CORRELATION OF ROCK SPECTRA WITH QUANTITATIVE MORPHOLOGIC INDICES: EVIDENCE FOR A SINGLE ROCK TYPE AT THE MARS PATHFINDER LANDING SITE. R. A. Yingst[1], K. L. Biedermann[1], N. M. Pierre[2], A. F. C. Haldemann[3], J. R. Johnson[4]. [1]University of Wisconsin-Green Bay, Natural and Applied Sciences, 2420 Nicolet Dr., Green Bay, WI 54311, yingsta@uwgb.edu. [2]University of Minnesota-Twin Cities, Aerospace Engineering and Mechanics, 107 Akerman Hall, 110 Union St. S.E., Minneapolis, MN 55455, pier0283@umn.edu. [3]Jet Propulsion Laboratory, MS238-420, 4800 Oak Grove Dr., Pasadena, CA 91109-8099. [4]U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001.

Background: The Mars Pathfinder (MPF) landing site was predicted to contain a broad sampling of rock types varying in mineralogical, physical, mechanical and geochemical characteristics. Although rocks have been divided into several spectral categories based on Imager for Mars Pathfinder (IMP) visible/near-infrared data, efforts in isolating and classifying spectral units among MPF rocks and soils (e.g. [1-9]) have met with varying degrees of success, as many factors influencing spectral signatures cannot be quantified to a sufficient level to be removed. It has not been fully determined which spectral categories stem from intrinsic mineralogical differences between rocks or rock surfaces, and which result from factors such as physical or chemical weathering. This has made isolation of unique rock mineralogies difficult.

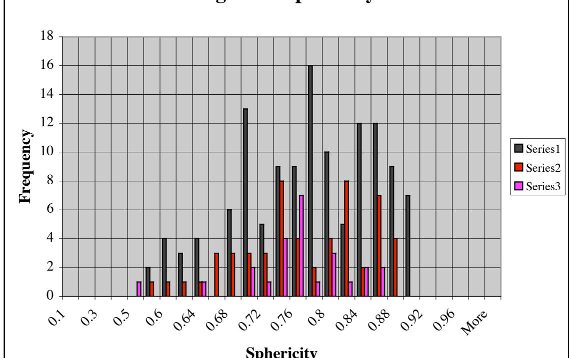
Approach: Morphology, like composition, is a characteristic tied to the intrinsic properties and geologic and weathering history of rocks. Rock morphologies can be assessed quantitatively and compared with spectral data, to identify and classify rock types at the MPF landing site. They can also isolate actual rock spectra from spectral types that are surficial in origin, as compositions associated with mantling dust or chemical coatings would presumably not influence rock morphology during weathering events. We previously reported on an initial classification of rocks using the quantitative morphologic indices of size, roundness, sphericity and elongation [10]. Here, we compare this database of rock characteristics with associated rock surface spectra to improve our ability to discriminate between spectra associated with rock types and those from other sources.

Data collection: To assess mineralogy, we used the most recent mosaics of the IMP SuperPan [11-13] to examine 801 spectra of 439 rocks [14]. These spectra were analyzed and classified based upon overall reflectance, spectral shape, and the presence or absence of absorption features. Rocks in this study were classified as gray (relatively flat spectrum between 671-801 nm with a weak kink at 968 nm), red (maximum at ~752 nm and a steeper slope from 480-670 nm) or pink (maximum at 801 nm and a steep slope from 480-670nm) [14], based upon the nomenclature of [15]. Of the 439 rocks for which spectra were taken, 188 rocks had previously been analyzed for morphological characteristics, including location, size, sphericity, relative roundness and elongation [10, 16] (because of the limitations of the MPF image dataset, roundness numbers are relative and should not be directly compared to values calculated in terrestrial settings). Rocks in each spectral class were assessed for correlations between classes and these characteristics.

Results. The majority of rock surfaces in this study were classified as gray rocks (61%, or 114 of 188). Approximately 26% of the rocks studied (49) were classified as red, while the remaining 25 (13%) were classified as pink. Rock classes were randomly distributed over the study area; no spatial clusters of types were observed. In terms of size, pink rocks were slightly smaller than red or gray rocks – 61 cm median major axis length [15], as compared to 96 cm (red) and 91 cm (gray) median major axis lengths. Since the majority of partially buried rocks were classified as pink rocks and therefore would be the most likely to be underestimated in terms of size, this result is not surprising.

As shown in Figure 1, both gray and red rocks have a mean sphericity of 0.76. Pink rocks are similar in sphericity, with a mean of 0.74. Relative roundness is also similar for the three categories of rocks, as shown in Figure 2, with gray rocks displaying a mean relative roundness of 0.093, red rocks 0.095 and pink rocks 0.097, which translates to an average classification of sub-angular to sub-rounded for all classes [17]. Gray rocks may have a slightly bimodal roundness distribution, with peaks at 0.09 and 0.16.

Figure 1. Sphericity



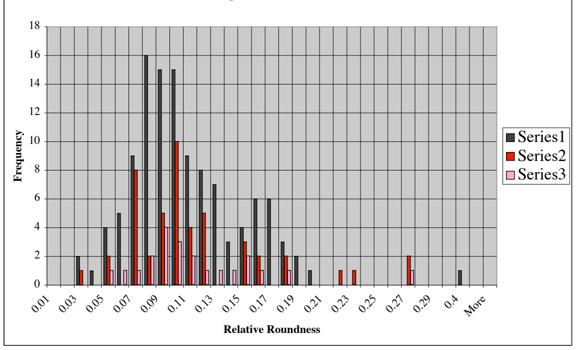


Figure 2. Roundness

Geologic interpretations. Terrestrial studies have shown that there is no single rule that equates a shape index to rock history or depositional environment (e.g. [18]). This is so because the variables affecting rock shape are numerous and interact in ways that are highly complex. However, shape indices that are two-dimensional (e.g. roundness) are largely controlled by the type and extent of weathering and wear during transport, while three-dimensional indices of rock shape (e.g. sphericity and elongation) are more related to the structure of the material [18]. Thus, rock shape indices can yield some information about composition, while roundness data is more useful in deciphering transport history.

Previous studies have shown some evidence for more than one morphologic class of rocks at the MPF site [21-24], For this study, however, rocks classified as gray and red in the Rock Garden have nearly identical shape and roundness values. Pink rocks, while slightly less spherical, have similar roundness values to rocks in the other two classes. There is thus essentially a single average morphology within the study area. The implication is that all rocks in the scene within the size limits of this study (~2-64 cm or pebble to cobble-sized [19]) are of the same general composition and were transported to the site in a similar fashion. Rock shape and roundness values are not associated with rock size (shown in Figure 3), distribution or distance from the lander [10, 16], as would be expected if these morphologic indices were a function of resolution. Thus, our preliminary conclusion must be that all rocks have a similar composition, regardless of the variant spectral signatures displayed at their surfaces. We preliminarily identify all rocks in the study as gray rocks; red and pink spectra are interpreted to be due to chemical rock coatings, mantling dust or surrounding soil.

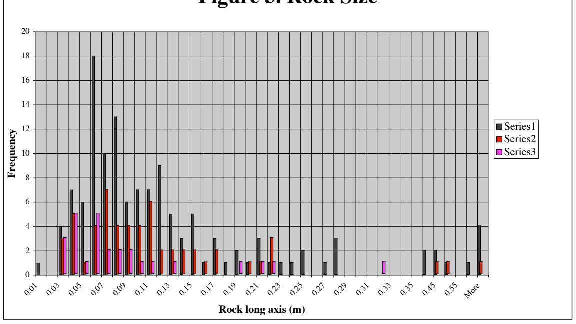


Figure 3. Rock Size

However, the possible bimodal distribution of roundness in gray rocks merits further investigation. Clast roundness is strongly influenced by the transport mechanism(s) responsible for deposition. A bimodal distribution of roundness is consistent with more than one transport mechanism or episode responsible for the wearing of rocks at the site [20]. There are too few red or pink rocks in the study to determine whether this bimodal distribution is mirrored in these categories as well. We are continuing to collect and analyze spectral data to resolve this issue, widening our field of study to rocks around and outside the Rock Garden.

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