PRELIMINARY OBSERVATIONS OF LUNAR SURFACE BY CHANDRAYAAN-2 IMAGING INFRARED SPECTROMETER (IIRS). Satadru Bhattacharya[1*], Aditya Kumar Dagar[1], Arup Banerjee[1], Ankush Kumar[1], Amitabh[1], K Suresh[1], Ajay Prashar[1], Abhishek Patil[1], Arup Roy Chowdhury[1], Anish R. Saxena[1], S. Gomathi[2], Vijaysree[2], Prakash Chauhan[3], Mamta Chauhan[3], Sumit Pathak[4,5], Deepak Dhingra[6], Shovan Lal Chattoraj[3], Himela Moitra[4] and Saibal Gupta[4]. [1]Space Applications Centre, Indian Space Research Organisation (ISRO), Ahmedabad – 380015, India. [2]U. R. Rao Satellite Centre, ISRO, Bengaluru – 560017, India. [3]Indian Institute of Remote Sensing, ISRO, Dehradun – 248001, India. [4]Indian Institute of Technology, Kharagpur – 721302, India. [5]Dept. of Geology, Banasthali University, Rajasthan – 304022, India. [6]Indian Institute of Technology, Kanpur – 208016, India ([*]satadru@sac.isro.gov.in).

Introduction: Spectrometer instruments on-board Chandrayaan-1 and other recent lunar missions have mapped the surface mineralogy and hydration features of both exogenic and magmatic origin on the Moon [1 and references therein]. However, due to the limited spectral range of Chandrayaan-1 Moon Mineralogy Mapper (M^3) up to 3.0 µm, the nature of the hydration signatures cannot be ascertained.

Thus, in order to completely characterize the lunar hydration feature, Imaging InfraRed Spectrometer (IIRS) [2] aboard Chandrayaan-2 is designed with an extended spectral range up to 5.0 µm that is presently mapping the lunar surface at a Ground Sampling Distance (GSD) of 80 m in 256 spectrally narrow and contiguous channels. Chandrayaan-2 was launched on July 22, 2019 from Sriharikota and entered into the lunar orbit on August 20, 2019. This abstract presents the preliminary observations of lunar surface by IIRS from ~4300- and 100 km altitudes respectively during the commissioning phase.

Early Observations: The first light image of the lunar surface was acquired on August 23, 2019 from an altitude of ~4300 km. It covers part of the lunar farside in the northern hemisphere that include craters Sommerfield, Stebbins and Kirkwood (Figs. 1 & 2). Summary of instrument specifications are given in Table 1.

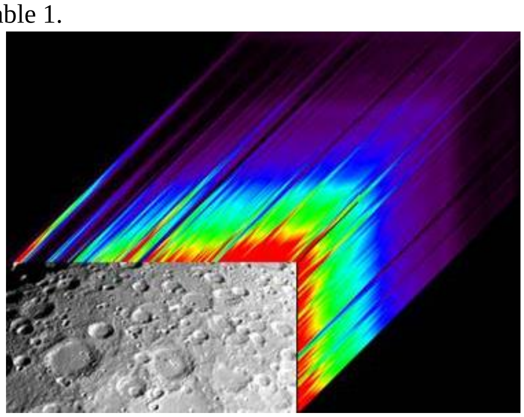

Figure 1. IIRS spectral data cube of a subset image acquired on August 23, 2019. The subset of the image has 169 cross-track samples, 73 lines and 251 spectral channels measuring from 810 to 5026 nm.

Table 1. Instrument specifications of IIRS

Parameter	Values
Platform Altitude (km)	100
GSD (m) at Nadir (with 2x2 binning)	80
Swath (km) at Nadir	20
Spectral Range (µm)	0.8 to 5
Spectral Resolution (nm)	~ 20-25
Noise-equivalent Differential Radiance, NEdR (mW/cm2/sr/µm)	≤ 0.005
No. of spectral bands	256
Quantization (bit)	14

Preliminary analysis suggests that IIRS could successfully measure the variations in the reflected and emitted solar radiation from the lunar surface from different kinds of surface types, namely, crater central peaks (e.g., Stebbins), crater floors (e.g., Stebbins and Sommerfield), very fresh reworked ejecta associated with small craterlets within the crater floor of a large crater (e.g., Sommerfield) and the sun-illuminated inner rims of craters (e.g., Kirkwood) (Fig. 2). Gaps in the spectral radiance profiles are due to the presence of Order Sorting Filters (OSFs) near ~1200, 1900 and 3500 nm (Fig. 2b). The measured radiance is low at the above regions and requires further analysis to obtain continuous spectral signature. Subsequently, the level 1 radiance data has been converted to reflectance by normalizing the measured spectral radiance by the incoming solar flux (Fig. 2c). Notable differences in the spectral shapes are observed as a function of surface types, degree of optical maturity and the mineralogy/litho-types attributable to the inherent compositional heterogeneity that exist in the lunar crust. A broad absorption near 3000 nm is seen in the mean spectra of Region of Interests (ROIs) obtained from the image in Figure 2a. This could be attributed to the presence of surface hydroxyl and/or water adsorbed in the lunar regolith. The shape and intensity of the 3000-nm feature is found to vary as a function of surface composition and degree of space weathering. However, these are very preliminary observations and require further detailed studies to infer the exact nature of the absorption

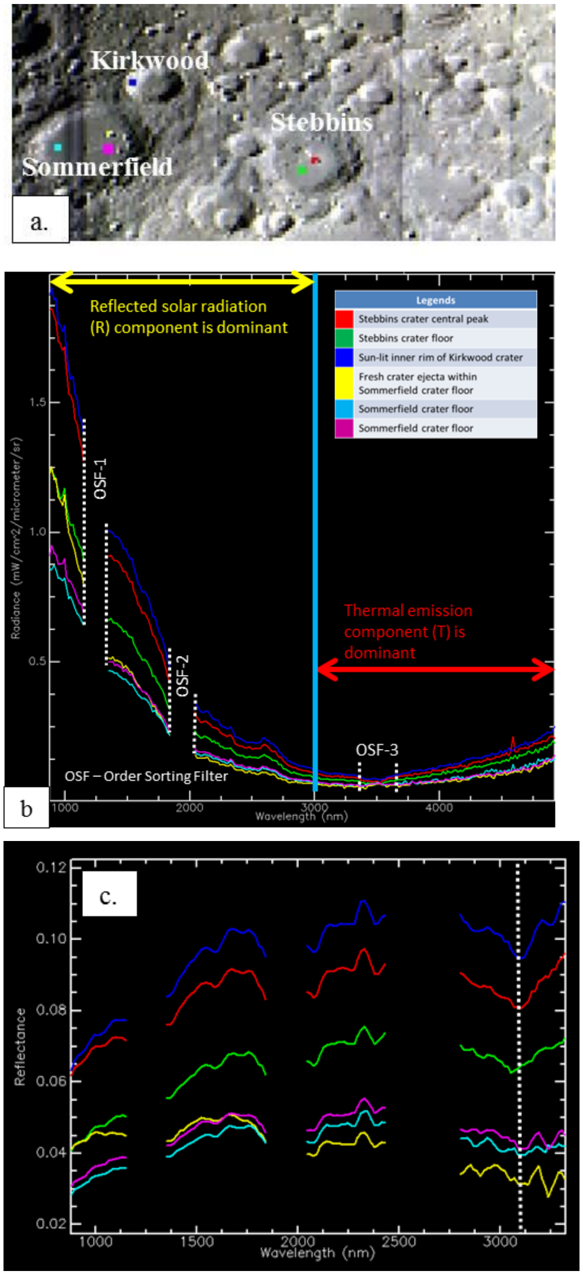

Figure 2. a. Locations of the region of interests (ROIs) in the image and b. corresponding spectral radiance profiles for different surface types such as crater central peak, crater floor, sun-lit inner crater rim and c. spectral reflectance of the corresponding ROIs as shown in a.

feature. Qualitative assessment of IIRS radiometric calibration is carried out with reference to Chandrayaan-1 M^3 for the same location on the Moon (Fig. 3). IIRS data covering western edge of Mare Moscoviense including Glauber crater was obtained from 100 km altitude on December 02, 2019 and the IIRS radiance profile has been compared with

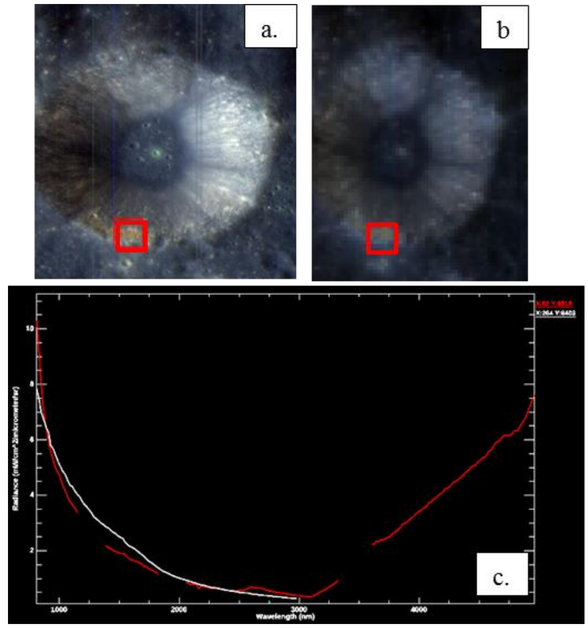

Figure 3. a. Chandrayaan-2 IIRS image showing crater Glauber situated south of Mare Moscoviense; b. the same crater as imaged by Chandrayaan-1 M^3; c. spectral radiance comparison of IIRS (in red) and M^3 (in white) from a fresh exposure along the southern inner rim of Glauber crater wall.

that of Chandrayaan-1 M^3 spectra from the same region within the southern inner rim of Glauber crater as shown in Fig. 3 and both are found to be in close agreement. Glauber is situated south of Mare Moscoviense and north of Mendeleev crater. The better spatial details of Glauber crater are evident from Figure 3 in IIRS image having ~80 m GSD as compared to Chandrayaan-1 M^3 (GSD: ~280 m).

Future Work: On-orbit calibration and validation will be continuing with acquisition of data over the Apollo sites. Data sets having common illumination and observation geometries with Chandrayaan-1 M^3 will also be acquired. Earth-imaging will be planned for spectral validation of IIRS by comparing spectral features of the atmosphere.

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References: [1] Dhingra 2018, Geosciences, Vol. 8, 498, doi:10.3390/geosciences8120498 and references therein. [2] Roy Chowdury et al. 2011, 7th Chandrayaan-1 Science Meet, PRL PLANEX.