

CLASSIFICATION OF MARS PATHFINDER ROCKS USING MULTISPECTRAL DATA. N. M. Pierre¹, R. A. Yingst², and J. R. Johnson³, ¹University of Minnesota-Twin Cities, Aerospace Engineering and Mechanics, 107 Akerman Hall, 110 Union St. S.E., Minneapolis, MN 55455, pier0283@umn.edu. ²University of Wisconsin-Green Bay, Natural and Applied Sciences, 2420 Nicolet Dr., Green Bay, WI 54311, yingsta@uwgb.edu. ³U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001.

Introduction: This study represents the first attempt at a systematic spectral classification of a significant percentage of rocks at the Mars Pathfinder (MPF) landing site. This work is part of a larger effort to correlate quantitative rock shape and roundness characteristics with spectral data, to better determine the geologic history of rocks at the site. Here, we use spectral analysis to reveal the composition of rock surfaces primarily in the MPF Rock Garden.

Approach & Method: The Pathfinder landing site lies at 19.3° N, 33.6° W on the southern edge of Chryse Planitia, a region that may have experienced inundation from the Ares and Tiu Vallis floods [1-3]. This research concentrates particularly on the area most densely packed with rocks, the south-west side of the lander (170-270°; also known as the Rock Garden), though many samples were taken outside of this area as well.

We examined 801 spectra of 439 rocks at the Mars Pathfinder landing site to assess mineralogy using the most recent Imager for Mars Pathfinder (IMP) multi-spectral mosaics [4-6]. For each rock in the study region, a 3x3 pixel box was used to take one or more 15-band spectra [7]. These spectra were analyzed and classified based on overall reflectance, spectral shape, and the presence or absence of absorption features. At least one sample spectrum was taken for every rock. Each rock was viewed as an idealized square and up to 9 spectra of each rock were taken (one every 45° around the rock's perimeter and one in the center) to get the most representative average spectra. Locations with excessive weathering were avoided, as were formations such as pits, knobs, lineations, bumps or ventifacts that might cast shadows that would skew results. Places with mantling dust or soil were also avoided when possible, as well as areas in deep shadow, over-saturated pixels and rock faces that were parallel or sub-parallel to the camera's line of sight.

Constraints: This study was limited in its ability to characterize the full spectral range of each rock by the view of the IMP imager; a three-dimensional spectral image of each rock would be ideal. Additionally, there is a margin of error for alignment of the 3x3 pixel spectral samples, as spectra taken by the IMP right and left eyes are aligned to a 5% accuracy [8]. Finally, many rocks were too small to take more than one spectral sample, which limits our ability to make conclusive statements about the smallest rocks.

Results: Two different classifications of rocks were found at the Mars Pathfinder landing site, which we note as gray and red, following the nomenclature of

McSween et al. [9]. Preliminary results show a separate category similar to the pink rocks of [9], and as suggested by [9], these spectra appear to be associated with unconsolidated material rather than rock mineralogies. We did not see evidence within our study area for a separate spectral category that matched the description of [9] for "maroon" rocks.

Our preliminary analysis defines gray rocks as having a relatively flat curve between wavelengths of 671 nm-801 nm with an 8%-20% reflectance. They also have an approximate slope of 3% from 480-670 nm and a weak kink (1-2% dip in relative reflectance) at 966 nm.

A good example of a gray rock is one numbered 86 in Haldemann et al. [10] (Figure 1). Three different samples were taken from different locations on rock 86, as shown in Figure 2. Note that the location of the spectral peak in Figure 1 is not clear in gray rocks; the curve is flat from 671 nm-801 nm. The peak reflectance is between 11% and 15% which again, is very typical of gray rocks.

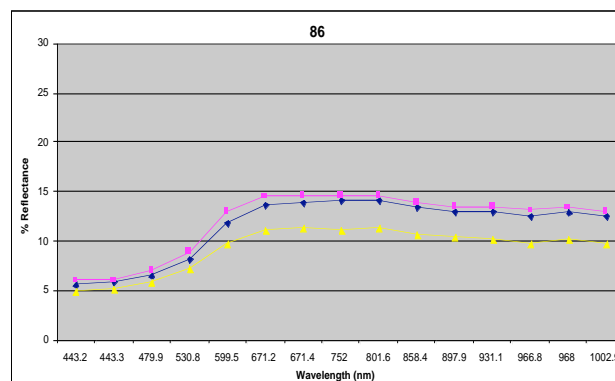


FIGURE 1



FIGURE 2

The preliminary definition of Red rocks was adapted from that given by [9]. Red rocks peak at 752 nm and have an approximate 5% slope from 480-670

nm. The relative average reflectance of a red rock peaks at about 14.5%, with a range of 6%-26%, somewhat lower than McSween's [9] range of 15-30%. Preliminary results show similarities between red rocks and pink rocks (description following), suggesting that red rocks may simply be gray rocks with a layer of dust. This may be the case because nearly half of the red spectra were taken on rock surfaces that appear to have a layer of mantling dust.

For example, Rock 732 [10] (Figures 3 & 4) is a red rock with a weak kink at 931nm. This rock has a relatively flat peak at 752 nm at a relative reflectance of about 13%.

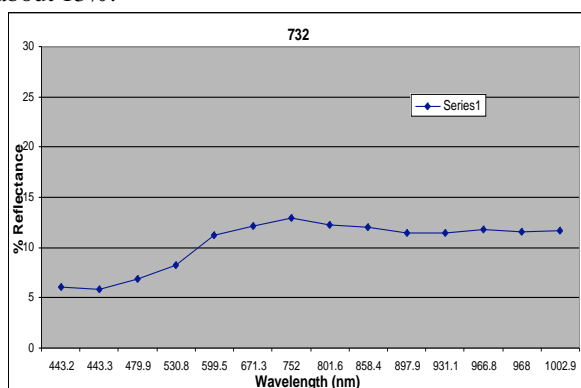


FIGURE 3



FIGURE 4

A third classification, analogous to the pink rocks of McSween et al [9], likely describes material such as soil or atmospheric dust. Pink spectra peak at 801 nm. Preliminary results show these rocks to have an approximate 8% slope from 480-670 nm. These spectral shapes are also evident in dusty portions of many red and gray rocks. Also, all rocks classified as pink are partially or fully buried. This is consistent with the original conclusion of McSween et. al. [9] that pink spectra usually sample dust coatings or soil.

Of the 439 rocks studied, preliminary classifications show that 129 of them are gray, 68 are red, and 136 are pink. In addition, there are 35 rocks that have both pink and gray spectra in different locations, 8 rocks that have both pink and red spectra, 11 rocks that have both red and gray spectra on different faces, and 13 rocks that each exhibit pink, red, and gray spectra. There are an additional 39 rocks that have not yet been classified.

Conclusions: To continue this research, we will compare spectral classes with azimuth variations to differentiate between soil, dust, and problems due to IMP image misalignment. We will compare these findings with corresponding morphologic characteristics that may reveal correlations between the morphology and mineralogy and aid in rock classifications to further determine the geologic history of these rocks [11, 12].

References: [1] Golombek M. P. et. al. (1999) *JGR*, 104, 8523-8553. [2] Golombek M. P. et. al. (1999) *JGR*, 104, 8585-8594. [3] Ward A. M. et. al. (1999) *JGR*, 104, 8555-8571. [4] Bell J. F. III et al. (2002) *Icarus*, 158, 56-71. [5] Johnson J. R. et al. (2001) *LPS XXXII*, 2062. [6] Murchie S. et al. (2001) *LPS XXXII*, 1825. [7] Smith P. H. et. al. (1997) *JGR*, 102, 4003-4025. [8] Reid R. J. et. al. (1999) *JGR*, 104, 8907-8925. [9] McSween H. Y. et. al. (1999) *JGR*, 104, 8679-8715. [10] Haldemann A. F. C. et. al. (2000) *LPS XXXI*, 1846. [11] Yingst R. A. et. al. (2004) *LPS XXXV*, 1272. [12] Yingst R. A. and Pierre N. M. (2005) *LPS XXXVI*, this volume.