VARIABLE BEDDING ORIENTATIONS WITHIN THE CLAY-SULFATE TRANSITION, GALE CRATER, MARS. M. L. Turner[1] and K. W. Lewis[1], [1]Dept. of Earth and Planetary Sciences, Johns Hopkins University, Baltimore, MD, USA (mturner@jhu.edu)

Introduction: The Curiosity rover has been traversing Gale Crater and Mount Sharp, a 5km high sedimentary mound at the center of the crater, since landing in 2012. Curiosity has revealed a complex depositional and diagenetic history within this field site [1]. Curiosity's route up Mount Sharp involved travel through a region which shows a large shift from clay-bearing rocks to sulfate-bearing rocks which was first captured from orbital data [2]. This transitional zone spans several 10s of meters vertically, and is hypothesized to mirror global shifts in stratigraphy due to large scale climatic shifts or changes in depositional environment [2,3]. Because of this, it is important to understand how this transition is preserved within the rocks at Gale crater, in order to better characterize the environmental changes reflected in the stratigraphic record.

We address this by examining geometries of exposed bedrock encountered in situ along the traverse and from the bedding identifiable from orbit using topography derived from stereo imagery. In this study we use both of these methods in order to analyze layering identified in the Clay-Sulfate transition zone, a structurally complex region of Mount Sharp encountered by the Curiosity rover. With these data, we can better understand variations in the different scales of bedding within the study area, and assess how they relate to bedding elsewhere on Mount Sharp.

Methods: The study area is located in the Clay-Sulfate transition region, as it was encountered by the rover approximately from Sols 3200 to 3355. The site contains several arcuate ridges identifiable from orbit with alternating recessive and resistant bedrock. We utilize stereo imagery from the Mars Reconnaissance Orbiter (MRO) High Resolution Imaging Science Experiment (HiRISE) instrument for analysis of the larger scale geomorphic features in the region while the local bedrock is analyzed with the stereo imagery from the Curiosity rover's Mast cameras (Mastcam) when encountered within a 10 m distance from the rover. Identifiable layers are traced on the original images. From these traces, the corresponding [x y z] data are extracted for each pixel and a planar surface is fit to the 3-dimensional trace using ordinary least squares linear regression. Regression is performed in a rotated coordinate system [x' y' z'] for layer profiles from Mastcam stereo images, where z' is always along the camera's optical axis for each image. This allows for a minimization of error aligned downrange from the camera look-direction.

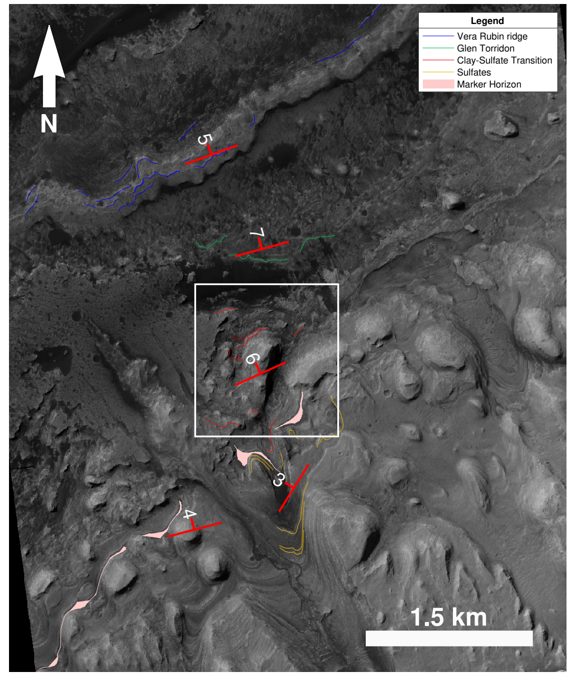

Figure 1: Map showing the northwestern flank of Mount Sharp with layer measurements from HiRISE orbital stereo of key regions of interest including the Vera Rubin ridge (blue), Glen Torridon (green), the Clay-Sulfate transition zone (red), the Sulfates (yellow), and the marker horizon (pink). Dip symbols display an average result of the measurements for each region. The study area is outlined with the white box.

Results: Our resulting dataset incudes 217 measurements from 18 mosaics at different locations in this region from Mastcam stereo and 43 measurements from HiRISE orbital stereo (Fig. 1, 2). Dips of different notifiable regions from orbit seem to converge to a shallow dip to the northwest, although there is a possibility of more local changes in steepness as shown in Figure 1. Data from Mastcam stereo allow us to measure strata exhibiting a variety of depositional facies, including cross-stratification. In addition, because of the large topographic relief of some of the features along the traverse, bedding can be quantitatively evaluated vertically both along the traverse and within single mosaics. Furthermore, in much of the traverse through the Clay-Sulfate transition, layers that are immediately alongside the rover path are not easily identifiable in orbital imagery. This broadens the importance of Mastcam data in this region by allowing us to probe the stratigraphy that we are unable to measure with HiRISE. Overall, results from Mastcam stereo show local agreement within single mosaics, but are more variable from site to site, which we attribute to occurrences of cross-bedding, as has been proposed by past long distance observations [4]. This is exemplified in the distribution of layer azimuths, or dip directions (Fig. 3). The more variable orientation of layer azimuths may reflect a more common presence of cross-bedding. Overall, results from both km- and mm- to cm- scale bedding allow us to demonstrate the transitions recorded in this region, and the contrast between bedding captured both from orbit and the Curiosity rover. Additionally, results from Mastcam stereo can be mapped based off of vertical height in the stratigraphic column in order to show sharp transitions in bedding.

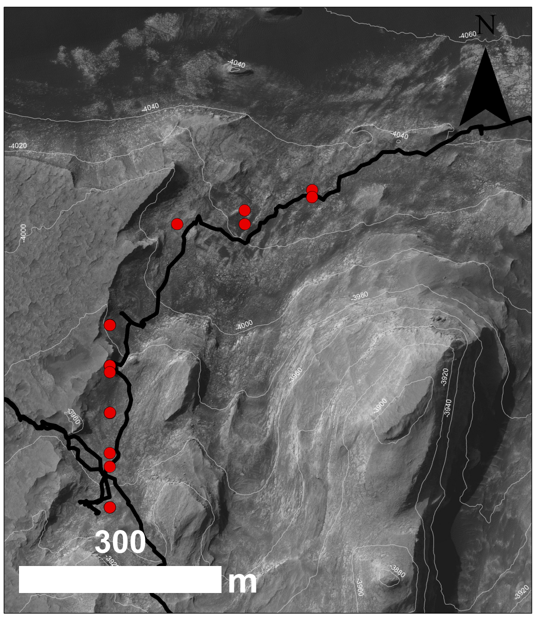

Figure 2: Map of locations along the traverse route in the Clay-Sulfate transition zone where Mastcam stereo was utilized for data collection.

This allows for a quantitative reflection of the cross-stratification shown in Mastcam images, and demonstrates how physical properties of the bed-sets change up section. These physical characteristics (ex. dip direction, scale) can aid in understanding environmental constraints at the time of deposition.

Together these data allow us to further understand the environments preserved within the Clay-Sulfate transition, and how those conditions differ from those represented in underlying stratigraphy. Analyses of Mastcam data in direct comparison with stratigraphic height allow us to further probe for details about cross-stratified rocks. Furthermore, the combined dataset allows for a large-scale view of the transitions in structure of the rocks at Gale encountered by the rover in a key stratigraphic interval.

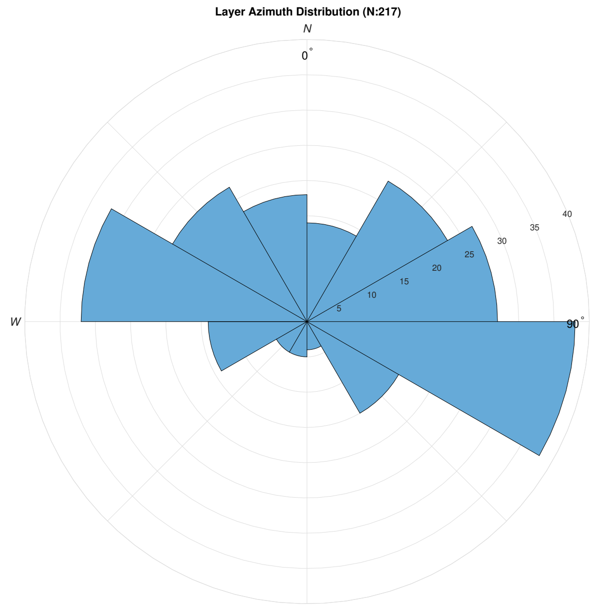

Figure 3: Rose plot displaying the total distribution of layer azimuths (dip directions) calculated from Mastcam traces in the Clay-Sulfate transition zone. The results show a highly scattered distribution of dip directions, consistent with cross-stratification, as discussed by Rapin et al. (2021).

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References

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