

GLOBAL COMPARISONS OF MARE VOLCANISM FROM CLEMENTINE NEAR-INFRARED DATA. M. I. Staid, L. R. Gaddis, and C. E. Isbell. U.S. Geological Survey, Astrogeology Program, 2255 N. Gemini Dr., Flagstaff, AZ 86001.

Introduction: Clementine ultraviolet-visible (UVVIS) data have been merged with empirically calibrated multispectral data from the Clementine near-infrared (NIR) camera in order to characterize the reflectance properties of the Moon's major mare deposits. The high spatial resolution and global coverage of the merged Clementine data provides an opportunity to compare the spectral properties (0.4 to 2.0 μm) of craters small enough to have sampled individual volcanic deposits [1,2,3]. The spectral properties of optically immature craters are especially important targets for remote sensing because crystalline lunar materials exhibit diagnostic absorption features related to their mineralogy [e.g. 4,5].

Empirically calibrated Clementine NIR data: The addition of calibrated NIR data to previous studies of lunar basalts provides new information for determining the abundance and composition of pyroxenes, olivine and glass components within unsampled mare deposits. A major component of this research has been the empirical calibration and merging of Clementine NIR data with existing UVVIS data in order to obtain the data necessary for global spectral comparisons. These empirical calibrations are in addition to previous radiometric and photometric calibrations of the NIR camera [6,7,8] and have been included in a recent global release of 500 m/pixel NIR data by the U.S. Geological Survey [9].

After radiometric and photometric calibrations, frame offset corrections were derived for every NIR frame to adjust for residual problems in the characterization of specific camera modes and the drift of radiometric properties over the two month Clementine observation period. Frame offset corrections were derived by identifying truth sets where various camera settings exhibited the least amount of radiometric variability, and by differencing the global ratio of each NIR band to the UVVIS 0.75 μm channel by the same ratio after applying spatial filtering. The global NIR data was then normalized to reflectance based on convolution of Apollo 16 soil measurements [10] through the first four NIR filter transmission curves and comparison of results to NIR data of the Apollo 16 location used to calibrate the UVVIS data. The longest NIR bands (2.6 and 2.7 μm) were not normalized to these soil measurements because reflectance information at these wavelengths may be complicated by thermal emissivity. These calibrations are described in more detail in [9], which accompanies the USGS calibrated NIR dataset.

Application to Mare Basalts: A broad range of near and far side mare deposits have been selected for global comparisons of mare crater spectra. The spectral properties of small mare craters from each deposit were compared with associated mature soils to define the optical weathering of individual basalt types based on the approach of Staid and Pieters [3]. Spectra representing mare soils with low levels of feldspathic contamination and the least weathered mare crater materials (0.5 an 0.1% of each surface) were then derived using the merged 500 m/pixel UVVIS and NIR dataset described above.

Clementine 415/750 and 750/1000 μm band ratios are plotted for fifteen mare despositos in **Figure 1**. This plot provides a comparison of estimated titanium content and ferrous band strength for each mare deposit. Mare deposits appear to fall into three groups: basalts with low-titanium contents and weak 1 μm mafic bands outside of the major basins (e.g. Australe, Sominorum, Mosoviense), basalts with moderate to high titanium contents and a range of iron contents within major basins (e.g. Serenitatis, Tranquillitatis, South-Pole-Aitken and Orientale) and the compositionally unique high-titanium, high-iron Procellarum basalts which include the youngest major volcanic deposits on the Moon [e.g. 11].

Figure 2 compares the Clementine 0.95/1.1 μm ratio (determined by 1 μm band position and width) to the 1.5/2.0 μm band strength for the freshest 0.5% of each mare surface. Because the relative proportion of olivine, pyroxene and glass components affect the 1 μm band shape as well as the relative strength of the 1 and 2 μm bands, **Figures 1 and 2** provide insight into the mineralogical diversity of lunar basalts. The basalts plotted in **Figure 2** also appear to fall within three major groups. Several very-low titanium basalts identified in **Figure 1** tend to have narrow, short wavelength 1 μm absorptions and relatively high 1.5/2.0 μm ratios (perhaps related to a lack of opaques rather than abundant pyroxenes). The majority of basalts, however, fall in the center of the plot and have a range of 1.5/2.0 μm ratios but similar 0.95/1.1 μm band shape ratios. Only immature mare materials from the Western Procellarum basalts exhibit very unique spectral properties in this plot. The strong, broad, and long wavelength 1 μm absorption and a relatively weak 2 μm absorption of these materials are consistent with these last major eruptions of lunar basalt having a unique iron-rich composition with an abundant olivine component [12,13].

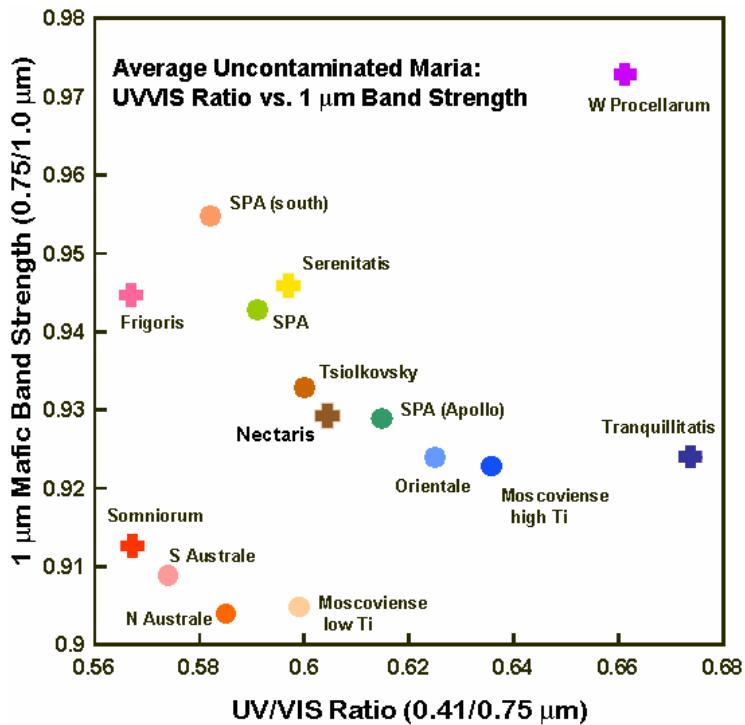


Figure 1. Spectral ratios derived for uncontaminated areas of 15 major mare deposits. Near side maria are shown as plus symbols while far side maria are represented by circles. The UV/VIS ratio provides an estimate of titanium content while the 1 μm mafic band strength is related to the abundance of ferrous minerals such as pyroxenes and olivine for surfaces with similar average optical maturities. Mare materials within Oceanus Procellarum (upper right) have both strong mafic bands and high UV/VIS ratios, indicating basalts with uniquely high iron and titanium compositions.

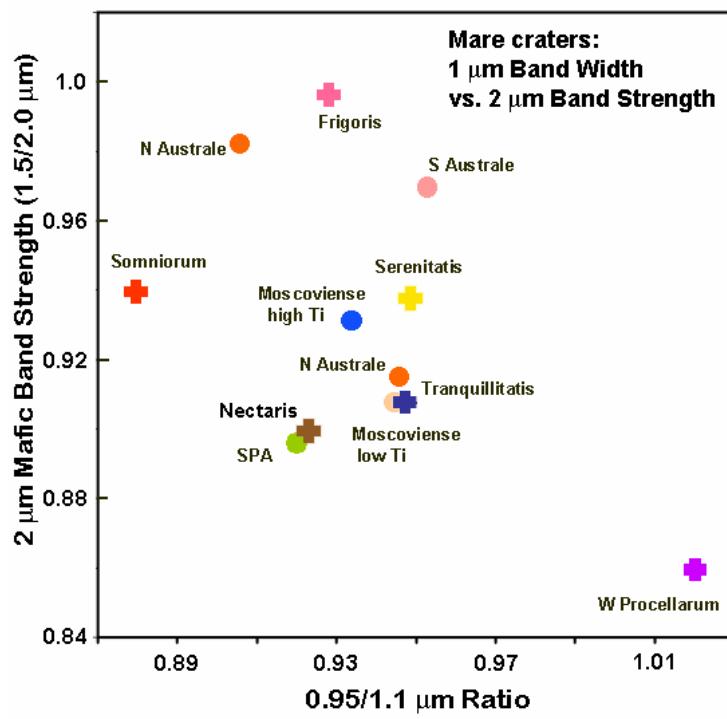


Figure 2. Spectral ratios derived from mare crater materials after merging data from the Clementine UV/VIS and NIR cameras. Clementine ratio values are shown along the x-axis for the UV/VIS 0.95 μm channel over the NIR 1.1 μm channel in order to examine the band center and width of optically immature craters. The y-axis plots a measure of the 2 μm band strength. Of all mare materials examined, optically immature craters from Oceanus Procellarum have a uniquely long wavelength 1 μm band and a relatively weak 2 μm absorption. These spectral properties combined with the strong 1 μm absorption demonstrated in Figure 1 are consistent with abundant olivine in these basalts.

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