EMERGENCE OF A 3 MICRON BAND IN PARTIAL ECLIPSE AT CHANG’E 5 LANDING SITE

Abigail J. Flom¹, P.G. Lucey¹, C.I. Honniball², C.M. Ferrari-Wong¹, J.W. Head III³
1Hawaii Institute of Geophysics and Planetology, University of Hawaii at Manoa, 2500 Campus Rd, Honolulu, HI 96822 (aflom@hawaii.edu), 2 NASA Goddard Space Flight Center, Greenbelt, MD, 3 Brown University, Providence RI 02912

Introduction: Over the last decade, the behavior of volatiles on the lunar surface has become an important question in lunar science. This began with the discovery of the Moon-wide 3 \( \mu m \) band by multiple remote sensing instruments: EPOXI High Resolution Instrument, Cassini Visual and Infrared Mapping Spectrometer (VIMS), and the Moon Mineralogy Mapper (M3) [1][2][3]. This band signifies the presence of OH and possibly H\(_2\)O (collectively referred to as hydration), which is supported by the discovery of hydroxyl with solar wind hydrogen in lunar agglutinate glasses [4] and the detection of an H\(_2\)O specific 6 \( \mu m \) band [5]. Investigations of lunar hydration have important implications for understanding the conditions of the lunar surface environment as well as understanding volatiles on airless bodies throughout the Solar System. The Chang’e 5 sample return mission has returned the first lunar samples since the 1970s, providing an unprecedented opportunity to investigate the behavior of volatiles with the new perspective gained from the remote sensing discoveries. We will use the 3 \( \mu m \) band to characterize hydration at the Chang’e 5 site.

Data in the 3 \( \mu m \) region is complicated by the presence of both emitted and reflected radiation, and there is debate about how to best correct for thermal emission in M3 data, which does not contain any wavelengths beyond 3 \( \mu m \) to constrain thermal models for the data. Bandfield et al. [6] found a 3 \( \mu m \) feature across the Moon, but do not see differences with latitude or lunar time of day. On the other hand, Li et al. [7], Wohler et al. [8], and Honniball et al. [9] see strong differences with these parameters.

We deal with the thermal emission problem using observations collected during partial lunar eclipse with the SPeX infrared cross-dispersed spectrograph at the NASA InfraRed Telescope Facility (IRTF). This gives us two advantages for thermal correction. First, the instrument collects data from 1.67 to 4.2 \( \mu m \), allowing it to see wavelengths where the thermal emission dominates. A strong test of the quality of thermal corrections is their quality at longer wavelengths where the thermal emission is increasingly dominant. Second, observing during the decreased illumination of a partial eclipse causes the surface temperatures to decrease which decreases the thermal emission and moves it out to longer wavelengths in accordance with Wien’s law. Despite the decrease in reflected illumination, this greatly increases the ratio of reflected to thermally emitted light at 3 \( \mu m \) and reduces the impact of the thermal correction on the measurement.

![Figure 1: Reflectance spectra from the Chang’e 5 landing site throughout the progression of the eclipse. Most measurements were taken during the onset of the eclipse except for the 60% measurement which was taken as the site exited eclipse.](image)

We present data from the Chang’e-5 site obtained on November 30th, 2020 between 7:08 UT and 10:10 UT (less than 24 hours before the spacecraft landed). Spectral data were collected in 100%, 95%, 65%, 60%, and 40% illumination conditions. The results from this data set will also be compared to observations of other mare and highland terrain sights in eclipse conditions, including the lunar swirls Reiner Gamma and Airy.

Results: The spectra from the Chang’e 5 landing site show variation throughout the progression of the eclipse (Figure 1). The 100%, 95%, and 65% illumination are from the onset of the eclipse and show decreased reflectance at 3 \( \mu m \) as the eclipse progresses. The 45% illumination spectrum is from the deepest portion of this partial eclipse and it displays a distinct hydration band. This band continues to be apparent in the 60% illumination spectrum taken during exit from the eclipse.

Conclusions: Investigation is necessary to determine why a strong 3 \( \mu m \) band develops during eclipse. The asymmetry between the measurements entering and exiting the eclipse are inconsistent with an instantaneous optical effect due to the change in lighting and thermal emission, however it is also surprising that hydration would be forming or migrating on the short time scales of the eclipse.