Mars Sample Return Priorities in Light of Martian Samples (Meteorites) We Already Have. Marc Fries[1], Ralph Harvey[2] and Pamela G. Conrad[1], [1]Jet Propulsion Laboratory, 4800 Oak Grove Dr. MS 183-301, Pasadena, CA 91109. [2]Case Western Reserve University, Dept. of Geological Sciences, 112 A.W. Smith Bldg., 10900 Euclid Ave., Cleveland, OH 44106. Marc.D.Fries@jpl.nasa.gov

Introduction: Numerous previous efforts have made the case for performing sample return missions to Mars [e.g. 1-4]. Unlike the formative years of lunar sample return preparations, however, sample return planning for Mars can be done with the benefit of an extensive body of research available from martian samples in the form of martian meteorites. To date, more than 35 martian meteorites have been identified for a total mass in excess of 80 kg [5]. Criteria for and priorities in Mars sample return missions must take the existing body of data from these samples into consideration so as to maximize mission science return and prevent redundant effort.

Discussion: Existing martian samples provide a wealth of scientific information on a range of martian processes, ranging from geochemistry, geodynamics, and insights into martian aqueous processing [6,7] to a host of other subjects. With that said, these strengths are balanced by weaknesses inherent in the stochastic process of meteorite transfer. Items of interest include:

Martian sample site context. Although orbital imaging has provided information that can be used to select likely ejection sites for some martian meteorites [8], it is not currently possible to definitively identify these sites. As such, it is difficult to tie research conclusions derived from martian meteorites back to a specific region or geologic sequence on Mars. This information may be regained since the absolute ages of the meteorites give them a place in martian global history, and the lack of martian crustal recycling has likely preserved the parent orogenies. A well thought-out sample return mission, by contrast, would include detailed contextual data for returned material.

Surface vs. sub-surface sampling. The present suite of martian meteorites is composed of igneous, "hard-rock" samples extracted from various depths within the martian crust. While some of them show evidence of near-surface processes and the possibility exists that martian meteorites originating from surface settings may yet be found, none of the currently available samples can be directly compared to materials observed and analyzed by rover or lander missions. Such surface samples would also be very useful for assessing habitability and searching for evidence of extant or extinct martian life. A sample return mission could target surface and near-surface materials and in all likelihood would face mission and rock accessibility constraints that would result in sampling them exclusively.

Mineralogy suite. One of the limiting factors in the range of martian materials available through meteorite transfer is the durability of the source material. The present suite of martian meteorites is composed of relatively robust minerals such as olivine, pyroxenes, oxides, etc. which are well suited to surviving the dual shocks of ejection and terrestrial atmospheric interface. Both orbital imagery and MER rover data indicate the presence of other bulk minerals such as sulfates (i.e. jarosite via MER, gypsum via MRO), hematite spherules, and phyllosilicates, for example. Such samples are very important in understanding martian surface processes through geologic history, and in turn to better constrain and define Mars' geologic epochs.

Additionally, each martian meteorite represents a single site on Mars since there are no brecciated martian meteorites. Sample return missions may return multi-lithology samples such as regolith or breccias. While such samples would be less useful in terms of establishing petrogenetic history, they would be useful as witnesses to surface alteration, weathering, impact processing and transport processes relevant to the site under investigation.

Shock and weathering. All martian meteorites exhibit alteration due to shock incurred on ejection. However, the degree of shock is remarkably light to the point that this factor serves as an important constraint in modeling of their ejection dynamics [9]. Additionally, their residence on Earth includes a period of alteration by weathering that exposed them to a greater degree of oxidation than they had previously experienced. While these forms of alteration may be extensive, modern techniques and methods are capable of extracting extensive, minute detail about their parent setting in terms of geology, chemistry, isotopic content, alteration history and even their volatile content [10]. While microbial contamination has also been shown in martian meteorites in previous studies [11] and can be a contributing factor in terrestrial alteration, recent studies show that this can be quantitatively analyzed and accounted for [12,13]. Generally speaking, martian meteorites show very little in the way of martian weathering, possibly aided by their initial, subsurface setting.

Cost and risk. Retrieving martian samples on Earth is inexpensive, low-risk and can be performed over a long period of time to produce a large number of samples. A robotic sample return mission would be expensive, risky, and would produce a one-time yield of a small quantity of material.

Planetary protection considerations. Current plans for handling returned samples require extensive heat-sterilization processing before they can be released to scientists for study. While these plans may or may not be carried out as currently envisioned, martian meteorites do not face any planetary protection limitations.

Conclusions: Martian sample return presents an interesting deviation from past experience with lunar samples. Lunar sample return was geared towards recovery of "pristine" samples with an emphasis on evaluating their petrogenetic history. By contrast, martian sample return will be guided by the quest for altered, weathered materials representing the history of surface processes on Mars. Sample selection should proceed on this basis, targeting an appropriate sample suite that does not overlap with existing martian samples.

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