

**AN EXPLANATION FOR THE OBSERVED SPECTRAL CONTRAST REDUCTION BETWEEN FIELD AND LABORATORY INFRARED MEASUREMENTS OF SOILS;** J.R. Johnson, P.G. Lucey, K.A. Horton, and T. Williams, Hawaii Institute of Geophysics and Planetology, University of Hawaii at Manoa, 2525 Correa Rd., Honolulu, HI 96822, E.M. Winter, Technical Research Associates, Camarillo, CA, 93010, and A.D. Stocker, Space Computer Corporation, Santa Monica, CA 90404.

Comparison of emission spectra (7-14  $\mu\text{m}$ ) of pristine soils in the field with bidirectional reflectance spectra of soils obtained in the laboratory shows that laboratory spectra tend to have less contrast than field spectra. We investigated this phenomenon by measuring emission spectra of both pristine (in situ) and sampled soils (prepared as if for transport to the laboratory). The sampled soils had much less spectral contrast than the pristine soils in the reststrahlen region near 9  $\mu\text{m}$ . We hypothesize that this effect is due to a difference in grain size distribution of the optically active layer (i.e., fine particle coatings). This concept was proposed by Salisbury et al. [1,2] to explain their observations that soils washed free of small particles adhering to larger grains exhibited greater spectral contrast than unwashed soils. Unrecognized, this phenomenon could influence interpretations of remote sensing data since it is a common practice to use spectra of materials obtained in the laboratory to interpret spectra obtained remotely.

**Methodology.** The field emission spectra presented here were obtained using a Designs and Prototypes Micro-FTIR field spectrometer (cf.,3,4) to measure soils in southeastern Arizona near Sierra Vista. These soils consist dominantly of quartz and kaolinitic clays derived from the weathering of the nearby Huachuca Mountains to the south. After spectra were obtained of a pristine surface, the surface was dug into and turned over to a depth of about 25 cm. The sampled surface was given sufficient time to visibly dry and spectra were then obtained over the sampled area. Calibration of the spectra to radiance was done using blackbody measurements at temperatures above and below the target temperature. Apparent emissivity spectra obtained using a maximum-temperature method are shown in Figure 1. No correction for atmospheric absorptions has been attempted for these spectra.

Soil samples were also obtained at the site and later analyzed in the laboratory using a Nicolet 5SXC FTIR spectrometer with a diffuse reflectance attachment to obtain bidirectional reflectance spectra (2-25  $\mu\text{m}$ ). Samples were dried and dry-sieved to 300-1000  $\mu\text{m}$  and < 300  $\mu\text{m}$  size ranges. Reflectance spectra for these two size ranges (and a packed <300  $\mu\text{m}$  sample) are shown in Figure 2.

Following the observations of Salisbury et al. [1,2] that cleaned soils show greater spectral contrast than uncleaned soils, soils were dry- and wet-sieved to various size ranges (from 500-1000 $\mu\text{m}$  to  $\leq 53\mu\text{m}$ ) and reflectance spectra were obtained. Figure 3 shows the results for three of the size ranges.

**Discussion.** In Figure 1 the apparent emissivity difference between the 11 $\mu\text{m}$  region and the 9 $\mu\text{m}$  region for the pristine soils is about 12% while that for the sampled soils is about 5%. In Figure 2, the laboratory spectra show this difference to be 2-4%, similar to the sampled soils. Salisbury et al. [1,2] showed that laboratory spectra of soils cleaned in an ultrasonic bath show greatly enhanced contrast relative to soils not so prepared. Salisbury et al. also showed that prepared soils contained abundant fine-grained coatings until cleaned. Cleaned soils had few or no fine particles adhering to the larger soil particles and exhibited greater spectral contrast in their reflection measurements. Figure 3 shows that for our samples, the wet-sieved soils also exhibited greatly enhanced reflectance contrast relative to the dry-sieved soils, although this difference becomes less pronounced with decreasing grain size. The similar spectral contrast of wet- and dry-sieved <53 $\mu\text{m}$  soils suggests that the fine-grain coatings are probably < 50 $\mu\text{m}$ .

We suggest that bare soils exposed in the field for periods of weeks or months are cleaned of these fine particles, probably due to rain impact or possibly aolian processes (e.g., deflation), exposing surfaces of optically large grains. When the soils are sampled the fine material which is abundant in the subsurface coats the larger grains and reduces the contrast.

If spectral libraries prepared using laboratory soils are used to interpret spectra obtained in the field or remotely, significant mismatches between field and laboratory observations may cause spectrum matching methods to give spurious results. The problem may be aggravated by the compositional and mineralogic difference between the silt and sand size fraction in soil apparently dominant in spectra of pristine soils and the clay size fraction which appears responsible for the contrast reduction in sampled soils [1,2]. Figure 3 suggests that the spectral character observed in the field can be recovered and characterized in the laboratory by wet-sieving. This phenomenon has also been observed in other soils types, which will be reported in a subsequent paper.

## CONTRAST BETWEEN FIELD AND LAB SPECTRA: Johnson et al.

**ACKNOWLEDGEMENTS:** We thank W. Wadsworth and P. Dybwad of Designs and Prototypes for assistance with the Micro-FTIR field spectrometer.

**REFERENCES:** [1] Salisbury, J.W., A. Wald, and D.M. D'Aria, *J. Geophys. Res.*, **99**, 11,897, 1994; [2] Salisbury, J.W., and A. Wald, *Icarus*, **96**, 121, 1992; [3] Korb, A.R., P. Dybwad, W. Wadsworth, and J.W. Salisbury, submitted to *Applied Optics*, 1995; [4] Hook, S.J., and A.B. Kahle, *Rem. Sens. Environ.*, 1995 (in press).

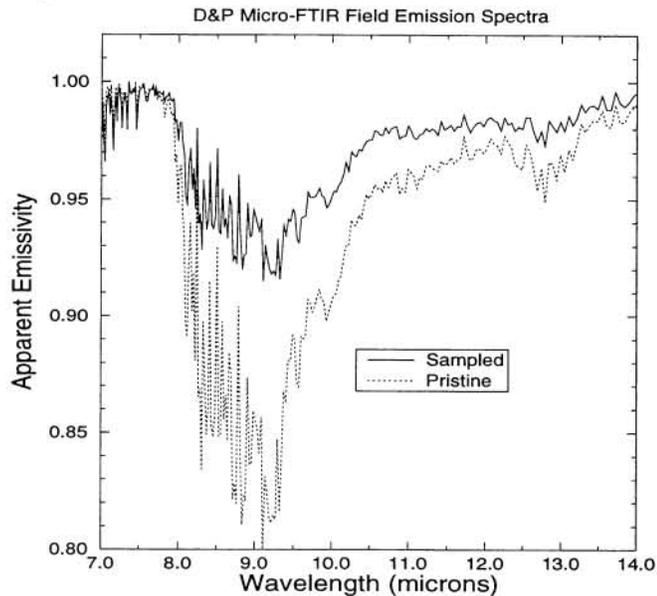


Figure 1. Apparent emissivity spectra calculated from calibrated radiance data obtained from a Designs and Prototypes Micro-FTIR field spectrometer. Shown are averages of two 16-scan measurements over pristine (in situ) and sampled (prepared for transport) patches of soil in southeastern Arizona. Resolution is  $6\text{ cm}^{-1}$ , and the patch size on the ground for each measurement was about  $15 \times 10\text{ cm}$ . Atmospheric sky lines have not been removed, resulting in the narrow absorptions throughout the spectra. Note that the pristine soil has greater spectral contrast than the sampled soil.

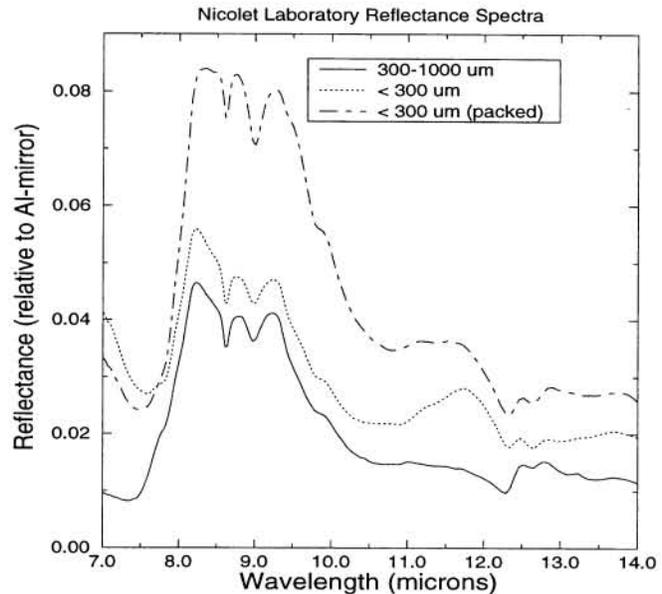


Figure 2. Reflectance spectra (relative to an aluminum mirror) obtained from a Nicolet 55XC FTIR laboratory spectrometer of soils from the same site as Figure 1. Soils were sieved to provide size ranges of  $300\text{-}1000\text{ }\mu\text{m}$  and  $< 300\text{ }\mu\text{m}$ ; the latter size range was also compressed manually to provide a packed, flat surface. Resolution is  $8\text{ cm}^{-1}$ , and each spectrum is an average of 256 scans. Note that the smaller grain size fraction has higher reflectance and greater spectral contrast.

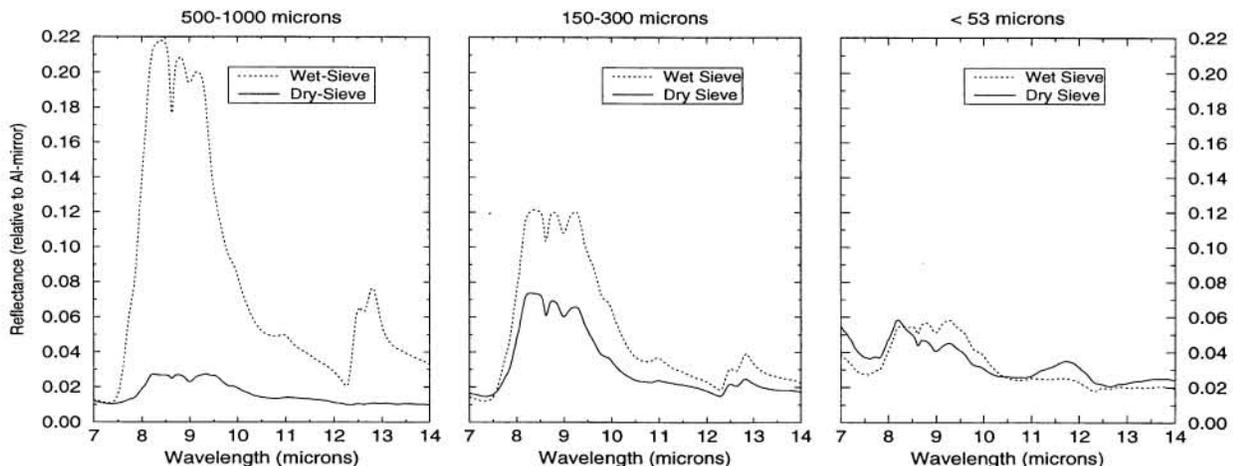


Figure 3. Nicolet laboratory spectra of dry- and wet-sieved soils from the southeastern Arizona site at various size fractions. Note the much greater spectral contrast for the wet-sieved fractions, and that this difference decreases at smaller grain sizes, suggesting that particle coatings  $< 50\text{ }\mu\text{m}$  may be responsible for the observed differences.