

LITHOLOGY AND TEXTURE OF A POTENTIAL CONGLOMERATE IN GALE CRATER AS IMAGED BY MAHLI. R.A. Yingst¹, R.M.E. Williams¹, K.S. Edgett², and L.C. Kah³, ¹Planetary Science Institute (1700 E. Fort Lowell, Suite 106, Tucson, AZ 85719; yingst@psi.edu), ²Malin Space Science Systems, San Diego, CA, ³University of Tennessee, Knoxville, TN.

Introduction: The discovery of conglomerates (coarse-grained sedimentary rocks composed of rounded fragments, >2 mm diameter, within a matrix of finer grained material) within Gale crater provided the first direct observation of water-transported gravels on Mars [1], and yielded concrete observational data from which to calculate flow depth and velocity [1, 2]. The lithology and texture (or textural arrangement) of individual particles within conglomerates are particularly critical in that they provide data concerning the nature and genesis of the parent outcrop, potential transport mechanisms, and the nature of postdepositional lithification and weathering. Because the lithology of the first observed conglomerates (informally known as Link and Hottah) could not be uniquely resolved from Mastcam images at the distance from which the rover imaged them, imaging conglomerate facies with the Mars Hand Lens Imager (MAHLI) became a high priority for the science team. MAHLI can acquire images at a resolution up to ~14 $\mu\text{m}/\text{pxl}$, allowing grain size, sorting, shape, roundness, fabric, and other characteristics to be resolved [3].

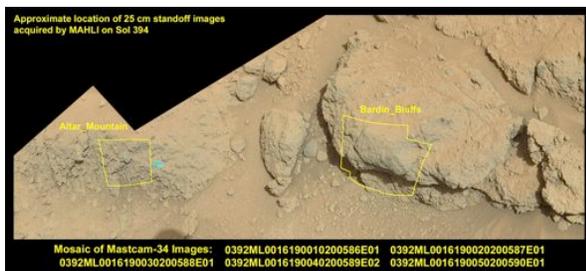


Figure 1. Mosaic of a conglomerate outcrop with locations of MAHLI images taken sols 394-398. Images acquired by the Mastcam-34 camera.

Data Collection: On sol 394 the Curiosity rover arrived at the outcrop informally known as Darwin, a conglomerate outcrop that lies approximately 1800 m from its last significant waypoint at the target Shaler, along an efficient traverse path to Mt. Sharp. MAHLI acquired 64 full-frame images of a clast-rich portion of the conglomerate (a target known informally as Bardin Bluffs), and of the material comprising the matrix (known informally as Altar Mountain). Locations where images were acquired are shown in Figure 1; the Altar Mountain target lies stratigraphically below the Bardin Bluffs target. Images were acquired at offset distances of 25 cm (100 $\mu\text{m}/\text{pxl}$), 5 cm (~30 $\mu\text{m}/\text{pxl}$) and 2 cm (~14 $\mu\text{m}/\text{pxl}$).

Observations: *Altar Mountain* (Figure 2) is a target composed of supporting material <5 mm diameter. Clasts, however, are very poorly-sorted, with individual grain sizes ranging from 22.4 mm to <1 mm, with subordinate matrix component largely below resolution. The average clast distribution skews to a larger size, with grains ranging from 4-10 mm long axis. The color variation of clasts is unclear in this target because of significant dust cover. Clasts average sub-angular to subrounded. Larger clasts stand out from the matrix, and are therefore more resistant to weathering or wear.



Figure 2. MAHLI image of the Altar Mountain target at a standoff of 25 cm, taken on sol 394.

Bardin Bluffs is a target that is more consolidated than the underlying Altar Mountain, and richer in large clasts. Capturing the internal lithology of these larger clasts was a primary imaging goal. Figure 3 shows the groundmass of this target, which is coarse-grained, but contains a larger sand-sized component than Altar Mountain. It appears poorly-sorted but context Mastcam data indicates a potential fining upwards [2]. Clast sizes range from 7 mm long axis to below resolution; the average resolvable particle in the groundmass is 200-600 microns long axis, while the population of larger particles within the groundmass averages 350-2200 microns long axis. The groundmass is a mix of light and dark particles that are subangular to subrounded in shape, with a few particles rounded; larger particles are more commonly rounded. All particles are relatively equant. Lighter particles appear more rounded, lumpy and pock-marked in texture than darker,

more fine-grained particles. It is still unclear if the color of individual grains is also associated with size, such that larger grains are darker on average.

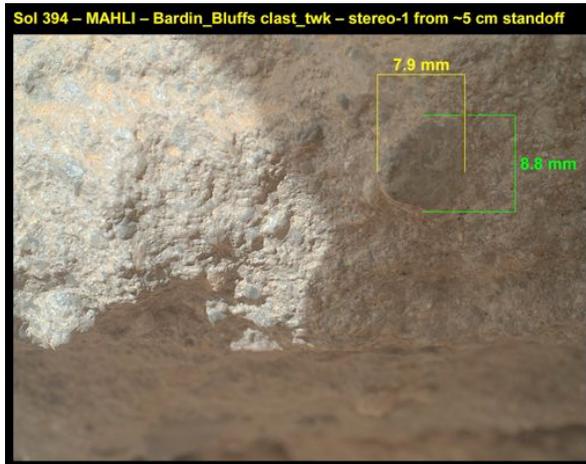


Figure 3. MAHLI image of a portion of Bardin Bluffs, taken on sol 394. The large clast in the upper right is shown in Figure 4.



Figure 4. MAHLI image of a clast embedded in the conglomerate target Bardin Bluffs. Note variation in angularity among the fragments within the clast surrounded by a matrix component with apparent flow banding.

Figure 4 focuses on a single clast within the Bardin Bluffs target. This composite clast is approximately 9 mm long axis and is comprised of black or grey, angular, elongated or blade-shaped fragments (110-120

pixels long axis), some containing a variety of paler more equant grains, embedded in a lighter toned, very fine-grained groundmass.

Discussion: One possible interpretation for the variation in roundness of light and dark particles at Bardin Bluffs is that lighter particles are less resistant to weathering and wear. Another is that these might represent multiple distinct origins of grains, with rounded, smaller grains potentially representing an earlier episode of hydrodynamic erosion and transport. For example, the lighter particles may have been rounded by fluvial transport, then mixed with a more angular (less worn) population for final transport and deposition. This would suggest, but not require, that the two populations have different lithologies.

As MAHLI did not acquire images resolving the lithology of individual mm-sized clasts at Altar Mountain, it is unclear whether the internal lithology (and therefore source) of clasts differs between the Altar Mountain and Bardin Bluffs targets. However, the fact that average clast roundness differs between the sites, and that there are potential differences in sorting, both indicate that sediment in each target has a different transport history. The low to moderate level of rounding is consistent with a high-energy, intermittent transport event such as what would occur within an alluvial fan environment [1, 2].

Finally, the high angularity of the constituent fragments within a single, large clast resolved in Bardin Bluffs, along with the very fine-grained matrix, suggest the clasts are fragments of impact breccia. The texture of mm-sized clasts only meters away (imaged on sol 400) is similar, and also displays multiply-fractured grains in a very fine-grained (potentially glassy) matrix. Taken together, the evidence indicates that at least the larger clasts in this outcrop (those for which we can resolve internal structure) are derived from a deposit of impact breccia. Although the exact source of clastic material is not known, it is likely to derive from a combination of sources internal [2] and external to Gale crater.

References: [1] Williams, R.M.E., et al. (2013), *Science*, doi: 10.1126/science.1237317. [2] Williams, R.M.E., et al. (2014), this volume. [3] Edgett, K.S., et al. (2012), *Space Sci. Rev.*, doi:10.1007/s11214-012-9910-4.