

MID-INFRARED EMISSIVITY OF IMPACT MATERIALS UNDER SIMULATED LUNAR ENVIRONMENT CONDITIONS. K. A. Shirley¹, S. J. Jaret², L. Thompson³ and T. D. Glotch¹, ¹Stony Brook University, Stony Brook, NY (katherine.shirley@stonybrook.edu), ²American Museum of Natural History, NY, NY, ³University of New Brunswick, Fredericton, Canada.

Introduction: Impact events are a dominant source of planetary surface processing within the Solar System resulting in the formation of craters, impact melt and shocked material. While these features can typically be identified by morphologic studies of remote imagery, identifying shocked material is more complex due to the microscale nature of most shock textures and changes to mineral structure. Because infrared spectroscopy is sensitive to the chemistry and structure of minerals, it is a useful tool for examining the effect of impacts. Multiple laboratory studies on naturally and experimentally shocked minerals have shown systematic changes to mid-infrared spectra as a function of shock level [1-5].

Here we focus on the mid-infrared ($\sim 6 - 25 \mu\text{m}$), which encompasses the region for the Reststrahlen bands (RBs), vibrational spectroscopic features directly related to the strength and movement of atomic bonds. With structural changes to the mineral it is likely that these features will also be altered.

Additionally, it has been shown that environmental conditions can greatly affect mid-infrared spectra, as on airless bodies where a thermal gradient exists in the upper hundreds of microns of regolith [e.g. 6]. Here, we examine the variation in spectra of naturally shocked plagioclase in response to measuring the spectra of material under simulated lunar environment conditions.

Methods: The samples used in this study are from Manicouagan impact structure (Canada), where anorthositic material is a significant component of the target material [7]. We measured 3 types of sample: 1) unshocked target rocks from adjacent to the structure, 2) Shocked anorthosite (“maskelynite”), and 3) impact melt-rock. The unshocked and shocked anorthosites are medium-to-coarse grained meta-anorthosite with 1 – 2 mm labradorite grains and a minor amount of subhedral garnets. The impact-melt rock is a fine-to-medium grained quartz monzodiorite [8].

Mid-infrared spectra were acquired using the Planetary and Asteroid Regolith Spectroscopy Environment Chamber (PARSEC) in the Center for Planetary Exploration at Stony Brook University. The samples were measured under Earth (ambient) conditions at 1 bar, samples heated to 80 °C, and chamber temperature at ~ 23 °C; and under simulated lunar environment (SLE) conditions at $\sim 10^{-5}$ mbar, samples heated from below

and through illumination to ~ 80 °C, and chamber temperatures < -130 °C.

Results: In the unshocked target rock material we see generally labradorite-like spectral features as expected with a Christiansen feature (CF) $\sim 1260 \text{ cm}^{-1}$, and major RBs at ~ 940 , ~ 1000 , and $\sim 1140 \text{ cm}^{-1}$ (Fig.1a). The shocked material shows similar locations for these features, though the $\sim 1140 \text{ cm}^{-1}$ RB is less prominent, and features at frequencies longward of 800 cm^{-1} are also far more muted (Fig.1a). Finally, the melt material has a CF shifted to $\sim 1280 \text{ cm}^{-1}$, main RBs at 1140 and 1040 cm^{-1} , and similar features at long wavelengths to the unshocked material.

The SLE spectra of all three samples show regions of greater spectral contrast (i.e. greater range of emissivity) than their respective ambient spectra, and all show an emissivity peak near 1240 cm^{-1} , which is the CF position in the unshocked material under SLE conditions (Fig.1b). The CFs for the shocked and melt material are ~ 1370 and $\sim 1400 \text{ cm}^{-1}$, respectively, based on polynomial fitting to the $1500 - 1100 \text{ cm}^{-1}$ region.

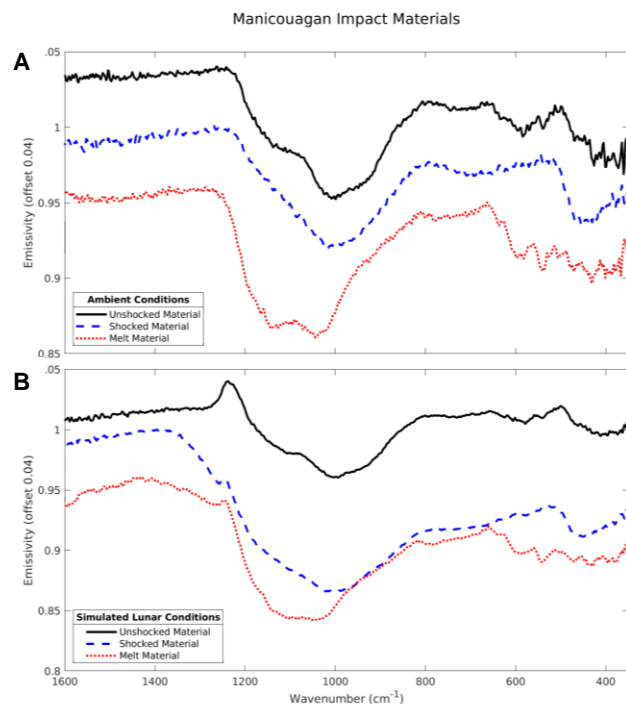


Figure 1. Comparison of the spectra from the unshocked, shocked and melt samples under ambient conditions (A) and under SLE conditions (B).

Fig. 2 provides a more comprehensive comparison of the effect of environmental conditions. The effect is minimal in the unshocked material, aside from a decrease in emissivity at frequencies short of the CF. The effect is most notable in the shocked material, which shows a large shift in the CF of $\sim 90\text{ cm}^{-1}$, creating a much broader $\sim 1000\text{ cm}^{-1}$ RB that has increased in spectral contrast by $\sim 5\%$. Finally, the melt shows a shift in the CF of $\sim 120\text{ cm}^{-1}$, and an increase in spectral contrast of $\sim 2\%$ in the RBs.

Discussion: The variations we see in the CF under ambient conditions, same position for unshocked and shocked, and shorter wavelength for the melt, are consistent with the maintenance of the silicate framework within the shocked material and the melt being more quartz-rich in composition. This variation is also shown in the RB positions between unshocked and the shocked or melt materials.

When we focus on the variation due to environmental conditions (Fig.2), we shifts in the spectra that are likely a major product of particle size variation. While the unshocked material is $>250\text{ }\mu\text{m}$, the other two samples are not sieved, though we did attempt to use the finer material. It is likely then, that the lack of variation in the unshocked material is due to the larger particle size of the material, which will have little to no thermal gradient effects because the particle size is on par with the depth of detection at these wavelengths [e.g. 6&9]. For the shocked and melt materials, because fine particles are present, a thermal gradient exists at our detection depths. This gradient is known to cause both the observed shifts in the CF position and spectral contrast. The peak in both of these samples around $\sim 1240\text{ cm}^{-1}$ may represent the CF position from the large particles in the sample, less affected by the gradient.

Conclusions and Future Work: This preliminary study shows that unshocked, shocked, and melt material can be readily identified in the mid-infrared and have varied reactions to environmental conditions. Further analysis of sieved size fractions is necessary to determine the true extent to which we can expect spectral features to shift under airless body conditions and better inform us about planetary surface composition and geologic history.

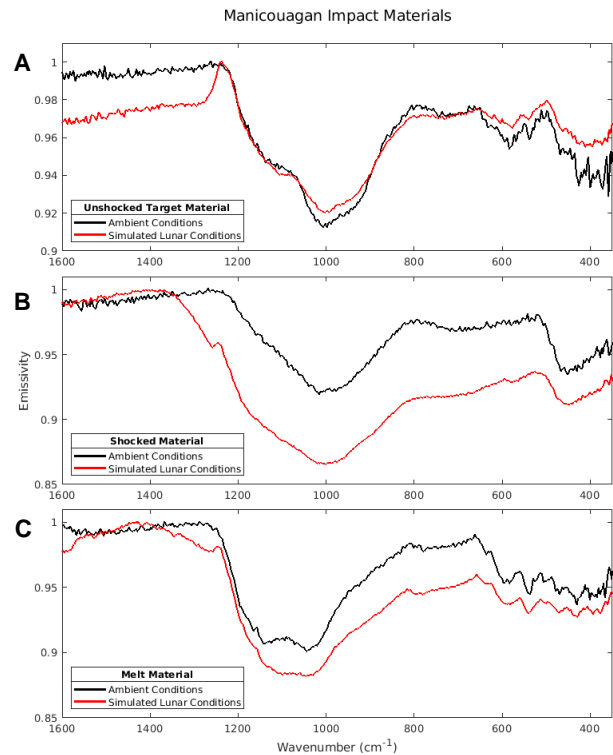


Figure 2. Comparison of the effect of environmental conditions on spectral features for the unshocked (A), shocked (B), and melt (C) material.

References: [1] Jaret S. J. et al. (2018) *JGR* 123, 1701-1722. [2] Johnson J. R. et al. (2002) *JGR* 107, 5073. [3] Johnson J. R. et al., (2003) *American Mineralogist* 88, 1575-1582. [4] Johnson R. J. (2012) *Icarus* 221, 259-264. [5] Fritz J. et al. (2017) *Meteoritics and Planetary Sci.* 52, 1216-1232. [6] Logan L. M. and G. R. Hunt (1970) *Science* 169, 865-866. [7] Spray, J. G. et al. (2010) *EPSL*. 58, 538-551 [8] O'Connell-Cooper C. D. and J. G. Spray (2011) *JGR-Solid Earth* 116. [9] Logan L. M. et al. (1973) *JGR* 78, 4983-5003.