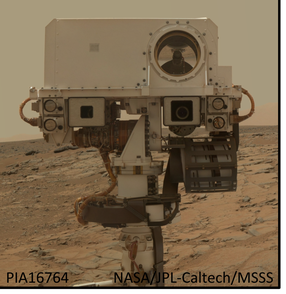

VIS/NIR Spectral Differences of Materials Within Gale Crater, Mars: Parameterization of MSL/Mastcam Multispectral Observations

#2885

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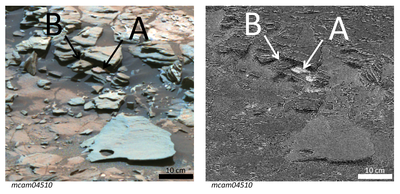
Introduction

- The Mastcam instruments on the MSL Curiosity rover can acquire images at up to 12 distinct filter wavelengths [1,2,3,4], allowing 12-point visible/NIR reflectance spectra (445-1012 nm) to be derived from averaged ROI values within the image [5].
- Unique spectral features allow different materials to be identified within images, often using a small subset of Mastcam filters. This parameterization can aid in mapping and reconnaissance, especially for small-scale exposures and/or uncommon materials, such as localized alteration.

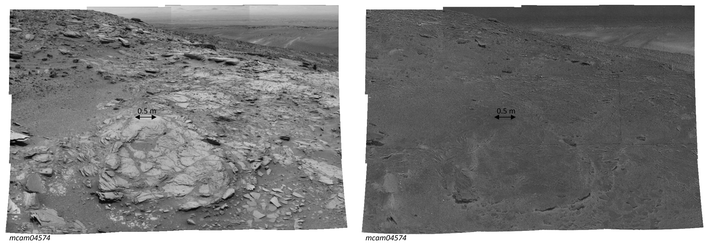
Above: The Mastcam calibration target on sol 66

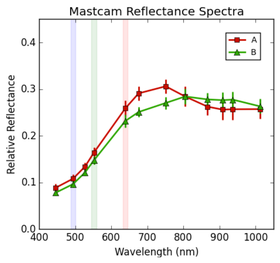
Fe-Sulfate

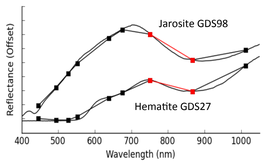
- In Marias Pass, multispectral observations documented small-scale exposures spectrally consistent with a ferric oxide or sulfate. Chemistry by LIBS is consistent with jarosite or a similar mineral [6].
- This material is distinguishable from surrounding Stimson by the strong NIR absorption that results in higher 751/867 nm filter ratios. A search of surrounding strata using these two filters revealed a lack of broad exposures.



Far left: Target "Coombs" false color composite (676-527-445 nm) from sol 1032. Left: Prev. as 867/751 nm ratio showing bright surfaces (center of FOV). Below left: "Apikuni Mountain" from sol 1044 in 751 nm grayscale. Below: Prev. as 867/751 nm ratio showing lack of "Coombs-like" features.

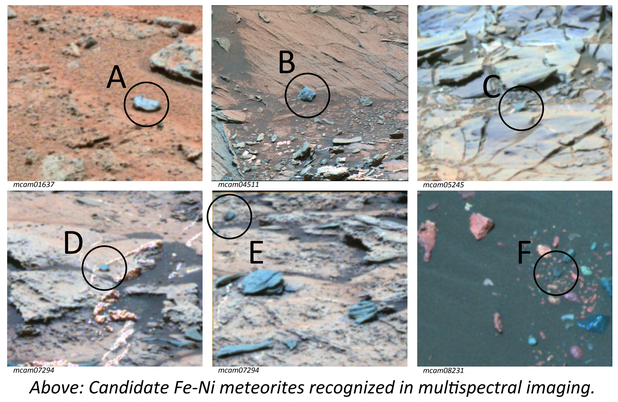






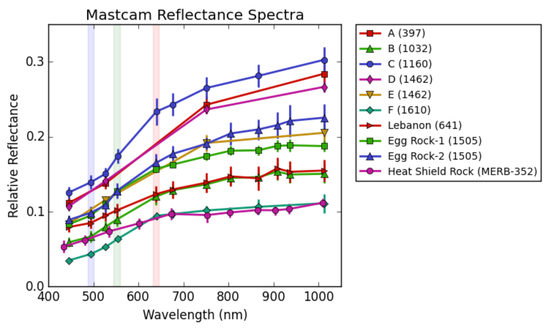
Left, top: Reflectance spectra of adjacent rock surfaces in "Coombs" observation (left). Surface A is the Coombs LIBS target; surface B is typical Stimson material. Left, bottom: USGS lab spectra [7] showing 751-867 downturn in hematite and jarosite. When the full spectrum is considered, jarosite is more consistent with the red spectrum (A) above.

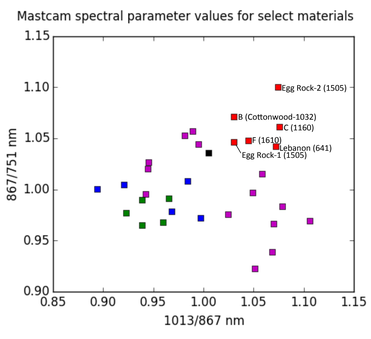
Potential Fe-Ni Meteorites



Above: Candidate Fe-Ni meteorites recognized in multispectral imaging. From left to right, top to bottom, these are from sols 397, 1032, 1160, 1462 (two frames showing different potential fragments) and 1610. All are false color composites of 751-527-445 nm except 1032, which is 805-527-445 nm.

- Iron-nickel meteorites have been observed several times by this and other missions [8,9,10] and can serve as markers of previous environmental conditions by their degree of alteration [11].
- Using decorrelation stretches and ratio parameter maps based on the positive NIR slope of these materials, we identified several additional candidates within the multispectral dataset.

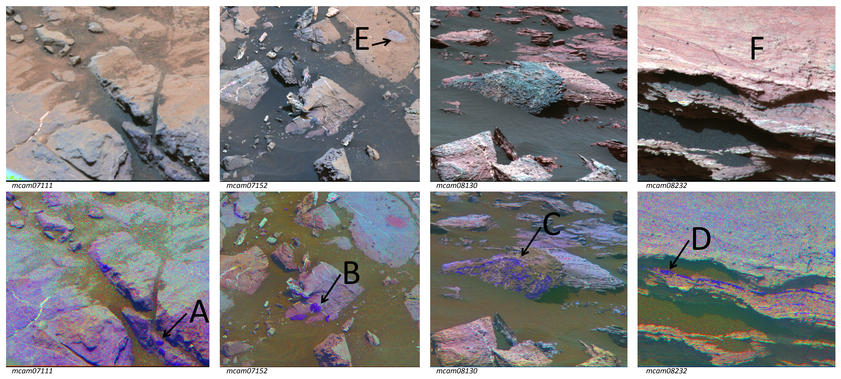


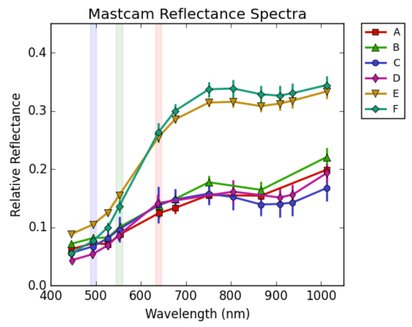


Far left: Reflectance spectra of several candidate meteorites, and other MSL meteorites recognized based on morphology and (for Egg Rock, [9]) chemistry; and Pancam spectrum of brushed surface of Heat Shield Rock from the Opportunity mission. Left: Parameter plot of two different band ratios for possible meteorites (red), as well as Murray (magenta), Stimson (green), Bradbury group materials (blue), and dust (one, black).

Fe-Oxide

- Mastcam has observed hematite spectral signatures in the Murray bedrock since approximately sol 1160, consistent with ChemCam passive and CRISM orbital spectra [12,13,14].
- Additional small-scale features with stronger ferric-oxide-like spectral features have been observed with a variety of morphologies.
- These may be areas where liquid water moving through fractures mobilized and reprecipitated Fe^{3+} from the hematite in the surrounding bedrock.

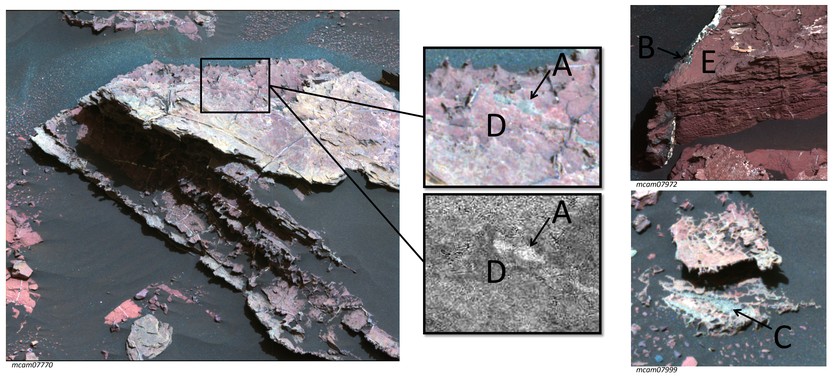


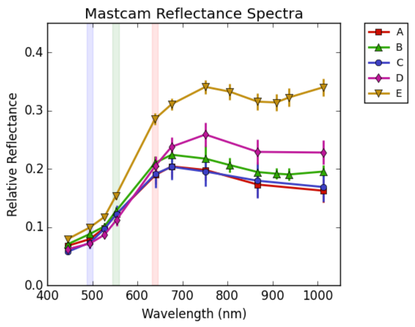


Above: Each top/bottom pair shows the same FOV in 676-527-445 nm false color composite (top) and L3-L5-L6 decorrelation stretch (bottom). From left to right, these are: sol 1438 "Conda" (cropped), sol 1445 "Ganda" (cropped), sol 1596 "Parker Bog", and sol 1610 "Spurwink" (cropped). Small features are ~cm in scale. Right: Letters correspond to reflectance curves shown in plot; A-D for small-scale features, E-F for bedrock.

Grayish Layers or Coatings

- Isolated rock surfaces observed occasionally since approximately sol 1524 have exhibited unusual spectra characterized by less red visible slopes, decreased or absent 867-1012 nm upturns, and shorter reflectance peaks resulting in negative 676-751 nm spectral slopes.
- These spectral characteristics may be consistent with magnetite (perhaps from reduction of hematite), or perhaps a ferrous sulfate mineral.





From left to right: Color composite (676-527-445 nm) of mottled Murray rock from sol 1524; Box shows zoom-in of region with grayish layer exhibiting a 676-751 nm downturn (bright in lower grayscale frame); Other locations with similar spectra are shown as well: top is sol 1552 "Western_Head" observation shown as 805-527-445 nm with dark-toned material near a bright vein, bottom is 676-527-445 nm composite from sol 1571 covering the "Goose_Cove" target showing different layer colors. Plot shows material with 676-751 nm downturn (A-C) and bedrock (D-E).

Summary

- Small-scale exposures of alteration are often poorly characterized by and only weakly recognizable in RGB Bayer imaging, but can be mapped with Mastcam by their NIR reflectance properties.
- Other exotic materials with distinct reflectance behavior, such iron-nickel meteorites, are likely overlooked when their morphologies are not sufficiently noticeable. Mastcam multispectral imaging can distinguish these materials from local bedrock.

References

[1] Malin et al. (2010) *41st LPSC,* 1123. [2] Bell et al. (2012) *43rd LPSC,* 2541. [3] Malin et al. (2017) *Earth & Space Science*, in review. [4] Bell et al. (2017) *Earth & Space Science*, in revision. [5] Wellington et al. (2017) *Am. Min.*, in press. [6] ChemCam Team, pers. commun. [7] Clark et al. (2007) USGS splib06 [8] Johnson et al. (2014), *AGU Fall Mtg.* P51E-3989 [9] Meslin et al., this conf. #2258 [10] Ashley (2015) *Elements* **11** [11] Fairén et al. (2001) *Met. & Plan. Sci.* [12] Fraeman et al. (2013) *Geology* **41** [13] Johnson et al., this conf. #1310 [14] Fraeman et al., this conf. #2185