

THERMAL INFRARED REFLECTANCE AND EMISSION FOR REMOTE ANALYSIS OF PLANETARY SURFACES. J. M. Byrnes¹ and J. J. Byrnes², ¹Oklahoma State University, School of Geology, Stillwater, OK 74078; jeffrey.byrnes@okstate.edu, ²SRI International, San Diego, CA 92130.

Introduction: Emissivity (ϵ , a material property [e.g., 1]) derived from thermal infrared (TIR) remote sensing is widely used in analyzing surficial geology of the Earth and other rocky planetary bodies [e.g., 2-5]. Both TIR reflectance [e.g., 6] and emission [e.g., 7] measurements have been found to be useful for geologic studies. TIR reflectance techniques measure the proportion of thermal energy from a source reflected off of a sample back to a detector as a function of wavelength or, more typically, wavenumber (cm^{-1}). The TIR emission method uses the sample itself as the thermal source and compares the emitted energy to a blackbody ($\epsilon=1$) radiating at the same temperature (Figure 1). The reflectance approach is desirable because calibration is simple and a high signal to noise ratio is easily achieved. The ability to acquire laboratory-based TIR emission measurements was developed more recently because it is more directly analogous to measurements made by TIR sensors flown on airborne and spaceborne platforms [7]. The purpose of this study is to establish the utility and limitations of using TIR reflectance and emission data together in order to leverage the beneficial aspects of each technique.



Figure 1. Thermal infrared emission spectrometer configuration in the IVIS Laboratory.

Approach and Preliminary Results: Laboratory TIR reflectance and emission data are compared to determine differences in spectral characteristics as a function of the method utilized. Figure 2 illustrates TIR reflectance and emission spectra for six mineral samples (represented by individual mineral crystals) and five rocks (including monomineralic samples). All data illustrated were collected August 2010 in the Image Visualization and Infrared Spectroscopy (IVIS) Laboratory at the University of Pittsburgh. Emission data were collected using a laboratory bench top Fourier transform infrared (FTIR) spectrometer (Figure 1) following the methodology of Byrnes et al. [8] (cf. [7]). Immediately following acquisition of emission data for each sample, reflectance data were collected

using a field-portable FTIR spectrometer configured to collect diffuse TIR reflectance (Remote Sensing Analysis Laboratory, Oklahoma State University).

Discussion: Care was taken throughout data collection to ensure that for each specimen, the same surface was sampled for the reflectance and emission measurements. Additionally, spectral variations due to minor differences in measurement spot size and location were minimized. As expected, the TIR reflectance spectra are less noisy than the emission spectra and show more small spectral features for some samples (such as microcline). Also as expected, reflectance and emission spectra are grossly similar, each pair displaying the same overall spectral features at similar wavenumbers (Figure 2; cf. [8]).

Details of the spectral shapes are different between the two techniques for each sample, however. Some of the observed differences were not expected, such as the change in relative spectral feature depths displayed around $775\text{-}805 \text{ cm}^{-1}$ (and to a lesser extent $1050\text{-}1250 \text{ cm}^{-1}$) for a single quartz crystal as compared to a monomineralic quartz rock. Such differences between the quartz crystal and quartz rock may be due to differences in crystallographic orientation; the quartz crystal was measured perpendicular to the c-axis whereas the quartz rock was sampled with individual grains in the rock situated at different, random measurement orientations. Also, small shifts in minima of spectral features are observed, such as the 4.3 cm^{-1} offset in the $\sim 950 \text{ cm}^{-1}$ feature in dunite, although this difference is at the limit of the spectral resolution and is unlikely to significantly affect spectral interpretation.

In order to quantitatively characterize the significance of the spectral differences for TIR remote sensing analyses, emissivity spectra will be deconvolved. Spectral deconvolution will make use of both TIR reflectance and emission library spectra [e.g., 9] for a wide range of geologic materials.

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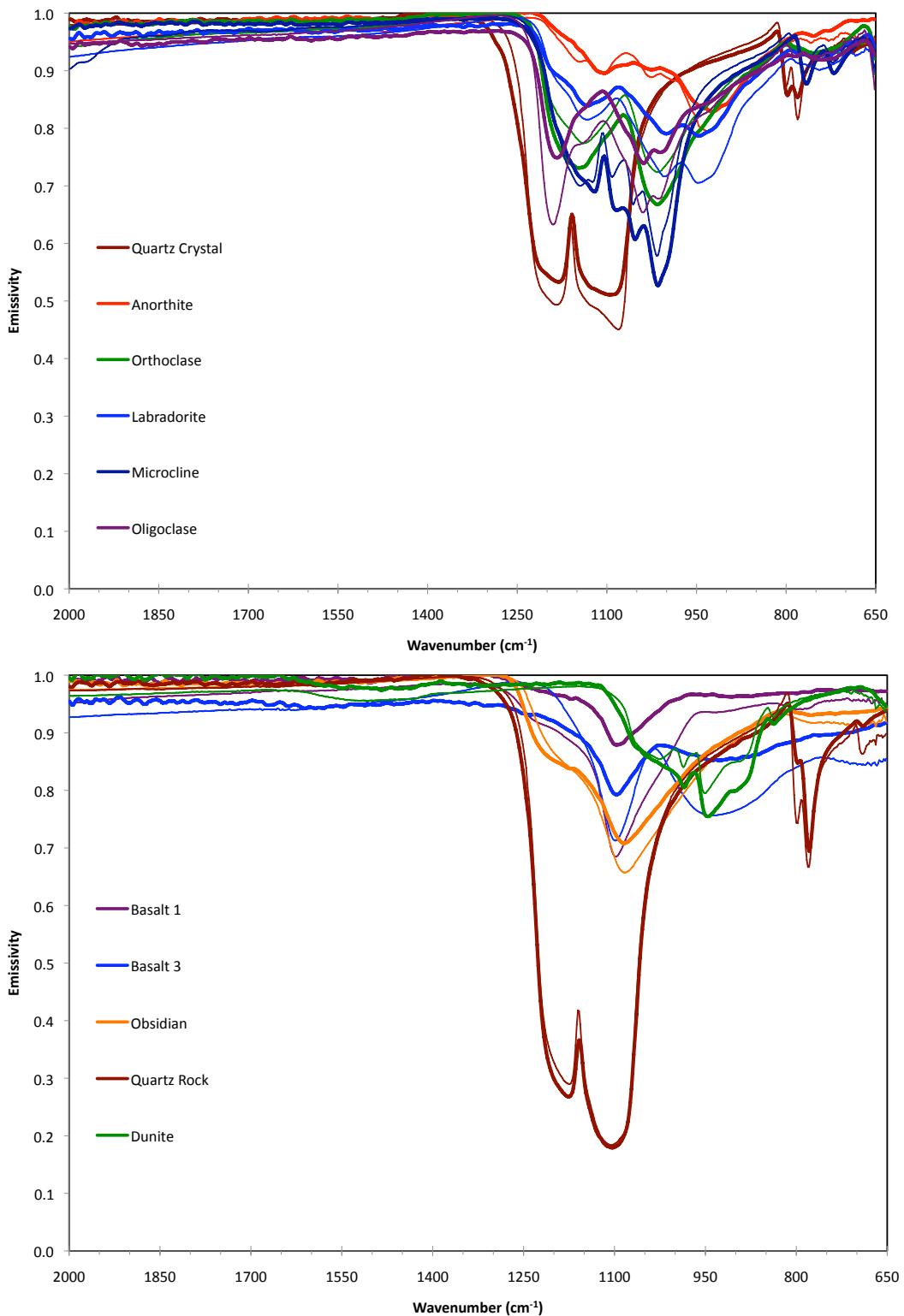


Figure 2. Thermal infrared emissivity spectra of mineral (top) and rock (bottom) samples; light lines represent reflectance data whereas heavy lines represent emission measurements.