INVESTIGATION OF THE PRESENCE OF VOLATILES AT THE ARTEMIS 3 CANDIDATE LANDING SITES WITH THE CHANDRAYAAN – 2 IMAGING INFRARED SPECTROMETER. A. Srivastava[1], G. R. Osinski[1], L. L. Tornabene[1], and V. G. Rangarajan[1] [1]Department of Earth Sciences, University of Western Ontario, 1151 Richmond St., London, ON, N6A 5B7, Canada (asriva57@uwo.ca)

Introduction: The search for water-ice on the Moon has been one of the most intriguing questions of space exploration over the past few decades, especially in light of upcoming missions that will return humans to the Moon. Any permanent or semi-permanent future presence on the Moon will require *in-situ* resource utilization (ISRU) of lunar materials, including water-ice. Multiple remote sensing and *in situ* missions to the Moon have sought, and are currently seeking, to undeniably detect, characterize and quantify water-ice to enable ISRU. This includes NASA's Artemis III mission to the south polar region of the Moon.

Reflectance spectroscopy is a key tool that has been previously employed to detect hydration (OH/ H_2O or water-ice) in the lunar regolith [1-3]. Most spectral interpretations of the lunar surface have been based off observations from the Moon Mineralogy Mapper (M^3) aboard ISRO's Chandrayaan – 1, which provided nearly complete coverage of the Moon in 430 – 3000 nm wavelength range in a combination of global (140 m/px) and targeted acquisition modes (70 m/px) [4]. The near infrared wavelength range of M^3 encompasses the diagnostic overlapping overtone and combination absorptions for water-ice around 810, 900, 1040, 1250, 1500 and 2000 nm [5,6]. The detection of some of the stronger aforementioned features has previously been used to confirm presence of water-ice bearing features on the Moon.

More recently, data from the Imaging Infrared Spectrometer (IIRS) aboard ISRO's Chandrayaan – 2 orbiter has become available, which allows for an extended insight into the spectral characteristics of the lunar surface, owing to its wider spectral range (800 – 5000 nm) at a similar spatial scale (80 m/px) to M^3 [7,8]. IIRS also provides additional coverage of water-ice spectral features including stronger features around 3000 nm indicative of OH/H_2O, which complements the spectral information provided by M^3. Thus, IIRS provides a unique opportunity to better understand the character of hydration in the observed surface features (i.e., mineral-bound OH and/or H_2O, or water-ice).

Thirteen candidate landing site regions have been shortlisted by NASA for the Artemis III mission [9]. We are carrying out a study of these sites using the IIRS instrument. Here, we assess one of these sites (Faustini Rim A) based on new observations from IIRS for presence/absence of associated hydration features (Fig. 1).

Methods: Radiometrically calibrated IIRS strips overlapping the Faustini Rim A, were acquired from the Indian Space Science Data Center (ISSDC), which are available with corrections for detector non – uniformity, dark subtraction, and keystone correction. Reflectance observations in the IR, particularly around ~2000 and greater than 3000 nm, are a combination of reflected sunlight and emitted thermal emission [10,11]. This necessitates application of a correction to isolate surface reflectance properties from those related to surface emission to enable more confident spectral interpretations.

Thermal correction of the IIRS spectra has been carried out using the Chandrayaan – 2 IIRS QGIS plugin [12]. This method thermally corrects the reflectance values by subtracting the thermal component which is calculated based on assumed emissivity values from 0.85 – 0.95 at 4500 nm and calculated average surface temperature [12]. Spectral extraction was then performed on the thermally corrected data over two 2-pixel ROIs, one exactly overlapping the potential water-ice rich location near the crater rim identified by [1], and another ROI representing a non-icy region dominated by the surrounding volatile-poor lunar regolith (Fig. 1). The band positions and shape of the 3-μm absorption were then plotted and assessed in ENVI. We note that the reflectance of the IIRS data has not been calibrated using standard spectra of Apollo samples; however, that does not change the spectral shape of the absorption but only offsets the reflectance values by ~2x.

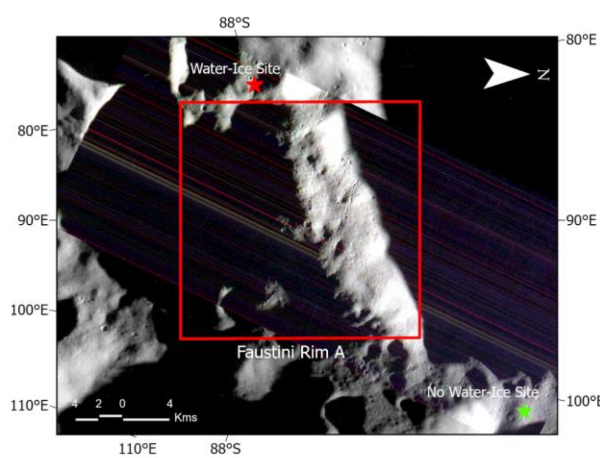

Figure 1: Image showing the Artemis 3 Candidate Landing site region – Faustini Rim A (red box) and the locations of the two ROIs on the Faustini Crater Rim

used for spectral analysis. The red star indicates the region where water-ice signatures were previously detected by [1]. Corresponding ROI indicative of a non-icy regolith dominant location is indicated by a green star. Images used are IIRS image ID ch2_iir_nci_20201220T1413058281_d_img_d32 overlain on LROC WAC South Pole Mosaic.

Results: Figure 2 shows that the IIRS spectral data over the Faustini Rim A region indicates the presence of a 3000 nm absorption indicative of hydration (red star in Fig. 1), which appears to be absent for the spectrum extracted from the surrounding regolith (green star in Fig. 1). This is consistent with the water-ice diagnostic absorptions of wavelengths shorter than 2500 nm reported by [1] using M^3.

Furthermore, the position of the band minima in the IIRS data beyond ~3000 nm is more consistent with the spectral behavior of water-ice rather than bound OH/H_2O [2].

Conclusions and Future Work: The combination of the wavelengths of M^3 and IIRS can provide us with more reliable spectral information about the presence and nature of water-ice in the proposed Artemis III landing regions, given their overlap and IIRS' extended wavelength range. From this work, we provide new evidence consistent with the presence of water-ice in the Faustini Crater Rim A region, a site of relevance to the Artemis III mission, based on the strength and position of the 3000 nm hydration band as observed by IIRS.

This study will be extended to other Artemis III candidate landing site regions, which will provide a better assessment of the hydration character of the lunar regolith in the region. The thermal correction of IIRS can be improved for more accurate information which would enable us to perform a direct comparison of the overlapping wavelengths between the two instruments.

Acknowledgments: The authors would like to thank the PDS Geosciences team for supplying the LROC WAC mosaic for the base map of this study. We would also like to thank ISRO ISSDC for supplying the Chandrayaan – 2 IIRS calibrated data and Dr. Prabhakar Alok Verma, Scientist/ Engineer – "E" at the Indian Institute of Remote Sensing – Indian Space Research Organisation, Dehradun for creating algorithms for thermal corrections of the data.

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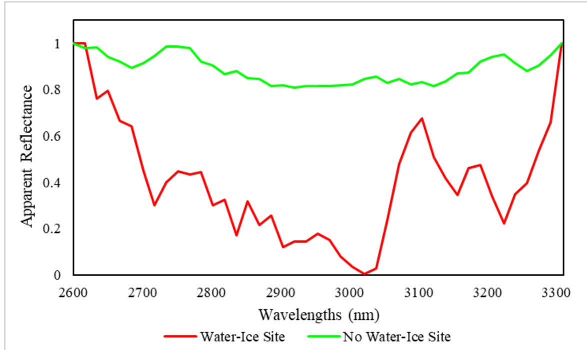

Figure 2: Representation of the 3000 nm absorption in IIRS spectra between the two sites marked by red and green stars in Figure 2. The two spectra shown here are continuum removed to isolate and enhance the absorption features. Note how no significant absorption feature is observed in the surrounding regolith (green) unlike the potential water-ice rich site (red).