USING MULTISPECTRAL IMAGERY OF FLOAT ROCKS TO PREDICT UPCOMING STRATIGRAPHY AT GALE CRATER. T. E. Trigler, J. Buz, C. S. Edwards, M. M. Rice, M. Starr, C. Seeger, Northern Arizona University Department of Physics and Astronomy, Flagstaff, AZ (tet48@nau.edu), Western Washington University Department of Geology, Bellingham, WA

Introduction: Float rocks, “pieces of rock that have been removed and transported from their original outcrop” [1], are often thought of as inferior to in situ rocks for the purposes of geologic mapping [1]. However, in the case of a stratigraphy too thick to fully explore, as may be the case of the Mars Science Laboratory (MSL) mission at Gale crater [2], we hypothesize that float rocks offer invaluable glimpses into overhead, perhaps never to be visited, geologic layers.

The MSL Curiosity Rover was sent to Gale crater on Mars with the goal of assessing past habitability within an ancient lake environment [2]. Within Gale Crater lies a ~5-km tall sedimentary mound, informally known as Mt. Sharp, with a stratigraphy observable from orbit showing a progression from clay-bearing to sulfate-bearing strata [3–6]. The materials within and around Gale crater show evidence for a gradation of multiple potentially habitable environments [2,7,8].

Curiosity has been exploring Gale Crater with the aid of eleven scientific instruments since its arrival in August 2012. One of these instruments, the Mast Camera (Mastcam), is composed of two camera systems mounted on a rotating, sensing mast, two meters above the surface, that have the ability to take multispectral images between the wavelengths 445-1013 nm [9]. These images can be used to constrain mineral compositions and surface properties present on the surface of Mars [9,10].

The stratigraphy of lower Mt. Sharp is roughly flat-lying [7] with younger layers at higher elevation (i.e., uphill). Therefore we can assume that in most cases float rocks are either coeval or younger than the bedrock surrounding them. The exception to this would be meteorites or impact debris, which we expect to be rare. Curiosity rover has been climbing Mt. Sharp and observing in-situ and float rocks along the way with the Mastcam instrument. If float rocks display a different spectral signature than the surrounding bedrock, it may be possible to determine the overlying layer from which they originated. Identifying and analyzing these outliers may allow for predictions to be made about the stratigraphy of the higher elevations of Mt. Sharp, that Curiosity will not be able to explore.

Methods: As a test of our hypotheses we are attempting to identify float from early in the mission which shares spectral similarities to bedrock from later in the mission. Regions of interest (ROIs) have been created on outcrops and rocks present in the Mastcam images. Pixels within these ROIs are averaged and input with classification as float or bedrock within the Western Washington University spectral database [1] and Mastcam Spectral Plotter (MSP) [12] (Figure 1).

We have adapted common spectral parameters for mafic and clay minerals that have distinct absorptions within the wavelength range of Mastcam [13–15] in order to plot and compare slope, band depth, and ratios for ROIs. Float rock spectra can be plotted using the MSP program, along with spectra from in situ rocks to show trends between the rocks’ band depth (Figure 2A) and elevation. For example, iron bearing minerals show an absorption in the 1-μm range, where several Mastcam filters exist (Figure 2B), and therefore can be identified by their reflectance in relation to these band depths.

We have analyzed the full set of Mastcam multispectral images from MSL and identified additional float rocks for further investigation.

Figure 1) Example Mastcam decorrelation stretch image (sol 1608, seq ID mcam08215) with filters L1, L5, and L6 depicting the differences between a float and in situ rock. Colored polygons are examples of regions of interest. These ROIs are classified as either float or in situ rock.

Results: Spectral parameters and their ranges vary with elevation (Figure 2A). Spectral changes within the suite of float rocks mimic the trends observed within the suite of in situ rocks, however, the two suites of spectra
do show some differences (Figure 2A/C). In many instances, the float rocks demonstrate a broader range within a calculated parameter when compared to in situ rocks (Figure 2A). This leads us to believe that there is sufficient evidence that the mineralogy of these float rocks is, in many cases, is not the same as the surrounding bedrock.

**Future Work:** So far our work has centered on analysis of entire suites of spectral parameters. We will do statistics on these suites to demonstrate their differences. We have and continue to identify additional float rock ROIs to add to the Western Washington University spectral database. Once complete, we will begin detailed spectral analysis on individual Mastcam images, to reduce effects of atmospheric variation and viewing geometries. We will compare textural and morphological differences between the float and in situ rocks using Mastcam with additional help from the Mars Hand Lens Imager and ChemCam Remote Micro Imager, also on board MSL. We will do detailed spectral analysis on float rocks that show particularly unusual characteristics (fall outside the normal distribution of minerals ) when compared with surrounding materials to potentially identify materials sourced from outside of Gale Crater, e.g., meteorites and impact debris.

As we collect more data and strengthen our hypothesis, we will create a stratigraphic graph of the layers of Mt. Sharp to further our understanding of the processes that took place on the Martian surface in and particular in Gale Crater.

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Figure 2 A) Band depth in the broad 1-μm absorption feature for float (red) and in-situ (black) rocks. Dashed lines represent lithological boundaries observed throughout the mission. B) Vis-NIR spectra of two common iron bearing minerals, goethite and hematite, with Mastcam filters used for the band-depth calculation overlaid. C) Spectra from float and in situ rock from Figure 1, highlighted in Figure 2A.