MARS HYPERSPECTRAL DATA PROCESSING IN THE JEZERO CRATER AND NE SYRTIS REGION: IMPLICATIONS FOR MINERALOGICAL ANALYSIS.

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Introduction:

Visible to near-infrared (VNIR) spectroscopy is essential for understanding the mineralogy of planetary surfaces from orbit, and data acquired by the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) [1] on the Mars Reconnaissance Orbiter (MRO) [2] has provided spectroscopic data leading to key discoveries since 2006.

- MultiSpectral VNIR (MSV) images have 90 spectral channels ranging from (364 – 1055 nm) with a spatial sampling of ~100 m/pxl [3]
- MSVs have a high (30 Hz) frame rate
- Mosaic created using these MSV image strips for the purpose of mapping the Jezero Crater and North East Syrtis regions. (Mars 2020 landing site candidates)

Site Selection:

- Bounds encompass 106 MSV observations, relevant geologic features, and 3 of the 4 candidate landing sites for Mars 2020.
- MSVs chosen due to spectral range and sampling, spatial resolution, and accumulated coverage density.
- VNIR mapping strips have become one of the primary latter-mission CRISM observing modes [5].

Coverage Density

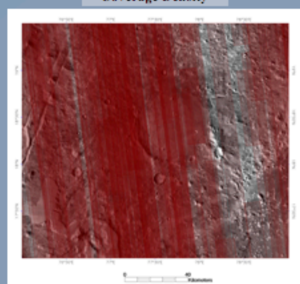

Figure 1 (above): A map over the Jezero crater/NE Syrtis region showing the coverage density of MSV observations in red. **Figure 2 (below):** An example MSV. 106 of the multispectral VNIR observations were used in the mosaic.

Methods:

The MSV data processing included standard CRISM pipeline procedures (pre-processing/downselection, basic corrections, dust opacity corrections, and a coverage density analysis.

- **Basic Corrections:** The **Lambertian *(cos(i))*** method was used to correct for non-normal solar incidence angles, the **Spectral Smile correction (ESC)** was used to fix the brighter, bluer edges of the MSV strips, and the **Ratio Shift correction (RSC)** was used for de-striping the images.
- **Dust Opacity Considerations*:*** Atmospheric dust loading on Mars cycles seasonally. A stacking order based on dust opacity (τ) values was created using Dr. Luca Montabone's Mars climate database [4], with lowest τ on top and highest τ on the bottom.
- **Coverage Density Analysis:** The coverage density of the MSV observations in the study area was analyzed by encoding the connectivity of the individual images in an graph theory adjacency matrix. Adjacency matrix transforms allowed the mosaic connectivity at different path lengths to be explored and weak connections in the overall mosaic system to be identified. **The most well-connected image with a low dust opacity was used in the mathematical optimization as a reference point.**

Optimization:

A linear least squares optimization was performed by singular value decomposition (SVD) to calculated observation- and wavelength-dependent linear transform parameters that minimize the radiometric discrepancy across the mosaic:

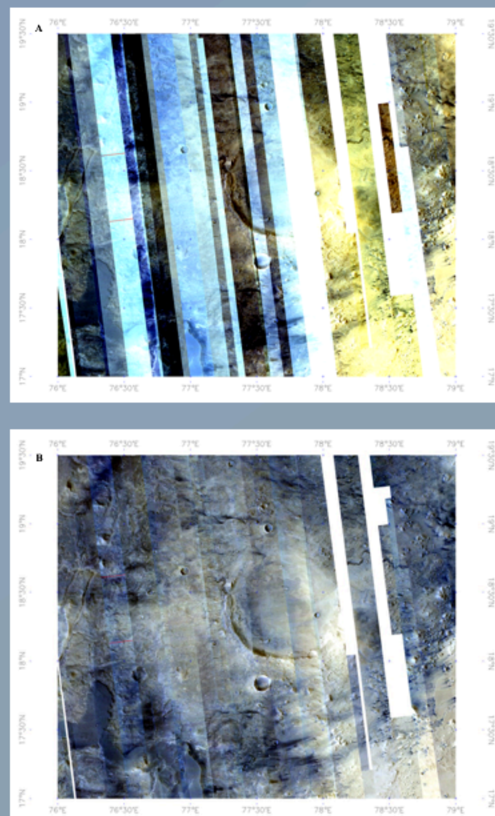

Figure 3: Before (A) and after optimization (B). 2A and 2B were stretched identically with Red: 716.2 nm, Green: 598.86 nm, and Blue: 533.74 nm.

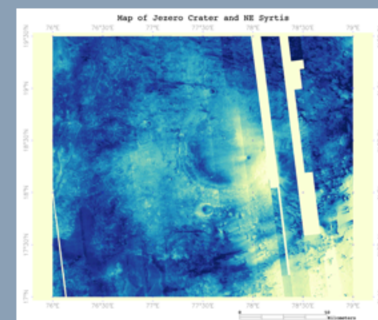

Figure 4 (right): Informative mineralogical map from the processing pipeline: RPEAK1, which shows Fe mineralogy like olivine and pyroxene (Linear stretch: 718-774 nm).

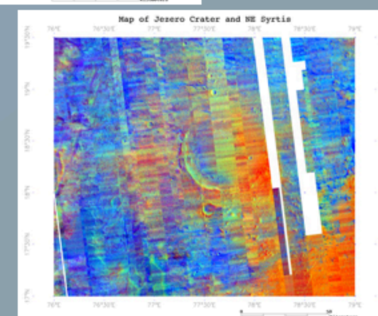

Figure 6: FEM Browse Product. Red indicates nanophase or crystalline ferric oxides, green is usually a result of textural effects, and blue is usually dust-free or more mafic surfaces. This image also revealed low-level calibration residuals that were not as present in other products (and were difficult to resolve).

Conclusions:

- The pipeline provided a more cohesive mosaic product than the original, which will **allow for scientific analysis of the mineralogical diversity at the Jezero Crater** landing site. This helps to provide geologic context for the formation and history of the surrounding areas.
- Since VNIR mapping strips have become one of the primary CRISM latter-mission observing modes, it is important to use them to their full extent.

Future Work:

The mathematical optimization performed on this dataset was purely linear - future work will include expanding the processing to support nonlinear optimization. These products will also be used to simulate spectroscopic images that can be acquired at these sites by the Mastcam-Z cameras on the Mars 2020 rover, and then compared to similarly transformed images taken around Gale Crater to analyze the Curiosity rover's traverse.

References: [1] Murchie, S. et al. (2008) JGR, 112, issue E5. [2] Zurek R. W. and Smrekar S. E. (2007) JGR, E05, S01. [3] Viviano-Beck, C. E., Seelos, F. P., & Murchie, S. L. et al. (2014) JGR, 119, issue 6, pp. 1403-1431. [4] Montabone, L. et al. (2015) Icarus, 251, pp. 65-95. [5] Murchie, S., Arvidson, R., Bedini, P. et al. (2007) JGR, 112, E05S03.