

MINERALOGY OF AN ANCIENT LAKESHORE IN GALE CRATER, MARS, FROM MASTCAM MULTISPECTRAL IMAGERY. J. T. Haber¹, B. Horgan¹, A. A. Fraeman², J. R. Johnson³, D. Wellington⁴, J. F. Bell III⁴, ¹Purdue University (haberj@purdue.edu), ²Caltech/Jet Propulsion Laboratory, ³JHU/Applied Physics Lab, ⁴Arizona State University.

Introduction: The Sutton Island member of the Murray formation is characterized as a “heterolithic mudstone and sandstones facies” and makes up ~98 m of section of Mt. Sharp within Gale crater that the Mars Science Laboratory mission (MSL) has investigated. [1] This area is of particular interest within the Murray in part because of dark patches in the bedrock, which are visually similar to terrestrial reduction spots, and the desiccation cracks that have since been filled in by other sediment on several rocks, indicative of periodic wetting and drying of this area and suggesting that at least some of these deposits record low lake levels [2]. Studying this region may allow us to evaluate how the lake chemistry varied with depth, but there is a large gap in data on the quantitative mineralogy of the Sutton island member due to a lack of drill samples in the region. To address this gap, here we use Mastcam multispectral data to constrain the mineralogy of Fe-bearing phases within the Sutton Island member and evaluate the redox conditions associated with this stratigraphic interval.

Methods: Mastcam is a multispectral imager composed of two cameras (100 mm and 34 mm) mounted on the mast of the Curiosity rover. With 12 spectral channels centered from 445 to 1013 nm, Mastcam multispectral images can be used for mineral identification, especially for iron-bearing minerals, and can be used to differentiate iron redox states [3,4]. Here we investigate images in the Sutton Island member where bedrock is visible in both the right and left Mastcam camera images (Fig. 2 and 3), and compare the spectral properties of these images to previous targets from the Murray buttes (Fig. 1). In order to assess spectral diversity, we applied decorrelation stretches (DCS) using the R3 (805nm), R1 (527nm) and R2 (447 nm) multispectral images from the M100 camera (Fig. 1b/2b). Spectra were extracted from identical regions of interests (ROIs) within homogenous areas in M34 and M100 images. Values from each spectral filter were averaged within the ROI and the right eye was scaled to the left eye at 1013 nm. All of the spectra from both eyes were then averaged at overlapping wavelengths and plotted for comparison.

Results: Figure 1 shows Mastcam multispectral data from the Quela drill site, acquired just before the start of the Sutton Island member. Spectra from the excavated material around the drill hole show weak hematite bands centered at 860 nm in most of the ROIs selected, as well as weak ferric iron absorptions at 530 nm. Similar hematite spectra with variable band strengths have been observed throughout the Murray [5].

Figure 2 and 3 show Mastcam multispectral data for the rocks Old Soaker and Squid Cove within the Sutton

Island member. Polygonal fracture patterns are likely mud cracks, formed by desiccation [2]. The decorrela-

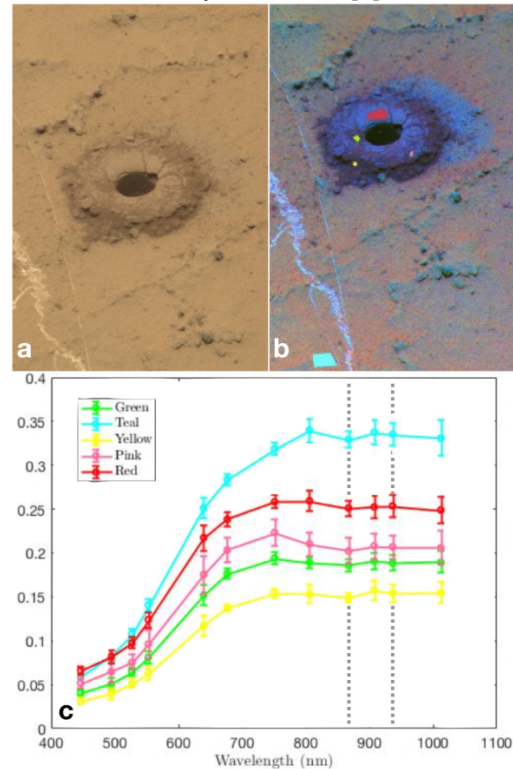


Figure 1: Quela drill site imaged by Mastcam on Sol 1465 in (a) true color and (b) DCS of filters R312. (c) Spectra from ROIs shown in (a), lines indicate hematite and Fe/Mg-clay band centers at 860 and 930 nm.

tion stretches of both sites reveals significant variability, both in the form of gray to red transitions in the bedrock and circular gray mottles (blue in the DCS in Fig 2b). While clear ferric iron bands are present in the area, in both the red and gray bedrock, these tend to be centered at longer wavelengths (~900 nm or greater) than the 860 nm band characteristic of hematite. Hematite might contribute to some of the broader bands, such as the gold and pink ROI's in this image, and both the strong downturn at short wavelengths and band near 530 nm in all spectra indicate significant ferric iron. However, Fe-bearing mineral phases other than hematite must be present to account for the longer wavelength band centers. Shortward shifts in the peak reflectance of some of the ROI's suggest the addition of a spectrally flatter phase, potentially a ferrous mineral or coarse-grained oxides.

Squid Cove (Fig. 3) was observed during the same sol as Old Soaker and has similar spectral patterns, but exhibits strong absorption features consistently centered at longer wavelengths. Some mottled gray areas in the

bedrock exhibit distinct flat spectra (e.g., orange in Fig. 3) with less absorption at short wavelengths consistent with ferrous iron or gray (coarse grained) hematite.

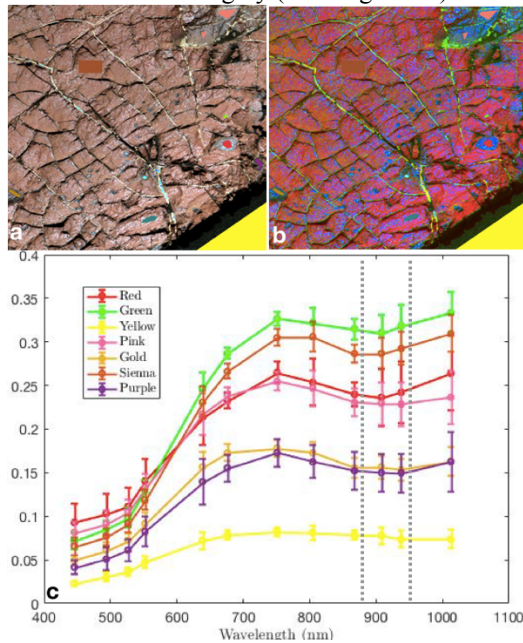


Figure 2: Old Soaker imaged by Mastcam on Sol 1566, shown in (a) grayscale and (b) DCS of filters R312. (c) Spectra of ROI's shown in (a), lines indicate hematite and Fe/Mg-clay band centers at 860 and 930 nm.

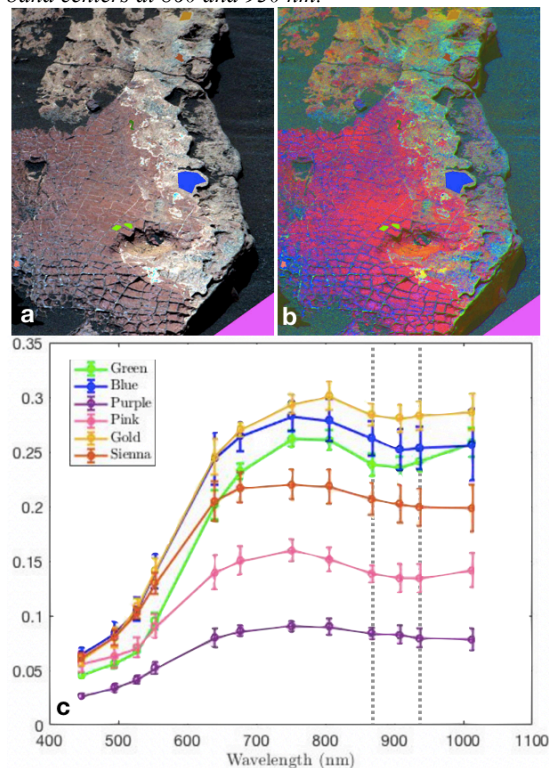


Figure 3: Squid Cove imaged by Mastcam on Sol 1566, shown in (a) true color and (b) grayscale. (c) Spectra of ROI's shown in (a), lines indicate hematite and Fe/Mg-clay band centers at 860 and 930 nm.

Discussion: Comparing the results from Old Soaker and Squid Cove (Figs. 2,3) to the Quela drill site (Fig. 1) reveals some disparity between these rocks in the Sutton Island member and typical Murray formation. While hematite bands are common throughout the Murray [4], ferric absorptions centered at 860 nm are rare in the bedrock at Old Soaker and Squid Cove. This could be due to the presence of additional phases that have ferric absorption features centered at longer wavelengths than hematite. Some of the spectra (Figs. 1,3) appear closer to Fe/Mg-smectite (band center near 930 nm), jarosite (~920 nm), akaganeite (~910 nm), or goethite (~920 nm), or perhaps a mixture of these phases with minor hematite [6]. Goethite could imply a somewhat more reducing environment than hematite and akaganeite would imply Cl-rich fluid alteration. Of these minerals, Fe/Mg-smectite and hematite have been detected from orbital spectra in this part of the Murray formation [5,8]. However, these minerals are also present in CheMin XRD analysis of the Quela drill sample, which found 7.1 ± 0.4 wt% hematite and 16 ± 3 wt% phyllosilicates [7], and Quela is spectrally dominated by hematite. Thus, the mineralogy in the vicinity of Old Soaker may be different, perhaps due to the presence of additional Fe-oxides like goethite or akaganeite, which has been detected by CheMin on the Vera Rubin Ridge [9]. The variability in strength of hematite signatures in these areas may also be affected by differences in hematite crystallinity or photometry. [10]. Both Squid Cove and Old Soaker also exhibit significant spectral variability (Fig. 2b,3b). Strong hematite bands are not very common in the observed targets, but where they are visible, they occur in close proximity to spectra consistent with possible ferrous alteration phases, within the gray mottled areas that appear diagenetic in nature.

These observations suggest that portions of the Sutton Island member may have experienced a different alteration history than previously studied parts of the Murray formation, perhaps including different redox conditions during early or late diagenesis. Further investigations will determine whether these observations can be extended to the rest of the Sutton Island member. Early diagenetic differences in alteration could be related to the lake environments, for example, a redox gradient that existed between the shore at Sutton Island and deeper parts of the lake [11]. Alternatively, these differences could be due to different late diagenetic processes after lithification, perhaps related to variations in porosity or permeability of the sediments.

References: [1] Siebach et al, this conference [2] Stein et al. (2018) *Geology* [3] Bell et al. (2017) *Earth and Space Science* [4] Wellington et al. (2017) *American Mineralogist* [5] Fraeman et al. (2016) *JGR-Planets* [6] Morris et al. (1989) *JGR* [7] Horgan et al, this conference [8] Bristow et al. (2018) *Science* [9] Morris et al. this conference [10] Johnson, J.R. et al, this conference. [11] Hurowitz et al (2017)