GEOLOGIC OBSERVATIONS OF THE GRUITHUISEN DOMES. C. M. Weitz[1], H.M. Meyer[2], B. Garry[3], T. D. Glotch[4], L. Jozwiak[2], and B.T. Greenhagen[2]. [1]Planetary Science Institute, 1700 E Fort Lowell Rd, Tucson, AZ 85719 (weitz@psi.edu); [2]Johns Hopkins Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel, MD 20723; [3]Planetary Geology, Geophysics, and Geochemistry Lab, NASA Goddard Space Flight Center, Greenbelt, MD 20771; [4]Department of Geosciences, Stony Brook University, Stony Brook, NY 11794.

Introduction: The three Gruithuisen domes (Gamma, Delta, and Northwest (NW)), located on the western edge of Mare Imbrium, are volcanic structures with anomalously silica-rich compositions compared to other lunar volcanic materials that are dominated by basaltic compositions. The three domes have steep slopes 10-23°, low ultraviolet to near-infrared reflectance, elevated Th abundances, and low TiO_2 and FeO abundances [1-5]. The morphologies of the domes are also distinct from both the mare and highlands due to the presence of ridges and possible flow structures, consistent with high-viscosity, silica-rich melts [1]. Estimated ages for the Gamma and Delta domes are ~3.8 Ga [1].

In this study, we used recent lunar data sets to map geologic features at the three domes (fig. 1), expanding upon previous work done by [1]. We mapped out the domes based upon the morphology as observed in NAC images, the slopes and topography as measured in the NAC- and WAC-derived DTMs, and the mineralogy measured by several instruments, but especially the Christiansen feature (CF) derived from the LRO Diviner instrument [6]. This research identifies several ridges and potential lava flow fronts, summit plateaus and mounds, and correlations between silica composition and impact features. The work will be useful in interpreting future science results from the domes, which are the target of a recently solicited NASA PRISM opportunity.

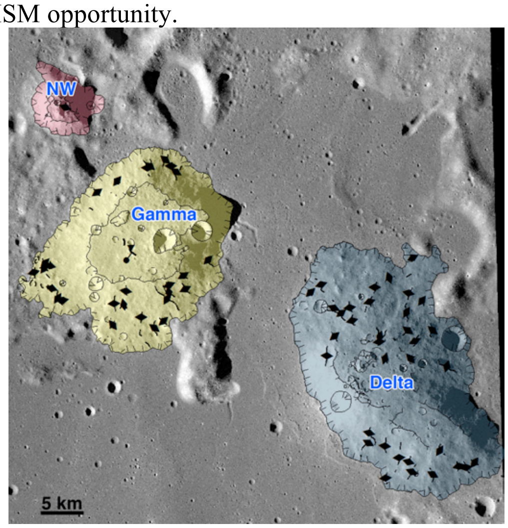

Figure 1. NAC mosaic showing the three domes mapped in different colors. Mapped linear features include ridges, craters, and depression margins/scarps.

Delta Dome: Delta is the southernmost dome situated predominantly within the mare. The dome appears kidney-shaped with possible flow structures in the northeast embaying older highland and mare materials. Topographic profiles taken across the dome show the presence of a saddle that appears to separate Delta into two coalesced domes, with a smaller dome to the southeast and a larger dome to the northwest (fig. 2), consistent with concavity measurements made along the dome flanks by [1] that suggested the presence of two lobes.

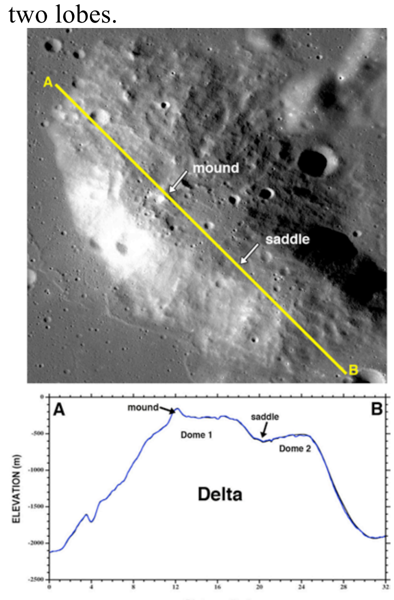

Figure 2. (top) NAC mosaic showing the Delta dome. Yellow line shows where the topographic profile was extracted. (bottom) Topographic profile using the SLDEM2015 +LOLA data [7].

The top of the dome is a relatively flat plateau, except for the presence of larger craters and a 2.9 km long mound found in the northwest (figs. 2,3). Sinuous ridges are commonly seen along the flanks of the dome, with heights ranging from a few meters to up to ~50 m. Some ridges could be older impact crater rims, but most are oriented radially from the dome center, which is more consistent with a flow origin.

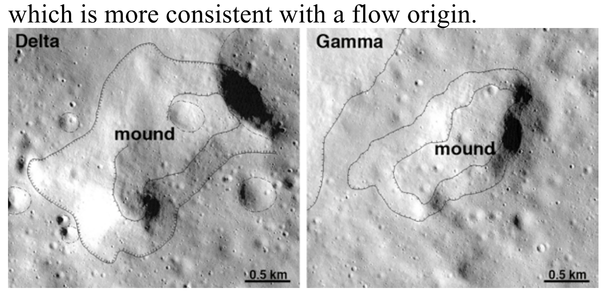

Figure 3. Mounds found on the northwestern plateau of the Delta and Gamma domes.

A young 2.3 km diameter crater on the western flank exposed fresh materials within the dome, and some of this ejecta was deposited on the adjacent mare. Layering is visible within the upper crater walls and the floor has possible impact melt flows (fig. 4a). Boulders are clustered along the upper walls of the crater and also collecting on the floor (fig. 4b). The ~9 km diameter crater Gruithuisen B that impacted in the mare a few kms to the southeast of Delta ejected mare materials onto this SE flank of the dome.

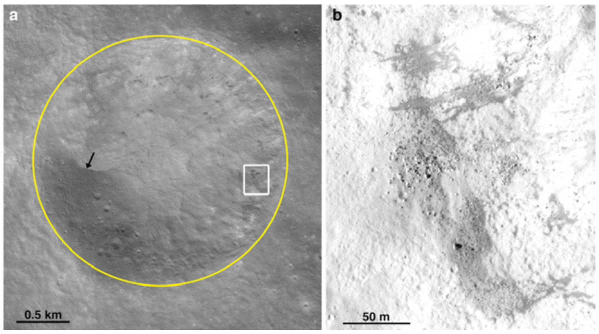

Figure 4. (a) NAC mosaic showing a young crater (yellow circle) along the western flank of Delta. Black arrow shows the contact between rougher wall materials and smooth, likely impact melt, materials on the crater floor. White box identifies location of blowup shown in b. (b) NAC image showing clusters of boulders and darker materials along the upper crater walls.

Gamma Dome: Gamma appears elliptical in shape and is located partially on highland material. Like Delta, there are numerous sinuous ridges along the dome flanks. The ridges at Gamma are more pronounced and higher in relief than those at Delta, especially along the western lower flank where ridge heights can reach 75 m. There is a 2.3 km long mound on the northwestern plateau of the dome, similar to the mound on Delta (fig. 3). Both the Delta and Gamma mounds are elongated in the SW-NE direction with heights of 120 m for Gamma and 150 m for Delta.

There are two ~2.5 km diameter craters on the eastern side of the Gamma dome that exposed deeper silica-rich materials. The more eastern crater is younger and hummocky bedrock is seen along the upper crater wall beneath ~10 m of regolith. The bedrock is shedding boulders that collect along the crater floor. The rough layers are consistent with high viscosity lava flows [1].

NW Dome: The NW dome is much smaller in size and height relative to the Delta and Gamma domes. The dome also lacks the prominent sinuous ridges observed along the flanks of the larger domes. The dome is elliptical in shape and is situated within highland materials. The plateau of the dome is disrupted by several craters, making it appear more hummocky relative to the Delta and Gamma domes.

Correlations between geologic features and high silicic compositions: We used Diviner Lunar Radiometer PDS-archived level 1 data products to produce maps of normalized-to-equatorial noon Christiansen feature (CF; after [6]) and concavity index (CI; after [5]) at 128 ppd. The data shown in Figure 5 represent the photometrically corrected CF with a stretch to highlight the silicic compositions, where blue=7.6 µm and red=8.25 µm. Those locations with the darkest blue colors correlating to the strongest silicic compositions are associated with larger fresh craters at each dome. The large fresh crater on the western flank of the Delta dome has the darkest blue color for that dome (fig. 5A), the large fresh crater on the eastern side of the Gamma dome has the darkest blue color for that dome (fig. 5B), and the numerous craters clustered on the top of the NW dome exhibit the bluest colors (fig. 5C). Hence, missions seeking to understand the composition of the silica-rich material should consider targeting these regions exposed by the larger craters.

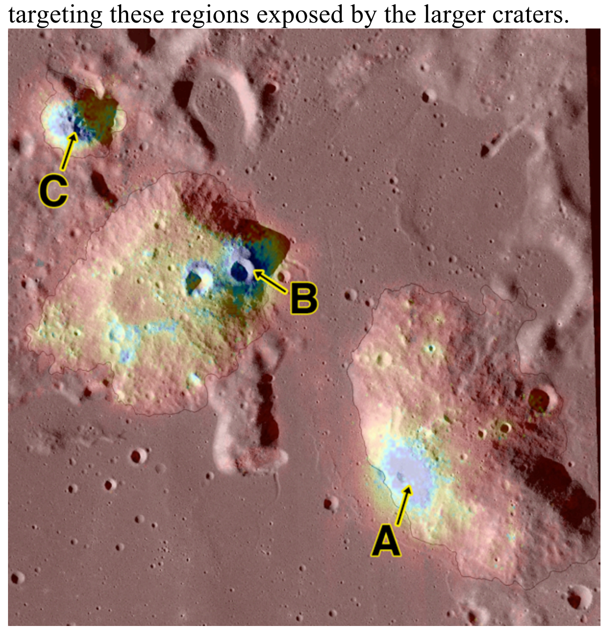

Figure 5. Diviner photometrically corrected CF value map merged to a NAC mosaic, where blue colors (A,B,C) correlate to the strongest silicic compositions.

References: [1] Ivanov M.A. et al. (2016) *Icarus 273*, 262-283. [2] Head, J.W. and T.B. McCord (1978) *Science, 199*, 1433-1436. [3] Wagner, R. et al. (2002) *JGR 107*, doi:10.1029/2002JE001844. [4] Hagerty, J.J. et al. (2006) *JGR 111*, doi:10.1029/2005JE002592. [5] Glotch, T.D. et al. (2010) *Science 329*, 1510-1513. [6] Greenhagen, B.T. et al. (2010) *Science 329(5998)*, 1507-1509. [7] Barker, M.K., et al. (2015) *Icarus, 273*, 346-355.