Exploring the Lunar Gruithuisen Domes: A Landing Site Analysis


This project was undertaken by a Planetary Science class at Durham Academy Upper School, an independent private day school in Durham, NC.

Introduction: Interest in the Gruithuisen Domes, a nearside Lunar silicic construct, has been heightened in response to NASA’s expectations outlined in the 2021 ROSES F.10 PRISM solicitation. These domes, which are presumably of Imbrian age, have long been the focus of study based on their unique ‘nonmare’ composition; they are enriched in potassium, rare earth elements, and phosphorous (‘KREEP’ composition) in addition to having elevated thorium content. [1] [2].

The Gruithuisen Domes represents one of the largest silicic volcanic complexes on the Moon. Their high-silica, low-iron composition, as compared to typical mare rock compositions, has made them a target for lunar geologic studies for decades. The presence of the Gruithuisen Domes and other lunar silicic constructs demonstrate that the Moon is a complex planetary object worthy of much closer study that may well enhance our understanding of our entire planetary system [4]. Exploring the silica-rich materials here would greatly further our understanding, not only of the Moon, but also the planet on which we live. The Gruithuisen Domes include three distinct bodies referred to as (from SE to NW) Delta, Gamma, and NW. The Gamma Dome is essentially a rounded flat-topped structure of about 20 km diameter.

The size and geometry of the Gamma Dome allow for landing of future missions upon the dome itself [5]. With this in mind, we have undertaken the identification of landing sites using the criteria and data sets below:

- Within a 500 m traverse from the landing site
- Adjacent to a fresh crater of at least 20 m depth
- Adjacent to areas of high albedo ejecta
- Within gently sloping areas
- Thorium content of at least 9 ppm
- FeO wt. % of less than 10%

(These Th and FeO values are consistent with silicic alkali-suite lithologies [i.e. (6)]

We agreed to focus our study on two landing sites (see below). The more ‘southerly’ site (Site 1) represents what we believe to be the most promising based on study criteria. The second, more ‘northerly’ site (Site 2) was selected as an alternative keeping in mind different approach traverses that might constrain the mission.

Data sets were gathered via the LROC Quickmap web-based application and include imagery produced by the LROC Narrow Angle Camera (NAC), topographic data from the NAC Digital Terrain Model (DTM), the Lunar Orbiting Laser Altimeter (LOLA), and compositional data from the Kaguya, and Lunar Prospector missions.

Site 1: located at 36.45°N, 319.19°E, 180 meters in horizontal diameter. [see Fig. 1] It is 24 meters deep, so the impact has penetrated the regolith.
Conclusion for Site 1 Landing: We specifically are studying Gruithuisen Gamma because it is more accessible for a landed mission and due to its higher modeled thorium content. We propose a crater located at (36.45°N, 31.91°E), to study because of the nearby low-slope landing sites, the size and low iron abundance indicating the crater is fresh, and the plentiful supply of exposed boulders in the area. This site will allow for multiple in-situ analysis opportunities in order to determine the geologic setting of an important feature on the lunar surface.

Site 2: This crater has a diameter of 190m and depth of around 22m, and is located at 36.695°N, 31.938°E.

Conclusion for Site 2 Landing: Although this crater does satisfy most criteria for a landed in-situ analysis mission to Gruithuisen Gamma, the crater appears less fresh and the opportunity for boulder analysis is not clear. In addition, the landing area appears to be smaller and less flat than that at Site 1. However, this site has a higher modeled thorium content.

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