THE MARS METHANE ANALOGUE MISSION (M3): RESULTS OF THE 2012 FIELD DEPLOYMENT.

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Introduction: The search for signs of past or extant life on Mars is a high priority for future Mars exploration [e.g., 1]. This search will likely be undertaken with a variety of landed and orbital missions.

The Canadian Space Agency (CSA), through its Analogue Missions program, supported an analogue mission designed to simulate a Mars micro-rover mission geared toward identifying and characterizing the sources of methane emissions on Mars. This analogue mission included two rover deployments, in the summers of 2011 and 2012. The results of the 2011 mission have been reported in [2]. The basic goals for the 2012 field deployment remain unchanged from the previous year:

- Test technologies that could be used to search for methane on Mars and determine its biogenicity
- Assess different search methodologies for detecting and characterizing methane
- Acquire operational experience for rover missions designed to search for methane on Mars
- Test possible next-generation technologies
- Explore synergies between different instruments.

Pre-deployment activities and goals were described in [3]. These activities included selecting a suitable site for the rover trials and defining a suite of core and non-core instruments for the deployment.

Analogue site: Selection of an analogue site for the field trials converged on the Appalachian ophiolites in southern Quebec [4-6]. This region was chosen because of the expectation that methane is being produced in serpentinized terrains (albeit at low levels), and because putative detections of methane on Mars coincide with areas that have surficial serpentine [7].

Investigation of possible sites was conducted in 2010 and the team selected the abandoned Norbestos mine, located near the town of Asbestos, Quebec, Canada, for the 2012 rover field trial for various reasons: suitable geology, probable subsurface methane generation, and accessibility (Figs. 1 and 2). A 70 x 25 m "exploration zone" was chosen for rover deployment.

Instrument suite: The instruments included in the second deployment consisted of "core" (mission-critical) and "non-core" investigative instruments. The core instrument suite included a Bumblebee stereo colour camera system, an ASD FieldSpec Pro HR point spectrometer (350-2500 nm), a B&W Tek 532 nm Raman point spectrometer, a Picarro methane detector, and a 405 nm laser and Ocean Optics S-2000 point spectrometer (200-860 nm) for UV fluorescence detection. The non-core instruments included a Channel Systems 400-700 nm hyperspectral imager (10 nm band passes), an electromagnetic induction sounder (EMIS [8]), and a 3-band UV-vis imager.

Rover operations: In order to better simulate Mars rover operations, uplinks and downlinks were planned for twice-daily 30 minute windows with suitable time delays. As not all instruments used in the field deployment could be mounted on the rover, gas samples were brought back from the rover sampling site to the base camp and analyzed in a manner analogous to how the rover would conduct sampling and data acquisition. Rock samples were analyzed by instruments mounted in a cart that followed the rover with the various light sources and fiber optic probes mounted on a sampling arm. Rover operations were directed by a science team located off-site.

Search strategy: Using methane concentrations as the primary search strategy was found to be unfeasible during the first deployment. Therefore the 2012 deployment search strategy was based on the following protocol: use the colour stereo imagery to identify possible methane sources, specifically the presence of major ground fractures, surface discolouration at fractures, or water seepage. Targets in the field of view were prioritized based on these criteria. The rover was directed to these targets and conducted spectral reflectance, Raman, UV fluorescence, and gas sampling measurements at different distances (from 0 to 24 cm) from the target of interest.

For the non-core instruments, EMIS traverse were conducted after rover deployments [9], hyperspectral images were collected from rocks at the mine site and the walls of the mine, and UV-vis images were acquired at the target locations.

Results: The instruments performed nominally during the deployment, with no major outages. It was found that the science team was able to use the rover-based imagery to identify the major ground fractures at the site, as verified by the field team. The rover was able to navigate to these targets autonomously. Reflectance spectra were successfully acquired at all the target sites (e.g., Fig. 3). Raman spectra were of variable quality at the target sites (Fig. 4), and we suspect that this is due to surface texture, grain size, and presence of opaques; we are currently investigating the causes of this variable-quality data. UV-induced fluorescence spectra were also successfully acquired, but it was found that the biology present in the fractures was too low to allow for measurable fluorescence.

For the non-core instruments, the EMIS was towed on a sled through the mine site and rover exploration zone, and was able to characterize electrical conductivity and magnetic susceptibility of the near surface (depth <3.0 m). The hyperspectral imager showed spectral differences for rocks at the site [Greenberger et al. - this meeting]. The UV-vis imagery appears most sensitive to phase angle effects rather than mineralogy, and the results are still being analyzed.

Major findings: The major findings from the 2012 deployment are: (1) color imagery is well-suited for identifying targets of interest for detailed investigation, on the basis of tone (color) and texture; (2) methane concentrations decline rapidly from a point source (generally to background levels) within <~1 metre from a source [10]; (3) reflectance spectra are generally more useful than Raman spectra, as they show characteristic absorption bands for a wider range of target physical properties.

References: [1] MEPAG Goals Committee (2010) Mars Science Goals, Objectives, and Priorities: 2010, http://mepag.jpl.nasa.gov/reports/MEPAG_Goals_Document_2010_v17.pdf. [2] Cloutis E.A. et al. (2012) *LPSC XLIII*, abstract #1569. [3] Cloutis E.A. et al. (2010) *LPSC XLI*, abstract #1174. [4] Schroetter J.-M. et al. (2005) *Tectonics*, *24*, TC1001. [5] Tremblay A. and Castonguay S. (2002) *Geology*, *30*, 7-82. [6] Hébert R. and Laurent R. (1989) *Chem. Geol.*, *77*, 265-285. [7] Ehlmann B.L. et al. (2008) *Science*, *322*, 1828-1832. [8] Boivin, A. et al. (2012) *LPSC XLIII*, abstract #2140. [9] Ralchenko, M. et al. (2013) *LPSC XLIV*, abstract #1027. [10] Olsen, K.S. et al. (2012) *GRL.*, *39*, L19201.

Acknowledgments: Support provided by the Canadian Space Agency through their Analogue Missions program is gratefully acknowledged.

Fig. 1. Ground-level view of the Norbestos Mine.

Fig. 2. Kapvik microrover at the Norbestos mine site.

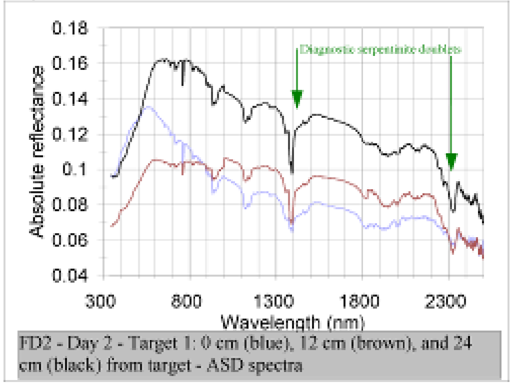

Fig. 3. Reflectance spectra of serpentinites from site showing characteristic bands in all of the spectra.

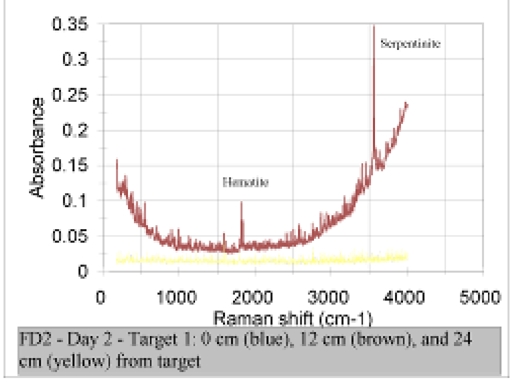

Fig. 4. Raman spectra from the Norbestos site.