DIVERSE PHYLLOSILICATE AND SULFATE ASSEMBLAGES IN THE MAWRTH VALLIS CHANNEL.
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Abstract: Several new assemblages of phyllosilicates and sulfates were discovered in the channel cutting through the Mawrth Vallis region using improved algorithms for processing CRISM images. Fe/Mg-smectite is the most abundant component in the channel, similar to the entire Mawrth Vallis region. These new methods are enabling characterization of smaller deposits and weaker spectral signatures. Numerous outcrops containing alunite+halloysite, allophane, bassanite, gypsum+opal, jarosite, and polyhydrated sulfates (PHS) are observed at the tens of meters scale (or larger), often in between the transition from Fe/Mg-smectite to Al-rich phyllosilicates. The hydrated sulfates may have formed as evaporites in the channel or by brine percolating through the horizons, whereas the alunite and jarosite likely formed in acidic waters. Alunite occurs commonly together with halloysite and gypsum with opal or hydrated silica.

Methods: *Image Processing.* CRISM images were processed using the SUBCONV algorithm for simultaneous atmospheric correction and denoising of CRISM images in the 1.0-2.6 µm spectral range [1]. This removed most of the residual atmospheric bands and spurious noise, enabling a clearer view of the surface. Additionally, we applied a new mapping algorithm that employs Generative Adversarial Networks (GANs) to learn the diagnostic spectral features needed for discriminating among spectral types using hyperspectral components in the feature extraction [2]. This technique extends the CRISM mineral parameters developed using a spectral band, ratio, or slope [3] and is highly effective in identifying promising locations in the images that contain specific compositional units through the use of machine learning algorithms.

CRISM Analyses. CRISM images HRS0000307A, FRT00003BFB, FRT00009326, FRT0000C872, FRT00013E29, and FRT00012E72 were investigated for this study. Using the mineral maps (**Fig. 1**) as a guide, we collected spectra from 5x5 (or sometimes 3x3) pixel regions using ENVI. Spectra were often averaged from 2-4 outcrops to decrease the noise, but spectral ratios were not used for this study.

Results: CRISM images of the Mawrth Vallis channel typically display blotchy surfaces (**Fig. 1A**) that differ from most of the region. We mapped these images with Fe/Mg-smectite in red, Al-phyllosilicates

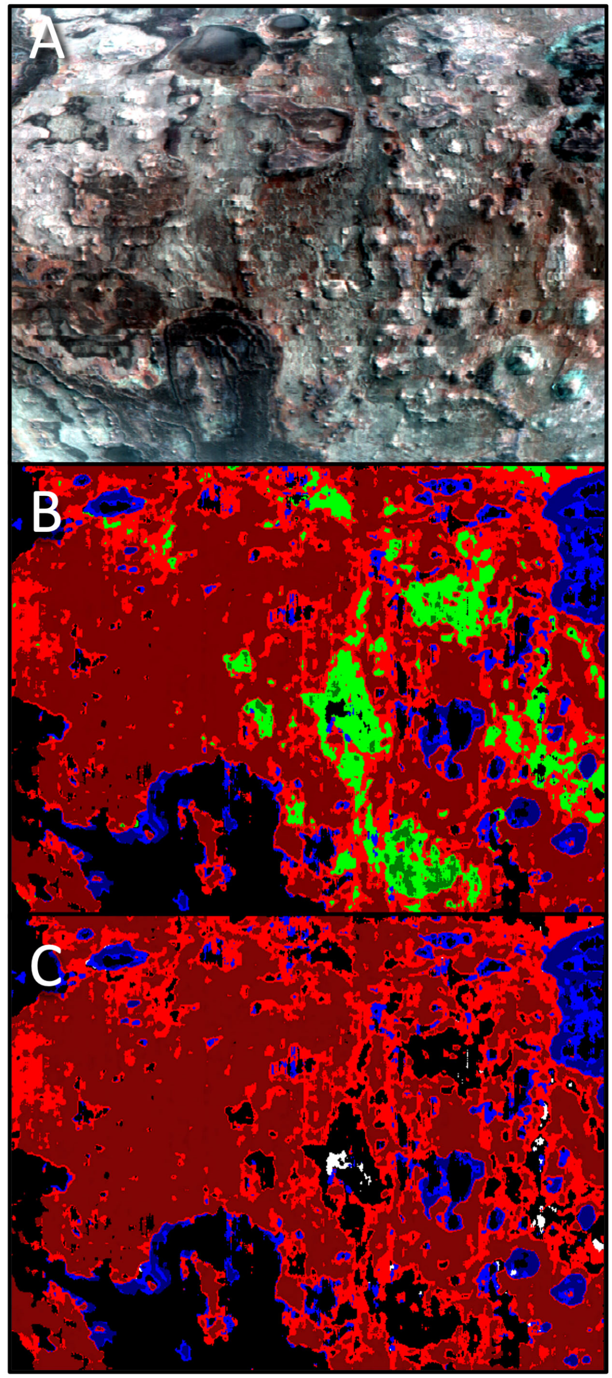

Fig. 1. *A) Portion of CRISM image FRT00013E29. B) mineral map with Fe/Mg-smectite in red, PHS in green, and Al-phyllosilicates in green. C) Same red and blue as B, but with bassanite in white.*

in blue and several different options in green to look for variations in the mineralogy (**Fig. 1B-C**). Most images included PHS and many also contained very small patches of gypsum or bassanite. The new mapping algorithm also provides spectral types for each image that were compared with spectra acquired by hand in the images (**Figs. 2-3**).

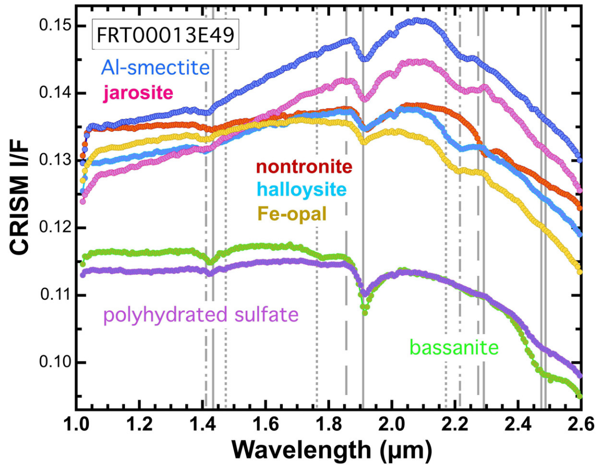

Fig. 2. *CRISM spectra of selected outcrops in image FRT00013E49. Lines mark the key spectral features for minerals as in Fig. 4.*

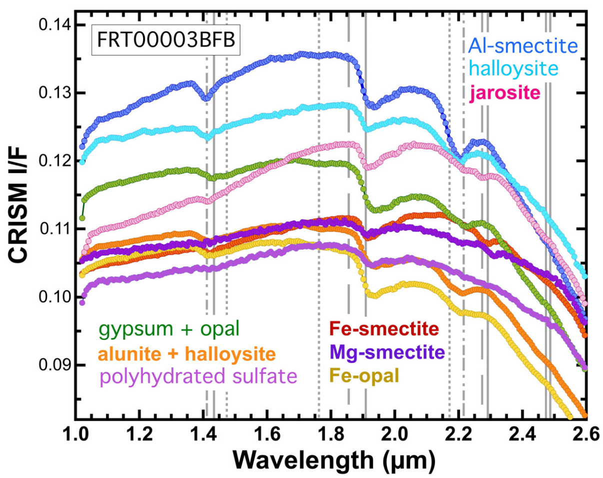

Fig. 3. *CRISM spectra of selected outcrops in image FRT00003BFB. Lines mark the key spectral features for minerals as in Fig. 4.*

Implications: Sulfates generally occur in small outcrops with variable size and chemistry at Mawrth Vallis on Mars, sandwiched in between expansive clay-bearing regions of Al-rich phyllosilicates above Fe/Mg-smectite [4]. Sulfates are more prevalent in the channel at Mawrth Vallis and a wider variety of assemblages containing phyllosilicates and sulfates is also present. Multiple tiny outcrops of sulfate-bearing assemblages containing alunite, jarosite, bassanite, gypsum, and Mg- or Fe-polyhydrated sulfates appear to have formed during an evaporative period

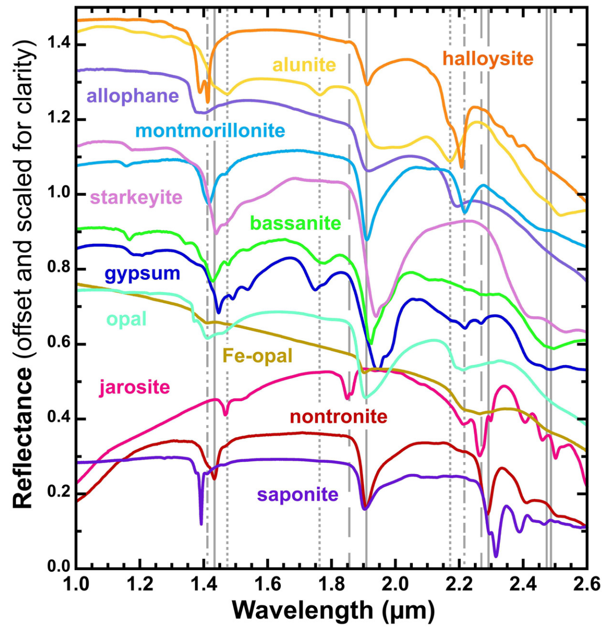

Fig. 4. *Lab reflectance spectra of minerals occurring in the CRISM scenes. Solid lines mark the key spectral features for nontronite, dotted lines for alunite, broken lines for halloysite, dashed lines for jarosite, and a double line for hydrated sulfates.*

dominated by variable microclimates as these minerals generally require distinct formation environments, whereas the clay-rich materials likely formed during longer term regional aqueous events to produce the wide and thick outcrops. Brine experiments have found that sulfate brines lead to gypsum precipitation whenever Ca is present [5], supporting gypsum and bassanite in this region. Gypsum has even formed through alteration of jarosite in Ca-rich brines [5].

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