Laboratory and Modeling Results to Decipher Changes in Recent Curiosity Mastcam Multispectral Data from Drill Targets in the Clay/Sulfate Transition Zone. S.R. Jacob¹, J. Bell¹, E. Cloutis², E.B. Rampe³, M. Rice⁴, J.V. Clark⁵, B. Sutter⁶, J.R. Johnson⁷, ¹Arizona State Univ., Tempe, AZ (*samantha.jacob@asu.edu); ²Univ. Winnipeg, Winnipeg, MB, Canada; ³Astromaterials Research and Exploration Science Division, NASA JSC, Houston, TX; ⁴Western Washington Univ., Bellingham, WA; ⁵GeoControls Systems – Jacobs JETS Contracts at NASA JSC, Houston, TX; ⁶Jacobs JETS Contract at NASA JSC, Houston, TX; ⁷Johns Hopkins University Applied Physics Laboratory, Laurel, MD

Introduction: For the past ~9 months the Curiosity rover has been exploring a mineralogical transition from the Glen Torridon trough, which had the highest phyllosilicate abundance measured in the mission thus far, to rocks with minor phyllosilicate abundances. In addition to in situ mineralogical changes, interpretations of CRISM orbital data suggest the presence of polyhydrated Mg-sulfates [1]. The search for sulfates in Gale crater is not only a search for significant mineralogical transitions but is also a search for a major climatic shift in Mars’ geologic history that could be diagnostic of a change in the ancient aqueous surface environment. This abstract discusses how recent mineralogical changes affect the shape of spectra from the Mastcam instrument onboard Curiosity.

In situ rover analyses: There have been 5 drilled samples in the “clay/sulfate transition (CST) zone” analyzed by the Mastcam (Fig. 1), Chemistry and Mineralogy (CheMin) X-ray Diffractometer (XRD), Sample Analysis at Mars-Evolved Gas Analysis (SAM-EGA), and other instruments onboard Curiosity. Nontron and Bardou were drilled at the base of and on top of Mt. Mercur, respectively. Pontours, Maria Gordon, and Zechstein were drilled at ~25 m elevation intervals as Curiosity ascended Mt. Sharp. CheMin has not measured crystalline Mg-sulfates in any of the drilled samples [2]. However, SAM-EGA has detected Mg-sulfates in some of the stratigraphically higher drill targets [3], and other instruments are tracking increases in sulfur abundance particularly in diagenetic features [4,5]. Other notable mineralogical changes found by CheMin and SAM-EGA include a decrease in phyllosilicates and hematite. Modeling and laboratory work was conducted to determine if recent Mastcam spectra from the drill targets in the clay/sulfate transition region could be reproduced with a combination of poly-hydrated Mg-sulfate and other minerals measured by CheMin.

Mastcam spectra: Mastcam spectra (Fig. 2a) from stratigraphically lower drill samples (Nontron and Bardou) and newer stratigraphically higher samples have two significant differences that are indicative of changes in mineralogy, 1) the NIR slope from 867 nm to 1 µm, and 2) the peak visible wavelength. Nontron and Bardou, have steeper NIR slopes and don’t have a strong peak in the visible wavelengths (<800 nm) but instead have near continuous increase in reflectance. Newer drill samples, however, have a fairly flat NIR slope and an obvious peak at 751 nm. Nontron and Bardou have major abundances of hematite and phyllosilicates, while Pontours and Zechstein have minor abundances [2]. Maria Gordon has a major abundance of hematite, but a minor abundance of phyllosilicates. Interestingly, despite the similar abundances of hematite between Maria Gordon and stratigraphically lower drill samples Nontron and Bardou, Maria Gordon has spectral features (NIR slope and peak wavelength) more similar to Pontours and Zechstein. This suggests that the major abundance of phyllosilicate inNontron and Bardou is strongly controlling the NIR slope of Mastcam spectra in the CST. While Zechstein does have a major abundance of gypsum, this is not expected to affect Mastcam spectra and likely represents a vein that was drilled below the surface.

Visible to Near-Infrared Mg-Sulfate spectroscopy: Mg-sulfates vary in hydration states ranging from Kieserite (1·H₂O) to at least 11·H₂O (Meridianiite; [5]). Poly-hydrated Mg-sulfates with intermediate hydration states include Starkeyite (4·H₂O), Hexahydrite (6·H₂O), and Epsomite (7·H₂O). Absorption features of Mg-sulfates that could affect Mastcam spectra are at ~0.94 µm and 1.13 µm and are the result of H₂O-H overtones [6]. For drilled rocks with minimal ferric mineral abundance, these hydration absorption features may be visible in Mastcam spectra. However, for samples such as Nontron and Bardou with significant hematite and phyllosilicate abundance, any possible hydration features have likely been overwhelmed by the ferric absorption features. The ~1 µm hydration band in Mg-sulfates would be seen in Mastcam data as a negative slope in the NIR filters (~900-1000 nm). One caveat is that this hydration band is not unique to Mg-sulfates and could be caused by other hydrated minerals, including amorphous silica.

Modeling Results: Binary linear models using various Mg-sulfates from the RELAB spectral library (Fig. 3) suggest that spectra from newer CST drill samples could represent a combination of Mg-sulfate and plagioclase. Additionally, models using epsomite with smaller grain sizes (<45 µm) show that epsomite + pyroxene could also be a possible combination. The ~1
µm Mg-sulfate absorption feature not only varies with hydration state, but also varies with grain size and degree of crystallinity [2]. Laboratory spectral analyses of possible combinations identified by the model will be done to validate the model results. As Curiosity continues its ascent of Mt. Sharp, Mastcam continues to search for bedrock with the hydration band to identify valuable drillable targets that could then be analyzed by the CheMin and SAM instruments.


Figure 1: Mastcam right eye RGB composite images of the 5 recent drill targets discussed above

Figure 2: a) Mastcam spectra from drill targets in the clay-sulfate transition region. b) Visible to Near-Infrared lab spectra of various Mg-sulfates