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CUMBERLAND AND ROCKNEST ANALOG NEAR-INFRARED REFLECTANCE MEASUREMENTS.

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Introduction: ChemCam is a Laser-Induced Breakdown Spectroscopy (LIBS) instrument on-board the NASA Mars Science Laboratory (MSL) rover that has been exploring Gale Crater, Mars for the past six years [1, 2]. Its spectrometric capability can be used to retrieve reflectance signals from martian surfaces of interest in the 400-840nm region which can show spectral features of iron-bearing oxides, pyroxenes, and calcium sulfates [3, 4]. Similarly, the rover's Mastcam CCD cameras (1600×1200 pixel) use an 8-position filter wheel of broadband near-infrared cutoff filter for RGB Bayer imaging and twelve narrow band geology filters distributed between the two cameras, spanning the 445-1013 nm wavelength range [5, 6].

Analogues of the Rocknest (RN) windblown deposit (sol 84) and Cumberland (CB) mudstone drill fines (sol 281) have been generated in the laboratory based on the mineralogical information retrieved by MSL. Here, we report initial results of the near-infrared analysis of these analogues compared to the MSL measurements made of the targets on Mars.

Analog samples: The mineralogical understanding of martian rocks and regoliths have dramatically improved thanks to the use of X-ray diffraction by the Curiosity rover [7]. A new generation of Mars simulants is being generated based on MSL's mineralogical analyses to provide further understanding of these materials in the laboratory.

The mineralogy of the Rocknest (RN) windblown deposit's mineralogy (26wt.% plagioclase, 20wt.% pyroxene, 13wt.% olivine, 2wt.% magnetite, 1wt.% hematite [8, 9]) was used to generate the Mars Global Simulant-1 (MGS-1) analog [10]. The remaining 35wt.% amorphous component was simulated by 23wt.% of basaltic glass and 5wt.% of hydrated silica, 4wt.% of Mg-sulfates and 1.7wt.% ferrihydrite. The simulant grain size is <1mm and its spectral properties have been favorably compared to rover and orbiter's observations of Mars soils [10].

Similarly, the mineralogy of the Cumberland (CB) drilled sample by MSL [11] (which is broadly similar to Rocknest, but contains less abundant olivine and ~20 wt% smectite clays) was used to generate a simulant of this mudstone composition by the SAM team, which is described in Fig. 1 to compare with the SAM

instrument measurements [12, 13]. Since the CB analog sample is a powder (grain size <150µm), we chose to compare its spectral properties with those of the tailings produced by the MSL drill when it acquired the sample.

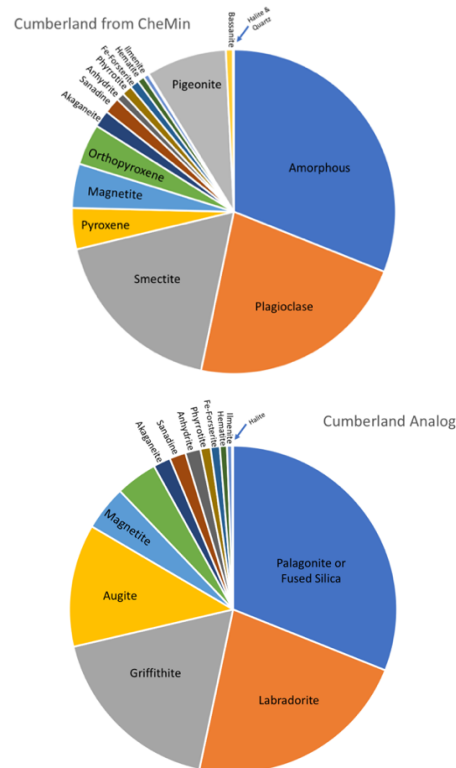


Figure 1: Mineralogy of the CB analog and sample [11, 12]. Additional Augite substituted for Pigeonite; additional Anhydrite substituted for Bassanite; Quartz omitted – trace amounts exist in other minerals.

Method: Infrared reflectance spectra were measured using the spectro-gonio-radiometer available at the IPAG in Grenoble [14]. Bidirectional reflectance spectra were measured with a photometric accuracy below 1% in the 0.5–3.0 µm range with a sampling interval of 10 nm.

Results: Fig. 2 presents the infrared spectra obtained for the two samples compared to the Mastcam observations of Rocknest scoop 4 and of the Cumberland drill hole tailings [6]. Both measurements follow the same trends.

The CB analog exhibits greater reflectance >600nm than the RN analog, which is in agreement with the Mastcam spectra. The CB analog also displays a less prominent ferric absorption near 535nm than the RN analog, likely resulting from the use of palagonite to represent its amorphous component. The ChemCam passive spectra of the martian targets (Fig. 3, [3]) also show CB to have a weaker ferric absorption, but a lower relative reflectance at >600 nm. Such variations in overall albedo likely result from a combination of dust cover, surface texture, and photometric effects.

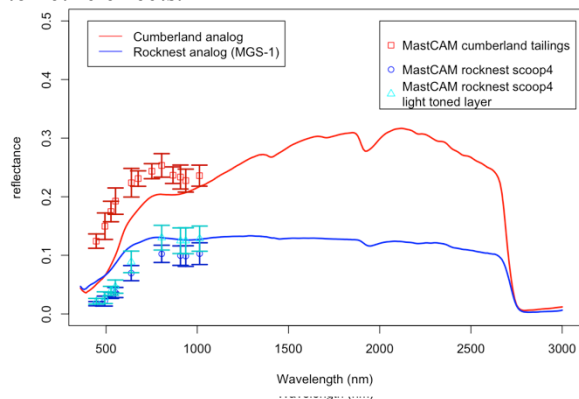


Figure 2: Near-infrared reflectance spectra of the RN and CB analogs compared to the Mastcam observations [5].

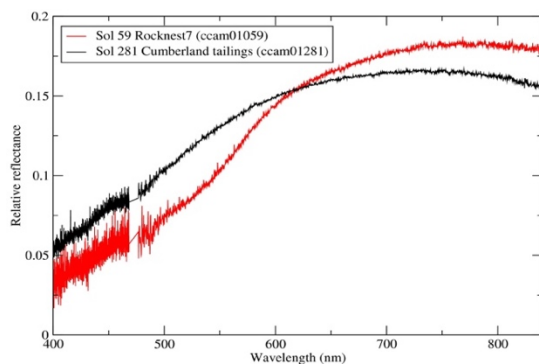


Figure 3: Passive ChemCam reflectance spectra of the Rocknest windblown deposit and the Cumberland tailings MSL targets [3].

The greater band depth at 1.9 μm in the CB analog is peculiar, since RN and CB are supposed to have similar amounts of H₂O based on SAM measurements (~2 wt.% [15]). Note that the water content of the CB analog was not monitored for practical reasons. While we took care to keep the samples under dehydrated conditions, this may indicate that some mineral phases present in the CB analog sample (e.g., smectite, palagonite) are more hydrated than their martian counterparts. This could also be related to variations in grain size of the hydrated phases in the mixtures.

The bands around 1.4 and 1.9 microns in the CB spectrum are mainly due to the presence of the ferroan saponite griffithite used in the mixture (Fig. 4). Also,

the metal-OH bands associated to smectites around 2.3 μm are not obvious. This is a reminder that clay minerals within complex mixtures may not be easy to detect from orbit, even at the ~20wt.% level and without dust cover.

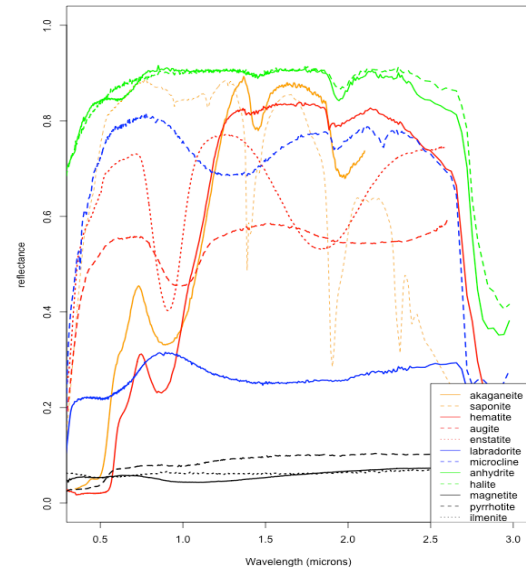


Figure 4: IR spectra of minerals from laboratory databases [16, 17].

Conclusion and future work: The Cumberland and Rocknest analogs are spectrally distinct, CB being brighter and showing stronger OH/H₂O absorption signatures. Still, these two analogs do not appear to reproduce entirely the differences observed in passive observations of the actual (Martian) Rocknest and CB samples. The analog samples will also be analyzed with active LIBS and the results will be combined in future work.

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