National Aeronautics and Space Administration

Integrated Multi-Scale Spatial and Spectral Observations of Mars Relevant Material in Support of Future Mars Missions

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Program: Strategic Initiative

Project Objective:

The objective this year's work was to compare results from CRISM orbital data over Mt. Sharp with ground truth data from Curiosity to enable a better understanding of the strengths and limitations of CRISM spectral data. Analysis specifically focused on comparing how millimeter and meter scale spectral observations Curiosity collected along its traverse linked to tens of meter scale spectral observations acquired from orbit. Results were integrated to better understand drivers of orbital spectral datasets.

FY18/19 Results:

Curiosity data revealed how ground factors influence orbital observations:

1. *Dust.*

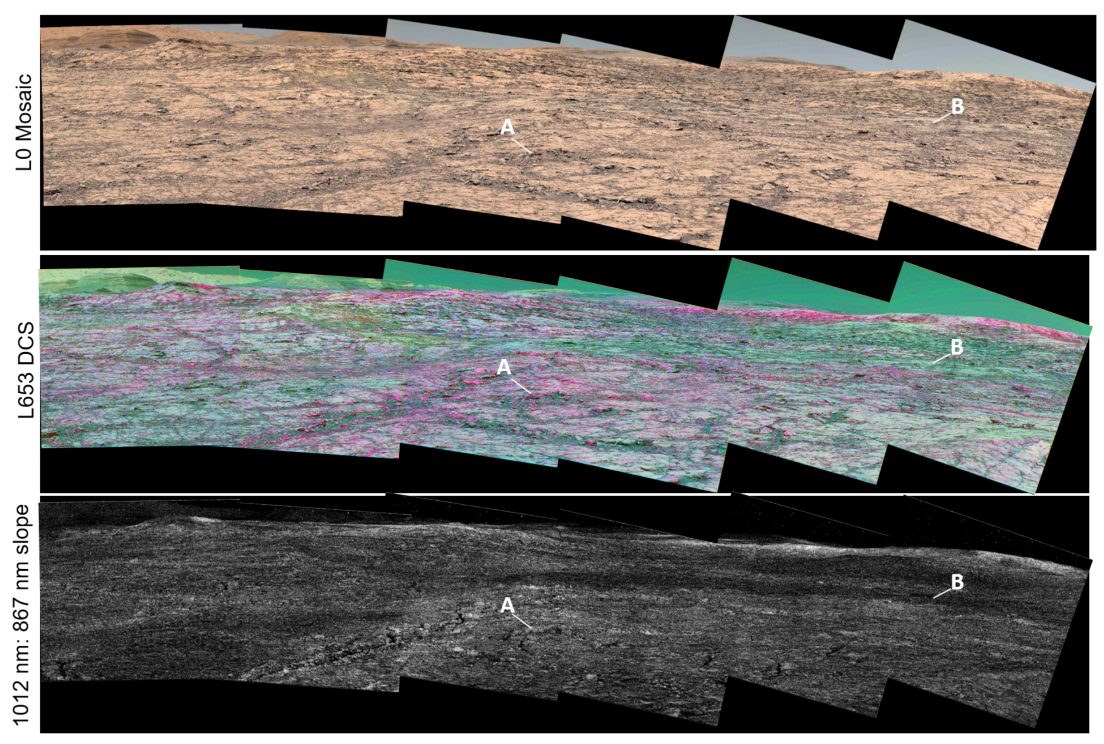
- Evident when Curiosity first climbed onto feature called Vera Rubin ridge (VRR) where large fractures crossing the surface.
- Mastcam multispectral data showed a strong 867 nm absorption feature (hematite indicator) associated with rocks near the fractures and a weaker or absent feature in the smooth areas between fractures
- Up-close investigation of locations near a fracture vs. an area between fractures showed no differences in the chemistry or spectral properties of the two areas; instead, a thicker layer of dust had settled on the smooth surface between fractures and rough, upturned rocks near fractures were less dusty

2. *Sub-pixel mixing of sand and bedrock.*

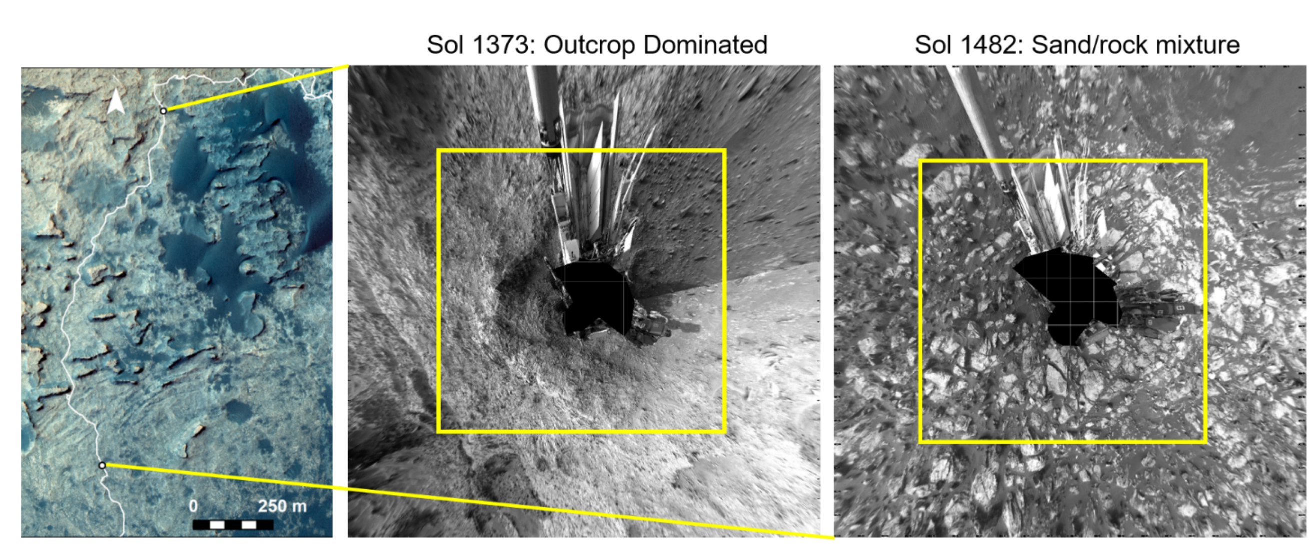
- Portions of Curiosity's traverse are dominated by bedrock or mixtures of broken bedrock and sand
- Checkerboard mixing models using bedrock and sand endmembers are self consistent with ground observations

3. *Bedrock spectral variability.*

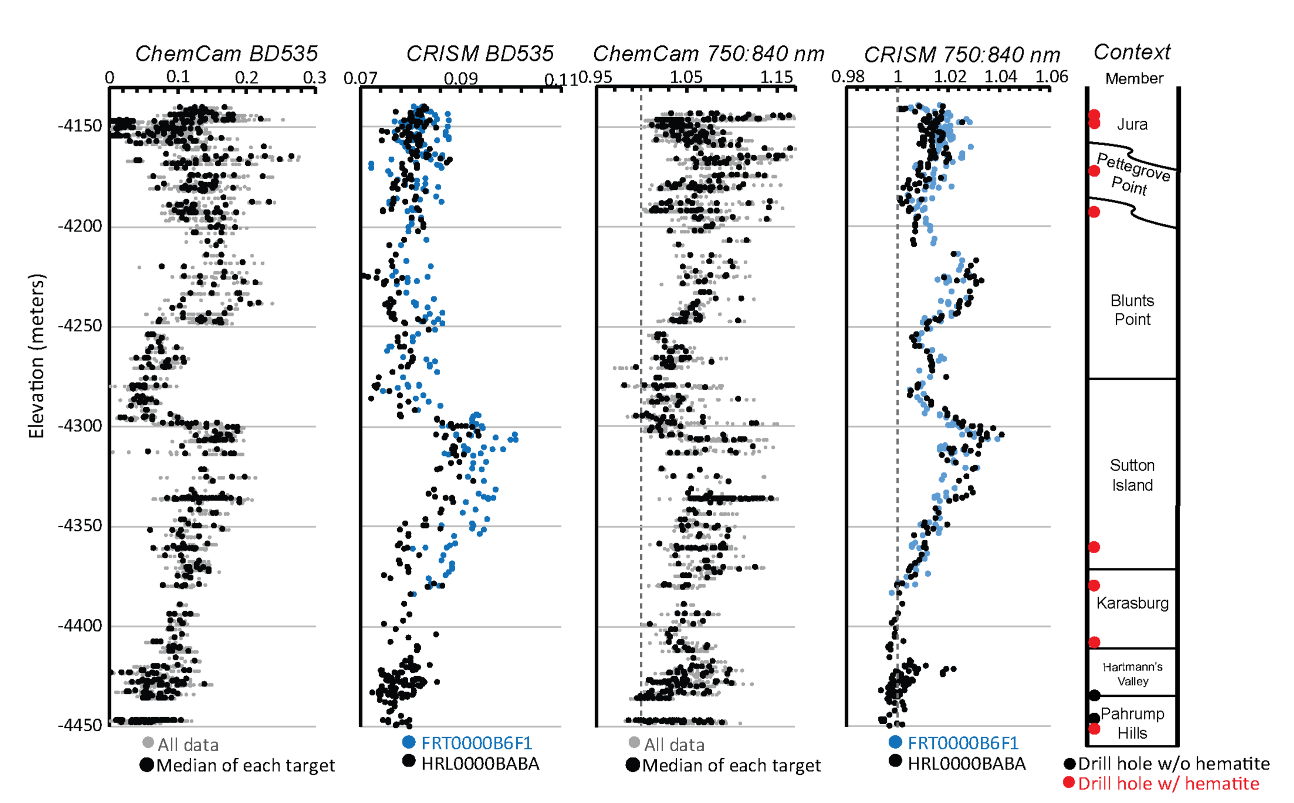
- 535 nm band depth and 750 - 840 nm slopes calculated from CRISM data along Curiosity's traverse and from ChemCam bedrock targets largely show similar trends. So even with sand and dust, CRISM is still picking up on real variability of bedrock.
- The spectral contrast of CRISM data is greatly reduced compared with ChemCam and there are some discrepancies in particularly sand-dominated areas of the traverse



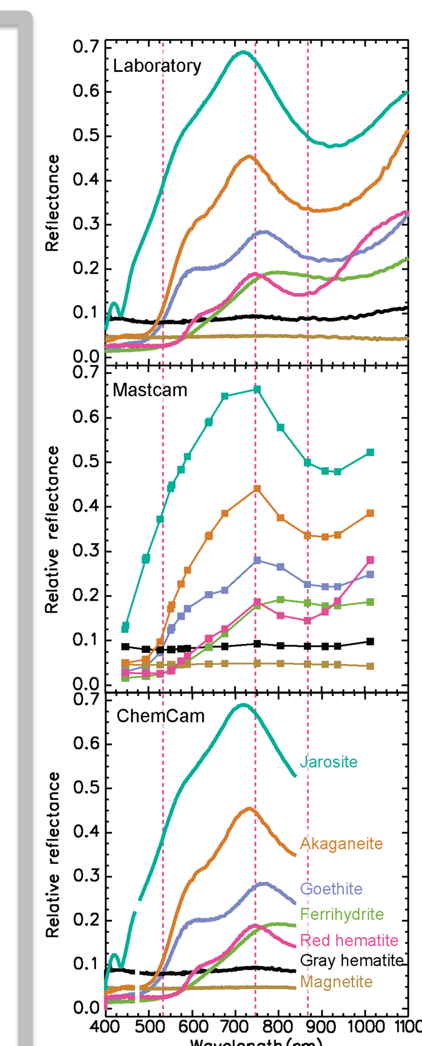
(Top) Mastcam L0 mosaic sol 1812, (Middle) Decorrelation stretch from L653 filters. Areas that are more purple have deeper ferric absorptions, (bottom) 1012 : 867 nm slope map. Curiosity investigated a workspace near a fracture at "A" and away from a fracture at "B" but found no chemical or spectral differences once dust was removed from the outcrops.



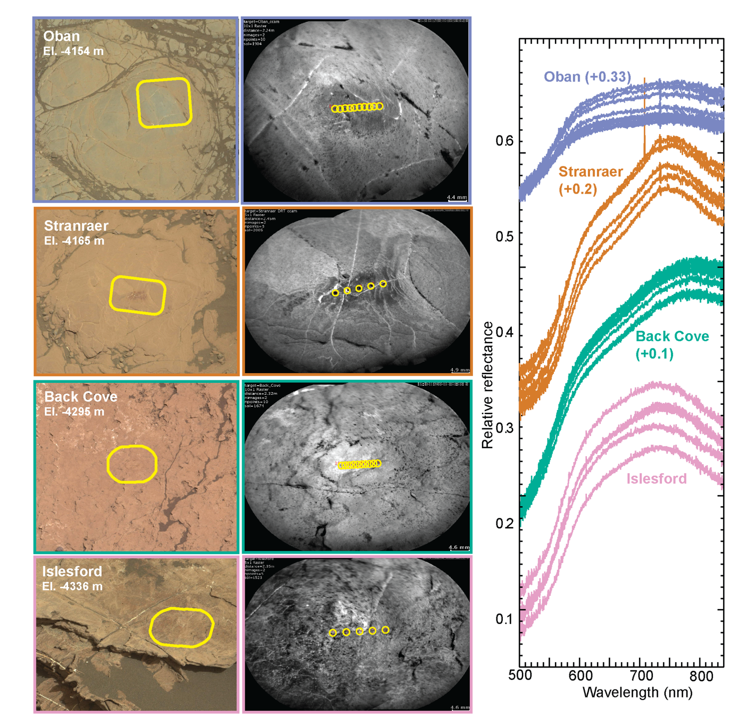
(left) HiRISE image showing a portion of Curiosity's traverse near the Murray Buttes area. (middle) Orthorectified Navcam image of a rare outcrop dominated area from sol 1373. (Right) Orthorectified Navcam image of a more typical mixed sand and bedrock area from sol 1482. The yellow boxes are 18 m on a side and represent the area covered by a single CRISM pixel.



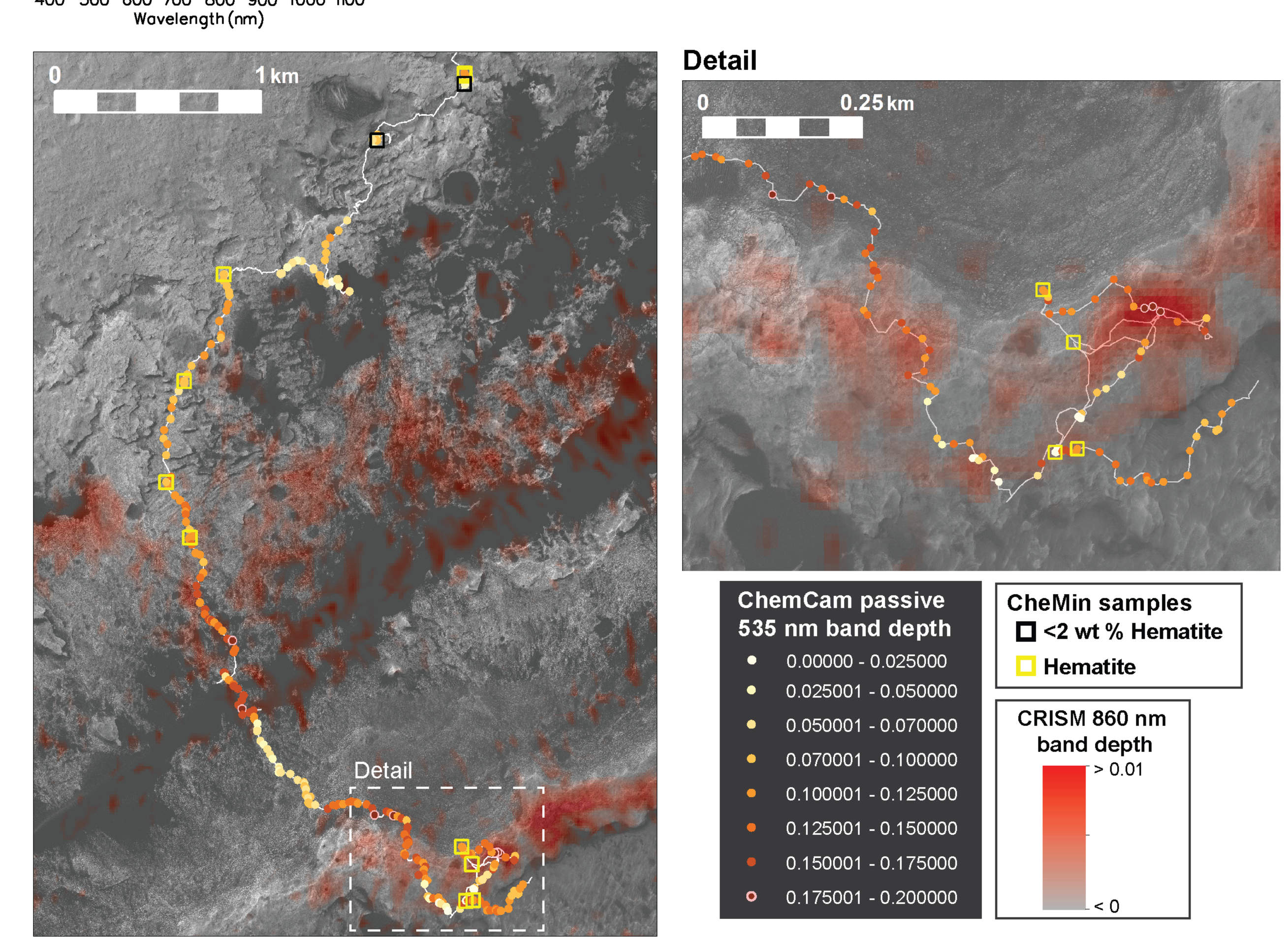
(left) Variability of 535 nm band depth versus elevation seen in ChemCam passive bedrock observations compared with CRISM data from two scenes along Curiosity's traverse. (center) Variability of 750:840 nm ratio from ChemCam passive and CRISM spectra. (right) Stratigraphic members versus elevation for context. CRISM and ChemCam parameters were calculated using the same formulas. Note the x-axis scale bars are different for the ChemCam and CRISM parameters.



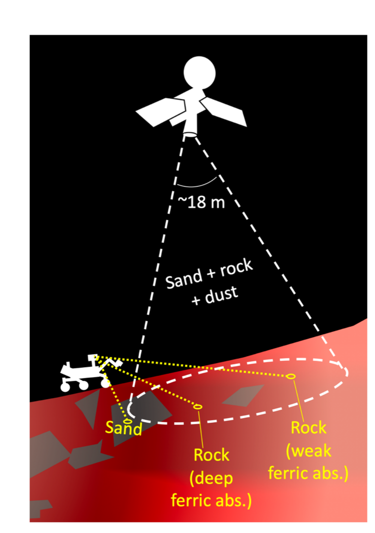
(Top) CRISM-like laboratory spectra of geologic materials convolved to how they would look to Curiosity's Mastcam (middle) and ChemCam (bottom) instruments.



(left) Context Mastcam images showing typical bedrock targets along Curiosity's traverse through Mt. Sharp. (center) Associated RMI images for ChemCam observations. Approximate locations of RMI images are outlined in yellow on the Mastcam scenes. (right) ChemCam passive spectra associated with targets. These spectra demonstrate the range of variability of ChemCam passive spectra throughout the Murray formation.



(Left) Average ChemCam 535 nm band depth along Curiosity's traverse overplotted on CRISM 860 nm band depth map from atmospherically corrected and MLM smoothed HRL0000BABA. Locations of CheMin hematite detections are show in yellow squares. (top right) Detail on Vera Rubin ridge with CRISM 860 nm band depth from atmospherically corrected and MLM smoothed FRT0000B6F1. (lower right) Key.



Cartoon summarizing factors that influence orbital data.

Benefits to NASA and JPL (or significance of results):

- Minerals detected from Mars orbit are trustworthy
- CRISM data sensitive to actual spectral variability in bedrock targets, although sand and dust reduce spectral contrast and can complicate interpretations
- Promising implications for future Mars landing sites selected in part based on spectral observations
- Also emphasizes the importance of coordinated orbital observations with *in situ* data; all scales are needed to understand the geologic history of Mars.
- Future Mars missions should continue to push for landed exploration and increasingly higher resolution orbital datasets.

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