POTENTIAL STRATEGIES FOR MAKING ORGANIC MEASUREMENTS IN RETURNED MARTIAN SAMPLES OF RELEVANCE TO SCIENCE AND PLANETARY PROTECTION. L. E. Hays[1], D. W. Beaty[1], R. Shotwell[1], and R. Mattingly[1]. [1]Mars Program Office, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109 (lhays@jpl.nasa.gov).

Introduction: A crucial aspect of our assessment of the biological potential of Mars is the character of organic material in martian rocks and soils, which could be measured in returned samples. This has the potential to tell us not just whether life is or was present in the sampled material, but also whether life is or was present in the surrounding environment. This information would be of central importance both to life-related scientific hypotheses and interpretations, and planetary protection decision-making. For this reason, considering specifics of how these measurements could be made is important.

The proposed Mars 2020 rover would take samples of martian material and seal them in individual tubes for a potential return to Earth. Last year, the Mars 2020 Organic Contamination Panel (OCP) recommended limits to the amount of terrestrial organic contamination that could be permitted on these samples, to allow potential indigenous martian organic molecules to be recognized with reasonable confidence [1]. Although currently there is no commitment to return samples collected by the Mars 2020 rover, consideration of the implications of organic material detection from potential returned samples follows the line of inquiry from the OCP report. Here we present potential responses to different results from investigations that would be performed on returned samples, and raise potential planning questions to encourage community discussion.

Considered areas of the sample: In the situation where samples are returned and made available for analysis, three different sub-samples could be measured for each larger, named sample. These are distinguished not only by physical location, but also operationally on how measurements of organics could be carried out.

1. Exterior of the metal sample tube – would presumably be coated with martian dust, and would presumably also be more contaminated than the interior contents of the sample tubes.
2. Sample tube interior and sample core exterior – during the extended time between sample collection and opening the tubes, the sample tube interior and core exterior would have been in contact and may have exchanged significant organic material.
3. Sample core interior – within the sample core would be the material least likely to be contaminated by terrestrial organic compounds.

Q1: What would comparison of the organic measurements of the above sample types tell us about the nature of indigenous organics in the returned samples?

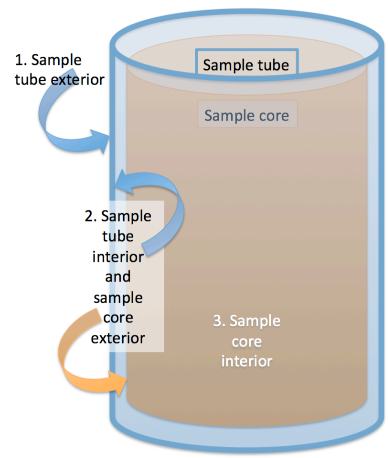

Figure 1. Regions of the sample tube and core considered in this study.

Implementation planning for sample analysis: First, inherent to Mars sample return is a limitation of the quantity of sample material. Every portion of the sample must be used productively, as there would be no immediate option to go back and retrieve additional sample material.

Second, a premise of MSR planning is that a statistically significant sub-sample of the returned material would be analyzed for biological hazards, and that the results from that analysis could be applied to the remainder of the sample. This would maximize the availability of pristine sample material for other types of sample investigations. Therefore, whatever measurements would be made must be done so that remaining unanalyzed sample material could be interpreted as non-hazardous. If not, there is no logical way for untested, unsterilized sample material to leave containment. Unless a non-destructive way to test the entire sample is developed, current methods would consume the entirety of the sample, which would defeat the broader scientific purposes of MSR.

Q2: What sterilization methods would be effective against as-yet unknown, hypothetical martian organ-

isms? What would be the effect of sterilization on the other sample investigations that have been envisioned as a part of MSR?

However, finding a technical basis for agreeing to what constitutes "statistically significant sub-sample" would be a difficult task. Rock samples are always heterogeneous, on a range of spatial scales, and both mineralogically and with respect to their organic material. Moreover, understanding the relationship between geological heterogeneity (e.g. minerals, grains, clasts) and biological heterogeneity (or organic geochemical heterogeneity) in rock samples here on Earth is a nascent field.

Q3: How much advance planning could go into the strategies for addressing heterogeneity when dividing potential samples, or would this be a discovery-responsive set of decisions?

Comparison list: As described in the OCP report, any organic material measured from returned samples would have to be compared to archived organic and trace biological materials known as potential sources of contamination through all steps of the sample return architecture. This list could include spacecraft material, samples collected at the assembly facility(ies), witness plates on the sampling hardware, sample blanks collected on the surface of Mars, as well as potentially any known terrestrial organism or compound that may have been incorporated but not cataloged.

Q4: Are there other classes of organic material that should be included in a comparison list? Do all known terrestrial organisms and compounds belong on this list? If so, are there unknown, but Earth-like organisms and compounds that should also be included – where would the distinction of "Earth-like" cut-off?

Measurements: Although improvements in the state of the art instrumentation are all but assured in the time before samples would be returned and analyzed, measurements possible today were considered by OCP for recommendations for limiting contamination levels. We have implemented a similar strategy, considering general instrumentation and types of measurements that might be informative without addressing concentration limits. For this study, we considered four types of measurements that could be informative when made with appropriate spatial resolution on the samples:

- Spectroscopy – Could be used for both survey and targeted measurements on surfaces to identify regions with more organic material as well as providing information about the type of compounds present. Of the four, this is the only non-destructive measurement.
- LCMS/GCMS – Could be used for both survey and targeted measurements on either washes/wipes of surfaces or extracted sample powders to identify specific organic molecules present.
- Isotope ratio – Could be used for targeted measurements on the same sample types as MS techniques to identify if different compounds have unique isotopic signatures compared to source rock or other compounds.
- RNA/DNA – Could be used for very targeted measurements on the same sample type as MS techniques or on samples identified by spectroscopy; could be the best way to identify particles that are terrestrial in origin.

Q5: Are there other types of measurements that are definitive enough to be used for the purpose of Planetary Protection decision-making?

Additional considerations: The above considerations apply to the samples that would be returned as intact rock cores, but different assessments could be made for cores that had broken into many pieces and regolith samples. Additionally, we have only considered samples individually, but results from one sample core would likely have implications for the entire suite of samples, and may provide context for interpretation of results across the set.

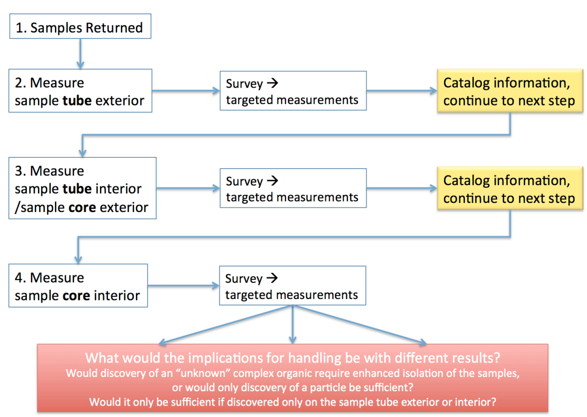

Figure 2. Logic tree leading to potential outcomes for discussion.

Q6: How could the data collected in situ by the proposed Mars 2020 rover serve to provide a foundation for the strategic planning for sample analysis?

References: [1] Summons R. E., and Sessions A. L., et al. (2014) *Astrobiology, 14 (12),* 969-1027.