WHAT ARE THE ACCEPTABLE LIMITS OF ORGANIC CONTAMINATION IN POTENTIAL RETURNED MARS SAMPLES? Summons, R.E.[1], A.L. Sessions[2], A. Allwood[3], H. Barton[4], D. Beaty[3], J. Canham[5], B. Clark[6], J. P. Dworkin[7], S. Feldman[3], M. Fries[8], Y. Lin[3], R. Mathies[9], S. M. Milkovich[3], and A. Steele[10], [1]Earth, Atmospheric and Planetary Sciences, Masschusetts Institute of Technology, Cambridge, MA 02139; [2]Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA, 91125; [3]NASA Jet Propulsion Laboratory, California Inst. of Technology, Pasadena CA 91109; [4]Dept. of Biology, Univeristy of Akron, Akron, OH, 44325; [5]ATK Space Systems, Beltsville, MD; [6]Space Science Institute, Boulder, CO; [7]NASA Goddard Space Flight Center, Greenbelt, MD 20771; [8]NASA Johnson Space Center, Houston, TX 77058; [9]Dept of Chemistry, University of California Berkeley, Berkeley, CA 94720; [10]Geophysical Laboratory, Carnegie Inst for Science, Washington DC, 20015.

Introduction: The goal of a Mars sample return (MSR) campaign would be to collect and return geological samples to Earth for a well-defined set of scientific analyses. Among the most important would be to investigate the samples for the presence of Mars-sourced organic molecules. This could have significant implications for understanding the pre-biotic chemistry of Mars, for interpreting the potential for past and present life on Mars, and for planetary protection.

However, in order to carry out this investigation in a scientifically credible way, it is essential to establish acceptable levels of Earth-sourced organic contamination on the samples at the point they are first analyzed. Given that it will be impossible to achieve zero contamination, it will be important to establish a set of strategies that would enable Earth-sourced contamination to be recognized and distinguished from any Mars-sourced material. This requires careful planning for organic contamination control and characterization beginning with the collection and storage of samples on Mars.

Introduction to the Proposed Mars 2020 Rover: Mars 2020 is a strategic mission sponsored by NASA's Planetary Science Division, through the Mars Exploration Program (MEP), all of which are part of the Science Mission Directorate (SMD). This proposed mission would be designed to advance the scientific priorities detailed in the National Research Council's Planetary Science Decadal Survey [1]. Mars 2020 rover development and design would be largely based upon the Mars Science Laboratory architecture that successfully carried the Curiosity rover to the martian surface

The Mars 2020 Science Definition Team report [2] recommended that, among other *in-situ* science and technology objectives, the mission should acquire scientifically selected samples and place them into a cache that could potentially be returned to Earth by a future mission. These samples, should NASA choose to return them, would provide opportunities for performing a variety of Earth-based experiments including ones related to the search for signs of past life.

In order to meet the requirement that the cache be returnable, the MEP and the Project must define hardware requirements and mission characteristics that would ensure the integrity of the samples and viability of meaningful future measurement results. One such attribute is the ability to reduce terrestrial organic contamination to a point where its presence would not interfere with sensitive investigations of martian organic geochemistry—or with our ability to distinguish terrestrial from martian organic molecules. It is anticipated that these requirements will place constraints on spacecraft cleanliness (particularly organic cleanliness) and sampling/caching system capabilities, including potentially introducing a requirement for blanks, witness plates, and check material.

In order to further define these requirements, the MEP convened a Contamination Study Panel (Fig 1). The summary statement of purpose of the Mars 2020 Contamination Study Panel is as follows:

Evaluate draft Mars 2020 mission sample contamination requirements. Assess implementation approaches with respect to returned sample science objectives to support the investigation of martian organic geochemistry in the returned samples and differentiation of indigenous molecules from terrestrial contamination.

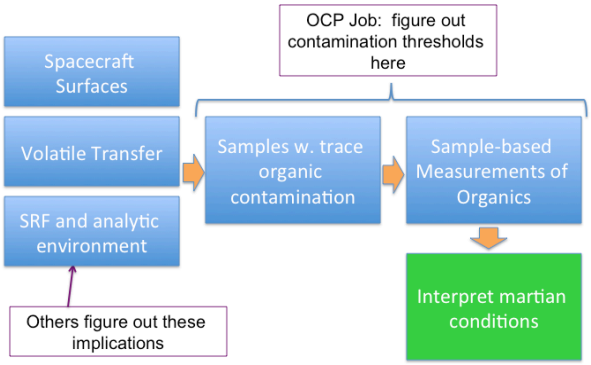

Fig.1: Role of the Organic Contamination Panel in determining organic contamination control plans for Mars 2020.

Assumptions: The Organic Contamination Study panel has been given the following assumptions in its Charter:

1. Assume that one central purpose for returning samples to Earth is to make scientifically defensible, measurement-based interpretations of Mars-sourced organic molecules in the samples. This requires either avoiding or recognizing and distinguishing potential Earth-sourced organic contaminants.
2. For the purpose of this study, assume that Earth-sourced organic molecules are the only source of organic contamination on returned Mars samples that would interfere with our objectives. Contamination by Mars-sourced organics, for example from a previously collected sample, is not in the scope of this study.
3. Assume that eventual life-detection/biohazard protocols will be defined by a later panel and are not in the scope of this study.
4. The type and quantity of organic contaminants that may affect the samples during their time in a Sample Receiving Facility prior to analysis are assumed to be small relative to the contaminants delivered to the samples by the Mars 2020 mission—and, thus, can be ignored for the purpose of this study.

Organic Contamination: For the purpose of this study, organic contamination is defined as any substance that significantly interferes with our ability to detect the presence of martian organic compounds or prevents our confidently determining that an organic compound is of martian and not terrestrial origin.

Contamination Control Strategy

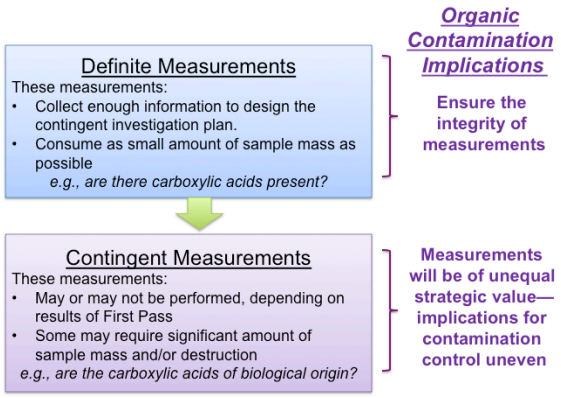

Fig 2: Proposal for a Mars 2020 contamination control strategy, dividing measurements into two groups based on the information collected and the amount of sample mass consumed.

Results: In this presentation, we will identify the following:

1. Proposals for limits for Earth-sourced organic contamination on the potential returned martian samples at the point in time when they are first analyzed for organic molecules: either a) total organic contamination or b) total unrecognized organic contamination (i.e., contamination above measured blank levels).
2. A list of measurements, based on current knowledge and capabilities, to be made on the returned samples in support of scientific objectives related to martian organic geochemistry, including the presence of past or present life; list of representative instruments capable of these measurements and their performance characteristics, including detection limits.
3. A summary of the types and quantities of Earth-sourced organic contaminants of greatest concern, if they were on the samples, with regard to their possible adverse impact on the scientific objectives of potential future returned sample science.
4. An assessment of possible implementation approaches for recognizing and distinguishing Mars-sourced organic molecules in the samples from Earth-sourced organic molecular contamination. Approaches will include, but not be limited to:
   A system of positive and/or negative control standards, in order to document the state of contamination at specific times/places and a list of separately control standards that would need to go to Mars on the Mars 2020 sampling rover vs. those that wouldn't.
5. Design characteristics for a set of blanks, witness plates, and other kinds of control samples that are taken before the rover is launched from Earth, then preserved for analysis when the Mars samples are potentially returned to Earth in the future.
6. Design characteristics for a set of control standards that could be used in association with the organic molecule measurements within the Sample Receiving Facility.

References: [1] NRC (2011) Vision and Voyages for Planetary Science in the Decade 2013-2022. [2] Mars 2020 SDT (2013), posted at http://mepag.nasa.gov/reports/MEP/Mars_2020_SDT_Report_Final.pdf