QUANTITATIVE MORPHOLOGY OF CLASTS ALONG THE SPIRIT ROVER TRAVERSE FROM SOL 450 TO SOL 800. R. A. Yingst[1], N.A. Cabrol,[2] L.S. Crumpler[3], R. Li[4] and the Athena Science Team, [1]University of Wisconsin-Green Bay (Natural and Applied Sciences, 2420 Nicolet Dr., Green Bay, WI 54311; yingsta@uwgb.edu), [2]NASA Ames Research Center, Moffett Field, CA, 94035-1000, [3]New Mexico Museum of Natural History and Science, Albuquerque, NM 87104, [4]The Ohio State University, Columbus, OH 43210.

Introduction: The morphologic characteristics of the loose clasts that make up a sedimentary population contain the best record of sorting and abrasive processes that altered those clasts [1-3]. Because they can be assessed qualitatively and quantitatively to a high degree of accuracy [3, 4], morphologic characteristics have the potential to give meaning to physical characteristics where appropriate comparisons to 'standard' populations can be made (e.g. [5, 6]). They also yield a metric for categorizing clast types [7, 8]. We report on a preliminary examination of quantitative morphologic characteristics of surface clasts in Gusev Crater imaged along the traverse of the Spirit rover from sols 450 to 800. Our goal is to determine the nature of these clasts, and their variance by location.

Data Collection: The region traversed by Spirit over the last 1000+ sols is characterized primarily by fine-grained basalts, with materials from the surface down to ~10 m depth being interpreted as impact-generated regolith developed over basalt flows [9-12]. The region is awash in pebble-cobble sized [13] surface clasts. To better systematize a study of the characteristics of these clasts (also referred to as float), we chose to take advantage of the clast survey campaign, a collection of single frame images taken with the Pancam instrument [14, 15] looking at an angle of 70° down from horizontal and generally 0° azimuth in the rover frame. The goal of the campaign has been to capture high-resolution details of the clasts along a transect. So far, we have examined 21 out of 53 clast survey images or image cubes taken by Spirit's Pancam from sol 450 to sol 800, and assumed these clast survey images to be representative of the float population at each location they were taken. Most images consist of filters L7 and R1, though three are comprised of all 13 geologic filters. Spirit's location for each sol associated with a clast survey image was determined by [16] using Doppler radio positioning and triangulations utilizing landmarks in orbital and ground images.

We utilized the methodology of [8] to calculate quantitative indices. Those measured include clast diameter, sphericity (how closely clast shape resembles a sphere) and roundness (how sharp the corners of a clast are). Clasts truncated by the image were not included in this study.

Results: The number of resolvable objects > 5 mm in diameter that can be seen in each of the images ranges from a minimum of zero to a high of ~5000. Many of the smaller of these are likely not loose float, but are part of the knobby basement material. A range of clast sizes is present, from below image resolution to over 200 mm in diameter. Clast morphology, however, does not appear to change dramatically along the transect. It is essentially bimodal, with one population displaying smoother textures, often with flat facets ending in sharp edges, and a second population with a rough, nodular, possibly vesiculated texture. This bimodality is demonstrated in Figure 1.

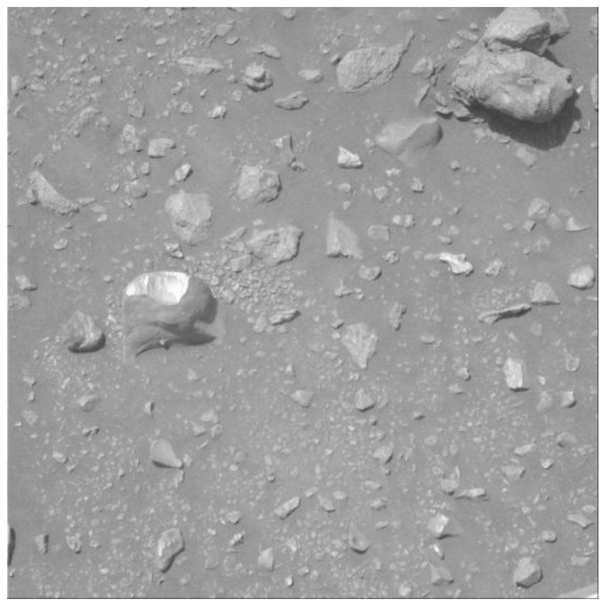

Figure 1. Pancam clast survey image taken on sol 523. Knobby basement texture is apparent below the float. The clast in the upper right corner is ~ 23 mm across.

In this example image, smaller clasts are angular, platy, but smooth-sided, while rougher-textured rocks are more rounded and spherical. However, in general there is no clear association with the two morphologic populations and clast size. The image also shows one clast that has a significant portion missing, possibly through local impact. This is representative of ~5% of clasts studied. There is a smaller clast to the left of this rock that may represent the spalled portion.

The mean size of clasts along the transect is 5.93 mm, though the range of means per image is very broad (2.5-25 mm), putting most clasts within the pebble size range [13]. The sphericity mean for the traverse is 0.75 (standard deviation 0.07), as shown in Figure 2, and the roundness mean is 0.30 (standard deviation 0.16). Only 20 clasts were large enough that the surface texture could be resolved sufficiently for quantitative measurement of roundness, so the bimodality displayed in clast texture cannot be quantified and compared directly to roundness values for other sites.

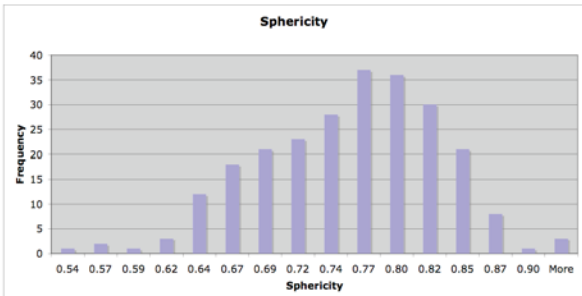

Figure 2. Histogram of sphericity values for all clasts along the Spirit rover traverse from sol 450-800.

Mean clast size is shown in Figure 3 for each sol for which images are available. Size varies along the transect, from over 8 mm to less than 4 mm between sol 455 and 523 (the largest variation). Variations in sphericity along the transect are much smaller, with a single significant increase from approximately 0.72-0.79 between sol 508 and 516. The average change from sol to sol is less than 0.02. The range of roundness changes most significantly from sol 516 to 521, from 0.24-0.56. In terms of qualitative roundness, there is a decrease along traverse. Clasts from sol 450-sol 650 are sub-angular to sub-rounded, while those from 650-800 are sub-angular to very angular.

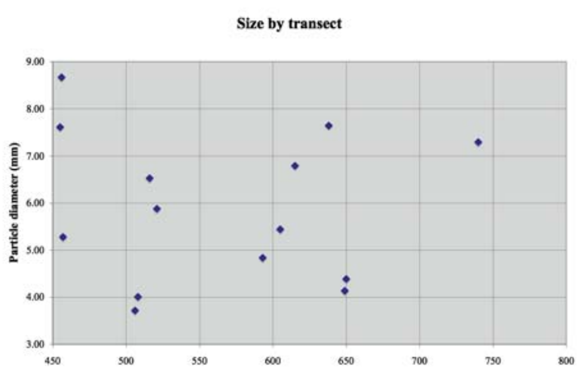

Figure 3. Variation of clast diameter along the Spirit rover traverse from sol 450-800.

Discussion: Sphericity is closely associated with the lithology (internal structure) of clasts, while roundness and texture are most dependent on transport and wear mechanisms that altered clasts [17, 18]. Sphericity values in Figure 2 have a unimodal distribution. This is consistent with the hypothesis that most rocks along the transect have a similar lithology — that is, the internal structure of these rocks at the macroscale behaves similarly when exposed to the conditions of transport and wear present at the site. It is important to note, however, that there is currently no evidence that these two populations are compositionally similar.

The texture of clasts along the traverse is bi-modal, as is qualitative roundness values. We infer that these two morphology populations may represent different cooling histories: clasts derived from vesicular lava and clasts derived from more massive, intrusive flows. Quantitative roundness values are consistent with this conclusion. However, the low number of clasts sampled for roundness precludes making firm interpretations regarding transport or wear mechanisms.

Comparison to terrestrial and martian values. Clasts sampled in the clast survey are smaller than average clasts at the Mars Pathfinder landing site (110 vs. 5.9 mm), but sphericity is identical (0.75). Roundness is much higher (0.30 vs. 0.083), but lower than roundness values typical of long-term fluvial wear in a terrestrial setting (0.54-0.77 [1]). This combination of qualitative and quantitative results may indicate that most clasts were altered by one or more transportation processes that were nevertheless not highly efficient rounding mechanisms, such as impact.

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