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Science Planning for a Potential Mars Sample Return Campaign

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1. Introduction

The transport to Earth of samples from Mars was first proposed within NASA's space science program in the 1970s. Since then it has progressively gained support from the international Mars exploration community. There have been developments in several areas surrounding Mars Sample Return (MSR) that have changed within the past decade or so that have caused interest to increase:

1. **Advances in the study of martian meteorites;** Although the number of martian meteorites has now grown to over 100, it has become apparent that meteorite studies have several limitations.
2. **New mission results from Mars**: Fabulous new results have been obtained from in-situ missions (of particular note, MSL and the results expected to come from ExoMars). These results have served to emphasize the additional value that would come from narrowing the spatial focus, and widening the diversity of instrumentation, both of which would happen by means of making Mars samples available to terrestrial laboratories.
3. **Human exploration**.: We have a greatly improved understanding of the ways in which the risks, performance, and cost of putting humans on Mars can be improved by acquiring advance information—especially sample-related information.
4. **Astrobiology:** Although the search for extra-terrestrial life has been key driver of Mars exploration, we now have a much better understanding of the potential for preservation in the geologic record, the evolution of Mars on a planetary basis, and (via study of biochemistry on Earth) the details of biological processes. This allows for far more effective search strategies.
5. **Instrument developments**: We are seeing unprecedented improvements in our collective ability to prepare and analyze very small samples in Earth laboratories. Highly visible examples are the work on Hayabusa asteroid samples (JAXA) and the Stardust comet samples (NASA).
6. **Engineering developments:** Over the past decade there have been substantial improvements in the capability of the world's space agencies to acquire and preserve samples (most notably, the M-2020 sampling system), the development of the Mars Ascent Vehicle, and critical progress in breaking the chain of contact.

As recently summarized at the technical conclusion of the 2018 2nd International MSR Conference;
'The scientific exploration of Mars and the search for extra-terrestrial life have advanced to the point that the return of samples from Mars is more important than ever to enable the next big discoveries in Mars exploration. Capitalising on major engineering progress in recent years by the world's space agencies and industries, we are technically ready to start the development of the flight missions associated with retrieving the samples. In parallel, planning for the potential receipt and evaluation of the samples has started, and should accelerate, as well as for the processes associated with making the samples available to the world's science community. Given the nature and scope of the Mars Sample Return campaign, we expect that engaging the public early and keeping them involved throughout will be a particularly important component of this effort. We have the opportunity and the motivation to make the Mars Sample Return campaign an international endeavour and a reality for all humankind.'

2. Planning for MSR Science

In response to the increased interest in MSR, NASA and the European Space Agency (ESA) signed a Statement of Intent in 2018 to jointly define roles & responsibilities for leading respective elements of an MSR campaign [1].

2.1 iMOST

Part of the renewed science planning has involved revisiting the science objectives for MSR. IMEWG (the International Mars Exploration Working Group) has evaluated 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 the samples to be collected by the Mars 2020 rover [2]. iMOST has 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 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) Geochronology, 4) Volatiles, 5) Planetary Evolution, 6) Understand/Reduce the Risks for Humans to Mars, 7) In-Situ Resource Utilization (ISRU).

2.2 MSPG

The MSR Science Planning Group (MSPG) has been 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. MSPG's approach is to formulate and propose mechanisms through which the international scientific community can achieve our shared scientific objectives.

First, MSPG scheduled a series of workshops to facilitate the development of a mutually acceptable set of science-driven functional recommendations for the handling and scientific analysis of samples returned from Mars. Broadly, the MSPG workshop series aims to establish and document positions amongst a diverse set of planetary and sample scientists, as well as curatorial and laboratory technique experts, related to planning assumptions and/or potential requirements involving the handling and analyses of returned samples.

Workshop #1-Science in Containment: A key planning question related to a potential future Mars Sample Return (MSR) Campaign is 'To what extent does MSR science need to be done in containment?' The answer to this will determine the character of the science-sourced requirements on the Sample Receiving Facility (SRF), including the number and definition of additional supporting science-related facilities (both within and outside of containment). This question was discussed at a 3-day workshop 14-16 January, 2019 in Columbia, MD, USA.

The starting point of these discussions was the list of scientific investigations described in the iMOST report (2019) [1]. From this initial list the workshop group attempted to determine which measurements would be time- or sterilization-sensitive in order to determine how many of these measurements would need to take place at the SRF. The workshop participants worked to develop several preliminary findings relating to sample characterization (including basic characterization and preliminary examination), time and sterilization-sensitive measurements, the potential use of isolation cabinets, and recommendations for further research.

Workshop #2-Contamination Control: This workshop took place 1-3 May, 2019 in Leicester, UK. Findings are currently being refined and will be available during the poster presentation related to this abstract. The overarching topic of MSPG Workshop #2 was the science-driven contamination control (CC) requirements, derived from the requirements on the sample caching system on Mars 2020, and their implications for the possible future Sample Receiving Facility (SRF) or any other similarly rated facilities involved in handling of returned Mars samples. The challenge considered is what is practical in terms of managing potential contamination during sample transportation, characterization, manipulation, processing and analysis, and how potential contamination could be minimized or mitigated in order to allow all of the science objectives of MSR to be achieved.

Disclaimer

NASA's decision to implement its elements of a Mars Sample Return Campaign will not be finalized until NASA's completion of the National Environmental Policy Act (NEPA) process. This document is being made available for information purposes only.

References

[1] https://mepag.jpl.nasa.gov/announcements/ 2018-04-26%20NASA-ESA%20SOI%20(Signed).pdf

[2] iMOST (2019), The Potential Science and Engineering Value of Samples Delivered to Earth by Mars Sample Return, (co-chairs D. W. Beaty, M. M. Grady, H. Y. McSween, E. Sefton-Nash; documentarian B. L. Carrier; plus 66 co-authors), Meteoritics & Planetary Science, vol. 54 (3), p. 667-671 (executive summary only), https://doi.org/10.1111/maps.13232; open access web link to full report (Meteoritics & Planetary Science, vol. 54, S3-S152): https://doi.org/10.1111/maps.13242.