PARTICLE SIZE EFFECTS ON MID-IR EMISSION SPECTRA OF SILICATES IN A SIMULATED LUNAR ENVIRONMENT K. A. Shirley[1], T. D. Glotch[1], [1]Department of Geosciences, Stony Brook University, Stony Brook, NY 11794-2100 (katherine.shirley@stonybrook.edu)

Introduction: Remote sensing is an important tool for understanding the Moon and other airless bodies throughout the Solar System. To properly interpret remote sensing data, we require detailed laboratory validation in addition to an understanding of other variables that may affect our measurements. One of these variables is the thermal environment of the planetary body being studied.

On airless bodies like the Moon and asteroids, a thermal gradient is present in the regolith and will affect mid-infrared (MIR) spectroscopic measurements. This gradient is a direct result of the lunar or asteroid environment: lack of atmosphere, low pressure and temperature, and exposure to direct sunlight.

Regolith particle size has a strong effect on terrestrial MIR spectra, so is a particularly important variable to evaluate in an environment with a thermal gradient.

Here we present MIR spectra for several grain sizes of forsterite, augite, albite, anorthite, and labradorite obtained under lunar-like conditions using the Planetary and Asteroid Regolith Spectroscopy Environmental Chamber (PARSEC) at Stony Brook University. PARSEC is capable of measuring samples at down to 10^{-6} mbar and appropriate temperatures, and thus, can recreate lunar- and asteroid-like thermal gradients within regolith samples.

Methods: We ground and sieved samples into < 63 μm, 63-90 μm, 90-125 μm and >125 μm powders, and placed within PARSEC. We acquired spectra (400 – 28000 cm^{-1}) under terrestrial environment (TE) conditions and under simulated lunar environment (SLE) conditions. TE consisted of samples measured at 1000 mbar and heated to 80 °C (to increase spectral contrast) within a ~23 °C chamber. SLE conditions for these measurements were defined as <10^{-3} mbar pressure and chamber temperature of < -150 °C. For MIR measurements, samples were heated from below to 127 °C and exposed to heating from above by the solar lamp. Black body measurements were taken at 60 °C and 100 °C for TE and 117 °C and 137 °C for SLE using the internal black body set into the sample wheel to calibrate the MIR spectra.

We converted spectra to emissivity using the Davinci open source software following [1] for ambient spectra and [2] for SLE spectra.

Results: Near the Christiansen feature (CF) and Reststrahlen bands (RB), each mineral shows marked differences with variations in grain size and between the SLE conditions and TE conditions. The CF peak generally shifts to larger wavenumbers (shorter wavelengths) under SLE conditions and narrows with decreasing grain size. RB minima have higher spectral contrast under SLE which increases with decreasing grain size. The transparency features (TF) are also
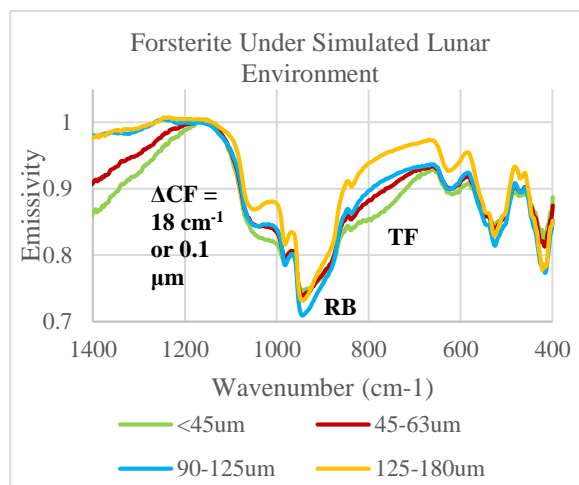

Figure 1. Spectra for grain sizes (see legend) of forsterite. Note the narrowing of the CF peak with grain size, as well as the decrease in TF minima with grain size. There is a general trend of decreasing RB with grain size, with the exception of the 90-125 μm grain size.
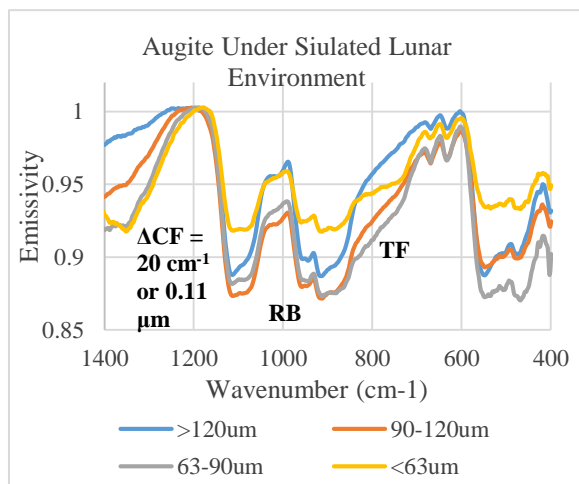

Figure 2. Spectra for grain sizes (see legend) of augite. Note the shift and narrowing of the CF peak with grain size, as well as the decrease in TF minima with grain size. There is no trend in the RB.

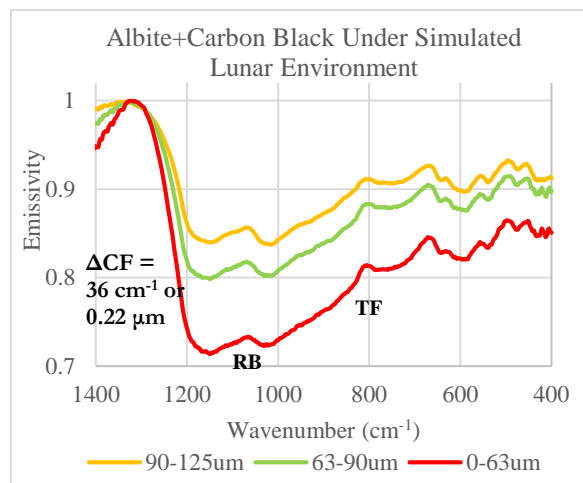minima that become more pronounced with decreasing grain size. See Figures 1-5.

Figure 3. Spectra for grain sizes (see legend) of albite. Carbon black was added because albite was too bright to take spectra otherwise. Note the narrowing of the CF peak with grain size, as well as the decrease in RB with grain size.
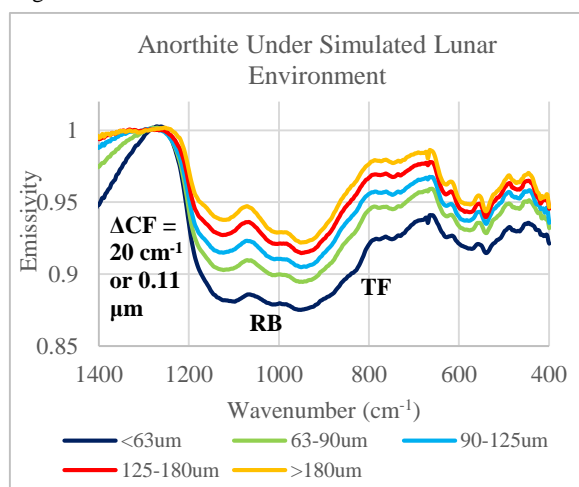

Figure 4. Spectra for grain sizes (see legend) of anorthite. Note the shift in CF with grain size, as well as the decrease in RB and TF minima with grain size.

Discussion: The narrowing of the CF peak is consistent with the increased prominence of the TF at higher wavenumbers and directly adjacent to the CF. The decrease in emissivity of the TF with decreasing particle size is present in terrestrial spectra as well, and a second TF directly adjacent and at lower wavenumbers to the RB starts to appear in the smallest grain sizes measured. The shift of the CF with grain size is harder to explain, and while relatively small (~20 cm^{-1}) is significant when attempting to identify a mineral from remote sensing data.
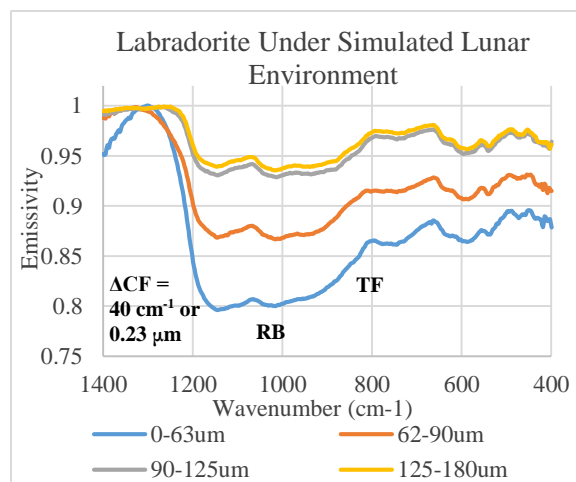

Figure 5. Spectra for grain sizes (see legend) of labradorite. Note the narrowing of the CF with grain size, as well as the decrease in RB minima.

The variation in the RB under SLE conditions, generally decreasing in emissivity with decreasing grain size, is directly opposite of the trends observed in terrestrial spectra. This trend is likely due to the thermal gradient. It could also be due to a change in porosity of the sample. The chamber evacuation rate may compress the sample and influence the spectra; however, preliminary tests with different evacuation rates have not shown a definitive trend.

Conclusions: These laboratory experiments are necessary to understand and interpret the spectral information returned from planetary surfaces like the Moon, and directly relate to the data acquired from the Diviner Lunar Radiometer Experiment currently in orbit [3-6].

We will continue to acquire the spectra of minerals of different grain sizes and, eventually, mineral mixtures, Apollo samples, and meteorite powders. These experiments will give us a better understanding of the environmental conditions in which spectra are acquired on the Moon and asteroids.

References: [1] Ruff S. W. et al. (1997) *JGR*, 102, doi:10.1029/97JB00593. [2] Thomas I. R. et al. (2012) *Rev. Sci. Intrum.*, 83(12), 124502. [3] Donaldson Hanna K. L. et al. (2013) *LPSC XLIV*, Abstract #2225. [4] Donaldson Hanna K. L. et al. (2015) *LPSC XLVI*, Abstract #1377. [5] Donaldson Hanna K. L. et al. (2012) *JGR*, 117, doi:10.1029/2011JE003862. [6] Greenhagen B. T. et al. (2012) *LPSC XLIII*, Abstract #2092.