**MARS METHANE ANALOGUE MISSION (M3): ANALYTICAL TECHNIQUES AND OPERATIONS.** E. Cloutis[1], H. Vrionis[2], A. Qadi[3], J.F. Bell III[4], G. Berard[1], A. Boivin[5], A. Ellery[3], W. Jamroz[6], R. Kruzelecky[6], P. Mann[1], C. Samson[5], J. Stromberg[1], K. Strong[7], A. Tremblay[8], L. Whyte[2], and B. Wing[9], [1]Department of Geography, 515 Portage Avenue, University of Winnipeg, Winnipeg, MB, Canada R3B 2E9; e.cloutis@uwinnipeg.ca, [2]Department of Natural Resources, McGill University, Ste. Anne de Bellevue, QC, Canada, H9X 3V9, [3]Department of Mechanical & Aerospace Engineering, Carleton University, Ottawa, ON, Canada K1S 5B6, [4]Department of Astronomy, Cornell University, Ithaca, NY, USA 14853-6801 – now at School of Earth and Space Exploration, Arizona State University, Tempe, AZ, USA 85287-1404, [5]Department of Earth Sciences, Carleton University, Ottawa, ON, Canada K1S 5B6, [6]MPB Communications Inc., Pointe-Claire, QC, Canada H9R 1E9, [7]Department of Physics, University of Toronto, Toronto, ON, Canada M5S 1A7, [8]Départment des Sciences de la Terre et de l'Atmosphère, Université du Québec à Montréal, Montréal, QC, Canada H3C 3P8, [9]Department of Earth and Planetary Sciences, McGill, University, Montréal, QC, Canada H3A 2A7.

**Introduction:** 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 the Martian surface. This analogue mission program will run until mid-2012.

The objectives of this analogue mission include:

- Gaining operational experience in guiding and controlling a microrover under realistic operational conditions as possible;
- Assessing the utility of a suite of scientific instruments for determining methane concentrations, carbon isotopic ratios, and site surface geology.

**Background:** The recent discovery of methane in the Mars atmosphere [1-2], is one of the key drivers for this analogue mission. While both the mechanism of formation and regional source of this methane are currently poorly constrained, one scenario is that the methane is being produced as a byproduct of weathering of serpentinites. This is a process that operates on Earth and can proceed both biogenically and abiogenically [3-4]. Briefly, methane is generated via weathering of preexisting olivines to serpentine and magnesium carbonates through interactions with $CO_2$-charged water [5].

While the precise locations on Mars where this methane is being generated are unknown, there does appear to be a rough correlation between elevated methane concentrations in the Mars atmosphere and phyllosilicate-bearing regions [1]. These phyllosilicate-bearing regions include areas that exhibit surficial serpentine and magnesium carbonates [6, 7].

This correlation, and the production of significant methane in serpentinite-rich terrestrial environments, are the primary drivers for conducting a microrover analogue mission in a representative terrestrial environment.

**Analogue Mission Site:** Given the geological requirements for identifying a suitable terrestrial analogue environment, our search for a suitable analogue site focused on the Appalachian ophiolites in southern Quebec [8-10]. Whether methane production in serpentinite deposits in this region is actively proceeding is not well constrained, but there is strong evidence of methane production in the past [11].

This region contains a large number of active and abandoned open-pit mines, providing a wide range of terrain types for microrover trials, weathering environments, and exposed bedrock. One of the project requirements is to test the microrover over traverse distances of 500 m. This limits the suitability of some potential analogue sites that we have identified in the region.

**Analogue Mission Profile:** Two field trials are planned at our analogue site (an active serpentine open-pit mine) for June 2011 and June 2012. Preliminary site visits and investigations were conducted in June and November 2010 to assess the suitability of candidate analogue sites. The microrover that we plan to use for the field trials is being developed through a companion CSA program (Figure 1).

While precise traverse routes are still under development, the microrover trials are based on the notion that enhanced methane concentrations at the surface will be correlated with structural elements such as joints, fractures, and faults. This correlation assumes that methane production is greater at depth than at the surface, and that these structural elements provide enhanced pathways for methane release to the atmosphere.

The field trials will include a combination of microrover-mounted instruments and handheld units, supplemented by sample (gas, rock) collection in the field for off-line analysis and laboratory verification of field results.

**Proposed Instrument Suite:** Based on the overall mission goal to detect methane, characterize its abundance and isotopic composition, and relate it to specific geological and tectonic features, our site investigations include a range of instruments and activities.

The main suite of instruments that will be used in the field trials, and which will be microrover mounted, include a CMOS stereographic imager with a filter wheel for panoramic imaging of the site in selected wavelength bands, a 900-3400 nm miniature guided wave spectrometer [12], a tunable fibre-optic spectrometer for methane detection and characterization in the 1520-1660 nm range, and a fiber-optic laser for fluorescence studies.

As mentioned, microrover-mounted instruments will be supplemented with handheld, field-portable instruments, and sample collection in the field for follow-on laboratory studies. Potential additional instruments include various geophysical instruments (e.g., electromagnetic induction sounder, magnetometer, 3D laser camera), a weather station, and a Raman spectrometer. Field sample collection will include both gases and solids which will be analyzed in the laboratory by reflectance spectroscopy (for mineralogy), methane abundances, methane C isotopic ratios, methane : higher hydrocarbon ratios, and microbiological culturing and analysis.

**Preliminary Results:** Our initial site visits included collection of a variety of geological samples, designed to assess the suitability of the site as a Mars analogue. Spectroscopic analysis of these samples shows that the serpentinite deposits in the area have suitable mineralogy to adequately represent the conditions found on Mars. Phases identified in a sample from the Appalachian ophiolite area shows spectral signatures consistent with serpentine, magnesium carbonate (magnesite) and iron oxides – all phases known to be present on Mars [6, 7].

**Future Activities:** We are preparing for the upcoming June 2011 field campaign by conducting additional investigations of samples retrieved from the field sites. These analyses include additional spectroscopic studies to better assess the mineralogy of the site, and imaging of the rock samples by X-ray diffraction to gain a more complete understanding of sample mineralogy. By the time of the June 2011 field campaign we plan to have a good understanding of the performance characteristics and utility of the instruments that will be deployed during the field campaign. Preliminary traverses will be selected and operational sequences defined.

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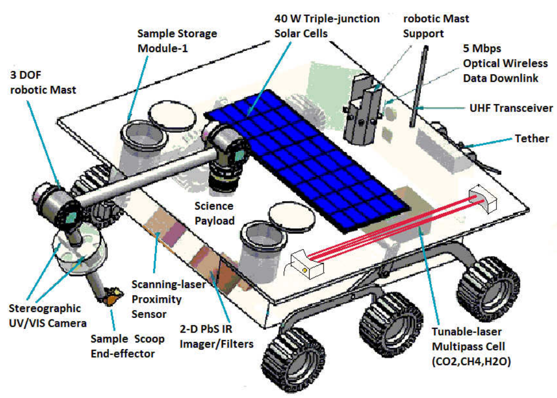


**Figure 1.** 3-D rendition of Kapvik microRover currently under construction for CSA.

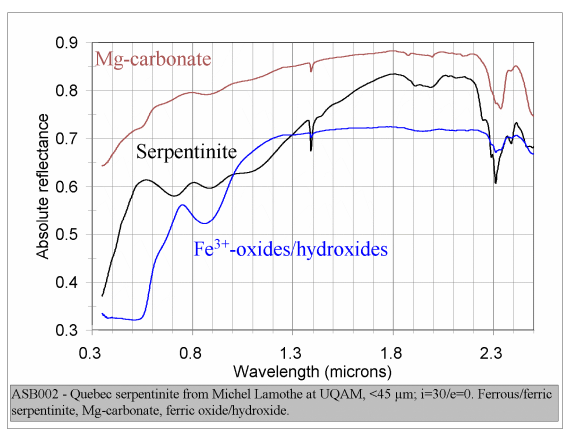


**Figure 2.** Laboratory reflectance spectra of phases from Appalachian ophiolite serpentinite deposit sample.