TRANSITION BETWEEN ALTERED AND NON-ALTERED MINERALS IN MAWRTH VALLIS AND ARABIA TERRA. 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], E. Malaret[10], C. Hash[10], 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] ACT, Inc. Herndon, VA 20170

Introduction: There are two primary objectives that a sample return mission to another planet should accomplish: 1) return samples that will allow us to answer key questions about a planet's geological history, and 2) return a set of samples that can be considered "characteristic" of a planet's surface in order to understand the planet's current geological state. In the case of Mars, there are a few outstanding questions that will greatly benefit from a sample return mission.

One aspect that is of particular interest to understanding the geological history of Mars is constraining the time period and style in which aqueous alteration occurred. The identification of phyllosilicates by the OMEGA team [*e.g.,* 1, 2] and recent observations by the Compact Reconnaisance Imaging Spectrometer for Mars (CRISM) of the Noachian highlands on Mars provide strong support to the idea that there was a period of significant aqueous alteration on Mars, and that the strata associated with this time period have been since overlain by unaltered materials such as lava flows and airfall dust and/or ash. Determininig the age and alteration style of the strata associated to the alteration period, as well as the age of the contact between the altered and unaltered materials will provide definitive measurements that will allow us to address the question of the duration and chronology of aqueous alteration on Mars.

Phyllosilicate exposures on Mars: The two largest exposures of phyllosilicates observed on Mars are located on the plains around Mawrth Vallis [1,3] and in the region around Nili Fossae [4,5**]**. Smaller exposures have also been identified scattered throughout the highlands of Terra Tyrrhena [6], some portions of Arabia Terra [7], Eridania Basin [8], and Meridiani Planum [9]. Although numerous hypothesis have been suggested regarding the formation of these phyllosilicates-bearing units, there is one thread of observation that appears to be common to all these units: they all appear to have been exhumed or excavated from under a layer or layers of unaltered (sometimes mafic) material. This observation, coupled to the global distribution of the observed phyllosilicates, suggests that aqueous alteration was a globally-active process early in Martian history. However, we still do not know long this period lasted, whether it was a continous or cyclic event, or what was the geologic cotext in which the aleration too place. In this work, we focus on the phyllosilicates observed in the Mawrth Vallis and Arabia Terra Region because they present mineralogies and landforms that may allow us to address at least some of these unknowns.

Mawrth Vallis*:* The largest exposure of phyllosilicates on Mars occurs on the plains surrounding Mawrth Vallis, where phyllosilicates are detected over a continous area of roughly 200 x 300 km [*e.g.*, 1,3,10]. The phyllosilicate units are observed to underlie a ~100 m thick layer of competent (*i.e.*, cliff forming), boulder-shedding dark material which drapes unconformably over the clay-bearing units [11] and forms a cap rock. This material is spectrally featuresless and contrasts starkly with lighter-toned underlying material, which presents absorptions diagnostic of hydrated silicates. At least three different types of phyllosilicates have been found in this region (Fe/Mg-smectites, Al-smectites, and Kaolinite-group phyllosilicates) [12,13,14]. These minerals appear spatially distinct at CRISM resolutions (~20 m/pixel), and are typically associated with either light-toned, finely layered units or massive layered units that show a variety of distinct surface textures. Fe/Mg smectites (identified by absorptions around 1.4, 1.9, and ~2.3 mm) are typically found at the bottom of the stratigraphic sequence, and appear to be spatially the most abundant (14). Sandwiched between the Fe/Mg smectites-bearing units and the overlying dark unit is a unit that displays spectral absorptions at 1.4, 1.9, and ~2.2 µm. The specific band-center and shape of the 2.2-µm band can be used to discern between Al smectites and hydrated glasses, such as Opal-A. Comparisons of CRISM and OMEGA spectra of these units to laboratory spectra of phyllosilicates and hydrated glasses present in volcanic ashes suggest that this unit contains both of these mineralogical candidates. The exact spatial distribution of these minerals is still being studied.

Arabia Terra: Ongoing spectral studies of western Arabia Terra have also identified the presence of hydrated minerals in small (~10 km) localized areas [7]. Mineralogically and stratigraphically, these hydrates are very similar to those observed in the Mawrth Vallis region, up to 500 km away: Light-toned and layered Fe/Mg smectite-bearing units are overlayed by a unit which interpreted contain hydrated glass, which is in turn overlayed by a dark, spectrally featureless unit (Figure 1). Each of these untis is morphologically similar to those observed around Mawrth Vallis, suggesting that the alteration process that formed the hydrated minerals in the Mawrth Vallis region were not constrained only that region, and that it may have been part of the same processes that produced the altered minerals that have been identified in the Nilli Fossae and Terra Tyrrhena region.

Relevance to a sample return mission: At least some of the samples collected by a sample return mission should be expected to be characteristic of the planet as a whole, and should allow us to obtain general information about its geological history. Data being returned by OMEGA and CRISM strongly suggest that aqueous alteration was a global process at some point in Martian history, and that after this process ended, additional unaltered materials were deposited on top of the altered units. It would therefore seem necessary that samples representative of both the alteration period (or periods) non-alteration period(s) be returned. As such, it is important to identify locales where a boundary between these two periods is well defined.

In the Arabia Terra/Mawrth Vallis region, the stratigraphic transition from an upper layer of unaltered material, to a middle layer that appears to contain hydrated glass, to a lower layer that contains Fe/Mg bearing smectites strongly suggests that the middle layer is an alteration front, and that it defines a boundary between a period of aqueous alteration and a subsequent period of no alteration. Additionally, the smectites-bearing units in this region are in many cases layered down to the limit of resolution (~50 cm in HiRISE data). Return of both altered and unaltered samples from such a region would allow us to constrain the age at which aqueous alteration processes became less significant, as well as constrain the degree of aqueous activity at different time periods, based on samples return from the different layers that could be sampled.

References: [1] Poulet, F., *et al.* (2005) *Nature, 438*, 632-627. [2] Bibring J-P. et al, *Science* v307, 1576-1581 (2005). [3] Noe Dobrea, E.Z. and Michalski J.R. (2006) *AGU Fall 2006*, #P23D-0091. [4] Mustard *et al.*, (2007) *J. Geoph. Res.* 112, E8. [5] Mangold *et al.* (2007) *J. Geoph. Res.* 112, E8. [6] Pelkey *et al.* (2007) *LPSC 38* # 1338. [7] Noe Dobrea *et al.* (2008) *LPSC 39* # 1077. [8] Noe Dobrea *et al.*, (2007) *2nd MSL Landing Site Workshop*. [9] Ehlmann B. et al. 7th Mars Conference (2007). [10] Loizeau D. *et al.* (2007) *JGR*, *112.* [11] Michalski, J.R. and Noe Dobrea, E.Z., (2007) *Geology*,*35*, pp. 951-954. [12] Ehlman [13] Bishop J. L. et al. (2008) LPSC 39, [14] McKeown N. K. et al. (2008) LPSC 39.

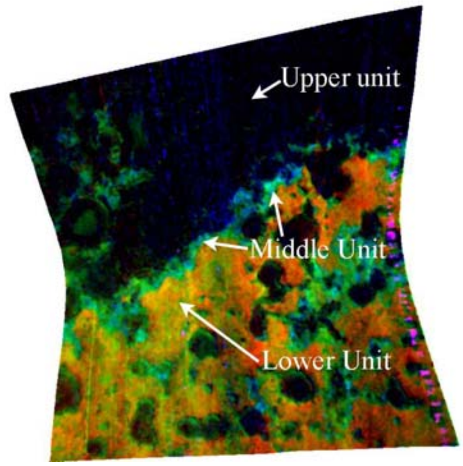

Figure 1: (B) Color composite of parameters maps for FRT8838, where R: D2300 (2.3 m feature [7]), G: OLINDEX (ferrous index), B: BD2210 (2.21 μm feature). In this figure, Fe/Mg smectites appear as red/yellow, hydrated glass and/or Al phyllosilicates appear as blue, and featuresless units appear as black.

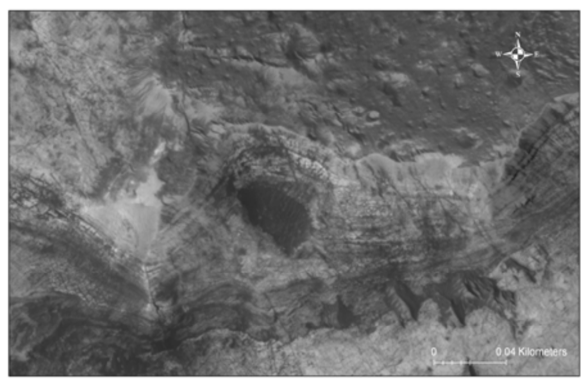

Figure 2: HiRISE view of layered light-toned outcrops overlayed by a darker cratered unit in the Mawrth Vallis region. North is up and sun is from the lower left.