POSSIBLE SEDIMENTARY FEATURES IN PHYLLOSILICATE-BEARING ROCKS AT MAWRTH VALLIS, MARS.

J.L. Bishop[1] L. Saper[2], R.A. Beyer[1], D. Lowe[3], J.J. Wray[4], N.K. McKeown[5] and M. Parente[2], [1]SETI Institute & NASA-Ames (Mountain View, CA), [2]Brown University (Providence, RI), [3]Stanford University (Stanford, CA), [4]Cornell University (Ithaca, NY), [5]MacEwan University (Edmonton, AB, Canada).

Introduction: The Mawrth Vallis region harbors one of the largest phyllosilicate outcrops on Mars with abundant exposures of many aqueous minerals and phases [e.g. 1-6]. The goal of our study is to characterize the mineralogy and morphology of phyllosilicate -bearing rocks at Mawrth Vallis that exhibit possible sedimentary attributes. There are currently many hypotheses for the formation of these phyllosilicate-rich units including emplacement of impact ejecta, volcanic ash, and/or sedimentation via aeolian, fluvial or lacustrine processes. Each process has distinct implications for the paleo-environment and its potential for habitability and biomarker preservation. If the Mawrth Vallis region is shown to have a sedimentary origin, then that increases the probability that life could have been present here and preserved. Many of the phyllosilicate-rich beds exhibit discordant layering consistent with sedimentary features. Here we present analyses of CRISM and HiRISE images of possible sedimentary deposits in Oyama crater and in the walls of a smaller crater just outside Oyama (marked in red in Fig. 1).

Crater Wall Exposures: A pair of small craters just outside the large Oyama crater and 20 km NW of the candidate landing site region exhibit clear spectral signatures of the phyllosilicate units with evident stratigraphy. These are depicted in a CRISM mineralogy map (Fig. 2) and a HiRISE mosaic (in Fig. 3). The phyllosilicate stratigraphy observed here is similar to elsewhere in Mawrth Vallis [e.g. 3,5]; however it is much more accessible along these wall exposures. The HiRISE images illustrate differences in color and texture of each unit (Fig. 3). The band of Fe^{2+} material is clearly observed dividing the Al-phyllosilicate and hydrated silica unit above and the Fe^{3+}/Mg-smectite unit below. Figs. 3b-f highlight examples of discordant layering in the oldest Fe^{3+}/Mg-smectites. In many cases

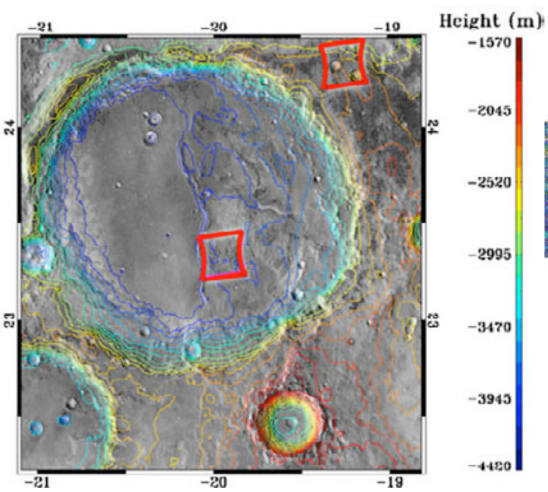


Fig. 1: Map of Oyama crater. CRISM image locations marked by red boxes; HiRISE image sites within CRISM borders; elevations from MOLA; ~100 km wide.

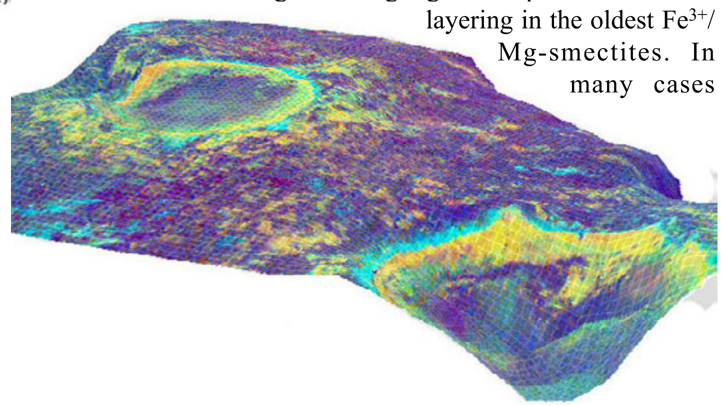


Fig. 2: 3D mineral map of CRISM image FRT000094F6 draped over MOLA elevations. Colors are R: Fe^{3+}/Mg-smectite (2.3 µm band), G: Fe^{2+} material (1-1.8 µm slope), and B: Al-phyllosilicate and/or Si-OH (2.21 µm band); [parameters from 7]. White box marks location of HiRISE image in Fig. 3a.

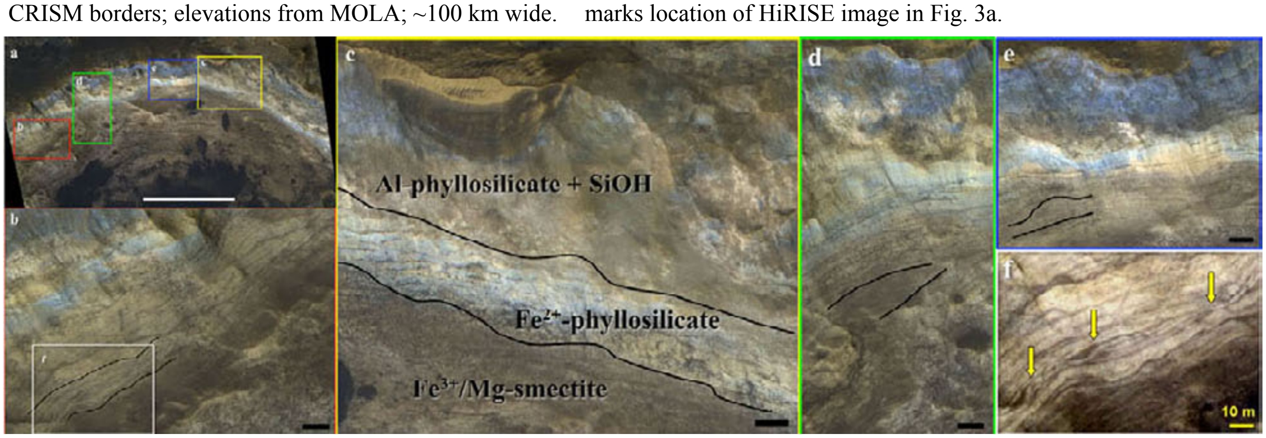
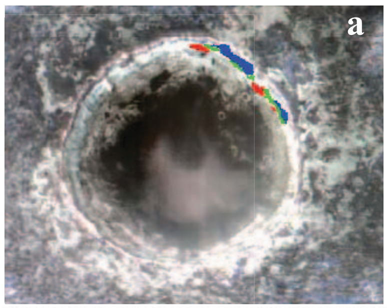


Fig. 3: HiRISE mosaic built from images PSP_ 004052_2045 and ESP_012873_2045. a) Phyllosilicate outcrops shown in crater wall (white bar ~500 m), b-e) discordant layering in Fe/Mg-smectite units (black bar ~25 m), f) expanded view of discordant layering (from Wray et al. [4]). Phyllosilicate stratigraphy illustrated in c).

the bedding either converges or diverges, whereas in other cases it appears almost parallel. There are also a few exposures where morphologies reminiscent of soft-sediment deformation are observed (Fig. 3f).

Spectra were collected from the CRISM image shown in Fig. 2 for three Region of Interest (ROI) units marked in Fig. 4a following standard image processing techniques [8]. These spectra were ratioed to another ROI of a spectrally unremarkable caprock unit and are displayed in Fig. 4b in stratigraphical order. Present in distinct mineralogical and morphological units are an Al-smectite such as montmorillonite (Fig. 4b top, blue); a mixture of Fe^{2+} material, Al-smectite, and Fe^{3+}/Mg-smectite (2nd, light green); Fe^{3+}/Mg-smectite with a Fe^{2+} phase (3rd, dark green); and Fe^{3+}/Mg-smectite (bottom, red). Continued analyses using the DiREX transform [9] are planned in order to define additional minor components in the phyllosilicate units.



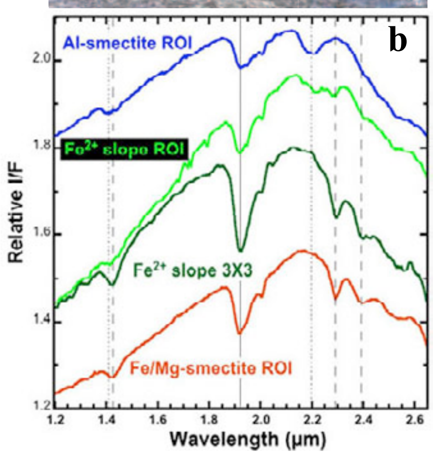


Fig. 4: Phyllosilicate spectra from crater wall deposits.

a) ROI sites on CRISM image FRT000094F6.

b) Ratio spectra of stratigraphic units containing phyllosilicates.

Inside Oyama Crater: A pair of CRISM and HiRISE images captured aqueous features inside Oyama crater (Fig. 5). The phyllosilicate-rich material here is dominated by Fe^{3+}/Mg-smectite and exhibits the strongest features in deposits near a crater ~2 km across. An expanded view of the morphologies of the phyllosilicate-bearing rocks along the crater rim indicates discordant layering (Fig. 5b). Here, it appears that a lower set of layers is truncated by other strata higher in the stratigraphy. Alternatively, these might be large-scale cross-beds. These clear exposures of layering in crater walls indicate that this was present prior to impact. Thus, these phyllosilicate-bearing rocks appear to be sediments; ongoing analyses are investigating their origin in more detail.

Implications: Phyllosilicate units up to 200 km thick are observed throughout the Mawrth Vallis region and many of these exhibit discordant layering that closely resemble scour and truncation surfaces common in terrestrial sedimentary deposits. The two sites described here illustrate examples of discordant layering that are consistent with a changing environment and depositional processes. If these are sedimentary deposits, then the chances of early life here and preservation of any biosignatures is increased.

Acknowledgements: Support for this project from the MRO mission, as well as NSF and the NAI for the SETI REU program are greatly appreciated.

References: [1] Poulet F. et al. (2005) *Nature, 438,* 632-627. [2] Loizeau D. et al. (2007) *JGR, 112,* doi:10.1029/2006JE002877. [3] Bishop J.L. et al. (2008) *Science, 321,* 830-833. [4] Wray J.J. et al. (2008) *GRL, 35,* doi:10.1029/2008GL034385. [5] McKeown N.K. et al. (2009) *JGR, 114,* doi:10.1029/2008JE003301. [6] Noe Dobrea E.Z. et al. (2010) *JGR, 115,* doi:10.1029/2009JE003351. [7] Pelkey S.M. et al. (2007) *JGR, 112,* doi:10.1029/2006JE002831. [8] Murchie S. L. et al. (2009) *JGR, 114,* doi:10.1029/2009JE003344. [9] Parente M., J.L. Bishop (2010) *LPS IVI*, #2633.

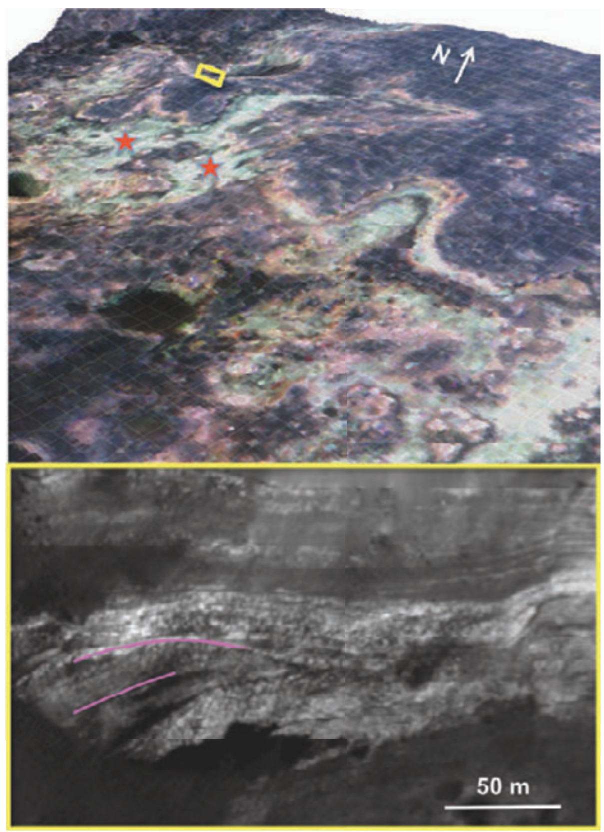


Fig. 5: Discordant layering inside Oyama crater. a) 3D CRISM image FRT0001903B draped over MOLA elevations with red stars marking strong Fe^{3+}/Mg-smectite exposures. b) Phyllosilicate units in HiRISE image ESP_017963_2035 in crater wall illustrating discordant layering.