NON-LINEAR UNMIXING OF CRISM SPECTRA OVER THE MAWRTH VALLIS REGION: IMPLICATIONS FOR LEVEL OF ALTERATION. W. H. Farrand[1], T. D.Glotch[2], J.W. Rice[3], J.A. Hurowitz[4], [1]Space Science Institute, 4750 Walnut St. #205, Boulder, CO 80301, farrand@spacescience.org, [2]Stony Brook University, Stony Brook, NY, [3]NASA Goddard Space Flight Center, Greenbelt, MD, [4]Jet Propulsion Laboratory, Pasadena, CA.

Introduction: Since it was recognized as an area with extensive exposures of ancient phyllosilicate-bearing layered rocks [1], the Mawrth Vallis region has been a focus of intense scrutiny. The region is also among four remaining areas as a landing site for the Mars Science Laboratory rover Curiosity. Studies of OMEGA data indicated the presence of both Fe/Mg smectite and Al-phyllosilicate minerals in the Mawrth Vallis region [2-3]. Recent studies utilizing CRISM spectral data have identified a number of new minerals including, intriguingly, jarosite and bassanite [4-5]. Some work has been done with OMEGA data to determine approximate fractions of the phases present in the various lithostratigraphic units at Mawrth Vallis [6]. Here we present results of non-linear unmixing of average unit spectra from CRISM FRT and HRL scenes in the Mawrth Vallis region and discuss the implications of these results.

Data and Data Reduction: We worked with CRISM exoatmospheric I/F FRT and HRL data from the PDS. The "volcano scan" atmospheric correction [7] in the CAT toolbox [8] was used to correct the data to approximate surface I/F. The CIRRUS denoising approach in CAT was also applied to the data. Average spectra from spectrally featureless areas in each scene were extracted and divided into the volcano-scan corrected data. While generally featureless, these denominator spectra have a curved slope. To eliminate the spurious slope introduced by dividing this into every pixel, a smooth sloping hull was fit over each denominator spectrum and this was multiplied back into the ratioed dataset.

Nonlinear Unmixing Methodology: The scattering model developed by Shkuratov et al. [9] has been used by others to derive approximate fractions from near-infrared (NIR) reflectance spectra [e.g., 6, 10-11]. Our implementation follows that outlined by [10]. We use a relatively small number of expected endmembers and several candidate spectra from existing spectral libraries (often with differing grain sizes) are iteratively tried for each endmember. The best fit is selected on the basis of lowest root mean square error between the measured and modeled spectrum.

For the application to the CRISM data, spectral averages of 20 to 30 pixels were used. The endmember set used for the Fe/Mg smectite unit consisted of a "ferrous mica" material [3] to account for the positive NIR slope. Mineral spectra used for this endmember were chamosite, cronstedtite, glauconite, and clinochlore. Several nominal nontronites from the CRISM spectral library were used for the Fe/Mg smectite endmember. Several plagioclases and augites were used for the respective plagioclase and high-Ca pyroxene endmembers. For some CRISM Fe/Mg smectite unit spectra adequate fits were achieved with these 4 endmembers. We also tried two variants of a 5 endmember model using respectively ferrihydrite or a sulfate or zeolite as the 5th endmember.

For the Al phyllosilicate unit spectra a 5 endmember model was used. The same minerals were used for the "ferrous mica" endmember, several spectra representing the kaolin family (kaolinite, halloysite, and dickite) were used for the second endmember, several montmorillonites and a beidellite spectrum were used for the third endmember. Several plagioclases were used for the fourth endmember. We found a paucity of hydrated silica spectra in available libraries and used siliceous sinter and opal spectra for the fifth endmember.

Results: **Fig. 1** shows representative examples of measured vs. modeled spectra for different Fe/Mg smectite areas and **Fig. 2** shows the same for different Al-phyllosilicate areas. **Tables 1** and **2** shows a subset of results of derived fractions from CRISM FRT and HRL scenes.

Discussion: The larger number of processed scenes support the results indicated by the fractions in **Tables 1** and **2**- namely that there are higher fractions of primary silicates (plagioclase and augite) in the Fe/Mg smectite unit than in the Al phyllosilicate unit. This is suggestive of a higher level of alteration in the latter relative to the former. The presence of kaolinite and silica in the Al phyllosilcate unite are also consistent with our interpretation of a higher degree of alteration for the aluminous endmember.

We are also working on detailing differences in the relative fractions of these endmember materials across the Mawrth Vallis region and between sub-units in the local stratigraphy. For example, in [12] the Fe/Mg smectite unit was divided into a broader unit with strong 2.29 and 1.9 μm absorption bands and isolated exposures of an older paleosurface where these bands are markedly weaker.

References: [1] Bibring, J.P. et al. (2005) *Science*, **307**, 1576-1581. [2] Loizeau, D. et al. (2007) *JGR*, **112**, 10.1029/2006JE002877. [3] Bishop, J.L. et al. (2008) *Science*, **321**, 830-833. [4] Farrand, W.H. et al. (2009) *Icarus*, **204**, 478-488. [5] Wray, J.J. et al. (2010) *Icarus*, **209**, 416-421. [6] Poulet, F. et al. (2008) *Astron. & Astrophys*., **487**, 41-44. [7] Langevin, Y. et al. (2005) *Science*, **307**, 1584-1586. [8] Murchie, S. et al. (2007) *JGR*, 112, doi:10.1029/2006JE002682. [9] Shkuratov, Y. et al. (1999) *Icarus*, **137**, 235-246. [10] Poulet, F. and Erard, S. (2004) *JGR*, **109**, doi:10.1029/2003JE002179. [11] Arvidson, R. et al., *JGR*, **111**, doi:10.1029/2006JE002728. [12] Loizeau, D. et al. (2010) *Icarus*, **205**, 396-418.

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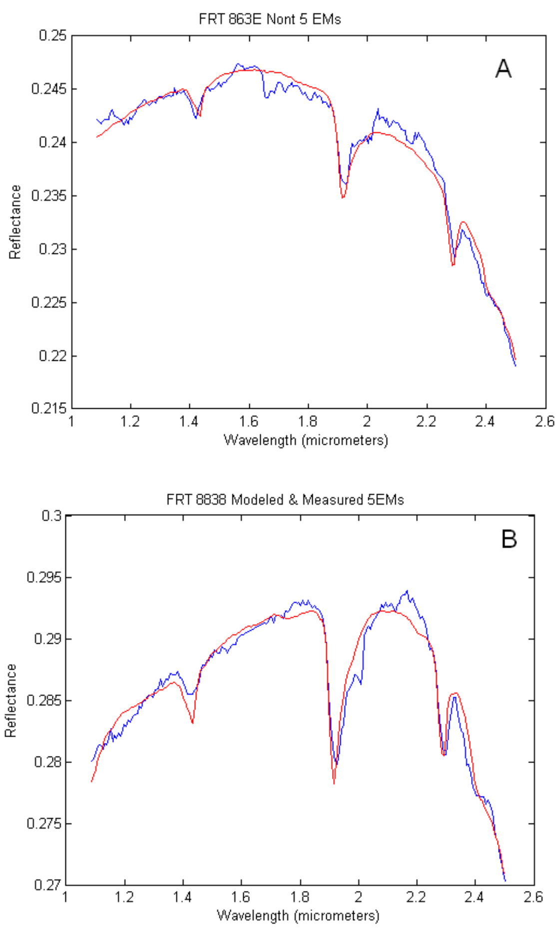

Fig. 1. A. Measured vs. modeled spectra of Fe/Mg smectite unit from FRT 863E with little 1 to 1.8 μm slope. **B**. Measured vs. modeled spectra of Fe/Mg smectite unit from FRT 8838 with moderate 1 to 1.8 μm slope.

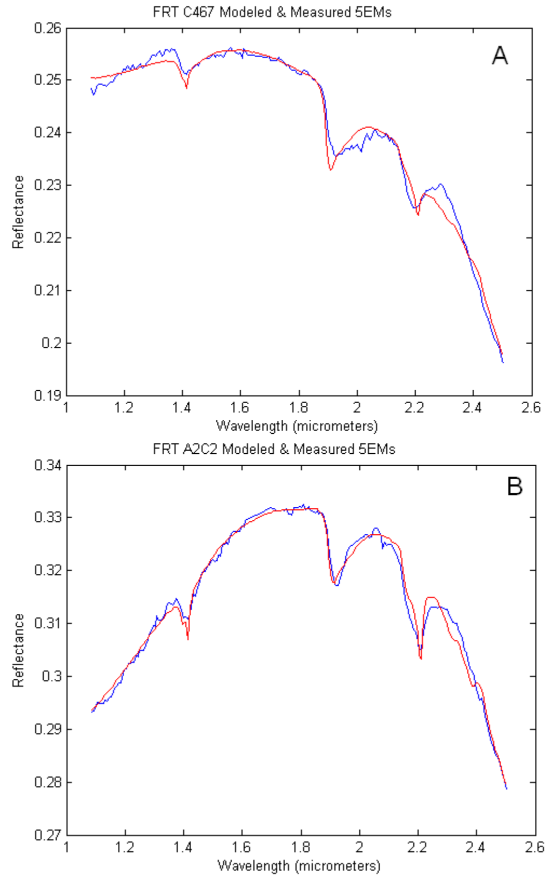

Fig. 2. A. Measured vs. modeled spectra of Al phyllosilicate unit from FRT C467 with little 1 to 1.8 μm slope. **B**. Measured vs. modeled spectra of Al phyllosilicate unit from FRT A2C2 with moderate 1 to 1.8 μm slope.

Table 1. Fractions of Fe/Mg Smectite Endmembers

FRT	Fe2M	Nont.	Plag.	Aug.	Zeo/Sul
863E	0.092	0.259	0.605	0.005	0.039
8838	0.077	0.321	0.496	0.060	0.046

Table 2. Fractions of Al Phyllosilicate Endmembers

FRT	Fe2M	Kaol.	Mont.	Plag.	Silica
C467	0.168	0.104	0.283	0.073	0.372
A2C2	0.226	0.182	0.421	0.046	0.125