

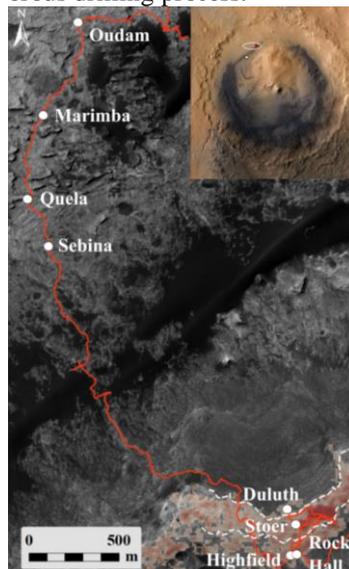
MASTCAM MULTISPECTRAL RESULTS FROM VERA RUBIN RIDGE AND LABORATORY STUDIES TO SUPPORT AND ENHANCE THE INTERPRETATION OF MULTISPECTRAL DATA FROM THE CURIOSITY ROVER.

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Introduction: Data from Mastcam multispectral observations have been instrumental in understanding mineralogical variations seen throughout the Mars Science Laboratory mission, especially during the exploration of Vera Rubin ridge (VRR). Explored for over a year and a half, VRR was identified mainly from its erosional resistance and strong 860 nm absorption feature seen from orbital data taken by the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM; Fig. 1) [1,2].

To help interpret the multispectral data from VRR, we compared Mastcam multispectral data from drilled targets with a known mineralogic composition measured by CheMin XRD data [3] to spectra of mineralogical mixtures created in the lab. We found that variations in the depth of the 867 nm absorption feature in Mastcam data observed across VRR could be controlled by a combination of variations in ferric phyllosilicate abundance, clinopyroxene abundance, and the presence of red crystalline hematite.

Understanding potential mineralogical controls on Mastcam spectral absorptions is critical for understanding the possible mineralogy of rocks in areas where we do not have CheMin results. Mastcam multispectral observations are easier to acquire than mineralogical results from CheMin which requires a rigorous drilling process.



~ Figure 1 ~
Map of the eight drill targets discussed in this work. Vera Rubin ridge is in the bottom right corner, overlaid with CRISM 860 nm data (red color variations indicate changes in strength of the CRISM signal). Red line is the Curiosity rover traverse. Inset shows Gale Crater, the landing ellipse, the Bradbury landing site (red circle), and Vera Rubin ridge (white circle).

Methods: We compared the Mastcam multispectral and CheMin XRD [3] results of eight drill targets on VRR and stratigraphically below VRR to understand how mineralogical variations affect the Mastcam multispectral results (Fig. 2). On average, these eight drill targets have similar major element composition measured by APXS [4]. We also conducted laboratory spectral studies on powdered mixtures of phyllosilicate (nontronite), plagioclase, pyroxene (augite), and red hematite, which were common minerals observed by CheMin in all eight drilled samples [3]. Laboratory mixtures had varying abundances of nontronite and plagioclase + pyroxene, while the abundance of hematite was held constant at 5 wt.%. The plagioclase, pyroxene, and hematite in all lab mixtures had the same grain size of 75-106 μm .



Figure 2: Mastcam right eye visible wavelength RGB approximate true color images of the drill targets compared in this study. Top row, left to right: Oudam (sol 1363; mcam06671), Marimba (sol 1425; mcam07034), Quela (sol 1465; mcam07323), and Sebina (sol 1496; mcam07566). Bottom row, left to right: Duluth (sol 2059; mcam10916), Stoer (sol 2138; mcam11468), Highfield (sol 2225; mcam11791), and Rock Hall (sol 2262; mcam12094). The drill hole is 1.6 cm in diameter.

Results: Comparisons between Mastcam multispectral 867 nm band depth and CheMin quantitative mineral results show that the strength of the 867 nm absorption is negatively correlated with variations in red crystalline hematite abundance. But there is a strong positive correlation between CheMin abundances of ferric phyllosilicates and the 867 nm band depth (Fig. 3). Resulting lab spectra and 860 nm band depth calculations show that the 860 nm band depth also has a strong positive correlation with phyllosilicate abundance (Fig. 4). Laboratory results also show that the 867 nm and 527 nm absorption features can

be affected by mineralogical variations alone and do not have to involve grain size variations (Fig. 5). Laboratory spectra show that mixtures with hematite have an absorption feature centered at ~860 nm, while mixtures without the red crystalline hematite have an absorption centered at ~920-980 nm.

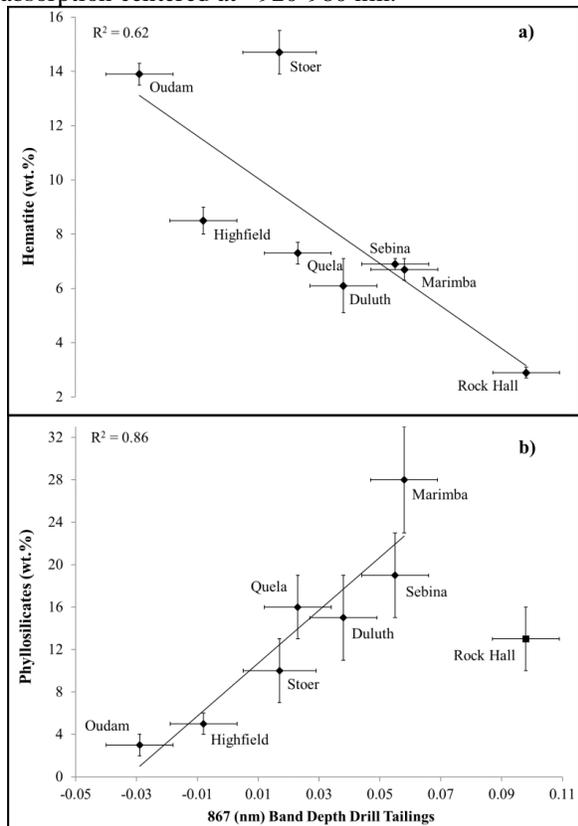


Figure 3: a) moderate negative correlation between hematite abundances and 867 nm band depth, b) strong positive correlation between phyllosilicate abundances and 867 nm band depth.

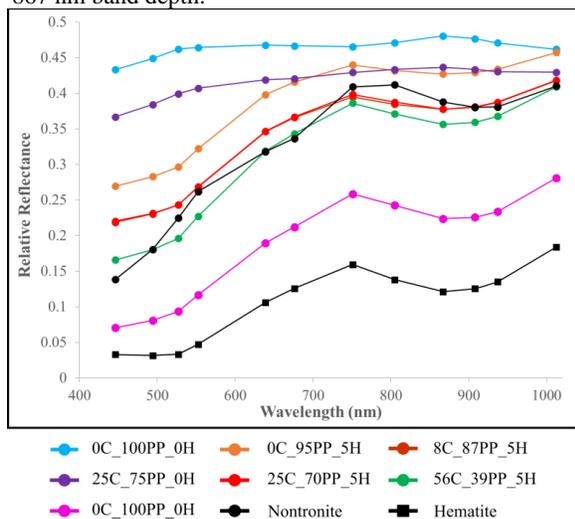


Figure 4: Lab spectra for all eight mixtures and the endmembers hematite and nontronite.

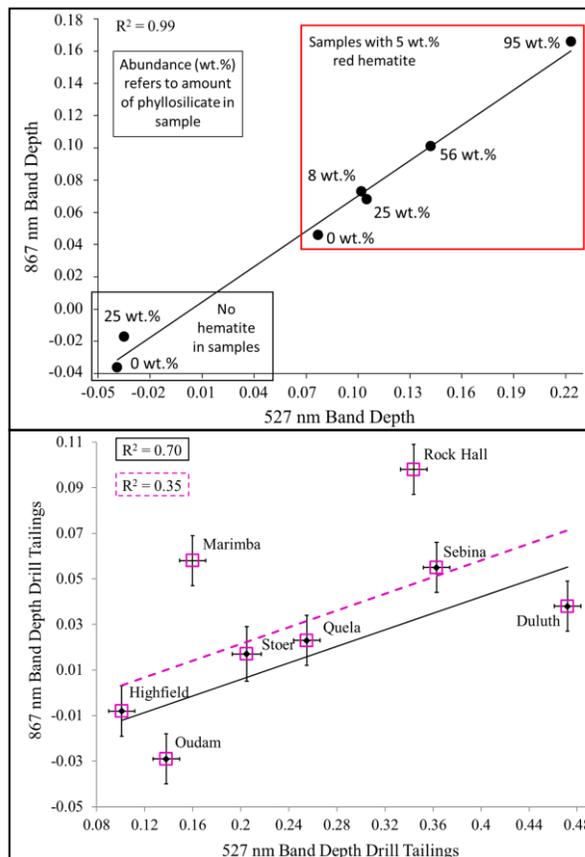


Figure 5: Studies show that both the ~860 and 530 nm band depth can be affected by variations in hematite grain size [5]. Specifically recent studies have shown that the strength of the 860 and 530 nm absorptions increase with decreasing grain size below ~100-200 μm [6]. Top) Laboratory data showing the variations in 867 and 527 nm band depth caused by mineralogical variations alone. Bottom) Variations in 867 and 527 nm absorption strength calculated from Mastcam multispectral observations.

Conclusions: Data from the Mastcam and CheMin instruments onboard Curiosity show that the depth of the 867 nm absorption feature could be controlled by the abundance of ferric phyllosilicates, while the wavelength position of the 867 nm absorption is driven by the presence of red crystalline hematite. New laboratory studies of physical multi-mineral mixtures confirm that the depth of the ~860 nm absorption feature can increase without changing the abundance or grain size of red crystalline hematite. Future laboratory analyses will incorporate variations in hematite grain size to understand how grain size might affect the results from the laboratory work discussed above.

References: [1] Milliken R.E. *et al.*, *GRL*, 37, L04201, 2010. [2] Fraeman A.A. *et al.*, *Geology*, 40, 1103, 2013. [3] Rampe, E.B. *et al.*, *JGR*, submitted. [4] Thompson, L.M. *et al.*, *JGR*, submitted. [5] Morris R.V. *et al.*, *JGR*, 90, 1985. [6] Johnson, J.R. *et al.*, *LPSC 50 #1314*, 2019.