LITHOLOGICAL DISCRIMINATION OF APOLLO 17 LANDING SITE USING CHANDRAYAAN1 MOON MINERALOGICAL MAPPER DATA.

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Introduction: Mapping of surface compositional units on large areas of the Moon is a key step for interpreting its geology and evolution process. In addition, the spatial distribution and relative abundances of minerals and glasses are essential for the study of mixing processes and maturation of the soil.

In the present scenario, a great volume of lunar multispectral and hyperspectral data sets were available. The Apollo returned samples are being used as a ground truth for all remote sensing measurements. The objective of the present study is Apollo 17 landing site surface compositional analysis using M3 data from India's first lunar mission Chandrayaan-1.

Manned and unmanned missions to the Moon have returned about 382 kg of lunar rocks and soils [1]. These samples were all collected from rather a typical regions on the lunar near-side, within and around the Procellarum KREEP Terrane [2] or from equatorial latitudes on the eastern limb. The Apollo 17 soils are previously interpreted as the combinations of mare basalt, orange glass, anorthositic gabbro and noritic breccia [3]. The model suggests that, the highland components in the Apollo 17 mare soils are of two types. One is coarse grained anorthositic either excavated from below the mare surface or ejected onto the mare surface following impacts into the lower slopes of the massifs and other is fine grained with composition similar to the light mantle soils [3].

From visible through near-infrared (NIR) wavelengths, the diagnostic absorption bands in reflectance spectra allow mafic minerals such as olivine and pyroxene and other minearals including plagioclase and glassy materials could be identified remotely [4]. The Chandrayaan1 Moon Mineralogical Mapper (M^3) acquired global mode lunar hyperspectral images with pixel resolutions of 140m, for 85 spectral channels between 460 and 2976nm [5]. In the present study, the standard band ratio generated to discrimate the lithology of Apollo 17 landing site. Based on that spectral profiles have drawn and the absorption features were characterized and spatial distribution of different rock types were estimated. The full set analysis of Apollo landing site mineral mapping using Chandrayaan1 Moon Mineralogical Mapper data are in process. Here we have discussed the Apollo 17 landing site centre lies near 20.19 ° north latitude and 30.77 ° east longitude [6].

Methodology: The FeO and TiO_2 estimation was performed using conventional Lucey's et al (1998) algorithms [7]. Band ratio of M^3 data provides useful information on crater morphology, lithology and elemental composition. In the present study, the following band ratios were carried out; 750nm/415nm, 750/950nm, 415nm/750nm and 950nm/750nm. From these ratio outputs FCC were generated.

Results: The standard color composite image (Figure.1) defined from ratio images provide compositional and maturity variations across the region. The standard composite control the spectral channels as red = 750nm/415nm, green = 750nm/950nm and blue = 415nm/750nm. The 415/750 and 750/415 ratios indicate the continuum slope which is a function of maturity (the continuum steepens, or "reddens," as a surface gets more mature owing to the production of metal iron grains by micrometeorite impact and reduction of FeO by the solar wind [8, 9] as well as titanium content in mare basalts. Typically, in these images, a red color indicates mature highland materials, blue regions are immature highland lithologies, and green and yellow areas represent more mafic units. Bright reds/ oranges are typically glassy impact melts [10]. From the Standard band ratio and FeO & TiO_2 elemental maps, we could able to observe, the mafic lithologies.

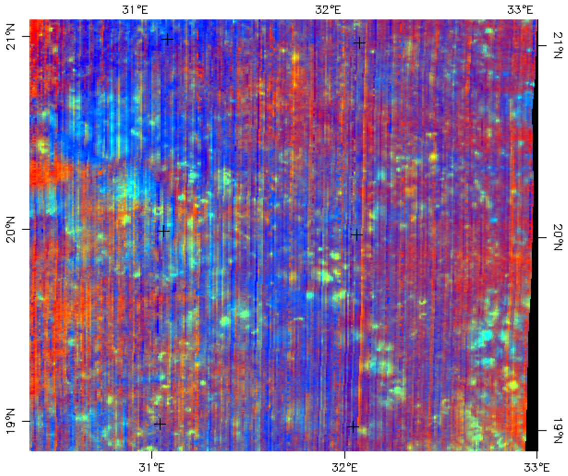
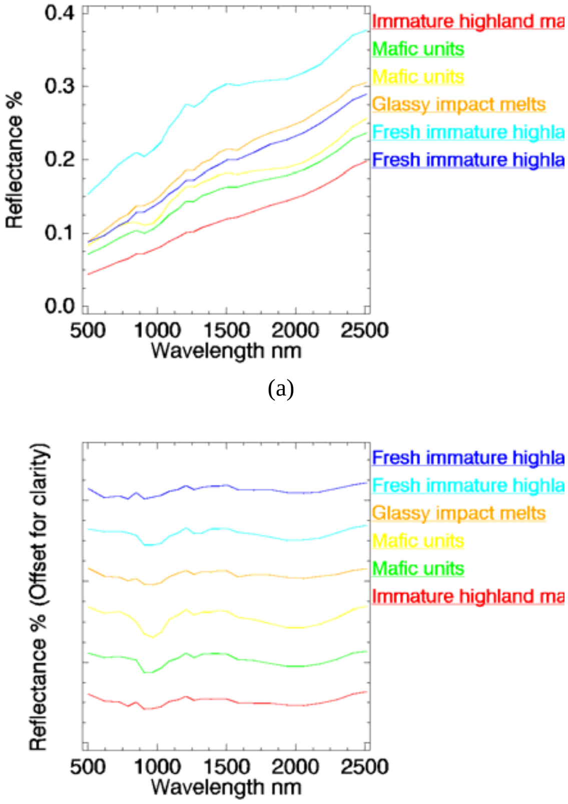


Figure 1: Standard band ratio image of Apollo 17 landing site. Red color indicates mature highland materials, blue regions are immature highland lithologies, and green and yellow areas represent more mafic units. Bright red/ orange are typically glassy impact melts.

In the Figure 2a, cyan & blue spectral profiles indicate that fresh/ immature highland lithology. It has higher reflectance and absorptions at 900nm, 1250nm and 1900nm which are indicating the ortho pyroxene and plagioclase composition. Red and orange spectra are due to immature highland and glassy/ impact melts. The red spectrum has lower reflectance and does not have any significant absorption bands. Green and yellow spectra imply that, the mafic lithology. It also has broad absorptions at 950nm, and 1950nm indicate that the high calcic pyroxene and 1250nm absorption is due to plagioclase. Compare to the fresh/ immature highland lithology and glassy and impact melts, the mafic lithology has lower reflectance. This study has good consistent in between standard band ratio and spectral profiles.

The spectral offset is shown in the figure 2b. From this figure, we could able to observe the yellow and green spectra band depth and width near 1000 and 2000nm implies the mafic absorptions. Fresh immature highland spectra (cyan) has absorption at 1250nm along with higher reflectance indicates the plagioclase mineralogy. The glassy impact melts and immature highland material have absorption at 930nm indicates the low-calcic pyroxene mineralogy. The results of FeO (Figure 3) and TiO_2 (Figure 4) are consistent with the Apollo 17 landing site returned samples [11] as well as Clementine results [12].



(a)

(b)

Figure 2: Spectra showing different lithology in the Apollo 17 landing site using M3 data (a); Refletacne offsetted for clarity (b)

Conclusion:

The area selected for this present study is mostly dominated with mature and immature highland lithologies, and rest of the area were covered by mafic units and glassy impacts. From this study, the mafic units which are having absorptions at nearly 1000, 1250 and 2000nm denote that the basaltic composition. Apollo 17 basalts comprise the high-Ti basalt varieties [12]. The highland lithologies having absorptions near to 950, 1250 and 1950nm with higher reflectance indicate that the Anorthositic Gabbroic compostion. The standard band ratio, spectral profiles and image fractions based on their lithology is presented here for an alternative approach that could be a complement for traditional methods and which may strengthen the interpretations. For rest of the Apollo landing site, analysis are in process. These kind of studies reinforce the regional and global geological study and also for validation. We could expect the variation in the results because, the regional geology of the Moon is complex due to the interaction of volcanic and impact process over long periods of time.

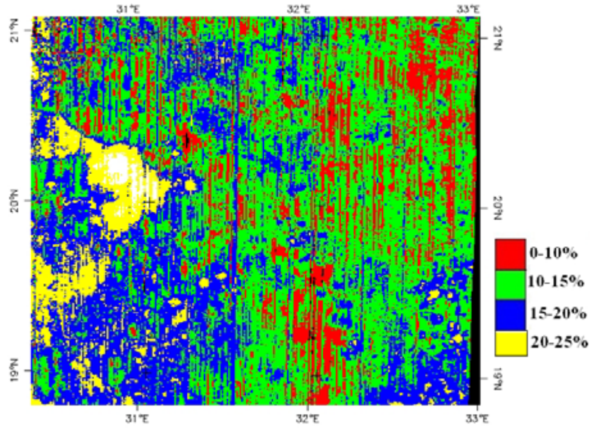


Figure 4: The FeO concentration map of Apollo 17 landing site

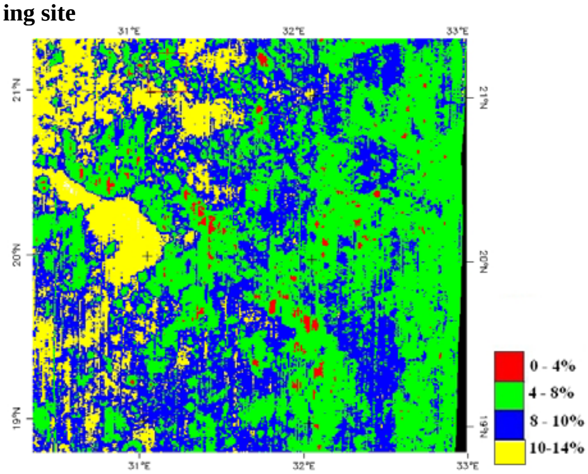


Figure 5: The TiO2 concentration map of Apollo 17 landing site

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