CLAY BEARING UNITS IN THE REGION AROUND MAWRTH VALLIS: STRATIGRAPHY, EXTENT, AND POSSIBLE ALTERATION FRONTS. E. Z. Noe Dobrea[1], J.L. Bishop[2], N.K. McKeown[3], G. Swayze[4], J.R. Michalski[5], F. Poulet[5], J.-P. Bibring[5], J.F. Mustard[6]; B.L. Ehlmann[6]; R. Arvidson[7], R.V. Morris[8], S. Murchie[9], A.S. McEwen[10], E. Malaret[11], C. Hash[11], and the CRISM Team. [1] Calif. Inst. Tech./JPL, 4800 Oak Grove Drv, Mail Stop 183-501, Pasadena-CA-91109 (eldar@caltech.edu); [2] SETI Institute/NASA-ARC, Mountain View, CA; [3] UCSC, Santa Cruz, CA; [4] USGS, Denver, CO; [5] IAS, Univ. of Paris, Orsay, France; MD, [6] Brown University, Providence, RI; [7] Washington University, Saint Louis, MO 63130; [8] NASA-JSC, Houston, TX; [9] APL, Laurel, MD [10] U. of Arizona, Tucson, AZ; [11] ACT, Inc. Herndon, VA 20170

Introduction: The largest exposure of phyllosilicates on Mars occurs on the highland plains around Mawrth Vallis. This exposure extends for about 300 km southward from the edge of the dichotomy boundary, covering an area greater than 200 x 300 km over an elevation range of ~2000 m [*e.g.* 1,2,3,4]. At least two different types of hydrated phyllosilicates (Fe/Mg-rich and Al-rich phyllosilicates) have been identified in OMEGA data based on absorption bands near 2.3 and 2.2 μm, respectively. These clay-bearing units are associated with layered, indurated light-toned units with complex spatial and stratigraphic relationships, and are unconfomably overlain by a darker, indurated, more heavily cratered unit [3]. Ongoing analysis of OMEGA (~1 km/pixel) and CRISM multi-spectral (MSP, 200 m/pixel) data reveal hydrated minerals with absorptions at ~2.2 or 2.3 μm in locations up to 300 km away from the borders of the previously identified extent of clay-bearing units [5]. We seek to: 1) further constrain the mineralogy of the hydrated species identified in [5], and 2) understand spatial and stratigraphic relationships between the different hydrated minerals and the cratered plains units in which they are found. In this work we perform mineralogical and stratigraphic comparisons between units to test whether these extended units may be related, in order to establish a broad zone of alteration.

Data and methods: We have used observations from the Compact Reconnaisance Imaging Spectrometer for Mars (CRISM), the Context Camera (CTX), and the High Resolution Imaging Science Experiment (HiRISE) aboard the Mars Reconnaisance Orbiter (MRO). Full resolution targeted (FRT) CRISM observations used in this work are shown in Fig. 1.

Processing of calibrated CRISM FRT data and subsequent derivation of parameter maps was performed as described in [6, 7]. The resulting parameter maps were map-projected at 20 m/pixel and corregistered to map-projected CTX and HIRISE of the same area to characterize the spatial distribution and stratigraphy of hydrated minerals.

Results: Hydrated minerals have been identified in the FRTs labeled 2-6 in Fig. 1. These identifications are consistent with [5], and may be indicative of a coherent assemblage of units. This would broaden the previously known extent of phyllosilicates around Mawrth Vallis to an area of roughly 700x900 km.

Mineralogical constraints: Analysis of the FRTs shows that the light-toned units have a 1.9 μm band, whereas the dark mantling unit generally does not. FRT spectra of the dark mantling unit have a negative slope in the 1-2.6 μm region, and are otherwise featureless. Selected CRISM FRT spectra of hydrated regions are compared to laboratory spectra of minerals in Fig. 2. All spectra where a ~1.9 μm band is identified also show absorptions near 2.2 or 2.3 μm. The CRISM spectra with a band at 2.28-2.31 are consistent with the presence of Fe- and/or Mg-bearing smectites (Fig 2a). Spectra exhibiting a band near 2.21 μm are consistent with either montmorillonites (Al-OH), or with hydrated silica/glass or opal (Si-OH) in altered ash. Whereas montmorillonites tend to have a band center at 2.21 μm, hydrated silica and hydrate glass have a broader band in the range 2.18-2.26 μm (Fig. 2b) [11,12, 14]. Most of the spectra we observe here have band centers shortwards of 2.21 and breadths similar to that of hydrated silica/glass. This component has also been observed in CRISM spectra from other regions [6,10,14]. A doublet near 2.17 and 2.20 μm, consistent with kaolinite, was identified in the spectra of some regions of FRT8438. Additional discussions of the spectral properties of the Mawrth Vallis images are present in [15,16].

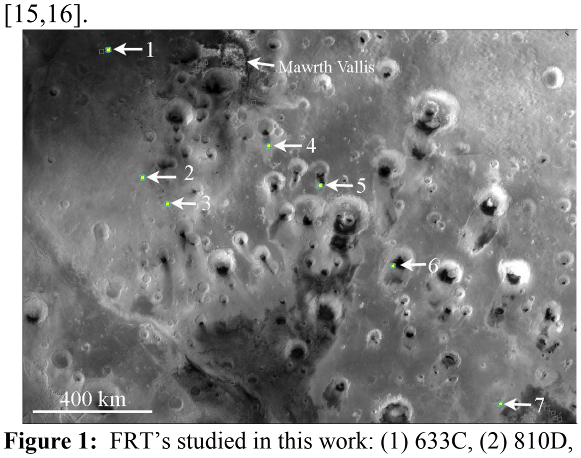

Figure 1: FRT's studied in this work: (1) 633C, (2) 810D, (3) 8438, (4) 8838, (5) 8690, (6) 8351, (7) 839D.

Spatial and stratigraphic relationships: Spectral data combined with CTX and HiRISE images show that the hydrated materials underlie a darker mantling unit and that the regions bearing Fe/Mg-smectites are spatially distinct from those bearing either montmorillonite or hydrated silica/glass signatures. With very few exceptions, we find that the Fe/Mg-smectites underlie the Al-phyllosilicates/Si-OH, and kaolinite layers, which appear to form part of a relatively thin (~meters) set of layers that underlies a dark, mantling unit (Fig. 3) .

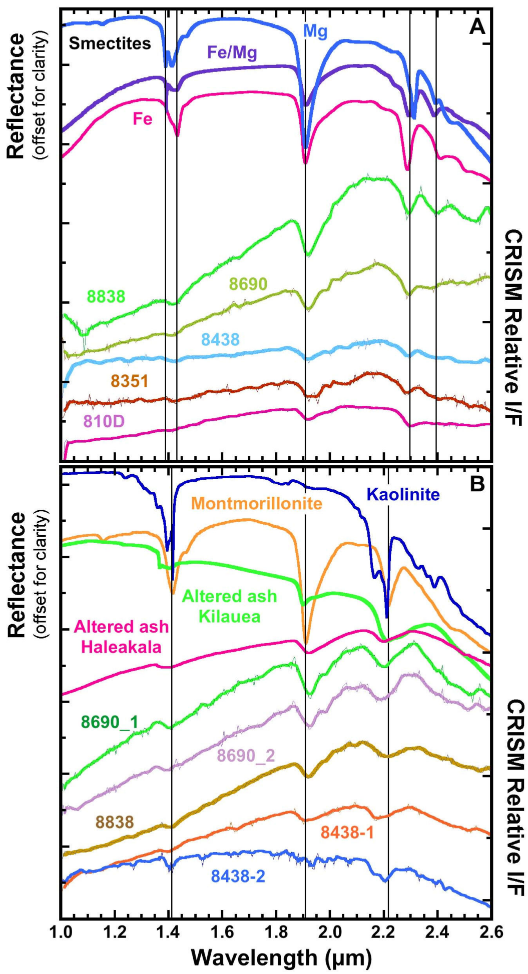

Figure 2: Bottom of A and B: CRISM relative IF spectra 3X3 averages (labeled by FRT), offset for clarity. Top of A and B: Lab reflectance spectra: (A) Fe-smectites (magenta); Fe/Mg smectites (dark blue); and Mg-smectites (light blue) [8]. (B) Kaolinite (dark blue), montmorillonite (orange) [8], Opal-A bearing phase in altered ash from Kilauea caldera (green); hydrated silica bearing phase in altered ash from Haleakala caldera (magenta) [9].

Correlations with morphology: Analysis of HiRISE and CTX images shows that although the hydrated units generally appear to be indurated, they only support small cliff-forms and do not appear to shed boulders that can be observed at HiRISE resolution. This contrasts with the dark mantling unit, which supports significantly taller cliff-forms (~10s of meters), forms a more resistant cap unit, and sheds boulders (Fig. 3A). Comparisons between the hydrated units at HiRISE resolutions show broad differences in meter-scale texture among the different spectral types.

Discussion: The hydrated units observed around Mawrth Vallis are found in stratigraphic windows over a discontinuous area of roughly 700 x 900 km, underlying a strong, dark mantling unit. Of particular importance is the observation that, sandwiched between the Fe/Mg smectites bearing units and the dark mantling unit is usually a layer that may contain hydrated silica/glass (middle unit, Fig 3). This relationship occurs in practically every FRT where we observe smectites in the region, regardless of elevation, and suggests that the middle unit may represent an alteration front between the Fe/Mg smectites units and the unaltered dark-toned overlying unit.

The observation that phyllosilicates underlie dark materials of possible volcanic origin is broadly consistent with observations elsewhere on Mars [6,11,12], and suggests that the observed clay units may form part of a large, regional- or possibly global-scale unit representing an epoch of aqueous alteration [13], that is now overlaid by un-altered materials deposited after the period of aqueous alteration.

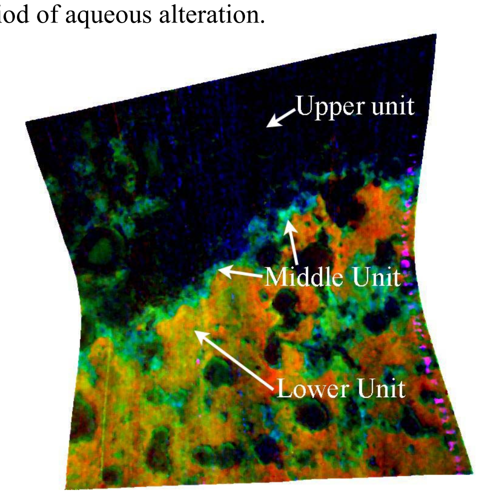

Figure 3: (B) Color composite of parameters maps for FRT8838, where R: D2300 (2.3 μm feature [7]), G: OLINDEX (ferrous index), B: BD2210 (2.21 μm feature).

References: [1] Poulet, F., *et al.* (2005) *Nature, 438*, 632-627. [2] Noe Dobrea, E.Z. and Michalski J.R. (2006) *AGU Fall 2006*, #P23D-0091. [3] Michalski, J.R. and Noe Dobrea, E.Z., (2007) *Geology,35*, pp. 951-954 [4] Loizeau D. *et al.* (2007) *JGR, 112* (E8). [5] Noe Dobrea, E.Z. *et al.* (2007) *AGU Fall 2007,* #P13D-1560. [6] Mustard *et al.* (2008) *Nature (submited)*. [7] Pelkey S.M. (2007) *JGR 112,* E8. [8] Bishop J.L. *et al.* (2002) *Clay Minerals*, *37,* 617-628. [9] Bishop J.L. *et al.* (2007) *Clays and Clay Minerals, 55,* 1-17. [10] Milliken *et al.*, (2007) *AGU, Fall*, #P12A-02. [11] Mangold, N. *et al.* (2007) *JGR 112*, E8, E08S04. [12] Mustard *et al.* (2007) *JGR, 12,* E8. [13] Bibring *et al.* (2006) *Science 312*, p 400-404. [14] Swayze *et al.*, (2007) *7th Intl. Mars Conf. #3384*. [15] Bishop J. L. et al. (2008) LPSC 39, [16] McKeown N. K. et al. (2008) LPSC 39.