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# A FIELD- AND LABORATORY-BASED QUANTITATIVE ANALYSIS OF ALLUVIUM: RELATING ANALYTICAL RESULTS TO TIMS DATA

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## 1. INTRODUCTION

Thermal Infrared Multispectral Scanner (TIMS) data were acquired over the McDowell Mountains northeast of Scottsdale, Arizona during August 1994. The raw data were processed to emphasize lithologic differences using a decorrelation stretch and assigning bands 5, 3, and 1 to red, green, and blue, respectively (Gillespie et al., 1986). Processed data of alluvium flanking the mountains exhibit moderate color variation. The objective of this study was to determine, using a quantitative approach, what environmental variable(s), in the absence of bedrock, are responsible for influencing the spectral properties of the desert alluvial surface.

## 2. ANALYTICAL METHODS AND RESULTS

### 2.1 FIELD

To quantify the surface properties of the alluvium, two linear field traverses were defined along which data were collected at individual points and appropriately averaged. By averaging the data, the effect of small-scale surface variability is removed, thus the data better reflect the overall character of the surface. The positions of the transects were defined to cross alluvial surfaces displaying the maximium color variation in the TIMS image. The boundaries of the adjacent distinctly colored areas are washes, as verified during fieldwork. Large-scale vegetation such as creosote, palo verde, saguaro, and low scrub constitutes 10-15% of the surface area surrounding the transects. Because this value applies to both transect locations, macro-vegetation was ruled out as a controlling factor for the variation in the TIMS data. At twenty-foot intervals along the transects, three-foot square sample sites were examined and rock samples were collected for laboratory spectral analysis. Prior to sample collection at each site, the areal percentage of soil and the percentage of each rock type were quantified (Figures 1 and 2). The average percentage of soil over the entire length of transects 1 and 2 (ignoring the data points within washes) is 11.8% and 0.8%, respectively. When sample points within a given color unit are averaged, the soil percentage deviates from the average by a maximum of 2.9% (transect 1) and 0.6% (transect 2); these values are too small to account for the image color variation along each transect. Two dominant rock types were identified as various quartzites and phyllitic schists. Figures 2a and 2b display the systematic variation in rock type percentage along each transect. Transect 1 is segmented by two washes and transect 2 is segmented by one wash. For each transect segment the average percentage of rock compositions was calculated. From the first segment (A) to the last segment (C) of transect 1, the percentage of quartzite increases from 20.6% to 66.1% as the percentage of phyllitic schist decreases from 58.6% to 19.1%. A similar trend occurs along transect 2, along which the percentage of quartzite increases from 1.4% to 70.2% as the percentage of phyllitic schist decreases from 97.8% to 26.8%. The shifts in dominant mineralogy correlate well to the areas defined by the TIMS colors, suggesting that the rock composition of the surface alluvium determines the TIMS spectral signature and swamps the effects of vegetation or soil.

## 2.2 LABORATORY

Thermal infrared spectra of nineteen rock samples were acquired in emission over the range of 1400 to 450 $cm^{-1}$ (~7 to 22 μm) using a modified Mattson Cygnus 100 interferometer/spectrometer. These vibrational spectra were separated into two groups based on the most apparent distinction which is overall absorption feature depth. Subsequently, these two groups were found to correspond to the two general rock types identified in the field. The nine quartzite and eleven schist laboratory spectra were averaged to produce a representative endmember spectrum for each rock group; the resulting quartzite and phyllitic schist spectra are shown in Figure 3. The spectrum of the average quartzite exhibits deep absorptions at frequencies similar to those of quartz, suggesting a quartz composition with minor impurities. The spectral positions and shapes of the average phyllitic schist absorptions suggest that the schists are silicic and similar to the quartzites; however, the absorptions are 45% shallower than the quartzite features and the schist spectrum exhibits an additional feature within the TIMS wavelength range at 1040 $cm^{-1}$ (9.6 μm) which was determined by normalizing the two average endmember quartzite and phyllite spectra over the range of 770 to 750 $cm^{-1}$ (~13.0 to 13.3 μm) and differencing them. The difference spectrum (Figure 3) is indicative of clay mineralogy. No further spectral analysis was performed to identify the specific type of clay. The compositional dissimilarity between the schists and the quartzites provides the basis for distinguishing the alluvial surfaces in the TIMS data. The overall spectral similarity of the rock samples prompted thin section preparation and compositional analysis to verify the presence of clay in the phyllitic schists. We anticipate results of thin section analysis by the time of the conference.

# 3. CORRELATION OF TIMS DATA WITH FIELD AND LABORATORY RESULTS

## 3.1 PROCEDURE

*Spectral endmembers derived from TIMS image*

Quartzite and phyllitic schist endmember compositions of the alluvial rock suite (Figure 4) were selected from the digital TIMS image using the bedrock compositions nearest the transects. We have assumed that the primary sources of the alluvial materials are proximal because the rock fragments are angular. To evaluate the method of mixing endmember spectra derived from TIMS data and determine accurate areal percentages of mixed pixels, endmember spectra derived from the TIMS image were linearly summed according to Ramsey and Christensen [1992] using the average percentage of quartzite and phyllitic schist observed for each distinctly colored area along the transects. The resultant mixed spectra were then compared to spectra averaged over 4 by 4 pixel squares for each distinct color area in the TIMS image along the transects.

The mixed spectra derived from the TIMS endmembers have emissivities that plot within 2% of the spectral emissivities derived directly from the transect segments in the TIMS image. This degree of accuracy suggests that the rock percentages were correctly quantified in the field.

*Spectral endmembers derived from laboratory analysis*

Laboratory spectra were linearly mixed [Ramsey and Christensen, 1992] according to the average rock percentages observed for each segment along the transects. Because the laboratory spectra were acquired at 4 $cm^{-1}$ resolution, the mixed spectra were deconvolved to TIMS resolution (Figure 5).

Subsequent comparison of the lab spectra with TIMS spectra of the same alluvial areas shows two primary differences. Firstly, the emissivities of the TIMS spectra are greater than .96, whereas the laboratory spectral emissivities are as low as .72. Secondly, quartzite-dominated spectra in both data sets exhibit a distinct quartz absorption feature in band 3; however bands 1, 5, and 6 in the TIMS data show additional absorptions not present in the laboratory spectra. We believe these additional TIMS features do not result from vegetation (assuming unit emissivity) but may be due to absorptions from a soil component which was not included as a laboratory endmember.

## 4. CONCLUSIONS

In order to determine the effects of vegetation, soil, and rock mineralogy on the thermal emission spectral properties of two alluvial surfaces flanking the McDowell Mountains, AZ, a quantitative survey of the areal extent of these environmental variables was conducted. Our study suggests that vegetation and soil do not strongly affect the TIMS image and that the composition of rock fragments is the primary control on the spectral signature. The two main lithologies present along the field transects are quartzites and phyllitic schists derived from separate upslope bedrock sources. Effective mixing of these lithologies is inhibited by washes that intersect the transects and act as natural barriers to talus migration. Washes in the field area correlate with the boundaries of the various colored areas in the TIMS data confirming that mixing is inhibited and that TIMS color differences result from dominant rock type. Mixing TIMS-derived endmember (bedrock) spectra according to the average percentage of each rock type for the five transect segments produced spectral emissivities which lie within 2% of the emissivities derived from the same transect areas in the TIMS image.

NOTE: A color slide of the processed TIMS data of the field area may be obtained from the authors by request.

## 5. ACKNOWLEDGEMENT

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## 6. REFERENCES

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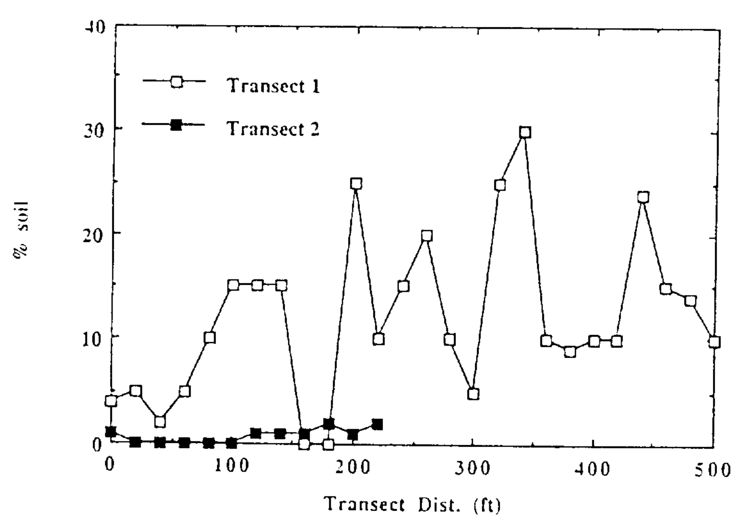


Figure 1. Areal percentage of soil at each sample site along transects 1 and 2.

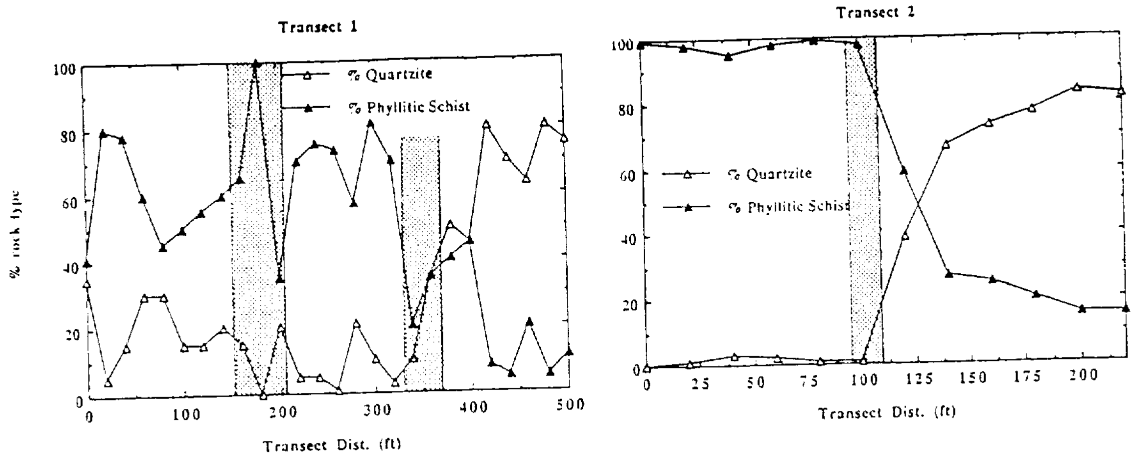


Figure 2. Areal percentage of rock type at each sample site along transect 1 (a) and transect 2 (b). Stippled areas represent data points acquired in washes.

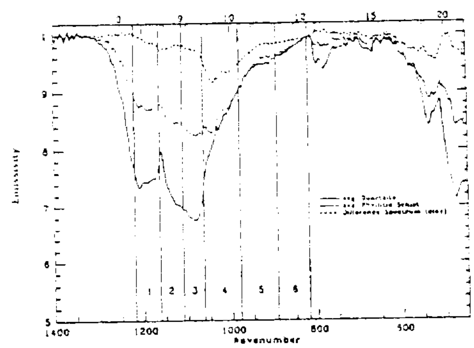

Figure 3. Averaged laboratory quartzite, phyllitic schist, and differenced clay spectra. TIMS bands are labeled 1-6.

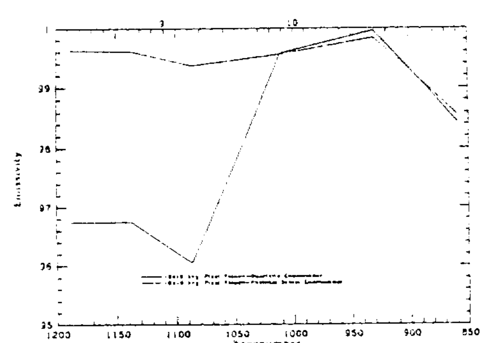

Figure 4. Quartzite and phyllitic schist endmember spectra derived from TIMS data. Bedrock proximal to the transects was used.

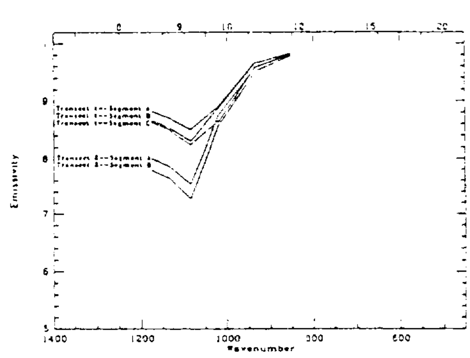

Figure 5. Mixed laboratory spectra deconvolved to TIMS resolution.