MINERAL DETECTION USING CHANDRAYAAN-2 IMAGING INFRARED SPECTROMETER (IIRS): SOME INITIAL RESULTS

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Introduction:

Lunar mineralogy is mainly characterized by silicates and oxides, especially pyroxenes, plagioclase feldspar, ilmenite and olivine, forming the abundant crustal and mantle rocks. These minerals are significant in understanding lunar crustal evolution as their composition reflects the physical and chemical conditions under which the lunar rocks were formed. Analysis of the reflectance spectra for specific mineralogy involves characterization of the spectral features that arises from the electronic transitions between transition elements and the chemically bound anions [1]. With the progressive advancement and improvement in the optics and detectors capabilities information about the lunar crustal composition have led to several interesting discoveries and important findings through remote spectral measurements. It includes discovery of Mg-Spinels, global occurrence of pure anorthosites, and presence of OH/H_2O in the upper lunar surface, etc. [e.g., 2,3,4,5]. Hyperspectral sensors, especially with their ability to provide both spatial and spectral information are very important for systematic acquisition and global mapping of lunar crustal composition. ISRO's Imaging Infrared Spectrometer (IIRS) sensor onboard Chandrayaan-2 mission orbiter is an advanced hyperspectral imaging spectrometer that simultaneously collect spectra at very high spatial resolution of ~80m [6]. Here, we report detection of some common lunar minerals along with detection of spinel from IIRS data. Further, in order to evaluate the initial results, the reflectance data used for compositional analyses have been compared with Chandrayaan-1 Moon Mineralogy Mapper (M^3).

Datasets and methodology:

Chandrayaan-2 is Indian Space Research Organization's (ISRO) second mission to the Moon launched on 22nd July 2019 with an orbiter, lander and rover for detailed analysis of lunar topography, mineralogy, surface chemistry, regolith's thermo-physical characterization and atmospheric composition. Imaging Infrared Spectrometer (IIRS) is a grating-based dispersive instrument designed to measure the reflected solar radiations and thermal emissions from the lunar surface in spectral range of 800 to 5000 nm with spectral sampling of ~16.8 nm in 256 contiguous spectral bands [6]. Imaging with 80 m ground sampling distance and 20 km swath at nadir view from 100 km orbit altitude provides high-resolution spectral information to detect, characterize and map the lunar surface composition and volatiles. In the present study Level 1 radiometrically calibrated IIRS radiance data strip was utilized to analyze mineralogy after initial for radiometric processing. It was converted to reflectance by normalizing with solar flux. The results were compared with Chandrayaan-1 Moon Mineralogy Mapper (M^3) reflectance data (Strip ID: M3G20090214T074247_V01_RFL) with spectral sampling from the same location. M^3 reflectance data (level-2), corrected for thermal and photometric effects have been used for the present study [7]. Chandrayaan-1 Moon Mineralogy Mapper (M^3) data is NASA's hyperspectral imaging spectrometer onboard ISRO's Chandrayaan-1 with spectral coverage 450-3000 nm in 85 spectral bands and ~140 m spatial resolution [8,9]. The wavelength range of 800 nm to 2500 nm part of the spectrum have been utilized for detection of common minerals from the analyzed strip. The low response bands of IIRS spectra at order sorting filter (OSF) joining locations have been removed (near to 1200 nm and 1900 nm) during spectral analysis. Band ratio images were generated using standard band combination for lunar mafic components to detect mineral. Representative spectra for specific minerals were extracted from the three locations are presented in Fig. 2.

Results and discussions:

The study reports detection of Mg-Spinel, plagioclase feldspar and pyroxenes based on the location of band centers that is a crucial indicator for a particular mineral species present in VNIR region. The spectra sampled from location Figure 1(a) for IIRS strip is characterized by an absorption near 2000 nm with negligible 1000 nm absorption feature (Figure 2 (i) for IIRS and 2 (ii) for M^3. It marks the detection of Mg-Spinel with the 2000 nm absorption feature arising due to presence of Fe^{2+} in its tetrahedral crystallographic site [10]. The broad absorptions centered at 1300 nm are displayed as Figure 2(iv) for IIRS (location in Figure1b) and (v) and M^3 respectively, is indicative of plagioclase feldspar. It is the most abundant lunar mineral with the characteristic absorption feature due to Fe^{2+} in its crystal structure [11,12]. Also, presence of other mafic minerals, especially pyroxenes even in small amount conceals this diagnostic plagioclase feature [11]. Hence, this is most likely showing presence of crystalline plagioclase feldspar. A broad, weak feature around 2000 nm could be observed which may indicate presence of some mafics most probably Mg-Spinel. The spectra with dual absorptions features at ~1000 nm and 2000 nm regions in Figure 2 (vii) and (viii) for IIRS (Location Figure 1(c)) and M^3, respectively are diagnostic of pyroxenes. It arises due to electronic transitions of Fe^{2+} in their crystallographic sites with the band position shifting with increase in calcium content [e.g. 13].

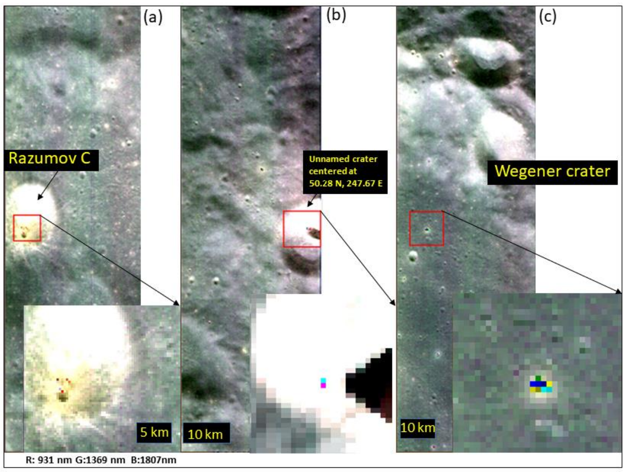

Figure 1 Locations for the acquired Ch-2 IIRS spectra shown in False colour composite (FCC) images (Red=931 nm, Green=1369nm and Blue=1807nm) with their respective regions of interest shown in close-up images.

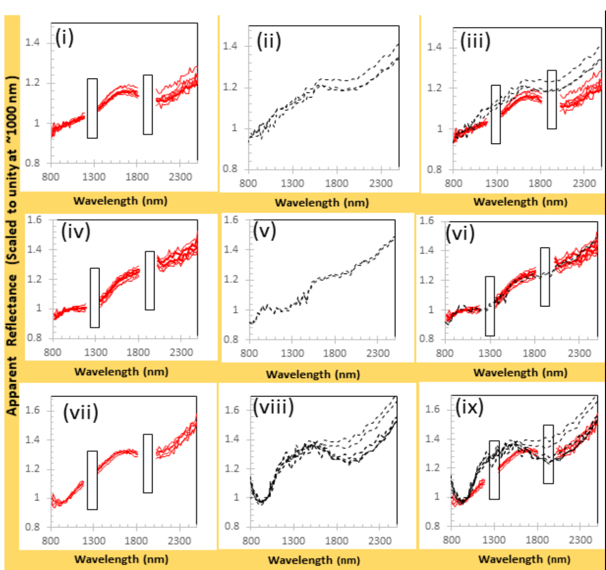

Figure 2 Normal Ch-2 IIRS spectra extracted presented from locations (shown in Figure 1) as (i) (1a); (iv) (1b) and (vii) (1c). Normal spectra from the same locations extracted from corresponding Ch-1 M^3 data strip are shown as (ii), (v) and (viii). Both the spectra are presented for comparison in (iii), (vi) and (xi). OSF region marked by rectangles.

The study presents initial results of mineral detection using IIRS data strip from ISRO's recent Chandrayaan-2 mission. The results when compared with Ch- 1 M^3 Fig. 2 (iii), (vi) and (ix) the spectra are showing similarity. Despite variation in the observation geometry, spatial resolution, and wavelength resolution, the derived reflectance spectra matches well in their spectral shape. A detailed and a carefully analysis is required and is in progress. Further processing for thermal removal, normalizing to the standard geometry, ground-truth corrections IIRS sensor is likely to provide better results with its higher spectral resolution capability.

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