DETECTION OF KAOLINITE AT MAWRTH VALLIS, MARS: ANALYSIS OF LABORATORY MIXTURES AND DEVELOPMENT OF REMOTE SENSING PARAMETERS. E. S. Amador[1], J. L. Bishop[2], N. K. McKeown[1,2], M. Parente[2,3], J. T. Clark[2], [1]University of California Santa Cruz (Earth and Planetary Sciences, 1156 High St., Santa Cruz, CA 95064, eamador@ucsc.edu), [2]SETI Institute/NASA-ARC (515 N. Whisman Rd., Mountain View, CA 94043), [3]Stanford University (Stanford, CA, 94305).

Introduction: Laboratory mixtures and spectral parameters were created to better characterize and detect kaolinite in the Mawrth Vallis region of Mars where Al-phyllosilicates, including kaolinite and montmorillonite, have been detected. We have prepared laboratory mixtures of the phyllosilicate minerals montmorillonite with kaolinite in seven intervals to better characterize spectra of Mars. Kaolinite and montmorillonite have been detected in hyperspectral visible/near-infrared (VNIR) Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) spectra of Mawrth Vallis [1] and continuing analyses of these spectra suggest that mixtures of kaolinite with montmorillonite and/or hydrated silica best replicate the spectra observed at Mawrth Vallis [2]. Spectra taken from the laboratory mixtures were used to gain information on detection limits for these phyllosilicate minerals in CRISM images. Laboratory spectra and CRISM spectra were used for development of an algorithm that detects kaolinite in CRISM images.

Methods: The kaolinte (KGa-1b JB766) from Washington County, GA, and montmorillonite (SWy-2 JB784) from Crook County, WY, were dry sieved to <125 μm. The samples were mixed from pure montmorillonite to pure kaolinite at intervals of 15, 25, 30, 40, 50, 60, 75 wt.% kaolinite. The mixtures were then sieved again at <125 μm to homogenize the samples. Spectra were then measured using an ASD handheld spectrometer.

Spectra from both the lab mixtures and Mawrth Vallis, Mars, were used to write an algorithm for detection of kaolinite in the CRISM images. Several CRISM images of Mawrth Vallis were examined and the purest kaolinite endmember pixels were identified and used as reference points for coding and testing the algorithm. Mineral detection parameters have been generated for use in analyzing CRISM images [3] and a parameter to measure band depth at 2.2 μm has been successful in detecting Al-phyllosilicates at Mawrth Vallis [1] and elsewhere on Mars [4]. Kaolinite spectra exhibit a characteristic doublet absorption feature with minima centered at 2.17 and 2.21 μm. Two separate parameters were written to describe and identify this feature in the images. One algorithm calculates the spectral slope of the maxima in between the doublet absorptions (slope from ~2.17-2.18 μm), while the other algorithm uses a spectral parameter to measure the band depth of the kaolinite absorption at 2.17 μm.

Results: Mixture spectra are shown in Figures 1-2, a CRISM spectrum from Mawrth Vallis dominated by kaolinite is shown in Figure 3, and a map of kaolinite-bearing regions in Mawrth Vallis image FRT848D is shown in Figure 4A,B.

Kaolinite-montmorillonite Mixtures. The laboratory mixtures show that the spectrum of pure kaolinite has a doublet at 2.17 and 2.21 μm, while the pure montmorillonite spectrum has only a single absorption at 2.21 μm. The mixture spectra show that with decreasing kaolinite abundance, the 2.17 μm feature becomes shallower, as expected. At 60 wt.% kaolinite the 2.17 μm absorption feature becomes a shoulder and at 15 wt.% kaolinite the feature is no longer detectable.

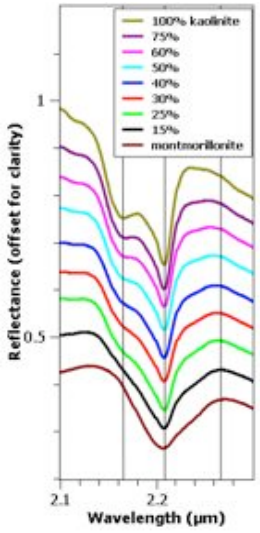

Fig.1 (left). Reflectance spectra from 2.1-2.3 μm of mixtures of kaolinite and montmorillonite. Vertical lines from left to right show the position of the 2.17 and 2.21 μm doublet and the maximum inflection point of pure montmorillonite longwards of 2.21 μm.

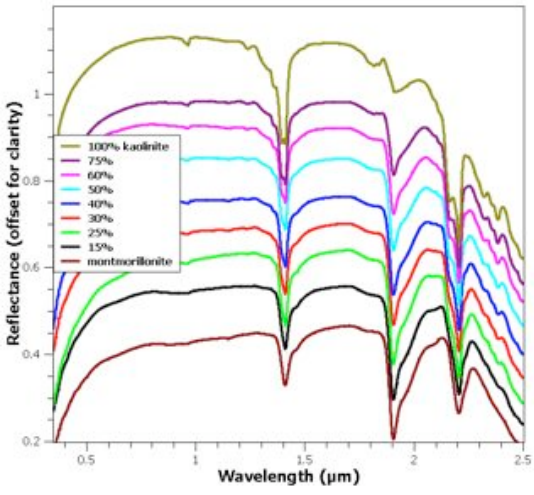

Fig. 2 (below). Reflectance spectra from .3-2.5 μm of pure kaolinite and pure montmorillonite as well as the 7 mixtures.

Kaolinite parameterization. Pure kaolinite pixels were found in several CRISM images of Mawrth Vallis, typically in very small units on the order of a few pixels or less. An algorithm is desirable for detection and characterization of these kaolinite-bearing outcrops as they are difficult to identify. The kaolinite spectrum shown in Figure 3 (taken from a 2X2 pixel spot) is an example of one of the better kaolinite spectra. Though this is still a work in progress, two parameter maps have been created using the two separate methods developed to date, which have produced similar results. Both techniques are successfully identifying kaolinite-bearing units in the bright terrain from CRISM image FRT848D (Fig4). The brighter patches of orange were detected using the band depth parameter, while the lavender areas were found using the spectral slope parameter. The bright purple/red areas were selected by both algorithms. Ongoing work involves refining these algorithms and generation of a third, combined parameter for detection of spectra with the highest kaolinite abundance.

Fig. 3 (left). Reflectance spectra from 2.05 to 2.4 μm of kaolinite pixel found in CRISM image FRTB141

Summary: In the CRISM images of Mawrth Vallis only a few pixels are spectrally dominated by kaolinite. A larger number of pixels appear to be a mixture of kaolinite with some other mineral, such as montmorillonite. Many pixels have a spectrum resembling the kaolinite - montmorillonite mixture spectra acquired here. Ongoing work will address setting detection limits and approximate abundances for the phyllosilicate components of these bright outcrops at Mawrth Vallis. Continuued progress on the kaolinite algorithm is expected to enable accurate mapping of this phyllosilicate on Mars.

Fig 4A (below) CRISM image of FRT848D mapped with R 0.7, G 0.6, B 0.5 μm

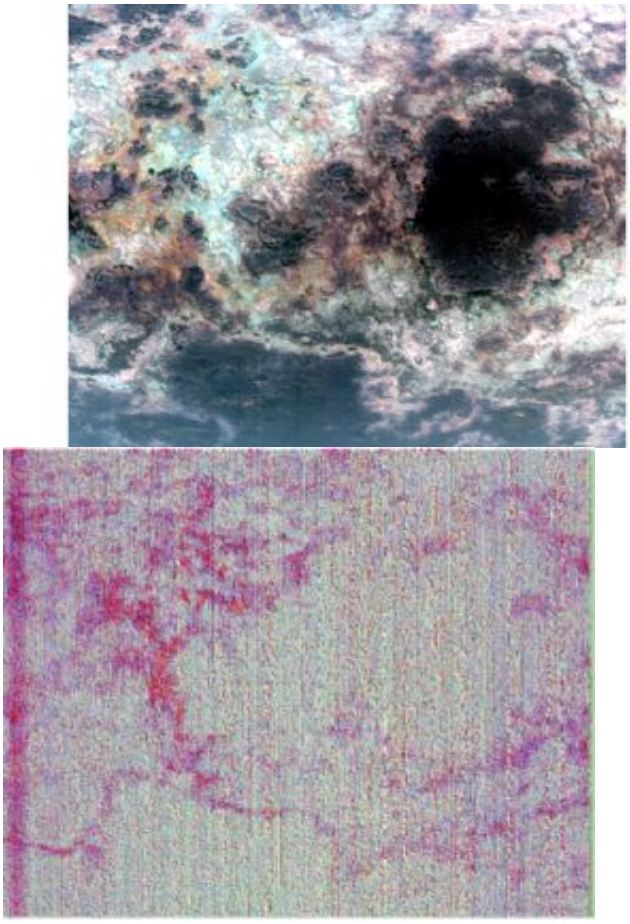

Fig. 4B (above). CRISM image FRT848D mapped with two kaolinite parameters overlain.

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References: [1] Bishop J. L. et al. (2008) *Science,* Phyllosilicate diversity and past aqueous activity revealed at Mawrth Vallis, Mars. *321,* DOI: 10.1126/science.1159699, pp. 830-833. [2] McKeown, N. K., et al. (2008) Martian Phyllosilicates: Recorders of Aqueous Processes, 7033. [3] Pelkey S. M. et al. (2007) *JGR,* CRISM multispectral summary products: Parameterizing mineral diversity on Mars from reflectance. *112,* doi:10.1029/2006JE002831. [4] Mustard J. F. et al. (2008) *Nature,* Hydrated silicate minerals on Mars observed by the Mars Reconnaissance Orbiter CRISM instrument. *454,* doi: 10.1038/nature07097, 305-309.