CHARACTERISTICS AND ORIGIN OF A CRATERED UNIT NEAR THE MSL BRADBURY LANDING SITE (GALE CRATER, MARS) BASED ON ANALYSES OF SURFACE DATA AND ORBITAL IMAGERY.
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Introduction: Before landing, the MSL landing ellipse was divided into quadrants to be mapped by contributing scientists. Later, the mapped quads were compiled into a single map consisting of six geomorphic units [1] which are the alluvial fan material (AF), light-toned, bedded, fractured unit (BF), cratered plains/surfaces (CS), smooth hummocky plains (HP), rugged terrain (RT), and striated light-toned outcrops (SR). The units were mapped and named almost exclusively on their textural and albedo characteristics.

Objective: This project focuses on the cratered plains/surfaces (CS). The first objective was to create a detailed geomorphic map (Fig. 1) of the original CS unit mapped in [1]. Characteristics used to subdivide the CS unit include differences in albedo, crater density, and erosional state of crater rims. This map highlights the stratigraphic and geomorphic differences in the CS unit. The second objective was to investigate the geologic origin of the CS unit. Both efforts are ongoing. The MSL science team has proposed various formation mechanisms for the CS unit including volcanic and sedimentary processes.

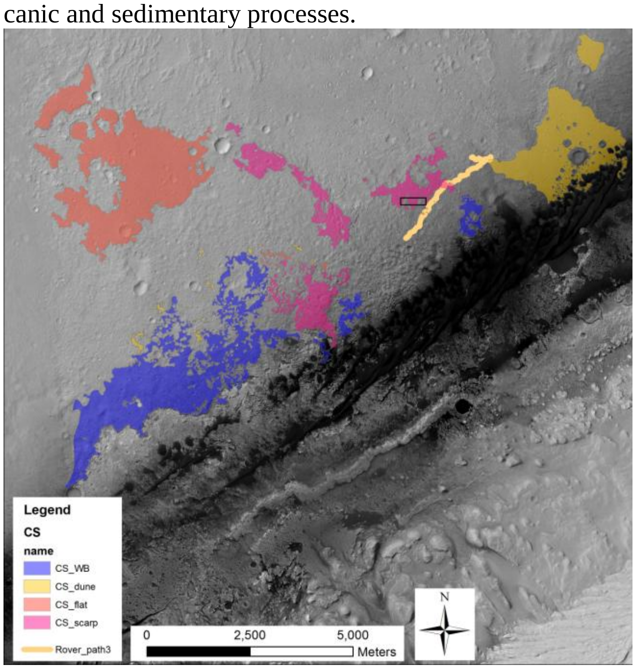

Figure 1: Detailed geomorphic map of the CS unit subdivisions. The black box shows the location of figure 4.

Methods: This project has relied mostly on images from the High Resolution Imaging Science Experiment (HiRISE) [2] onboard the Mars Reconnaissance Orbiter (MRO). The two instruments onboard Curiosity that are particularly useful for mapping the geology of Gale Crater include the Mars Hand Lens Imager (MAHLI) [3, 4] and the two mast cameras (Mastcam) [4]. These are the latest additions to an extensive suite of cameras imaging the Martian surface. Combining orbital and surface images helps correlate surface textures to regional geologic differences seen in the orbital images.

Cratered Surface

Unit Description As its name implies, the CS unit retains impact craters better than any other units in the Gale landing ellipse. Additionally, in HiRISE the margins of most CS outcrops consist of a scarp (Fig. 2). This scarp implies that the CS unit is more resistant to erosion than the units beneath.

The most distinct geomorphic characteristic of the CS unit, as seen in the HiRISE images, is a high crater density. The high crater density implies either that the CS unit has been exposed on the surface longer than any other unit in Gale Crater, or that it preserves craters better. Because it is the uppermost layer in much of our study area (and therefore stratigraphically young), we prefer the latter explanation. In Mastcam images (Fig. 3), the CS unit is characterized by a variety of surface features. The base of the unit appears to be composed of fine grained material. Sitting on top of the fine grained material are numerous boulders of various sizes. The boulders range from angular to rounded in shape and are poorly sorted. The boulders appear rugged and vary in color; some are a dark black color whereas others are lighter brown. Aside from the boulders the CS unit also consists of outcrops of lighter toned, rugged material (Fig. 3).

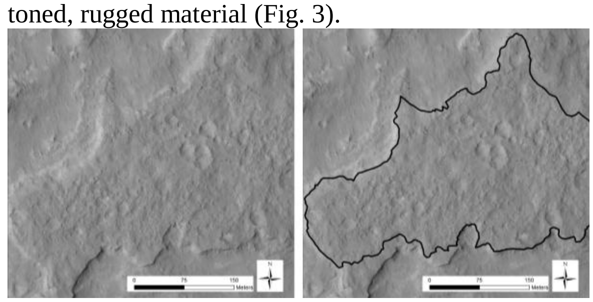

Figure 2: Plain and annotated HiRISE image (ESP_018920_1755) showing a portion of the CS unit scarp.

Figure 3: This image is a mosaic of three Mastcam_right images taken on sol 407, showing an outcrop of the CS unit (above the dashed line). The CS unit is ~47m away from the rover's position as of sol 406. Unfortunately this is as close as the rover has come to an outcrop of the CS unit. The images used for this mosaic are http://mars.jpl.nasa.gov/msl-raw-images/msss/00407/mcam/0407MR1687006000E1_DXXX.jpg, http://mars.jpl.nasa.gov/msl-raw-images/msss/00407/mcam/0407MR1687005000E1_DXXX.jpg, and http://mars.jpl.nasa.gov/msl-raw-images/msss/00407/mcam/0407MR1687004000E1_DXXX.jpg

Unit Geomorphology HiRISE images show that the CS unit surrounds and partially infills some larger crater floors, but doesn't bury the crater rims (Fig. 4). This suggests that the CS unit might have been emplaced laterally by some sort of flow process. Volcanic possibilities include lava or pyroclastic flows. Alternatively, if the CS unit is a sedimentary flow, it could be a submarine sediment avalanche. Regardless of its origin, the isolation of topographic highs indicates the ability to be emplaced laterally over very gradual underlying slopes (Fig. 5c).

An alternative hypothesis is that the isolation of topographic highs indicates preferential downward erosion of the CS unit relative to the underlying material (which develops the topographic highs; Fig. 5d). The topographic highs, however, appear to be much less indurated, at least with respect to their ability to retain craters, so this downward-erosion idea is problematic.

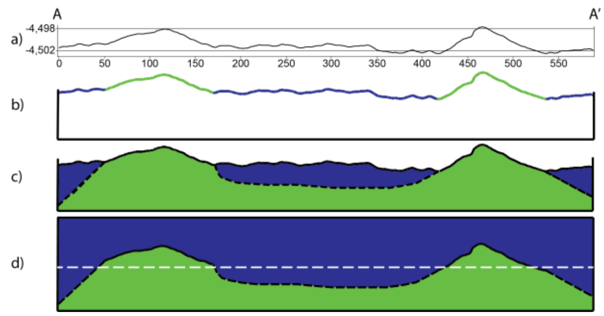

Figure 5a: Topographic profile (see location in Fig. 4). 5x vertical exaggeration. 5b: topographic profile with colors indicating surface units; blue = CS unit, green = topographically higher but stratigraphically lower crater rim. The thickness of each unit is unknown. 5c shows the interpretation of the CS unit (blue) as some sort of lateral flow which surrounded and partially buried the underlying unit. 5D shows an alternative explanation, namely that the CS unit was once much thicker and erosion to the present surface (dashed line) has lowered it preferentially compared to the underlying unit.

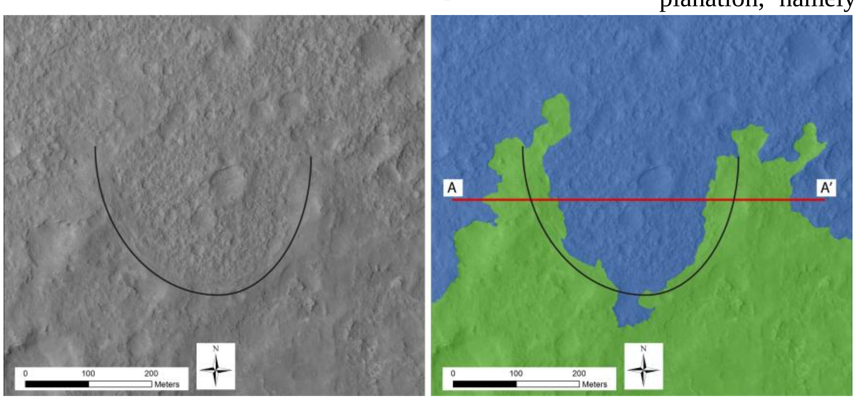

Figure 4: Portion of HiRISE image ESP_018854_1755, showing a crater (the rim is outlined in black) that has been partially infilled by the CS unit (blue). The center of this crater is ~1800 m SW of the Bradbury landing site. The highest part of the rim is 1-2 m above the nearly horizontal top surface of the infilling CS unit. Note that some of the CS unit appears to have flowed out a gap in the southern part of the crater rim. The red line shows the location of the cross section in figure 5.

Future Work: More work will be done to clarify the extent of the CS unit and how it was emplaced. Regardless of how the CS unit was formed, understanding its origin is important to understanding the geology of Gale Crater. Having rover data from a heavily cratered surface could help understand other heavily cratered surfaces in areas of Mars that are only accessible with orbiting instruments.

References: [1] Grotzinger J. P. et al. (2013) Science, submitted. [2] McEwen A. S. et al. (2007) JGR, 112. [3] Edgett K. S. et al. (2012) SSR, 170, 259-317. [4] Ghaemi, F. T. (2009) Optical Engineering, 48(10), 103002.