

DIURNAL VARIATIONS IN HYDRATION ACROSS THE LUNAR SURFACE AS OBSERVED BY LRO LAMP.

Amanda R. Hendrix¹, Jade Decker⁶, Michael J. Poston⁵, Dana Hurley², Benjamin T. Greenhagen², Paul O. Hayne⁴, Kurt D. Retherford⁵, Kathleen Mandt², Faith Vilas¹, Joshua T. S. Cahill².

¹Planetary Science Institute, ²JHU/APL, ³NASA GSFC, ⁴LASP/CU, ⁵Southwest Research Institute,

⁶Mamaroneck High School (arh@psi.edu).

Introduction: The Lyman Alpha Mapping Project (LAMP), a far-ultraviolet (FUV) spectrograph on the Lunar Reconnaissance Orbiter (LRO), has been observing the Moon since September 2009. In addition to using stellar sources and interplanetary hydrogen emissions to study the dark polar regions [1] and night side of the Moon, LAMP measures reflected sunlight from the dayside of the Moon. The presence of a strong water absorption at 165 nm allows small amounts of hydration to be sensed in the LAMP reflectance spectra, and indeed LAMP measures spectral variations across the surface [2] attributable to diurnally-varying levels of hydration [9]. In this report, we build on our initial work to study more of the lunar surface and to investigate larger-scale trends in diurnally-varying hydration.

The LAMP dataset provides the most comprehensive diurnal and spatial coverage of the lunar surface at UV wavelengths, allowing for study of hydration with terrain type and temperature. The data are not complicated by thermal emission, though here the data are relatively low resolution given the nature of the binning. The dataset allows us to investigate effects of temperature, latitude, local time of day, and activation energy.

Background: In our initial work [9], we focused on a large mostly-mare region and a large mostly-highlands region, and found that FUV spectral slopes (164-173 nm) in each region decrease at mid-day, consistent with a loss of hydration. The observed trends are consistent with chemisorption and desorption of H₂O, where H₂O molecules adsorb directly onto soil grains and then desorb when the temperature is sufficiently high [3][4][5]. We [9] modelled the signature in terms of a layer of H₂O overlying lunar regolith [7] and determined the range of optical depths of the water layer required to produce the observed spectral slopes. For the maximum optical depth, the areal coverage is <1% of a monolayer [9], suggesting that $\sim 6 \times 10^{12}$ molecules/cm² desorb between ~ 10 AM and noon local time, from these regions of the lunar surface. It is likely that the vast majority of these molecules re-adsorb somewhere else on the lunar surface, possibly many kilometers away after many desorption-re-adsorption cycles.

Analysis: In this study, to strike a balance between adequate signal-to-noise and spatial resolution, we

study regions (bins) that are 30° in longitude, 10° in latitude. Due to phase angle limitations in the photometric correction, analysis is limited to latitudes 20-70°. To analyze hydration, we make a linear fit to each reflectance spectrum in the 164-173 nm range and determine the slope of that line, after using the photometric correction of Liu et al. [8]. Steeper (redder) slopes are expected to be consistent with increased hydration. Slopes are determined throughout the lunar day (between ~ 6 AM and ~ 6 PM local time) for each bin.

Results: For each analyzed bin, we find that the observed spectral slopes (between 164 and 173 nm) are roughly constant in the ~ 6 AM to ~ 10 AM period, suggesting the chemisorbed water sensed by LAMP is stable with the early morning thermal environment. Approaching local noon, the slopes begin to decrease, suggesting thermal desorption of molecular H₂O as the temperature increases. After noon, the slopes begin to increase and return to roughly their morning slope values by ~ 2 PM local time. However, the shape of the diurnal curve that characterizes this behavior near mid-day is not consistent from one lunar surface locality to another, and may provide clues to differing adsorption/desorption properties globally due to varying chemical composition or surface microstructure.

We also plot measured FUV slopes vs. Diviner-measured bolometric temperatures, and use this relationship to estimate activation energy for regions across the lunar surface. The adsorption residence time is related to U_e/T where T is temperature and U_e is activation energy [6].

We report on:

1. Overall hydration abundance across the surface and with latitude
2. Variation in activation energies across the surface and with latitude

References: [1] Gladstone, G R. et al. (2012) *JGR*, 117; [2] Hendrix, A. R. et al. (2012) *JGR*, 117, E12001, [3] Hibbitts, C. et al. (2011) *Icarus*, 213, 64-72; [4] Poston, M. J. et al. (2015) *Icarus*; [5] Poston, M. J. et al. (2013) *JGR*, 118, 105; [6] Barrie, P. J. (2008) *Phys. Chem. Chem. Phys.*, 10, 1688-1696; [7] Hapke, B. (1993) *Theory of Reflectance and Emittance Spectroscopy*. Cambridge Univ. Press, New York. [8] Liu, Y. et al. (2018) *JGR*, 123, 2550-2563. [9] Hendrix,

A. R. et al. (2019) *GRL* 46. DOI 10.1029/2018GL081821

Acknowledgements: This work has been supported by a LRO/LAMP subcontract between Southwest Research Institute and Planetary Science Institute, and by the National Aeronautics and Space Administration through the Toolbox for Research and Exploration (TREX) node of the Solar System Exploration Research Virtual Institute 2016 (SSERV16) Cooperative agreement (NNH16ZDA001N).