SIZE FREQUENCY DISTRIBUTIONS OF BLOCKS ON LUNAR VOLCANIC LANDFORMS: RESULTS FROM LROC. S. J. Lawrence[1,2], B. W. Denevi[3], B. R. Hawke[4], T. A. Giguere[4,5], M. S. Robinson[1], J. D. Stopar[1], T. Tran[1], B. L. Jolliff[5], D. B. J. Bussey[3], R. Stelling[1] [1]School of Earth and Space Exploration, Arizona State University, Tempe, AZ [2]samuel.lawrence@asu.edu [3]Applied Physics Laboratory, Johns Hopkins University, Laurel, MD, [4]Hawaii Institute of Geophysics and Planetology, SOEST, University of Hawaii at Manoa, Honolulu, HI [5]Intergraph Corporation, Honolulu, HI [5]Department of Earth and Planetary Sciences, Washington University in St. Louis, St. Louis, MO

Introduction: The Lunar Reconnaissance Orbiter Camera (LROC) Team is executing a comprehensive high-resolution (0.5 meter/pixel) Narrow Angle Camera (NAC) imaging campaign for lunar volcanic domes [1-4]. Domes are key to elucidating the compositional diversity of the lunar crust and the evolution of lunar volcanic processes. One focus of LROC study has been the Marius Hills region, which is located in Oceanus Procellarum (~13.4° N, 304.6° E) northeast of the Reiner Gamma formation and south of the Aristarchus Plateau, and includes a Constellation Region of Interest. The Marius Hills region is the largest concentration of volcanic features on the Moon (including domes, cones, and sinuous rilles) [5-11]. We continue to leverage the new data from LRO and investigate the geology of the Marius Hills region and other volcanic domes across the lunar surface [3, 12].

Background: The association of blocks (defined here as coherent boulders 1m or larger in diameter) with landforms on the lunar surface such as impact craters was noted by Apollo-era investigators and was directly observed by the Apollo astronauts. Numerous studies have investigated the size-frequency distribution of blocks produced by impacts on the Moon [13-17] as well as the block distribution of the Viking and Venera landing sites [18].

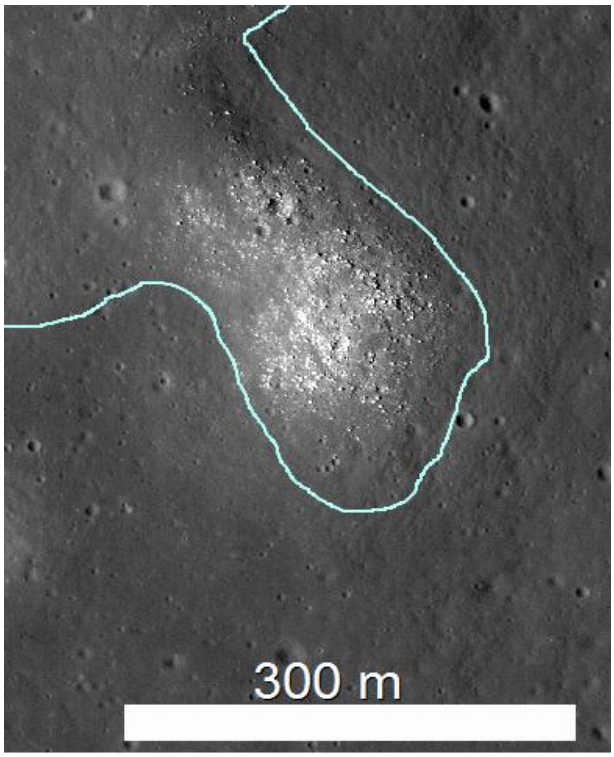

Figure 1. Example of a landform interpreted to be a lobate lava flow (outlined). Features of this type are relatively common in the Marius Hills region; the terminal ends of these features are covered in large, high-reflectance boulders.

Substantial block populations on volcanic landforms are discernable in LROC NAC images, in particular volcanic cones and lava flows [e.g., Fig. 1]. These block populations are not proximal to large impact craters, suggesting a non-impact origin. For this investigation, we digitized block abundances on representative geologic units in the Marius Hills region (including the inner walls of two sinuous rilles, two volcanic cones located on the summit of volcanic domes, and the terminal ends of three lava flows). The purpose of this study is to determine whether the different classes of volcanic landforms in the Marius Hills have measurably different block populations from either impact craters or each other. Quantitative measurements of block abundance can be used to investigate origin mechanisms as well as provide insight into the roughness of a particular surface [13,18,19].

Methods: NAC images of the Marius Hills region have a resolution of ~0.5 m/pixel [20]. Boulder count regions on representative geologic terrains in the Marius Hills region were identified through exhaustive visual inspection of NAC frames.

Block populations were then digitized from map-projected NAC frames, producing the coordinates and diameter of each digitized block. To date, 2,744 blocks were digitized in ten NAC study areas. Only blocks that could be unambiguously identified (i.e., ≥ 1m diameter) are included in this digitization process. The likeliest sources of uncertainty in an iterative analysis of this type are the misidentification of blocks due to such factors as lighting conditions, along with discrepancies between the measured block diameter and the actual block diameter. To be conservative, all diameter measurements are therefore assumed to have an associated uncertainty of ± 0.5 m (i.e., 1 pixel).

The block abundances determined from the NAC images were compared to block abundances determined from digitizing the size and locations of 13,000 blocks in and around two lunar craters with diameters of 589 m and 1002 m, respectively, in Lunar Orbiter frames LO3-153-H2 and LO2-70-H1.

LRO can be rolled off-nadir to acquire a limited number of geometric stereo observations [21]. One pair of NAC images with offset viewing geometries (offset angle

of 32°) were used to create a LOLA-controlled Digital Elevation Model (DEM) with 2 m/pixel postings using the SOCET SET toolkit. This DEM was used to obtain morphometric measurements of specific features and to calculate various derived products, including elevation profiles and slopes according to the methods of [22].

Discussion: The dominant sizes of the blocks associated with volcanic landforms are larger than the impact-produced blocks digitized in this study. The average size of the blocks on volcanic landforms digitized from the NAC frames is 5.4 m, and the mode is 4.8 m; 55% of the digitized blocks have diameters between 3.5 and 6.5 m. This is illustrated in Fig. 2, a block size frequency plot (slightly modified from the approach of [18]) of the percentage abundance as a function of block diameter in the Marius Hills region for the different classes of landform included in this study. Blocks associated with cones have the largest dominant size (average diameter: 8 m, mode: 7 m). This preliminary finding suggests that the block size-frequency can provide useful information for characterizing the geology of volcanic features on the Moon, possibly facilitating differentiation between impact and volcanic processes.

To facilitate comparisons between this dataset and previous investigations, we are also testing the approach of [13], where the cumulative block frequency is plotted in log-log space as a function of block diameter (representative curves from individual count areas are shown in Fig. 3). [13] used the slope (*b)* of a power–law function fit to the data in this parameter space to characterize the nature of a block population. The calculated *b* values for the block abundances associated with volcanic landforms in this study range from 0.31 (for a cone) to 1.66 (for a sinuous rille). The volcanic landform *b* values overlap with the *b* values calculated for the crater-derived block population, which ranges from 1-2. More block abundance measurements are needed in order to determine whether the *b* values of volcanic landform block populations digitized from LROC NAC images can be used effectively as a unique diagnostic tool.

Future Work: Block digitization efforts remain ongoing and are expanding to include other volcanic dome complexes in order to provide useful new information about the morphology and geology of these features. Correlations between these study areas and data acquired by other LRO instruments will also be executed in order to provide useful calibration data for future investigations. For example, a preliminary investigation involving the correlation of these block abundance study areas and Mini-RF S-Band radar data indicates that these areas have enhanced radar backscatter [23].

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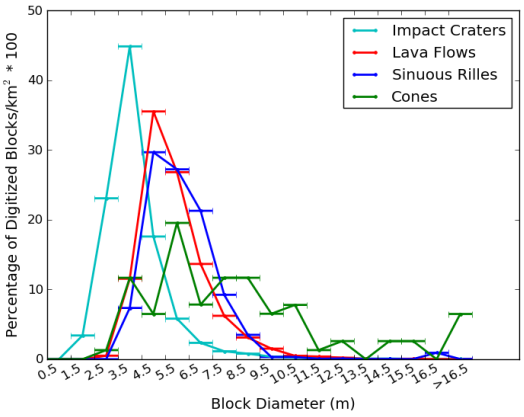

Figure 2. Aggregate block size frequency for geologic features in the Marius Hills region as a function of block diameter.

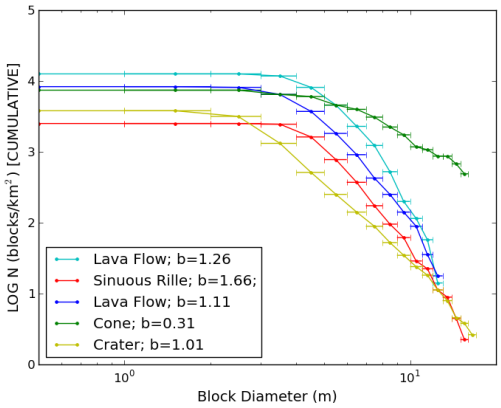

Figure 3. Cumulative frequency of block abundances and associated *b* values from different volcanic features in the Marius Hills region. The crater block abundance was collected from a 589 m-diameter crater in Lunar Orbiter frame LO-153-H2.