PLANNING FOR THE SCIENTIFIC USE OF SAMPLES OF MARTIAN GRANULAR MATERIALS POTENTIALLY TO BE RETURNED BY MARS SAMPLE RETURN

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Introduction: Returning samples from Mars to Earth is a high-priority objective for the planetary science community [1]. Numerous specific technical objectives have been identified, related to both unresolved science questions and to future human Mars exploration endeavours, which could be achieved or significantly advanced via the analysis of martian rocks, "regolith," and gas samples [1-3]. NASA's Mars 2020 rover is scheduled to land on Mars in 2021 to collect a set of samples that could be returned to Earth in the near future, and as such the community needs to begin paying serious attention to what we would do with these samples if they arrived in our laboratories. Mars 2020 will be equipped with a sampling system capable of collecting rock "cores" of up to 10 cm in length/depth, as well as a specialized drill bit for collecting unconsolidated granular material.

The purpose of this analysis is to think through the following logic:

1. What are the specific reasons (and their priority) for collecting samples of granular materials?
2. How do those reasons translate to sampling priorities?
3. In what condition would these samples be expected to be received on Earth?
4. What is our best projection of the approach by which these samples would be divided, prepared, and analyzed to achieve our scientific objectives?

Terminology: The term "regolith" has more than one definition, including one that is general and one that is much more specific. To avoid confusion, for the purpose of this analysis we use the term "granular materials" to encompass the most general, non-genetic meaning, and restrict "regolith" to a specific subset of that. Our working taxonomy includes the following specific categories: 1) globally sourced airfall dust (dust); 2) dune or fluvial material (sand); 3) locally sourced decomposed rock (regolith); 4) crater ejecta, which may contain exotic lithologies (ejecta); and, 5) other. Note that because of the design of the specialized bit for Mars 2020, particles larger than 8.5 mm cannot be collected by the rover, so relatively coarse size fractions will not be sampleable.

Goals/Objectives: Analysis of martian granular materials would serve to advance our understanding in many areas of Mars science including habitability and astrobiology, surface-atmosphere interactions, surface chemistry, mineralogy, geology and environmental processes including weathering, erosion and transport. Results of these analyses would also provide specific input into planning for future human exploration of Mars, elucidating possible health and mechanical hazards caused by the martian surface material, as well as providing valuable information regarding available water and other resources for in-situ resource utilization (ISRU) and for civil engineering purposes. Results would also be relavant to matters of planetary protection and for ground-truthing orbital observations. We will be seeking feedback from the community on all issues relating to the planning for all of the objectives we want to achieve using samples of martian granular materials.

Sampling: Current thinking regarding potential Mars sample return is that there would be space in the return vehicles for about 30 sample tubes. Past planning [4] has concluded that about five samples of granular materials should be included, but this is, of course, partially dependent on the array of sampling possibilities available at the landing site eventually chosen. We are seeking community discussion and input on the relative importance of sampling the different types of granular material described above.

Sample Analysis: Working from our current understanding of martian surface materials (especially as observed by PHX, MER, and MSL), the expected state of the returned samples, and lessons learned from how the samples of granular materials returned by Apollo (the drive tubes) were processed, we have constructed a preliminary outline of the analytical flow by which the samples could be characterized, divided, prepared, and subsequently analyzed. Relevant analysis techniques best suited to addressing each technical objective have been identified, along with the expected sample masses required to complete these analyses. An issue, of course, is that the sample mass would be severely constrained, and it is certain that not everything that could be measured would be possible. It will be important to think this through before the samples are collected, so that decisions about sample number and character can be optimized.

References: [1] Vision and Voyages for Planetary Science in the Decade 2013–2022. (2011) National Academies Press. [2] MEPAG E2E-iSAG. (2011) Planning for Mars returned sample science: final report of the MSR End-to-End International Science Analysis Group (E2E-iSAG). *Astrobiology* 12:175-230. [3] MEPAG (2015), Mars Scientific Goals, Objectives, Investigations, and Priorities: 2015. V. Hamilton, ed., 74 p. white paper posted June, 2015 by the Mars Exploration Program Analysis Group (MEPAG) at http://mepag.nasa.gov/reports.cfm [4] J. F. Mustard, et al (2013): Report of the Mars 2020 Science Definition Team, 154 pp., posted July, 2013, by the Mars Exploration Program Analysis Group (MEPAG) at http://mepag.jpl.nasa.gov/reports/MEP/Mars_2020_SDT_Report_Final.pdf.