

COMPOSITIONAL AND MORPHOLOGICAL STUDY OF CLASS-5 LUNAR FLOOR-FRACTURED CRATER ARZACHEL. Sumit Pathak^{*1,2}, Satadru Bhattacharya^{1,3}, Mamta Chauhan², Saibal Gupta³ and Mruganka Kumar Panigrahi³. ¹Space Applications Centre, Indian Space Research Organisation, Ahmedabad-380015, India; ²Dept. of Geology, School of Earth Sciences, Banasthali University, Rajasthan-304022, India; ³Dept. of Geology and Geophysics, Indian Institute of Technology, Kharagpur-721302, India (*spathak.sac@gmail.com).

Introduction: The lunar floor-fractured craters (FFCs) are those that could be generated due to the magmatic intrusion within the lunar crust, subsequent to the impact event [1, 2]. In this study, an attempt has been made to infer the compositional variability that exists within the Arzachel Crater, a class-5 lunar FFC, in a spatial context and also to study the morphological entities present in the crater. Arzachel (18.2°S, 1.9°W) is located on the eastern flank of Mare Nubium and southern side of crater Alphonsus. It is a Lower Imbrian aged, nearly circular complex crater with a diameter of ~97 km. This crater has a flat floor with a prominent central peak and radial and concentric fractures. However, the concentric fractures are more prominent and identifiable than its radial counterpart. The mineralogical distribution in the central peak region is found to be dependent on the angle, intensity and period of the impact event with some post-impact modification [3-5]. Thus, the compositional study of the complex floor-fractured craters provide insights to constrain the lunar crustal stratigraphy and magmatic evolution [1-5].

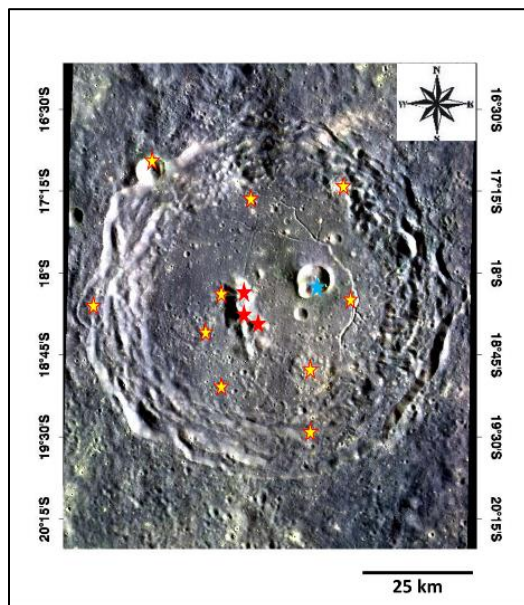


Figure 1: FCC mosaic of crater Arzachel from M³ datasets

Dataset used and Methodology: For mineralogical analysis, the photometrically and thermally corrected level-2 hyperspectral data of Chandrayaan-1 Moon Mineralogy Mapper (M³) instrument have been

utilized [6]. M³ mapped the lunar surface in the spectral range of ~450-3000 nm at a spatial resolution of ~140 m [7, 8]. For morphological study, the global datasets with 100-m spatial resolution from Wide Angle Camera of NASA's Lunar Reconnaissance Orbiter (LROC-WAC) [9] have been used along with Lunar Orbiter Laser Altimeter-Digital Elevation Model (LOLA-DEM) datasets with 30-m spatial resolution [10]. To depict the mineralogical diversity present within the study area, a false color composite (FCC) mosaic (Fig. 1) has been prepared by assigning the 930-nm, 1249-nm and 2137-nm spectral bands of M³ in red, green and blue channel, respectively. Later, we derived the reflectance spectra from this FCC image to detect and map the various mineralogical constituents (Fig. 2) present in the studied site.

Results and discussions: The representative reflectance spectra indicate that the central peak area is mainly composed of spinel- (marked by red star) and low-Ca pyroxene- (LCP) (yellow starred area) bearing lithologies (Figs. 2a, b) [11, 12]. Exposures of spinel-bearing litho-units appear in the lighter/brighter tones, whereas, LCP-dominated regions are highlighted in light yellow to green (Fig. 1). The spinel-bearing mineralogies can be characterized by their relatively strong spectral absorption near 2000 nm as compared to a weak to non-existent (sometimes) absorption near 1000 nm (Figs 2b & b1). Here, the spinel-bearing lithologies possibly suggest the pink-spinel anorthosite composition mixed with low-Ca pyroxene and plagioclase [11, 12] in relatively minor quantities. In the reflectance spectra (Figs. 2a & a1), the LCPs can be identified by their dual absorptions near 930 nm and 2000 nm. Within the crater floor, the fresh crater Arzachel-A has the spectral signature of two major mafic mineralogies, LCPs and olivine-plagioclase-spinel assemblages (blue star marked region in Fig. 1). The olivine-plagioclase-spinel assemblage can be identified by their three representative absorptions near 1049 nm, 1250 nm and 2018 nm (Figs. 2d & d1).

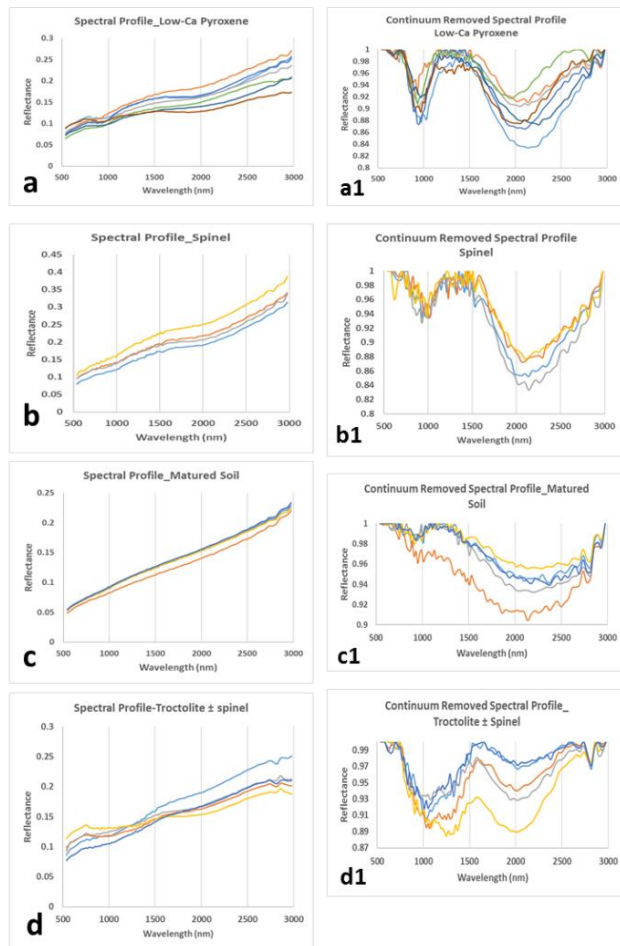


Figure 2: (a-c1) Representative reflectance spectra and continuum removed spectra derived from FCC mosaic of crater Arzachel. (d-d1) The reflectance spectra and continuum removed spectra of olivine-plagioclase-spinel derived from crater Arzachel-A.

The crater floor and rim area might have been draped by the highland matured soil (Figs. 1 & 2). In addition, some dispersed mounds of LCPs can be located over the crater floor (Figs. 1 & 2). The morphological data suggested that the crater floor has prominent concentric fractures with prominent wall slumps over the crater wall. Few degraded radial fractures are also seen. The crater has a very steep

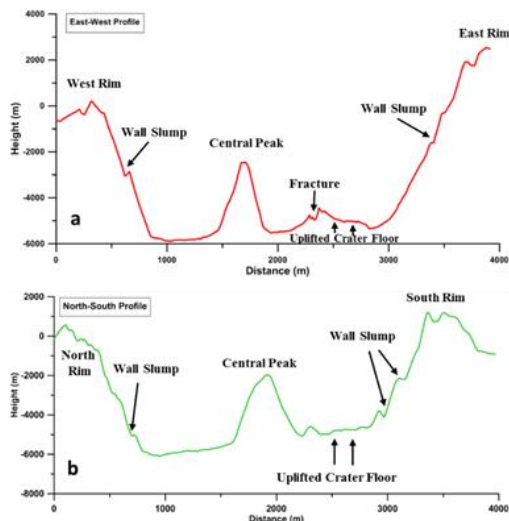


Figure 3: The figures show the (a) East-West and (b) North-South spatial profile of crater Arzachel derived from LOLA-DEM data. (c) 3D image of crater Arzachel has been prepared for topographic analysis.

wall with no sign of moat areas present in between crater wall and floor (Fig. 3). The analysis of LOLA-DEM spatial profile (Figs. 3a & b) and LROC-WAC image (Fig. 3c) also suggest that the crater floor is nearly flat but rugged near the peripheral region and slightly uplifted towards southeastern side (Figs. 3a & b).

Conclusion: From the morphological study, it can be concluded that crater Arzachel is a nearly flat floored, complex crater with concentric and radial fractures. The fracture systems are not that prominent as is the case for most of the other classes of FFCs. The LOLA-DEM spatial profile indicates that the crater wall is having a steep gradient with the presence of prominent wall slump and slight upliftment of the floor at SE side within the crater. The compositions analyzed through M³ datasets suggest that the central peak of the crater is mainly dominated by pink spinel anorthosite-bearing lithologies along with some minor amount of low-Ca pyroxene and plagioclase. However, the floor mineralogy is indicating the mixture of pristine highland crustal composition along with some deeper crustal assemblages. Here, the LCP-bearing lithologies are mostly manifested by pigeonitic composition; whereas the olivine-plagioclase-spinel assemblage possibly suggests a spinel-bearing troctolite. The central peak mineralogies probably hint towards a mid to lower crustal composition. From the present study, it can be inferred that there is no indication of any late stage pyroclastic activity in the crater floor. Further detailed study is required to understand the stages of evolution of this studied crater.

References: [1] Jozwiak et al. 2012, JGR, Vol. 117, E11005. [2] Jozwiak et al. 2015, ICARUS 248, 424-447. [3] Sun et al. 2017, EPSL, 465, 48-58. [4] Bennett et al. 2016, Icarus, 273, 296-314. [5] Martinot et al., JGR, doi:10.1002/2017JE005435. [6] Goswami and Annadurai, 2009; Curr. Sci., 96(4), 486-961. [7] Green et al. 2011, JGR, Vol. 116, E00G19. [8] Boardman J. et al. (2011) JGR 116, E00G14. [9] Robinson et al. 2010, 38th COSPAR Scientific Assembly, 15-18 July 2010, Bremen, Germany. [10] Smith et al. 2010, GRL, 37(18). [11] Cahill et al., 2009, JGR, VOL. 114, E09001. [12] Bhattacharya et al., 2015, ICARUS, 260, 167-173.