SEDIMENTOLOGY, STRATIGRAPHY AND ASTROBIOLOGY ON MARS IN 2018, POTENTIALLY USING TWO ROVERS.

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Detailed study of the sedimentary record on Mars, both by *in situ* methods and by means of sample return, is becoming progressively more important as our Mars exploration strategies evolve from "follow the water" and "seeking habitable environments" to "seeking evidence of life" [1]. A key mission in the future exploration sequence is the proposed 2018 joint NASA-ESA rover mission, that would have both advanced capabilities for *in situ* science, and would collect and cache samples for possible subsequent return to Earth.

Present plans for the 2018 mission envision landing two rovers at the same site. The potential NASA-provided Mars Astrobiology Explorer-Cacher (MAX-C) rover and the ESA-provided Exo-Mars rover would have separately defined objectives related to seeking evidence of past - and possibly also present - life on Mars, in an environment with high inferred habitability potential. Possible collaborative science for the two rovers operating together is under discussion. The landing site for this potential two-rover mission probably would contain sedimentary rocks, as subaqueously deposited sediments are among the most prospective kinds of geologic environments in which to pursue these objectives.

If a sedimentary site is chosen for this proposed mission, the rovers would need to carry out a robust sedimentological field study, not only to maximize the chances of detecting potential biosignatures and selecting the best samples for analysis or possible return, but – crucially – to have the necessary contextual information to interpret potential biosignatures if any are found either *in situ* or upon return to Earth.

Science measurement capabilities: The two rovers would have different and complementary measurement approaches. The potential MAX-C science payload would have an approach similar to that on the Mars Exploration Rovers (MER), focused on analysis of outcrops through arm- and mast-mounted instruments, rather than onboard analysis of samples. However, MAX-C would have significantly updated instruments compared to MER, with the arm-mounted instruments capable of compositional micro-mapping rather than bulk compositional analysis. MAX-C would also have an instrument capable of detecting and micro-mapping organics. In effect, the envisioned MAX-C payload could carry out spatially-resolved geochemistry and rudimentary field petrography. These capabilities would be crucial for interpreting depositional and post-depositional history, and for discerning the possible influence of microbiological processes. The proposed MAX-C rover would also collect and cache shallow (~10cm depth) core samples for possible return to Earth by a future mission.

The ExoMars rover would include cameras and a close-up imager for surface studies, and would be able to investigate the shallow subsurface stratigraphy with ground penetrating radar, drill to 2m depth, measure compositional variations of the borehole walls, and collect and analyze small core samples with an on-board analytical laboratory. The laboratory would include a mass spectrometer for detecting and characterizing a broad array of organic molecules, a competitive immunoassay laboratory-on-a-chip sensor for detecting specific biomarkers, a microscope (15 µm resolution), and instruments for mineralogy analyses including X-ray diffraction and IR and Raman spectrometers. A range of potential collaborative possibilities arise from the currently envisioned payloads of the two rovers, or from small modifications of those payloads.

Possible exploration strategies: The rover *Opportunity* demonstrated the first *in situ* sedimentology/stratigraphy studies on another planet, and that experience constitutes a valuable guide for future exploration approaches. If the MSL (2011) landing site is in sedimentary terrane (that decision is still pending), the MSL rover's experiences will further expand our understanding of exploration strategies. For the proposed 2018 rovers, there are two important kinds of open planning questions. Firstly, how should the two rovers be equipped (in the case of MAX-C, the instruments have not yet been selected). Secondly, how should the rover capabilities be used, separately and jointly, to interrogate sedimentary rocks? Another important consideration would be how to balance the collection of compelling samples (which are best recognized after a certain amount of field analysis has been conducted) against the ticking mission clock and limited number of opportunities to collect samples.

References: [1] http://mepag/meeting/jul-09/MEPAG_DSMustard_07-2009-v9.ppt; [2] MEPAG Mars Astrobiology Explorer - Cacher (MAX-C) (2009) http://mepag.jpl.nasa.gov/reports/ index.html