Soils

- Previous missions analyzed soils to <10-20 cm depth.
- From the surface to shallow depth, dust-rich and dark soils are typically present (exceptions exist), and chemical variations with depth are observed occasionally.
- Global, Regional, and Local Input. Broadly basaltic with diversity in soils, e.g., sulfur- or silica-rich soils at Gusev
- Chemistry suggestive of fluid activity
- Unconsolidated materials display a wide size range from 10’s of μm to a few mm.

Pre-decisional draft for discussion purposes only: Subject to Revision
# Soil-related Recommendations

<table>
<thead>
<tr>
<th>Questions</th>
<th>Recommendation</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need to preserve stratigraphy?</td>
<td>Important to sample coarse-scale stratigraphy, but accept that fine stratigraphy can’t be maintained in sample tube</td>
<td>Hypotheses related to atm-regolith interactions, or changes with surface/sub-surface conditions</td>
</tr>
<tr>
<td>Number of samples?</td>
<td>Minimum 1-2 soil samples, with the capability for more if peculiar soils are encountered</td>
<td>Depend on landing site One for the very top surface; and the other (mature, no dust); if peculiar soils (e.g., sulfur-rich, silica-rich) or stratigraphy are encountered</td>
</tr>
<tr>
<td>Collect rock fragments?</td>
<td>Yes as long as they fit in the sampling holder</td>
<td>Soil may contain rock types not sampled by rovers or meteorites</td>
</tr>
</tbody>
</table>

Sample quality requirement for rocks can be applied to soils

The final sampling strategy is landing-site dependent, and would consist of numerous *ad hoc* decisions until we have a chance to interrogate the Mars-2020 site on the surface
Summary

- Understanding the relationship between the condition of the samples as received by a potential future analyst, and the science that could be achieved, is central to understanding the cost/benefit relationships of Mars Sample Return.

- Feedback from all sectors of the community on this draft analysis is encouraged.

- Please send comments to:
  - Dave Beaty, david.w.beaty@jpl.nasa.gov
  - Yang Liu, yang.liu@jpl.nasa.gov