IDENTIFICATION OF CARBONATE DEPOSITS IN HUYGENS BASIN, MARS, USING FACTOR ANALYSIS AND TARGET TRANSFORMATION TECHNIQUES. A. M. Zastrow[1] and T. D. Glotch[1], [1]Department of Geosciences, Stony Brook University (allison.zastrow@stonybrook.edu).

Introduction: Carbonates have been identified in multiple regions on Mars using visible/near-infrared data collected by the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) [1]. In this work, we focus on carbonate deposits identified in Huygens basin by [2] as an assessment of the factor analysis and target transformation (FATT) method for robustness in identifying carbonates, which may appear in small abundances across a scene.

Methods: We analyze data collected by CRISM's IR detector from 1.0 to 3.9 μm due to the presence of multiple diagnostic carbonate features in this wavelength region. Due to excessive noise in the data around ~2.7 μm, the region has been split into two sections: 1.050 to 2.625 μm and 3.150 to 3.900 μm. Diagnostic carbonate absorptions appear at ~2.3 and 2.5 μm, between ~3.3 and 3.5 μm and at ~3.9 μm.

CRISM data are atmospherically corrected using DISORT [3] to remove the effects of dust, ice, and other aerosols in the martian atmosphere according to the methods of [4]. The atmospheric correction results in a data cube of surface single scattering albedos (SSAs) for each scene, and can be converted to reflectance values using Hapke's bidirectional reflectance function [5] for comparison to laboratory reflectance spectra.

In this initial work, three CRISM images in the Huygens basin identified as definite (FRT0B5AF and FRT0A0A0) and possible (FRT0BA91) detections of carbonates [2] have been atmospherically corrected and used in the FATT analysis. FRT0B5AF covers the central peak of an unnamed crater in the northeast corner of the basin. FRT0A0A0 is just to the southwest of that crater rim. FRT0BA91 is on the western side of the basin.

Factor analysis. Factor analysis is a statistical approach that determines the most significant endmembers of a given set of linearly-adding data. The technique has been used successfully with thermal infrared data [6] and visible/near-infrared data [7]. The result of factor analysis is a set of abstract eigenvectors, each of which has an associated eigenvalue that indicates its importance to the given data set. Higher order eigenvectors (typically those past approximately the 10^{th} eigenvector [e.g. 7]) are often random noise and are discarded in the next steps. Due to the computing required for factor analysis, only every fifth pixel in every fifth column is analyzed. Subsets of a full scene can be analyzed in full if more detail is deemed necessary.

Target transformation. Once the number of significant eigenvectors in a scene has been determined, the eigenvectors undergo target transformation to compare them to a test library of laboratory spectra. Eigenvectors are transformed using a least squares fit to the spectra in the library. If a test spectrum is well-fit by the modeled data, then it is likely to be an endmember of the scene. If a test spectrum is not well-fit by the modeled data, then it is most likely not present.

The spectral library used in the target transformation has the spectra of 22 minerals, including the carbonates calcite ($CaCO_3$), magnesite ($MgCO_3$), siderite ($FeCO_3$), and ankerite ($Ca/FeCO_3$).

First Results: *Spectral library target transformation.* In our initial work, we modeled CRISM spectra from 1.050 to 2.625 μm. Using the typical 10 eigenvectors to model each scene, none of the carbonates in the spectral library were good fits. In scenes FRT0B5AF and FRT0A0A0, the 2.3 μm absorption of siderite was well-modeled, but the 2.5 μm absorption was not. Using 20 eigenvectors, siderite became well-modeled for scene FRT0A0A0, while calcite and magnesite remained poor fits (Figure 1). This indicates that there may in fact be significant spectral information at the higher eigenvectors for this scene. Overall, for the three scenes examined here, spectral fits for both carbonates and other minerals in the spectral library improved when 20 eigenvectors were used to model the library.

Analysis of the 3-4 μm range. Due to the interplay between surface reflectance and thermal emission, the 3-4 μm range in general has not been heavily studied. Good fits for the siderite and ankerite spectra with 20 eigenvectors from 3.150 to 3.900 μm for CRISM scene FRT0A0A0 (Figure 2) match the analysis from the shorter wavelength region. This is an encouraging result that indicates that the FATT techniques might be used in this wavelength range for positive carbonate identification.

Next Steps: In addition to being used to model a spectral library of potential endmembers, the factor analysis-derived eigenvectors can be used to model the original CRISM scene. The best number of eigenvectors used in the model will both recreate the original scene and also limit the amount of noise in the scene. This increases the signal to noise ratio of spectral ratios and spectral indices.

Modeling of scenes using physical endmembers. Once the number of significant eigenvectors and

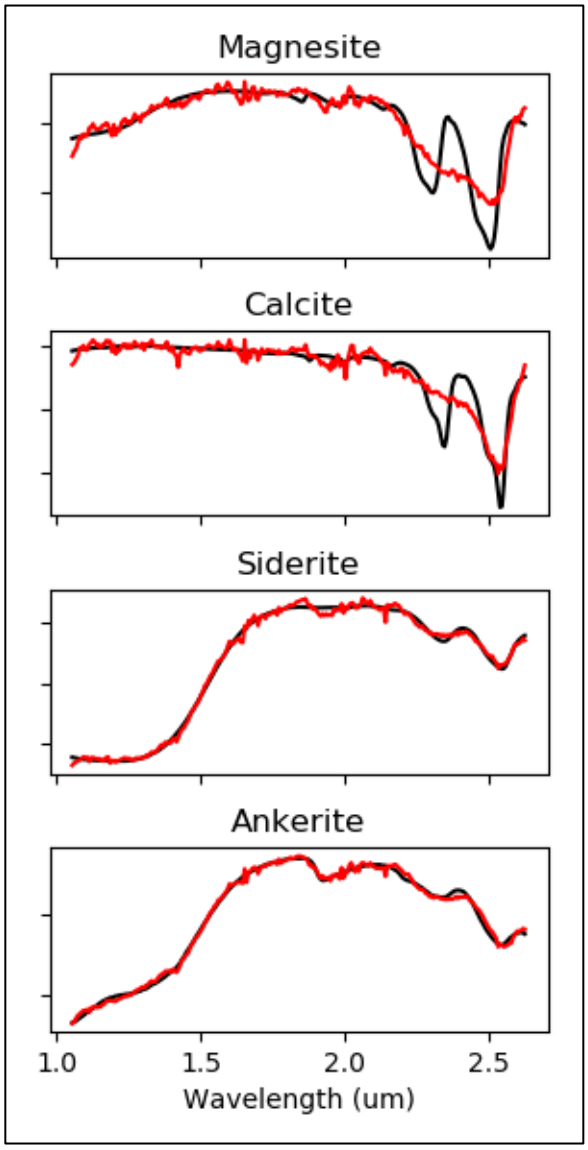

Figure 1. Results from 1.050 to 2.625 µm for FRT0A0A0. Laboratory carbonate spectra (black) versus 20 eigenvector-modeled spectra (red).

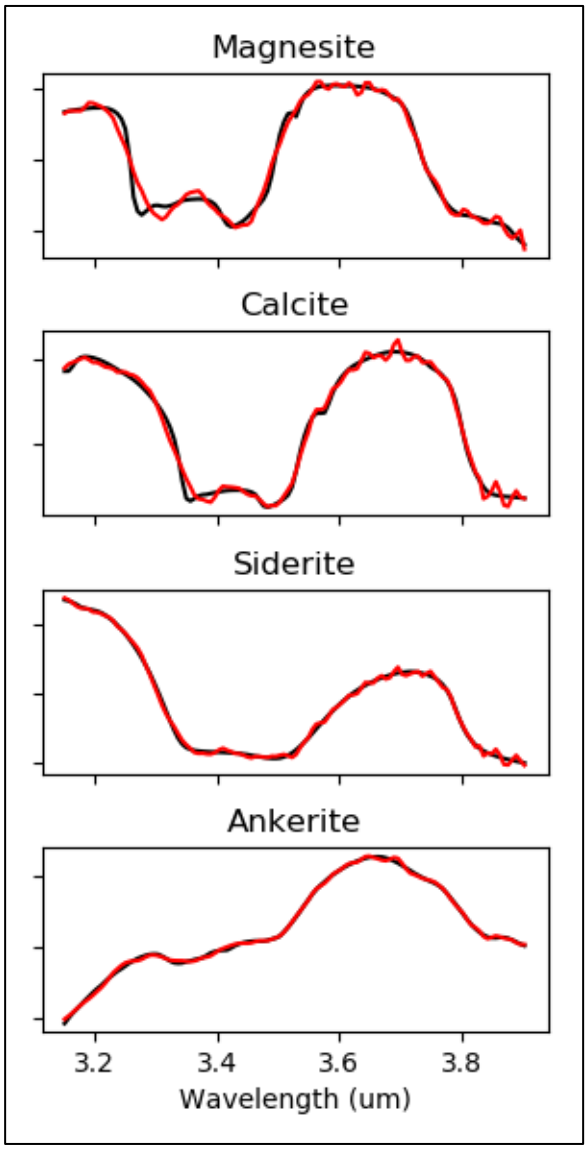

Figure 2. Results from 3.150 to 3.900 µm for FRT0A0A0. Laboratory carbonate spectra (black) versus 20 eigenvector-modeled spectra (red).

members of the spectral library match, the original scene can be modeled using the derived physical endmembers. This results in the retrieval of quantitative abundances for each of the endmembers for each scene (e.g. [4]).

Analysis of CRISM scene subsets. In our initial work, factor analysis was performed on every fifth pixel of every fifth column in each scene. This means that we are attempting to recreate an entire scene's worth of data using only a portion of the actual data. For minerals that may only appear in a few pixels per scene, the factor analysis method may miss them entirely. Analysis of smaller subsets of the CRISM data where every pixel can be taken into account will provide a more accurate quantitative representation of that area.

References: [1] Ehlmann B. L. and Edwards C. S. (2014) *Annu. Rev. Earth Planet. Sci*, *42*, 291-315. [2] Wray J. J. et al. (2016) *JGR*, *121*, 652-677. [3] Stamnes K. et al. (1988), *Appl. Opt.*, *27*, 2502-2509. [4] Liu Y. et al. (2016), *JGR*, *121*, 2004-2036. [5] Hapke B. (2012), pp.530. [6] Bandfield J. L. et al. (2000), *JGR*, *105*, 9573-9587. [7] Thomas N. H. and Bandfield J. L. (2017), *Icarus*, *291*, 124-135.