NEAR INFRARED SPECTRAL PROPERTIES OF SELECTED NEARSIDE AND FARSIDE SITES. D. Steutel[1], P. G. Lucey[1], and J. J. Gillis[1], [1]dsteutel@higp.hawaii.edu, Hawai'i Institute of Geophysics and Planetology, University of Hawai'i, 1680 East-West Road, Honolulu, HI 96822.

Introduction: The 1994 Clementine mission [1, 2] to the Moon collected global multispectral imagery using two instruments: ultraviolet-visible (UVVIS, wavelengths 0.415, 0.750, 0.900, 0.950, & 1.000μm) and near-infrared (NIR, wavelengths 1.10, 1.25, 1.50, 2.00, 2.60, & 2.78μm) cameras. While the UVVIS data have been calibrated and high resolution global data have been available since 2000 [3], the NIR data have only recently been calibrated [4] and made available [5]. In this study we examine the UVVIS and NIR spectral features of selected nearside and farside sites. Previous studies have compared derived properties of these or similar surfaces, but only now can the full visible and NIR spectral properties be directly compared.

Data Set: The USGS mosaics of Clementine UVVIS and NIR data were used in this analysis. Data were resampled to 1km spectral resolution to improve signal-to-noise ratio. In early analysis of these data, we found dark mare surfaces showed anomalously low band depths relative to ground based telescopic data. Acknowledging the major issues with zero-level fluctuations in the raw data, we elected to perform a "two-point" calibration of the data using both the usual Apollo 16 soil [6] and a second site near the Apollo 11 landing site and a spectrum of Apollo sample 10084 obtained from the Brown University RELAB facility [7]. A set of gains and offsets were developed from these data to adjust the Clementine data to yield band depths consistent with groundbased spectroscopy of dark regions (Table 1).

Wavelength (μm)	Gain	Offset
0.415	1.2701	0.0337
0.750	1.1447	0.0341
0.900	1.1221	0.0300
0.950	1.1197	0.0308
1.000	1.1278	0.0326
1.100	1.1316	0.0324
1.250	1.1121	0.0278
1.500	1.0091	0.0051
2.000	0.9922	0.0019

Table 1. A two-point calibration based on Apollo 16 & Apollo 11 landing site spectra and returned sample spectra was used to correct for anomalously low band depth in dark spectra.

Data Analysis: We selected regions of mature mare and highlands on the nearside and farside. Spectra from each region (listed in Table 2) were extracted from the data, averaged, and then compared (see Figures 1-3).

Region	Category	Continuum slope	R_750
maria			
Serenitatis	nearside	0.082	7.9%
Nectaris	nearside	0.085	10.9%
Crisium	nearside	0.076	8.2%
Orientale	nearside	0.071	9.6%
Procellarum	nearside	0.052	6.4%
Imbrium	nearside	0.087	9.5%
Frigoris	nearside	0.094	12.9%
Moscoviense_1	farside	0.107	10.7%
Moscoviense_2	farside	0.079	8.9%
Smythii	farside	0.088	8.7%
Marginis	farside	0.087	9.5%
Australe	farside	0.077	9.7%
Ingenii	farside	0.078	10.2%
Bose	farside	0.057	9.5%
Liebnitz	farside	0.074	9.5%
Tsiolkovsky	farside	0.092	9.9%
Apollo	farside	0.055	7.9%
highlands			
Apollo_14	highlands	0.094	13.1%
Apollo_16	highlands	0.120	17.9%
Farside_highlands	highlands	0.129	18.8%
SPA_highlands	highlands	0.113	16.3%

Table 2. Regions used in analysis. Continuum slope is the slope between reflectance values at 0.750 and 1.50μm (in units of Reflectance/micron of wavelength). R_750 is reflectance at 0.750μm.

Discussion: Figure 1 illustrates the diversity of nearside mare basalt spectral types reflecting the diversity of compositions including variations in Ti, FeO and olivine content [*e.g.*, 8]. On the farside, spectral variations are much less, with most of the locations having spectra similar to Orientale and Imbrium on the nearside. Using compositional interpretations others [9] have come to similar conclusions. This suggests the mantle source on the farside is much more homogeneous, or possibly that farside basalts have been "sorted" by the density effects of the thick crust [10].

Highlands spectra of the Apollo 14 and 16 regions are compared to spectra of the northern farside highlands and a region with the albedo anomaly in South Pole-Aitken Basin, as well as the low-FeO Frigoris basalts in Figures 3 and 4. The northern farside highlands are much brighter than the other regions, reflecting their very low iron content. The mafic band is also very narrow, causing the continuum to peak at 1.25μm rather than 1.5μm, indicating the presence of pyroxene but no olivine. SPA-highlands are intermediate in reflectance to Apollo 16 and Apollo 14, but in terms of

band shape are most similar to Apollo 14. This suggests a similar mineralogy to Apollo 14 but lower iron content.

Conclusions: The full wavelength range Clementine data can be used to compare the spectral properties—and therefore the mineralogic properties—of the entire lunar surface at a resolution of a few hundred meters. While only ~0.05% of the nearly 200 million spectra available are summarized here, we demonstrate the diversity and reach of the data.

References: [1] Nozette, S. *et al.* (1994) *Science, 266*, 1835-1839. [2] McEwen, A. S. and M. S. Robinson (1997) *Adv. Space Res., 19*, 1523-1527. [3] Eliason, E. M. *et al.* (1999) Mission to the Moon: The Clementine UVVIS Global Lunar Mosaic, PDS Volumes USA_NASA_PDS_CL_4001 through 4078, USGS. [4] Eliason, E. M. *et al.* (2003) *LPS XXXIV*, Abstract #2093. [5] Staid, M. I. *et al.* (2003) http://astrogeology.usgs.gov/Projects/ClementineNIR/ [6] McCord, T. B. *et al.* (1981) *JGR, 86*, 10883-10892. [7] NASA Planetary Data System, Spectroscopy Subnode, www.planetary.brown.edu/pds/LSCCsoil.html [8] Staid, M. I. and C. M. Pieters (2001) *JGR, 106(E11)*, 27887-27900. [9] Gillis *et al.* (2000) *LPS XXXI*, Abstract #2089. [10] Head, J. W., III and L. Wilson (1992) *GCA, 56*, 2155-2175.

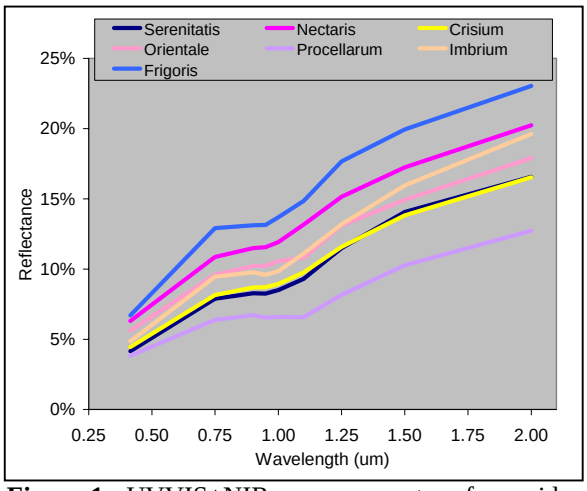

Figure 1. UVVIS+NIR average spectra of nearside maria. Variations in Ti, FeO, and olivine are evident in the variations of 0.750μm/0.415μm, absolute reflectance, and depth, position, and breadth of the absorption feature around 1μm.

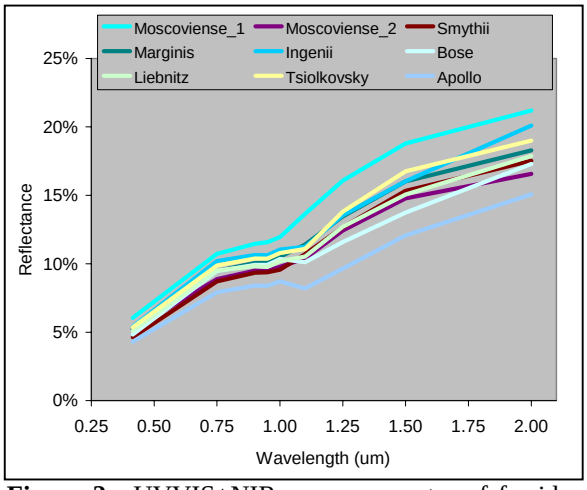

Figure 2. UVVIS+NIR average spectra of farside maria. Note the spectral similarity among many of the farside mare basalts.

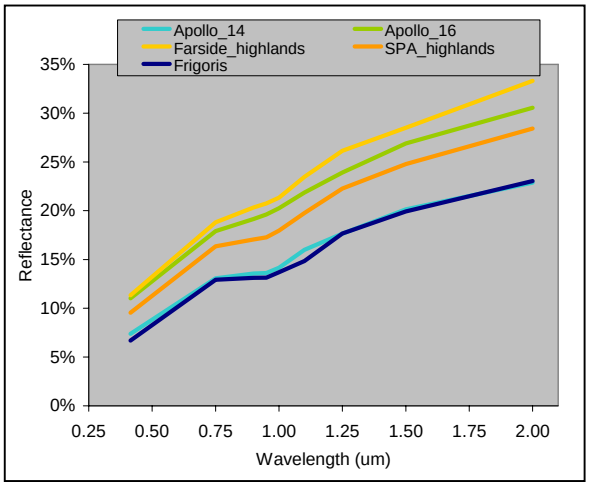

Figure 3. UVVIS+NIR average spectra of highlands regions. Frigoris (low FeO basalt) is included. Note the similarity between the spectra of the Apollo 14 site and Mare Frigoris.

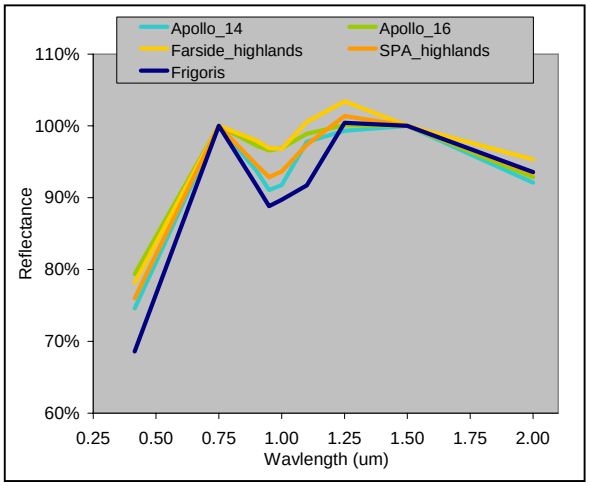

Figure 4. Same as Figure 3, but with continuum (0.750 to 1.50μm) removed.