SPECTRAL CLASS DISTINCTIONS OBSERVED IN THE MPF IMP SUPERPAN USING A SELF-ORGANIZING MAP.

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Introduction: The recent success of the Mars Exploration Rover (MER) mission [1,2] prompts a reexamination of data from previous landed missions in order to see if insights gained from MER can be applied to unresolved questions from these earlier missions. The predecessor to MER was the Mars Pathfinder (MPF) mission which landed on the Ares Valles floodplain. The landscapes examined by MPF and by Spirit have intriguing similarities and significant differences. In the investigation described in this paper we have reanalyzed a set of multispectral data, the so-called "SuperPan" from the MPF Imager for Mars Pathfinder (IMP, [3]). We have performed this analysis using state-of-the-art Self-Organizing Map (SOM) Artificial Neural Network (ANN) software [4,5]. In addition to gaining additional insights into the nature of the MPF landing site from this analysis, we are also using insights gained into the nature of the bright regions at Gusev crater explored by Spirit.

Data and Processing Approach: We analyzed a recalibrated and geometrically registered version of the "Super Pan" data set, acquired in all 12 IMP bands (440-1000 nm) and covering most of the MPF landing site. The Super Pan was acquired in eight separate image mosaics or octants, with each mosaic consisting of many separate but contiguous camera azimuth and elevation pointing positions. The data analyzed were released by the USGS and corrected to relative reflectance by Version 3 of the IMP calibration algorithm [6]. Further empirical corrections were applied to the data in order to mitigate differences between component segments [7].

Class maps of each octant were produced using a two-stage hybrid Artificial Neural Network architecture that contains a SOM component. First, a 40 x 40 SOM was used to obtain a cluster map of albedo-normalized versions of each of the left and right eye S0184 octants. Approximately 7 million unsupervised learning steps were performed, in order to approximate the unknown probability distribution of the spectral signatures to a fine precision level, which in turn enables the discovery of very small spectral clusters (such as the black rock types) or spectral clusters with subtle but consistent spectral differences [7]. Identification of spectrally unique clusters was performed with limited user interaction. After this unsupervised clustering phase, the resulting 31 clusters were labeled and a subset of them were selected as training material for supervised classification. The training spectra, taken from the selected clusters, were checked against previous analyses, where applicable, for consistency.

For other octants, the select spectral classes identified from initial results were mapped in a supervised classification step using the same ANN architecture, previously trained on the S0184 classes. In some octants, classes that are not well represented in S0184 occur and these classes were added as required to the classification. Some areas still remained unclassified and can be revisited in another classification round. The validity of the classifications was evaluated based on the statistics of the individual classes: unique mean spectral signatures, small standard deviations, and their small difference from the training statistics. Where possible, we also compared our classifications against results published earlier in the literature.

Results and Discussion: Significant results from the classification include the following:

Far Field Spectral Classes. The MPF Sojourner rover was only able to investigate rocks and soils close to the lander; thus the only information available on far field materials is the multispectral IMP imagery. As is shown in Fig. 1, there are three classes that are most abundant in the far field. Class M (purple) is associated with the top of North and South Twin Peak and classes b (aquamarine) and K (cyan) cover much of the rest of the far field. Averages of these classes from the S0183 left scene indicate that class M has a shallow 900 nm absorption. Classes b and K are similar with b having a flatter NIR spectrum than K. In the near field, classes b and K can be associated with "rock soil", a class identified in [8].

Soil Classes. The aforementioned "rock soil" class was identified on the basis of its similarity to the "gray rock" spectral signature [8]. It can occur in close proximity to rocks and in octant S0185, it is associated with the low albedo cover on dune forms (Fig. 2). The identification of this class as a mixture of minimally weathered rock fragments and bright drift seems highly likely on the basis of comparison to measurements that Spirit has performed on similar duneforms in Gusev crater. Spirit has observed rounded basaltic pebbles armoring the Gusev crater dunes [9]. Significantly, the ANN derived classes that cover the duneforms are the same ones discussed above in association with the far field.

Gray Rock and Black Rock Spectral Variability. The predominant spectral class identified in previous studies (e.g., [10]), is the "gray rock" class, a material with negative NIR slope (without a clearly defined band minimum) and a reflectance maximum near 760 nm. While referred to as a single spectral class in previous studies, our ANN classification indicates that several classes are required to map out gray rock occurrences. What is observed is that an individual rock can be mapped by three or more classes (classes D, E, and Z in Fig. 3). Work is on-going to determine if these differences are due to actual spectral differences on the rocks or apparent spectral differences caused by variability in viewing geometry (i.e., macroscopic roughness on the rock faces).

The "black rock" class had been identified as a single spectral class, but two classes with significant long wavelength absorptions (in our classification scheme, these were classes O and R) were identified. One of these classes might represent additional examples of the "orange rock" class noted by [11].

Conclusions: Reanalysis of the IMP SuperPan data reveals a wealth of spectral classes at the MPF landing site. Individual spectral classes are related to sometimes subtle spectral differences between materials exposed at the landing site and in the far field. Work is on-going to relate these spectral differences to physical material classes and to relate observations made at the MPF landing site to those observed by the Spirit and Opportunity rovers.

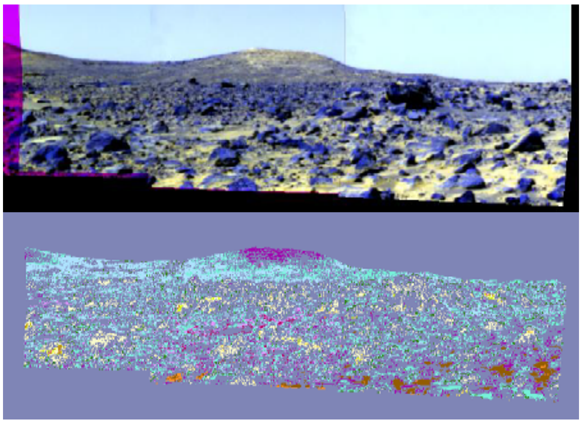

Figure 1. Top: Composite of left eye bands 802, 671, and 443 nm for far field portion of octant S0183. Bottom: Class map for the far field of S0183 (left eye data). Note the purple color (class M) associated with the top of North Twin Peak and prevalence of cyan colors of classes b and K in the far field.

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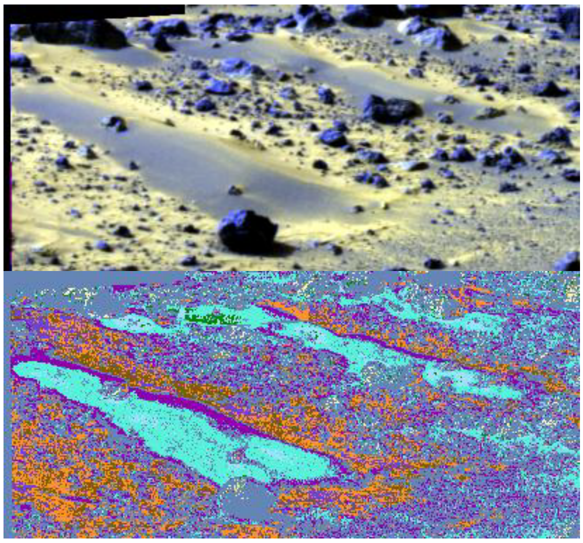

Figure 2. Top: Composite of left eye bands 802, 671, and 443 nm for subsection of octant S0185 covering dune forms. Bottom: Class map derived from left eye data over same subsection. The central portions of the dune forms are mapped by classes b and K (aquamarine and cyan) and the perimeter by class M (purple). Bright drift is mapped in orange.

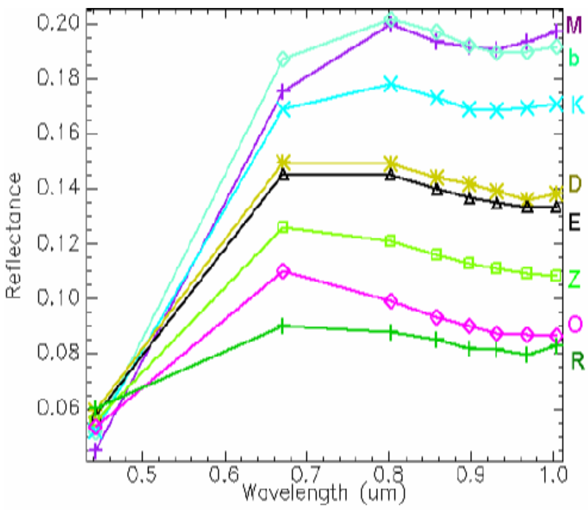

Figure 3. Left eye reflectance spectra of classes discussed in the text. M, b, and K are far field classes (Fig. 1). D, E, and Z represent variability within the "gray rock" class. O and R are unique "black rock" classes.