Characterization of Jarosite-Bearing Outcrops at Mawrth Vallis. J. M. Danielsen[1,2], J. L. Bishop[2], [1]San Jose State University (San Jose, CA; jacob.danielsen@sjsu.edu), [2]SETI Institute (Mountain View, CA).

Introduction: Compact reconnaissance imaging spectrometer for Mars (CRISM) images are analyzed and characterized for various materials including sulfates and smectites in the Mawrth Vallis region on Mars (Figure 1). Recent new MTRDR processing of two CRISM images, FRT00003BFB and FRT0000-A425, allows for a better understanding of the materials on the Martian surface [1]. Using spectral analysis of visible-near infrared data, we found the presence of smectites (nontronite & montmorillonite) and jarosite. We used the improved calibration currently available of these images to gain a better understanding of the jarosite-bearing units and their relationship to the associated phyllosilicate-bearing rocks.

Methods: Multiple spectral parameters [2] were tested to visually aid in identifying and characterizing specific mineral groups in the CRISM images. The spectral parameters R (SINDEX2), G (BD2100_2), B (BD1900_2) and R (BD530_2), G (BD920_2), B (BD1000VIS) were most helpful for identification of jarosite in these images, while the parameters R (D2300, G (BD2190), B(BD2200) were used for detection of the Fe-rich smectite (nontronite) and Al-rich smectite (montmorillonite).

Spectra of areas of interest were collected using a spectra profile tool and a pixel average of either 3x3 or 5x5. To reduce the effects of atmospheric contributions and instrument effects, image FRT-00003BFB was ratioed to a spectrally neutral 20x20 spot. This technique produced a cleaner spectral profile for analysis. Image FRT0000A425 exhibits spectral features due to aqueous components across most of the image. Therefore, a good location for ratioing the image is not present, and the spectral profiles were taken without being ratioed.

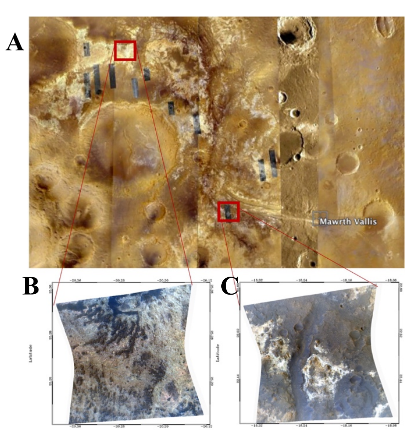

Figure 1. (**A**) showing map of Mawrth Vallis region on Mars and locations of CRISM images. (**B**) Crism image FRT00003BFB. (**C**) Crism image FRT0000A425

Results: Phyllosilicates have been found in abundance in the Mawrth Vallis region and are well documented [e.g. 3-5]. Sulfates have also been identified in isolated, small outcrops [e.g. 6-9]. We extended these analyses with the recently available, improved CRISM images to characterize in more detail the types of sulfates present and their relationships to the phyllosilicate-bearing rocks.

FRT00003BFB: The spectrum of the phyllosilicate nontronite contains bands at 1.42, 1.91, and 2.29 – 2.30 µm [10]. Our nontronite data contain a weak band at 1.42 µm and strong bands near 1.9 µm and at 2.29 µm (blue spectrum in Figure 2). The sulfate mineral jarosite [$KFe^{3+}{}_3(SO_4)_2(OH)_6$] contains bands at 1.47, 1.86, and 2.26 µm [11-12] that we used for identification of this mineral (Figure 2). It is also notable that jarosite spectra do not contain the water band near 1.9 µm that is found in smectite clays and other hydrated materials. While the 1.47 band is difficult to resolve in our data (red spectrum in Figure 2), the 1.86 and 2.26 µm bands were identified. Further, regions having these two characteristic jarosite bands, exhibited weaker water bands near 1.9 µm, strengthening the detection of this mineral.

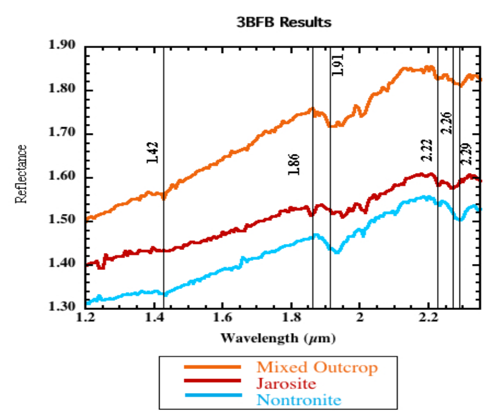

Figure 2. Spectra of the mixed "doublet" material (orange), jarosite (red) and nontronite(blue) in FRT00003BFB

The orange spectrum (Figure 2) contains bands at 1.42, 1.91, 2.22, 2.26, and 2.29 µm. This is characteristic of the "doublet" material identified recently [9] that is likely a mixture of hydrous clays and sulfates, or may be an acidic alteration product of the nontronite. Montmorillonite and opal have spectral bands at 1.91 and 2.21 µm and could be mixed with alterated nontronite or jarosite. Locations of outcrops are shown in figure 3.

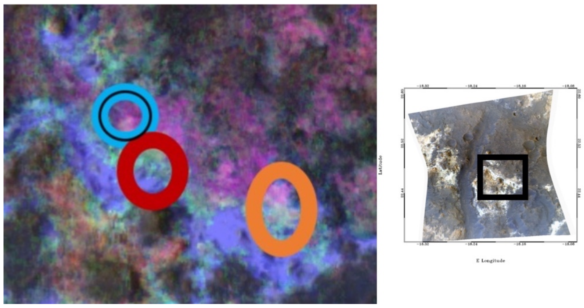

Figure 3. FRT00003BFB with focus location (black box). Overlay of R(BD2300), G(BD2210), B(BD1900). Blue circle showing location of nontronite, red circle showing location of jarosite, and orange circle location of the mixed outcrop.

FRT0000A425: Smectites including nontronite and montmorillonite are observed in this image (Figure 4). Montmorillonite contains a water band at 1.92 and at 2.22 µm. Jarosite was previously identified in this image by the spectral band at 2.26 µm, but the accompanying jarosite band at 1.86 µm that is more diagnostic was not observed [6]. Our spectral analysis confirms the presence of jarosite with both bands at 1.86 and 2.26 µm, but only in three small knobs within the area previously discovered (Figure 6).

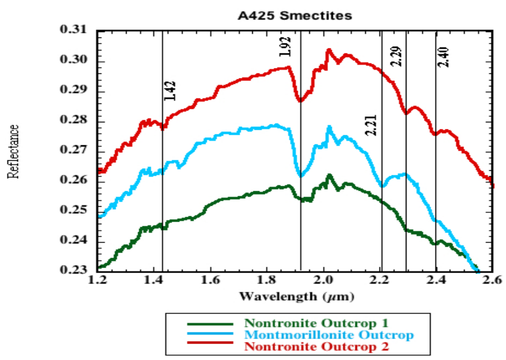

Figure 4. Spectra showing spectra of smectites including nontronite and montmorillonite in FRT0000A425.

A previously undiscovered area of jarosite was also found (Figure 5). The spectra from these areas contain bands near 1.48, 1.86, and 2.26 µm, all consistent with jarosite. The band at 1.86 µm is very characteristic of jarosite, albeit weak. Locations of outcrops are presented in figure 6.

Summary: Spectral analysis using CRISM images allows for characterization of the Martian surface. Two CRISM images were analyzed in this study (FRT0003BFB and FRT0000A425) that were thought to have combinations of phyllosilicates and jarosite [7,9]. Using newly processed MTRDR imagery, we were able to refine the previous position of discovered jarosite, and find new outcrops of jarosite-bearing outcrops, and find new outcrops of jarosite in these images. Characterization of aqueous outcrops at Mawrth Vallis using CRISM imagery will allow us insight into the formation of this region. Jarosite outcrops were found above the Fe-rich smectite in the stratigraphy. The jarosite units we identified likely formed in situ, either in low pH water or in salty evaporate ponds.

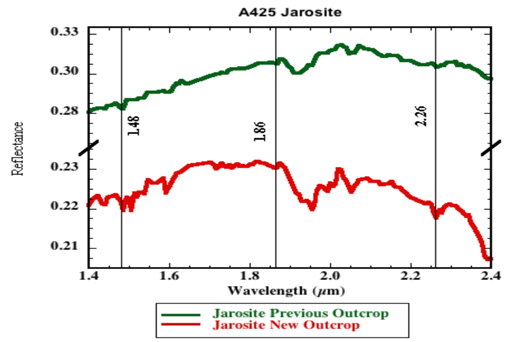

Figure 5. Spectra of jarosite in FRT0000A425. Green spectral line is jarosite previously discovered. Red spectral line is newly discovered jarosite.

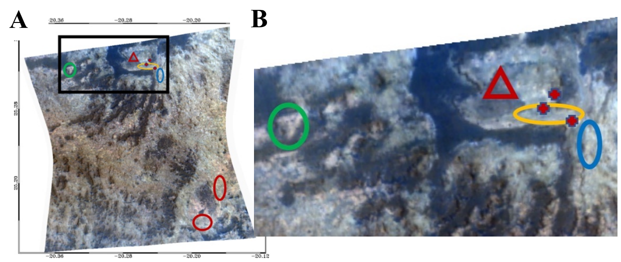

Figure 6. FRT0000A425 (**A**) with red circles near bottom corresponding with nontronite outcrop 2 (Figure 4). Black box inlay showing zoomed region (**B**). Yellow oval shows previously identified jarosite [6], while red dots show refined jarosite knobs. Red triangle shows location of newly identified jarosite. Blue circle is location of montmorillonite & green circle is location of nontronite outcrop 1 (figure 4).

References: [1] Seelos F. P. et al. (2016) *Lunar Planet. Sci. Conf. XLVII*, Abstract #1783. [2] Viviano-Beck C. E. et al. (2014) *JGR, 119,* 2014JE004627. . [3] Bishop J. L. et al. (2008) *Science, 321,* doi: 10.1126/science.1159699, pp. 830-833. [4] McKeown N. K. et al. (2009) *JGR, 114,* doi:10.1029/2008JE-003301. [5] Bishop J. L. et al. (2013) *PSS, 86,* 130-149. [6] Farrand W. H. et al. (2009) *Icarus, 204,* 478-488. [7] Wray J. J. et al. (2010) *Icarus, 209,* 416-421. [8] Farrand W. H. et al. (2014) *Icarus, 241,* 346-357. [9] Bishop J. L. et al. (2016) *LPSC. XLVII*, Abstract #1332.[10] Bishop J. L. et al. (2008) *Clay Miner., 43,* 35-54. [11] Bishop J. L., E. Murad (2005) *American Miner., 90,* 1100-1107. [12] Cloutis E. A. et al. (2006) *Icarus, 184,* 121-157.

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