

COMPARISON OF NEWLY ACQUIRED LUNAR SPECTRA WITH THE TITANIUM ABUNDANCE MAPS DERIVED FROM CLEMENTINE. G. M. Holsclaw¹, W. E. McClintock¹, M. S. Robinson², ¹Laboratory for Atmospheric and Space Physics, 1234 Innovation Dr., Boulder, CO 80303 (holsclaw@colorado.edu), ²Northwestern University, Loy Hall 309, 1847 Sheridan Road, Evanston IL 60208.

Introduction: The Mercury Atmospheric and Surface Composition Spectrometer (MASCS) is one of seven science instruments onboard NASA's MESSENGER mission, currently en-route to the planet Mercury. One of MASCS's components, referred to as the Visible and Near Infrared Spectrograph (VIRS), will record reflectance spectra of the surface in order to characterize the mineralogy of the planet [1].

The lunar highlands and the average mercurian crust are proposed to be compositionally similar [i.e. 2]. In preparation to interpret VIRS reflectance spectra of Mercury to be first obtained in 2008, the Moon has been observed with an engineering model of the VIRS from a ground-based telescope. In this study, the ultraviolet and visible region of the spectrum is compared with titanium content in the lunar regolith.

Background: Apollo and Luna samples indicate titanium in lunar mare soils is found principally in ilmenite (FeTiO₃), an opaque mineral. Soils rich in ilmenite are darker and less red than those low in content [3, 4]. A technique was derived by Lucey and co-workers [5] to generate TiO₂ abundance maps of the Moon using the multispectral imaging data set obtained with the Clementine UVVIS camera. Based on a 415/750nm color ratio vs. 750nm albedo scatter plot of six sample return sites, a parameter correlated with the titanium content was found. The error in the non-linear fit of this parameter vs. known Ti content was found to increase with higher Ti.

The efforts to date at understanding the content of titanium in the soil have involved the visible spectral slope (415/750nm or 400/560nm ratio). Here we consider the short-wavelength side of the ~450nm-centered absorption of ilmenite (Figure 1). The 350/450nm color ratio is examined for its correlation with the titanium abundance maps derived by Lucey and coworkers.

Measurements: The VIRS is a fiber-fed spectrograph with two spectral channels: the VIS covering the wavelength range 300 to 1050nm and the NIR covering 850 to 1450nm. Atmospheric absorption and glass transmission in this ground-based implementation limits the effective wavelength coverage to 350-1350nm. Its band-pass is 5nm. A shutter is located at the entrance to the spectrometer to allow for measurements of the detector dark field.

The spectrograph was mounted to the 24" Sommers-Bausch Observatory telescope at the University

of Colorado at Boulder. The telescope optical speed of f/8 was changed to the spectrograph's focal ratio of f/5 using a single achromatic lens as a focal reducer. Ray-trace analysis of this configuration yields spot sizes slightly smaller in diameter than that of the optical fiber, 0.1mm, across the wavelength range of interest. With a plate scale of 67.7 arc-seconds/mm the diameter of the angular footprint is about 7". This equates to a spatial sampling of ~14km at the sub-earth location. The end of the fiber at the telescope focal plane looks through a small slit etched in a tilted mirror. This mirror redirects the lunar image through a series of lenses and filters to a CCD camera for pointing knowledge. Images consist of a lunar scene with a small rectangular slit in the center. The fiber position was measured in the lab relative to the slit boundary.

Many single-point spectra of various targets on the Moon were obtained on the night of December 23, 2004. Targets were chosen to represent the full range of expected titanium content as given by the Clementine-derived abundance maps [5]. Also, both highlands and mare regions were chosen to sample a variety of compositionally distinct geologic units. Most of the targets considered here represent mature soils. The standard sites of Apollo 16 and Mare Serenitatis (MS2) were monitored throughout the night for airmass correction and reflectance derivation.

Data Reduction: First, the detector background was removed by subtracting the dark scans obtained by interleaving the shutter during a measurement. Next, scattered light was removed by subtracting the constant value of pixels on the visible detector where there is known to be zero signal. Using the repeated standard site measurements, airmass correction coefficients were derived for each wavelength and then applied to all spectra to arrive at uniform airmass. Because the apparent color of lunar soil varies with viewing geometry, each spectrum was divided by the average Apollo 16 measurement, yielding a unique relative spectral reflectance.

Results: Figure 2 shows a plot of the titanium abundance derived from both Clementine and Lunar Prospector versus 360/450nm color ratio (normalized to the Apollo 16 value) of the same location. The expected positive correlation, which appears to be linear, is evident in this plot. With increasing titanium content the depth of the expected absorption at ~450nm increases. The dashed curves are linear fits to each

data set, the residuals of which are shown in Figure 3. These results are preliminary and work continues in order improve the color ratio accuracy by refining the airmass correction and to more accurately register the ground based images with the Clementine maps.

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References: [1] Solomon, S. C. et al (2001) *Plan. Sp. Sci.*, 49, 1445-1465. [2] Blewett, D. T. et al (1997) *Icarus*, 129, 217-231. [3] Lucey, P. G. et al (1996) *LPS XXVII*, 781-782. [4] Rava, B. and Hapke, B. (1987) *Icarus*, 71, 397-429. [5] Lucey, P. G. et al (1998) *JGR*, 103, 3679-3699.

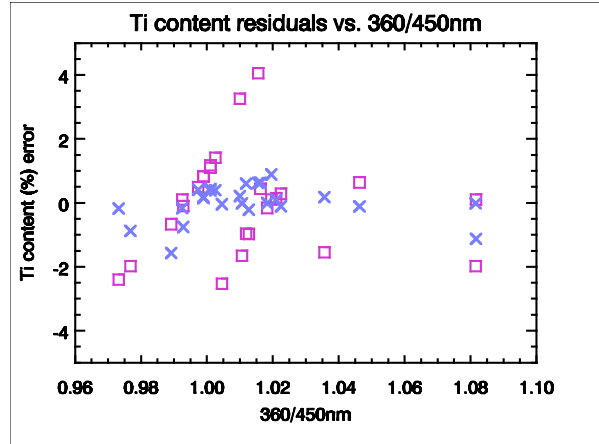


Figure 3 - Fit residuals vs. color ratio

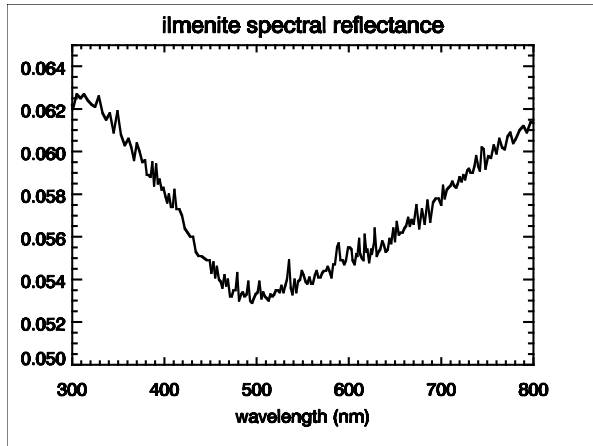


Figure 1 - Typical spectral reflectance of the mineral ilmenite

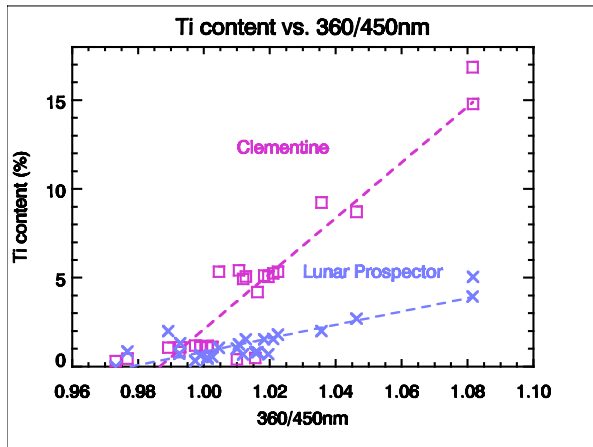


Figure 2 - Titanium content vs. color ratio