FAR-ULTRAVIOLET BIDIRECTIONAL PHOTOMETRY OF APOLLO SOIL 10084: LABORATORY STUDIES IN THE SOUTHWEST ULTRAVIOLET REFLECTANCE CHAMBER (SwURC). U. Raut, P.L. Karnes, K.D. Retherford, M.W. Davis, E.L. Patrick, Y. Liu, P. Mokashi. Southwest Research Institute, Space Science and Engineering Division, San Antonio, Texas 78238.
(uraut@swri.edu)

Introduction: A detailed understanding of the physico-chemical properties of the lunar volatiles and an accurate assessment of its abundance and distribution are critical to the in-situ utilization of these resources in future explorations. Our understanding of the nature, abundance, and distribution of these volatiles emerges mainly from remote-sensing spectroscopy. For instance, observations of the several permanently shadowed regions (PSRs) of the moon by LRO-LAMP showed relative reddening (> 155 nm) in their far ultraviolet (FUV) spectra that is best explained by the presence of < 2% water frost mixed with the lunar regolith [1]. Similarly, LAMP dayside observations reveal variations in the FUV spectral slopes attributed to the diurnal/latitudinal variation of hydration at the lunar surface. However, the water abundance needed to produce the spectral signatures remains poorly constrained, estimated at < 1% [2].

Such estimates, derived from photometric modeling of observed FUV albedo, would benefit from laboratory measurements and verification. Some key laboratory measurements that would improve/constrain previous estimates are FUV bidirectional reflectance and optical constants of Apollo soils, water frosts, and ice-soil aggregates. To this end, we report new measurements of FUV bidirectional reflectance distribution function (BRDF) of mare soil 10084. To the best of our knowledge, the only existing FUV measurement of lunar soil was performed decades ago [3]. We improved over this existing dataset, specifically with respect to the vacuum conditions, counting statistics and sampling intervals, and geometry (i.e. BRDF measurements at multiple phase angles).

Experimental Setup: The measurements reported here were conducted in the SwURC [4], a high-vacuum (base pressure ~10^{-8} Torr) ultraviolet reflectance chamber. We filled a rectangular trough (13 mm *L* x 13 mm *W* x 0.5 mm *D*) on our anodized aluminum sample tray with ~ 0.2 g of Apollo soil 10084.2018 obtained from CAPTEM. This is a mature mare soil (I_s/FeO = 78) containing nanophase Fe and enriched rich in Ti content, returned by the Apollo 11 mission. The soil sample was subject to a ~ 250 °C, 24 hours vacuum bake-out prior tray assembly.

A 30 W deuterium lamp illuminates a grating monochromator which provides monochromatic light that is collimated with a pair of reflective cylindrical mirrors, prior to illuminating our sample at a fixed 45° incidence. A channeltron detector (Photonis 5901 Spiraltron, CsI-coated) is rotated in the principal plane over emission angles of -70° to + 90° with respect to the surface normal to collect diffuse light reflected by the Apollo soil. The angular steps can be as small as 0.01°. We also measure the incident beam intensity by retracting the sample tray and directly intercepting the beam with the detector positioned at 135°. The intensity of the reflected light at a particular emission or phase angle is divided by the incident beam intensity (plus geometrical corrections) to yield the BRDF.

Results: Figure 1 shows the BRDF spectra of Apollo soil 10084 collected at 45 and 115° phase angles (phase angle is the angle between incidence and emission). The Apollo soil BRDF is featureless, except for a small blue slope. The soil appears brighter at higher phase angles, implying the lunar soil anisotropically scatters FUV photons in the forward direction.

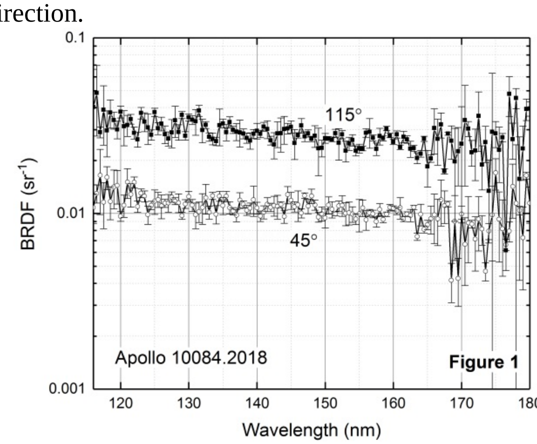

Figure 1

We will present additional BRDF spectra obtained at various phase angles and discuss the fits of Hapke's model to the angular distribution of BRDFs at Ly-α and 160 nm. Future plans will include BRDF measurements of several mare and highland soils of varying maturity index (I_s/FeO) and lunar soil-ice aggregates, to directly compare to LRO-LAMP datasets to constrain the lunar water ice abundances.

References: [1] Gladstone, G.R., et al., Far-ultraviolet reflectance properties of the Moon's permanently shadowed regions. JGR, 117, E00H04, 2012. [2] Hendrix, A .R., et al., The lunar far-UV albedo: Indicator of hydration and weathering, JGR, 117, E120001, 2012. [3] Wagner, J.K. et al., Atlas of reflectance spectra of terrestrial, lunar, and meteoritic powders and frosts from 92 to 1800 nm. Icarus, 69 (1), 14, 1987. [4] Karnes, P., et al., Radiometric calibration of the SwRI ultraviolet reflectance chamber (SwURC) far-ultraviolet reflectometer, SPIE, 8859, 2013.