MAPPING THE PAHRUMP HILLS OUTCROP USING MARDI SIDEWALK MOSAICS.

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Introduction: With her arrival at the base of the Pahrump Hills outcrop on Sol 753, the Mars Science Laboratory Curiosity rover began her exploration of the foothills of Aeolis Mons (i.e., Mt. Sharp). The Pahrump Hills, which encompass ~15 meters of vertical section, are a part of the Murray formation, which represents the basal layer of Mt. Sharp. The science team chose to interrogate the geology and chemistry of Pahrump with a series of campaigns, including a reconnaissance imaging survey of the outcrop to identify and characterize the lithologies present (Fig. 1). The findings from the reconnaissance campaign guided the subsequent contact science campaign to study the sedimentary structures, grain size distributions, diagenetic textures and chemistry of a subset of the identified lithologies [1]. These findings have in turn informed current sampling activities at Pahrump.

During the reconnaissance campaign, the most continuous record of the outcrop was acquired by the Mars Descent Imager (MARDI) operating in “sidewalk” video imaging mode. Images collected in sidewalk mode during each drive of the campaign enabled the creation of a mosaic of the ~152 meter drive path. The goal of this work is to create a geologic map of the sedimentary structures with the Pahrump Hills outcrop from the MARDI sidewalk mosaic, document the lateral variability of structures both across and along strike, and gain insight into the depositional and diagenetic processes represented by the observed sedimentary structures and diagenetic textures.

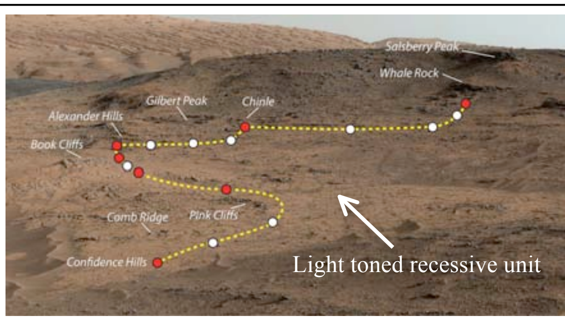

Figure 1: Reconnaissance campaign (yellow line) across the light toned recessive unit [5] of the Pahrump Hills outcrop. Red spots mark locations of end-of-drive imaging or sampling. White spots mark locations of mid-drive imaging. Labels mark prominent outcrops that were the focus of further study. *Image PIA19039 (NASA/JPL/MSSS).*

MARDI and Sidewalk Background: MARDI is a fixed-focus, nadir-pointing color camera attached to the bottom of the rover chassis above the left front wheel. 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 geotechnical analysis of terrains traversed by the rover [3]. MARDI achieves ~1 mm/pixel resolution over a ~92 x 64 cm patch of ground underneath the rover.

In sidewalk mode, MARDI acquires images at a constant pace (one image/three seconds) during a drive, but onboard software only saves an image if it is significantly different than the previously saved image. This technique yields MARDI images with at least 75% overlap. All MARDI images saved during a sidewalk video activity are located in MARDI’s internal flash memory, and review of the image thumbnails allows us to select which frames from a given sidewalk are returned to Earth. A result of the significant overlap of the sidewalk images is that a complete mosaic of the drive path can be created using only every third frame of a sidewalk, thus reducing the downlink data volume necessary to create the mosaic. However, to produce digital elevation models with mm-scale error levels, consecutive frames must be downlinked [3,4].

During the reconnaissance campaign, sidewalk videos were acquired on Sols 780, 785, 787, 790, 792, 794 and 797. Only Sol 787 failed to yield a continuous record of the drive, for reasons not fully understood, leaving 1-6 meter gaps in the mosaic. Mosaics were created from geometrically corrected full frame images using the open source software Hugin (http://hugin.sourceforge.net).

Sedimentary Structures: There are a variety of primary and secondary sedimentary structures observed throughout the Pahrump Hills outcrop, and their distributions and relationships can be tracked in the MARDI sidewalk mosaic.

Laminae. Laminae are defined as thin (mm-scale) parallel layers that can be traced over tens of centimeters (Fig. 2). They are restricted to the light-toned recessive unit ([5] and Fig. 1), and they are observed only intermittently across the traverse. They are most prominent near the base of Pahrump (e.g., Confidence Hills drill site) and between the Alexander Hills and Chinle waypoints (Fig. 1). Mars Hand Lens Imager (MAHLI) observations indicate that they consist of laminae with abundant crystals of an as-yet-undetermined evaporite mineral (in a fine-grained matrix) that alternate with fine-grained laminae. Fine-grained is ≤60 μm, as constrained by the highest resolution utilized by MAHLI on these features (~20 μm/pixel).

Figure 2: Laminae visible in a cropped portion of one frame of the Sol 790 sidewalk video (0790MD0003330010102841M01). Image is radiometrically and geometrically processed, filtered and sharpened, white balanced, gray matched and stretched. Field of view is ~60 cm wide.

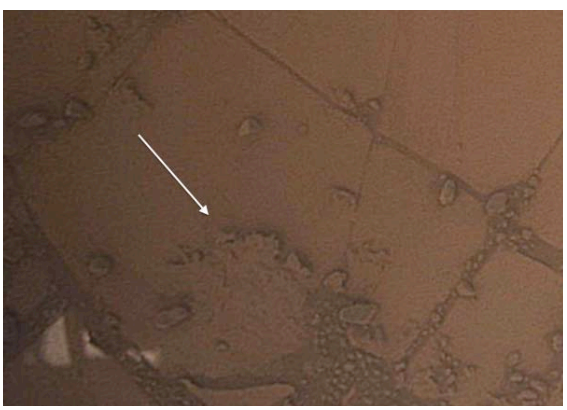

Figure 3: Cluster of resistant material (arrow) visible in a cropped portion of one frame of the Sol 780 sidewalk video (0780MD0003270010102631M01). Image is processed as in Fig. 2. Field of view is ~30 cm wide.

Clusters. Clusters are defined as resistant features that are embedded in the recessive unit of Pahrump. Clusters first observed at the Confidence Hills drilling site at the base of the Pahrump Hills have dendritic morphologies, but other morphologies are also observed (Fig. 3) [6]. They occur within individual bedrock slabs, or emanate from fractures or veins that cut the bedrock. Mg and S enrichments in the clusters relative to the bedrock host material are observed by both ChemCam LIBS and APXS [7,8]. Their structure and chemistry suggest clusters are diagenetic in origin, formed after lithification of the recessive unit because the clusters do not deform laminae within the bedrock.

Veins and fracture fills. Light toned veins and fracture fills typically <5 mm in thickness (Fig. 4) are distributed throughout Pahrump. They exhibit multiple morphologies, from straight over tens of centimeters, to curvilinear. In some instances, they occur with clusters along the same fracture. ChemCam LIBS analyses of veins indicate they are enriched in Ca and S relative to the surrounding bedrock [7].

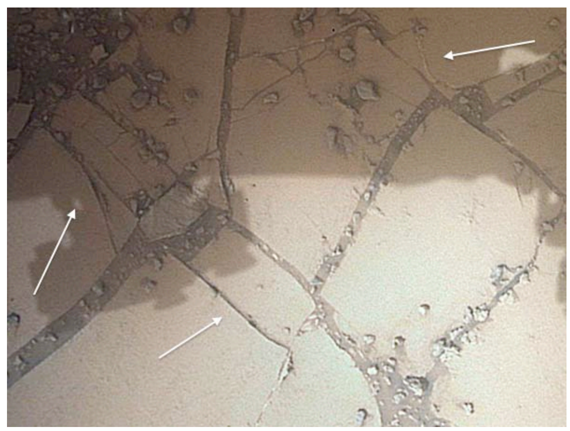

Figure 4: Thin veins and fracture fills (arrows) visible in a cropped portion of one frame of the Sol 797 sidewalk video (0797MD0003390010103534M01). Image is processed as in Fig. 2, but is not stretched. Field of view is ~30 cm wide.

Additional Work: The nature, distribution and relationships of laminae, clusters and veins across the Pahrump Hills will also be cross-checked against complementary Mastcam imaging acquired during the reconnaissance campaign, and be further refined through close-up MAHLI observations.

References: [1] McBride, M.J. et al. (2015) *LPSC XLVI,* this vol. [2] Garvin J.B. et al. (2014) *LPSC XLV,* Abstract #2511. [3] Minitti M.E. et al. (2014) *AGU,* P43D-4016. [4] Garvin J.B. et al. (2015) *LPSC XLVI,* this vol. [5] Stack, K.M. et al. (2015) *LPSC XLVI,* this vol. [6] Kah, L.C. et al. (2015) *LPSC XLVI,* this vol. [7] Nachon, M. (2015) *LPSC XLVI,* this vol. [8] Thompson, L.M. (2015) *LPSC XLVI,* this vol.