SPECTROSCOPIC SIGNATURE OF THE HIGH TITANIUM BASALTS AT MARE TRANQUILLITATIS FROM MOON MINERALOGY MAPPER (M^3) D. Dhingra[1], C. M. Pieters[1], P. Isaacson[1], M. Staid[2], J. Mustard[1], R. Klima[1,3], L. A. Taylor[4], G. Kramer[5], J. Nettles[1] and M3 Team [1]Geological Sciences, Brown University, Providence, RI 02912 (Deepak_Dhingra@Brown.edu), [2]PSI, [3]JHU/APL, [4]Univ of Tenn., [5]Bear Fight Centre, WA

Introduction: Titanium abundances have been widely used for classifying lunar basalts [1]. TiO_2 content of basalts (along with their age) is directly related to the character and evolution of their source regions in the lunar interior and contributes to an understanding of lunar evolution. Ilmenite ($FeTiO_3$) is the dominant titanium bearing mineral on the lunar surface. It is spectrally opaque across visible wavelengths and reduces the overall reflectance of the material. Its blue character (high UV/VIS ratio) at shorter wavelengths has been used to estimate the TiO_2 content [2, 3] for mare soils. However, the UV/VIS ratio has been found to be affected by multiple components [4] and may therefore not be uniquely diagnostic.

Scope of Study: Recent laboratory studies involving synthetic and lunar ilmenites [5, 6] have shed new light on their spectral properties in the Near-IR region. Specifically, ilmenite exhibits significantly increased reflectance at longer wavelengths (>1800 nm). Grain size in general, affects the reflectance spectrum. In the case of ilmenite, the finer fraction has a disproportionate effect on the spectral contrast. These effects can now be studied using high resolution datasets obtained recently by NASA's Moon Mineralogy Mapper (M^3) instrument onboard India's Chandrayaan-1 mission [7]. M^3 is an imaging spectrometer operating between ~430 – 3000 nm with spectral resolution of 20-40 nm and spatial resolution of 140 m (at 100 km orbit) in its reduced resolution mode.

Present Work: The work here focuses on Mare Tranquillitatis, which is known to be composed generally of very high titanium basalts based on the samples from the Apollo 11 mission. The abundance of titanium shows correlation with UV/VIS ratio images of the Tranquillitatis region [3, 8]. Spectral mixture analysis [9] for the region shows basaltic flows of varying titanium abundances. M^3 coverage of the study area during optical period 1b is shown in Fig. 1. These datasets have been analysed to evaluate whether there are differences in the spectral character of the Ti-rich basalts within Tranquillitatis as compared to the surrounding basalts in Serenitatis. Numerous approaches (guided by the recent laboratory spectral measurements) have been devised to capture and study this variation.

Results: The results shown here were extracted from a hemispheric global cube with a resolution of 1.4 km [9]. Results from full resolution dataset would

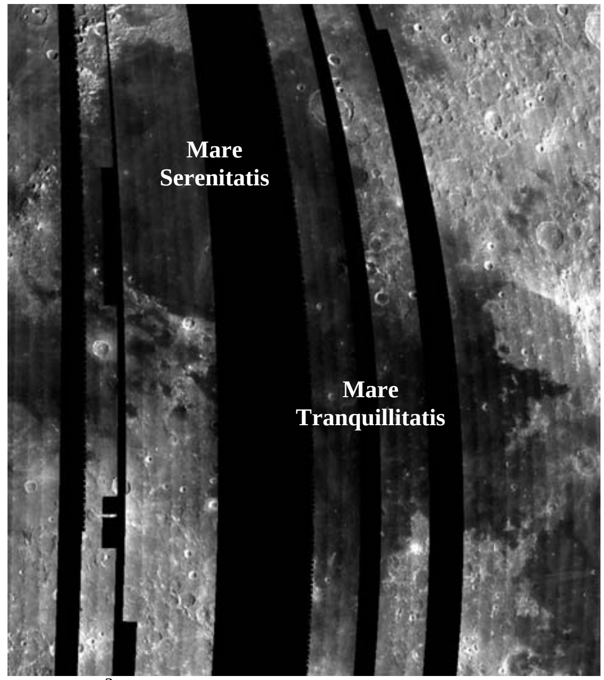

Fig. 1 M^3 750 nm albedo image mosaic showing coverage of Mare Tranquillitatis and nearby areas studied in the present work.

be presented at the conference. The high spectral resolution of M^3 along with it's wide wavelength coverage captures the spectral diversity in variety of ways. Initially, broad variations across the whole scene were evaluated including contribution from both soils and fresh craters. Subsequent focus was on the variations across the spectral range in soils and fresh craters from selected locations within the two regions (Mare Serenitatis and Mare Tranquillitatis).

Variation in the strength of the 1000 nm ferrous absorption band for the study area is shown in Fig. 2. It is represented in the form of an integrated band depth (IBD-1000) image which is an integration of band strengths relative to a local continuum between 789 nm and 1308 nm. In the IBD image, fresh craters in Tranquillitatis and Serenitatis show strong ferrous absorption bands due primarily to pyroxenes. The soils within both the regions are expected to be well developed. However, it is noted that the soils in central Mare Tranquillitatis have a weaker ferrous absorption than those in Serenitatis. Within Tranquillitatis, some soil areas have relatively high values of IBD-1000. These are believed to have relatively lower titanium

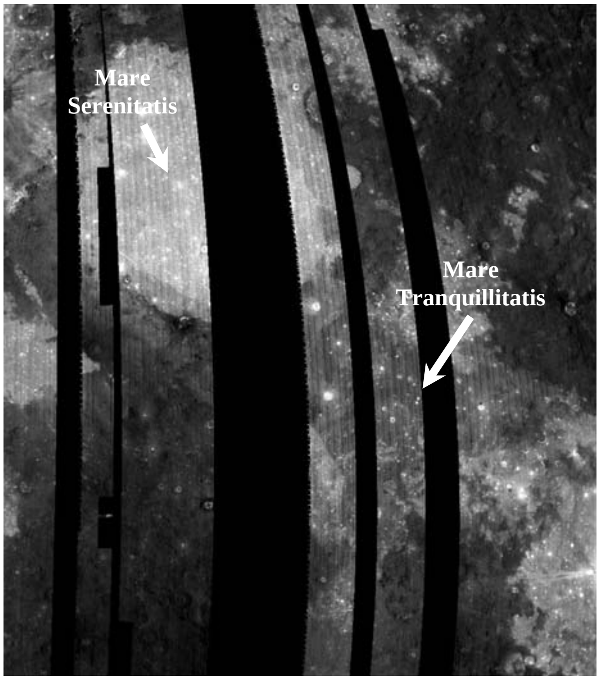

Fig.2 1000 nm integrated band depth image for Mare Traquillitatis and nearby areas.

abundances based on earlier work [10]. Inspection of Fig. 2 suggests that the density of fresh craters in central Mare Tranquillitatis might be lower than Serenitatis, which is peppered with numerous fresh craters. This observation is not related to the age of the surface [11] and both regions should encounter comparable abundance of recent impacts. The differences seen in Fig. 2 therefore may be due to the effect of ilmenite which weakens the band strength. Spectral variation in soils for selected locations within each mare region has also been studied and is shown in Fig. 3. The spectra have been truncated at 2400 nm to minimize the effect

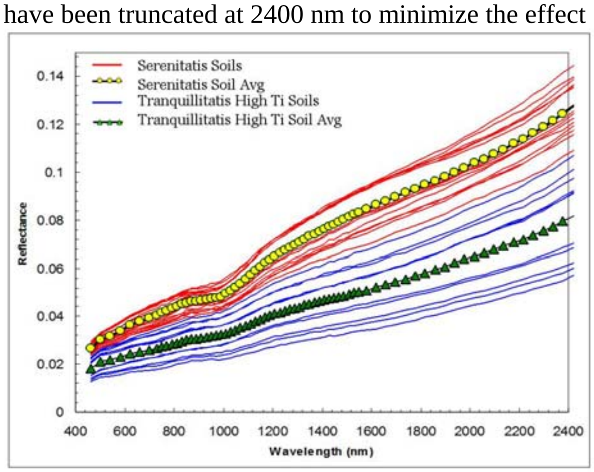

Fig 3. Basaltic soil spectra from Mare Tranquillitatis (High Ti) and Mare Serenitatis. Green and yellow curves are the average values of selected spectra from the two regions respectively.

due to thermal contribution. The soils within Tranquillitatis differ from soils in Serenitatis in three aspects: a) weaker ferrous absorption b) uniformly lower reflectance across all the wavelengths (though to different extents) and, c) flatter slope in the Near-IR. The spectral variation of fresh craters from both regions, shown in Fig. 4, is much larger and spectra from the two regions often overlap. The variations observed for soils (weaker ferrous absorption, uniformly low reflectance, flatter slope) also hold true for the fresh craters.

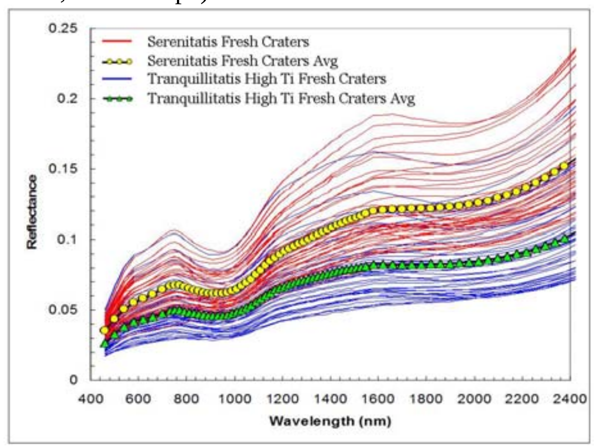

Fig. 4 Spectra from fresh craters in Mare Tranquillitatis (High-Ti) and Mare Serenitatis. Green and yellow curves are the average values for the selected spectra from two regions respectively.

Conclusions: Analysis of high resolution M^3 datasets for the Traquillitatis-Serenitatis region based on insight from recent laboratory studies of ilmenites document some notable differences which may help in constraining the spectral character of this mineral. The capabilities of M^3 have opened up a new window in the Near-IR region to search for ilmenite signatures. Future work will focus on combining the strengths of the most useful parts of spectrum in order to better understand the contribution of ilmenite to the overall spectral variation seen in mare basalts.

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