
The Galileo spacecraft, carrying the Near Infrared Mapping Spectrometer (NIMS), flew by the Earth-Moon system for the second time in December of 1992. The highest resolution NIMS image of the Moon acquired during the flyby covers primarily the northern hemisphere of the lunar nearside with 204 wavelengths in the spectral region from 0.7 to 5.2 μm. Spatial resolutions are approximately 27 km/pixel in the final calibrated image cube. Although many spectral channels of the data set are saturated, as the instrument was designed for the lower flux levels at 5 AU, we have had good success in working with the unsaturated data to map the lunar mineralogy. Noise or jitter in the spectral dimension is introduced by the motion of the spacecraft between grating steps. We have designed simple algorithms that effectively remove this component, resulting in reasonably noise-free spectra. We have used these spectra to map the 1- and 2-μm silicate absorption features of the moon, including band center position, asymmetry, and depth.

Systematic processing of the NIMS data first corrects for detector gain states and chopper modes, detector sensitivity as a function of temperature and background dark subtraction. Interband geometric registration is applied based upon the spacecraft motion. The image cube was then converted to radiance. In order to compare with published and earth-based reflectance observations of the moon we needed to remove the solar spectral response and viewing geometry effects. Our first efforts at calibration focused on the spectral region without contributions from thermal emissivity of the lunar surface. Future work will calibrate the entire spectral range. The work presented here uses either the first 5 detectors for the spectral range 0.7 to 1.8 μm, or the first 9 detectors for the range 0.7 to 2.9 μm. Because the instrument was not designed for the lunar flux levels, many spectral channels are saturated. Our current analysis works only with pixels that are unsaturated in all spectral channels for the wavelength range of interest. Additionally due to the spatial binning (described in the next paragraph) pixels near the terminator or the limb may contain a component of space or nightside observations. Therefore pixels on the limb or with incidence angles larger than 88 degrees were eliminated from our analysis. This results in approximately 1300 near-terminator pixels where we can map the 1-μm silicate absorption and 700 pixels where we can map both the 1- and 2-μm absorption features. Figure 1 shows the location of the majority of these pixels on the lunar near side.

The data are acquired spectrally in a “jail-bar” fashion. At the first grating step the 17 individual detectors will sample wavelengths throughout the entire spectral range (0.7-5.2 μm). The second grating step will move the “jail-bar” pattern slightly upward in wavelength, so that the detectors sample an adjacent set of wavelengths. After a full set of grating steps the bar pattern is filled in to provide a complete spectrum from 0.7 to 5.2 μm. Each detector therefore, measures a short, contiguous range of wavelengths in twelve grating steps. This process is illustrated schematically for the first three detectors in Figure 2. Unfortunately, there is spacecraft scan platform motion occurring during the acquisition of a complete spectrum and this leads to a periodic noise component in the spectra. That is, the observations at wavelengths in any given grating step are spatially co-registered but wavelengths from different grating steps are not. Data calibration combines spatially adjacent observations into a single pixel, thus providing a complete spectrum but results in periodic variations in intensity. In order to remove this periodic noise or “spectral jitter” we apply simple algorithms described next.

To remove the spectral jitter introduced by spatial binning we begin by smoothing the original spectrum. This is done with a box filter whose width is the number of grating steps. We next take the ratio of the
smoothed spectrum to the original. For each grating step we add the ratio values at each detector and then divide by the number of detectors being used in our analysis. This results in a jitter pattern that is a function of grating step number. We divide this jitter pattern into the spectrum obtained by each detector to obtain a dejittered spectrum for the entire wavelength range. There are occasionally residual offsets at detector boundaries, and these are removed if they are larger than the noise level in adjacent spectral segments. Because there is a wavelength overlap between the last grating step of one detector and the first grating step of the next detector, the detector boundary offsets are removed using a linear interpolation of wavelength versus intensity. These corrections result in reasonably clean spectra where band depth, asymmetry, and band center can be mapped systematically and results in identification of specific minerals on the lunar surface.

Lunar surface mineralogy is dominated by high- and low-Ca pyroxene, plagioclase feldspar and olivine [e.g., 1]. All of these exhibit diagnostic spectral absorption features in the near-infrared and can be used to map lunar mineralogy including mineral composition and mineral mixing [e.g., 2, 3, 4]. Our results are consistent with global maps of mafic band depths presented by Spudis and Pieters [5], with the highest 1-µm band depths occurring in the dark mare, particularly the Oceanus Procellarum and Sinus Roris regions. Larger band depths are also indicated in the Mare Humboldtianum region; however, only a few pixels are available in this area. Band depth decreases over the pole, and a second region of moderately strong band depth is noted on the lunar farside near Maxwell and Lomonosov craters. Band depths of the 1- and 2-µm absorptions are, in general, highly correlated. Maps of band center position, depth, and asymmetry, which are indicative of both olivine and pyroxene composition as well as the relative proportion of olivine and pyroxene [6-9], will be presented at the meeting.


Figure 1: Location of NIMS pixels on the lunar near side.

Figure 2: Relation of grating step, detector, and wavelength.