THE COMPTON-BELKOVICH REGION OF THE MOON: REMOTELY SENSED OBSERVATIONS AND LUNAR SAMPLE ASSOCIATION. J. J. Gillis[1], B. L. Jolliff[1], D. J. Lawrence[2], S. L. Lawson[2], and T. H. Prettyman[2], [1]Washington University, Dept. of Earth and Planetary Sciences, St. Louis, MO 63130 (gillis@levee.wustl.edu), [2]Los Alamos National Laboratory, MS-D466, Los Alamos, NM, 87545.

Remotely sensed chemical and mineralogical data of the lunar crust [1, 2, 3, 4] exhibit lateral and vertical variations with respect to the average feldspathic highlands, which contains low concentrations of FeO (~5 wt%) and Th (<1 ppm) [5]. A small-scale Th-anomaly exists on the northeastern limb of the Moon, near the craters Compton and Belkovich, and has been called Compton-Belkovich high-Th anomaly [6]. Here, we present an analysis of the Compton-Belkovich region through an integrated approach of remotely sensed and sample data.

Regional Geology: The Compton-Belkovich high-Th area is situated in rugged feldspathic highlands crust on the northeastern limb of the Moon (61.1°N, 99.4°E). The area of interest occurs on the floor of the Nectarian aged Humboldtianum basin (56.8N, 81.5E; 650.0 km diameter), between two of its inner rings (250, and 350 km). The locality also lies 45 km from the eastern edge of Nectarian aged crater Belkovich (61.1°N, 90.2°E; 214 km diameter) and 100 km northwest from the edge Compton crater (55.3°N, 103.8°E; 162 km diameter), early Imbrian in age. Topographically, the high-Th area sits on the eastern side of a saddle with higher topography situated to the north and south, and lower topography to the east and west. The topographic low to the east is likely responsible for the eastward smearing of high-Th values from the main Th anomaly.

UVVIS Data: Clementine 5-band (415, 750, 900, 950 1000 nm) mosaics were created for the Compton-Belkovich region from the USGS Clementine multispectral digital image model CD-ROM set [7, 8]. These images were processed with the latest photometric calibration constants [9, 10] and at 100 m/pixel resolution. Five-band spectra were acquired from the freshest areas in the study and used to characterize surface mineralogy. Unfortunately some data covering a portion of the Compton-Belkovich region was not acquired due to a filter-sequencing problem [T. C. Sorensen, personal communication, 1997]. This includes a data gap for 750 nm images east of Compton-Belkovich and another data gap for 950 nm images covering a portion of Compton-Belkovich.

Associated with the Compton-Belkovich Th enrichment is an area that exhibits higher reflectance values (at all Clementine wavelengths) when compared with the surrounding mature highland materials (Fig. 1). The distinct difference in reflectance between the Compton-Belkovich region and surrounding highlands allows the Compton-Belkovich albedo feature to be noticed readily. When compared with fresh highlands, however, reflectance at UV and visible wavelengths is slightly higher but the slope is slightly shallower than fresh highlands. Thus, reflectance trends crisscross in the near infrared, and as a result fresh highlands appear brighter. A major factor controlling the reflectance at longer wavelengths for the albedo anomaly is an absorption at 900 nm, indicative of the presence of orthopyroxene.

FeO concentrations were calculated using the 750 and 950 nm Clementine data and the method developed by [4]. The composition of Compton-Belkovich is 3.0±0.2 wt% FeO, slightly lower than the surrounding highlands, 4.0±0.5 wt% FeO. FeO data reported here is for only a small fraction (4 km^2) of the total area (350 km^2) of Compton-Belkovich because some of the 750 and 950 nm data are missing for portions of Compton-Belkovich. We advocate that the FeO values reported are representative of Compton-Belkovich as a whole, on the basis that the area from where the FeO values were acquired, exhibited similar 900/750 and 1000/750 ratios as the main portion of Compton-Belkovich.

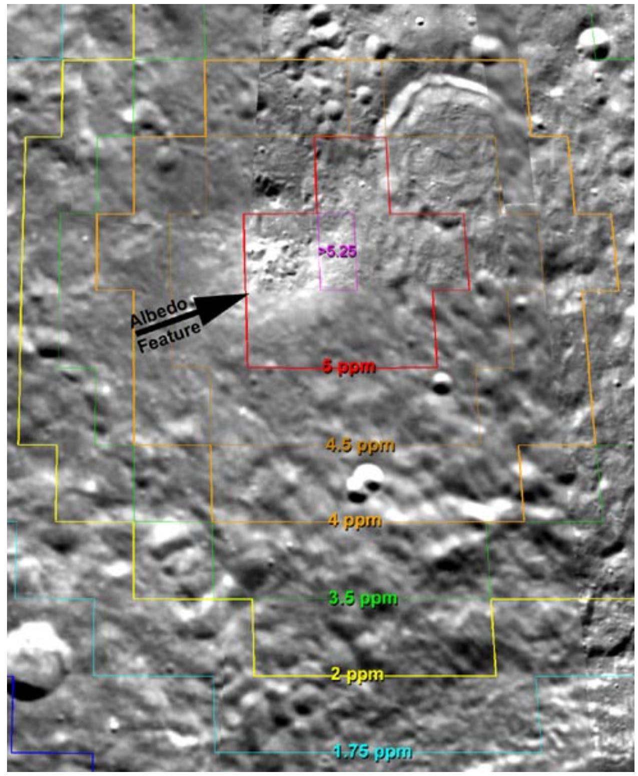

Fig 1. Th contours from LPGRS in half ppm increments merged with a Clementine albedo map (100m/pixel).

LWIR data: The Clementine Long-Wave Infrared data were obtained at a single bandpass centered at a wavelength of 8.75 µm, with a full-width half-max of 1.5 µm, and with a resolution of 80 m/pixel. The Clementine LWIR data was used to determine whether the bright feature at Compton-Belkovich is related to albedo or topography. Brightness temperatures, obtained using the thermal infrared data, provide information about the various thermophysical properties of the lunar surface: Daytime surface temperatures are largely a function of albedo (fraction of incident sunlight reflected from the surface), surface roughness (i.e., if a facet is facing the sun, it's hot and bright), and latitude (less solar radiation per square-foot at the poles than at the equator) [11, 12]. Figure 2 illustrates a side-by-side comparison of Clementine reflectance at 0.9 µm (there was no 0.75 µm data available at this location) and emittance at 8.75 µm. Craters, and the mound north of the albedo feature (white arrows in Fig. 2) have very bright sun-facing slopes (i.e., warmer) and dark sun-shaded slopes (i.e. cooler); thus, their reflectance is controlled by topography. The albedo feature, however, is the same temperature in the LWIR image as the surrounding highlands, and therefore it is a true albedo feature.

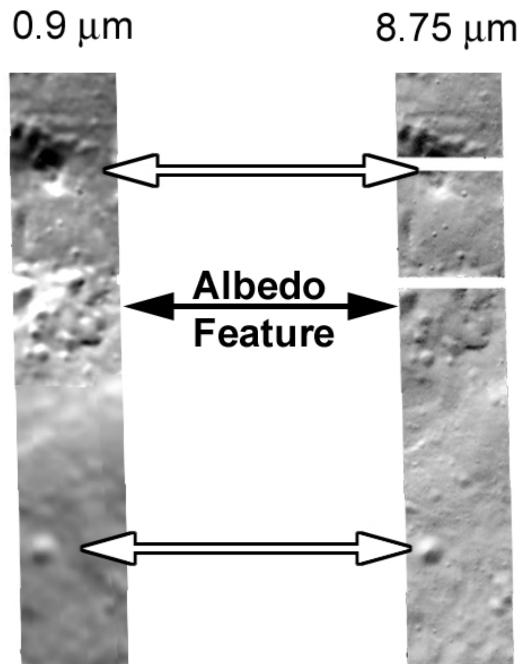

Fig 2. Side-by-side comparison of Clementine UVVIS and LWIR data.

Th data: The Th content of the Compton-Belkovich region was characterized using the Lunar Prospector γ-ray spectrometer (LP-GRS) data, which has recently been smoothed and mapped on 0.5°x0.5° pixels. Note: these pixels are not equal area [13]. Previous Th measurements were mapped using 60 km x 60 km pixels (2° x 2° at the equator) [6]. Measured Th abundances range from 4 to 5.5 ppm, and average 4.8 ppm Th for the Compton-Belkovich region. For comparison, the typical composition of highlands materials surrounding Compton-Belkovich is 1.4±0.07 ppm Th.

Sample data: Data suggest a possible connection between the Compton-Belkovich region and the small but important component of lunar soil and breccia samples, alkali anorthosite (Fig. 3). The material within the Compton-Belkovich region contains high-Th, and low-FeO and TiO_2 suggesting that this region contain rocks with evolved compositions such as alkali anorthosite, and felsites/granites, which contain similar concentration of these elements. Both rock types have high (but varying) concentrations of Th and low compositions of FeO and TiO_2. Recent LP-GRS results by [14] confirm that the K abundances in the Compton-Belkovich region are not anomalously high, but are consistent with a standard KREEP K/Th ratio [15]. Low levels of K, and low ratios of K to Th favor alkali anorthosite as the rock type present. In addition the average FeO abundance of granite/felsite is 7.7 wt% while the average alkali anorthosite is 2.8 wt% FeO [15], which again supports that the Compton-Belkovich region is alkali anorthosite.

Discussion: Most of the anorthosites from the Apollo 12 and 14 landing sites are alkali, whereas all of the pristine anorthosites from eastern landing sites are ferroan. Warren & Wasson [16] suggested that the alkali anorthosites were precipitate from Mg-suite magmas on the basis of they lie close to the extrapolation of the Mg-suite on a plot of Mg/(Mg+Fe) in mafic silicates versus An content (Ca/(Ca+Na+K)) diagram. If this is the case, and what we observe is truly alkali anorthosite, then where are the associated Mg-suit rocks? Is it possible that KREEP lithologies are hidden below this outcrop of alkali anorthosite? Or is this Th-anomaly associated with a rock-type that is presently not in the sample collection? Remote sensing studies of mare basalts [17] have shown that ~2/3 of mare surface are not represented in the sample collection, and the feldspathic highlands are considerably more vast than maria.

Conclusions: Without more data, and for the lack of a better alternative, we favor that the Compton-Belkovich high-Th anomaly is an outcropping of alkali anorthosite. As such, this evidence for nonmare igneous activity outside the Procellarum KREEP Terrane has major implications for the thermal history and crustal evolution of the Moon.

References: [1] Davis, P.A., 1980, *JGR*, **85** , 3209; [2] Elphic, R.C., et al., 2000, *JGR*, **105**, 20,333; [3] Lawrence D.J., et al., 2000, *JGR*, **105**, 20,307; [4] Lucey, P.G., et al., 2000, *JGR*, **105**, 20,297; [5] Jolliff, B. L., et al., 2000, *JGR*, **105**, 4197; [6] Lawrence, D. J., 1999, *GRL*, **26**, 2681; [7] Eliason, E.M., et al., 1999, *LPSC XXX*, #1933; [8] Isbell, C.E., 1999, *LPSC XXX*, #1812; [9] McEwen, A.S., 1996, *LPSC XXVII*, 841; [10] McEwen, A.S., 1998, *LPSC XXIX*, #1466; [11] Lawson, S. L., et al., 2000, *JGR*, **105**, 4273; [12] Lawson, S.L., B.M. Jakosky, 2001, *JGR*, **106**, 27,911; [13] Lawrence et al., *LPSC XXXIII*, *this issue*; [14] Korotev, R.L., 1998, *JGR*, **103**, 1691 [15] Prettyman et al., 2002, *LPSC XXXIII*, *this issue*; [16] Warren, P.H., and J.T. Wasson, 1979, *Rev. Geophys. and Space Phys.*, **17**, 73; [17] Pieters, C.M., 1978, *PLPSC 9*, 2825; [18] Korotev, R.L., 2001, *LPSC XXXII*, #1134; [19] Korotev R.L., et al., 2002, *LPSC XXIII, this issue*.

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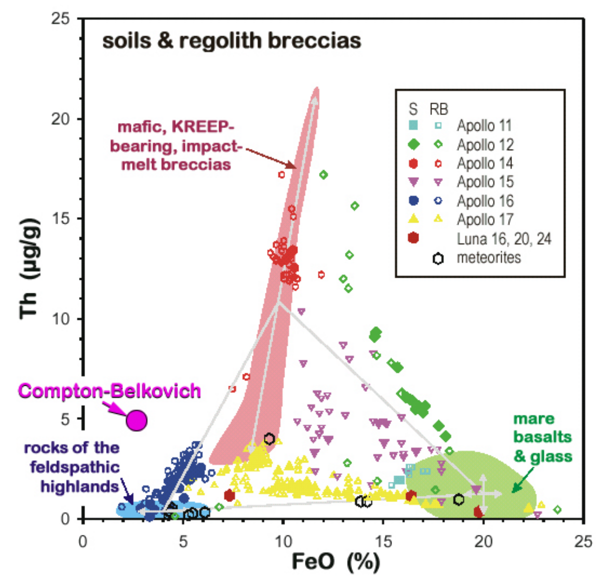

Fig 3. shows how regoliths are mixtures of 3-classes of materials [18]. Compton-Belkovich falls out side this triangular array and in the region of alkali anorthosite (see [19]).