IMAGING SPECTROMETER ANALYSIS OF THE POTENTIAL HYDRATION OF LUNAR VOLCANIC AREAS. W. H. Farrand[1], C. S. Edwards[2], S. Bhattacharya[3], C. J. Tai Udovicic[2]. [1]Space Science Institute, Boulder, CO, farrand@spacescience.org, [2]Northern Arizona University, Flagstaff, AZ, [3]Space Applications Center, ISRO, Ahmedabad, India.

Introduction: The discovery that there are OH and H_2O spectral features across the lunar surface [1-4] has raised questions about the source of the hydration and its extent. Moon Mineralogy Mapper (M^3) data was used to show the presence of an OH and/or H_2O spectral feature near 3 µm associated with numerous lunar pyroclastic deposits [5] and also in association with several lunar "red spots" [6], areas of silicic volcanism [7-8]. The characterization of the 2.7 to 3 µm reflectance feature requires thermal correction of imaging spectrometer data since thermal emission from the lunar daytime lunar surface ramps up from approximately 2.2 µm on. Characterization of this feature with M^3 data is also complicated by the fact that that instrument's spectral range ends at 2.98 µm allowing for characterization of only the short wavelength portion of this hydration band. This feature may also be influenced by surface roughness, which causes the effective surface temperature to vary as a function of wavelength and the bi-directional geometry of the observation [9, 10]. Recently collected imaging spectrometer data extending out to 5 µm has become available from the Indian Space Research Organization's Infrared Imaging Spectrometer (IIRS) instrument [11]. A physics based thermal correction [9, 10] that can be applied to both M^3 and IIRS data has also been demonstrated and is being used in this work.

Data: M^3 mapping data covers the spectral range from 0.46 to 2.98 µm at a spatial resolution ranging from 140 to 280 m in 85 channels. IIRS data extends from 0.8 to 5 µm over 250 channels with a spatial resolution of 80 m [11]. Data from both instruments have been calibrated by their respective instrument teams to at-sensor radiance.

Thermal Correction: Thermal correction of M^3 data is an issue that has been fraught with competing models [9-10, 12-14]. The wider spectral range of the IIRS data allows for utilizing the purely thermal component of the measured data to estimate a surface temperature and thermally correct the shorter wavelengths [15]. Additionally, the physics-based M^3 thermal correction, that considers the anisothermal nature of the lunar surface [9, 10], has been adapted for use with the IIRS data and is being applied to the volcanic areas considered here. This approach accounts for sub-pixel anisothermality caused by surface roughness and predicts emission as a function of wavelength, dropping the assumption of isothermality (that temperatures derived from longer wavelengths are applicable at the shorter 2.7-3 µm range). Also considered here are data corrected via the methods of [12] and [13].

Volcanic Study Areas: Considered in this study are several lunar pyroclastic deposits noted as showing evidence of an OH and/or H_2O absorption [5, 16]. Also considered are the silica-rich volcanic domes that previous studies have indicated as having an associated hydration band [8, 17-18]. Among the areas considered in this present study are those listed in **Table 1**.

Feature	*Feature Type*
Aristarchus Plateau	Regional LPD
Sulpicius Gallus	Regional LPD
Alphonsus	Localized LPD
Rima Birt E	Localized LPD
Mairan Domes	Silica-rich domes
Compton-Belkovich	Lunar red spot

Table 1. Areas considered.

Early Results: While analysis is on-going of all the areas listed in **Table 1**, examination of IIRS scene ch2_iir_nci_-20200627T0527542988 over the western part of the Compton-Belkovich feature [18-20] shows the value of the higher spatial resolution of the IIRS in providing added detail over this feature in the OH Integrated Band Depth (OHIBD) [14] image in **Fig. 1B**. While DN values are marginally greater over the broader feature, they are elevated more in specific regions, some topographically higher areas, but not all, indicating heterogeneity in the feature. Also, the spectrum shown in **Fig. 2**, drawn from a region of interest over one of the areas with higher OHIBD values, displays a 2.8 µm hydroxyl absorption rather than a broader H_2O or a mixed OH/H_2O feature. The ch2_iir_nci_20200627T0527542988 scene was thermally corrected for this example using the method of [15], although for the higher northern latitude of this scene the contribution from thermal emission is minimal.

Discussion: Utilizing several thermal correction approaches we are studying the areas in **Table 1** using both M^3 and IIRS data in order to assess the extent and level of hydration associated with these deposits. Factors assessed include the position and width of a feature in the 2.8 to 3 µm range. Such a distinction was not fully achievable with M^3 data, but can be considered with

IIRS data as shown in **Fig. 2** here. We are examining also the strength of the OH / H_2O bands and their likely source(s) as constrained by the independent means of thermal correction described above. These studies will help constrain whether the presence of OH and/or H_2O in association with these volcanic materials is the result of exogenous, implanted solar wind H^+ or potentially endogenous volatiles from the lunar interior.

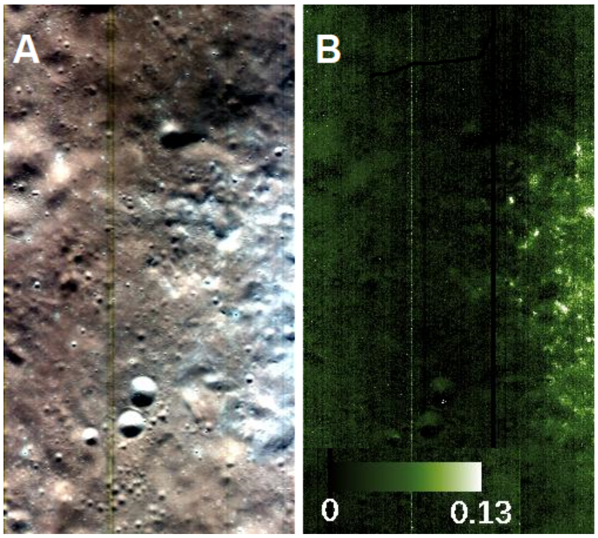

Fig. 1. A. Composite of 2, 1, and 0.84 µm bands for a subsection of IIRS scene ch2_iir_nci_-20200627T0527542988 over western half of Compton-Belkovich complex. **B.** Pseudo-colored OHIBD image indicating depth of 2.8 µm hydroxyl absorption.

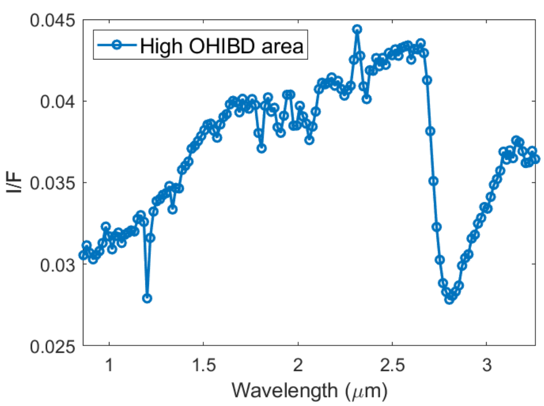

Fig. 2. Spectrum from a high OHIBD area for the Compton-Belkovich IIRS scene shown in **Fig. 1**.

Acknowledgements: This work is being performed under NASA Lunar Data Analysis Program grant 80NSSC22K1341.

References: [1] Clark R.N. (2009) *Science*, *326*, 562-564. [2] Sunshine J.M. et al. (2009) *Science*, *326*, 565-568. [3] Pieters C.M. et al. (2009) *Science, 326*, 568-578. [4] Honniball C. et al. (2021) *Nature Astro.*, 121-127. [5] Milliken R.E and Li S. (2017) *Nature Geosci.*, *10*, 561-565. [6] Whitaker E.A. (1972) *The Moon, 4*, 348-355. [7] Glotch T.D et al. (2010) *Science, 329*, 1510-1513. [8] Bhattacharya, S. (2013) *Curr. Sci., 105*, 685-691. [9] Bandfield J.L. et al. (2018) *Nature Geosci.*, *11*, 173-177. [10] Tai Udovicic, C.J. (2022) *PhD dissertation,* Northern Arizona University, ProQuest (30243545). [11] Chowdhury A.R. (2020) *Curr. Sci., 118,* 368. [12] Clark R.N. et al. (2011) *JGR, 116*, E00G16, doi:10.1029/2010JE003751. [13] Li S. and Milliken R.E. (2016) *JGR*, *121*, 2081-2107. [14] Wöhler, C. et al. (2017) *Sci. Adv*., *3*, e1701286. [15] Verma P.A. et al. (2022) *Icarus*, *383*, 115075. [16] Trang D.T. et al. (2022) *Icarus*, *375*, 114837. [17] Li S. and Milliken R.E. (2017) *Sci. Adv., 3*, doi:10.1126/sciadv.1701471. [18] Petro N.E. et al. (2013) *LPSC 44*, #1719. [19] Jolliff B.L. et al. (2011) *Nature Geosci*., *4*, 566-571. [20] Wilson J.T. et al. (2015) *JGR, 120*, 92-108.