MSR Science Planning Group 2 (MSPG2): Planning for the curation of MSR samples in a Sample Receiving Facility

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MSR Science Planning Group 2 (MSPG2)

- Established by NASA and ESA to help develop a stable foundation for international scientific cooperation for the purposes of returning and analyzing samples from Mars.
- Formulate and propose mechanisms through which the international scientific community can achieve our shared scientific objectives.
- This planning was accomplished via:
  - Bi-weekly telecons with focus groups and full MSPG-2 group
  - Developing "Planning for the Curation of MSR Samples in a Sample Receiving Facility" manuscript, *in press* Astrobiology and compendium documents [1,2,3,4,5]
  - **Community feedback-We are seeking your input**-Please email the authors
  - Full reports can be viewed at: https://mepag.jpl.nasa.gov/reports.cfm?expand=mspg

Introduction

- All material that is collected from Mars (gases, dust, rock, regolith) will need to be carefully handled, stored and analyzed following Earth return to minimize the alteration or change that could occur on Earth, and to maximize the scientific information that can be extracted on the samples, now and into the future.
- A sample receiving facility (SRF) would be where the EES is opened, and the sample tubes would be opened and processed after they land on Earth

FINDING: The Sample Receiving Facility should operate at room temperature (~15–25°C) and the samples held at this temperature through all steps of initial sample characterization, with the option for cold storage of sub-samples available in the SRF when needed.

MAJOR FINDING: Careful collection and storage of the serendipitous dust on the outside of the sample tubes is a critical step in the curation process in the Sample Receiving Facility. The dust collected is a valuable resource to the scientific community.

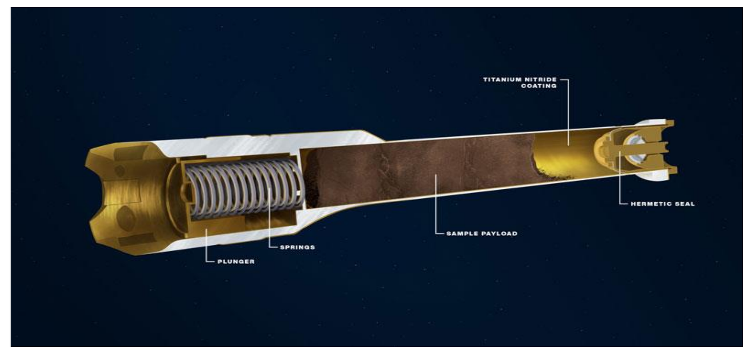

Figure 1 (left). This illustration depicts the interior of a sample tube being carried aboard the Mars 2020 Perseverance rover. About the size and shape of a standard lab test tube, the 43 sample tubes headed to Mars are lightweight, hardy enough to survive the demands of the round trip, and so clean that future scientists will be confident that what they are analyzing is 100% Mars, without terrestrial contaminants. Credit: NASA/JPL-Caltech.

Figure 2 (right). This image shows a concept model of NASA's orbiting sample container, which will hold tubes of martian rock and soil samples that will be returned to Earth through a Mars sample return campaign. At right is the lid; bottom left sits a model of the sample-holding tube. The sample container will help keep contents at less than about 30°C to help preserve the Mars material in its most natural state. Photo Credit: NASA/JPL-Caltech.

Initial Sample Characterization

MAJOR FINDING:: The initial sample characterization in the Sample Receiving Facility of the MSR samples can be broken down into three stages for simplicity, Pre-Basic Characterization, Basic Characterization, and Preliminary Examination. While the whole collection would be assessed through pre-BC and BC, only subsets of samples would be used during the PE phase.

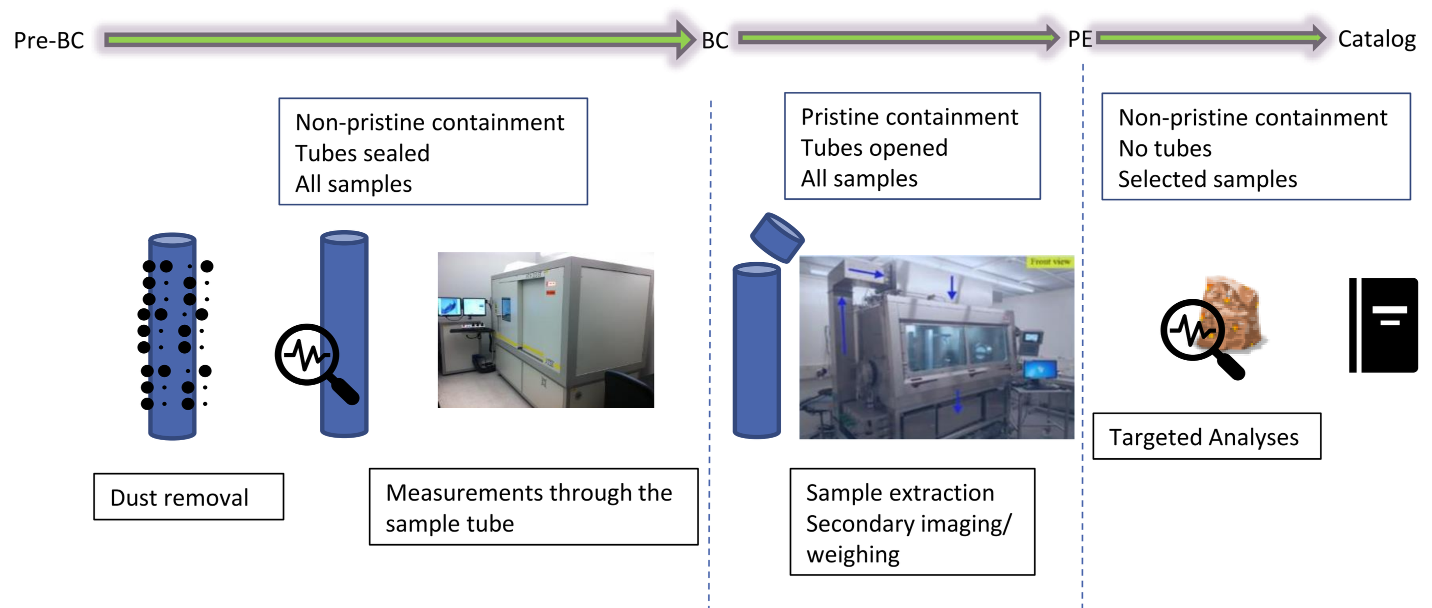

Figure 3. Proposed sequence of activities within the Pre-Basic Characterization (Pre-BC), Basic Characterization (BC) and Preliminary Examination (PE).

MAJOR FINDING: Measurements on all the sample tubes before they are opened is essential to conduct as they could be compromised upon opening of the tubes. These are measurements that would inform how the tubes are opened, processed, and subsampled during Basic Characterization. This step is called Pre-Basic Characterization (Pre-BC).

FINDING: Immediately after landing, the spacecraft will be recovered and placed in a container designed to control and stabilize its physical conditions. The optimum temperature ($T_{optimum}$) of the sample tubes during transport to the Sample Receiving Facility should be the same as the operating temperature of the Sample Receiving Facility to avoid unnecessary temperature shock.

FINDING: To minimize the interaction of Earth atmospheric gases and gases that are in the sealed sample tubes, once the dust is removed from the exterior of the sample tubes, they should be placed into individual sample tube isolation chambers (STIC) as quickly as possible.

Curation Goals

- All material that is collected from Mars (gases, dust, rock, regolith) will need to be carefully handled, stored and analyzed following Earth return to minimize the alteration or change that could occur on Earth, and to maximize the scientific information that can be extracted on the samples, now and into the future.
- A sample receiving facility (SRF) would be where the EES is opened, and the sample tubes would be opened and processed after they land on Earth

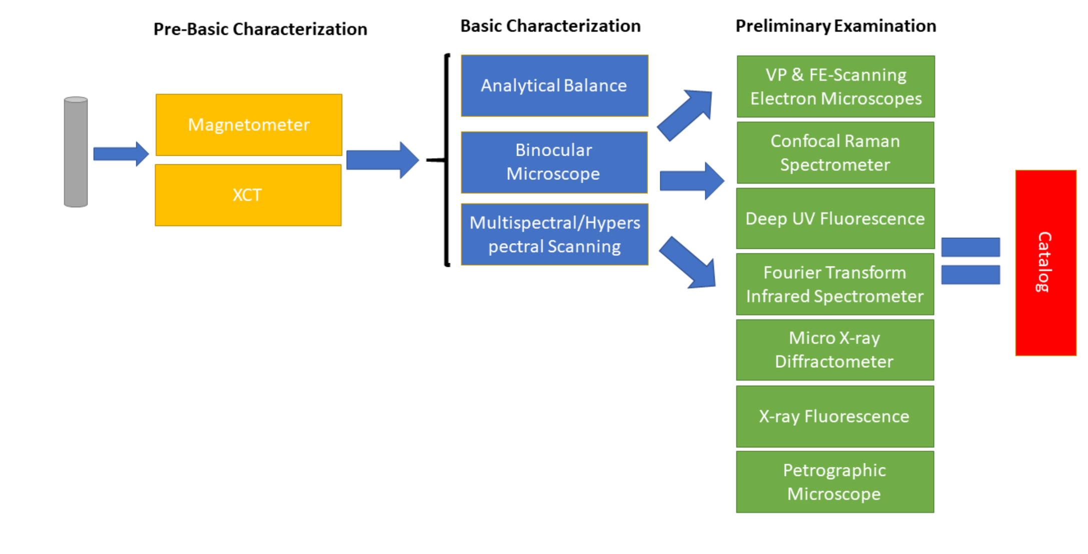

Figure 4. Proposed list of instrumentation for Pre-Basic Characterization, Basic Characterization and Preliminary Examination to produce a sample catalog.

FINDING: There are compelling reasons to perform penetrative 3D imaging prior to opening the sample tubes. A laboratory-based X-ray Computed Tomography scanner is the best technique to use and is the least damaging to organics of the penetrative imaging options considered.

MAJOR FINDING: Measurements on all the samples once the sample tubes are opened within the pristine isolators is essential to make initial macroscopic observations such as weighing, photographing and optical observations. The first step to this stage is removal and collection of the head-space gas, which then starts the clock for time-sensitive measurements. This step is called Basic Characterization (BC).

MAJOR FINDING: More advanced measurements on sub-samples, beyond those included in BC, are essential for the allocation of material to the scientific community for investigation, including some measurements that may make irreversible changes to the samples. These types of measurements take place during Preliminary Examination (PE).

MAJOR FINDING: Assuming reasonable sample processing rates, and that the samples are organized into five sets for cross contamination avoidance purposes, at least twelve pristine isolators are required to perform Basic Characterization on the MSR samples. This total will increase by two for each additional distinct processing environment.

Pristine and Non-Pristine Isolators

KEY DEFINITION: Pristine Sample Containment: Clean controlled environment (isolator/glovebox/isolation chamber) with a controlled atmosphere where BC will take place. Limited controlled list of materials would be allowed. Once samples are removed from Pristine Containment, they should not be allowed back into Pristine Containment.

KEY DEFINITION: Non-Pristine Sample Containment: Clean environment (isolator/glovebox) with, or without a controlled atmosphere, for samples removed from Pristine Containment or were never in Pristine Containment. Limited (but not highly restrictive) list of materials would be allowed. Once samples are removed, they would be allowed back into Non-Pristine Containment.

FINDING: To avoid cross contamination between samples, it is recommended that for processing through the isolators, the samples be organized into groups that have like properties. Given what we know about the geology of Jezero Crater, a reasonable starting assumption is five such groups.

Sample Catalog

- The sample catalog will provide data for the scientific community to make informed requests for samples for scientific investigations and for the approval of allocations of appropriate samples to satisfy these requests.

FINDING: The output of the initial sample characterization, and a key function of the curation activities within the Sample Receiving Facility, is to produce a sample catalog, which provides relevant information on the samples' physical and mineralogical/chemical characteristics (derived from the Pre-Basic Characterization, Basic Characterization, and Preliminary Examination investigations), sample safety assessments, time-sensitive studies, and information derived from mission operations to enable allocation of the most appropriate materials to the scientific community.

Long-term curation

- There are two main mechanisms for allocation of samples outside the SRF: 1) Wait until the implementation of the Sample Safety Assessment Protocol (Planetary Protection) results conclude that the samples are non-hazardous, 2) Render splits of the samples non-hazardous by means of sterilization. To make these samples accessible, a series of observations and analytical measurements will need to completed to produce a sample catalog for the scientific community.

FINDING: A staffing model for curation activities, including technical support and informatics/ documentation support, should be developed (as part of ongoing Sample Receiving Facility development) to ensure that the Sample Receiving Facility is staffed appropriately to support sample curation activities.

FINDING: To reduce the risk of catastrophic loss of samples curated in a single facility up to and including decadal timescales the sample collection should be split, once it is possible to do so, and housed in more than one location for the purpose of maximizing the long-term safety of the collection.

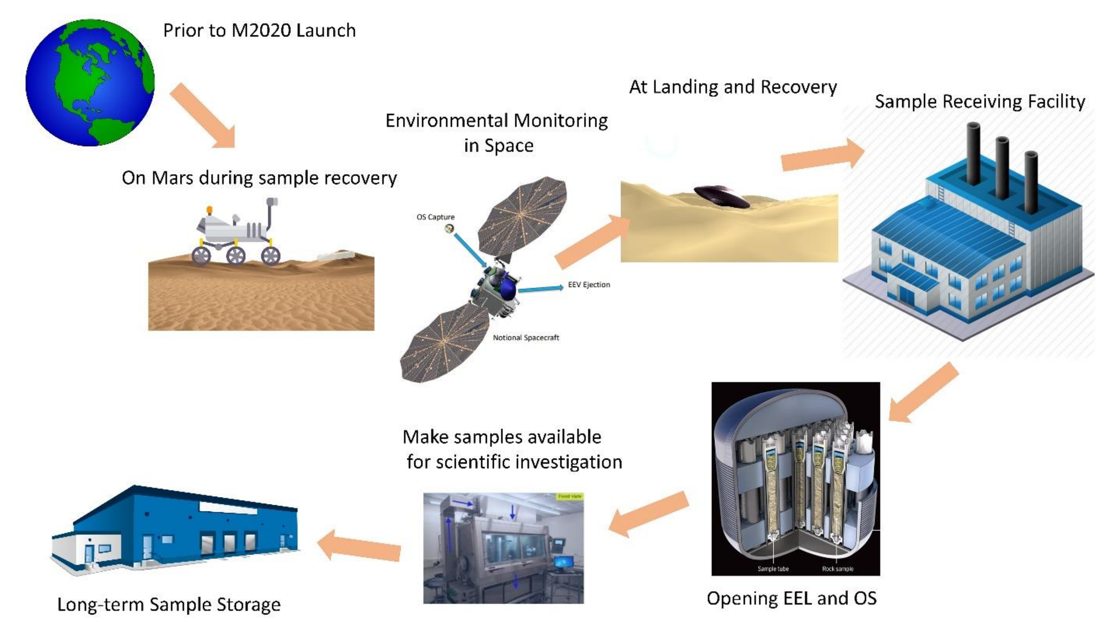

Figure 5. End to end curation schematic. Graphic OS: C. BICKEL/*SCIENCE, ROCS NASA/JPL-CALTECH.*

References: Disclaimer: [1] Haltigin *et al.,* (2021) Rationale and Proposed Design for a Mars Sample Return (MSR) Science Program. *Astrobiology*, in press, doi: 10.1089/ast.2021.0122. [2] Tosca *et al.* (2021) Time-sensitive aspects of Mars Sample Return (MSR) science. *Astrobiology* in press, doi:10.1089/ast.2021.0115. [3] Velbel *et al.* (2021) Planning implications related to sterilization-sensitive science investigations associated with Mars Sample Return (MSR). Astrobiology in press, doi:10.1089/ast.2021.0113. [4] Grady *et al.* (2021) The Scientific Importance of Returning Airfall Dust as a Part of Mars Sample Return (MSR). *Astrobiology* in press, doi:10.1089/ast.2021.0111. [5] Carrier *et al.* (2021) Science and curation considerations for the design of a Mars Sample Return (MSR) Sample Receiving Facility (SRF). Astrobiology in press, doi:10.1089/ast.2021.0110.