MINERAL STRATIGRAPHY AROUND MT. SHARP SUGGESTS AQUEOUS PROCESSES AFFECTED THE ENTIRE MOUND: DIRECTIONS FOR UPCOMING ROVER OBSERVATIONS FROM ORBITAL DATA. R. Y. Sheppard1*, R. E. Milliken1, Y. Itoh2, and M. Parente2. 1Dept. Earth, Environmental, and Planetary Sciences, Brown University, 2Dept. Electrical and Computer Engineering, University of Massachusetts, Amherst. *rachel_sheppard@brown.edu

Introduction: Mt. Sharp in Gale crater contains ~5 km of strata that may span the transition in Mars’ climate from conditions favoring clay formation to those favoring sulfate formation [2,6,7,8]. Continued in situ investigation of these units by the Curiosity rover in the coming months and years will provide a detailed view of the nature of this mineral transition and associated processes. Morphologic and mineralogical attributes that occur throughout Mt. Sharp are of interest, as these imply spatially extensive processes that occurred within Gale, not simply local conditions. One such feature is transition in tonality of strata [2] that overlie the lacustrine sequence observed thus far by Curiosity [1]. Here we present mineral maps (Fig. 1) of newly processed CRISM images to examine the broad context of the mineralogical stratigraphy of Mt. Sharp and the nature of this light-dark-light transition in particular (Fig. 2). We find that this transition corresponds to the changes in mineralogy, primarily sulfate hydration state, and appears to be present throughout Mt. Sharp. In situ observations are necessary to determine whether this transition is primary or diagenetic, and the Curiosity rover is likely to cross this transition as it moves stratigraphically up through the sulfate section that superposes the clay-bearing unit (Fig. 1b).

Methods: Stratigraphic variations in mineralogy are documented using nine CRISM images (Fig. 1a) processed using a corrupted linear spectral mixing model (CLMM), which reduces the effects of instrument noise and atmosphere [3,4]. Mineralogical mapping is performed using CRISM spectral parameters [5], and mineral detections are verified by manual inspection of individual pixels. HiRISE and CTX data are also used to assess the geologic context and geomorphology.

Results: Sulfate spectra (Fig. 2) are consistent with Mg sulfate, and both monohydrated (most consistent with kieserite) and polyhydrated (PHS) forms are present. The stratigraphic boundary between sulfate hydration states is sharp at the orbital scale. The entire mound appears to be affected by a throughgoing transition in sulfate hydration state and/or composition (Figs. 1,2). The lower light-toned region is spectrally dominated by PHS; in some locations it is spectrally mixed with Fe-Mg smectite and in some localities it transitions laterally to clay-dominated spectral signatures but is not spectrally mixed (Fig. 1 b,c). This light-toned zone transitions to the dark-toned zone that contains kieserite, which is then overlain by the more spectrally pure PHS. This upper light-toned PHS area hosts the “marker bed” [2].

Discussion and implications: The light-dark-light tonality transition observed around Mt. Sharp corresponds to the same mineralogical transition, suggesting that this is a coherent package of strata that is enriched in sulfates with lesser clay that exists throughout the entire mound. Because of their high solubility, it is unlikely that the Mg sulfates represent a detrital component. As presumably authigenic phases, they represent chemical precipitates formed by primary (direct precipitation from water column) or diagenetic (early or late) processes. Determining whether they are primary or diagenetic requires rover-scale observations of whether the transitions conform to stratigraphic boundaries, the textural attributes of
the strata, and occurrence relative to other components in the rocks. However, the approximate vertical distance between the upper and lower transition (or the vertical thickness of the kieserite enriched strata) varies significantly around Mt. Sharp (Fig. 3). The thinnest exposure is 38 m vertically, while the thickest is 393 m. Although the geologic context is unknown, based on the current range of dip values measured in Gale crater [9], the geometry of bedding alone cannot account for this significant difference in apparent thickness.

Furthermore, the coexistence of mono- and polyhydrated Mg sulfates is notable as it would imply that two forms of hydrated Mg sulfate co-exist under current surface conditions. This represents a disequilibrium condition and would likely indicate two different formation mechanisms for these sulfate phases [10]. Information on the distribution, chemistry, and hydration state of sulfates in the mound can help constrain the past conditions of this environment, including during deposition within Lake Gale and post-depositional diagenetic processes. For example, it is possible that the observed mineralogical transition formed primarily during lacustrine deposition as the lake became increasingly saline, with patchy clay layers in the lower light-toned zone representing lateral variability in conditions during this dynamic time. Another option is that the sulfates could represent primary precipitates that formed after the canonical “drying out” of the martian environment, representing post-lacustrine episodes of aqueous activity (e.g., playa-like environments) at the planet’s surface. Alternately, the sulfate minerals could represent an entirely diagenetic signature associated with groundwater infiltration or mobility of basinal brines, possibly into porous sandstones, with lateral variation recording the pathways of diagenetic fluids.

The generally through-going nature of these mineralogical zones and their associated morphologies suggests that whatever process created them occurred throughout Mt. Sharp. This suggests that at least some processes documented along the rover traverse are applicable to the crater environment as a whole. Curiosity will approach these sulfate transitions during its extended mission, offering the opportunity to observe these mineralogical changes in situ. This will allow for placing these transitions in a clear geologic context, which in turn can be used to test possible formation hypotheses and lend insight into the lateral and temporal evolution of the climate and fluid history in Gale crater during and/or after its lacustrine period.

References: