THE EFFECT OF ALBEDO ON MID-INFRARED SPECTRA OF AIRLESS BODIES WITH IMPLICATIONS FOR DIVINER DATA ANALYSIS. K. A. Shirley[1], D. McDougall[1], and T. D. Glotch[1], [1]Geosciences Department, Stony Brook University, NY 11794 (katherine.shirley@stonybrook.edu).

Introduction: Albedo is a major optical component affected by space weathering: increased exposure to space weathering results in lower albedo or darker regolith. Reduced albedo, and other effects of space weathering (formation of nanophase iron rims, formation of agglutinates, physical breakdown of regolith) have long been studied in the visibile to near-infrared (VNIR), but we are just now beginning to see its effect on the mid-infrared (MIR).

Work by [1] noted that space weathering is apparent in the Diviner dataset, which targets the MIR, and, specifically, the Christiansen Feature (CF). The CF is an emissivity maximum the corresponds to silicate polymerization and is used by Diviner to determine bulk silicate composition across the lunar surface. [2] proposed an empirical correction to the Diviner CF dataset to account for variation due to space weathering by using the OMAT parameter [3], and noted the inverse correlation between CF position and albedo. Our previous laboratory work [4] has shown that reduced albedo, rather than compositional changes caused by space weathering is the main factor contributing to variation in the CF position with optical maturity. Here we provide a comparison between laboratory and lunar data to better understand the effects of albedo on the Diviner data set.

Methods: Samples of forsterite, augite, and anorthite of size fraction 00-32 μm were darkened using nanophase carbon to produce sample sets with varying albedo. Albedo was determined at 750 nm using an ASD FieldMax3 spectrometer. MIR thermal emission data for these samples was then collected under both terrestrial and simulated lunar environment (SLE) conditions at Stony Brook University's Center for Planetary Exploration. SLE is defined as a chamber temperature of <150 K, pressure of 10^{-6} mbar, samples heated from below to 350 K and illuminated with a solar lamp to achieve brightnes temperatures ~350 K. Data is processed via methods of [5,6] to obtain full resolution emission spectra. The CF position is then defined as the maximum of a polynomial fit to the ~7-9 μm region of the spectrum.

On the lunar surface, we expect to see the most variation in albedo at the youngest craters, due to the exposure of fresh regolith that is less affected by space weathering. Here, we examine Giordano Bruno Crater, a young (<10 Ma, [7]) crater in the highlands terrain of the lunar far side, where we anticipate relatively little variation in composition. Giordano Bruno has prominent rays that appear at visible wavelengths, as well as in the OMAT parameter maps. Using JMARS [8], we compared the Diviner normalized CF maps to Kaguya albedo at 750 nm, and to the OMAT parameter map as our index for space weathering.

Results: The laboratory data exhibit a clear trend of CF shifts to lower frequency as albedo decreases (Fig.1). All minerals exhibit this correlation, though the slope of the trend varies slightly in conjunction with the starting albedo; i.e. anorthite has the highest starting albedo, and the steepest trend.

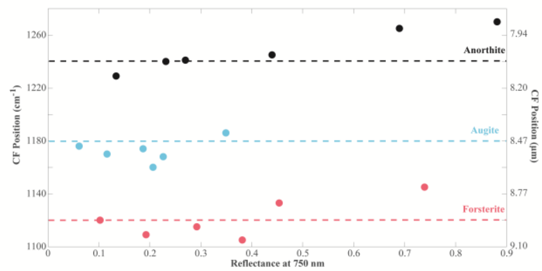

Fig 1. Comparison of CF position under SLE to albedo of the sample with the terrestrial CF position as the dashed line for each sample set. Anorthite (black) has the steepest trend, forsterite (red) has a less steep correlation, and augite (blue) has the shallowest trend.

Giordano Bruno Crater is shown in Fig. 2a with its rays extending to the southeast as seen in the OMAT parameter with immature or fresh material (bright tones), corresponding directly to albedo. Fig. 2b shows a comparison of CF, OMAT and albedo for the red transect (on Fig. 2a) going from a low-albedo region outside the crater to the bright fresh regolith within the rim as seen by the increasing albedo and OMAT parameter data (in blue and green). The normalized CF shows an overall increase in wavelength by ~0.3 μm, an inverse relationship with OMAT and albedo. Figure 2c shows a cross-section of a single ray, which displays the same inverse correlation, though with a smaller difference in CF position of ~0.15 μm.

Discussion: The differences we detect in the Diviner data are small, but within the detection limits of the instrument (0.02 μm). The change in CF position in both transects is comparable to that observed in the laboratory data. Our laboratory data are measured over a much wider range of albedo, however, the overall trends in the samples with the lowest albedo values, within the <0.2 range of those observed in the lunar data, are consistent with the lunar surface values.

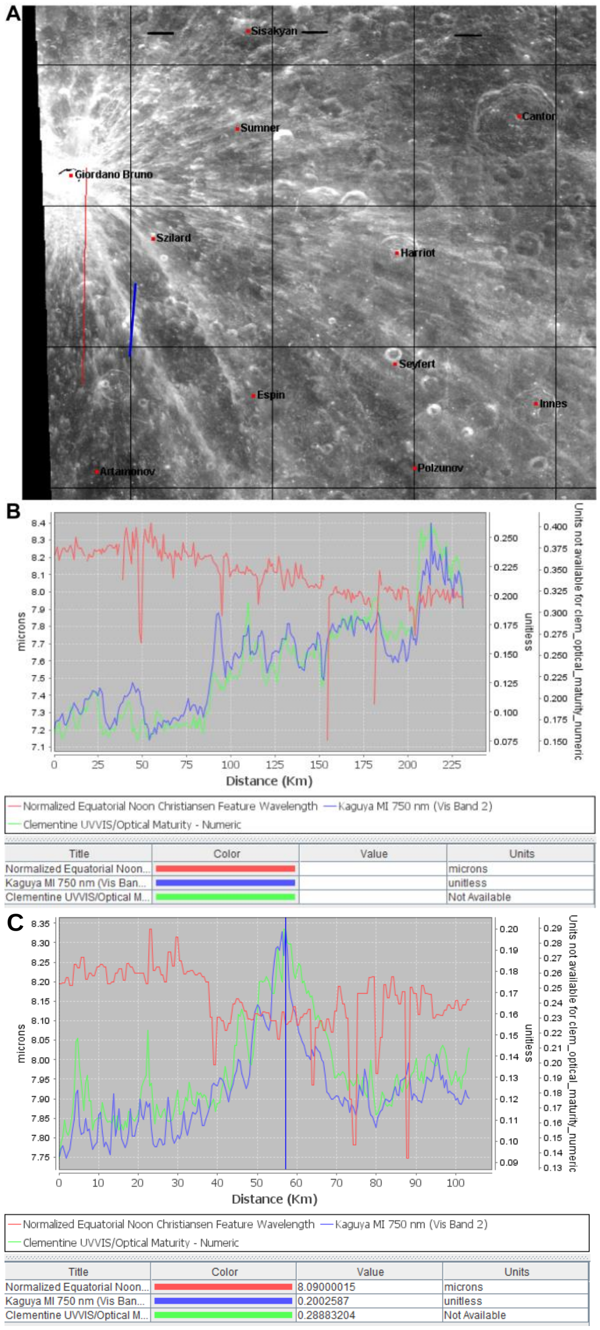

Fig 2. (A) shows a red transect on an OMAT parameter map (white=optically immature) of Giordano Bruno and a blue transect of a ray extending to the southeast. (B) shows the data from the red transect from outside to the rim of Giordano Bruno Crater showing normalized CF (red), albedo (blue), and optical maturity (green). (C) shows the data from the blue transect crossing a ray.

The difference between the observed trends for each mineral set is likely due to the thermal gradient induced in the simulated lunar environment. The presence of a thermal gradient within regolith on airless bodies is a complication we are beginning to better understand with the use of environment chambers.

In addition to analysis of the CF data, we produced Diviner channel 6/5 ratio maps (Fig. 3), which highlight these high albedo rays due to the increased spectral contrast in the Reststrahlen bands of brighter material, to assess the usefulness of using newly corrected Diviner data at long wavelengths as an additional constraint on determining effects of space weathering [9]. This work may lead to a solely Diviner-based CF correction to account for bright young material on the lunar surface.

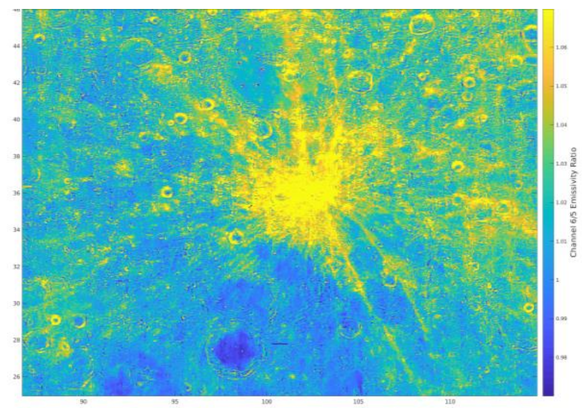

Fig 3. Diviner channels 6/5 ratio map of Giordano Bruno Crater. The crater rays show up as high values similarly to what we see in 750 nm albedo and OMAT parameter maps.

Conclusions and On-going Work: The variation in all parameters is small, but on the scale of what we observe in the laboratory. We will continue to investigate these trends at other young craters such as Jackson and Kepler, and compare our trends to the correction applied by [2]. By understanding the effects of albedo as observed between laboratory and Moon, we can begin to extrapolate and model the effects of albedo on other airless bodies, which will be affected by space weathering, such as asteroids and Mercury, that are targets of current missions.

References: [1] Lucey P. G. et al. (2010) *LPSC XLI*, Abstract #1600. [2] Lucey P. G. et al. (2017) *Icarus, 283,* 343-351. [3] Lucey P. G. et al. (2000) *JGR-P*, *105*, 20377-20386. [4] Shirley K. A. & Glotch T. D. (2017) *LPSC XLVIII*, Abstract #2115. [5] Ruff S. W. et al. (1997) *JGR*, 102. [6] Thomas I. R. et al. (2012) *Rev. Sci. Instrum.*, *83*, 124502. [7] Morota T. et al. (2009) *Met. & Plan. Sci.*, *44*(8), 1115-1120. [8] Gorelick N. S. et al. (2003) *LPSC XXXIV*, Abstract # 2057. [9] McDougall D. S. (2017) *LPSC XLIX*.