A HOLISTIC VIEW OF GRUITHUISEN DOMES – SILICIC CONSTRUCTS ON THE MOON.

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Introduction: The Gruithuisen domes, located near 35°N and 40°W are silicic constructs located in the Procellarum KREEP Terrain region of the Moon. These three domes (Gamma, Delta and North-West (NW)) (Fig.1) have been suggested to be formed as a result of eruption of SiO_2-rich lavas during the early-Imbrian period [1,2]. Mare volcanism on the Moon has been studied in detail using remote-sensing, in-situ and sample measurements, but lunar silicic volcanism still largely remains a mystery due to a lack of appropriate remote sensing and limited sample measurements. Despite knowledge that these regions are high in silica content, there are not yet sufficient data/samples [2] available to characterize where they lie on the scale of andesite to rhyolite, which is important to understand their formation. In-situ observations are necessary to better understand and weigh the existing formation hypotheses [3,4] of non-mare volcanoes on the lunar surface. In this study, we aspire to understand the relationship between these domes and nearby mare regions and also put forward a holistic view of the Gruithuisen domes from remote sensing measurements to prepare for future landing by an upcoming Commercial Lunar Payload Services (CLPS) mission in 2025.

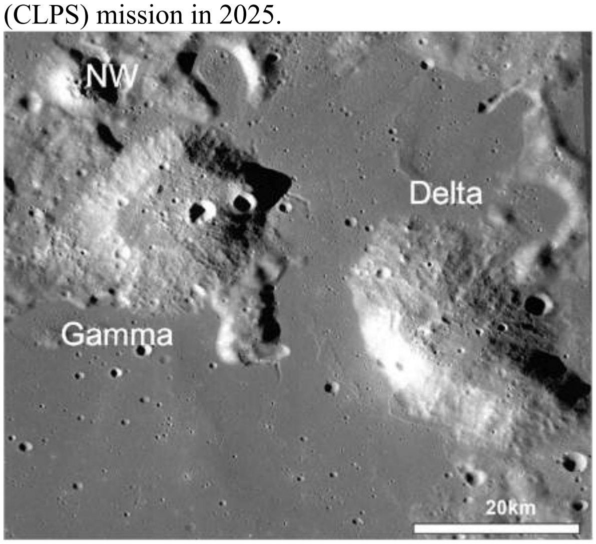

Fig.1 *NAC image of the three domes: Gamma, Delta and NW.*

Datasets: We have used Kaguya Multi-band Imager (MI; ~20 m/pixel), Moon Mineralogy Mapper (M^3; ~140 m/pixel) and Diviner Lunar Radiometer Experiment (Diviner; 128 ppd) datasets to constrain the composition of the domes. We also used a Kaguya SELENE DTM (~8 m/pixel) and a NAC DTM (~5 m/pixel) to characterize the slopes in the region and high resolution NAC images(~0.5 - 1m/pixel) for ongoing mapping activities.

Composition: The FeO- map derived using Kaguya MI data (Fig. 2a) indicates that these domes have low FeO (5-10 wt%) content [5].

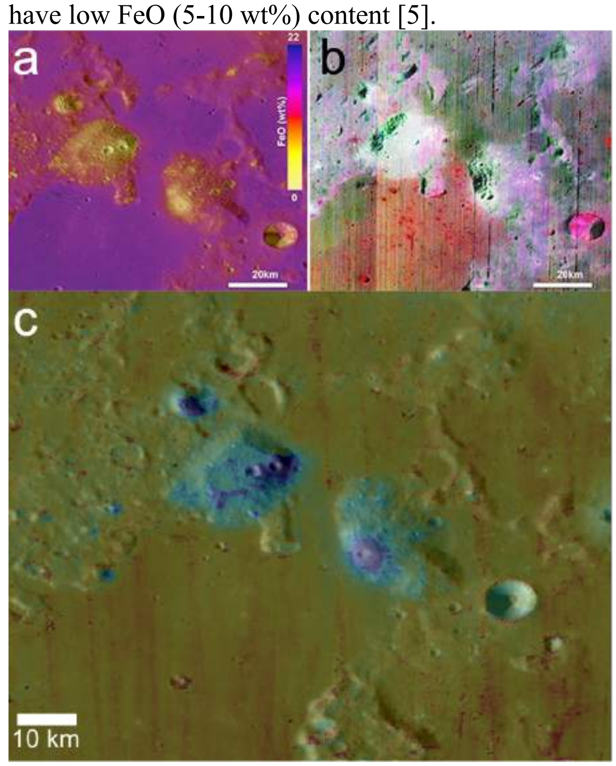

Fig.2 a*) FeO wt% map b) Continuum removed map using M^3 where R is band depth at 1000 nm, G is band depth at 2000 nm and B is band depth at 1578 nm. The white regions in the image display featureless spectra and the red regions display presence of pyroxene. c) CF value map of Gruithuisen domes with bluer shades indicating anomalously low CF values.*

Low FeO content combined with featureless VNIR spectral observations from M^3 on the domes is indicative of a lack of mafic minerals in the region (Fig. 2b). The lower FeO content in the ejecta exposure from the fresh craters on these domes might also indicate that the FeO we observe on the surface could be from the ejecta of the nearby craters enveloping the surface of the domes.

Thermal IR data from Diviner indicate that these regions have Christiansen feature values[6] located at anomalously low wavelengths, indicative of high polymerization of silicates (felsic mineralogy) (Fig. 2c).

Topography: The domes are approximately ~2 km higher than the nearby mare and have absolute model ages of ~3.8 Ga [1] indicating they erupted during the early Imbrium epoch (Fig.3a). The top surface of both the Gamma and Delta domes is relatively flat with slopes within 15°. The slope maps show that the NW dome has the steepest slope (>25°) and the flanks of the Gamma dome has similar slopes, while the Delta dome has shallower slopes in the northern portion of the flanks (Fig. 3b).

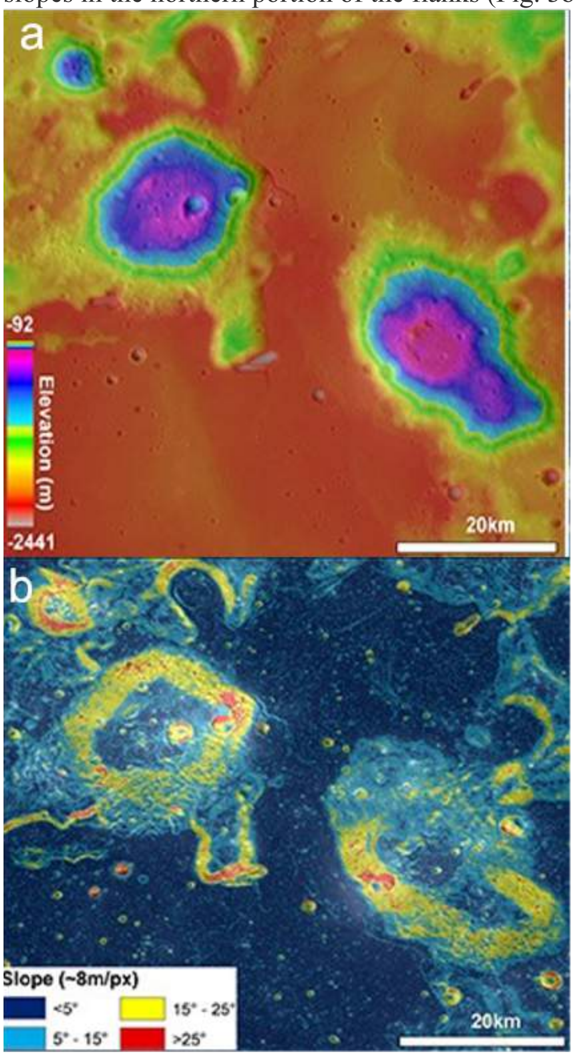

Fig 3 a*)Selene DTM map of the region b)Slope map of the region.*

Boulders: It is important to study boulders in a region to identify the hazardous sites for landing and traverse of a mission [7,8]. Boulders also serve as ideal sites for in-situ observations and to collect and analyze samples. Having been excavated from beneath the surface, boulders are good indicators of compositions lying beneath the regolith. Boulder falls can also be used to measure the bearing capacity of the soil [9]. In this study, however, we also want to understand the role of such boulders in anisothermality observed in Diviner measurements [10]. High number of boulders alongwith surface roughness can lead to illumination and thermophysical variations within a pixel. The measurement of different temperatures at different wavelengths due to variable illumination and/or thermophysical properties in a pixel is known as "anisothermality". Currently we have mapped 33,000 boulders on the surface of the Gamma dome (Fig. 4).

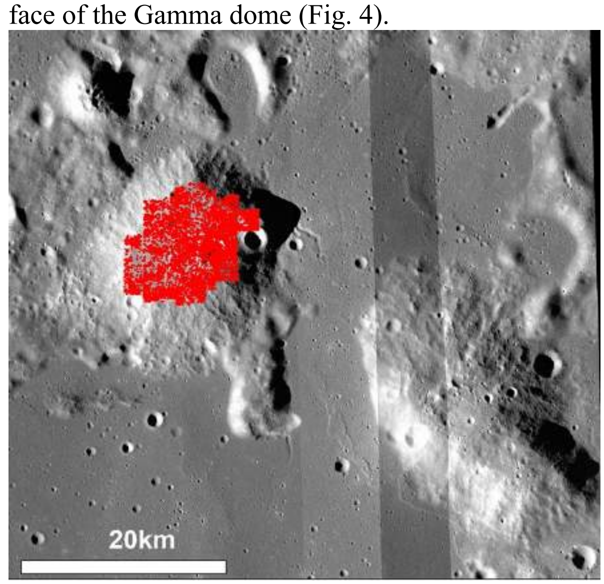

Fig 4. *Boulders on the surface of Gamma domes marked in red.*

Future Work: The future work will compare Diviner anisothermality and rock abundance maps with boulder density maps to understand the role of boulders in anisothermality and surface roughness with phase-ratios from NAC images. We also plan on carrying out a detailed temperature-dependent analysis of heterogeneity within and around these three domes (Gamma, Delta and NW). Crater counting of the surrounding region and different lobes will be conducted to understand the temporal relationship between these regions.

References: [1]Ivanov M.A et al (2016), Icarus, 273, 262-283 [2] Glotch T.D. et al (2011), GRL,38(21) [3] Jolliff B.L. et al (1999), Am. Mineral., 84,821-837 [4]Hagerty J.J., et al (2006), JGR, 111,E06002, doi:10.1029/2005JE002592 [5]Lemelin M. et al (2016), 47th LPSC abs#2994 [6]Greenhagen B.T. et al (2010), Science 329, no.5998 [7]Watkins R.N et al (2019), JGR, 124(11), 2754-2771 [8]Kumari N. et al (2021), 52nd LPSC, abs# 2548 [9]Bickel V.T. et al (2019), JGR, 124(5), 1296-1314[10]William J.P. et al (2021), ESS, e2021EA001966