STUDY OF ENDOGENIC WATER/HYDROXYL IN ASSOCIATTION WITH NOMINALLY ANHYDROUS MINERAL OLIVINE AT CRATER LANGRENUS. Sumit Pathak, Satadru Bhattacharya, Space Applications Centre, Indian Space Research Organisation, Ahmedabad – 380 015, India. (spathak.sac@gmail.com; satadru@sac.isro.gov.in).

Introduction: One of the important contributions of Chandrayaan-1 Moon Mineralogy Mapper (M^3) instrument [1, 2] is the discovery of endogenic/magmatic water on the Moon [1, 2]. Recent studies reveal that few of the lunar complex craters having central peaks show prominent hydration signatures [2, 3]. These complex craters are mainly characterized by the presence of a conspicuous central peak surrounded by a relatively flat surface, the crater floor, with an extensive marginal collapsed terrace zone along the crater rim. The central peak regions are often associated with diverse mineralogies having deeper crustal and/or upper mantle affinity resulted from the elastic rebound of the crust subsequent to the impact [4]. The mineralogical distributions and morphological features observed at central peaks are highly dependent on the period, angle and intensity of the impact and also some post-impact tectonic modifications [4]. Therefore, the study of the complex craters are extremely important in understanding the crustal vis-à-vis compositional stratigraphy of the Moon.

Here we present the mineralogical analysis of the lunar complex crater Langrenus (8.9°S, 60.9°E). It is an Eratosthenian aged crater, situated in the eastern edge of Mare Fecunditatis. The crater is having a diameter of ~132-km [5] having an extended ejecta-ray up to the Fecunditatis basin.

Data used and methods: For mineralogical analysis, photometrically and thermally corrected Level-2 data products of Chandrayaan-1 Moon Mineralogy Mapper (M^3) have been used having a spectral range from ~460–3000 nm [6] with a spatial resolution of ~140 m/pixel from 100-km orbit and ~280 m/pixel from 200-km raised orbit [7].

Results and discussions: To depict the mineralogical diversity that exist in the study area to a first order, a false colour composite (FCC) mosaic image (Fig: 1) has been generated by using the geo-referenced orbital strips of M^3 datasets. We have assigned the red, green and blue channels to M^3 930-nm, 1249-nm and 2137-nm bands respectively to distinguish the compositional variations in the area. In such an FCC, mafic minerals appear in yellow to green, whereas crystalline plagioclase-bearing exposures appear in pink. The representative spectra from the mafic- and crystalline plagioclase-bearing exposures are then analysed and spectral band parameters, namely, band center, band depth, band area and continuum slopes have been computed. The FCC image shows some patches of olivine-bearing lithologies (purple regions) associated with prominent hydration features (blue stars in Fig. 1) mostly occurring along the crater rim and also within the hummocky crater floor. These olivine and OH^- features are identified based on the absorption features near ~1070 nm and ~2816 nm, respectively

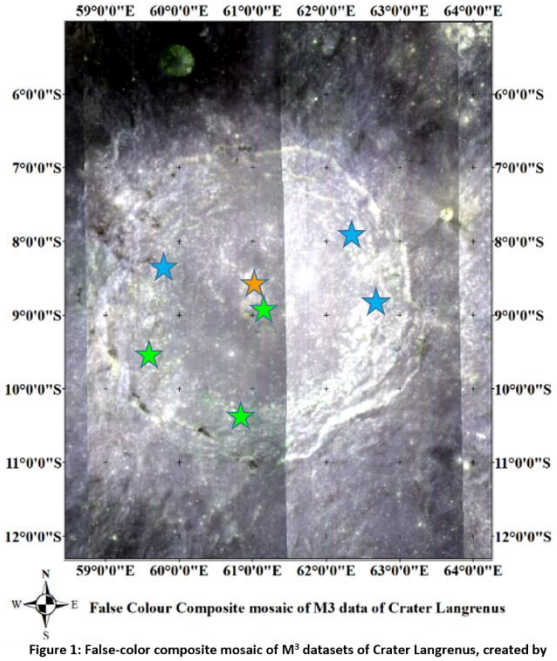
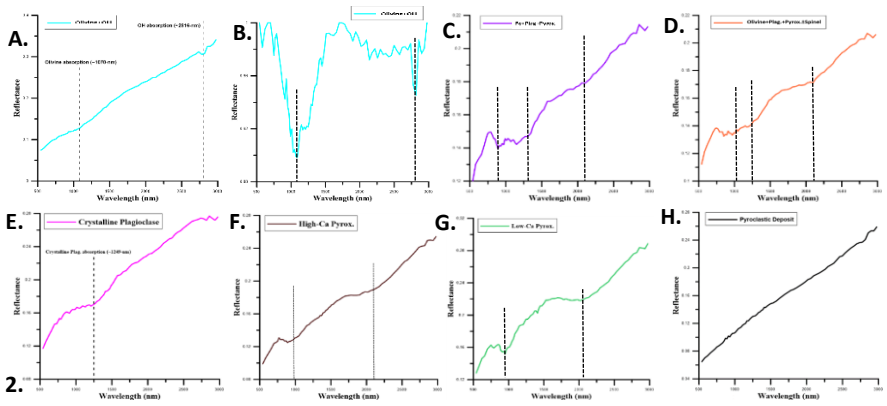


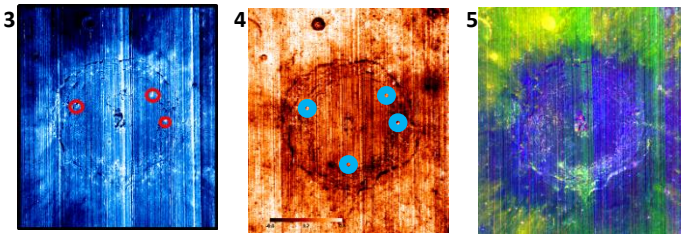
Figure 1: False-color composite mosaic of M^3 datasets of Crater Langrenus, created by assigning Red, Green and Blue Channel to 930-nm, 1249-nm and 2137-nm of M^3 bands respectively.

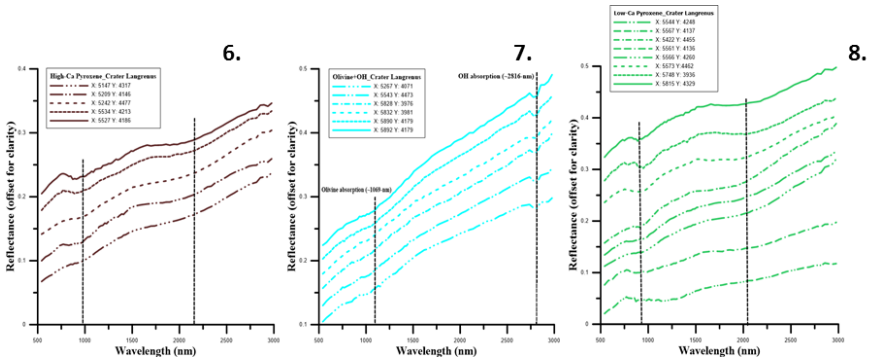
(Figs. 2A & 2B) with the band strength of ~7-9% for olivine and ~ 5-6% for OH/H_2O features (Fig: 7). To further study the absorption strength of the 2800-nm hydroxyl feature, a 2800-nm band depth image (Fig: 3) has been generated using the methodology given by [2]. To detect olivine-bearing exposures, we have used OLIVINE Index (Fig. 4) given by [8]. The FCC image also shows some patches of mafic minerals (orange and green stars in Fig. 1) at the central peak and at the crater rim and floor close to the rim. The mineralogical diversity has been nicely depicted in the integrated band depth (IBD) [9] image of the study area

(Fig. 5). The crystalline plagioclase exposures at the central peak are characterized by the absorption feature near 1269 nm (Figs. 2C-E), whereas low-Ca pyroxenes (LCPs) and high-Ca pyroxenes (HCPs) are described by their band I absorption features near 940 nm and 985 nm respectively and band II absorption features near 2045 nm and 2135 nm respectively (Figs. 2F, 2G, 6 and 8). The LCP and HCP signatures are spread over the crater floor within the matrix of an otherwise featureless optically matured spectra (Fig. 2H).

Conclusions: The present study reveals mineralogical diversity at crater Langrenus. The mineralogy of the central peak and its surroundings indicate that they are probably the exposures of subsurface mafic body that might have been excavated and redistributed by the subsequent impact process. The central peak shows the presence of crystalline plagioclase-bearing anorthosite, whereas, olivine- and high-Ca pyroxene-bearing lithologies are mostly occurring along the terraced crater wall and crater floor close to the crater rim. Hydroxyl signatures are seen in the spectra of olivine that were excavated from deeper crustal level and/or upper mantle. Localized nature of the hydroxyl exposures, presence of a sharp, narrow and prominent feature near 2800 nm in association with nominally anhydrous olivine of possible mantle affinity and equatorial location of the crater suggest that the observed hydration at crater Langrenus could possibly of magmatic/endogenic nature.







Figures: 2. **A-H.-** The individual reflectance spectra of various minerals within the crater Langrenus. **3.** 2800-nm IBD image to identify the hydration features (designated by red circle), modified after Klima et al. 2012. **4.** The Olivine-Index map of Langrenus using the band parameter given by Pelkey et al. 2007, where the blue circled portions are having some noticeable olivine spectra. **5.** IBD mosaic of the absorption strength near 1000-nm and 2000-nm of crater Langrenus acquired from M^3 L2 global datasets by using the relation given by Mustard et al. 2011. **6.** The combined spectra of various high-calcium pyroxene in the crater. **7.** The representative spectra of olivine and OH features with their two absorptions near 1069-nm and 2816-nm. **8.** The characteristic spectra of low-calcium pyroxene in the crater Langrenus.

References: [1] Bhattacharya S. et al. (2013) *Curr. Sci.*, *105(5)*, 685-691. [2] Klima R. et al. (2013) *Nat. Geosci.*, DOI:10.1038/NGE01909. [3] Bhattacharya S. et al. (2015) *Icarus*, *260*, 167-173. [4] Melosh H. J. (1989) *Impact cratering: A geologic process*, New York: Oxford University Press. 245 p. [5] Song E. et al. (2013) *JGR*, *118*, 689-707. [6] Clark R. N. et. al. (2009) *JGR*, *116*, E00G16. [7] Boardman J. et al. (2011) *JGR*, *116*, E00G14. [8] Pelkey S. M. et al. (2007) *JGR*, *112*, E08S14. [9] Mustard J. F. et al. (2011) *JGR*, *116*, E00G12.