MARE SMYTHII: A DETAILED LOOK AT THE EASTERN LIMB OF THE MOON USING HIGH-RESOLUTION DATA.

Ananya Srivastava and Mamta Chauhan, Indian Institute of Remote Sensing – Indian Space Research Organisation (IIRS – ISRO), Dehradun. (whereisananya@gmail.com)

Introduction: Mare Smythii is a nearly circular, multi–ringed, pre-Nectarian basin on the eastern limb of the Moon. Its striking location at the boundary of lunar crustal dichotomy, exposures of some of the youngest basaltic flows (1 – 2 b.y. old), and partially flooded nature make it a prime candidate to study the planetary crustal formation and evolution, and basin-filling mechanisms [1]. Highlands east of Smythii have a relatively higher Al: Si value (a sensitive indicator of rock type) than those on the west, indicating anorthositic crust in the east [2]. Smythii is situated at a geographical as well as a compositional transition zone between lunar nearside and farside. Smythii basin is approximately 5 km below the mean lunar radius (1735 km) while some segments of the basin ring rise 8 km above the lowest points on the basin floor [1][3]. Most mare basalts in Smythii are concentrated in the northeastern section of its inner ring coinciding with a topographic low and a very high Bouger gravity anomaly than the surrounding region (more than 500 mGals compared to only 125 mGals in Marginis Basin) [4]. A large mass concentration is thought to be present beneath Smythii because the gravity measurements are inconsistent with the thickness of basalts. Floor–fractured craters (FFCs) represent impact – induced volcano–tectonic activity and are associated with the edges of most lunar maria. In Smythii, however, these impact structures are found at the center of the basin forming kipukas with raised rims and deformed crater floors surrounded by basin floors which is completely resurfaced by basalts [4][5]. Dark mantling deposits (DMD) of possibly pyroclastic origin are found locally adjacent to features like fractures, crater chains, and sinuous rills indicating that these features act as volcanic vents [1]. The variability of volcanism in the region is supported by morphological evidence of highly effusive, flood–type eruptions in the northeast and fire–fountain plains-type eruptions in the adjacent areas [4]. The different volcano–tectonic features in Smythii are a result of a significant time interval between basin formation and the onset of multiple episodic volcanism [6]. Smythii is a viable candidate for a landing site as well as a future base, given its geological variability would advance lunar science and the absence of any radio noise from Earth would provide some of the best astronomical observations [7]. Understanding the intricacies of Smythii's evolution would solve prominent challenges in lunar science regarding the diversity of volcanism and evolution of the crust over the ages.

Data and Methodology: Previous researchers who studied Mare Smythii utilized data from early missions including Lunar Orbiter, Apollo 15 and 16 subsatellite observations, and Clementine which have limitations, especially in spatial and spectral resolution. In this study, high–resolution datasets from recent missions have been used to perform detailed mapping and analyses in the region. Mapping of geological units and features in the innermost ring of Smythii shown in figure 1 was done using ArcMap 10.5.1 at a scale of 1:1,500,000 based on visual interpretation of texture, pattern and albedo differences in SELENE Terrain Camera (TC) Ortho Map V2.0 images (10 m/pixel). Additionally, LRO LROC's Wide–Angle Camera (WAC) global base map mosaic (100 m/pixel) was used to aid the mapping. Topographic analysis was performed using LRO's LOLA DEM co–registered with SELENE TC images. Spectral characterization of geologic units in Smythii was performed using recent high-resolution hyperspectral data from Chandrayaan – 1's Moon Mineralogy Mapper (M^3) (140 – 280 m/pixel). Spectral band parameters such as band depth, band area, and band depth were analyzed to identify variability in minerals. An Integrated Band Depth mosaic was generated for mafic silicate absorptions at 1 and 2 μm from the M3 reflectance data.

Results and Discussion: Topographic analysis of DEM revealed innermost ring is slightly elliptical with a degraded rim at the northeastern end. Elevation data suggests that the impact event possibly excavated material from the lower crust or even the upper mantle. Wrinkled ridges associated with the cooling contractions in mare basalts are mostly present in the northeast where the thickness of basalts is maximum, about 325 m as reported by [1]. Dorsa Dana is the most prominent ridge in the area running from west to east in the north. Regional fractures follow the overall tectonic and geological setting. Most fractures are found along the mare–terrae contact which may have formed as cooling cracks. Additionally, fractures are also found inside floor–fractured craters in concentric, radial, or polygonal fashion. A limited number of sinuous rilles or lava tubes are found in the basin with an exception of the northwest portion. Partial flooding of the basin yielded the remanent of many pre–mare craters whose rims and inner rings are visible adjacent to the main mare at the central and south–central region. Most of the isolated mare patches are associated with a topographic low and indicate localized volcanism instead of association with the main mare in the northeast. Pyroclastic deposits are found in the western and southwestern parts where they can be recognized by their dark albedo and rough texture, associated with a network of fractures.

Compositional analysis of the basin using M^3 was preliminarily performed using band composites to highlight the dominant minerals such as pyroxenes and spinels. Integrated Band Depth analysis for 1 and 2 µm absorption features provided a detailed view of the spatial distribution of mineralogically diverse units as shown in figure 2, where yellow, blue, and pink hues denote basaltic, anorthositic, and noritic lithologies respectively.

Conclusions and Future Work: Mare Smythii houses a wide diversity of impact, tectonic and volcanic units representing features from all over the Moon, making it a viable future landing site for geological investigation. Smythii basin's old age (fifth–oldest basin on the Moon) and youngest basaltic eruptions provide an important combination that needs to be further investigated. Due to the limited coverage of M^3 data in the region, partial compositional information available will be complemented by results from recently available Chandrayaan – 2's Imaging Infrared Spectrometer (IIRS) data. Hydration maps will also be generated using IIRS data to understand the spatial and temporal variability of water in the region along with its association with specific morphologies. Further, the age of various geologic units will be determined using the crater-size frequency distribution (CSFD) technique on SELENE TC Ortho Map to understand their stratigraphic relationships.

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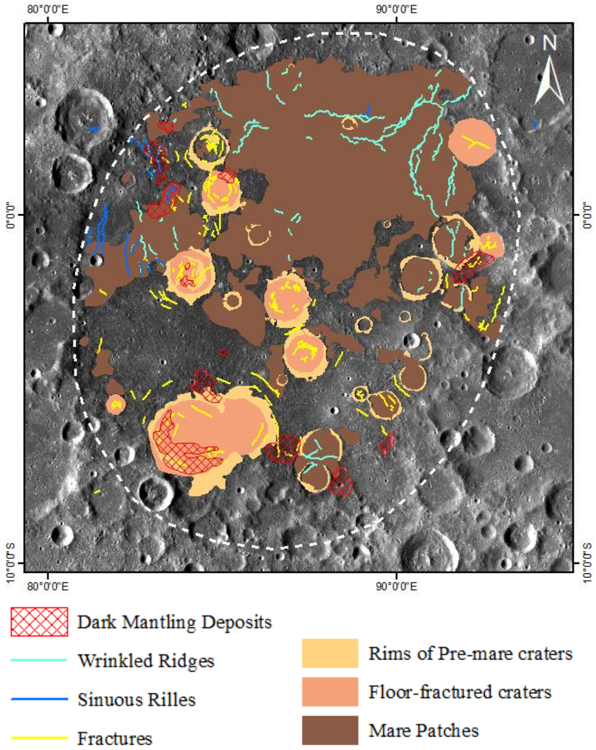

Figure 1 Geologic units and features of Mare Smythii generated using TC images and WAC basemap. White dashed line marks inner ring of the basin.

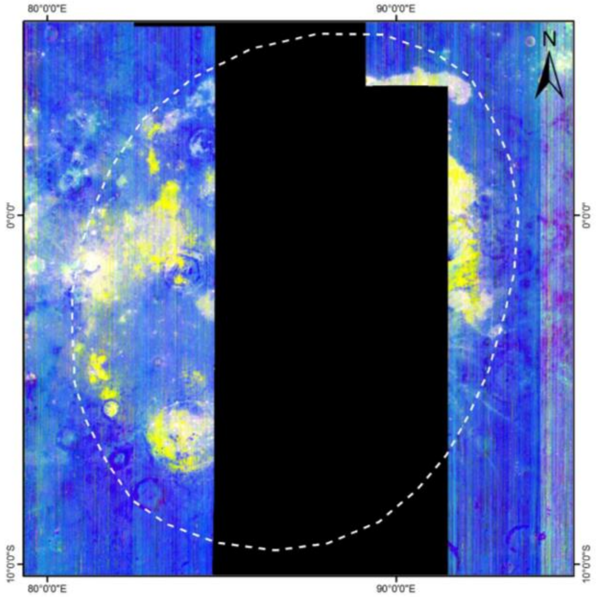

Figure 2 Integrated Band Depth mosaic of Mare Smythii with R: IBD Band 1; G: IBD Band 2; B: Albedo Band (1249 nm). White dashed line represents inner ring of the basin.