MAPPING GLOBAL LUNAR BASALT COMPOSITIONS WITH CLEMENTINE UVVIS AND NIR DATA. N. E. Petro[1], L.R. Gaddis[2], and S.R. Rodriguez[3,4], [1]NASA\GSFC, Code 698, Planetary Geodynamics Group, Greenbelt, MD, 20771, (Noah.E.Petro@nasa.gov). [2]USGS, Astrogeology Science Center, Flagstaff, AZ. [3]NASA Undergraduate Research Program-NASA\GSFC. [4]U. of Puerto Rico.

Introduction: With the online release of a calibrated and coregistered Clementine near infrared (NIR) global mosaic (100 m/pixel nominal resolution, 1100-2000 nm in four bands, [1]) both ultraviolet-visible (UVVIS) and NIR data can now be used for detailed spectral characterization of lunar surface materials. The two long-wavelength NIR bands suffer from uncorrected thermal effects and are not used here. Numerous studies have primarily used Clementine UVVIS data for characterizing compositional diversity of both fresh and mature lunar surface materials [2-6]. The NIR data provide additional information on longer wavelength absorption features (i.e., olivine, pyroxene) [7, 8]. We have applied these same methods to an analysis of combined Clementine and UVVIS and NIR data for characterizing basic compositional mapping properties of lunar basalts, including the UV/VIS ratio, albedo, and band depths at 1 and 2 µm. Here we report early results on a survey of lunar basalt types in the Mare Ingenii region of the lunar far side using integrated Clementine UVVIS and NIR data.

Prior color classification of lunar basalts by Pieters [9] used Earth-based telescopic spectra. Thirteen near-side basalt types were identified on the basis of their UV/VIS ratio, albedo, and strength of 1 and 2 µm absorption bands (Table 1). For the first time, basalts across the entire Moon can be similarly characterized using the global Clementine color data.

Table 1. Mapping parameters [after 9] for lunar basalts.

Values	UV/VIS Ratio (415/750)	Albedo (750nm)	1µm Band (1000/750)	2µm Band (2000/ 1500)
Low	**H**: High (>1.05)	**B**: Bright (>9.5%)	**S**: Strong	**P**: Present (e.g., MS2)
	h: Med. High (1.02-1.05)	**I**: Intermediate (8-9.5%)	**G**: General Average	
	m: Medium (0.9-1.02)			
High	**L:** Low (<.99)	**D:** Dark (<8%)	**W**: Weak	**A:** Absent

Known Issues With Clementine NIR Data: The NIR data proved difficult to calibrate (largely because of uncorrected noise and residual thermal effects at longer wavelengths), but a set of wavelength-dependent correction factors (UVVIS bands 3-5 and NIR bands 1 to 4, 900 to 2000 nm wavelengths) were provided by Lucey [1] to improve "ground-truth" calibration for the data as compared to Earth-based telescopic data [1] for Aristarchus Plateau. In an effort to improve upon this calibration to include a broader range of compositions, we are extending the "ground truth" to include other near side sites for which high-quality Earth-based telescopic spectra [e.g., 10] exist.

Application to Mare Ingenii: Mare Ingenii represents the most voluminous and thickest occurrence of mare basalts within the South Pole-Aitken Basin (SPA) [11]. This region is unique on the Moon in that it shows extensive mantling by high-albedo swirls of undetermined origin [12, 13] (*Figure 1*), a unique terrain possibly due to antipodal effects from nearside basins [14, 15], and is one of the largest areas of mare basalt on the lunar far side [16].

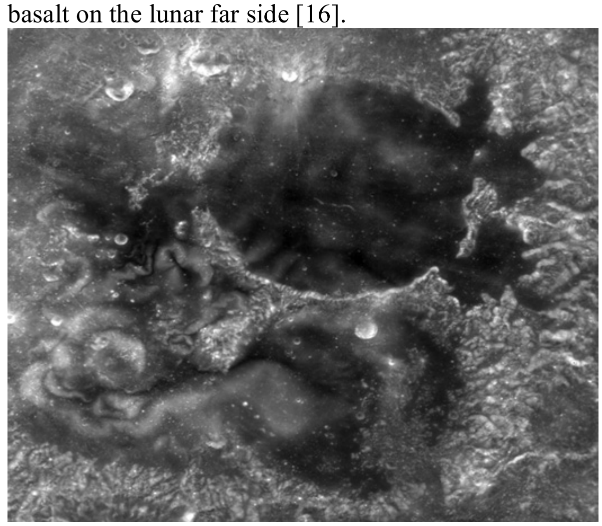

Figure 1. Clementine 750nm albedo image of Mare Ingenii. Projection is simple cylindrical. Bright swirls mantle much of the basalts within the basin.

Work by Staid et al. [7] has demonstrated the utility of the combined Clementine UVVIS and NIR data for characterizing and mapping mare basalts on the Moon. Our analyses of the Clementine UVVIS and NIR data for Mare Ingenii basalt deposits allows for better discrimination of the presence of high- and low-calcium pyroxenes and olivine in those mafic materials.

Mare Ingenii Basalts: The mare basalts within Ingenii are significantly mantled by swirl material as well as ejecta from nearby smaller craters (*Figures 1 and 2*). Large exposures of unmantled basalts are infrequent for a mare deposit of this size, but there are areas where the uncontaminated mature and fresh materials are exposed and the composition of the basalts can be determined. Nine-band spectra extracted from small fresh craters within Mare Ingenii maria show compositional variability within the basalt units (*Figure 2*). The "Fresh Mare" (green spectrum in *Figure 2*), selected in a region far from mantling material, shows a mafic absorption feature centered short of 1 µm, similar to other basalts within SPA [12]. The "Fresh 'Lane' Material" (a small fresh crater in a "lane" of unmantled material in between swirl deposits) shows a similarly positioned 1 µm absorption band. A small fresh crater in the mantling material (Fresh Mantling Material in *Figure 2*) also contains a strong 1µm absorption feature. Also included in *Figure 2* is a Clementine-derived spectrum of the MS2 standard site as the basalt parameters defined by Pieters [9] use the MS2 site as a reference.

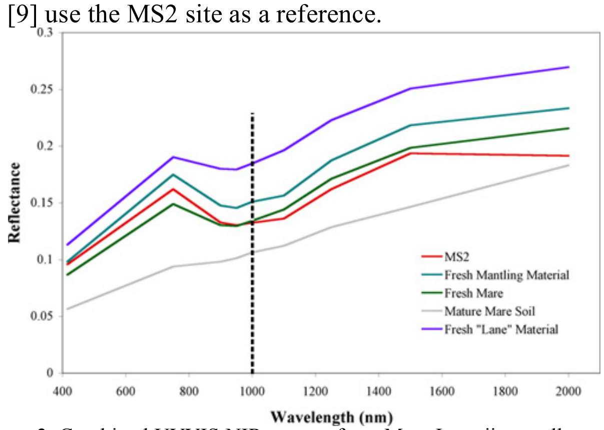

Figure 2. Combined UVVIS-NIR spectra from Mare Ingenii as well as the MS2 standard site [9]. The location of the 1000 nm "join" between the UVVIS and NIR data are marked by a dashed line.

Mare Basalt Classification: The integrated Clementine UVVIS-NIR data allow for the mare basalt classification parameters of Pieters [9] to be applied to far side basalts at Mare Ingenii and several results have been obtained: (1) The Ingenii basalts exhibit a comparable or steeper UVVIS ratio than MS2; (2) Unmantled basalts are generally the same albedo as MS2 (in the Pieters [9] Bright to Intermediate range); (3) The 1 µm band in Ingenii basalts is strong, however the MS2 site has a longer wavelength 1 µm band center, suggesting that the Ingenii basalts contain lower-Ca pyroxenes; (4) The Ingenii basalts do not show evidence for a 2µm band. These data suggest a classification of the Ingenii basalts of HISA (Table 1), similar to basalts in the Flamsteed (Ring) unit of Pieters [9]. However, there is no nearside basalt unit (thus far) mapped that is similarly classified. A major portion of our ongoing classification efforts will be to sample all basalt types and update the Pieters [9] classifications.

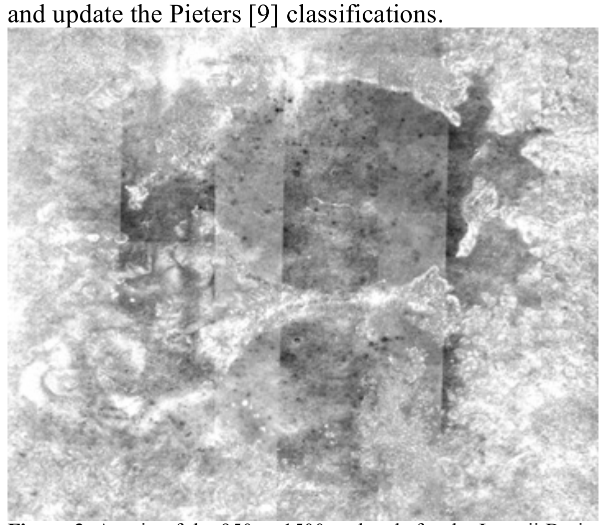

Figure 3. A ratio of the 950 to 1500nm bands for the Ingenii Basin. Artifacts in the NIR data are apparent in the "banding" of the data.

Conclusions: Clementine UVVIS-NIR data of the Ingenii basalts in northwestern SPA reveal that they are spectrally unique when compared to basalts on the nearside. More rigorous comparisons between the Ingenii basalts and other basalt types, indeed a full survey of basalt types, is underway. The Clementine UVVIS-NIR data still suffer from residual calibration issues (*Figure 3*) that make comparing units difficult and further calibration of the NIR data are required (note 1100 nm "kink" in "Fresh Mare" spectra in Figure 2). However, these global data are extremely useful for characterizing basalts (and other rock types [17]), especially for comparison with spectral reflectance data to be collected by instruments currently in orbit around the Moon (e.g., the Moon Mineralogy Mapper [18], SIR-2, and Hyper Spectral Imager on Chandrayaan-1 and the Spectral Profiler on Kaguya).

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