A MINERALOGICAL APPRAISAL OF THE LUNAR FLOOR-FRACTURED CRATER DANIELL USING DATASETS FROM RECENT LUNAR MISSIONS. Sumit Pathak, Ramdayal Singh, Satadru Bhattacharya, Space Applications Centre, Indian Space Research Organisation, Ahmedabad – 380 015, India. (spathak.sac@gmail.com; satadru@sac.isro.gov.in).

Introduction: The lunar floor-fractured craters (FFCs) are a special type of impact craters having the presence of prominent fractures system with very shallow crater floor and various other morphological features, namely, moats, ridges, lava tubes, surface lava flows etc. [1-3]. Among the different types of FFCs, few are known to have pyroclastic dark mantle deposits [2] on their crater floor. In a recent study [4], we have reported that these FFCs are also having diverse mineralogy along its central peak and the crater floor, thus providing clues to understand the compositional stratigraphy of the region and the overall geological evolutionary history of the FFC and its adjoining areas.

We have conducted analyses of multi-sensor data (from recent lunar missions) covering lunar crater Daniell (35.5°N, 31.2°E) having a diameter of ~28-km, placed on the southern portion of Lacus Somniorum and north-eastern part of Mare Serenitatis. It's a Copernican aged crater characterized by the basalt-filled uplifted crater floor with a prominent localized abundance of low-albedo pyroclastic deposits [2], a prominent concentric fracture system and no central peak on the crater floor. The primary objective of this study is to detect and map the occurrences of mafic and ultramafic mineralogies and/or assemblages and the localized concentrations of pyroclastic deposits in a spatial context.

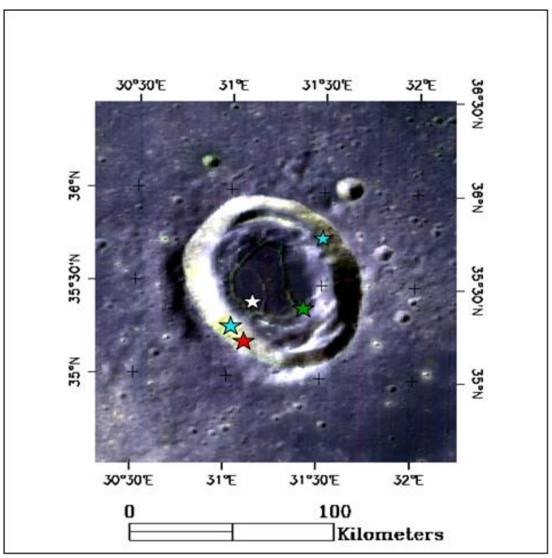

Figure 1: FCC Mosaic from M3 datasets of Crater Daniell marked by stars indicating the area of pyroclast concentration (white starred) and spectra extraction location, respectively.

Data used and methods: The photometrically and thermally corrected level-2 Moon Mineralogy Mapper (M^3) datasets from Chandrayaan-1 with the spectral range from ~460-3000-nm, have been used [5, 6] for the mineralogical analysis. The empirical data of Wide angle camera (WAC-EMP) from NASA's Lunar Reconnaissance Orbiter-Wide Angle Camera (LRO-WAC) with 7 bands (321-689 nm) have been used to study the TiO_2 concentration in the study area as the spectral slope from UV to visible wavelengths is known to be affected by variation in Ilmenite concentration [7, 8]. In addition, the LRO Diviner datasets from the 3-8 channel [9] have been used to understand the silicic mineralogy using Christiansen Feature (CF), lunar surface rock abundance and rock free regolith temperatures over Daniell crater. The Diviner data acquired from 11 August, 2009 to 21 August, 2012 used for CF computation. The Diviner data acquired from 17 August, 2012 to 26 August, 2015 used for rock abundance and rock free regolith temperature computation. The properties of vesicular basalt reported earlier [10, 11], are used in the present work.

Results and discussions: To identify the diverse mineralogy in and around the crater, a false colour composite (FCC) mosaic has been generated by assigning the 930-nm M^3 band to red channel, 1249-nm channel to green and 2137-nm to blue. The representative spectra from crater wall and floor as shown in Figure 1 are evaluated for the detection of major mineral phases that exist in the study site, based on the diagnostic absorption features of the chief mafic minerals (Figure 2a). In the FCC mentioned above, mafic exposures appear in the shades of yellow to green as is seen in Figure 1. Yellow to green pixels highlighting the presence of mafic mineralogies are found to be concentrated mostly along the inner crater wall and the rim and also within the crater floor in a scattered manner. Locations of the representative spectra are marked by the stars in figure 1. The major mafic mineralogies are represented by Low-Ca pyroxenes (cyan colored star) and High-Ca pyroxenes (red star) and are characterised by the presence of two broad absorption features near 950 nm and 2159 nm for low-Ca pyroxene-bearing noritic lithologies; and 1000 nm and 2215 nm respectively for high-Ca pyroxene-bearing gabbroic rock exposures (Figure 2a). The major portion of these pyroxenes are basically spread along the inner crater wall and crater rim, whereas the crater floor consists mostly of pyroclastic glass deposits as represented by black and green spectral plots in Figure 2a. Remarkably, some fractures on the crater floor show signatures of Low-Ca pyroxenes as well as High-Ca pyroxenes. Rock concentration and rock free regolith temperature maps (Figures 2b-i & -ii) are derived from the binned diviner channels 6 to 8 radiance data set for Daniell crater using thermal properties of vesicular basalt. Figure 2.c. shows CF map of Daniell Crater, in which the lower value of CF represents the feldspathic nature of framework silicates. From the rock abundance map, it is clear that the rock abundance value is higher (up to 4%) over NE portion, over terraced inner wall and over a small central hill, whereas the rock free regolith temperature is varying in the range from 90-120 K. In addition, from the WAC-EMP data, the TiO_2 concentration map (Figure 2d) is derived to study the abundance of TiO_2 within the pyroclastic deposits that is estimated to be ~3-4 % within the crater floor.

Conclusions: From the present study it is concluded that the crater Daniell is characterised by shallow and uplifted deformed crater floor, pyroclastic deposits and some prominent concentric fracture systems belong to Class 4b floor-fractured crater [1, 3]. The composition and mineralogy identified through the M^3 datasets indicate the presence of mafic minerals, namely, Low-Ca pyroxenes and High-Ca pyroxenes. The TiO_2 abundance map shows the concentration of ~3-4%, which signify that the low-albedo regions on the crater floor are enriched in low-Ti pyroclastic deposits [12]. It is conjectured that at later stage due to the degassing and/or volatile leakage the pyroclastic eruption might have emplaced [2] along the fractures as well as the crater floor, which suggests that they generated through the process of magmatic intrusion. Further detailed studies are needed to understand the petrological significance of FFCs in general and Daniell in specific and understanding the lithological evolutionary history of the FFCs.

References

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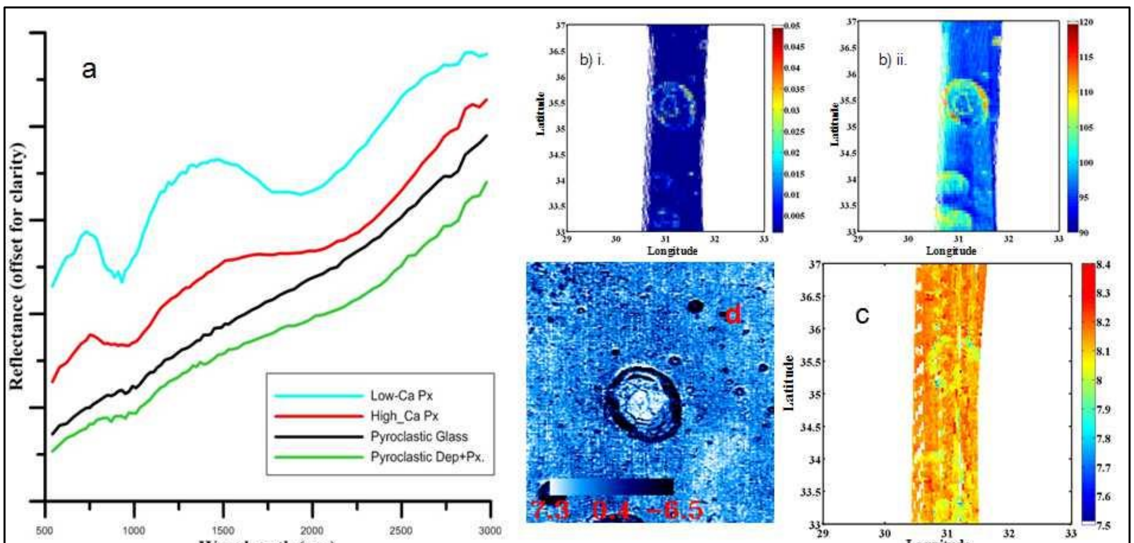

Figure 2 (around the clockwise manner): a) Representative mineral spectra extracted from the area marked by stars in Fig. 1; **b)** Thermophysical properties of Daniell crater (i) Rock abundance (ii) Rock free regolith temperature; **c)** Christiansen Feature over Daniell Crater; **d)** TiO_2 concentration (wt%) map for crater Daniell derived from WAC empirical image.