MARS HYPERSPECTRAL DATA PROCESSING IN THE JEZERO CRATER AND NE SYRTIS REGION: IMPLICATIONS FOR MINERALOGICAL ANALYSIS. K. R. Frizzell[1], F. P. Seelos[2], and M. S. Rice[1], [1]Western Washington University, Bellingham WA (frizzek@wwu.edu, melissa.rice@wwu.edu), [2]Johns Hopkins Applied Physics Laboratory, Laurel, MD (frank.seelos@jhuapl.edu).

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

One mode of CRISM observation modes acquires long, narrow mapping strips called MultiSpectral VNIR images (MSVs) [2], which contain 90 spectral channels and are often difficult to process because of their frame rates (30 fps) and residuals. However, these data are downlinked uncorrected and unprocessed and must be corrected for varying incidence angles, seasons, and dust concentrations in the atmosphere. In this work, we created a mosaic using these MSV image strips for the purpose of mapping the Jezero crater, Midway, and North East Syrtis regions, which were candidate landing sites for NASA's Mars-2020 rover (Jezero crater has since been selected).

Regular processing techniques such as Lambertian photometric and spectral smile corrections were used on the images at first. A graph theoretical approach was then used to analyze the connectivity of the mosaic from its overlapping pixels, so as to intelligently choose a reference point to hold constant for further optimization. Dust content was taken into account by sorting the images based on their atmospheric opacity values [3], and finally a singular value decomposition and least squares optimization was performed on the image strips in order to optimize them from a linear approach. The resulting mosaic is more cohesive than the original product and will enable improved mineralogical mapping and scientific analysis.

Site Selection: The Jezero crater, Midway, and NE Syrtis region was selected because it encompassed 3 of the 4 final candidate landing sites for the Mars 2020 rover. The chosen bounds encompass 106 MSV observations, and includes all of the relevant geologic features of interest in the area. MSVs were chosen over other CRISM observation modes due to their vast coverage of the surface of Mars. CRISM observation modes have also been limited due to the decrease in function in both the gimbal mechanism and the cryocoolers [4]. VNIR mapping strips (i.e. MSVs) have become one of the primary methods of data acquisition through the CRISM instrument due to this.

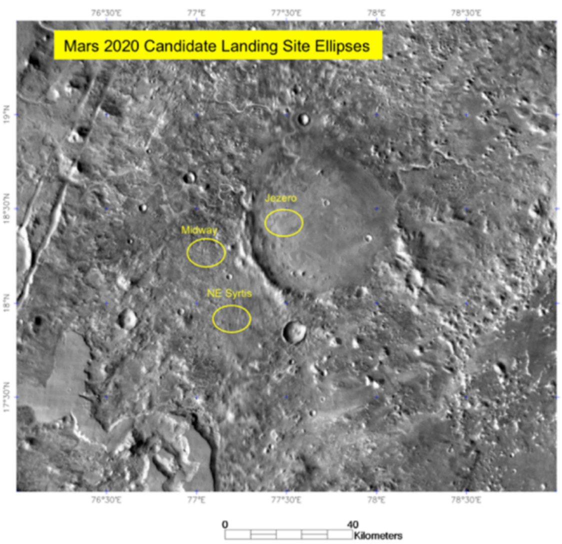

Figure 1: Themis Day IR map of study area including 3 of the 4 previous candidate landing sites for the Mars 2020 rover (credit: NASA/JHU/APL).

Methods: Including the regular CRISM processing pipeline (pre-corrections, Lambertian photometrics, spectral smile), extra steps were taken to process the MSV observations:

Basic Corrections. The Lambertian *(cos(i))* method was used to correct for non-normal solar incidence angles, the Spectral Smile correction 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. RSC was difficult to perform due to the nonlinear nature of the residuals and the frame rate used in MSV observations (30 fps).

Dust Opacity Considerations. Dust on Mars cycles with the seasons, often with a peak in the northern hemisphere's autumn and winter (global dust storms aside). Due to the high density of the MSVs in certain spots, a stacking order based on dust opacity (τ) values was created. Using Dr. Luca Montabone's Mars climate database, which is available at http://www-mars.lmd.jussieu.fr/mars/dust_climatology/ [3], the images were categorized by date and location to determine the dust optical depth. These ordered images were then prioritized with the lowest dust opacities on top and the highest dust opacities buried underneath. The dataset ran from MY 24-33, so some data was extrapolated from trends in previous years.

Coverage Density Analysis. The coverage density of MSV observations in the study site was analyzed by plotting the connectivity of the images into an adjacency matrix through a graph theoretical perspective. The adjacency matrix was plotted at different path lengths in order to reveal weaknesses or "holes" in the overall mosaic. These holes were sections with little to no data, and did not provide the luxury of redundancy that was present in other areas. The most well-connected image with a low dust opacity was used in the mathematical optimization as a reference point.

Mathematical Optimization. A Singular Value Decomposition and linear least squares optimization was performed on the data matrices to provide gain and offset parameters which were applied to each individual MSV observation as a modification function.

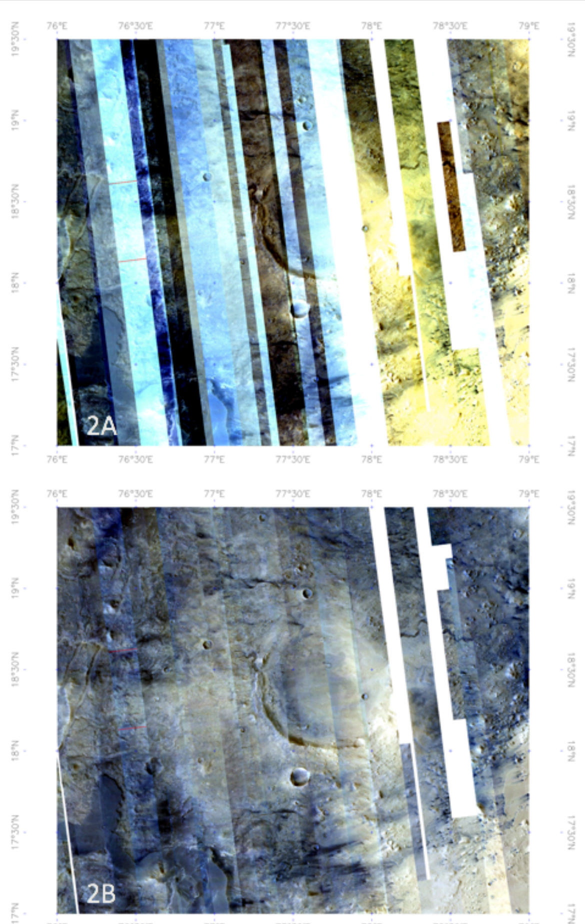

Figure 2A: Study area mosaic assembled at 90 m/px. Pre-corrected, photometrically corrected, and stacked based on dust optical depth (τ). 2B: The resultant mosaic after mathematical optimization processing.

Results: The processing pipeline provided a much more cohesive product than the original, which will allow for scientific analysis of the mineralogical diversity at the landing sites. This helps to provide geologic context for the formation and history of the surrounding areas. Figures 2A and 2B were stretched identically with the red band at 716.2nm, the green band at 598.86nm, and the blue band at 533,74nm. A few of the spectroscopic browse products (FM1, FM2) revealed artifacts in the data that were not present in other observation modes.

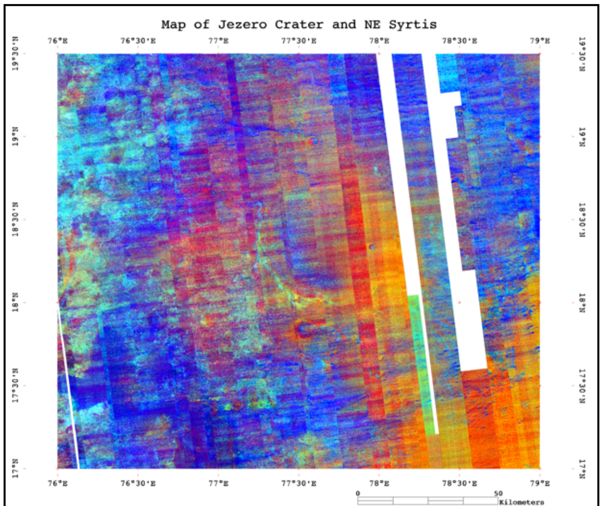

Figure 3: FM2 browse product revealing banding structure inherent to the CRISM instrument

Future Work: The mathematical optimization performed on this dataset was purely linear; future work will include a nonlinear optimization. Analysis of the inconsistencies in the processed spectroscopic images will also be done.

These products will also be used to create maps in other high priority sites, such as Gale crater. The MSV mosaics will allow improved mineralogical analyses of these sites due to their near-continuous spatial coverage (where FRT products are lacking) and the ease of which the images are applicable to more regional scales.

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

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