THE PROPOSED SCIENTIFIC OBJECTIVES OF MARS SAMPLE RETURN.
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Introduction. IMEWG (the International Mars Exploration Working Group) has been evaluating the degree of international interest in MSR science by means of a working group referred to as iMOST (the International MSR Objectives and Samples Team). A primary purpose of iMOST was to establish international consensus positions related to the potential value of returning to Earth the samples to be collected by the Mars 2020 rover mission. We have concluded that the analysis in Earth laboratories of the samples that could be returned from Mars is of extremely high interest to the international Mars exploration community.

The iMOST Study. The International MSR Objectives and Samples Team was comprised of a team of 71 members representing 15 different countries and a broad range of scientific disciplines.The group was chartered in November 2017 and completed their report in August 2018 [1].

Proposed Objectives. The iMOST Report has proposed a taxonomy of seven primary scientific objectives for Mars Sample Return, some of which have been broken down further into sub-objectives. The shorthand for these seven objectives is as follows 1) Geology, 2) Life, 3) Geochronlogy, 4) Volatiles, 5) Planetary Evolution, 6) Understand/Reduce the Risks for Humans to Mars, 7) In-Situ Resource Utilization (ISRU).

Objective 1-Geology: The first objective is to interpret the primary geologic processes and history that formed the martian geologic record, with an emphasis on the role of water. The intent of this objective is to to investigate the geologic environment(s) represented at the Mars 2020 landing site, provide definitive geologic context for collected samples, and detail any characteristics that might relate to past biologic processes. This objective has been further divided into 5 sub-objectives reflecting specific geologic environments which may be present on Mars: sedimentary systems, ancient hydrothermal environments, deep subsurface groundwater, subaerial environments and igneous terrane. These environments are detailed separately as the strategies and types of samples desired are different for each of them.

Objective 2-Life: Assess and interpret the potential biological history of Mars, including assaying returned samples for the evidence of life. The intent is to investigate the nature and extent of martian habitability, the conditions and processes that supported or challenged life, how different environments might have influenced the preservation of biosignatures and created nonbiological 'mimics', and to look for biosignatures of past or present life.

This objective has been broken down into 3 sub-objectives: 1) Assess and characterize carbon, including possible organic and pre-biotic chemistry; 2) Assay for the presence of biosignatures of past life at sites that hosted habitable environments and could have preserved any biosignatures; 3) Assess the possibility that any life forms detected are alive, or were recently alive.

Objective 3-Geochronology: Quantitatively determine the evolutionary timeline of Mars. The intent of this objective is to provide a radioisotope-based time scale for major events, including magmatic, tectonic, fluvial, and impact events, and the formation of major sedimentary deposits and geomorphological features.

Objective 4-Volatiles: Constrain the inventory of martian volatiles as a function of geologic time and determine the ways in which these volatiles have interacted with Mars as a geologic system. The intent of this is to recognize and quantify the major roles that volatiles (in the atmosphere and in the hydrosphere) play in martian geologic and possibly biologic evolution.

Objective 5-Planetary Evolution: Reconstruct the processes that have affected the origin and modification of the interior, including the crust, mantle, core and the evolution of the martian dynamo. The intent is to use returned Mars samples to quantify processes that have shaped the planet's crust and underlying structure, including planetary differentiation, core segregation and state of the magnetic dynamo, and cratering.

Objective 6-Understand the Risks for Humans to Mars: Understand and quantify the potential martian environmental hazards to future human exploration and the terrestrial biosphere. Returned martian samples could be used to define and mitigate an array of health risks related to the martian environment associated with the potential future human exploration of Mars.

Objective 7-Prepare for In-Situ Resource Utilization: Evaluate the type and distribution of in-situ resources to support potential future Mars exploration. The primary intent is to quantify the potential for obtaining martian resources, including use of martian materials as a source of water for human consumption, fuel production, building fabrication, and agriculture.

Other Findings from the iMOST Report:

Several specific findings were identified during the iMOST study. While they are not explicit recommendations, we suggest that they should serve as guidelines for future decision-making regarding planning of potential future MSR missions.

1. The samples to be collected by the Mars 2020 (M-2020) rover will be of sufficient size and quality to address and solve a wide variety of scientific questions.

2. Samples, by definition, are a statistical representation of a larger entity. Our ability to interpret the source geologic units and processes by studying sample sub-sets is highly dependent on the quality of the sample context. In the case of the M-2020 samples, the context is expected to be excellent, and at multiple scales: (A) Regional and planetary context will be established by the on-going work of the multi-agency fleet of Mars orbiters; (B) Local context will be established at field area- to outcrop- to hand sample- to hand lens scale using the instruments carried by M-2020.

3. A significant fraction of the value of the MSR sample collection would come from its organization into sample suites, which are small groupings of samples designed to represent key aspects of geologic or geochemical variation.

4. If the Mars 2020 rover acquires a scientifically well-chosen set of samples, with sufficient geological diversity, and if those samples were returned to Earth, then major progress can be expected on all seven of the objectives proposed in this study, regardless of the final choice of landing site. The specifics of which parts of Objective 1 could be achieved would be different at each of the final three candidate landing sites, but some combination of critically important progress could be made at any of them.

5. An aspect of the search for evidence of life is that we do not know in advance how evidence for martian life would be preserved in the geologic record. In order for the returned samples to be most useful for both understanding geologic processes (Objective 1) and the search for life (Objective 2), the sample collection should contain BOTH typical and unusual samples from the rock units explored. This consideration should be incorporated into sample selection and the design of the suites.

6. The retrieval missions of a MSR campaign should (1) minimize stray magnetic fields to which the samples would be exposed and carry a magnetic witness plate to record exposure, (2) collect and return atmospheric gas sample(s), and (3) collect additional dust and/or regolith sample mass if possible.

References: [1] iMOST (2018), The Potential Science and Engineering Value of Samples Delivered to Earth by Mars Sample Return. *Meteoritics & Planetary Science*. https://doi.org/ 10.1111/maps.13232

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