2016 CANMARS MSR ANALOGUE MISSION: VISIBLE/NEAR-INFRARED SPECTRAL AND MINERALOGICAL RESULTS BASED ON A "STAND-IN" SPECTROMETER FOR THE MARS 2020 SUPERCAM-VIS-IR. A. Bina[1], F. Cao[1], Y. Li[1], J.T. Poitras[2], L. L. Tornabene[1], C. M. Caudill[1], G. R. Osinski[1] [1]Centre for Planetary Science & Exploration/Dept. Earth Sciences, University of Western Ontario, London, ON, Canada. [2]Dept. of Geography, University of Winnipeg, Winnipeg, MB, Canada.

Introduction: The 2016 CanMars Mission was a 3 week Mars Sample Return (MSR) analogue mission carried out in partnership between the Canadian Space Agency and the Centre for Planetary Science and Exploration (CPSX) at the University of Western Ontario, as part of the NSERC CREATE project "Technologies and Techniques for Earth and Space Exploration" (create.uwo.ca) [1]. In this mission scenario, the Mars Exploration Science Rover (MESR) – a Mars rover prototype developed by the CSA and MDA [2] – was deployed at an undisclosed site in Utah.

The mission emulated the logistical framework and workflow of "mission control" to remotely execute a sample return mission. The primary goal of the mission was to assess and select materials indicative of the geology and past/present habitability of site that could be determined via the rover and the instrument payload capabilities. The instrument payload was closely matched to the instruments selected for NASA's Mars 2020 rover [3].

This abstract summarizes the results based on visible/near infrared (VNIR) reflectance spectra collected from an Analytical Spectral Devices Inc. (ASD) FieldSpec 3 that was used to emulate the VNIR capabilities of SuperCam instrument. The overarching objectives laid out for the ASD instrument team was to: 1) provide constraints on the VNIR spectral characteristics (*e.g.*, mineralogy) of rocks and soils at the analogue mission field site, and 2) provide an assessment of the capabilities of the dataset within an MSR mission framework.

Instrument and Methods: The ASD Fieldspec 3 measures the VNIR spectral range from 350 nm to 2500 nm [4]. This is comparable with a subsystem of SuperCam, which has a dual range that covers both the visible and near-infrared (*i.e.*, 400-900 nm and 1300 – 2600 nm) [5]. The ASD was calibrated as follows: 1) Radiance, 2) Irradiance, 3) 90-minute warm-up, and 4) Raw data conversion via the FieldSpecPro software [6]. The ASD instrument has both a stand-off and a contact mode, both of which were tested for comparative analysis; it should be noted that SuperCam will operate only in stand-off mode. In this case, "Stand-off" pertains to targeting a surface from 15 cm away from the target, without a direct contact between the instrument and target [7]. "Contact" mode employs an external light source where the instrument meets the target. During the first two weeks of the mission stand-off mode was utilized, and in the last week, contact mode was used.

The calibrated spectra obtained from the FieldSpecPro software (*.asd files) were imported into the ENVI 5.3 software for analysis. Additional corrections and resampling were made to facilitate spectral matching to lab-derived spectra of known minerals and phases (*e.g.*, bad-band filtering due to atmospheric interference in spectra collected in stand-off mode). The position, overall shape, and the intensity of the absorption features were considered in verifying the matched spectra within the literature [*e.g.*, see 8] or provided by the spectral libraries and analyst tools in ENVI 5.3. Post analysis of the field spectra are also compared here to lab spectra obtained from the Planetary Spectrophotometer Facility (PSF) [see 9].

Results: Two hundred and four ASD spectra were captured during the 3-week analogue mission. We highlight four key targets from the following locations and Sols: "Angul" from Sol 13 in stand-off mode (Fig. 1), as well as "Sweyn" (Fig.1), "Bjoamunjo" (Fig. 2) and "Anund" (Fig. 2) from sols 27, 28, and 32 in contact mode, respectively.

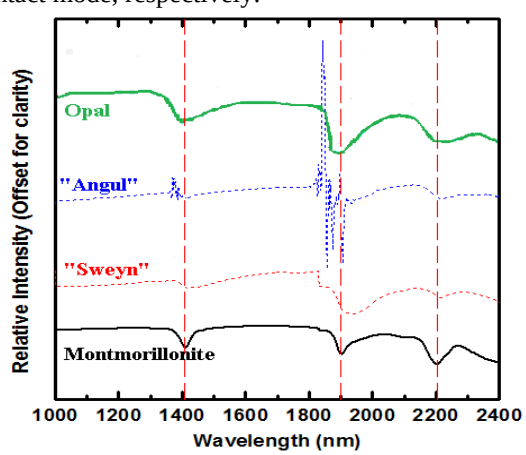

Fig 1. The plot of ASD spectra (dashed) obtained in stand-off ("Angul" on Sol 13) and contact modes ("Sweyn" on Sol 27) consistent with al-smectite, likely montmorillonite, rich rocks. However, the similarity between the obtained spectra and hydrated-silica should also be noted (*e.g.*, Opal).

Spectra of the Angul site (Fig. 1) show absorptions at 1415 nm and ~1938 nm due to OH and H_2O overtone and combination features [8, 10]. The exact

position of these absorptions is uncertain due to atmospheric interference present in stand-off mode. Angul spectra also exhibit a band centered at 2213 nm attributed to an Al-OH bend [8, 11]. These spectral features are consistent with an Al-smectite clay, likely montmorillonite, but hydrated silica may also be a possible match based on a slightly broad absorption at around 2200 nm [8].

A spectrum from the Sweyn site (Fig. 1) had spectral characteristics similar to Angul but was acquired in contact mode. As such, Swyen shows clearer montmorillonite features observed at 1419 nm, 1944 nm and 2213 nm.

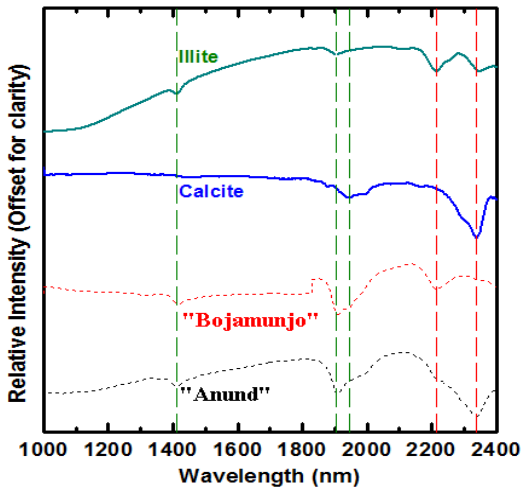

Fig 2. The plot of ASD spectra (dashed) obtained in contact mode ("Bojamunjo" on Sol 28, and "Anund" on Sol 32) consistent with a mixture, based on lab spectra, of calcite and illite (solid).

Anund site spectra (Fig. 2) have features that are similar to that of Angul and Sweyn, except additional features located at 2350 nm and 2440 nm. These additional features are consistent with the diagnostic features of both illite and muscovite [8, 11]; thus, indicating the presence of a mixed, layered illite-smectite clay at this site.

Bjoamunjo spectra (Fig. 2) also display similar features of both Anund, Sweyn, and Angul, but possessed additional features at 2341 nm and 2350 nm, which are consistent with the presence of calcite [12].

Discussion: Our analysis were coordinated with additional datasets provided by the other selected instrument payload for MESR. These include other spectral (*e.g.*, Raman) and geochemical (e.g., LIBS) instruments with context panorama imagers (MastCam emulators) to high-resolution imagers (*e.g.*, RMI and WATSON emulators) instruments. Cooperation of the instrument teams proved essential during the mission simulation for rover-derived interpretations of the field site. This supported the geological context for each VNIR spectrum, which aided the characterization and identification of materials. However, results and interpretations based on Raman and geochemical data [see LPSC abstracts from these teams], did not always correlate with the findings from VNIR spectral analysis. For instance, quartz and feldspar do not have diagnostic spectral features in the VNIR range [13]. Therefore, they would not be well-represented in this dataset. During the stand-off operation mode of the instrument, atmospheric H_2O was prevalent and resulted in interference centered on 1400 nm and 1900 nm (Fig 1).

Summary and Conclusions: The 4 sample sites and the other 200 spectra exhibit spectral features indicative of the presence of smectite-clays, and in some cases showing mixtures of other minerals (*e.g.*, illite/muscovite, carbonates, etc.).

Previous and current mission Raman spectra and geochemical data at the site suggested the presence of clay- and carbonate-bearing materials; and the VNIR instrument positively identified specific clay minerals and calcite for the first time in CanMars analogue mission history this year. [1]. However, remote sensing data from the previous mission also reported concentrated amounts of gypsum or other evaporites; and contrary to what was anticipated by the science team, no evaporites were detected by VNIR. Although, it should be noted that evaporites were positively identified by the Raman instrument [14].

In spite of difficulties due to atmospheric interference and difficulties in correlating between datasets, the VNIR instrument was an essential tool for assessing the geological setting of the field site. It provided an important insight into this and previous year's analogue mission interpretations, as it made the correlation between 2 or more geological units that may otherwise appear different possible through constraining their mineralogical composition.

Acknowledgments: This work was funded by the Natural Sciences and Engineering Research Council of Canada's CREATE program and the Canadian Space Agency. We would also like to thank the UK Space Agency for allowing the field team to use their ASD instrument.

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