ONE SPECTROMETER, TWO SPECTRA: COMPLEMENTARY HEMISPHERICAL REFLECTANCE AND THERMAL EMISSION SPECTROSCOPY USING A SINGLE FTIR INSTRUMENT.

V. E. Hamilton and P. G. Lucey, Hawai'i Institute of Geophysics and Planetology, University of Hawai'i at Manoa, 1680 East West Road, Honolulu, HI 96822; hamilton@higp.hawaii.edu.

Introduction: The Hawai'i Institute of Geophysics and Planetology (HIGP) at the University of Hawaii houses a new, dual-function FTIR spectrometer. This spectrometer provides an unprecedented opportunity to collect near-simultaneous (within tens of minutes) hemispherical reflectance and emission data of geologic samples, eliminating the disruption of particulate samples that necessarily occurs when such samples must be transported between laboratories. This dual setup also will facilitate cross-calibration between reflectance and emission spectra.

Background: Currently available thermal infrared spectral libraries contain reflectance and emission spectra acquired using a variety of instrument configurations [e.g., 1-3]. The differences between reflectance and emission spectra can be virtually nil, or significant [3, 4], arising from both the measurement type and assumptions made in the calibration process [e.g., 5]. For laboratory spectroscopy studies, the selection of measurement type does not matter if the data under study are acquired in a consistent manner. However, thermal IR remote sensing instruments collect emission data, so the most comparable laboratory data for quantitative analyses (as opposed to qualitative comparative analyses) are those collected in either emission or hemispherical reflectance.

Although laboratory thermal emission measurements have been referred to historically as complicated or difficult to make, they are acquired and calibrated readily if the appropriate factors are taken into consideration [5 – 7]. The spectroscopy laboratory at Arizona State University (ASU) [5, 8] houses a ThermoElectron Nexus 670 FTIR spectrometer modified to measure thermal emission over the range of ~5 – 50 µm (2000 – 200 cm^{-1}). The ASU facility was developed originally to support the Mars Observer Thermal Emission Spectrometer (TES) [9], and now supports the Mars Global Surveyor TES [10], Mars Odyssey Thermal Emission Imaging System (THEMIS) [11], and twin Mars Exploration Rover Mini-TES instruments [12] as well as educational outreach programs. Considering the quantity of emission data being returned from these instruments, and the growing number of investigators interested in analyzing those data, it will be increasingly useful to have more than one emission spectroscopy laboratory available to the planetary community.

The HIGP Spectrometer: Our ThermoElectron Nexus 470 FTIR interferometric spectrometer (essentially identical to the model 670) is equipped for reflectance and emission spectroscopy. The sample chambers and spectrometer are purged with scrubbed air to minimize water vapor and CO_2. Switching between emission and reflectance modes can be performed in 5 minutes; the conversion involves only the replacement (or removal) of a single, self-aligning mirror internal to the spectrometer and the turning on (or off) of the IR source, which is controlled via a software interface. Photos of the spectrometer and laboratory status updates are available at: http://www.higp.hawaii.edu/~hamilton/lab.html.

Hemispherical reflectance setup. Hemispherical reflectance measurements are acquired using an attachment that utilizes the viewing port on the left hand side of the spectrometer. The attachment provides an enclosure for the sample, and includes a gold-coated Labsphere (http://www.labsphere.com/) integrating sphere. The reflectance attachment acquires data from ~2.5 – 15.4 µm (~4000 to 650 cm^{-1}). Data are collected at an external, liquid nitrogen-cooled mercury cadmium telluride (MCT) detector. Sample spectra are ratioed to the spectrum of a diffusely reflecting gold plate (Figure 1); a full description of the Labsphere and sample analysis and calibration stream is provided by [13].

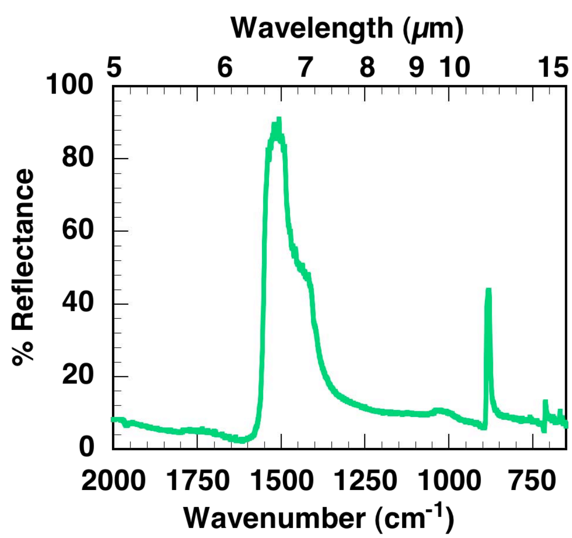

Figure 1. Hemispherical reflectance spectrum of calcite acquired using the HIGP/UH spectrometer. Spectrum is the average of 270 scans (~4.5 minutes).

Thermal emission setup. The right-hand port of the spectrometer is configured for emission measurements following the arrangement of the instrument at ASU, including the use of a water-cooled copper can for controlling the sample environment temperature [5]. This setup uses the spectrometer's internal, uncooled deuterated tryglycine sulfate (DTGS) detector, which, in conjunction with the cesium iodide (CsI) beamsplitter, permits the measurement of wavelengths from ~5 µm (~2000 cm^{-1}) out to nearly 50 µm (200 cm^{-1}). Calibration of the emission data follows the two-temperature method of [5] and [8]. At the time of this writing, the blackbody calibration target in use consists of a temperature-controlled, IR-black sample cup; data quality with this target is quite good (Figures 2 & 3). Conical blackbodies based on the ASU calibration target design currently are being fabricated. When they are delivered, we will begin thorough characterization of the instrument calibration and reproducibility.

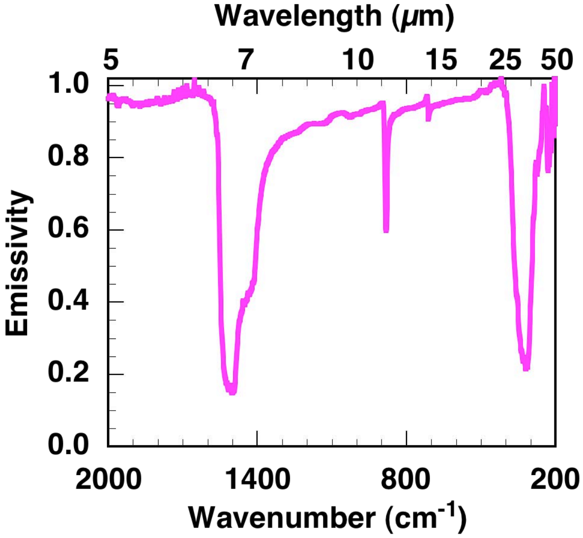

Figure 2. Emission spectrum of calcite (same sample as Figure 1) acquired with the HIGP/UH spectrometer. Spectrum is the average of 270 scans.

Anticipated Usage: The dual-use setup of the HIGP FTIR spectrometer permits local and visiting users to obtain both emission and hemispherical reflectance measurements with minimal effort. A particular benefit to the setup is that little to no disturbance of delicate samples is necessary, and users can collect both types of data, effectively yielding two spectral libraries, without the need to travel (or send samples) to multiple laboratories, resulting in time and cost savings for investigators. The dual configuration will be valuable for basic laboratory spectroscopic studies, spectral library development, calibration studies, and for aiding analysis of Mars data collected by TES and Mini-TES, which utilize the extended wavelengths offered by the emission setup.

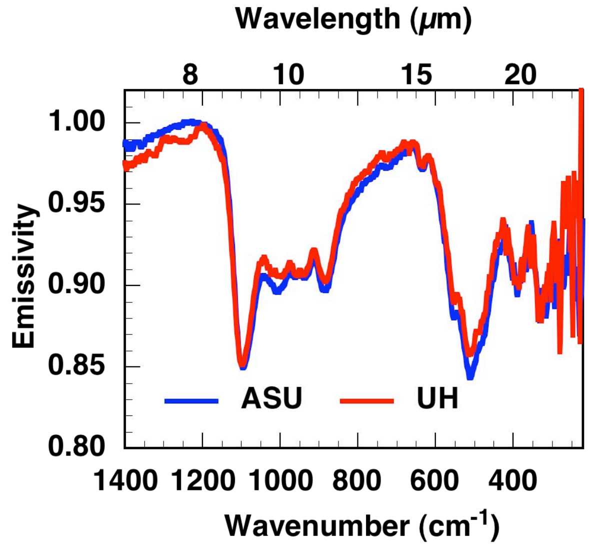

Figure 3. Emission spectra of the Zagami meteorite acquired at ASU and UH. Small variations in band shapes result from viewing slightly different surface areas of the meteorite. Note comparability of signal-to-noise. UH spectrum was acquired in an unpurged environment; narrow bands at long wavelength are water vapor rotational lines.

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