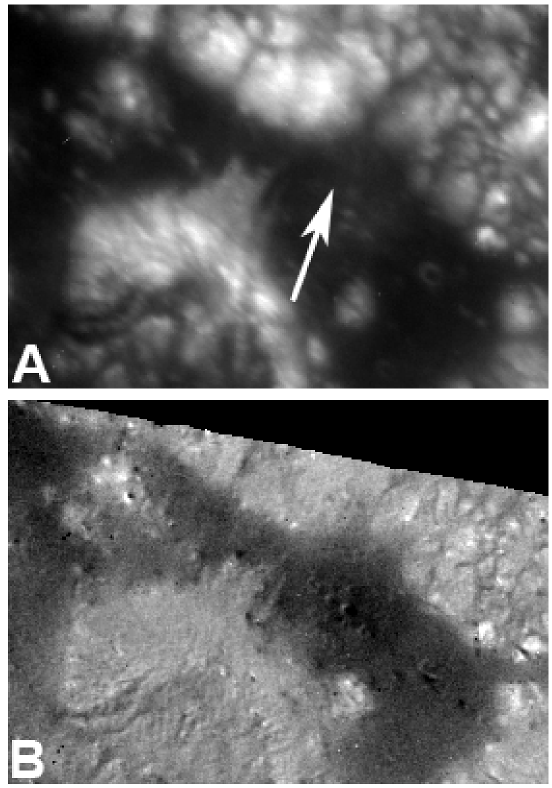
UV IMAGING OF THE MOON FROM THE HUBBLE SPACE TELESCOPE. J. B. Garvin[1], M.S. Robinson[2], B. Hapke[3], J.F. Bell III[4], D. Skillman[1], M. Ulmer[2], C. Pieters[5]. [1]NASA Goddard Space Flight Center, Greenbelt MD 20771 (james.b.garvin@nasa.gov), [2]Northwestern Univ., [3]Univ. Pittsburgh, [4]Cornell Univ., [5]Brown Univ.

Pioneering telescopic measurements of the Moon in the near UV (360 nm) and Visible (610 nm) wavelengths first indicated that compositional units on the Moon might be mapped through remote sensing techniques [**1**]. From these data it was noted that *mare* units exhibited a wide range of color contrasts and it was initially hypothesized that these differences might in part be due to varying abundances of *ilmenite* in lunar soils [**2**]. However, due to absorption in the Earth's atmosphere, ground-based telescopic observations of lunar UV reflectance below about 360 nm are not possible. Furthermore no spacecraft to date has acquired high resolution spectral observations across a broad range of the UV, thus the full potential of lunar compositional mapping in the UV has not been realized. The ***Hubble Space Telescope*** (HST) provides the unique ability to acquire multi-spectral (UV through near-infrared) lunar observations at scales approaching ~100 m/pixel (and down to ~ 60 m/pixel in the Visible). On the basis of the rapid relative velocities between the HST and the Moon, such observations are technically challenging in terms of pointing accuracy and stability, and had not been successfully achieved until August of 2005.

The new HST lunar data consist of ACS/HRC 4 filter observations (F250W, F344N, F502N, F658N) of three high priority targets: Apollo 17 landing site, Apollo 15 landing site, and the *Aristarchus* crater and plateau. The successfully-acquired HST observations had two primary objectives: (1) to assess the magnitude and spatial relations of contrast variations in the UV; and (2) to assess the ability of UV reflectance spectroscopy to quantitatively measure TiO_2 content within mare soils as one approach for identifying potential lunar resources in support of human exploration. The Apollo sites were chosen to allow calibration of the HST measurements in association with known compositions of lunar samples. The *Aristarchus* region was chosen for its diversity of composition and geologic processes, and to facilitate UV-based assessment of materials associated with a large, Copernican-age impact crater and adjacent pyroclastic deposits.

Figure 1. (A) HST 250 nm reflectance in region of Apollo 17 (*LM indicated with arrow*). (B) HST 502/250 nm ratio (same area as in A). Width is 32.4 km, North is up (see also [3]).



Due to the rapid velocity of the HST relative to the Moon, and the limitation of HST to track only at one constant linear velocity, accurate pointing (and sharp images) can only be obtained during the three brief periods per orbit when the apparent velocity of the lunar target is relatively constant: i.e., when the HST in its orbit about the Earth, from the point of view of an observer at the lunar target, reaches maximum elongation from the Earth center (twice per orbit), and when HST makes its closest approach to the Earth-target line (once per orbit). Even during these periods, pointing uncertainties were equivalent to the width of an ACS frame (~ 35km: ~ 1000x1000 pixels @ 60m/pixel), thus each target was imaged as a 2x2 pattern with a fifth observation centered on the target to insure coverage (for each filter). HST Observation timing constraints dictated that each filter set (5 images per target) had to be acquired at different times within an orbit and from adjacent orbits resulting in less than 3.2 degrees change of phase angle from the first image to the last image. Variation in phase angle within a filter set (5 images) was less than 0.8 degrees. In addition, the orbital motion of HST can cause as much as 2.2 degrees of variation in the angle between a target's local zenith and the line of sight to HST across all exposures. Despite these pointing and stability challenges, the HST observations met with a high level of success. For both the Apollo 15 and 17 sites, regions traversed and sampled by the astronauts were covered in all four wavelengths as were significant portions of the surrounding regions. At *Aristarchus* roughly half the crater was imaged in all four wavelengths as was a significant portion of the plateau including *Schroter's Valley* and the *Cobra head*. Due to the long exposures (4 seconds) required to obtain useful signal-to-noise for the two UV filters (F250W, F344N) and variable pointing stability, some of the UV images suffered significant motion smear (roughly 3 to 10 pixels). The angular resolution of a pixel projected on the surface of the Moon was ~ 60 m, the effective resolution was less depending on the wavelength dependant point spread function and motion-induced smear. The effective wavelength for each filter is the same as the nominal wavelength (indicated as 3 digit number in filter name), except for the F250W filter which has an effective wavelength of ~290 nm for the lunar observations.

Target	Date	Solar Lat	Solar Lon	Phase	Int. (s)
Apollo 17	2005-08-17	1.2°	34.8°	39°	4,4,1.5,0.7
Apollo 15	2005-08-20	1.2°	357.3°	5°	4,4,1.5,0.7
Aristarchus	2005-08-21	1.2°	346°	18°	4,4,1.5,0.7

Table 1. Summary of HST ACS/HRC lunar observations, Int. = integration times in seconds for F250W, F344N, F502N, and F658N filters, respectively.

Contrasts observed within the F250W and F344N nm images were equivalent to those seen at visible wavelengths and variegations closely follow those seen in visible and infrared wavelengths — mare units have relatively low reflectance, highlands intermediate, and Copernican-age highland material has the highest reflectance (**Fig. 1**). A comparative histogram between HST F250W and Clementine CSR 415 nm demonstrates overall correspondence in reflectance between the UV and visible. However, subtle yet important differences in the shape of the distributions exist (**Fig. 2**): 1) the FWHM of the F250W histogram is not symmetrical about the mode whereas the CSR 415 nm is (-0.0012 to +0.0022 and -0.0015 to +0.0015, respectively), and 2) the CSR exhibits a more pronounced plateau at higher reflectances (NB. HST absolute calibration is preliminary). Additionally, the HST F250W data show significant color contrasts that correlate with highland mare boundaries consistent with visible measurements of lunar soils [3]. These new HST observations demonstrate the utility of spectral observations into the UV for delineating compositional units in the lunar regolith. Correlations of HST 502/250 ratios and TiO_2 values from Apollo 17 returned soils indicate UV mapping can add to the lunar scientific communities ability to quantitatively estimate soil compositions [3: see Robinson et al., 2006 in this volume].

References: [1] Whitaker E. A. (1972) *Moon 4*, 348. [2] Wells, E. and Hapke, B. (1977) *Science 195*, 977. [3] Robinson M.S. et al. (2006) *LPSC XXXVII*, this volume.

Figure 2. Comparative histogram of HST 250 nm and Clementine CSR 415 nm reflectances.