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Introduction: Evidence of habitability and habitation of Mars may be forthcoming by returning samples to Earth [1]. Clear objectives and associated choices of samples is essential to maximize the opportunities presented by returned samples. In the context of the solar system, the relative similarity of Earth and Mars generates an expectation of biochemical harmony for Earth and Mars. We can confidently predict that any biochemical scaffolding on Mars would be based on carbon and any biochemical solvent would be based on water. To expect otherwise would require planetary conditions and chemistries [2] that differ dramatically from those of either Earth or Mars. Reduced carbon is therefore a beacon for the potential discovery of evidence of life in a sample [3]. Any reduced carbon detected in samples from Mars should also have features that provide the ability to discriminate between non-life and life sources and, preferably, between an origin on Earth and Mars. For detecting life, the usefulness of organic carbon to biochemistry is in its ability to form complex and specific organic structures. Recognizing the organic signatures of life is therefore an achievable goal. For discriminating provenance on Earth and Mars, detailed environmental adaptions must be sought. Although based on carbon and water the biochemical similarities between organisms on Earth and Mars would not be expected to be exact. Our terrestrial examples of environmental adaptations reveal substantial biochemical variations that reflect the challenges and opportunities presented by the host environment [3].

This is a provisional report from the iMOST subteam on the objective of Seeking the Signs of Life, identifying key samples and measurements needed to understand Martian Organic Carbon.

Organic Carbon sub-objectives:

1) Determine the presence and nature of carbon in multiple valence states on Mars. To measure inorganic carbon, reduced carbon, simple organic molecules and polymers, organic matter features, correlation with mineral catalysts and the cosmogenic nuclides to determine exposure age. Key samples would be organic-rich rocks, unaltered igneous rocks and regolith.

2) Determine stable isotopic fractionations (e.g., of C, H, N, O, P, S) between organic matter and carbon-bearing minerals such as carbonates and compare with isotopic compositions of water, organic compounds or minerals. Key samples would be carbon-rich in nature.

3) Identify minerals that may indicate biological processes. To detect and map the arrangement of minerals associated with biological or catalytic activity and any associated organic carbon. Suitable samples would contain appropriate minerals and organic carbon.

4) Establish whether chemical relationships could indicate biological processes. To seek evidence of chemical equilibria or disequilibria that are inconsistent with abiotic processes, and thus which would be indicative of biological activity. Suitable samples would contain appropriate mineral assemblages, especially those which contain organic carbon in concentrations significantly above average.

5). Identify morphological evidence of life. To assess rock or mineral fabrics and structures consistent with body or trace fossils. Suitable samples would contain appropriate mineral assemblages, especially those which contain organic carbon in concentrations significantly above average

6). Identify any aspects of the environment conducive to the existence and preservation of prebiotic chemistry. To identify components of pre-biotic chemistry, evidence for hydrothermal activity, presence of mineral catalysts, cosmogenic nuclides. Suitable samples would be rocks of any type which have been recently exposed and especially those whose formation age predates the cessation of the planetary magnetic dynamo.

References:

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[3] M. A. Sephton and O. Botta, International Journal of Astrobiology **4** (3 & 4), 269–276 (2005).