A COMPARISON OF SPECTROSCOPIC MEASUREMENTS OF MINERALS ON EARTH AND MARS.

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Introduction: The recent history of Mars surface exploration has been partially carried out by a series of rovers equipped with various spectrometers to analyze the chemical composition of the rocks and regolith at the surface. The twin Mars Exploration Rovers (MER) were each equipped with Mossbauer spectrometers; the Mars Science Laboratory (MSL) was equipped with an X-ray spectrometer and a laser-induced breakdown spectrometer (LIBS); and the Mars 2020 Rover currently under construction will be equipped with a Raman spectrometer. The chemical signatures generated using these and other spectrometers provide varying degrees of accuracy depending on the sensitivity of the instrument, with the final identification of each rock type resting on the scientists analyzing spectrometer data returned from each instrument. The accuracy of spectroscopic data [1] and the specific spectroscopic method(s) used [2] directly impact the interpretations and conclusions that can be drawn from a particular data-set. The purpose of this study was to analyze via Earth-based spectrometers samples of terrestrial mudstones that have known compositional similarities to rocks observed on Mars in order to identify any deviations for the range of accuracy returned by different spectrometers deployed to the Martian surface.

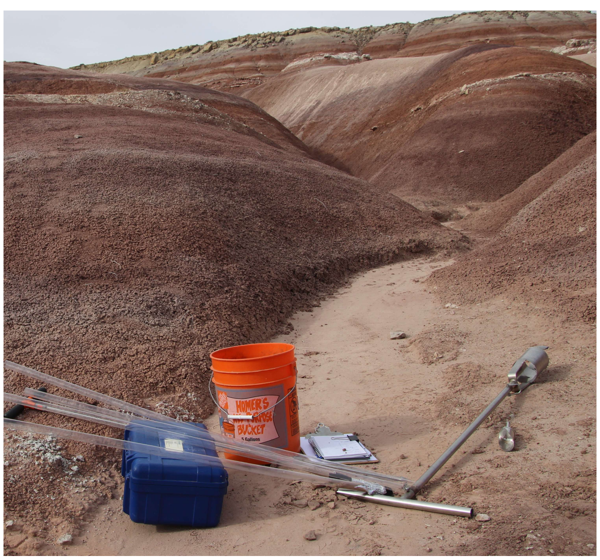

Figure 1: Photo of the outcrop of the Brushy Basin Member of the Morrison Formation that was sampled. (Photo: Paul Knightly)

Background: *Utah as a Mars Analogue.* The terrestrial samples used in this study were collected from an area located along the San Rafael Swell of central Utah near the Mars Desert Research Station (MDRS), a Mars analogue research facility founded and maintained by The Mars Society based out of Lakewood, Colorado. Samples of mudstone and clay originating from the Brushy Basin Member of the Morrison Formation [3] (Figure 1) were analyzed for their similarities to rocks that have previously been studied during past surface missions to Mars [4] [5]. The mudstone samples were formed by hydraulically altered volcanic ash that is representative of a fluvial environment that existed during the Late Jurassic.

Evidence for Ancient Hydrology on Mars. Mounting evidence suggests that water has flowed on the Martian surface at various times throughout its history. This work focused on comparing spectroscopic datasets of hydraulically altered sediments and mudstones analyzed by MSL at Gale Crater [4] and by the Opportunity MER at Endeavour Crater [5]. Separately, these samples indicate that varied aqueous environments existed in the past on the surface of Mars and that the presence of water altered the existing geological features of each region. Collectively, they point to a history in which water has played an important, if intermittent, role in shaping the Martian surface.

Methods: Grab samples were collected at MDRS along an outcrop of the Brushy Basin member at predetermined locations as outlined in Figure 2. Sample volumes of approximately 300-400 cubic centimeters were transferred from the surface into zip-lock bags using hand tools that were cleaned between each use. The bags were then labeled with the sample location, sample identification number, and date. The samples were shipped from MDRS at the conclusion of the field mission to the University of Arkansas where they were analyzed under controlled laboratory conditions using a Fourier Transform Infrared (FTIR) and Raman spectrometers. The results were compared with measurements made by MSL, the MER Opportunity, and previous spectroscopic data from the Morrison Formation in the same region [6]. A statistical evaluation of the data was used to project potential deviations between data from Earth-based Raman spectrometer data and Raman data that could be collected on Mars by the 2020 Rover.

Results: Two comparative analyses were performed with the collected samples. The first analysis was performed between the FTIR and Raman spectrometer data in the laboratory, and the second compared the laboratory FTIR and Raman datasets to spectroscopy data from previous Mars missions. The results of these two analyses produced a comparative dataset that can be utilized when analyzing previous and future spectroscopic data collected by surface Mars missions.

Figure 2: Locations sampled along the Brushy Basin Member. (Source: Jon Clarke, Google Earth)

Conclusion: Robotic missions exploring the surface of Mars increasingly rely on different types of mass spectrometers to collect information on the composition of geological formations on the Red Planet. This study was focused on analyzing samples of terrestrial rocks that have known compositional similarities to rocks observed on Mars by using laboratory-based spectrometers to identify any deviations for the range of accuracy returned by different types of spectrometers deployed to the Martian surface. The results of this analysis demonstrate the validity of using analogue environments on Earth to understand past conditions on Mars while also providing data on the reliability and fidelity of surface-based spectrographic measurements taken on Mars.

Future Work: The methodology applied to the Utah mudstone samples will be applied to additional analogue samples collected in the future. In addition to FTIR and Raman laboratory analyses, we seek to also analyze samples in the field using hand-held TerraSpec and X-Ray diffraction (XRD) spectrometers. An examination will be made of returned data to determine if there are any differences between the field and laboratory datasets.

References: [1] Milton E. J. et al. (2009), Remote Sensing of Environment, S92-S109. [2] Bishop J. L. (2004), Icarus, 169, 311-323. [3] Craig L. C. et al. (1955) Geological Survey Bulletin, 1009-E, 125-167. [4] Vaniman D.T. et al. (2014) Science, 343, 1243480-1-8. [5] Fox V. K. et al. (2016) Geophysical Research Letters, 43, 4885-4892. [6] Kolter J. M. et al. (2011) International Journal of Astrobiology, 10, 221-229