STRATIGRAPHY AND RELATIONSHIP OF HYDRATED MINERALS IN THE LAYERED DEPOSITS OF ARAM CHAOS, MARS.

K. A. Lichtenberg[1], R. E. Arvidson[1], R. V. Morris[2], S. L. Murchie[3], J. L. Bishop[4], T. D. Glotch[5], E. Noe Dobrea[6], J. F. Mustard[7], J. Andrews-Hanna[8], L. H. Roach[7], and the CRISM Team. [1]Washington University, St. Louis, MO 63130 (lichtenberg@wunder.wustl.edu), [2]NASA Johnson Space Center, Houston TX, [3]Johns Hopkins University Applied Physics Laboratory, Laurel, MD, [4]SETI Institute, Mountain View CA, [5]Stony Brook University, Stony Brook, NY, [6]California Institute of Technology, Pasadena, CA, [7]Brown University, Providence, RI, [8]Colorado School of Mines, Golden, CO.

Introduction: The post-chaos layered deposits in Aram Chaos (3N, 339E) extend laterally approximately 10,000 km^2. The deposits experienced significant erosion from the northwest, in some places exposing the original basement unit [1] and indicating a more extensive depositional coverage than evident today. Crystalline hematite and mono- and poly-hydrated sulfates have been identified in the layered deposits with TES, OMEGA, and CRISM data [1,2,3,4,5]. The presence of hematite and hydrated sulfates is evidence that water was involved in the formation of the depositional unit, and morphological and mineralogical variations in the layers indicate that there were temporal changes in the depositional environment. Here we map the mineralogical variations within the eroded portion of the depositional unit and construct a stratigraphic column of the depositional unit. We also obtain a maximum age for the depositional unit based on crater counts of the cap in order to place the unit in temporal context with other areas that show similar stratigraphies (e.g. Meridiani Planum).

Data Sets: The CRISM instrument aboard the Mars Reconaissance Orbiter acquires data in a number of modes, two of which are: a nadir-pointing, multispectral mode (72 bands, 100-200 m/pixel) and a targeted hyperspectral mode (544 bands, up to 18 m/pixel) [5]. While the multispectral mode provides consistent, global coverage at a lower resolution, the targeted mode is used to probe the mineralogy of small areas in detail. This work takes advantage of the targeted CRISM data set, as hyperspectral and high spatial resolution data are needed to evaluate minerology of small-scale deposits on the order of ~100 meters across, which is the largest extent of the ferric sulfate hydroxydes identified here. Data from both the Context Imager (CTX) and the High Resolution Imaging Science Experiment (HiRISE) instruments are analyzed in conjunction with the mineralogical information to provide structural and stratigraphic context.

A mosaic of georeferenced CTX (~6 m/pixel) strips over Aram Chaos was created and used to measure craters on the cap of the depositional unit. Modeling this crater distribution using a Hartmann production function and constant deposition/erosion rate of 25 meters/Ga yields a maximum age of 3.0 Ga for the depositional unit within Aram Chaos.

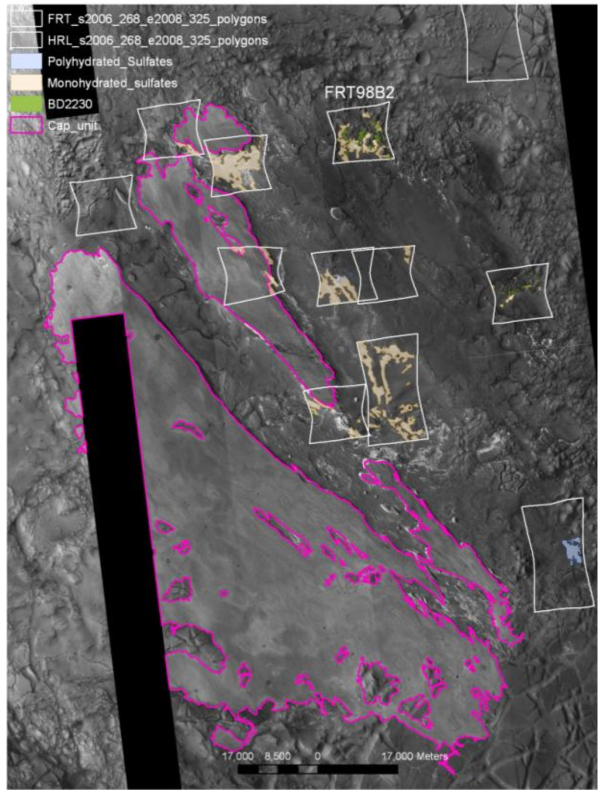

Figure 1: CTX Mosaic centered on the depositional unit in Aram Chaos. CRISM targeted observations used are shown in white; the cap unit is outlined in pink. CRISM-based detections of 1) polyhydrated sulfates are shown in blue, 2) monohydrated sulfates are shown in peach, and 3) 2.23 micrometer material are shown in green.

Results: A subset (10) of the 14 targeted CRISM observations (4 HRL, 10 FRT) over the depositional unit in Aram Chaos were examined based on mineralogy and location (Figure 1). Analysis of these ten CRISM targeted observations and CTX images in conjunction with previous work in this region shows a series of layers, listed here stratigraphically from top to bottom and shown in Figure 2: (1) a 250-500 m thick, erosionally-resistant cap unit dominated by nano-phase iron oxides but containing monohydrated sulfate, (2) a 200-400 m thick unit with polyhydrated sulfate and hematite signatures, (3) a ~50 m thick light-toned unit with 2.1 and 2.4 μm absorptions (monohydrated sulfate), and (4) a ~10 m thick medium-toned unit with spectra dominated by absorptions at 1.5, 1.82, and 2.23 µm. This is interpreted here to be a ferric sulfate hydroxide ($Fe(SO_4)OH$) that may be hydrated (Figure 3) [6,7]. The monohydrated sulfate layers occur throughout the depositional unit and are always at lower elevations than the polyhydrated sulfate/hematite layers. The ferric sulfate only occurs at the interface between the depositional unit and the basement chaos material, and always in conjunction with the monohydrated sulfates. We interpret this to signify that the ferric sulfate occupies the lowest stratigraphic level observable. Both monohydrated sulfate and iron sulfate layers appear to be unconformably draped over the basement topography, although more work is needed to confirm this.

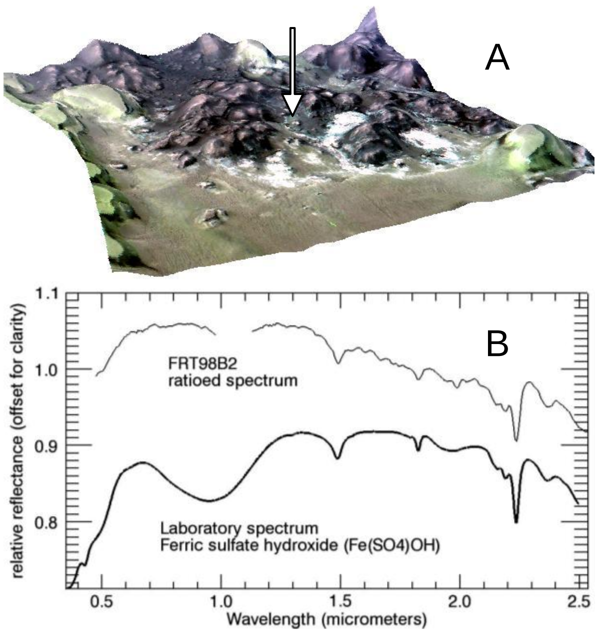

Figure 3: (a) CRISM false color RGB (2.53, 1.51, 1.08 µm); FRT98B2 (location shown in Fig. 1) draped over HRSC topography (3x vertical exaggeration). Image is ~10 km across. White/light green areas are monohydrated sulfate, turquoise areas are Fe-OH sulfate, and purple areas are the basement chaos unit. (b) Comparison of CRISM spectrum from ferric sulfate in 98B2 (location shown by arrow in A) to a laboratory spectrum of ferric sulfate hydroxide (spectrum after [6]).

Implications: Recent work on groundwater modeling [8] shows that Aram Chaos may have had a high hydrostatic head in the past and could have experienced high evaporation rates during periods of groundwater recharge. This area shows strong hydrated mineral signatures, further indicating that the area likely experienced groundwater upwelling and evaporation. The stratigraphy of the hydrated minerals in the post-chaos depositional unit shows a gradation in hydration states from polyhydrated in the middle of the sequence to monohydrated and finally hydroxylated minerals at the bottom. The sequence of sulfates and hematite overlain by an iron-oxide cap unit mimics the stratigraphy to the southwest in Meridiani Planum, implying similar aqueous histories for the deposits even though the ages differ for the two regions.

References: [1] Glotch T. D. and Christensen P. R. (2005) *JGR, 110*. [2] Gendrin A. et al. (2005) *Science, 307*. [3] Noe Dobrea et al. (2008) *Icarus, 193* [4] Masse et al (2008) *JGR, 113*. [5] Bibring J.P. et al. (2007) *Science 317*. [5] Murchie S. et al. (2007) *JGR, 112*. [6] Morris et al. (2009) LPSC, this issue. [7] Bishop et al. (2008) *AGU fall meeting, P43B-1397* [8] Andrews-Hanna J. et al. (2007) *Nature, 446*.

Figure 2, below: (left) Transect in yellow over HRSC DEM (75 m/pixel) ending at FRT98B2. (right) Inferred stratigraphy of depositional unit based on mineralogy and morphology. Solid lines indicate actual mineralogical observations; dashed lines show inferred locations for areas with no CRISM targeted coverage.