PROBING MINERAL ABUNDANCES IN OLIVINE- AND CARBONATE-BEARING UNITS IN JEZERO CRATER, MARS, WITH LINEAR SPECTRAL UNMIXING. A. M. Zastrow[1] and T. D. Glotch[1], [1]Stony Brook University, Stony Brook NY, 11794 (allison.zastrow@stonybrook.edu).

Introduction: As the landing site chosen for the Mars 2020 rover, Jezero crater has been the focus of much recent research. Of particular interest, of course, is the large delta in the western portion of the crater, with its diverse mineralogy. This work is focused on characterizing the olivine and carbonate deposits around the delta and probing their relationship to one another through the retrieval of mineral abundances by spectroscopic linear unmixing methods.

Methods: Our work uses spectral data in the near-IR from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM). Atmospheric corrections are made to the data using the DISORT method as described in [1]. The effects of dust and ice in the atmosphere are limited by using this method. The DISORT output is a surface single scattering albedo (SSA) hyperspectral image cube, for which spectral components add linearly [2].

To unmix the CRISM SSA data, we use a non-negative least squares unmixing algorithm, more commonly used in applications to thermal-IR data [3], but which has also been applied to near-IR data [1, 4]. Our spectral library used for unmixing is made up of a set of 26 minerals with SSAs calculated using mineral optical constants at various grain sizes.

In this work, we describe spectral unmixing results for CRISM image HRL040FF, which covers the whole Jezero delta, much of the western crater rim, and some of the crater floor. We produced three unmixing models: 1) using the full set of minerals, 2) excluding all the carbonate minerals (calcite, magnesite, siderite, ankerite, and dolomite), and 3) excluding the olivines (four different Fo #s from fayalite to forsterite).

Unmixing Results: In the full baseline model, HRL040FF is dominated by feldspars (specifically anorthite), phyllosilicates (dominated by serpentine with spots of kaolinite), and dust. Of greatest interest, carbonate and olivine are present in geographically distinct regions that appear to be anti-correlated. The rest of our work looks closer at these regions.

Carbonate unmixing results. Carbonate abundance reaches up to 35% per pixel, although the average across the scene is 4.1%. The regions of highest abundance average around 20%. The baseline model strongly prefers siderite (Figure 2). Magnesite appears more strongly in one area. The major difference between the two spectra (Figure 3) occurs in the band depth of the feature at ~2.315µm. The feature is deeper in the magnesite region (Figure 3 inset, continuum-removed).

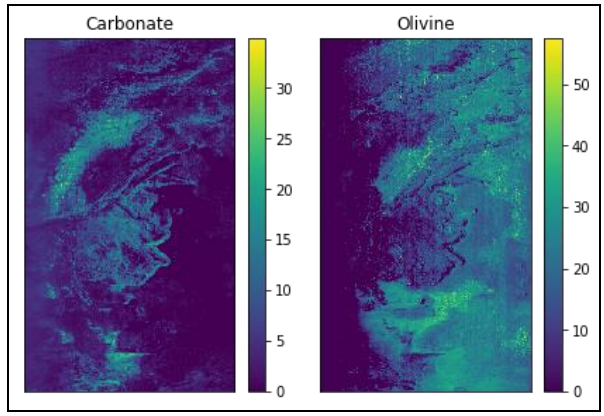

Figure 1. Baseline model unmixing results for carbonate and olivine groups. Note different scales.

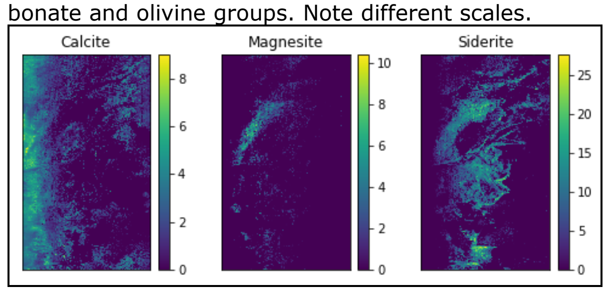

Figure 2. Breakdown of carbonate minerals in baseline model. Note different scales.

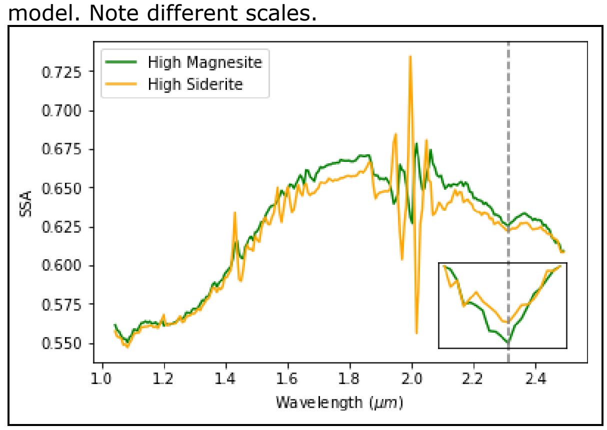

Figure 3. Spectra from regions of high magnesite and high siderite abundances. Inset is a close-up of continuum-removed 2.315µm feature.

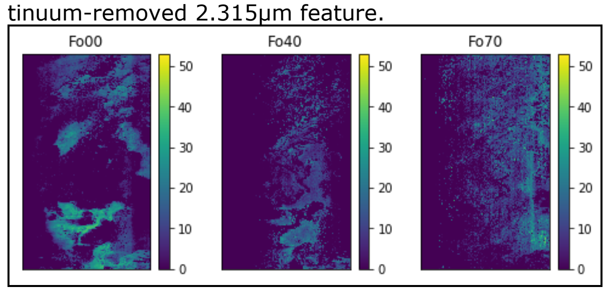

Figure 4. Breakdown of olivine minerals from baseline model by Fo#.

Olivine unmixing results. Olivine abundance reaches up to 58%, and the average across the scene is 14.7%. The baseline model used 4 different Fo#s of olivine: 0, 40, 70, and 100. Results for Fo0, 40, and 70 are in Figure 4. High-Fo00 regions have the highest average abundances. The modeled Fo# fits with results from [5]. Fo# sensitivity for the model has not yet been fully tested.

Removing Endmembers: The second two models were run to understand how modeled mineral abundances changed when olivine and carbonate were removed from the endmember library (Figure 5). For both mineral groups, the maximum abundance value did not change; however, the average abundance value across the scene did change. The carbonate average more than doubled when olivine was removed and the olivine averaged increased by 3% when carbonate was removed. Comparing Figure 1 and 5, there was an exchange of abundance when the opposite group was removed. For example, the largest olivine deposits in Figure 1 have now become large carbonate deposits in Figure 5.

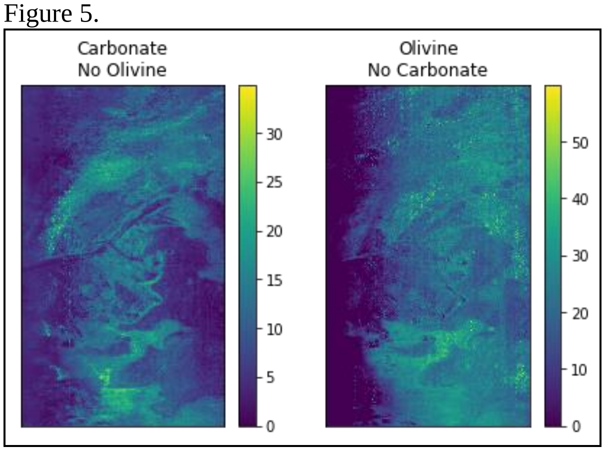

Figure 5. Carbonate and olivine abundances in models with the opposite group removed.

In addition to changes in the carbonate and olivine groups, the other minerals were impacted by the removals. Full group changes are shown in Figure 6.

The feldspar minerals were particularly impacted by the removal of olivine. Average pyroxene abundances jumped by about the same amount as the carbonate abundances did. Dust was the only "mineral" that had a drop in abundance when both olivine and carbonate were removed. Approximately twice as much dust was lost when olivine was removed as when carbonate was removed. The only mineral group that remained constant when the endmembers changed were the sulfates (both opal and oxide abundances were nearly zero for all three models).

We have also run models removing one mineral at a time: siderite, serpentine, and both. Magnesite distribution (Figure 7) is most affected by these changes.

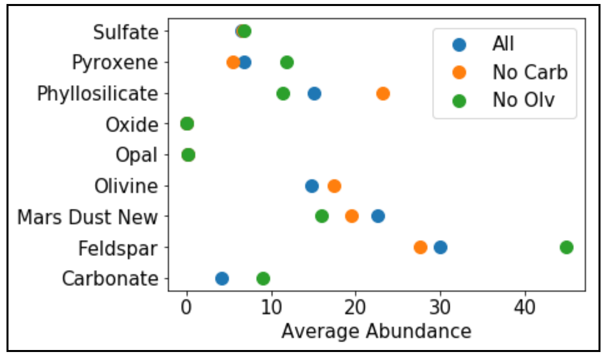

Figure 6. Changes in all mineral groups when carbonate and olivine were removed from the model.

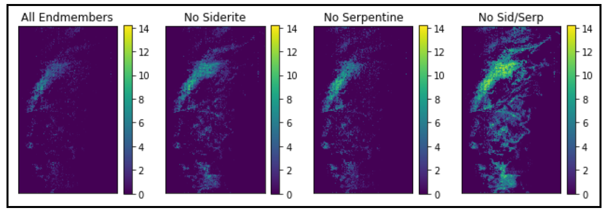

Figure 7. Magnesite distribution and abundance.

Error analysis. The root mean square errors for the baseline models fall between 0.005 and 0.025. Small changes occur between models. In the no carbonate model, the RMS goes up where the magnesite deposits occur in the baseline model. In the no olivine model, the RMS goes up predominately where the Fo00 deposits occur in the baseline model. For the magnesite in particular, this would suggest that although the magnesite abundances in the baseline model are significantly smaller than the siderite abundances, they are, in fact, real. The spectral fits degrade greatly when magnesite is omitted.

Discussion and Further Work: Our model results differ in at least one way from traditional index maps [6]. In the OLINDEX3 map for this image, the high-carbonate areas are also high-olivine areas, but in our model the high-carbonate areas contain no olivine. Our unmixing model appears to be picking out distinctions that index maps alone cannot make.

The spectral interplay between olivine, magnesite, siderite, and serpentine is fascinating and not yet fully understood. We are pursuing laboratory work, including the derivation of carbonate optical constants, to better distinguish these minerals in our model.

In all, our model can provide a more thorough look into the distribution and concentration of notable minerals and improve our understanding of spectral data.

References: [1] Liu Y. et al. (2016) *JGR*, *121*, 2004-2036. [2] Mustard J. F. and Pieters C. M. (1987) *JGR*, *92*, E617-E626. [3] Rogers A. D. and Aharonson O. (2008) *JGR*, *113*, E06S14. [4] Scudder N. A. et al. (2015) *LPS XLV*, Abstract #2977. [5] Brown A. J. et al. (2018) *LPS XLIX*, Abstract #1761. [6] Viviano-Beck C. E. (2014) *JGR*, *119*, 1403-1431.