USING MARDI TWILIGHT IMAGES TO ASSESS VARIATIONS IN THE MURRAY FORMATION WITH ELEVATION, GALE CRATER, MARS. M.E. Minitti[1], M.R. Kennedy[2], G.M. Krezoski[2], S.K. Rowland[3], J. Schieber[4], K.M. Stack[5], and R.A. Yingst[1], [1]Planetary Science Institute (1700 E. Fort Lowell, Tucson, AZ, 85719, minitti@psi.edu), [2]Malin Space Science Systems, San Diego, CA; [3]University of Hawai'i at Mānoa, Honolulu, HI, [4]Indiana University, Bloomington, IN. [5]Jet Propulsion Laboratory, Pasadena, CA.

Background: The Mars Science Laboratory Curiosity rover arrived at the Murray formation, identified as the basal unit of Aeolis Mons (informally known as Mt. Sharp) on Sol 753. From that time to the present (Sol 1555), Curiosity has traversed ~6 lateral km and ~125 m of elevation of the Murray formation, with two significant interludes within the Stimson formation, from Marias Pass to near Bridger Basin (Sols 1071-1127) and at the Naukluft Plateau (Sols 1281-1344). The Murray formation is hypothesized as a lake deposit [1], and observations of it along the traverse reveal laminations, diagenetic aggregates and veins of varying morphologies that provide insight into the depositional and post-depositional history of the Murray [1]. The Mars Descent Imager (MARDI) has systematically documented the character of the Murray along the rover traverse by acquiring images of the materials under the rover after each drive. MARDI images, with their consistent resolution and illumination, provide a valuable record of variations in Murray character with rover elevation. These observations are reported here.

MARDI: MARDI is a fixed-focus, nadir-pointing color camera attached to the bottom of the rover chassis. MARDI's chief mission task was to record Curiosity's descent and landing, but since landing, MARDI has acquired images on the surface that enable systematic study of clast size, spacing and distribution [2], and elements of surface roughness and texture that support the characterization of different terrain types traversed by the rover [3]. MARDI achieves ~1 mm/pixel resolution over a ~92 x 64 cm patch of ground behind the left front wheel of the rover.

Since Sol 310, MARDI has consistently acquired images of the ground beneath the rover after a drive, thus systematically documenting the materials traversed by the rover. These images are acquired 20-50 minutes post-sunset, as diffusely illuminated surfaces mitigate scattering of light off the dusty front lens element. A series of processing steps geometrically and radiometrically corrects MARDI images as well as sharpens them.

Observations: MARDI observed a range of features in the Murray including laminations; mm- to cm-sized aggregates; sulfate veins of varying morphology; and color variations (buff, gray, red, purple, orange; Fig. 1).

Laminations. Laminations are regular, thin (1-2 mm), parallel layers that can be traced for distances from a few cm to 80 cm (Fig. 1a). The degree of lamination expression ranges from strong (distinctive, coherent layers present across m^2-sized footprints) to weak (muted layers present in isolated cm^2-sized footprints). The fine-grained nature of the laminated bedrock (mud to siltstone; grain diameters <62.5μm) supports interpretation of the Murray as a lacustrine sediment [4] .

Aggregates. Aggregates are mm- to cm-sized structures with varying morphologies (rounded, pancake, dendritic) that are more resistant to erosion than surrounding bedrock (Fig. 1b). Aggregates are observed to cut across laminations without deforming them, suggesting the aggregates are post-depositional diagenetic features [1,5].

Veins. Veins of Ca-sulfate (determined in part by ChemCam measurements [e.g., 6]) assume a variety of morphologies. Straight veins are mm- to cm-wide and decimeters to meters in length (Fig. 1b). Irregular veins are mm-wide and cms- to decimeters in length, crosscutting bedrock in curvilinear patterns. Layered veins are mm-thick patches or sheets of sulfate concordant to local bedding, which is commonly horizontal. Hashed veins are mm-wide and cms- to decimeters in length that crosscut one another in perpendicular or quasi-perpendicular patterns (Fig. 1c).

Color. MARDI images are not color calibrated absolutely, but relative color comparisons among MARDI images are possible as the gray rover wheel visible in nearly all MARDI images allows the images to be consistently white and gray balanced. Additionally, relative color differences are sometimes apparent within a single image (Fig. 1c). The Murray formation takes on a range of colors including tan, red, buff, purple and gray (Fig. 1).

Preliminary Results: MARDI recorded variations in Murray formation characteristics with elevation including the presence (or lack) of laminations, diagenetic aggregates and hashed veins. Color variations were also apparent, as red and purple colors became more prominent as hematite became the dominant Fe-oxide within drilled Murray samples [7].

Changes in Murray characteristics with elevation will be analyzed to understand their implications for variations in depositional conditions and/or post-depositional alteration.

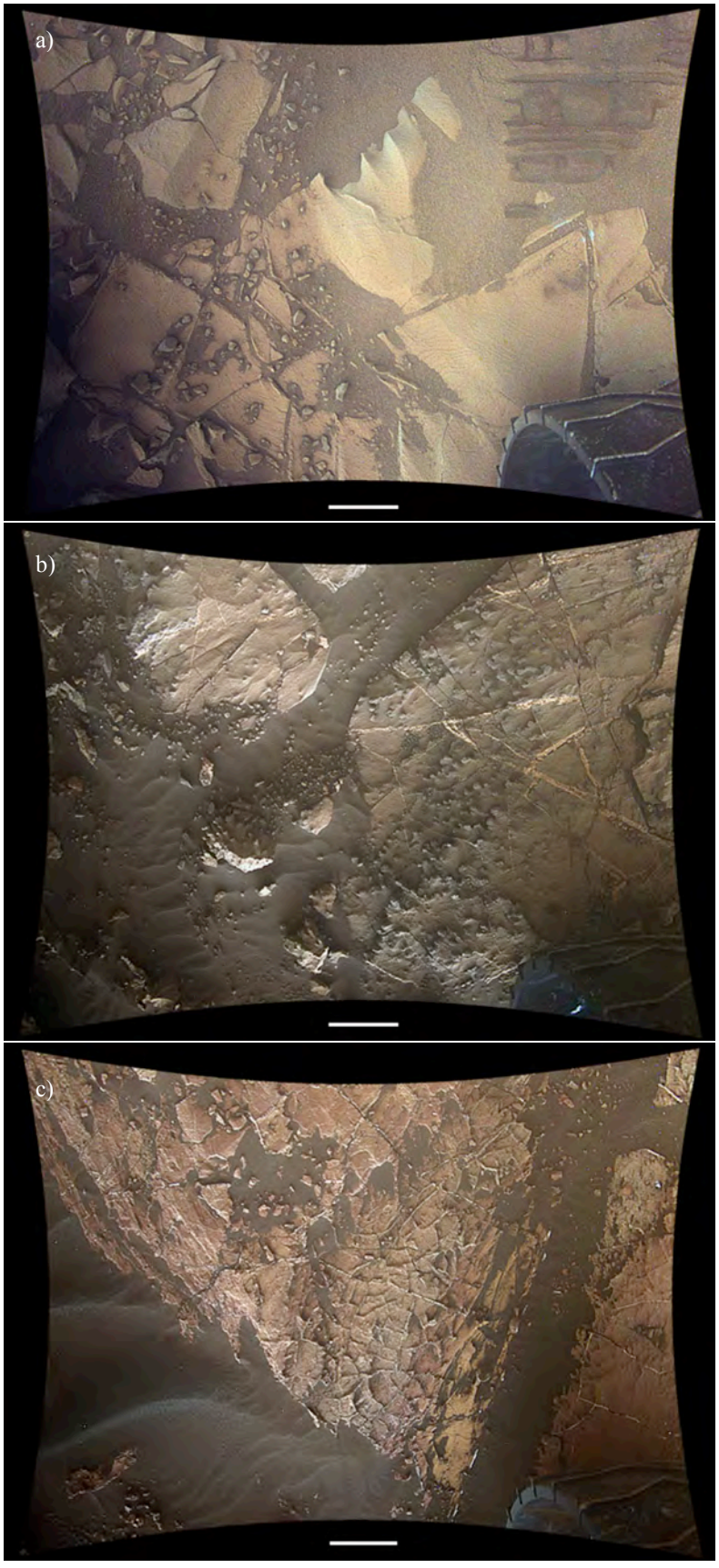

Figure 1: Variations in Murray character observed in MARDI twilight images. Scale bar on each image is 10 cm. a) mm-scale laminations (Sol 792), b) mm-scale laminations, cm-scale nodules and mm- to cm-wide straight sulfate veins (Sol 1255), c) mm-scale laminations, hashed veins and color variations (tan, red and buff) (Sol 1555).

References: [1] Grotzinger, J.P. et al. (2015) *Science*, 350, DOI: 10.1126/science.aac7575. [2] Garvin J.B. et al. (2014) *LPSC XLV,* Abstract #2511. [3] Minitti M.E. et al. (2014) *AGU,* P43D-4016. [4] Stack, K.M. et al. (2015) *LPSC XLVI,* Abstract #1994. [5] Kah, L.C. et al. (2015) *LPSC XLVI,* Abstract #1901. [6] Nachon, M. et al. (2016) *Icarus*, http://dx.doi.org/10.1016/j.icarus.2016.08.026. [7] Rampe, E.B., et al. (2017) *LPSC XLVIII*, this vol.