PRESENCE OF OH/H$_2$0 ASSOCIATED WITH THE LUNAR COMPTON-BELKOVICH VOLCANIC COMPLEX IDENTIFIED BY THE MOON MINERALOGY MAPPER (M^3). N. E. Petro[1], P. J. Isaacson[2], C. M. Pieters[3], B. L. Jolliff[4], L. M. Carter[1], R. L. Klima[5], [1]NASA GSFC, Planetary Geodynamics Laboratory, [2]University of Hawaii, [3]Brown University,[4]Washington University, [5]Johns Hopkins University-Applied Physics Laboratory. (Noah.E.Petro@nasa.gov)

Introduction: Recently, OH/H$_2$O has been identified in three distinct lunar surface settings. First, the positive identification of indigenous volatiles in volcanic glass samples revealed the deep interior of the Moon to be hydrated [1-3]. Second, the presence of OH/H$_2$O was detected remotely and mapped across the surface; likely in the form of a thin, possibly transient [4], surface layer on the regolith, with higher abundances in polar regions [4-7]. Third, the presence of polar water buried in the upper few meters of regolith was first measured remotely [8-11] and then directly by the LCROSS impact experiment [12]. Subsequent to these discoveries, enhanced hydration has been identified in association with the central peak of Bullialdus crater, the formation of which likely exposed a deep-seated KREEP-bearing Mg- of Alkali-Suite lithology [13]. Here we describe the enhancement in OH/H$_2$O associated with the lunar farside Compton-Belkovich [14] volcanic complex (CB) as measured by the Moon Mineralogy Mapper (M^3) experiment flown on Chandrayaan-1 [15], and its likely association with a mantling deposit identified by the Mini-RF instrument on the Lunar Reconnaissance Orbiter (LRO).

Compton-Belkovich Volcanic Complex (CB): A compositional anomaly associated with the CB was initially identified in Lunar Prospector Gamma-Ray Thorium data as a small-scale feature with an unusually high Th abundance [16]. Jolliff *et al.* [14], using high resolution images from the LRO Camera (LROC) and compositional data from the Diviner instrument, describe the CB as a series of small volcanic features with a silicic composition (Fig. 1). The complex is topographically elevated, has a higher albedo than its surroundings, and contains several small volcanic cones and domes.

M^3 View of Compton-Belkovich: The M^3 experiment mapped the Moon from 430 to 3000 nm [15], a wavelength range sensitive to both common lunar mafic minerals as well as a spectral feature near 3000 nm associated with OH/H$_2$O [6, 7]. The discovery of hydration features in polar regions [6] was due to the cooler surface temperatures which allowed the weak 3000 nm absorption feature to be identified. Spectra at lower latitudes (< ~60º) contain a thermal component at wavelengths greater than ~2500 nm [17] that mask longer wavelength absorption features. However, the CB is located where surfaces are sufficiently cold (<240K [7, 17]) so that the thermal component of the spectra does not effect the 3000 nm absorption feature.

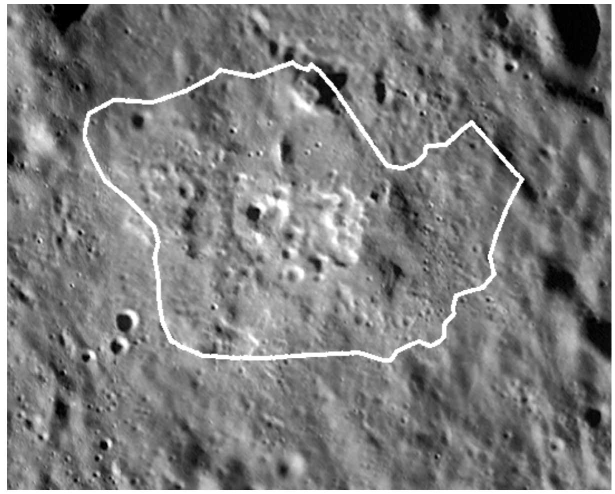

Figure 1. The Compton-Belkovich volcanic complex (61.1ºN, 99.5ºE) with an outline of the ~25 x ~35 km albedo anomaly as identified by Jolliff *et al.* [14]. Base image is a 100 m/pixel LROC WAC mosaic.

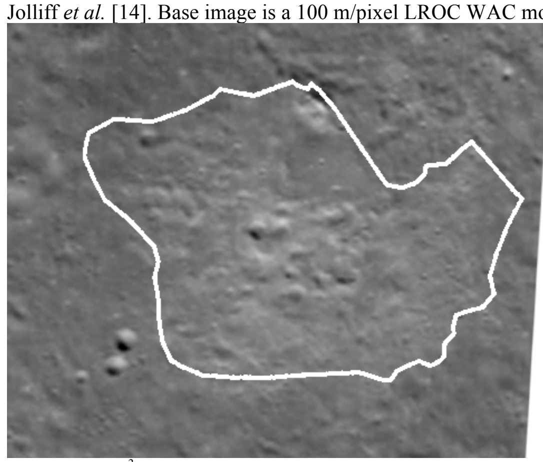

Figure 2. M^3 albedo (750nm) image of the Compton-Belkovich complex. Data is observation M3G20090601T064032, with a resolution of ~280 meters per pixel [18]. White outline as in Fig. 1.

Enhanced 3000 nm Absorption Associated with Compton-Belkovich: M^3 data of CB (Fig. 2) has a spatial resolution of ~280 meters per pixel [18]. Mature soils surrounding the CB are consistent with the aforementioned weak (~4%, Fig. 3) surface hydration absorption feature observed across polar regions [6]. However, spectra from within CB exhibit much stronger 3000 nm absorption features and vary across CB, from the general CB background absorption strength of ~10% (red spectrum in Fig. 3) to the strongest absorptions (~20%, green spectrum in Fig. 3). The strong absorption features are commonly, though not exclusively, associated with the sunlit portions of small craters and slopes on the flanks of the small volcanoes, domes, and fresh escarpments described by Jolliff *et al.* [14].

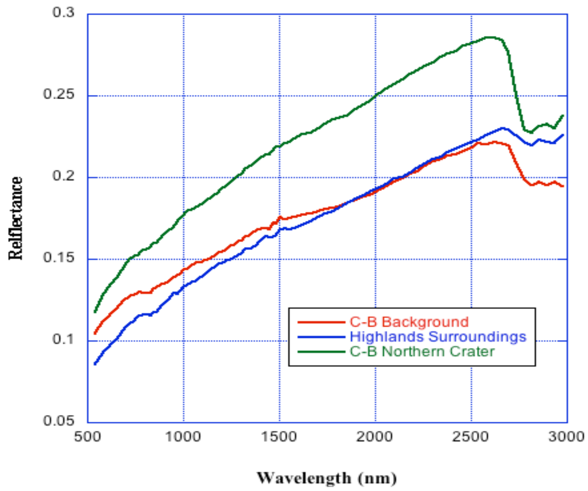

Figure 3. Example M[3] spectra from the CB (red and green) compared to surrounding highlands (blue). The "C-B Northern Crater" spectrum is from a fresh sunlit crater in the north of the complex exhibiting one of the strongest 3000 nm absorption features (green arrow in Fig. 4), while the "C-B Background" spectrum is a mature soil in the center of the complex. "Highlands Surroundings" is a spectrum of a mature soil to the west of CB.

A ratio of two M[3] wavelengths clearly illustrates a highly localized enhanced 3000 nm micron absorption feature associated with CB (Fig. 4). The areas with the strongest 3000 nm absorption (presumed to have more OH/H_2O) appear in white in Figure 4. The C-B Northern Crater in Figure 3 is indicated by a green arrow in Figure 4. Interestingly, the largest of the domes described by Jolliff *et al.* [14] (identified as the Big Dome [14] or "α Dome" [19]), shows no enhancement (red arrow in Fig. 4).

Mini-RF View of Compton-Belkovich: Jolliff *et al.* [14] speculated that the compositional anomaly associated with the CB is related to a volcanic complex that produced late-stage pyroclastic eruptions. One possible clue to the origin of the complex can be resolved with data from the Mini-RF radar on LRO [20]. S-Band (12.6 cm wavelength) total power and circular polarization ratio data of the CB reveal a very radar-dark surface with low to moderate CPR values (Fig. 5). This suggests that the upper centimeters to meter of the surface is relatively block-poor, apart from small radar-bright areas associated with volcanic cones and domes where surface blocks are visible in LROC images. It is likely that much of the complex is mantled by a uniformly rock-poor surface, consistent with the presence of fine-grained pyroclastic material.

Conclusions: The CB exhibits an unusually strong OH/H_2O absorption feature, in stark contrast to its surroundings [6]. The direct correlation of the abundance of OH/H_2O (as inferred from increased 3000 nm absorption strength) with the CB suggests that endogenic water [e.g., 3, 13] may be contributing to the overall strength of the absorption feature here. The possible effects of residual thermal contribution to the spectra and/or the role of the unique surface properties of CB need to be assessed. Additionally, constraints on the amount of OH/H_2O required to produce such strong features will be investigated. It is clear that CB is unique and should be a high priority target for future study and exploration.

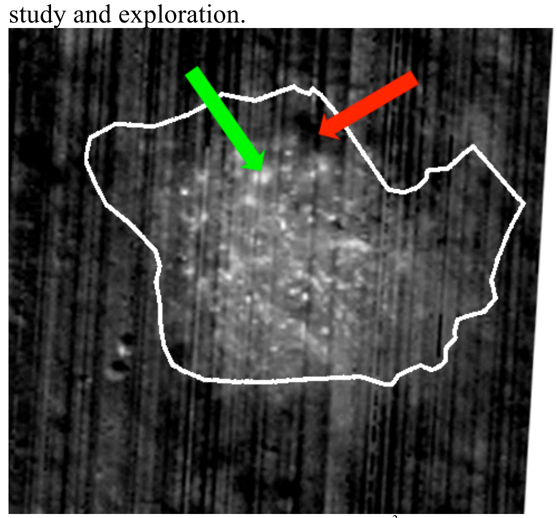

Figure 4. Ratio of two wavelengths of M[3] data (2736nm/2816nm) illustrated in Fig. 2. White outline same as in Fig. 1.

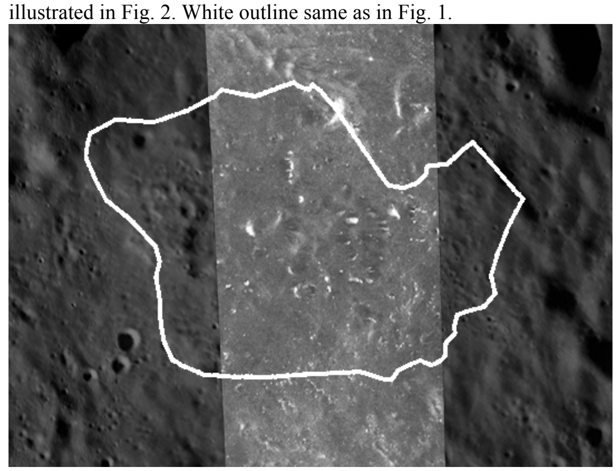

Figure 5. Mini-RF total power image covering a portion of CB (background in LRO WAC mosaic). The darker areas in Mini-RF data are indicative of smooth, block-poor regolith, while the brighter surfaces are rougher (more cm- to m-sized blocks). Mini-RF image LSZ_06870_61N100. White outline same as in Fig. 1.

References:[1] Hauri, E. H., et al., (2011) *Sci.* [2] McCubbin, F. M., et al., (2011) *GCA*, 75, 5073-5093. [3] Saal, A. E., et al., (2008) *Nat.*, 454, 192-195. [4] Sunshine, J. M., et al., (2009) *Sci.*, 326, 565. [5] Clark, R. N., (2009) *Sci.*, 326, 562. [6] Pieters, C. M., et al., (2009) *Sci,*, 326, 568. [7] Clark, R. N., et al., (2011) *LPI* 1621, 8. [8] Nozette, S., et al., (2001) *JGR*, 106, 23253. [9] Johnson, J. R., et al., (2002) *JGR*, 107b, 3-1. [10] Lawrence, D. J., et al., (2006) *JGR*, 111. [11] Mitrofanov, I. G., et al., (2010) *Sci.*, 330, 483-486. [12] Colaprete, A., et al., (2010) *Sci.*, 330, 463-468. [13] Klima, R., et al., (In Review) *Nat. Geosci*. [14] Jolliff, B. L., et al., (2011) *Nat Geosci.*, 4, 566-571. [15] Green, R. O., et al., (2011) *JGR.*, 116, E00G19. [16] Lawrence, D. J., et al., (2003) *JGR*, 108(E9), 5102. [17] Clark, R. N., et al., (2011) *JGR.*, 116, E00G16. [18] Boardman, J. W., et al., (2011) *JGR.*, 116, E00G14. [19] Jolliff, B. L., et al., (2012) *LPSC 43*, 2097. [20] Nozette, S., et al., (2010) *SSR*, 150, 285-302.