COMPOSITIONAL AND MINERALOGICAL CHARACTERISTICS OF ARCHIMEDES CRATER REGION USING CHANDRAYAAN – 1 M³ DATA. P. R. Kumaresan¹ and J. Saravanavel², ¹Research Scholar, ²Assistant Professor, Department of Remote Sensing, Bharathidasan University, Tiruchirappalli-23, Tamil Nadu, India, email: prkumaresan@bdu.ac.in, drsaraj@gmail.com

Introduction: The Earth’s natural satellite the moon is nearest celestial body appears brightest object in our night sky. Moon surfaces are composed of dark and light areas. The dark areas are called Maria which is made up of basaltic terrain and light areas are highlands mostly made up of Anorthositic rocks. The moon surface is littered with craters, which are formed when meteors hit its surface. To understand the evolution, geological process of the moon it is important to study the surface composition and minerals present in crustal surface. In this regard, in our study, we have attempted to map the minerals and surface composition of Archimedes crater region.

Study area: Archimedes crater is a large impact crater located on the eastern edges of the Mare Imbrium of near side moon (29.7° N, 4.0° W). The diameter of the crater is 83 km with smooth floor flooded (1) with mare basalt and lack of a central peak. The rim (2) has a significant outer rampart brightened with ejecta (3) and the some portion of a terraced inner wall. Archimedes Crater is named for the Greek mathematician Archimedes, who made many mathematical discoveries in the 200 B.C [1, 2]. Ejecta blanket are exposed seen only in northeastern and southern portion of the crater. The crater has a remarkably smooth floor clearly, indicates the Imbrium basin lavas (Figure 1, 4 & 1) buried the ejecta blanket and flooded the floor of Archimedes. This massive impact crater may be a reason for formation of steep sloped Montes Apenninus [3].

Data: Initially, the morphology of the crater has been visualized based on the topographic profile using Lunar Orbiter Laser Altimeter (LOLA) Digital Elevation Model (DEM) of Lunar Reconnaissance Orbiter (LRO) with 118m spatial resolution (Fig. 1). Chandrayaan-1 Moon Mineralogy Mapper (M³) is an imaging spectrometer covering the 0.43-3.0 μm wavelength region in 85 spectral bands and 140 m/pixel in global mode [4]. The M³ data are calibrated to radiance using prelaunch and inflight coefficients and divided by the solar spectrum and the cosine of the incidence angle to apparent reflectance values [5, 6]. For the present study, four number of M³ datasets downloaded from the Lunar Orbital Data Explorer (ODE) such as M3G20090205T211213, M3G20090205T225833, M3G20090206T010833, M3G20090206T030351. These four datasets are Level-2 global mode data products which are pixel located, thermally and photometry corrected reflectance data captured during the OP1B optical period.

Figure 1. Maturity retrieval result from M³ for Archimedes crater region

Methods: Lunar soil maturity carried out using Lucey et al. [7] have brought out the effect of maturity on ferrous ion of lunar soil on the basis of band ratio of R950 nm/R750 and this band ratio values increases with the lunar soil maturity increases. The Integrated Band Depth (IBD) analysis carried out to capture the fundamental mineralogical properties. The IBD analysis is portraying the band depths for 1 and 2 μm absorption features in order to obtain the spectral variations related to mafic and felsic minerals, surface maturity and weathering due to exposure of space using the following equations [8].

\[
\text{IBD at } 1\mu m = \sum_{i=0}^{n} \left( \frac{1}{R_i} (1 - \frac{R_i}{R_{cont}}) \right)
\]

\[
\text{IBD at } 2\mu m = \sum_{i=0}^{n} \left( \frac{1}{R_i} (1 - \frac{R_i}{R_{cont}}) \right)
\]

Where, \( R \) = reflectance at a particular wavelength and \( R_{cont} \) = continuum removed reflectance

The 1.578 μm wavelength region is free from lunar mafic silicate absorption therefore the IBD of 1- and 2 μm band depths together with band reflectance at 1.578
\( \mu m \) produce the RGB color composite image. This color composite has been used to depict the lithological and mineralogical diversity of lunar surface.

Results and Discussion: Lunar soil maturity map clearly depicts stratigraphy of the region. The rim (2) and ejecta materials (3) showing higher value of maturity, which indicates that they are older terrain. The mare basalts (1, 4) found in and around crater shows lower value of maturity indicates less exposed to weathering and younger than Archimedes crater. Fresh craters are showing very low maturity values specify they are recently formed (5, Figure 1). Compositional analysis using IBD parameter shows the lithological diversity of the region. Blue color indicates highland soil rich in felsic (1). Green to yellow color indicated basaltic mare region (2) and red color indicated the presence of olivine (3, Figure 2). Analyzed the image spectra collected from the various compositional units were compared with the RELAB Spectra and find out the absorption similarities. Through this analysis, identified olivine (1), Orthopyroxene norite (2), Clinopyroxene Augite + feldspar (3), Clinopyroxene Augite (4), Clinopyroxene pigeonite (5), basalt (6) and highland soil (7, Figure 2). On the basis of the strong absorption in 1000 nm and no or minute absorption in the 2000 nm, the mineral Olivine was identified in the study area and found in southern and eastern part of rim. The mineral pyroxenes generally have the distinguishing absorption features near the 1000 nm and 2000 nm. The position and shift on these two major absorption features are based on the percentage of concentration of Ca and Mg. The Ortho and Clinopyroxenes can be differentiated through the position of peak of absorption along the 1000 nm and 2000 nm. For the Orthopyroxene, these two major absorption features are fall in the 1000 nm and 2000 nm and nearly along the 900 nm and 1900 nm. Further, the Orthopyroxene indicates presence of the Noritic rocks in the study area. It is found in the northern rim part of the fresh crater (2). The Clinopyroxene pigeonite and Clinopyroxene augite were demarcated on the basis of the subtle changes in the position of absorption features along the 1000 nm and 2000 nm. The Clinopyroxene Pigeonite was identified by falling of these two absorption features along the 950 nm and 2200 nm (5). Similarly, Clinopyroxene Augite was recognized by the typical 1000 nm and 2200-2300 nm absorption features (4). Clinopyroxene Augite along with Plagioclase Feldspar have typical same 1000 nm, 2200-2300 nm absorption features and continuum removed reflectance curve flat for Clinopyroxene Augite in between 1100 nm and 1400 nm and for Clinopyroxene Augite + Plagioclase Feldspar, the spectral reflectance low at 1100 and gradually increases towards 1400 nm (3) [9]. The presence of basalt / bare soil in the study area was concluded on the basis of spectral curve and dark tone and smooth texture (6). Due to prolonged space weathering, a major impact cratering process and highly mixed nature, the image spectra collected from the high land region has less absorption feature. But on the basis image interpretation characteristics like tonal, textural and association, this spectrum was identified as high land soil (7, figure 2).

Conclusions and Summary: In the present study we explored the visible and near infrared mosaics from the M\(^3\) data and determined the compositional diversity and their mineralogical composition of the Archimedes crater region using optical maturity and integrated band depth analysis. Further analyzed the spectra of various compositional units confirmed the analysis in the VIS-NIR region.