MINERALOGICAL DIVERSITY AND HYDRATION FEATURE AT CRATER ARISTARCHUS AS REVEALED BY CHANDRAYAAN-2 IMAGING INFRARED SPECTROMETER (IIRS).
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Introduction: One of the major objectives of Chandrayaan-2 (Ch-2) Imaging InfraRed Spectrometer (IIRS) is to detect and map the lunar surface minerals and to understand the mineralogical make-up of the lunar crust vis-à-vis understanding the nature of lunar surface hydration [1, 2], wherever present. Here, we report the mineralogical diversity and enhanced hydration feature associated with crater Aristarchus (23.6°N, 47.5°W). Aristarchus is a 40-km diameter crater of Copernican age (~450 million years) situated at the junction between Procellarum basalts and Aristarchus Plateau (an elevated volcanic plain with abundant sinuous rilles and one of the largest pyroclastic deposits of the Moon) in the lunar near side.

Telescopic observations suggested diverse geological/compositional entities [3]. Chandrayaan-1 M^3 observation further highlighted the compositional diversity of crater Aristarchus [4] with special reference to the nature, mineralogy and morphology of the impact melts associated with the crater. Recent study reveals presence of magmatic water within the pyroclastic deposits of Aristarchus Plateau [5].

Ch-2 IIRS image of December 16, 2019 has been utilized for the present study that covers western part of crater Aristarchus. The data was obtained in E3G2 (exposure/gain) mode having exposure duration of 10 millisecond. This also results in saturation in the IIRS spectral channels beyond ~3200 nm that approximately correspond to band #147. The level 1 radiance data has been converted to reflectance by normalizing the measured spectral radiance by the incoming solar flux.

An empirical thermal correction model given by [6, 7] has been used for removing the thermally emitted component from the reflectance spectra beyond 2000 nm. Subsequently, the thermally corrected IIRS reflectance spectra have been converted to single scattering albedo (SSA) based on Hapke’s model [8], as the use of SSA spectra is preferred over the reflectance spectra in quantifying the absorption strength [9]. Finally, from the continuum-removed SSA spectra, the effective single particle absorption thickness (ESPAT) [8] values have been estimated.

False Color Composite (FCC) has been generated by assigning red channel to 995-nm IIRS band, green to 1366-nm band and blue to 2091-nm band to depict the spectral variability in the studied region (Fig. 1A). In addition, Integrated Band Depth (IBD) has also been generated to depict the spectral variability that exists within the crater Aristarchus. The IBD parameter is defined for characterizing the spectral absorption band depths for 1000- and 2000-nm absorption features arising due to the electronic transition in Fe^{2+} residing inside the crystal lattice of mafic (dark colored) silicates such as the pyroxenes and olivine. The 1586-nm IIRS spectral band is free from any lunar mafic silicate absorption, therefore, the IBD parameter mosaic of 1000- and 2000-nm band depths together with albedo band at 1586-nm captures the first-order mineralogical diversity. False Color Composite (FCC) has been prepared by assigning Red color to IBD-1000-nm, Green to IBD-2000-nm and Blue to the 1535-nm albedo channel. In the IBD-Albedo FCC, the mafic exposures appear in green to yellow to orange, whereas, mature highland soil and mafic-free plagioclase-bearing anorthositic lithology appear in blue (Fig. 1B).

Further, region of interests have been chosen from the spectrally homogeneous and distinct regions as identified based on the IBD-Albedo FCC and mean spectra were plotted to study the spectral signatures of various lithological (rock types) entities (Fig. 1C). Spectra show prominent absorptions near 1000, 1350, 2000 and 3000 nm arising from the varied rock types and hydration present within the crater. The first three spectral features correspond to the pyroxenes, olivine and crystalline plagioclase-bearing silicate rocks. In the studied site, the impact melt-bearing regions appear blue, whereas coarse ejecta and/or bed rock exposures appear green and red to magenta due to the presence of prominent absorptions near 1000 and 2000 nm. The pyroclastic deposits appear in yellow to green due to the presence of both the 1000- and 2000-nm features. However, the strength of the features is relatively weak as compared to that of the bedrock exposures.

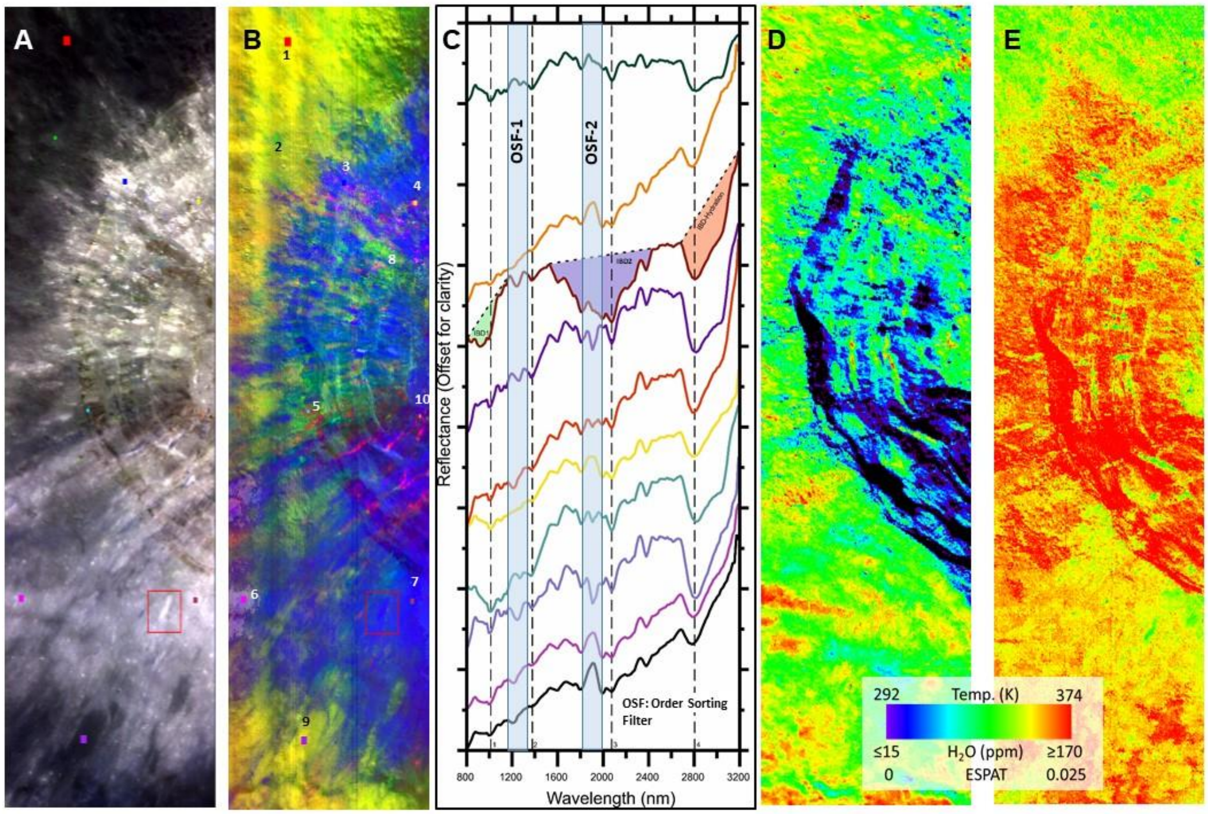

Fig. 1. A. Ch-2 IIRS FCC having 995-nm spectral channel as “Red”, 1366-nm channel as “Green” and 2091-nm channel as “Blue”. Colored boxes indicate regions of interests (ROIs) from spectrally homogeneous regions; B. IBD-Albedo-based FCC. ROIs are marked as 1-10; C. Mean spectral plot corresponding to the ROIs (low responsive band joining/Order Sorting Filter (OSF) regions near 1200- and 1900 nm are marked as light blue rectangles); D. Temperature map as obtained using Clark’s algorithm; E. ESPAT vis-à-vis H_2O concentration map of crater Aristarchus.

Prominent doublet as well as asymmetric absorption feature is seen near 3000 nm having shorter wavelength band/absorption minima around 2810 nm and longer wavelength at ~3030 nm owing to the presence of adsorbed OH/H_2O in the impact melts, ejecta, bedrock exposures and the pyroclastic deposits. The doublet and asymmetric nature of the hydration feature suggests it to be more of adsorbed OH than H_2O. The shape of the hydration features and its strength varies from pyroclasts to impact melts to coarse ejecta and/or bedrock exposures, and it ranges from ~5-20%. Observed water concentration has been quantified using ESPAT parameter that is linearly related with the amount of water present at a given location (pixel) [5]. The water concentration is found to vary from ~15-170 ppm with an average value of ~80 ppm in the studied site (Figs. 1D and E). For the first time, complete characterization of the 3000-nm hydration feature is carried out using Ch-2 IIRS data at highest ever spatial resolution of ~80 m.

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