GEOLOGICAL INVESTIGATION OF PETAVIUS CRATER, MOON USING HIGH-RESOLUTION DATASETS FROM RECENT LUNAR MISSIONS. Mamta Chauhan, Poonam S. Tiwari and Prakash Chauhan*, Indian Institute of Remote Sensing (IIRS), ISRO, Dehradun, India (prakash@iirs.gov.in)

Introduction: Floor-fractured craters are unique features on the Moon that have witnessed and recorded episodes of tectonic and volcanic events in form of various morphological and structural features. They are present near the edges of mare basins and are distinguished easily by the presence of prominent fracture system, moat features, volcanic activity in form of mare patches & dark mantle deposits. They provide an important insight into the thermal and morphological evolution of the region and thus, potential candidates to explore in order to understand the crustal evolution of the Moon. Petavius crater (25º S and 60º E), a ~180 km diameter crater is one such floor-fractured crater located SE of Mare Fecunditatis near the southeastern limb of the Moon (Figure 1). This lower Imbrian-aged [1] complex crater has inner terraced wall rising about 3.3 km above the crater floor and a massive complex central peak with several small peaks. The area has witnessed episodes of tectonic and volcanic activities. The floor of the crater is characterized by clefts and faults with the most prominent being Rimae Petavius that runs through the central massif of Petavius in form of a prominent fracture zone. Post-volcanic activity could be observed in form of few dark patches of pyroclasts (dark mantle deposits) on the floor of the crater towards its North and South. This crater is peculiar as it is gravitationally neutral, with no reports of either negative or positive anomalies due to fresh craters or mare basalt [2]. The present study is undertaken for detailed investigations of its mineralogy, morphology and structural features through the available high-resolution datasets from recent lunar missions to understand its geological evolution through time.

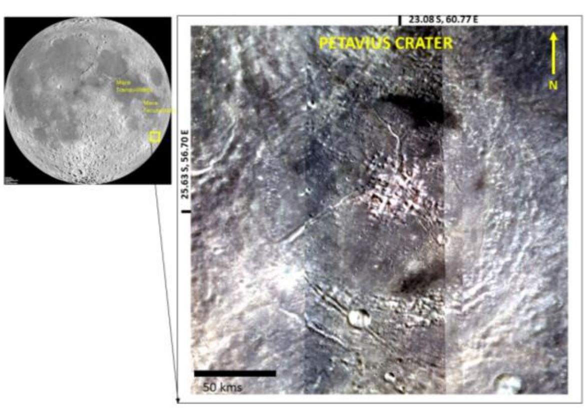

Figure 1: Location of Petavius crater on the LROC global mosaic and its close-up view in Ch-1 M^3 mosaic.

Datasets and Methodology: Spectroscopic data from the ISRO's Chandrayaan-1 hyperspectral imaging sensor, Moon Mineralogy Mapper (M^3) were used to derive the mineralogy of the crater. Photometrically and thermally corrected Level-2 (Global Mode) reflectance data with 85 spectral channels (460 to 3000 nm) and spatial resolution of ~140 m [3,4] were used for the present study. For morphological observations and topographical analysis data mainly from Lunar Reconnaissance Orbiter Camera (LROC) missions, Wide Angle Camera (WAC), Narrow Angle Camera (NAC) and Lunar Orbiter Laser Altimeter (LOLA) was used [5,6]. The Ch-1 M^3 data after georeferencing and mosaic generation have been utilized for generation of ratio images, false colour composites for detection of minerals and record their variability. Detailed spectral analysis was carried out from the sampled spectra obtained from central peak, rim, rimae, floor and terraces and then evaluated for detection of major lunar mafic phases based on the diagnostic absorption features [7,8,9]. High-resolution Digital Elevation Model was utilized for analyzing the topography of the crater. Kriging interpolation was used for generating a 3D surface. Different topographical parameters were generated and analyzed in conjunction with mineralogy of the area.

Results and Discussion:

Topographically the most unique feature in the crater is a major distinctive fracture on the floor called Rimae Petavius (Figure 2). The profiles in N-S, NE-SW, E-W, and SE-NW directions were generated to study the variation in topography and nature of slopes and associated structures (Figure 3). The crater has a diameter of 180 km with a pronounced central peak. The crater rim is asymmetrical and about 3500m high on the eastern part. To analyse the crater formation, topogrphical parameters such as slope, contours, aspect were calculated (Figure 4).

The crater shows mineral diversity as analyzed utilizing M^3 data. It shows unique lithology and compositional variability with several exposures of mafic minerals detected from the central peak region, along the rim and terraced ridges. Minerals were identified on the basis of their distinct spectral signatures in the visible to near-infrared (VNIR) region. The presence of Fe^{2+} Ca^{2+} and Mg^{2+} in the structure of common rock forming lunar minerals produces these spectral absorption features that are indicative of their presence.

Along the rimae exposures of olivine were detected (Figure 5a & b) as identified on the basis of broad composite absorption feature near 1.03 µm. It arises because of crystal field transitions of Fe^{2+} in crystallographic sites olivine structure [e.g 10]. Fe-plagioclase feldspar were detected from the central peak region characterized on the basis of absorption feature near 1.3µm produced due to presence of minor Fe^{2+} in its crystal structure [11] (Fig. 5c & 5d). Based on the position of 1 and 2 µm absorption features towards longer wavelength due to presence of Fe^{2+} and Ca^{2+} in the crystal structure [12] exposures of High-Ca-pyroxene (HCP) were recorded (Fig. 5e & 5f). They were present near a fresh crater along the rim and terraced ridges and from the central peak region.

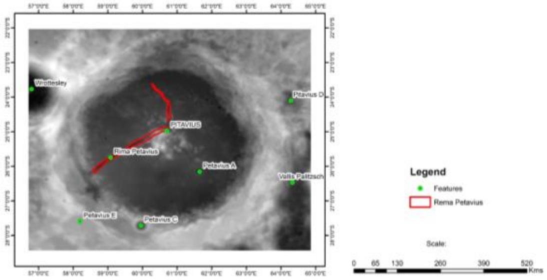

Figure 2: Rimae Petavius on crater floor

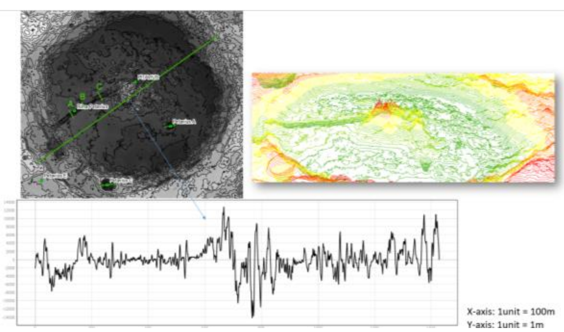

Figure 3: Topography of crater floor along a section line: Petavius crater

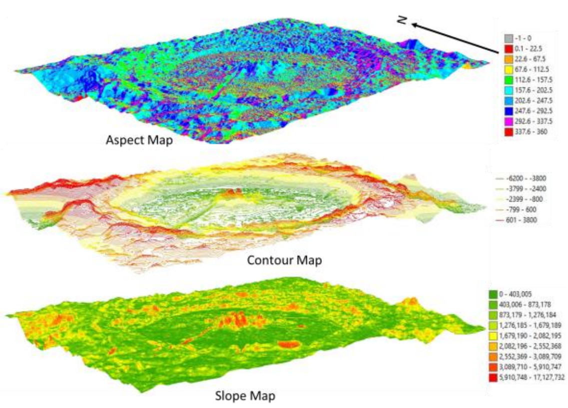

Figure 4: Topographical parameters: Petavius crater

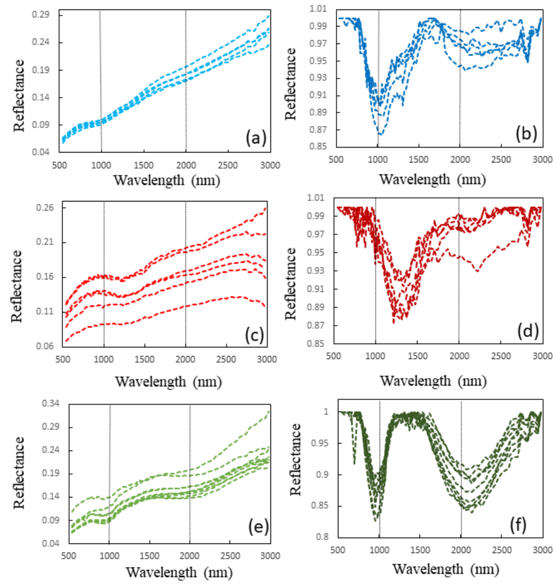

Figure 5: Normal and continuum removed reflectance spectra acquired from the central peak, along the rimae, crater rim and terraced ridges.

Conclusion: The unique tectonic setting of the crater Petavius alongwith associated morphological variability and various mafic exposures indicates their origin from the lower crust and formation in stages associated with the structural and morphological features. Further, age determination of various morphological units will be attempted to understand the geological evolution of Petavius crater.

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References: [1] Wilhelms and McCauley (1971) *U.S. Geol. Survey Misc. Geol. Inv. Map*, I-703. [2] Dvorak, J and Phillips, R J (1978) LPS IX- 3651-3668. [3] Pieters C. M. et al. (2009) *Curr. Sci,. 96(4),* 500-505. [4] Clark R. N. et al. (2011) *JGR*, *116,* E00G16. [5] Robinson M. S. et al. (2013) *Space Sci. Rev., 150, 1–4,* 81–124. [6] Smith D. E. et al. (2010) *GRL*, *37,* L18204. [7] Burns, R. G. (1993) *Cambr. Univ. Press*, New York, p. 551. [8] Cloutis E. A. and Gaffey M. J. (1991) *JGR* 96, 22809–22826. [9] Klima R. L. et al. (2007) *Meteorit. Planet. Sci.* 42, 235–253. [10] Burns R. G. (1993) Cambridge University Press, New York. 551p. [11] Pieters C.M. (1983) *14th Lunar Planet Sci. Conf*. 608-609. [12] Klima R.L. et al. (2011) *Meteorit. Planet. Sci.* 46:379-395.