THE POTENTIAL VALUE OF RETURNING SAMPLES OF MARTIAN DUST AND OTHER GRANULAR MATERIALS FOR ANALYSIS IN EARTH LABORATORIES TO PREPARING FOR THE HUMAN EXPLORATION OF MARS. B. L. Carrier[1], D. W. Beaty[1], M. H. Hecht[2]. [1]Jet Propulsion Laboratory, California Institute of Technology (Brandi.L.Carrier@jpl.nasa.gov), [2]MIT Haystack Observatory

Introduction: By means of numerous robotic missions to Mars over the past four decades, we have learned a lot about the dust on Mars, both in the atmosphere and on the ground. However, there are some aspects of the dust that cannot effectively be measured at Mars, and for which the analysis of returned samples would be required.

Dust is one dimension of a broader set of geological components which we encompass with the general term “granular materials.” Although granular materials are present everywhere on the martian surface, they are not equally hazardous either to humans or to the hardware that would be necessary to keep them alive and productive.

In order to construct quantitative models for the behavior of dust on Mars, we need to understand the geological processes by which dust is created, transported, and deposited. How do these processes cause the size distribution and chemistry of the dust to change with time? How does the dust that falls out of the atmosphere get admixed into the regolith? Knowledge of these processes would help us to understand and predict the chemical, mechanical, electrical, and biological effects of martian dust as it interacts with future human exploration systems.

It would also be valuable to determine the nature and concentrations of commodities of potential interest, such as water, in martian dust and other types of granular materials, which could possibly be used for in-situ resource utilization (ISRU). MEPAG Goal IV-D is centered around characterization of potentially extractable water resources to support ISRU [1]. Hydrated minerals present in granular materials have been identified as one potential source from which water for human activities might be captured. To advance this objective it will be necessary to better constrain the chemical composition and concentrations of hydrated minerals in martian granular materials. Knowledge of the physical and mechanical properties of these materials will also aid in the advancement of the technologies needed to capture this potential resource.

In order to fully address these knowledge gaps we will need a mixture of information from in-situ missions and from samples returned from Mars [1-3]. The in-situ data, from both orbiters and landers, are necessary to understand the context of how the atmosphere interacts with the surface to create, lift, and transport dust. Data from sample studies are needed to narrow the focus in order to understand the specific roles of mineralogy, geochemistry and, potentially, biology.

In order to advance this planning, and to decide what kinds of samples should be prioritized by the Mars 2020 sample-collecting rover, we need community discussion on the relative value and priority of various types of martian granular material to advancing our various objectives related to future human exploration. The purpose of this analysis is to encourage community discussion and feedback on the following issues:

1. What are the specific reasons (and their priority) for collecting and analyzing samples of granular materials?
2. How do those reasons translate to potential sampling priorities?
3. If we were to collect samples of martian dust and/or other granular matierals, in what condition would they 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 various objectives?

Terminology: In order to distinguish between various types of granular material, we are using a working taxonomy that includes the following end member categories: 1) globally sourced airfall dust (dust); 2) saltation-sized particles moved either by aeolian or fluvial processes, including dune material (sand); 3) locally sourced decomposed rock (regolith); 4) crater ejecta, which may contain exotic lithologies (ejecta); and, 5) other. Since granular materials, unlike solid rocks, can commingle, granular materials encountered on Mars will likely represent some combination of these end members.

For the purposes of this workshop, we find it most appropriate to focus on categories 1-3, as these are the types of material likely to be ubiquitous on Mars and therefore most likely to interact continuously with both humans and hardware.

Prior Work: Previous studies have identified outstanding knowledge gaps and scientific objectives that could be advanced through the return of martian dust and other granular materials [1-3]. Of particular importance for potential human exploration are questions relating to planetary protection, possible astronaut health, and possible mechanical, chemical, and electrical effects on engineered systems. Martian dust and other granular materials have also been proposed as possible sources of water and other resources for ISRU, but the concentrations and availability of these resources is currently poorly constrained.

A major part of the reason that Mars is interesting is that it has the potential for life, both past or present. This means that any current life would have the potential to be transmitted to Earth if and when samples are returned or astronauts come home. In order to understand any related risks, we have to know if such life could be transported by the globally circulating dust, because the astronauts would certainly come into contact with it, and there would be no way to completely leave it behind. Because the martian atmosphere is well circulated, the case has been made that one sample of this material from any location would be representative of Martian dust overall [2]. Analysis of this material would therefore test the hypothesis that airborne dust could serve as a vector for potential replicating biohazards, a critical planetary protection issue. Secondary objectives would include evaluation of its physical and chemical properties. As this dust is ubiquitous in the atmosphere and is thus inevitably going to interact with any systems placed on the martian surface this analysis has been considered to be of high priority for sample return.

Another likely target for sample return might be the saltation-sized particles that were found to dominate the landscape at the Phoenix landing site [4]. This is another instance where analysis of one sample might provide information about a much larger area. Samples of other types of martian granular material have also been identified as candidates for sample return in regards to both their relevance to human exploration as well as to advancing other more general knowledge gaps, but their relative importance and priority have not been fully explored by the community.

Goals/Objectives: We seek community feedback on the prioritization of the specific objectives relevant to the collection and possible subsequent analysis of martian granular material. We have identified six preliminary objectives that would be advanced via the return and analysis of martian granular material:

1) Address the possibility of extant life for both potential replicating biohazards and planetary protection
2) Identification of potential health hazards posed by the martian surface material and airborne dust
3) Identification of hazards to hardware and technological assets (including spacesuits)
4) Creation of a high-fidelity simulant for testing resources and technology
5) Assessment of resources for ISRU
6) Assessment of resources for civil engineering or other possible uses

We seek to prioritize these objectives and identify the types of granular materials which would best advance each objective in order to inform possible sampling strategies for Mars 2020. It will also be important to identify the types of analyses that would be necessary to best achieve the stated objectives in order to constrain the masses required and the appropriate handling, preparation, and division of any returned samples.

References: [1] 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. [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] Vision and Voyages for Planetary Science in the Decade 2013–2022. (2011) National Academies Press. [4] Pike et al. (2011). *Geophysical Research Letters* 38: L24201.