HST UV – VISIBLE OBSERVATIONS OF THE APOLLO 17 LANDING AREA. M.S. Robinson[1] and J.B. Garvin[2], B. Hapke[3], J.F. Bell III[4], M. Ulmer[1], D. Skillman[2], C.M. Pieters, [1]Northwestern Univ., 1850 Campus Drive, Evanston IL, 60208, [2]GSFC., [3]Univ Pitt., [4]Cornell Univ., [5]Brown Univ.

Introduction: Visible (VIS) and near-infrared reflectance (400 – 2800 nm) of the lunar regolith is dominantly controlled by variations in the abundance of three components: 1) opaque minerals (ilmenite), 2) iron bearing silicate minerals, and 3) maturation products (glasses, coatings bearing nanophase metallic iron). The same parameters control reflectance into the near-UV (250 to 400 nm), with varying degrees of importance.

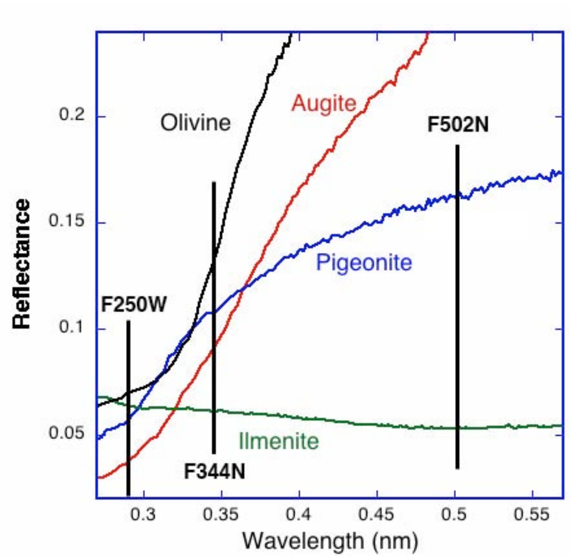

Fig 1. Spectra of mineral powders illustrating ilmenite's distinctive negative slope in the UV and VIS relative to typical iron bearing silicates. Effective band centers of HST filters shown as vertical lines (from USGS spectral library).

Laboratory spectra show that ilmenite (opaque mineral) exhibits a diagnostic reflectivity upturn below about 450 nm [1]. Therefore UV observations may help constrain TiO_2 abundances in lunar soils. However, it is nearly impossible to measure UV reflectance of the Moon below 360 nm from the surface of the Earth due to strong atmospheric absorptions, thus little progress has been made in terms of leveraging UV spectra to determine mineral abundances in lunar soils. Such mapping requires a UV instrument onboard a space-based platform. To this end the Hubble Space Telescope (HST) Advanced Camera for Surveys High Resolution Camera (ACS/HRC) acquired images through four filters (F250W, F344N, F502N, 658N) of three high priority targets: Apollo 17 landing site, Apollo 15 landing site, and the Aristarchus crater and plateau [2]. The angular resolution of these observations is ~60 m/pixel. While many of the HST lunar images suffered image smear, the frames covering the Apollo 17 site were relatively sharp.

Data Processing: HST standard radiometric processing was applied to the lunar observations, including a conversion to reflectance (I/F). Geometric distortions were first removed, and then the filter sets were co-registered using an automated subpixel scheme that employs a weighted least squares fit to account for local distortions. This strategy was dictated by parallax induced distortions between filter sets [2]. The final co-registered filter set was then roughly projected to map coordinates through correlation with a Clementine mosaic (100 m/pixel). Gross parallax differences between the nadir looking Clementine observations (0° emission) and oblique HST observations (~20° emission) result in poor pixel-to-pixel matches between the two datasets, especially in regions of steep relief such as North and South Massifs. Thus, comparisons between the two datasets require manual selection of corresponding pixel boxes (rather than a strict co-registration of the two datasets).

Discussion: Can the effects of the spectral upturn exhibited by ilmenite below 450 nm actually be detected in lunar soils? Ilmenite is a relatively low reflectance material (Fig. 1) and occurs in mare soils with abundances of 0 to 10-wt% [3]. Additionally, space weathering, agglutinates, and pyroclastic glasses may complicate ilmenite reflectance in the UV. These factors all require high SNR observations such as those provided by the HST ACS/HCR.

With the HST data, highland and mare materials are easily separated in terms of reflectance and UV contrast, and appear as distinct intersecting trends (Fig. 2). This reflectance vs. color contrast pattern grossly mimics trends seen in Clementine Spectral Reflectance (CSR) visible and infrared data. However, differences between the two datasets indicate that the UV data may hold complementary or unique compositional information: 1) the HST mare values form a trend more nearly parallel (1.2°) to the color ratio axis (y) and 2) the HST exhibits greater ratio contrast. Note some of greater spread seen in the CSR data (Fig. 2) may be an artifact due to small differences in *effective* resolution between the datasets and instrumental scattered light in the CSR data [4].

The HST F502N/F250W is plotted against regolith TiO_2 values from individual soil sample stations (Fig. 3) to check for correlation. Each individual sample station was located manually in both the HST and CSR data through comparison of published traverse maps and Apollo Pan photography. The exact pixel station locations are shown in figure 2 as 3×3-pixel boxes (representing the statistical area from which average values were computed). We estimate that the sample boxes contain the actual surface sample station in all cases except possibly for the L5/L6 box. These two LRV stations are found on relatively featureless white-mantle material. Triangulating from nearby features we are confident that at least one of the stations is in the box and the other is within one pixel. The sample box locations between the HST and CSR are within one pixel.

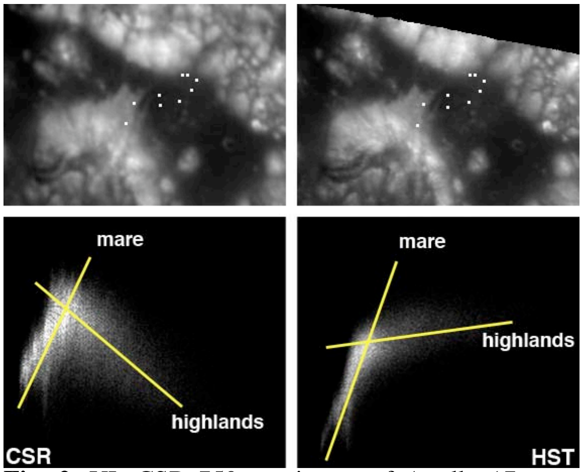

Fig. 2. UL CSR 750 nm image of Apollo 17 area, boxes indicate stations shown in Fig. 3, width 28 km. UR HST 502 nm image of Apollo 17 area, boxes same as in UL. LL CSR spectral density plot, x-axis 750 nm reflectance (0.03 to 0.11) y axis 750/415 nm ratio (1.4 to 1.8) LR HST spectral density, plot x-axis 502 nm reflectance (0.02 to 0.10) y-axis 502/250 nm ratio (1.7 to 2.3). Due to scale exaggeration, relative angles between trends are misleading.

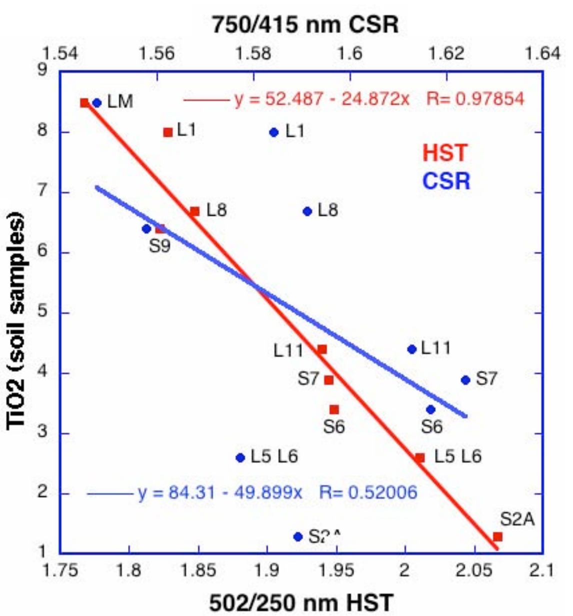

Fig 3. Spectral parameter plot for HST and CSR for the Apollo 17 landing area. Location of sample areas indicated in true size (300 m × 300 m boxes) in Fig 2.

The high degree of correlation between the HST ratio (F502N/F250W) and TiO_2 soil values indicates that UV soil color is more strongly controlled by variations in ilmenite abundances than maturity. The best-fit equation to the two parameters (Fig. 3) was used to transform a HST ratio image to absolute TiO_2 wt% (Fig. 4). The mare generally have TiO_2 values between 6 and 8 wt%, while highlands exhibit -1 to 2 wt%. The putative mafic pyroclastic material [5] found in valley floors between some highland massifs is 2-4 wt%.

The negative TiO2 values of some highland patches and the LR portion of Fig. 2 show that the HST correlation in figure 3 is not valid for all highlands. Possible reasons include effects of maturity and TiO_2 in augite rather than ilmenite. These negative patches correlate with materials shown to have a high maturity index [6]. Several of the soils used in our analysis are dominantly feldspathic and relatively mature (S2A, L5L6, S6, S7, L11) and are highly correlated with TiO_2 abundance supporting the idea that the UV ratio is dominantly controlled by TiO_2 for mature soils. The largest negative values are associated with immature materials within distinctive highland material known as the Sculptured Hills, north and east of the landing site. Other regions of highland materials exhibit TiO_2 values between 0 and 1 wt% (a 1500 m by 1500 m area on the north facing slope of South Massif exhibits 0.8 wt %).

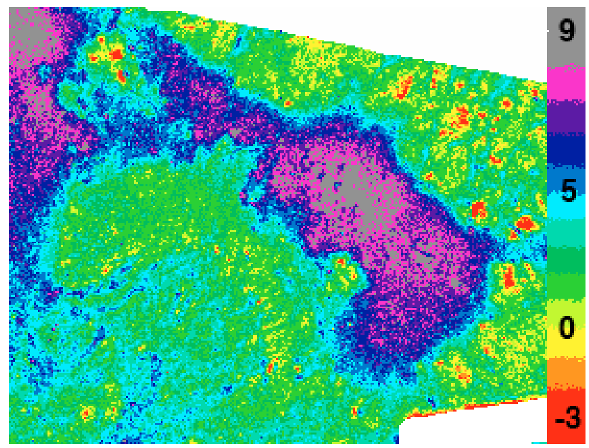

Fig 4. TiO2 wt% abundance map of Apollo 17 region (width 28 km) derived from HST UV ratio tied to Apollo soil sample analyses**.**

Conclusions: Ilmenite bearing soils exhibit relatively strong diagnostic spectral signatures in the UV and can be used to map the abundance of TiO_2 in the Apollo 17 region in both mare and mixed mare-feldspathic soils. The Apollo17 mare soils are known to contain admixed pyroclastic material to some degree, and this material does not appear to hinder this approach to TiO_2 estimates to a significant degree. Negative TiO_2 values do occur in highland exposures with UV ratios >2.1, probably due to uncorrected maturity related controls. Further work will include an analysis of the HST Apollo 15 and Aristarchus observations to determine if a robust correlation between TiO2 and mature soils exists that can be applied to large extents of lunar terrain.

References: [1] Wagner, J. et al 1987, Icarus, 69, 14; [2] Garvin et al. this issue; [3] Heiken, G. et al 1991, Lunar Sourcebook, Cambridge U. Press, Cambridge. [4]. Robinson et al, (2002) JGR 108, E4, 5028; [5] Lucchitta (1972) USGS Map I-800 Sheet 2; [6] Lucey et al. (2000), JGR 105, E8, 20,377-20-386.

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