NEW LABORATORY MEASUREMENTS OF MID-IR EMISSION SPECTRA OF SIMULATED REMOTE PLANETARY SURFACES; B. G. Henderson*, P. G. Lucey†, and B. M. Jakosky*. *Laboratory for Atmospheric and Space Physics, University of Colorado; †Planetary Geosciences, University of Hawaii.

Introduction: Thermal-infrared energy emitted from a particulate planetary surface is produced in the top few hundred microns of the material. On airless bodies, radiative cooling to space can create significant thermal gradients in this thin near-surface layer due to the importance of radiation relative to solid and gas conduction. The effects of a near-surface thermal gradient will show up in an emission spectrum due to the wavelength variation in the opacity and its relationship to the depth dependence of the temperature. We have measured emission spectra of particulate materials in conditions simulating that of remote planetary objects using an environment chamber at the University of Hawaii's spectroscopy lab. Our experiment parallels that of Logan et al. (1973) but is different in that the samples in our experiment were heated from below by a temperature-controlled substrate rather than from above by a simulated solar source.

Experiment Description: The emission measurements reported here were made using a scanning grating monochromator hooked up to a HgCdTe detector at the spectroscopy lab at the University of Hawaii . This particular setup allows spectral emission measurements to be made from 7-13 μm. The lab is equipped with a recently modified environment chamber in which the user can control the temperature of the substrate (77 K to 500 K), the radiation shield surrounding the mineral sample (77 K or 273 K), and the internal atmospheric pressure (10^{-5} to 760 torr). The main objective in this experiment was to look for spectral features due to a near-surface thermal gradient brought about by infrared radiative cooling of the near surface. The temperature of the radiation shield was therefore maintained at 77 K to simulate as closely as possible a cold-space background. Initial measurements were made in near-vacuum conditions in order to maximize any potential thermal gradient. Subsequent measurements were made at different pressures by adding dry N_2 to the chamber. Quartz was selected as the candidate sample and was prepared by sifting the powder through a 0-50 μm sieve directly into a 3 mm sample cup. The substrate temperature was maintained at $\approx$ 500 K in all trials. Spectra were obtained as emission of the sample relative to a hot reference blackbody. An estimated blackbody temperature was used to convert the relative emission spectrum to spectral radiance of the sample which was converted to an "effective emissivity" by assuming unit emissivity at the spectral location with the maximum brightness temperature.

Results: Figure 1 shows effective emissivity spectra of granulated quartz sitting on a 500 K substrate. Spectrum a was measured at an atmospheric pressure of 10^{-3} torr. The prominent emission feature at 7.35 μm is located at the wavelength of the principal Christiansen frequency and is interpreted as the result of a thermal gradient in the uppermost layer of the material. At the Christiansen frequency, the index of refraction of the material approaches unity and scattering is thus minimized. The material is more transparent, allowing increased emission from the warmer material at depth. The spectra labeled b and c were taken of the same sample but with 410 torr and 5 torr of dry N_2 added to the chamber, respectively. These data show reduced spectral contrast presumably due to a lesser thermal gradient brought about gas conduction in the pore spaces. However, the 410 torr spectrum shows more contrast than the 5 torr spectrum, counter to intuition. It is plausible that the effect of the gas at higher pressures is harder to predict since it is in contact with the 77 K radiation shield. The band near 12.5 μm is also a Christiansen-type feature and is evident in all three plots. Note that the 9-μm quartz doublet is more evident in the gas spectra than in the vacuum spectrum. Another interesting aspect which occurs in these spectra is that there is

virtually no discernable shift in the wavelength location of the emission maxima which was so notable in the measurements of Logan et al. (1973).

Conclusion: We measured emission spectra of particulate quartz heated from below in an environment chamber designed to simulate the conditions of remote planetary surfaces. Our results show that the spectra of particulate materials on the surface of warm airless bodies display prominent emission features due to the existence of near-surface thermal gradients. Increasing the gas pressure tends to decrease the magnitude of the thermal gradient, thus decreasing the spectral contrast. Our spectra are in general consistent with the measurements of Logan et al. (1973). However, our spectra do not show the shift in the wavelength location of the emission maxima with changes in gas pressure that occurred in their measurements. Since the samples in the Logan et al. (1973) experiment were heated from above with a solar lamp, it seems reasonable to conclude that the shifts seen in their spectra are due to differences in solar versus infrared absorption length scales. This result suggests that these wavelength shifts can be understood with further modeling and experimental measurements, and the emission features can be used to determine surface composition of airless bodies.

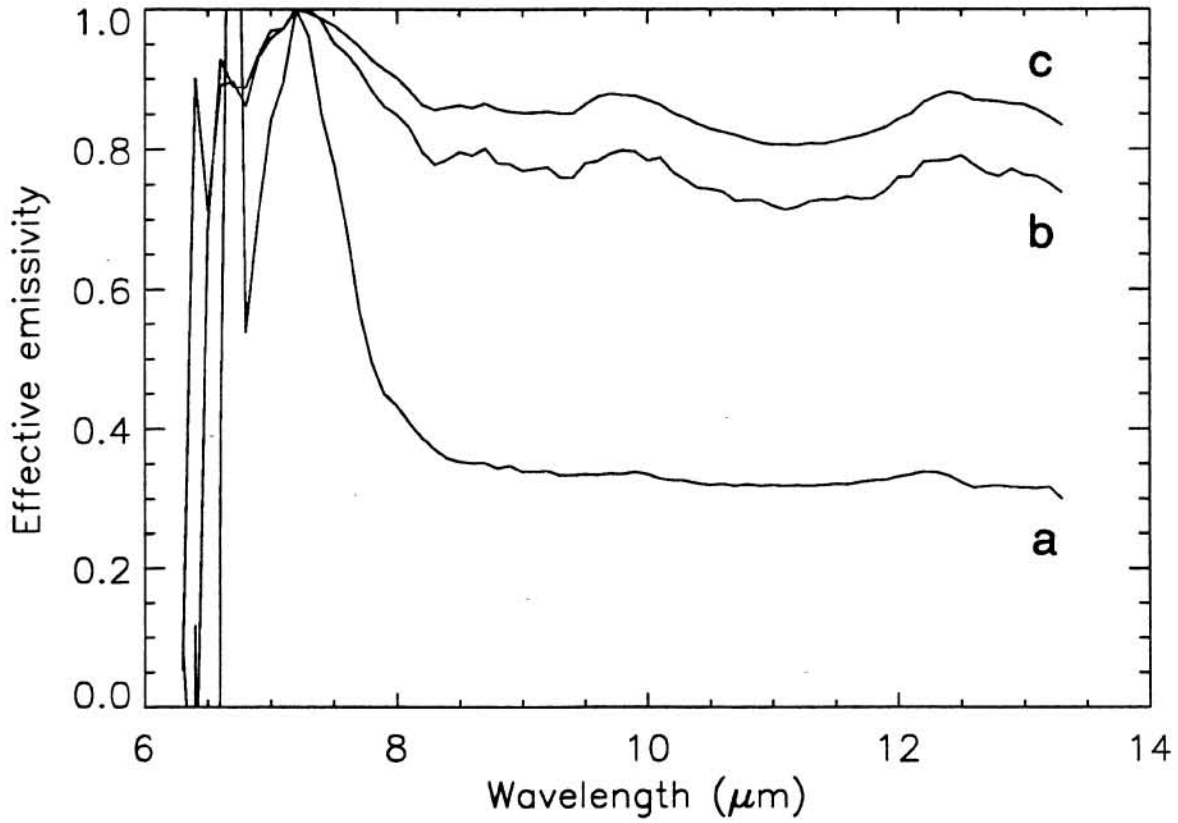

Figure 1: Effective emissivity spectra of granulated quartz measured at 3 different pressures: 10^{-3} torr (a), 410 torr (b), and 5 torr (c).

REFERENCES: Logan, L. M. et al., *J. Geophys. Res.* **78**, 4983-5003, 1973.