SEEKING SIGNS OF LIFE ON MARS: THE IMPORTANCE OF SEDIMENTARY SUITES AS PART OF A MARS SAMPLE RETURN CAMPAIGN.

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Introduction: Seeking the signs of life on Mars is often considered the "first among equal" objectives for any potential Mars Sample Return (MSR) campaign [e.g., ref. 1]. Among the geological settings considered to have the greatest potential for recording evidence of ancient life or its pre-biotic chemistry on Mars are lacustrine (and marine, if ever present) sedimentary depositional environments. This potential, and the possibility of returning samples that could meaningfully address this objective, have been greatly enhanced by investigations of an ancient redox stratified lake system in Gale crater by the Curiosity rover [2].

Lacustrine (and marine) environments are typically the ultimate repository of "source-to-sink" sedimentary systems [3]. In order to extract the maximum amount of information from such systems, and place that information into the context of the geological and climatological history of Mars, it is necessary to evaluate all pre-, syn- and post-depositional processes that may influence the compositions of sedimentary rocks.

Detailed Investigations: The iMOST team has established a list of detailed investigations designed to achieve the overall goal of characterizing the aqueous portion of a Martian sedimentary system:

1. *Investigate physical and chemical sedimentary processes in ponded water to better understand sustained, widespread liquid surface water on Mars, including the examination of evaporites;*
2. *Investigate sediment diagenesis, including processes of cementation, dissolution, authigenesis, recrystallization, redox, and fluid-mineral interaction;*
3. *Investigate mechanisms by which sediment is/was generated on Mars, by understanding the weathering and erosional processes;*
4. *Investigate provenance of sediment in the sedimentary system, including variation in lithology, tectonic association, and paleoclimate;*
5. *Investigate the nature of subaqueous (or subglacial) transport regimes that cut channels and valleys, including whether they were persistent or episodic, the size of discharge, and the climatic conditions and timescales of formation;*
6. *Characterize physical properties of aeolian materials to understand aspects of the surface processes and climate history.*

Critical Measurements: Many parts of these investigations can/will be accomplished by synergistic evaluation of combined rover *in-situ* and orbital measurements, and such data will further provide the fundamental context for returned sedimentary samples. However, many critical measurements can only be obtained on returned samples. The iMOST team has further identified more than twenty such measurements that cover the full range of stratigraphic, sedimentological, petrological, geochemical and isotopic characterization of the sediment suites and their various internal constituents.

Required Samples: Samples required to accomplish these measurements fall into nine (not all mutually exclusive) categories:

1. *Suite of sedimentary rocks representative of the stratigraphic section;*
2. *Suite of sedimentary rocks showing a range of lithification intensity and style;*
3. *Rocks of any type showing a range of weathering styles and intensity, including weathering rinds;*
4. *Sedimentary rocks with a variety of grain compositions;*
5. *Modern regolith, especially if locally derived;*
6. *Relatively coarse-grained sedimentary rocks;*
7. *Suite of sedimentary rocks representative of stratigraphy within an ancient stream channel;*
8. *Sample of modern aeolian sediment;*
9. *Sample(s) of lithified aeolian sedimentary rock.*

References: [1] McLennan S.M. et al. A. (2012) *Astrobiol, 12,* 175-230. [2] Hurowitz J. A. et al. (2017) *Science, 356,* doi:10.1126/science.aah6849. [3] Grotzinger J. P. (2013) *In: S. J. Mackwell et al. (Eds.) Comparative Climatology of Terrestrial Planets,* pp. 439-472, Univ. Arizona Press.