Ultraviolet Characteristics of the Lunar Compton-Belkovich Region from LRO/LAMP

Amanda R. Hendrix (arh@psi.edu), K.E. Mandt, T.K. Greathouse, K.D. Retherford, G.R. Gladstone, D.M. Hurley, P.D. Feldman, A.F. Egan, D.E. Kaufmann, P.F. Miles, J.W. Parker, M.W. Davis, W.R. Pryor, M.A. Bullock, S.A. Stern, N.E. Petro

Introduction/Overview:

The Lunar Reconnaissance Orbiter (LRO) is currently in orbit at the Moon. The Lyman Alpha Mapping Project (LAMP) onboard LRO has been making measurements of the lunar nightside, dayside and atmosphere since September 2009. We report here on recent work analyzing LAMP dayside data of the Compton-Belkovich region. Early results from LAMP indicate that this is a spectrally anomalous region in the far-UV (**Fig. 1**). In this analysis, we focus on data from the first year of the mission, October 2009-October 2010.

The Compton-Belkovich (C-B) region (**Fig. 2**) is named for two craters and is centered near 61°N, 99.5°E. It has been known since Lunar Prospector [1] to be an isolated high–thorium region within the northern highlands and from Clementine UVVIS data was found to be i) a high albedo region at all UVVIS wavelengths (415-1000 nm) [2], ii) to be low in FeO and TiO_2 and iii) consistent with alkali feldspars and non-mare igneous activity. LROC NAC and WAC data of the region have been interpreted [3] to indicate a volcanic region, and LRO Diviner data of the area indicated that the region is high in alkali feldspars and/or quartz [3,4]. Chandrayaan-1 M^3 data of the C-B region [5] show that it displays a strong OH/H_2O absorption, as compared with surrounding highlands terrains.

Questions:

- what is the relationship between the FUV slope and the thorium anomaly?
- does LAMP sense an increase in hydration at the location of the thorium anomaly?

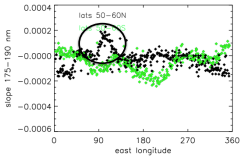


Figure 1a. Early results from LAMP showing measured spectral slopes in the 175-190 nm range vs. longitude for the 50-60° latitude bins. The Compton-Belkovich region stands out for its spectrally red slopes.

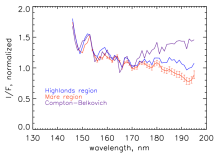


Figure 1b. Typical LAMP FUV reflectance spectra from highlands and mare regions compared to a sample Compton-Belkovich spectrum.

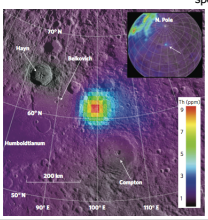


Figure 2. from Jolliff et al. (2011). Compton-Belkovich region and thorium anomaly.

Approach:

We determine the lunar FUV reflectance by dividing the LAMP data from each observed region by the full-disk solar spectrum from SORCE SOLSTICE [7], taken for the day of each observation and convolved to agree with the LAMP resolution and line spread function.

The FUV hosts a strong H_2O absorption edge near 165 nm (**Fig. 3a**), allowing LAMP to study hydration on the Moon. To separate out the effects of hydration and underlying composition, past analyses of LAMP dayside data (e.g. [8]) have shown that measuring spectral slopes in the 164-173 nm range is an indicator of hydration, while spectral slopes in the 175-190 nm region are insensitive to hydration but good indicators of weathering and composition. (e.g., **Fig. 3b**).

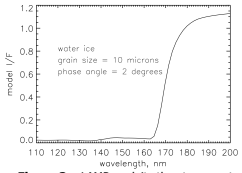


Figure 3a. LAMP exploits the strong water ice absorption edge near 165 nm [8] to look for H_2O ice and hydrated minerals in the PSRs, on the nightside and on the dayside of the Moon.

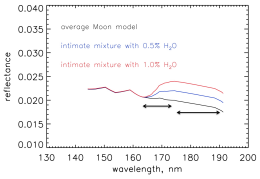
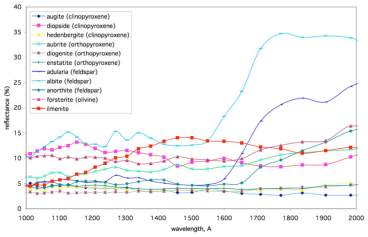


Figure 3b. Intimate mixture models for average lunar terrains with varying amounts of water ice. The slope in the 164-173 nm range is expected to increase (redden) with increasing water content; the slope in the 175-190 nm range should be unaffected by H_2O content.

What makes the Compton region spectrally red in the FUV? Could hydration be involved?

- It is likely, given the distribution of the reddish slopes, that the Compton ejecta blanket material is responsible for the spectral redness in this region. FUV spectra of lunar-like materials [11] indicate that feldspars can be dramatically spectrally red in the 160-200 nm region. (**Fig. 5**).
- If there were an increase in hydration at the C-B thorium anomaly, LAMP would see an increase in 164-173 nm slope right at that location, superimposed on the overall redness; LAMP does not see this (**Fig. 4**).
- The OH feature seen by M^3 [5] at the thorium anomaly could be related to hydration at a depth not sensed by LAMP (i.e. deeper in the regolith than several microns).

Figure 5. Feldspars could contribute to the FUV redness of the Compton region. Data from [11].



Results: FUV Spectral Slopes in Compton-Belkovich Region

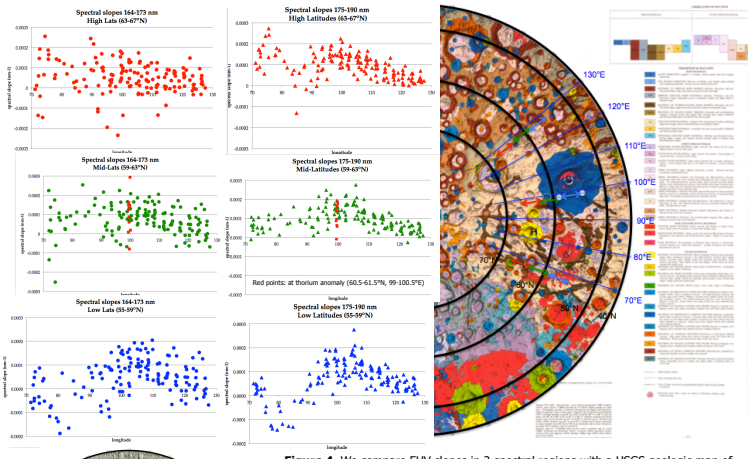
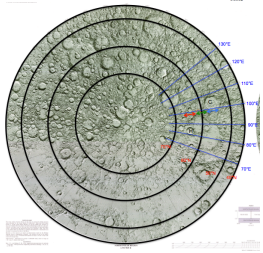


Figure 4. We compare FUV slopes in 2 spectral regions with a USGS geologic map of the C-B region. *The location of the thorium anomaly is noted with an orange circle* (99.5°E, 61°N).
The 164-173 nm slopes *could* indicate a change in hydration (redder slopes = more H_2O); the 175-190 nm slopes are unrelated to hydration and are associated with composition and weathering.



- Here we show slopes calculated in 4° latitude x 3° longitude bins
- The prominent red slope (175-190 nm) of this region appears to be associated with Compton crater itself, and not the smaller thorium anomaly region.
- We do not see a change in 164-173 nm slope, that would be consistent with an increase in hydration, associated with the C-B thorium anomaly.

MAJOR RESULTS:

- The prominent red slope (175-190 nm) of this region appears to be associated with Compton crater itself, and not the smaller thorium anomaly region.
- We do not see a change in 164-173 nm slope, that would be consistent with an increase in hydration, close to the C-B thorium anomaly.
- The far-UV spectrum generally becomes bluer with increased weathering [9], so the redness of this region suggests a different response of the composition to weathering.
- Perhaps this is such an Fe-poor region that the response to solar wind weathering is different from surrounding regions.

References:

[1] Lawrence, D. J. et al. (1999) *GRL, 26,* 2681–2683.
[2] Gillis, J. et al. (2002) *LPSC XXXIII* 1967.
[3] Jolliff et al. (2011) *Nat. Geo., 4,* 566-571.
[4] Greenhagen et al. (2010) *Science, 329,* 1507-1509.
[5] Petro, N. et al. (2013) *LPSC 44th,* #2688.
[6] Gladstone, G. R. et al. (2010) *SSR, 150,* 161-181.
[7] McClintock et al. (2000) Proc. *SPIE Earth Obs. Syst., 4135,* 225–234.
[8] Hendrix et al. (2012) *JGR, 117,* E12001, doi:10.1029/2012JE004252.
[9] Hendrix. A. R. & F. Vilas (2006) *A.J., 132,* 1396-1404.
[10] Klima et al. (2013) *LPSC 44th,* #2158
[11] Wagner, J. K. et al. (1987)