THE MARS METHANE ANALOGUE MISSION (M3): RESULTS OF THE 2011 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, is supporting a microrover-based analogue mission designed to simulate a Mars rover mission geared toward identifying and characterizing methane emissions on Mars. This analogue mission program will run until late 2012.

In July 2011, we conducted our first Mars methane analogue mission rover deployment (over 3 days) with the following goals:

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

Pre-deployment activities and goals were described in [2]. These activities included defining a suite of core and non-core instruments for the deployment, and selecting a suitable site for the rover deployment.

Analogue site: Selection of a suitable site for the analogue mission converged on the Appalachian ophiolites in southern Quebec [3-5]. 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 [6].

Investigation of possible sites was conducted in 2010 and the team selected the Jeffrey Mine in Asbestos, QC, Canada [7] for the first deployment for various reasons: suitable geology, probable subsurface methane generation, and accessibility (Fig. 1).

Instrument suite: The analogue mission was designed to: (1) search directly for methane emissions and track them to their source; (2) identify tectonic features suitable for the release of subsurface methane (joint, fractures, fissures); and (3) map site geology to assess relationships between methane release and "suitable" mineralogy (i.e., serpentine and Mg-carbonates). The instrument suite used in the field trials included: an ASD point spectrometer (0.35-2.5 μm); a Raman point spectrometer (100-2200 cm^{-1}); a Picarro methane detector; a colour imager; and an electromagnetic induction sounder (EMIS).

Rover operations: In order to better simulate Mars rover operations, uplinks and downlinks were planned for every microrover stop point. The downlinked data were transferred to the science team located at MPB Communications in Point Claire, QC, with suitable time delays. As not all instrument used in the field deployment could be mounted on the rover, rock and 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.

Rover traverses: Two types of rover traverses were planned and conducted: a long "reconnaissance" traverse with objective points at 25 m and data collection every 5 m for the nav system cameras to recognize and avoid obstacles; and a "detailed" traverse with data collected every 1 m around the "science target" of an area of elevated methane concentrations.

The reconnaissance traverse was conducted in an area of dewatering boreholes and subsurface gas release. The detailed traverse was conducted close to one of these boreholes (but was out of reach of the rover).

Reconnaissance rover traverse results. The reconnaissance rover traverse was designed to search for suitable tectonic features and to map out any changes in methane concentration along the rover traverse. The major findings from this activity were that colour imagery was the best data source for identifying tectonic features of interest (major fractures) as well as changes in mineralogy identified on the basis of colour changes.

Detailed rover traverse results. The detailed rover traverses were undertaken in proximity to a borehole that exhibited elevated methane concentrations (150 ppm vs 1.7 ppm ambient). The major finding from this exercise was that methane concentrations declined rapidly away from the borehole, falling to ambient levels 1 meter away from the point source.

Instrument performance: The utility of the various instruments was assessed as part of the deployment. It was found that, at least for this terrain, the reflectance and Raman spectrometers provided largely similar data. Both instruments could identify the presence of the major mineral phases at the site: olivine, serpentine, and iron oxides (hematite) (Figs. 2 and 3). The methane analyzer was able to provide rapid analysis of methane concentrations as well as $^{13}C/^{12}C$ ratios – the data are still being analyzed but suggest that the methane at the site is being produced both biogenically (the presence of methanogens at the site has been confirmed) and abiogenically (which is significant as the site is not located in an area of thermal activity). The EMIS probed the subsurface to a depth of ~3 m and was effective in identifying major contacts (including a complex shear zone) between different rock types (peridotite/serpentinite and slate).

Major findings: The major findings from this deployment, some of which will influence 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, and image analysis to identify targets of interest for detailed analysis is the most fruitful approach; (2) methane can be produced abiogenically at low-temperature sites located away from heat sources; (3) following methane gradients to a source is likely not viable, as methane seems to dissipate rapidly away from a point source.

Future deployment: The 2012 deployment is planned for an abandoned open-pit serpentine mine (Norbestos mine) for a variety of reasons:

- Access to the Jeffrey mine is not assured for 2012
- The Norbestos mine has a large tailings pile with elevated methane, perhaps more representative of how methane may be being generated on Mars
- The Norbestos mine has a greater variety of terrains to test rover performance.

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. (2010) *LPSC XLII*, Abstract #1174. [3] Schroetter J.-M. et al. (2005) *Tectonics, 24*, TC1001. [4] Tremblay A. and Castonguay S. (2002) *Geology, 30*, 7-82. [5] Hébert R. and Laurent R. (1989) *Chem. Geol., 77*, 265-285. [6] Ehlmann B.L. et al. (2008) *Science, 322*, 1828-1832. [7] Boivin A. et al. (2011) *LPSC XLI*, abstract #1472.

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Fig. 1. Google Earth view of the Jeffrey Mine.

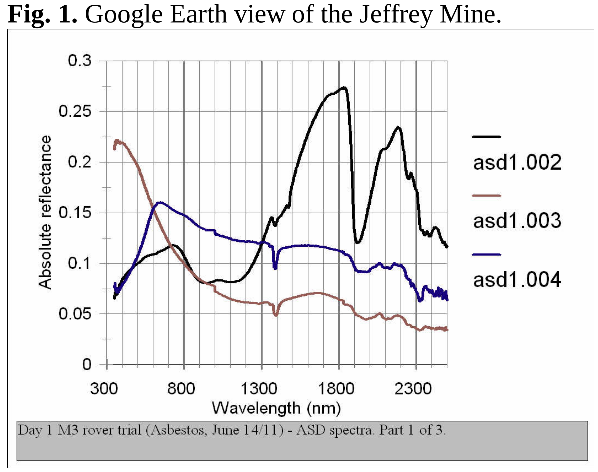

Fig. 2. Reflectance spectra of serpentinites from the Jeffrey Mine.

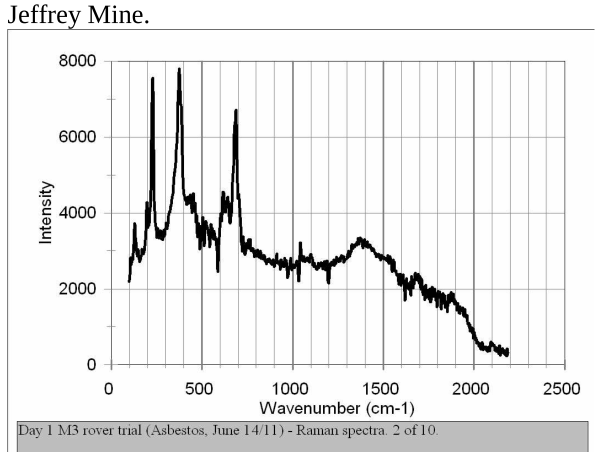

Fig. 3. Raman spectrum of an oxidized serpentine from the Jeffrey Mine rover traverse.