SUMMARY OF THE MARS SCIENCE LABORATORY ROVER SIMULATION AT THE HAUGHTON IMPACT STRUCTURE.

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Figure 1. A panoramic view of the field site within the Haughton Impact Structure. Distance to the ~ 3m tall ridge in the center of the figure is ~ 10m (no scale cues to simulate raw imagery from Mars). Samples were taken from three areas: the periglacial polygons in the left foreground, the face of the ridge in the center of the image, and around the right side of the ridge where the orange hydrothermal alteration is observed.

Introduction: A Mars Science Laboratory (MSL) rover simulation was conducted in the spring of 2011. The goals of this study were to produce a challenging simulation for MSL mission scientists using simulated reconnaissance tools available on MSL, to identify and understand the diversity of geologic materials present in a complex impact structure, and to study the role and effectiveness of analogue simulation studies as training exercises for planetary exploration.

Simulating MSL's Science Payload: MSL is an unprecedented mission in every way, the camera and instrument suites are no exception. For this study, the MastCam and Remote Micro-imager (RMI) were approximated using a Nikon D-80 camera with 18-135mm and 70-300mm lenses, respectively. Three of the analytical instruments aboard MSL were simulated: ChemCam, CheMin, and the APXS. The ChemCam laser-induced breakdown spectroscopy (LIBS) device was simulated using a laboratory setup with parameters virtually identical to the ChemCam instrument. The CheMin X-ray diffraction (XRD) device was simulated using an Innov-X *Terra* portable XRD instrument, technologically similar to MSL's flight instrument. The alpha particle X-ray spectrometer (APXS) was simulated using MSL's flight equivalent unit APXS instrument at the University of Guelph.

Haughton Impact Structure: Haughton Crater is an impact structure that lies within the Canadian Arctic on Devon Island, Nunavut territory (75°22'N, 89°41'W). Devon Island consists mainly of Paleozoic carbonate-sulfate sediments overlying a gneissitic basement. The crater, ~ 23km in diameter, is the result of an impact 39 mya (Late Eocene) [1].

Haughton as an Analogue. The use of analogue sites in the planetary explorations field provides essential training and testing environments; the Haughton site is ideal for analogue studies of Martian exploration. With both limited precipitation and a lack of vegetation, the geologic record of the impact and its associated deposits are relatively well preserved by the polar desert. SETI and the Mars Institute host a joint initiative at the impact structure, called the Haughton-Mars Project. The goals of this project are to understand the geology of the crater and also to use the environment as testing grounds for future planetary explorations [2].

Field site. This study focuses on an area (**Fig. 1**) of the crater at a site near Trinity Lake. It is a geologically complex area displaying evidence for hypervelocity impact (shatter cones), hydrothermal activity (Fe oxidation and carbonate/sulfate mineral re-precipitation), periglacial processes (polygons), and limited biologic features (epilithic lichen, fossilized stromatolites, and a friendly bird). Needless to say, this is an interesting area with highly complex geochemistry and mineralogy [3].

Simulation: Science team members participated in three different countries: the U.S., France, and Canada. Participants were provided with sets of documents for

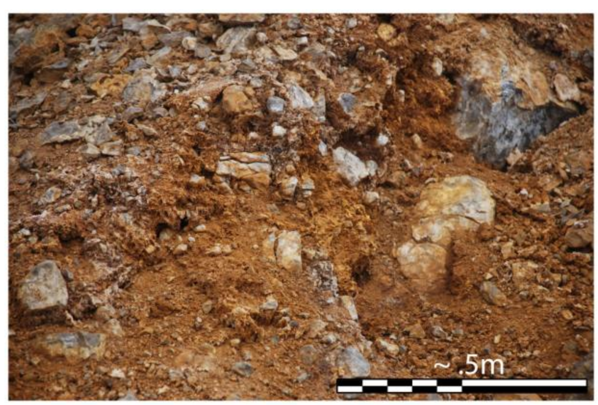

Figure 2. A simulated MastCam image of the third sample area showing hydrothermal alteration (middle right side of Figure 1).

each of the three simulated sols. These included panoramic views of the simulation area (**Fig. 1**), image packages showing close-ups of the sample areas (**Fig. 2**), image packages showing macro images of the selected samples to simulate the RMI (**Fig. 3**), and chemical and mineralogical data for selected samples. LIBS spectra were given for all twelve samples, XRD data for eight samples, and APXS data for three samples. The simulation was performed via telecom, without the use of video.

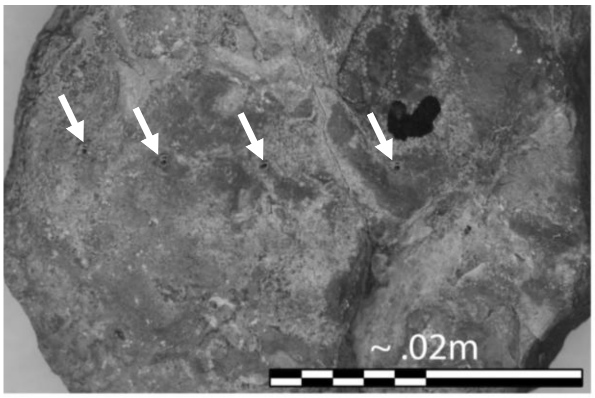

Figure 3. A simulated RMI greyscale image showing a trail of four LIBS shots across a sample from the area shown in Figure 2.

Results: Each simulated sol equated to around four hours of discussion about the local geology, individual samples, and plans for the following sol. For the purpose of this abstract, the observations made during the simulation are grouped into two categories:

Simulation observations and lessons learned

- Video communication would have facilitated more interaction and cut down on silences.
- Grids on the images are useful for pointing out areas of interest.
- A need was expressed for ChemCam spectra peak identification software.
- Science Theme Groups based on instruments or areas of expertise might have improved the simulation's organization.
- Separating communications and science staff eliminates the issue of speaker identification and decreases other misunderstandings (audibility, language barriers, etc.).

Science team observations and lessons learned

- Participants accurately interpreted the entire simulation area in terms of the geology and other processes present.
- Participants needed additional familiarization with MSL's analytical capabilities (e.g., using the scoop for CheMin instead of drilling).
- Participants were slow to correlate observations from the previous sols.
- Participants focused on the interesting samples more than the geology and processes of the site as a whole.
- Participants were uncertain about the question of thin coatings vs. solid rock in some samples.
- Participants did not request soil analyses.
- Judgments on the scale of the images varied.

Conclusions: The simulation was successful and this study has produced intriguing insights into planetary simulations that require more investigation.

Simulation participants. The simulation provided participants valuable experience in dealing with a mission scenario, and for some their first experience with mission operations. One of the participants commented saying that the simulation, "demystified the job". Another noted it as "too difficult of a site to decode"; however, challenging simulations are necessary when one cannot be certain about the complexity of sites explorers will encounter.

Geology. Through this simulation, much was learned about the geochemistry, mineralogy, and the processes at work within the study area. Each analysis, whether quantitative or qualitative, yielded valuable information about the area's past and present. The samples and data used in this simulation can be available upon request for future research purposes.

Planetary simulations. Simulations utilizing analogue sites are an important tool for planetary explorers. They provide authentic training experience as well as allow us to refine and reassess the methods employed to explore other planets, increasing science return [4]. This simulation gave participating scientists a chance to practice communicating amongst each other while both solving geologic puzzles and minor mission issues before they were encountered on Mars.

Future exploration, including manned missions to other bodies, will benefit greatly from analog training exercises. Extensive landing site studies have been conducted for missions to the Moon [5], now we have the charge of training our explorers with simulations.

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