

PHYLLOSILICATE AND HYDRATED SULFATE DEPOSITS IN MERIDIANI. S. M. Wiseman¹, R. E. Avidson¹, S. Murchie², F. Poulet³, J. C. Andrews-Hanna⁴, R. V. Morris⁵, F. P. Seelos², and the CRISM Team. ¹Dept of Earth and Planetary Sciences, Washington University, St. Louis, MO (sandraw@levee.wustl.edu), ²Applied Physics Laboratory, Laurel, MD, ³Institut d' Astrophysique Spatiale (IAS), Université Paris-Sud, Orsay, France, ⁴Dept of Earth, Atmospheric, and Planetary Sciences, MIT, Cambridge, MA, ⁵NASA Johnson Space Center, Houston, TX.

Introduction: Several phyllosilicate and hydrated sulfate deposits in Meridiani have been mapped in detail with high resolution MRO CRISM [1] data. Previous studies have documented extensive exposures of outcrop in Meridiani (fig 1), or 'etched terrain' (ET), that has been interpreted to be sedimentary in origin [e.g., 2,3]. These deposits have been mapped at a regional scale with OMEGA data and show enhanced hydration ($1.9\mu\text{m}$ absorption) in several areas [4]. However, hydrated sulfate detections were restricted to valley exposures in northern Meridiani ET [5]. New high resolution CRISM images show that hydrated sulfates are present in several spatially isolated exposures throughout the ET (fig 1). The hydrated sulfate deposits in the valley are vertically heterogeneous with layers of mono and polyhydrated sulfates and are morphologically distinct from other areas of the ET. We are currently mapping the detailed spatial distribution of sulfates and searching for distinct geochemical horizons that may be traced back to differential ground water recharge and/or evaporative loss rates.

The high resolution CRISM data has allowed us to map out several phyllosilicate deposits within the fluvially dissected Noachian cratered terrain (DCT) to the south and west of the hematite-bearing plains (Ph) and ET (fig 1). In Miyamoto crater, phyllosilicates are located within $\sim 30\text{km}$ of the edge of Ph, which is presumably underlain by acid sulfate deposits similar to those explored by Opportunity. The deposits within this crater may record the transition from fluvial conditions which produced and/or preserved phyllosilicates deposits to a progressively acid sulfate dominated groundwater system in which large accumulations of sulfate-rich evaporites were deposited.

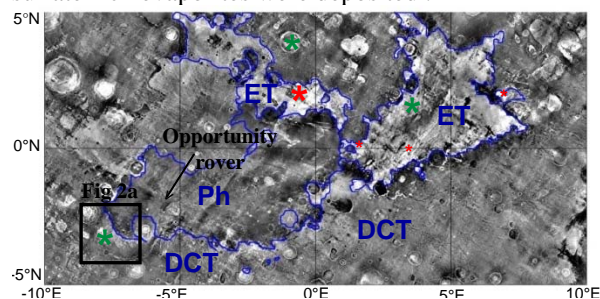
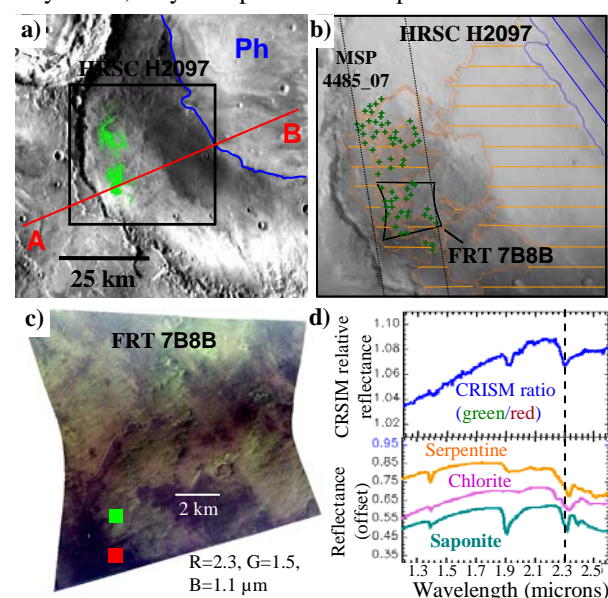


Figure 1. Regional map of Meridiani. Phyllosilicate detections are shown in green and hydrated sulfates in red.

Phyllosilicates: Phyllosilicates have been previously detected using OMEGA data within a large

crater in northern Meridiani as well as in a portion of the ET to the east [4] (fig 1). However, the geologic context of these deposits was difficult to decipher. Using CRISM and other orbital data, we have defined a lateral transition from phyllosilicate bearing material to layered terrain that occurs within the heavily modified $\sim 130\text{km}$ diameter Miyamoto crater. Phyllosilicates (fig 2a) are present within crater deposits $\sim 30\text{km}$ from the edge of the layered terrain explored by the Opportunity rover at the landing site $\sim 150\text{km}$ to the northwest (fig 1). Phyllosilicate exposures exhibit spectral features resulting from Fe/Mg-OH vibration at $2.3\mu\text{m}$ and bound H_2O at $1.9\mu\text{m}$. The band center and shape of the $\sim 2.3\mu\text{m}$ absorption feature indicates the presence of saponite, a smectite clay (fig 2d).

A geologic cross section of this area shows that Miyamoto crater was heavily infilled prior to the emplacement of the layered deposits (fig 2b). Analysis of HRSC data show that phyllosilicate exposures occur in areas where a capping unit has been stripped away (fig 2b). This capping unit appears to unconformably overlie the phyllosilicate bearing material and extends to the edge of and underlies the layered terrain to the east. This relationship indicates that the phyllosilicates predate the emplacement of the layered terrain. The phyllosilicate deposits within the crater in northern Meridiani, which are spectrally similar to those in Miyamoto, may also predate the emplacement of ET.



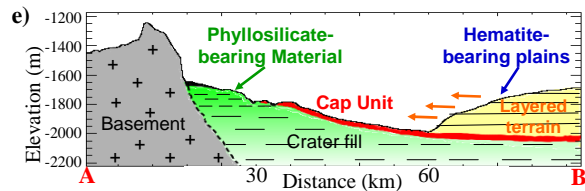


Figure 2. a) THEMIS DIR mosaic of Miyamoto crater with CRISM phyllosilicate detections shown in green, b) HRSC 2097 subset showing capping unit (orange), phyllosilicates (green), and hematite-bearing plains (blue), c) CRISM FRT 7B8B false color image (phyllosilicates in green), d) CRISM spectrum and library spectra, e) MOLA cross section.

Hydrologic modeling [6] suggests that layered deposits would have formed throughout the crater interior and only later been eroded back to the present extent to expose the pre-existing phyllosilicate-bearing material. The spatial juxtaposition of phyllosilicate and acid sulfate deposits provides a potentially important site for exploration by upcoming rover based missions, and is currently a candidate MSL landing site.

Hydrated Sulfates: Mono and polyhydrated sulfates (with absorption features at $2.1 + 2.4\mu\text{m}$ and $1.9 + 2.4\mu\text{m}$, respectively) were originally mapped within and near the northern Meridiani valley with OMEGA data [7]. Analyses of high resolution CRISM, HiRISE, and CTX images show that several spectrally and geomorphically distinct layers occur within the valley at the 10s of meters scale that have been exposed by differential erosion [8]. The apparent active erosion in this area may be responsible for exposing relatively fresh hydrated minerals.

Hydrated sulfate deposits have also been detected with CRISM at small spatial scales in several locations throughout the ET (fig 1). We are currently mapping these marker minerals. Initial results suggest that some of these small exposures may represent remains of more coherent units that have been stripped away or obscured from detection by overlying material. Deposits similar to the material exposed in the valley may occur at the base of the stratigraphic section explored by the Opportunity rover.

Opportunity rover observations show that hematitic concretions weathered from outcrop (ET) that consists of layers of dirty evaporites that formed in an acid sulfate environment [9,10,11]. The hydroxylated sulfate mineral jarosite occurs within the outcrop [12]. Orbital CRISM spectra of the outcrop exposed along the rover traverse are dominated by nanophase ferric oxide features and do not show distinct features related to hydroxylated or hydrated sulfates [14].

The lack of sulfate detection in CRISM data may be explained by the presence of coatings thick enough to obscure reflectance signatures of underlying sulfates, but thin enough to be transparent to the gama

radiation used by the MB, and/or the fine grain size of the sulfates precludes detection using VIS/SWIR data.

Discussion: The deposits in Meridiani record the waning of the hydrologic cycle on Mars. High energy erosive conditions which degraded and dissected the Noachian cratered terrain transitioned to a ground water dominated regime in which evaporation and aeolian reworking dominated to produce thick accumulations of layered outcrop (ET). Phyllosilicate deposits appear to be associated with the most ancient rocks on Mars [15] and hydrated sulfate deposits are present in some of the late Noachian or early Hesperian layered terrain in Valles Marineris and Meridiani. The transition in hydrologic regimes on Mars to an acid sulfate ground water system may be recorded in the phyllosilicate and layered deposits within Miyamoto crater.

Several distinct mineral assemblages are present within the layered outcrop material in Meridiani that have been grouped together as ET. Acid sulfate conditions are suggested by the presence of jarosite within the outcrop measured by the Opportunity rover. The hematitic spherules are derived from the outcrop, and the presence of the laterally extensive Ph indicates that much of the outcrop underlying this unit is similar in nature to the deposits explored by the rover. Areas of the ET that exhibit hydrated sulfate signatures experienced distinct geochemical conditions during deposition and/or diagenesis that preserved these minerals in measurable quantities. Active erosion may contribute to the orbital detection of these deposits.

The geochemical conditions experienced by ET at various locations were driven by ground water recharge and evaporative loss rates, both of which influence the water to rock ratio and therefore the fluid chemistry. Hydrologic modeling [6] predicts regions of groundwater upwelling and variation in evaporative loss throughout the Meridiani region. Continued high resolution spectral and geomorphic mapping of distinct terrains, including phyllosilicates and sulfates, within Meridiani will lead to a better understanding of the local and global scale hydrologic regime on Mars.

References: [1] S. Murchie et al. (2007) *JGR*, 112. [2] M. Malin and K. Edgett, (2000) *Science*, 288. [3] P.R. Christensen and S.W. Ruff (2004) *JGR*, 107. [4] F. Poulet et al. (2007) *Icarus*, in press. [5] A. Gendrin et al. (2005) *Science*, 307. [6] J.C. Andrews-Hanna and M.T. Zuber (2008), *this conf.* [7] J.L. Griffes et al. (2007) *JGR*, 112. [8] S.M. Wiseman et al. 7th Mars abst#3111. [9] S.W. Squyres et al. (2004) *Science*, 306. [10] R.E. Arvidson et al. (2006) *JGR*, 111. [11] J. Grotzinger et al. (2005) *E.P.S.L.*, 240. [12] R.V. Morris et al. (2003) *Science*, 306. [13] T. Glotch et al., (2006) *JGR*, 111. [14] S. Murchie. et al. (2007) *Nature*, submitted. [15] J-P. Bibring et al. (2006) *Science*, 312.