COLORFUL VIEWS OF THE MOON: COMPARING SPECTRA FROM CLEMENTINE AND THE MOON MINERALOGY MAPPER

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Introduction The Moon Mineralogy Mapper (M^3), which flew on India's Chandrayaan-1 has provided the lunar science community with a richest view of our Moon to date. Information of the lunar surface returned by M^3 provided the first conclusive evidence of the presence of OH, and possibly H_2O at the poles, and in isolated locations as far down as the equator [1]. The coming discoveries and new views of our moon [see related abstracts within this conference] we owe to the vastly improved spectral resolution of the M^3 instrument over previous lunar orbiters - in particular the reining standard, Clementine's ultraviolet-visible (UVVIS) camera [2]. M^3's spectral range is 4 times that of Clementine UVVIS, M^3's spectral resolution (85 channels) is improved over Clementine UVVIS (5 channels), and M^3's spatial resolution ($\sim$150 m/pixel over all channels) is improved over Clementine's (higher end at $\sim$125 m/pixel for the 750 nm channel and lower end at $\sim$250 m/pixel for the 415 nm channel). How does this improvement manifest in the data? How do M^3 spectra compare with those from Clementine? Is it simply a matter of more detail in a spectrum?

In an effort to answer some of these questions we focused on Mare Nectaris - a region previously studied in detail by [3]. We used the same technique of Small Crater Rim and Ejecta Probing (SCREP) [4] to extract "fresh" spectral information from pixels that depict the rims and proximal ejecta of small, immature craters (0.5-5 km in diameter) that impacted into the mare basalt. These small craters act as windows through the ubiquitous, obscuring regolith, exposing the underlying, uncontaminated mare basalt [5, 6, 3]. Impact cratering studies and analysis of impact ejecta mechanics demonstrate that near the crater rim the original stratigraphy of the impact target is inverted [e.g., 7]. Therefore collecting data from this region provides the best approach to deriving the composition of the underlying basaltic unit [8].

Previous Work [9] and [10] both mapped one mare basalt unit filling Nectaris. Using Clementine spectra and derived FeO and TiO_2 of the surface [11] concluded that although the entire basin is filled with basalts of a roughly uniform composition, the mare can be divided based on two different surface spectra. They described their unit *Nc2* spectra as having a higher UV/VIS ratio and stronger 1 micron absorption than that of their unit *Nc1*. However, since their spectra were derived from the mare surface their map represents the regolith composition and not the pristine basalt composition.

[3] characterized and mapped the pristine mare basalt units in Nectaris using Clementine multispectral data from

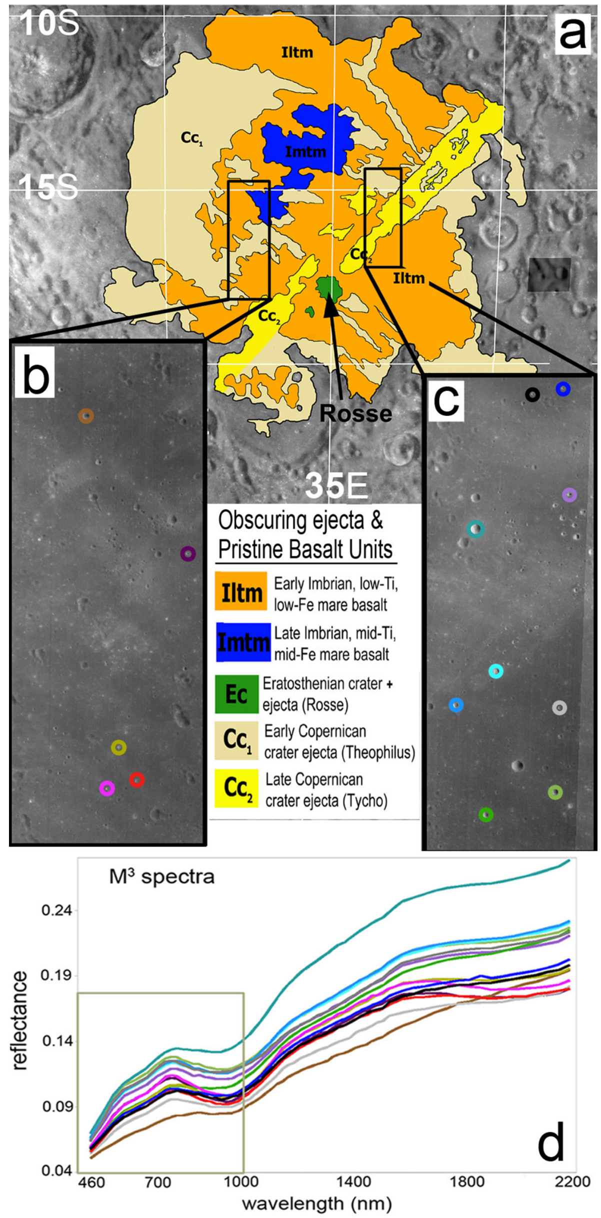

Figure 1: (a) Pristine basalt unit map and obscuring ejecta for Mare Nectaris, from [3]. Black rectangles depict locations of M^3 images (b) and (c), which detail locations of analyzed craters. (d) M^3 spectra craters in (b) and (c). The line color for each spectrum identifies the crater from which it was derived. Gold box in lower left of (d) outlines the spectral range from which Fig. 2a were resampled.

the rim and proximal ejecta of small, immature craters (Fig. 1a). They divided the mare into 2 spatially distinguishable basalt units: a low-Fe, low-Ti unit (*Iltm*) that filled the basin, and a thin <100 m thick), isolated mid-Fe, mid-Ti unit (*Imtm*). Although mapped as one unit,

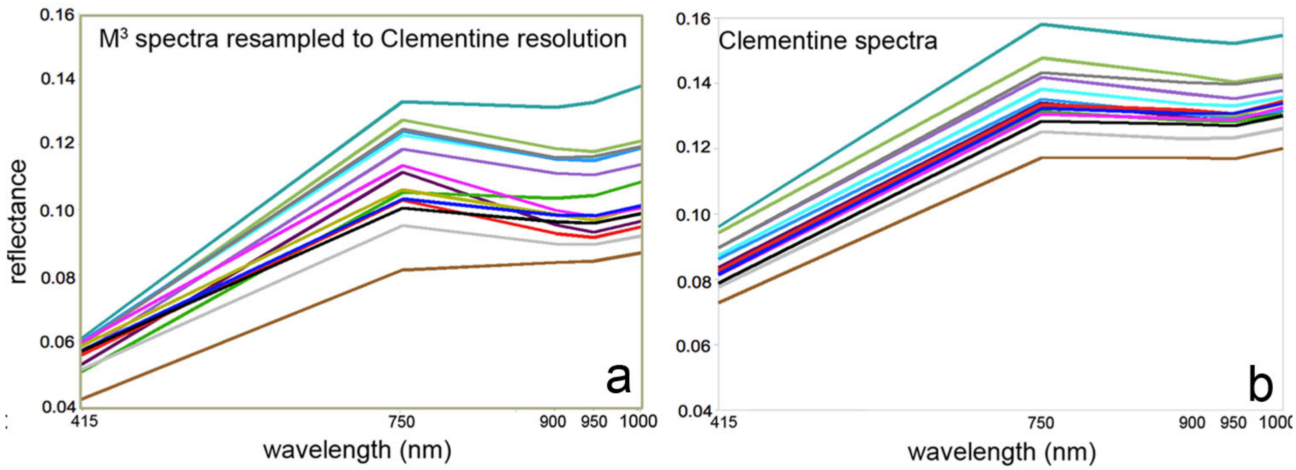

Figure 2: (a) SCREP-derived M^3 spectra of craters shown in Fig. 1b,c. M^3's spectra (gold box in Fig. 1d) are truncated and resampled to match Clementine UVVIS. (b) Clementine spectra of the same craters from [3]. M^3 spectra (a) show a greater spectral contrast over (b).

they identified two distinct spectral profiles with Clementine data (although different from the spectra described by [11]). They found that most of the spectra in unit *Iltm* have a maximum absorption at 950 nm, suggesting a mineralogy dominated by a high-Ca pyroxene (clinopyroxene-cpx), and ~20% of the analyzed craters' spectra have their maximum absorption at 900 nm, which alludes to a mineralogy dominated by lower-Ca-rich pyroxene (pigeonite or orthopyroxene - opx). A relationship between the spectral profiles and compositional parameters provided supporting evidence that sub-units *Iltm-1* (maximum absorption at 950 nm) and *Iltm-2* (maximum absorption at 900 nm) are two different basalt units. However, the two sub-units could not be spatially delineated. Analyzed craters seemed to be distributed randomly across the mare, having no correlation with particular crater sizes, locations, maturity, or morphological features, such as lava flow or volcanic domes. They concluded that the spectral and/or spatial limitations of the Clementine data set may have prevented the spatial delineation of the two spectral subsets of unit *Iltm*, and that re-visiting the region with improved images, as from M^3, may help toward resolving this dilemma. In broader lunar context, we take a first look at how our view of the Moon will be improved with this new data set.

M^3's Moon The M^3 data from which the spectra in Fig. 1d were calibrated from digital numbers to radiance [12]. Radiance was then converted to reflectance factor by division of a solar irradiance model with zero atmosphere from the MODerate spectral resolution atmospheric TRANSsmittance (MODTRAN) [13]. A Lommel-Seeliger photometric correction was applied to compensate the large-scale effects of the illumination and observation geometry [14]. With this M^3 mosaic cube, we revisited a selection of the craters sampled by [3] for Clementine UVVIS spectra (Figs. 1b,c). Fig. 1d shows the average reflectance spectrum for each crater derived from SCREP. Our mosaic did not include a thermal correction, so spectra are truncated at 2200 nm. The spectra show the clear influence of pyroxene and varying degrees of maturity.

For the purpose of comparing Clementine and M^3 SCREP results for each crater we truncated the derived M^3 spectra at 1000 nm and resampled them to Clementine's UV-VIS bandcenters (Fig. 2). The slightly higher overall albedo of the Clementine spectra and narrower range in albedo between the craters depicted in Fig. 2 likely reflects the differences in the photometric and empirical corrections between the two data sets. However, M^3 spectra derived from immature craters show a significantly increased spectral contrast compared with their Clementine counterparts. A new view of the Moon is not simply more colorful, it is more vibrant and robust. This preliminary comparison for a relatively simple mare region demonstrates that the M^3 data set certainly provides the means to improve our ability to interpret the mineralogy, petrology, surface and subsurface processes [e.g., 15, 16].

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