MARS-2020-LIKE STUDIES OF A LACUSTRINE-VOLCANIC MARS ANALOG FIELD SITE. P. E. Martin[1], B. L. Ehlmann[1,2], N. H. Thomas[1], R. C. Wiens[3], J. J. Razzell-Hollis[2], L. W. Beegle[2], R. Bhartia[2], S. M. Clegg[3] , and D. L. Blaney[2], [1]California Institute of Technology, Pasadena, CA (pmmartin@caltech.edu), [2]Jet Propulsion Laboratory, Pasadena, CA, [3] Los Alamos National Laboratory, Los Alamos, NM

Introduction: The upcoming Mars-2020 rover mission features a suite of seven instruments. Of these, two remote sensing instruments, Mastcam-Z and SuperCam, and two microscopic proximity science instruments, SHERLOC and PIXL, will collect compositional (mineralogy, chemistry, and organics) data essential for paleoenvironmental reconstruction. A field site near China Ranch in the Mojave Desert was selected as a Mars analog due to its mineral suite of sulfates, phyllosilicates, carbonates, and iron oxides and its geologic diversity (lacustrine, spring, and ashfall deposits) [1]. The synergies between and limitations of these four instruments were evaluated by exploration of this field site using instruments approximating the data that will be returned during the Mars-2020 mission. We also evaluated operational modes to most efficiently collect data during the mission.

Methods: Using standard cameras and the Ultra Compact Imaging Spectrometer (400-2500 nm) [2], the field site was surveyed and hand samples were gathered. The camera and visible/infrared imaging were resampled to the resolutions of Mastcam-Z [3] and SuperCam [4] to simulate data from these instruments. Guided by this information, a limited number of specimens were chosen for more detailed analysis. These were analyzed using the SHERLOC [5] prototype, a Renishaw M-1000 microRaman to partially mimic SuperCam's remote green Raman, SuperCam-like LIBS (laser-induced breakdown spectrometer) under Mars conditions [4] using the ChemCam testbed instrument, and a commercially available Horiba XGT-7200 micro-XRF to simulate some capabilities of PIXL [6]. The ground truth dataset consisted of hyperspectral geocompositional maps, XRD mineralogy, lithochemistry, and background literature [e.g. 1].

Mineralogy: Iron-related VNIR features were easily observed with the Mastcam-Z filter set, demonstrated here using surface coatings of iron oxides. This capability will be of increased utility on Mars, where more iron-bearing minerals will be present. Mastcam-Z also observed the 995 nm hydration in gypsum, but the weak H_2O feature in phyllosilicates is at 960 nm, where the 1013 nm filter will not detect it. SuperCam observes reflectance spectroscopy (400-850 and 1300-2600 nm). As expected, calcite, gypsum, and montmorillonite were all easily observed in the vibrational wavelength range (Figure 1).

By degrading the spectral resolution of the SuperCam 1300-2600 nm measurements from 30 cm^{-1} to

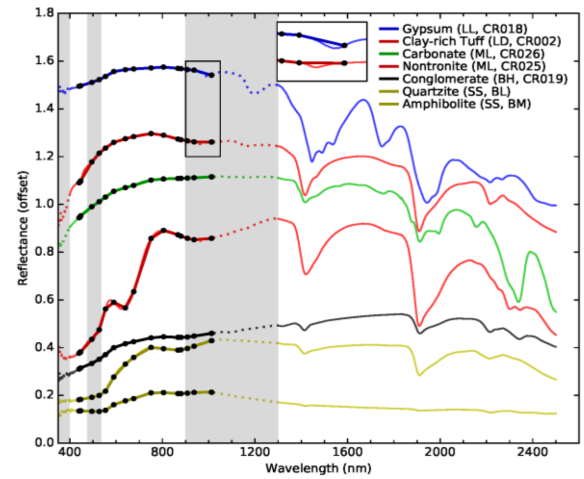

Figure 1: Simulated Mars 2020 passive spectroscopy data. Black dots indicate Mastcam-Z multispectral filter locations and spectra. Light gray regions with dotted spectra are not covered by Mastcam-Z or Supercam passive coverage.

100 cm^{-1}, information about mineral class may still be obtained (e.g., carbonate vs. calcite), while saving observation time and data volume. At wavelengths between 1013-1300, neither Mastcam-Z nor SuperCam have spectral coverage; important spectral bands of pyroxene and olivine therefore cannot be observed by any instrument in reflectance spectroscopy. To compensate, observations with Raman and LIBS can be used, and cross-calibration of the two instruments and careful analysis of data from Mastcam-Z's longest wavelength filters will be necessary for tracking changes in basaltic mineralogy.

Green Raman confirmed the identification of bedrock with gypsum, calcite, and montmorillonite, as well as quartz, which is not observable with passive techniques. SHERLOC's deep-UV Raman identified and mapped at small-scale the minerals calcite and gypsum, as well as observing H_2O-related features and textures. SiO_4-related features were not observed, possibly due to the weakness of these bands at higher frequencies than SHERLOC's 800 cm^{-1} filter.

Chemistry: LIBS allowed the determination of major chemistry with 5-15% relative accuracy. This capability will provide reconnaissance for closer examination with PIXL as well as provide compositions for elements uniquely detected by LIBS (e.g., Li, B, and C). PIXL-like XRF data demonstrated the ability to observe small-scale spatial patterns in chemistry measuring laminated mudstone and carbonate travertine/silica samples (Figure 2), including trace elements indicating the presence of minerals useful in age dating. By averaging over a large (several mm^2) area, PIXL may also be used to measure bulk chemistry, producing data similar to APXS measurements from past rover missions.

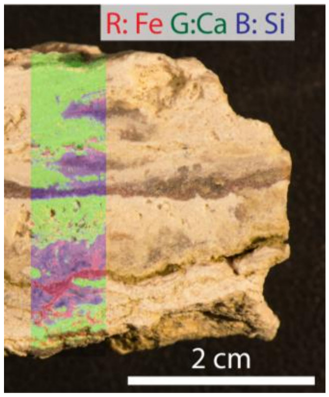

Figure 2: PIXL-like results from a travertine deposit. Note the bands of calcite and silica.

Organics: Deep-UV Raman identified several samples containing likely organics. Potential organic peaks were also present in the Green Raman data, though the sensitivity was lower and signal-to-noise ratio was too low for interpretation. Many deep-UV Raman samples contained relatively broad features often associated with organics, indicating the presence of variety of chemical compounds, which we interpret as evidence for pristine organics in these samples. The strongest organic signal appears in a travertine chalcedony hot-spring silica-carbonate sample (Figure 3).

Deep-UV fluorescence detected organics in every sample and allowed organic spatial mapping in several samples. However, detailed investigation of individual spectra did not yield information on organic species present, mostly due to a dearth of fluorescence spectral libraries. The development of such libraries should be a priority prior to the Mars-2020 landing.

"Rover" vs. Ground Truth: Using Mars-2020-like data, geologic units at this outcrop were defined and mapped primarily from Mastcam-Z- and SuperCam-like data. Multiple sedimentary rock units were identified and interpreted as lacustrine in origin with clay-rich sediments grading into sulfate-clay-rich rocks as well as potential hydrothermal/spring activity resulting in the deposition of a carbonate unit with associated silica. These interpretations and maps match ground truth data, though some details like faults were not recognized (Figure 4). Analyses of organics with Deep UV florescence and mineralogy and chemistry with SHERLOC and PIXL would result in a sample suite including travertine carbonate, hot-spring silica, gypsum, and clay-rich mudstones, important for study of Mars astrobiology and geology.

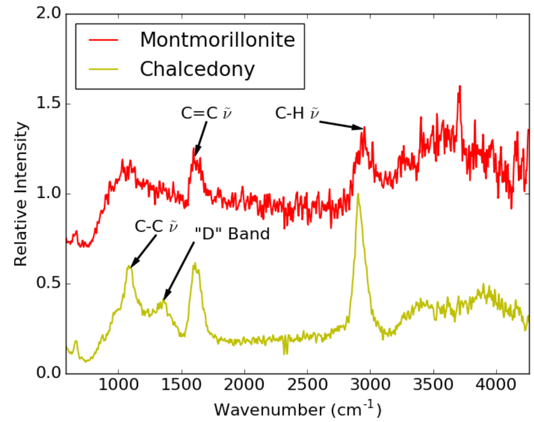

Figure 3: Organic deep-UV Raman signals.

References: [1] Hillhouse, J W., and USGS (1987). Late Tertiary and Quaternary geology of the Tecopa basin, southeastern California. [2] Van Gorp, B., et al. (2014). *J. Appl. Remote Sens.* 8.1. [3] Bell, J. F. et al. (2014) *IPM II*, Abstract #1151. [4] Wiens, R. C. et al. (2017) *Spec. Online*, 32, 5. [5] Beegle et al. (2015) *IEEE*. [6] Allwood et al. (2015) *IEEE*. [7] Beegle et al. (2017) *LPSC*, abstract #2839

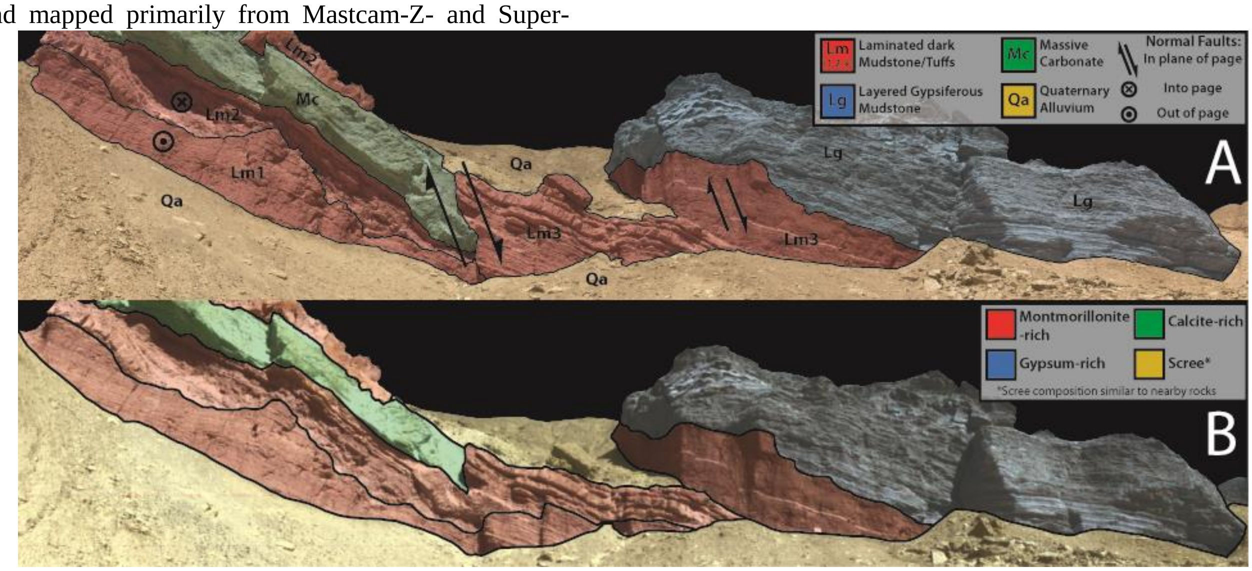

Figure 4: A) A compositional map of the field site based on Ground-truth data, compared with B) a unit map based solely on Mars-2020-like compositional data.