SHAPE, ROUNDNESS AND TEXTURE OF PARTICLES ALONG THE SPIRIT ROVER TRAVERSE FROM SOL 450 TO SOL 750.
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Introduction: The morphologic characteristics of the loose particles that make up a sedimentary population contain the best record of sorting and abrasive processes that altered those particles [1-3]. Because they can be assessed qualitatively and quantitatively [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 particle types [7, 8]. We report on the morphologic characteristics (size, shape, roundness, texture) of surface particles in Gusev Crater imaged along the traverse of the Spirit rover from sols 450 to 750. Our goal is to determine the nature of these particles, and their variance by location.

Data Collection: The region traversed by Spirit 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 particles. To better systematize a study of the characteristics of these particles (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.

From sols 450 to 750, clast survey image pairs of filters L7 and R1 were taken during 48 sols. Additionally, 13-filter image sequences were taken during this period on sols 734 and 738. Spirit's location for each sol 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 size, shape (sphericity and elongation) and roundness (how sharp the corners of a particle are). Texture, or how a particle surface varies from a perfectly flat surface at scales smaller than the corners and angles of the particle, was classified qualitatively.

Results: The number of resolvable objects > 5 mm in diameter in each image ranges from a minimum of zero to a high of ~5000. Many of the smaller of these are not loose float, but are part of the knobby basement material. The size, sphericity, elongation and textural characteristics of 931 particles determined to be loose, unburied surface particles > 5 mm in diameter were examined (162 particles were imaged at high enough resolution so that roundness could be determined).

Particle size and shape. A range of particle sizes is present, from below resolution to nearly 70 mm in major axis length, with the smallest measurable particle being 2.65 mm. All particles fall within the pebble to cobble size range (2-256 mm [13]). Most particles are ~7-12 mm in size, with a mean of 11.1. The range of mean values for each individual sol is very broad, however, ranging from a low of 4.1 mm for sol 525 to a high of 35.4 mm for sol 551, demonstrating the partial dependency of size upon location along the traverse, as shown in Figure 1.

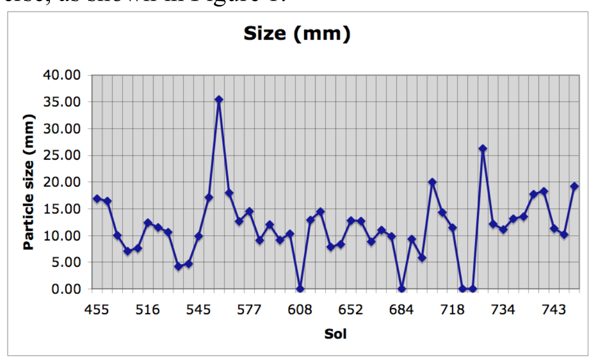

Figure 1. Mean particle size as a function of location (measured by sol). A null size indicates a sol in which a clast survey image pair showed no loose particles.

The mean value for particle sphericity is 0.72; 38% of particles cluster between sphericity values of 0.72 and 0.79. The distribution of values retains a bell curve, except for an anomalous peak at 0.60, where 5% of particles reside. The sphericity means for each sol ranged broadly from 0.54-0.92, again showing a likely locational dependency for this parameter.

Roundness. The roundness mean for the subset of particles for which this characteristic could be determined is 0.14, while the median is 0.10. Nearly 48% of all roundness values range between 0.08-0.11. Most particles are classified sub-angular, as assessed utilizing [17]. Qualitatively, roundness ranged from very angular to well-rounded, but most particles were classed as sub-angular, sub-rounded or angular. Sub-angular particles make up 31% (289 particles) of the population, sub-rounded particles comprise 27% (245 particles) and 21% (196) are classified as angular.

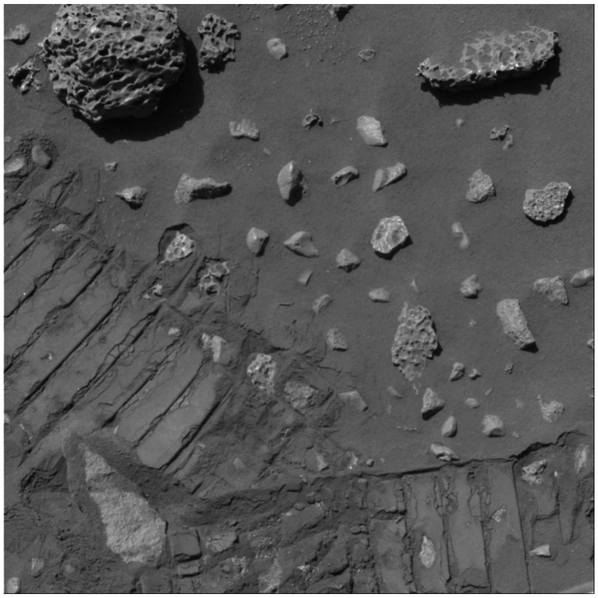

Figure 2. Pancam clast survey L7 image taken on sol 741. Particle in the upper right is ~ 20 mm across.

Particle texture. Particle texture is divided into four types (see Figure 2). Type 1 displays a jagged, vesiculated, in many cases scoriaceous texture. Type 2 shows a smoother (but not smooth) texture, often with flat facets ending in sharp to rounded edges. Type 3 is similar to Type 2, but is rougher along the flat surfaces, and commonly has more irregular edges. Finally, Type 4 is a very rough, conglomeratic texture that appears in only three sols (566, 574, 577). Examples of the first three types are shown in Figure 1. Locales are not uniform in terms of the number of each texture type present. Some images contain only Type 1, while others have only Type 2 and 3, and still others have varying percentages of each. Organized structure is lacking in most particles, but images taken near the Home Plate structure (sols 733 and 745), contain particles with stair-stepped edges suggesting layering.

We infer that the first three textural morphology populations may represent different cooling histories: particles derived from vesicular lava (Type 1 texture) and particles derived from more massive, intrusive flows (Types 2 and 3). Type 4's unusual texture defies simple interpretation.

Discussion: Sphericity is closely associated with the lithology (internal structure) of particles, while roundness and texture are most dependent on transport and wear mechanisms that altered particles [18, 19]. A histogram of sphericity values has a single maximum. 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. The spectral signature of particles bears out this conclusion: spectral signature compares favorably with that of plains basalts. Small variations in the red/blue ratio may plausibly be equated with varying amounts of mantling dust.

Sphericity values in the low 0.70s, such as these, are comparable to particles in glacial till or alluvial fan deposits [1, 6], implying that this population has been affected by high-energy transport (e.g. volcanism or impact). Likewise, the combination of qualitative and quantitative roundness results indicate that one or more transportation processes that were nevertheless not highly efficient rounding mechanisms altered most particles.

However, a subset of scenes contains a much higher percentage of more rounded particles (rounded to well-rounded; 0.25-0.35). This, along with the fact that sphericity, size and especially texture all are dependent upon location, indicates a strong locational bias; float at the site is not homogeneous in either formation or emplacement/transport history. That is, though individual morphologic variables are uncorrelated, and therefore appear not to be connected genetically, there are changes from sol to sol that indicate locational clustering of morphologic types. Interpretation is ongoing and will depend upon our ability to correlate our findings with the location and distribution of geologic units along the traverse.

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