CHARACTERIZATION OF JAROSITE-BEARING OUTCROPS NORTHWEST OF MAWRTH VALLIS.

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Introduction: Mawrth Vallis is a valley located on Mars between the northern lowlands and the southern highlands (Fig. 1A) that is known for thick (~200m) phyllosilicate stratigraphy with Al-rich phyllosilicates covering Fe/Mg-smectite [1]. Jarosite [$KFe^{3+}_3(SO_4)_2(OH)_6$] was also identified in a unique ovoid outcrop near the mouth of the channel [2]. Hyperspectral images acquired by the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) were analyzed to search for additional jarosite occurrences in this study. Jarosite absorptions occur at 1.46-1.47, 1.855, and 2.267 µm in visible/near-infrared (VNIR) spectra [3]. The 1.46 to 1.47 µm shift can be caused by differences between K- and Na-jarosite [4]. The 1.855 µm band also shifts to 1.86 µm in mixtures with smectites due to the strong water absorption at 1.91 µm. Absorptions consistent with nontronite are at 1.43, 1.91, and 2.29 µm [5]. Recent calibration advances are enabling resolution of weak features for smaller outcrops. A spectral study of several jarosite-bearing rocks and jarosite/nontronite mixtures provided insights on detection of jarosite-bearing units [6].

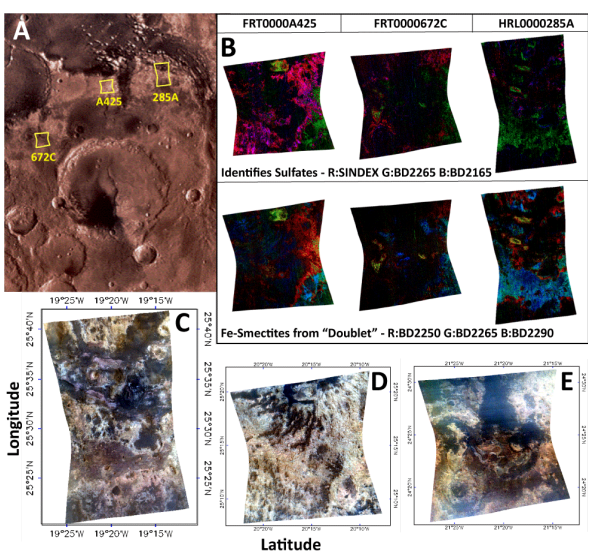

Figure 1. (A) *Mawrth Vallis region map showing locations of CRISM images.* ***(B)*** *Parameter views of these images highlighting potential jarosite outcrops.* ***(C)*** *HRL0000285A.* ***(D)*** *FRT0000A425.* ***(E)*** *FRT0000672C.*

Methods: MTRDR [7] and TRR3-IP (Itoh-Parente) [8] images were prepared for this project. VNIR spectra collected by CRISM were used to identify new jarosite deposits. Parameter maps [9] were created for several MTRDR images to screen the mineralogical units present and search for potential jarosite. Two different band depth parameter maps were the most useful for identifying jarosite: one that differentiates among sulfates, and one that differentiates Fe-bearing smectites from "doublet" [10-11] materials (Fig. 1B). In both parameter maps, areas highlighted in green or yellow-green were indicative of sites with potential jarosite. Three images with potential jarosite (FRT0000A425, FRT0000672C, HRL0000285A) were processed using an atmospheric separation and denoising model on the TRR3 image versions to enhance spectral signatures from the surface [8]. Regions of interest (ROIs) were created for each outcrop with spectra similar to jarosite using band depth thresholds at 2.265 µm. The resulting pixels encompassed in each ROI were then averaged together to produce one spectrum. Spectra were collected for a 5x5 pixel region within each outcrop.

Results: Analysis of CRISM spectra collected from these images revealed multiple small outcrops of jarosite occurring in mixtures with phyllosilicates across the region to the west of the channel and north of Oyama Crater in Mawrth Vallis.

FRT0000A425. The jarosite region of interest in this image occurs in an ovoid depression in the north.

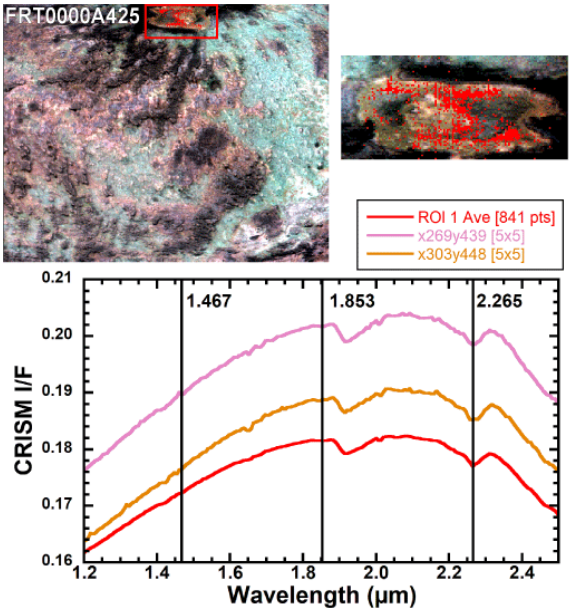

Figure 2. *Locations of ROIs in image FRT0000A425. Jarosite ROI outcrop spectra and 5x5 pixel spectra. Vertical lines indicate jarosite absorptions.*

Regions identifying jarosite in this image had resolvable absorptions for all three bands in the 5x5 pixel spectra. However, both the 1.46-1.47 and 1.86 µm bands appeared as shoulders in the ROI average spectra and were more difficult to resolve (Fig. 2). Spectra collected from phyllosilicates surrounding the jarosite outcrop are consistent with nontronite.

FRT0000672C. Three small jarosite outcrops were identified in this image. Two of these outcrops occurred in small depressions and the largest outcrop (ROI 1) occurred entirely on a slope. This is less consistent with typical sulfate forming geomorphology and may be due to uplift from impact cratering. Nontronite in the area was identifiable near the jarosite outcrops. Spectra from ROI 2 resolved the characteristic jarosite absorptions best of the 3 ROIs studied - particularly the 1.855µm band. All the ROIs possessed resolvable bands at 1.46-1.47 and 2.267 µm (Fig. 3).

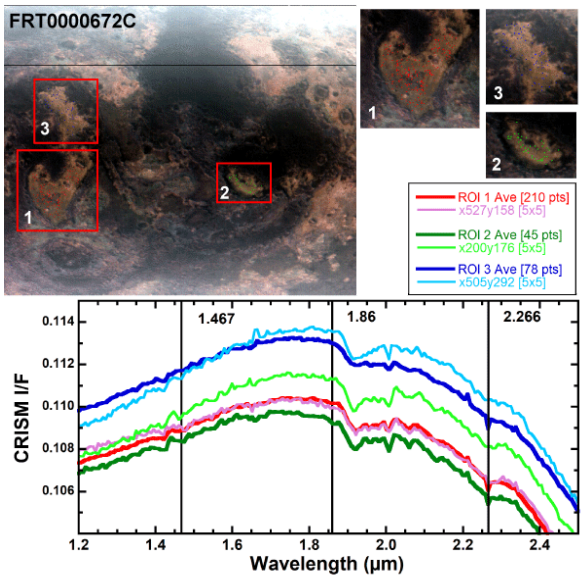

Figure 3. *Locations of all ROIs for FRT0000672C. Spectra of the jarosite ROIs and 5x5 pixel areas (reds, blues, greens). Colors of the ROI spectra correspond to the ROI colors indicated on map. Vertical lines indicate jarosite absorptions.*

HRL0000285A. An additional three small jarosite outcrops were identified in this image. The topography of the area encompassing the outcrops was slightly knobby with the outcrops occurring half on slopes and half in depressions. The 2.265 µm band was well resolved in all three ROIs; however, the 1.855 µm band was best resolved in 5x5 pixel spectra rather than averaged ROIs. The 1.46-1.47 µm band was only resolved as shoulders across all spectra (Fig. 4).

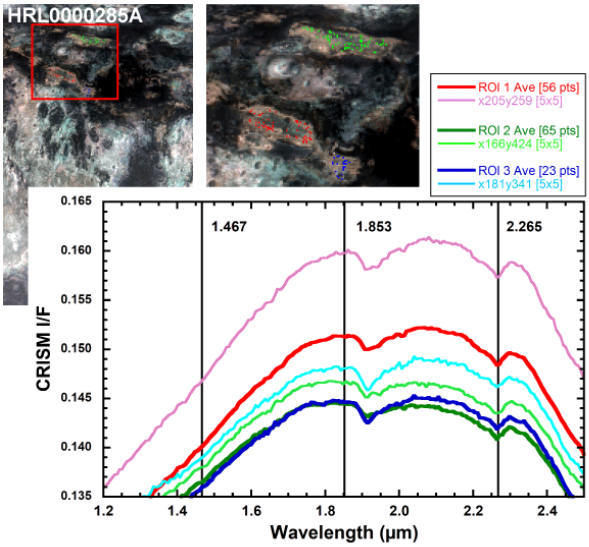

Figure 4. *Locations of ROIs in image HRL0000285A. Jarosite ROI spectra and 5x5 pixel area spectra (reds, blues, greens). Colors of the ROI spectra correspond to the ROI colors on the map. Vertical lines indicate jarosite absorptions.*

Implications: Identifying multiple small jarosite outcrops to the west of the Mawrth Vallis channel may be indicative of more abundant jarosite throughout the region than previously hypothesized. Jarosite requires acidic conditions to form and its presence indicates a change in the geochemical environment from the neutral or mildly acidic conditions thought to have governed formation of the phyllosilicates. Future work would involve characterizing the morphology and stratigraphic location of these jarosite occurrences and identifying more jarosite outcrops throughout the region to constrain the geochemical history.

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