Granulometry of the Surface of Mars from the Mars Descent Imager (MARDI) on *Curiosity*: Preliminary Comparisons with Earth: J. B. Garvin[1], M. C. Malin and M. A. Ravine[2], and [3]MSL Science Team; [1]NASA Goddard Space Flight Center, Greenbelt MD 20771, [2]MSSS, San Diego, CA 92191; [3]MSL Science Team c/o Caltech/JPL. (Contact: james.b.garvin@nasa.gov; TEL: 301-646-4369)

Introduction: The Mars Science Laboratory (MSL) *Curiosity* rover provided the first high resolution descent imaging of the martian surface as part of its sol 0 (EDL) activities on August 5, 2012. The MARDI descent imaging system [1] developed at MSSS offered 1600 x 1200 pixel color frames at ~ 4 frames a second during the final several minutes of EDL, with over 1000 frames acquired after touchdown. These images have an intrinsic spatial resolution of 0.525 mm from an altitude above the surface of ~ 70 cm (on the rover), given their angular resolution (IFOV) of 0.764 milliradians and FOV of 89.35 degrees (diagonally). After touchdown, viewing the surface at nadir from the side of the *Curiosity* rover, they cover an areal FOV of ~84 cm x 63 cm at ~ 0.52 mm/pixel resolution (at a mean height of 70 cm). From an altitude of ~41 m (after initiation of the SkyCrane propulsive rocket firing phase), the MARDI resolution is ~ 3 cm/pixel across a FOV of 49 m x 37 m. In order to investigate the provenance of local geologic materials at the Bradbury Landing site, where touchdown occurred, we have analyzed representative MARDI images using classical sedimentology techniques involving granulometry [2]. In particular, our intention has been to characterize the particle (clast) size distribution (PSD) and then conduct objective, quantitative comparisons with terrestrial PSD's for reference populations for which clast provenance is well established, as in flood deposits, explosive volcanic ejecta, and so forth (e.g. [5,6]). This report summarizes preliminary analysis of MARDI data from sol 0 only as context for the remainder of the surface mission of MSL and the geologic evolution of the region.

Approach: Using a representative suite of geometrically-corrected MARDI images after touchdown, including lossless compressed frames # 1504 and 1008, we adapted particle size measurement codes developed for use with Viking Lander data [4,6] to allow detailed measurement of clast size information including the orthogonal axes (a,b) of the best fitting ellipse to a given particle, mean particle diameter (d), particle height (h), and aspect ratio (h/d), all using the available sol 0 MARDI data and documentation.

Using MARDI sol 0 frames from after touchdown we measured 211 clasts within the FOV with reproducible results for all parameters of interest. The mean diameter of this population was 1.03 cm with a variance of 0.64 cm. Most of the gravel-size particles were equant in terms of their measured aspect ratio. **Figure 1** illustrates the binned data (see data circles) and the best hyperbolic distribution model fit (red) [3].

Using a low altitude MARDI image from the final ~50 m of descent (frame # 532) acquired when *Curiosity* was ~ 41 m above the Bradbury Landing touchdown position, we were able to measure 163 discrete clasts with the same reproducible parameters as from the surface (where MARDI is positioned ~69 cm above). The distribution of clasts measured from this ~ 3 cm/pixel image is shown in **Figure 1** via the "**o**"s, and the hyperbolic distribution model "fit" is illustrated (black curve) to the right of the surface distribution (red). Both distributions capture the distribution of particles at the site from ~ 0.3 cm to ~30 cm (gravel, cobble, to small boulder) with < 0.06 RMS model fit error.

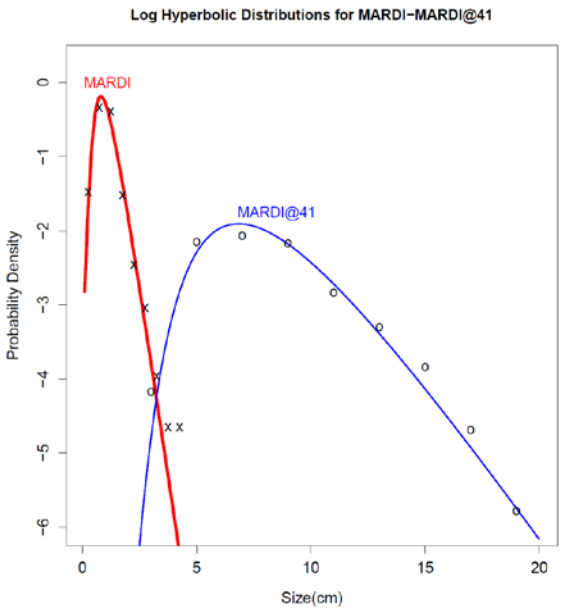

Figure 1: ***Comparison of clast size distributions from the landed MARDI images (RED) versus those taken from above (~ 41 m) prior to landing (BLUE). Hyperbolic distribution models shown with binned data represented as "x o"s. RMS values for the model fits are < 0.06 (both).***

Data Analysis: The distribution of gravels located under the *Curiosity* rover, as illustrated in **Fig. 1** (red curve), is well sorted and appears to serve as an armoring deposit in this location. It is possible that particles finer than 2-3 mm in diameter were mobilized by MSL rocket exhaust and removed, given the PSD's

very characteristic narrow appearance. In contrast, the broader distribution of particles from 4 cm to ~20 cm observed from the MARDI image acquired ~ 41 m above the surface is less well sorted and defines a distribution that appears to represent a mixed population, as at the VL-1 Site (*Mutch Memorial Station*) in Chryse Planitia [e.g., 4, 6]. When one merges the distributions independently measured from post-touchdown and pre-touchdown (from 41m above) into a single PSD, the resulting hyperbolic distribution (see **Fig. 2: "MARDI_mrg"**) illustrates aspects of sedimentary history of the Bradbury Landing site that can be contrasted with Earth [5,6] reference populations (see also **Fig. 3**).

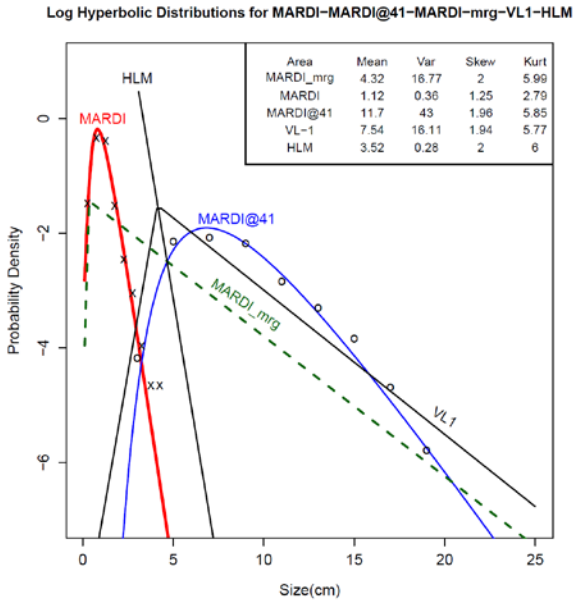

Figure 2: *Hyperbolic distribution model "fits" for the merged MARDI sol 0 population (surface and from 41m above as "**MARDI_mrg**") shown in dashed line in comparison with VL-1 Mars site and Earth reference population from Halemaumau. HLM is Halemaumau phreatic ejecta [4]. The surface (red) and that measured from 41m altitude (blue) are also shown, with measured size bins as symbols. The tail of the merged MARDI sol 0 population most closely resembles VL-1 [4] and may be an indication of a well-mixed distribution.*

Comparisons with Earth: The merged MARDI sol 0 distribution (with clasts from 0.3 to ~35 cm in diameter) most closely resembles the VL-1 distribution on Mars as measured by Garvin and others [4] (see **Figure 2**). However, there are similarities at the finer size fraction (gravels) with other terrestrial reference populations and with the surface of Venus [4]. **Figure 3** illustrates some further comparisons with terrestrial reference PSDs [4-6]. In this case the post-touchdown MARDI sol 0 gravels (red curve) show similarities with the fine fraction of Halemaumau (HLM) phreatic ejecta, and less affinity with VL-1 gravels.

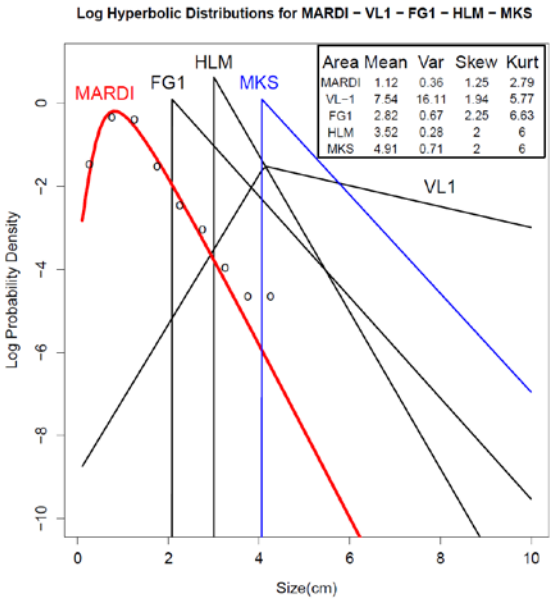

Figure 3: *Hyperbolic distribution model "fits" for the surface gravel population (RED) in comparison with Iceland flood gravels (FG1), Halemaumau phreatic ejecta (HLM), Mauna Kea pyroclastic ejecta (MKS), and VL-1. See Text.*

Conclusion: The MARDI sol 0 clast particle size distribution has been characterized at Bradbury Landing and compared with other reference PSD's using objective methods (Figs. 1-3). In general it appears that the immediate touchdown region (within 10's of meters) includes clastic particles that were emplaced in part by impact ejecta on the basis of general similarities in the coarse tails of the distributions (with VL-1 and HLM). Further analysis of the clast PSD's for the general region surveyed by *Curiosity* with its imaging suite are underway.

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