SIMULATING MASTCAM SPECTROSCOPY BY RADIOMETRICALLY TRANSFORMING CRISM IMAGES: A COMPARISON BETWEEN ROVER TRAVERSE AND ORBITAL DATA. K. R. Frizzell[1], M. R. Rice[1], and F. P. Seelos[2], [1]Western Washington University Geology Department, 516 High St, Bellingham WA, 98225 (frizzellkatelyn@gmail.com, ricem5@wwu.edu), [2]Johns Hopkins Applied Physics Laboratory, 11100 Johns Hopkins Rd, Laurel, MD, 20723 (frank.seelos@jhuapl.edu).

Introduction: The Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) instrument on the Mars Reconnaissance Orbiter (MRO) has been identifying mineralogy at Gale crater since 2006 [1], but it is only recently that MSL Curiosity has reached the extensively mapped terrain of Mount Sharp (formally known as Aeolis Mons) within the crater [2]. With the multispectral image data acquired by Curiosity's Mastcam instrument [3, 4], we are able to make comparisons between orbital predictions and ground-based observations.

To facilitate the comparison between orbital and landed spectral data, a radiometric transform was performed on a CRISM Full Resolution Targeted (FRT; ~18 m/pxl) image cube over the lower Mount Sharp region with the Mastcam instrument band passes applied to the CRISM hyperspectral data.

Parameter maps identifying hematite signatures from the 867 nm band depth were then made with the transformed orbital image cube and a ground-based Mastcam multispectral observation from the Curiosity rover traverse.

Background: Gale crater is a 154km diameter impact crater located near the Martian dichotomy boundary where the MSL Curiosity rover landed in 2012. The crater contains a 5.5km tall sedimentary mountain in the center called Mount Sharp.

Previous work by Fraeman et al. 2013 [5], Fraeman et al. 2016 [6], Milliken et al. 2010 [7] and others have identified a stratigraphic sequence in the central mound of Gale crater that contains 7 defined units including Fe-Mg smectites in the lower layers, and more hydrated sulfates in the upper layers. Crystalline hematite was observed in Gale crater, and later confirmed upon a visit by the Curiosity rover to the Vera Rubin Ridge, a hematite ridge in the foothills of Mount Sharp that is approximately 200m wide and extends about 6.5km northeast to southwest.

The CRISM instrument has broad wavelength range and high spectral resolution, with 544 channels spanning 362-3920 nm. The Mastcam instrument has 12 narrow band filters which sample the 445-1013 nm wavelength range, in addition to the RGB Bayer color filter array. The advantage of the Mastcam instrument is that while it has far fewer spectral channels, the spatial resolution of a landed instrument (<10 cm/pxl for 1km distance and 150 µm/pxl at a 2m distance) is much higher than that of the orbital CRISM instrument (~18 m/pxl) so it can be used to analyze the local geology in much finer detail.

CRISM Data Processing: Prior to the application of the CRISM/Mastcam transform, the CRISM image cube was corrected using a variant of the Targeted Empirical Record (TER) data processing workflow, which corrects the data for geometric, atmospheric, and instrument effects. The radiometric transform then results in a CRISM/Mastcam image cube that has the spatial, geometric, and calibration characteristics of the corrected CRISM image, and the spectral characteristics of the Mastcam instrument.

The CRISM data processing and CRISM/Mastcam transform together result in an orbital image cube that can be more effectively compared with observations made *in situ* by the MSL Curiosity rover.

Parameter Maps: A hematite spectral parameter map was made from the radiometrically transformed image (Figure 1) using an equation derived from Viviano-Beck et al. 2014 [8] to calculate the 867 nm band depth:

$$BD_{867} = 1 - \frac{R_C}{\left(\left(1-\left(\frac{867-751}{1018-751}\right)\right)R_L+\left(\frac{867-751}{1018-751}\right)R_R\right)}$$

Where R_C is the Mastcam simulated R5 (867 nm) reflectance, R_L is the left shoulder (Mastcam R3) and R_R is the right shoulder (Mastcam R6). The 867 nm band depth hematite signatures were also observed in a Mastcam image taken on sol 1877 (Figure 2).

Caveats: The orbital/landed comparisons are not 1:1 due to the spatial scale disparity, and since the CRISM/Mastcam image includes bidirectional contribution from the Martian atmosphere while the Mastcam instrument is on the surface. The transformed image also uses interpolated data over the 650-725 nm bands due to the 675 nm CRISM boundary.

Future work: Future work will include the investigation of additional spectral parameter maps, and an evaluation of the orbital/landed comparisons. In addition, we plan to apply this approach to the CRISM data for the Mars 2020 rover landing and field sites in and around Jezero crater, making use of the Mastcam-Z filter set. In this manner the spatial distribution of materials identified from orbit can be presented as they will appear spectrally to the landed remote sensing instruments.

References: [1] Murchie S. et al. (2007) *JGR: Planets, 112,* E5. [2] Grotzinger J. et al. (2012) *Space Science Reviews, 17,* 5-56. [3] Bell J. F. et al. (2017) *Earth and Space Science,* vol. 4. [4] Malin M. C. et al. (2017) *Earth and Space Science,* vol. 4. [5] Fraeman A. A. et al. (2013) *Geology, 41,* 1103-1106. [6] Fraeman A. A. et al. (2016) *JGR: Planets, 121,* 1713-1736. [7] Milliken R. E. et al. (2010) *Geophysical Research Letters,* vol. 37. [8] Viviano-Beck C. E. et al. (2014) *JGR: Planets,* vol. 119.

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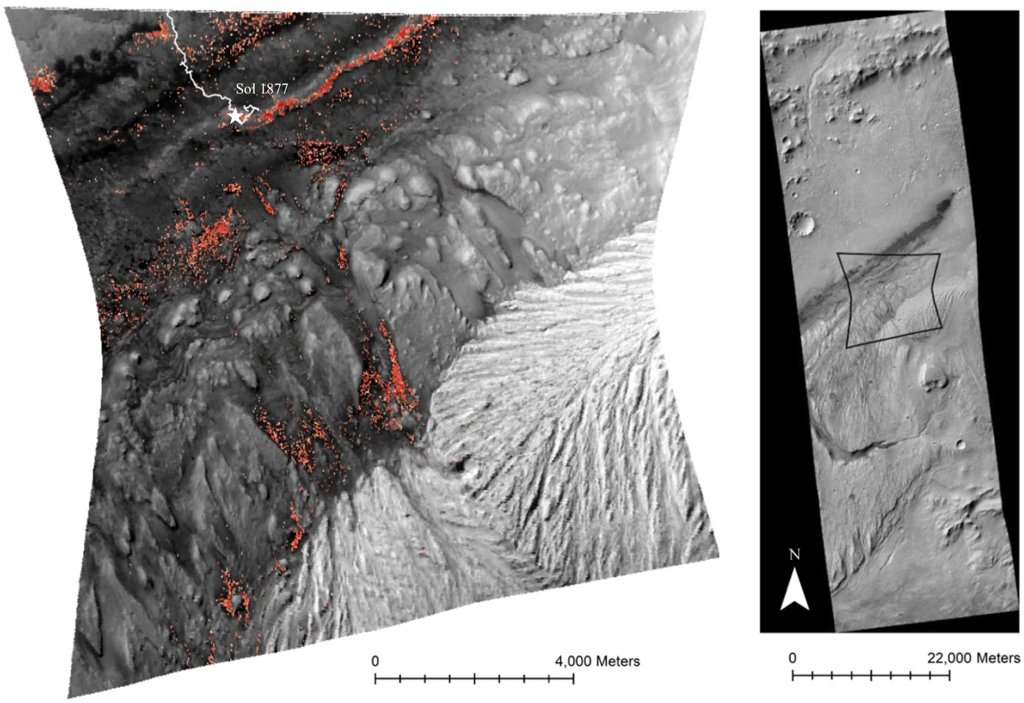

Figure 1: 867 nm band depth (Hematite signature) parameter map over Gale Crater as viewed through Mastcam band passes. The Curiosity rover traverse map through sol 2098 is marked in white. Hematite signatures are represented in a red color gradient with values of band depth greater than zero. (CRISM image: FRT0000B6F1, CTX context map: P21_009149_1752_XI_04S222W) CRISM stamp location on CTX image is approximate.

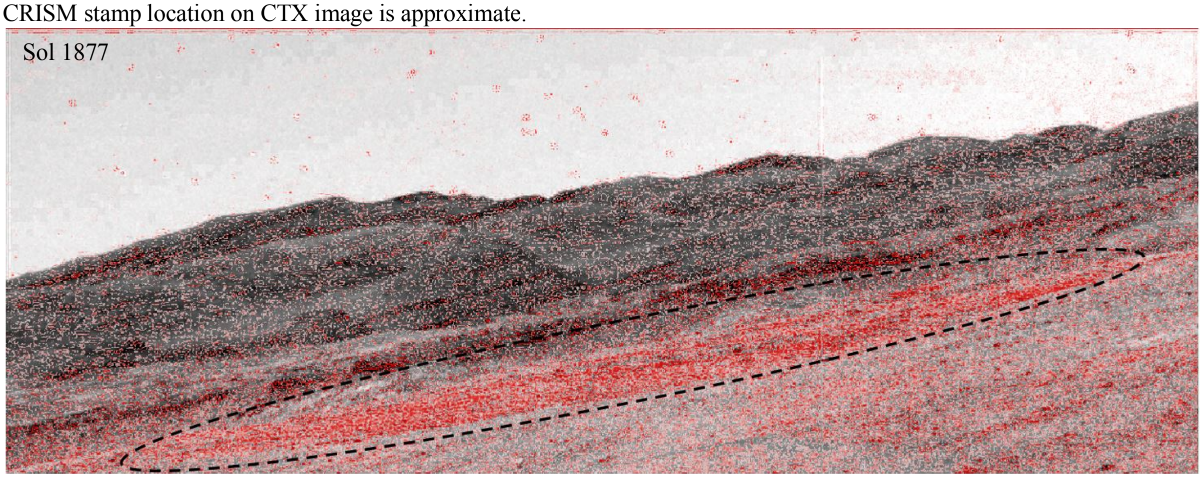

Figure 2: Table Mountain Mastcam image observed by MSL Curiosity on Sol 1877 displaying an 867 nm band depth gradient in red with values greater than zero. Includes a standard deviation stretch (n=2.5). This is a cropped Mastcam left eye image. Note the dashed line outlining stronger hematite signatures.