**COMPOSITIONAL AND CHRONOLOGICAL CHARACTERIZATION OF BASALTS OF MARE COGNITUM BASIN, MOON USING HIGH-RESOLUTION DATA**. Nupur Adarsh[1], Vinita Singh[1], Rashmi Sharma[1], Mamta Chauhan[2] and Prakash Chauhan[2], ([1]School of Earth Sciences, Banasthali Vidyapith, Rajasthan and [2] Indian Institute of Remote Sensing (IIRS), Dehradun. mamtachauhan@iirs.gov.in

**Introduction:** Lunar mare basalts covers a significant portion of Oceanus Procellarum and are well exposed in various basins present within. Mare Cognitum basin (10.5° S, 22.3° W) is one such basin of Imbrium age located towards the south eastern portion of Oceanus Procellarum with a diameter ~280 km. Morphologically, it is the flat region present in between the Monte Riphaeus and Mare Nubium basin. Earlier the basin was mapped into various basaltic units based on morphology and mineralogy [1,2,3]. In the present study the basin have been re-investigated based on spectral characterization of its five distinct basaltic units alongwith their age determination by crater size-frequency distribution measurements using high-resolution data mainly from ISRO's Chandrayaan-1mission.

**Datasets used:** The present work relies mainly on the data obtained from ISRO's Chandrayaan-1 (Ch-1) mission. For compositional analysis high-resolution datasets from Hyperspectral Imager (HySI) having 64 spectral channels operating in the wavelength range of 421-964 nm and spatial resolution of 80 m/pixel from 100km orbit have been used [4]. Also data from Moon Mineralogy Mapper ($M^3$) with spectral range of ~450-3000nm and spatial resolution of ~140m/pixel and 280m/pixel from 100km and 200 km orbit, respectively have been utilized [5]. The advantages of $M^3$ datasets includes full coverage of the area and used for generating mosaic of the area while HySI data have been used for mapping the lithological variations at better resolution. Further data from Chandrayaan-1 Terrain Mapping Camera (TMC) have been utilized for crater counting and determining age of the various basaltic units. TMC with stereo viewing capability in panchromatic band has a spatial resolution of 5m [4]. Data from Terrain Camera (TC) of JAXA's Kaguya-SELENE mission with spatial resolution of 10 m [6] was used to complement TMC data.

**Methodology and Results:** The hyperspectral data was analyzed for characterizing mineralogy of Mare Cognitum basalts using various spectral parameters and describe the lithological variations occurring within the basin. From HySI data spectral parameters viz., Band curvature (BC), Band tilt (BT) and Band strength (BS) given by [7] were used to generate rock type composite images for the available strips which were further delineated into various lithounits to map their lithology. Several spectra were also acquired from the region of interest and were further analyzed. Mosaic generated using orbital strips of $M^3$ scenes was used to generate a Integrated band depth (IBD) image [8] for producing false colour composite image for mineralogical characterization and their interpretation. To identify the locations of various minerals and analyze the mineral composition of various basaltic units their representative $M^3$ spectra were acquired. They were analyzed to characterize the individual mafic mineral constituents [9,10,11]. Diagnostic absorption features of these spectra in the reflectance spectra have been characterized in terms of Band Center, Band Area and Band Depth to obtain the compositional variability of mare basalts. Further to estimate the relative abundances of pyroxene and olivine in the basalts the ratio of Band-II vs Band-I area (BAR) [12] have been calculated and also various morphological features present in the basin were also analyzed. To understand their evolution through time the various basaltic units were delineated corresponding to their chrono-stratigraphic units as provided by earlier workers [2,3,13]. These units have been modified and redefined on the basis of visual observations from $M^3$ mosaic. The technique of crater size-frequency distribution (CSFD) measurements was utilized for determination of the age of the various basaltic units using data from both TMC and TC and compared with the earlier obtained results. Some of the results are presented in form of figures 1-3 and Table 1.

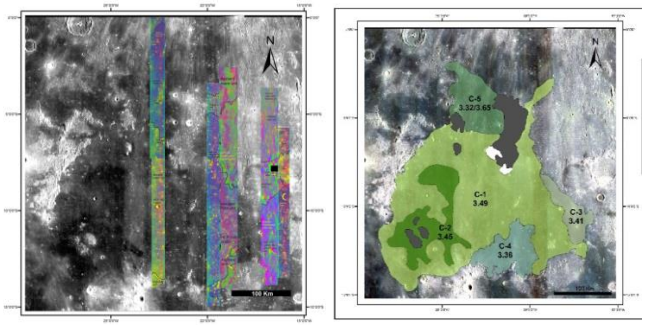


Figure 1. (a). Ch-1 $M^3$ Mosaic of Mare Cognitum basin, Moon overlain by band ratio images of HySI strips (b). Delineated basaltic units with their ages as given by [13].

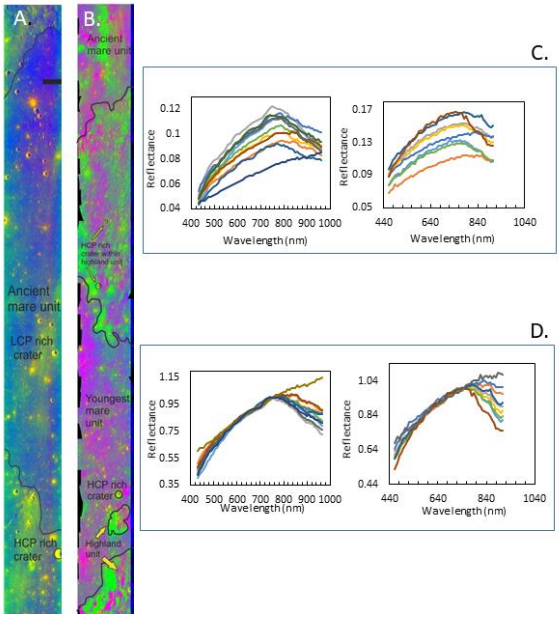


Figure 2. (A). & (B). Annotated band ratio image of HySI strips covering part of Mare Cognitum using band parameters and their acquired 64-band averaged reflectance spectra (C) Normal and (D) Scaled at 748.3 nm obtained from their corresponging lithounits. In these images, noritic rocks appear as red to orange, gabbroic rocks as green to yellow and mature soil and anorthosites as blue.

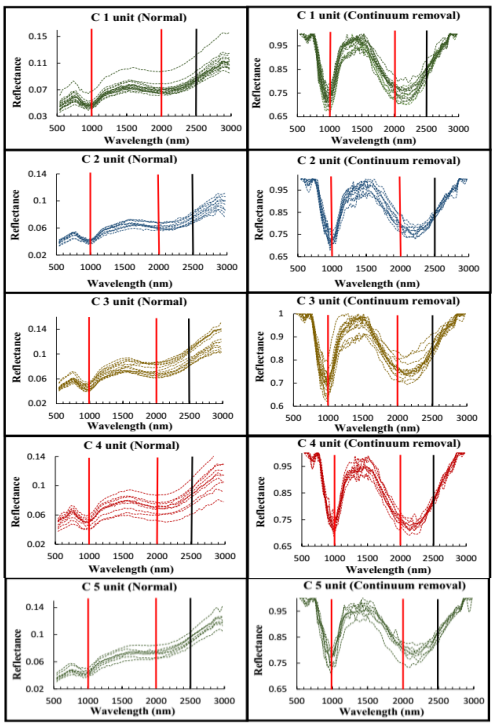


Figure 3. Normal and Continuum removed spectra acquired from basaltic units, C1-C5 of Mare Cognitum basin.

| Basaltic Units | Results (TC) | | Results (TMC) | | Hiesinger et al, 2003 |
|---|---|---|---|---|---|
| | CumF Age (Ga) | PDF Age (Ga) | CumF Age (Ga) | PDF Age (Ga) | Age (Ga) |
| C1 | 3.7 (+0.02)(-0.02) | 3.5 (+0.03)(-0.04) | 3.6 (+0.03)(-0.04) | 3.4 (+0.06)(-0.1) | 3.49 |
| C2 | 3.5 (+0.05)(-0.08) | 3.0 (+0.3)(-0.4) | 3.5 (+0.04)(-0.05) | 3.2 (+0.1)(-0.2) | 3.45 |
| C3 | 3.5 (+0.04)(-0.05) | 3.2 (+0.2)(-0.3) | 3.5 (+0.04)(-0.05) | 3.1 (+0.2)(-0.3) | 3.41 |
| C4 | 3.4 (+0.03)(-0.04) | 1.5 (+0.1)(-0.1) | 3.3 (+0.08)(-0.1) | 1.4 (+0.2)(-0.2) | 3.36 |
| C5 | 3.6 (+0.02)(-0.03) | 3.4 (+0.06)(-0.010) | 3.7 (+0.03)(-0.03) | 3.6 (+0.04)(-0.05) | 3.32/3.65 |

Table 1. Comparison of ages determined by using TC and TMC data with previously determined ages by [14] for Mare Cognitum.

## Conclusion:

High-resolution mineralogical investigation and chronological characterization of the basaltic units present at Mare Cognitum have been attempted in the present study to provide insight into the composition and thermal history of its interior. The obtained results have been utilized for determining the composition, sequence and duration of mare flows in the Mare Cognitum to reconstruct its volcanic history.

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## References:

[1] Whitford-Stark J.L. and Head III J.W. (1980), *JGR*, 85, B11, 6579-6609 [2] Hiesinger H. et. al. (2000), *JGR.* 105:29,239-29,275 [3] Bugiolacchi R., Spudis P. D. and Guest J. E. (2006), *Meteorit. Planet. Sci.* 41, 285-304. [4]. Goswami J. N. and Annadurai M. (2009), *Curr. Sci.* 96, 4, 486-491.[5]. Green R.O. et al., (2011), *JGR*, 116. E00G19. [6] Haruyama J. et. al., (2008) LPS, *XXXIX*, *Abstract #* 1391.[7] Bhattacharya S. (2011), *Icarus*, 212, 470-479. [8] Mustard J. F. et al. (2011) *JGR* 116, E00G12. [9] Burns R. G. (1993) 2nd ed., *Cambr. Univ. Press*, New York [10] Klima R. L. (2007) *Meteorit. Planet. Sci.* 42, 235-253. [11] Klima R. L.(2011) *Meteorit. Planet. Sci.* 46, 3, 379-395. [12] Cloutis E. A. and Gaffey M. J. (1986), *JGR*, 91, 11, 641-653. [13] Hiesinger H. et. al. (2003), *JGR*, 108, 7, 5065 *XXVII*, 1344-1345.