Investigating lunar domes in Arago region and in Mare Spumans

By Raffaello Lena

In this contribution I provide an analysis of some recent images submitted by Maximilian Teodorescu and Frank Schenck regarding the domes in Arago region and in Mare Spumans.

Arago is a well-known crater located in the western part of Mare Tranquillitatis. Mare Tranquillitatis is situated on the site of an ancient pre-Nectarian impact basin [1-2]. As reported in [3] the older lavas in Mare Tranquillitatis are characterized by a lower Titanium content (reddish in colour ratio), while the youngest lavas erupted in the region are blue (higher Titanium content). The Arago region has been described in my previous note [4]. As shown in Fig. 1 three low domes, located to the north of Arago, are aligned. These three aligned domes, named as A4-A6, have base diameters of 11.1, 8.4 and 9.5km respectively. The height amounts to 65±10m for A4, 50±5m for A5 and 45±5m for A6, yielding flank slopes of 0.7° (A4) and 0.6° (A5-A6).

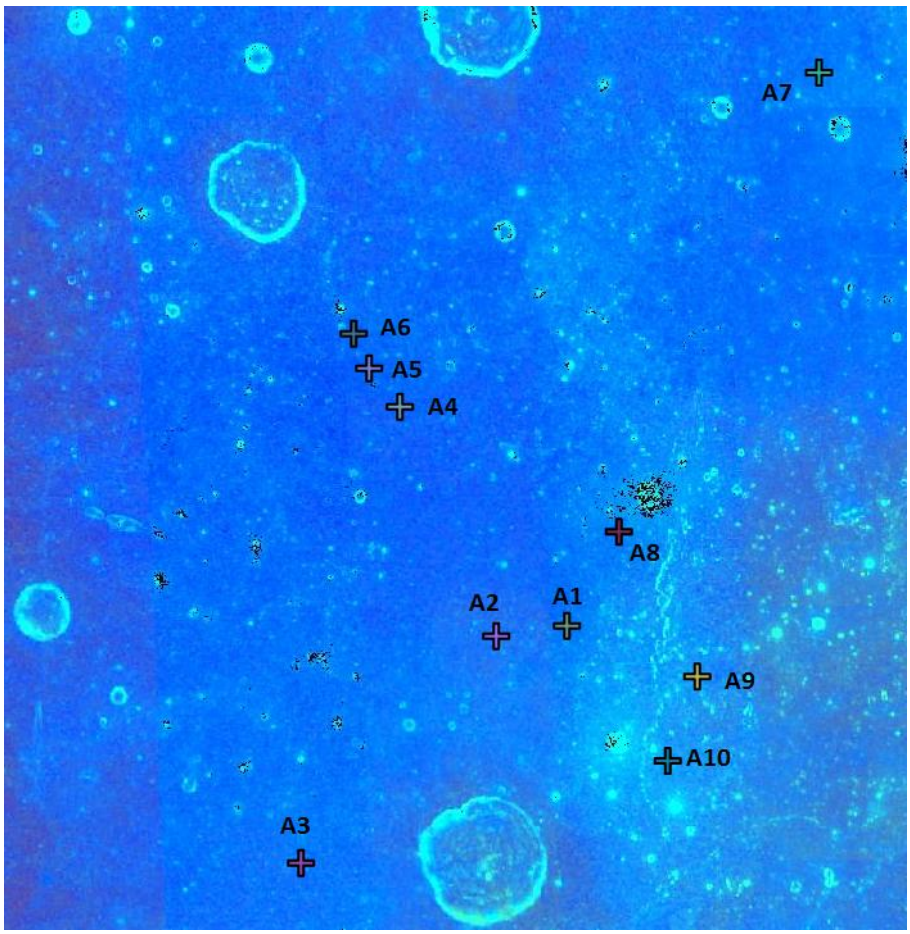

Figure 1: Clementine color ratio imagery of the Arago region including the lunar domes. The domes A1-A10 are described in a previous note by the author [4].

An excellent image of this region is shown in Fig. 2. The image was taken by Teodorescu on November 25, 2021 at 03:49 UT using a 355 mm Newtonian telescope. As very low solar illumination angles are required to reveal the gentle slopes of lunar domes, the subtle domes A4-A6 in the probes imagery are not prominent (Fig. 3) as in the telescopic image shown in Fig. 2 taken under oblique illumination.

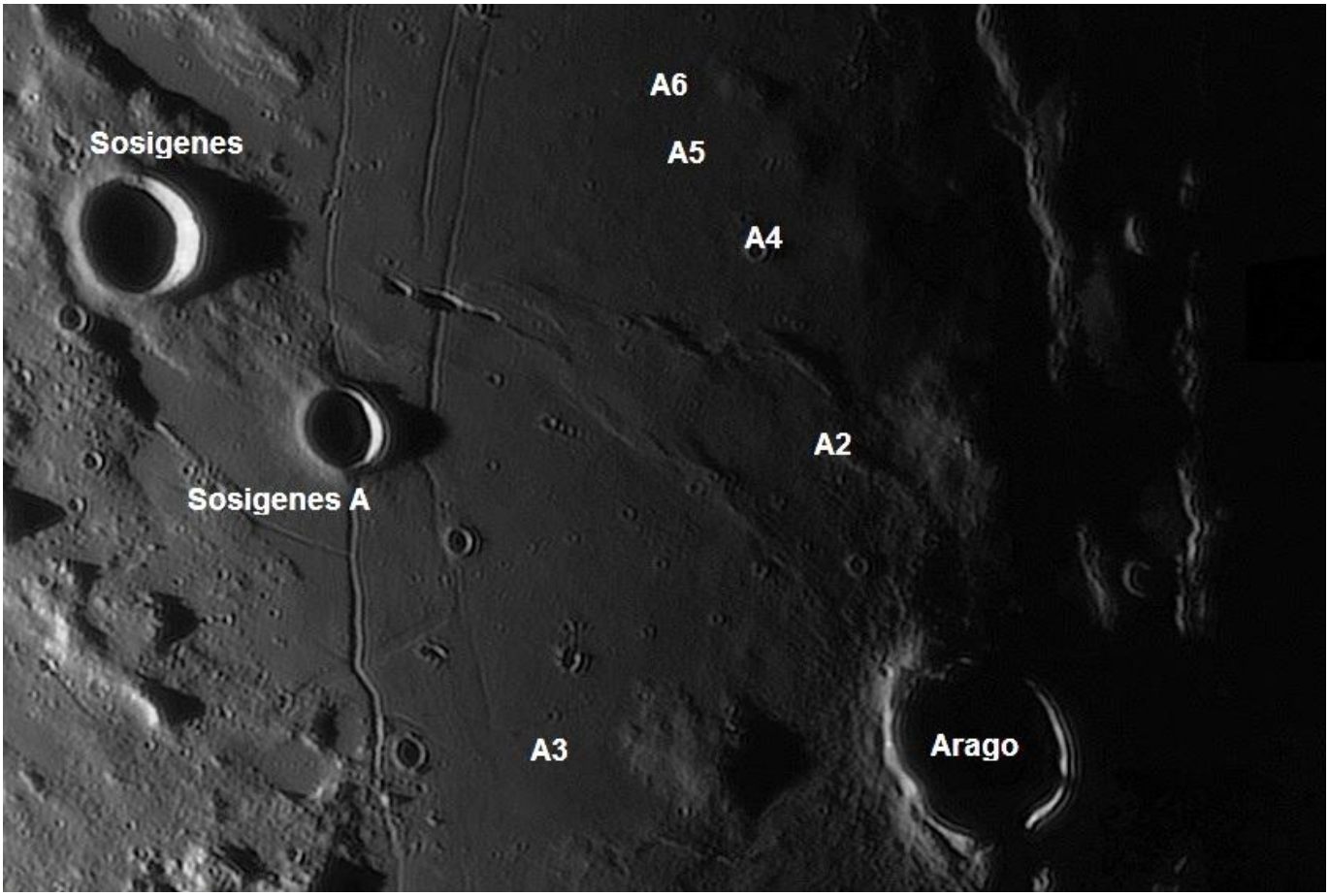

Figure 2: Telescopic image made by Teodorescu on November, 25 2021 03:49 UT.

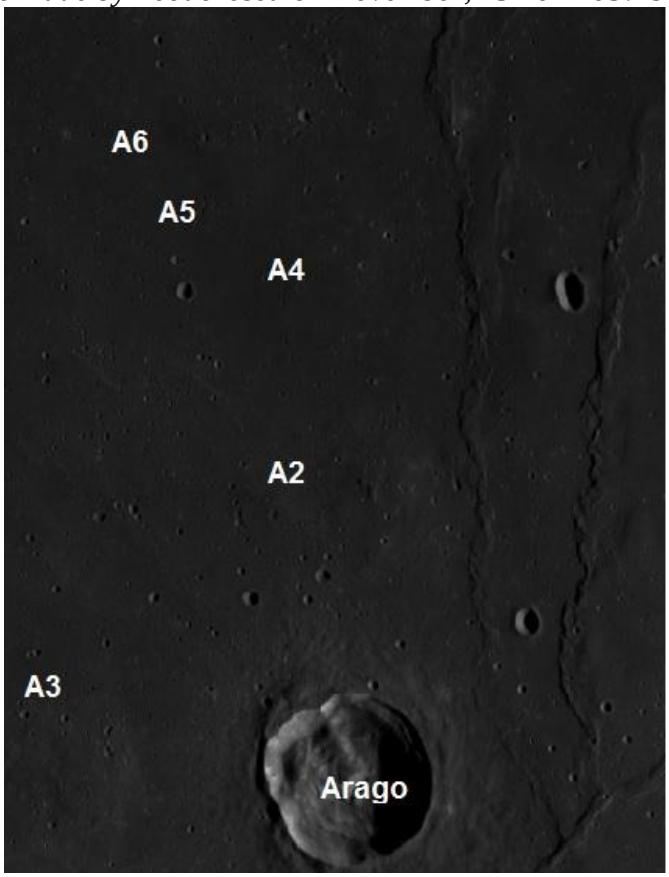

Figure 3: WAC imagery

The telescopic image shown in Fig. 2 was also used to derive an elevation map of the examined domes, obtaining a three-dimensional (3D) reconstruction. A well-known image-based method for 3D surface reconstruction is shape from shading (SfS). This technique makes use of the fact that surface parts inclined towards the light source appear brighter than surface parts inclined away from it. The SfS approach aims to derive the orientation of the surface at each image location by using a model of the reflectance properties of the surface and knowledge about the illumination conditions, finally leading to an elevation value for each image pixel [2]. Thus I have derived the DEM and the 3 D reconstruction (Fig. 4).

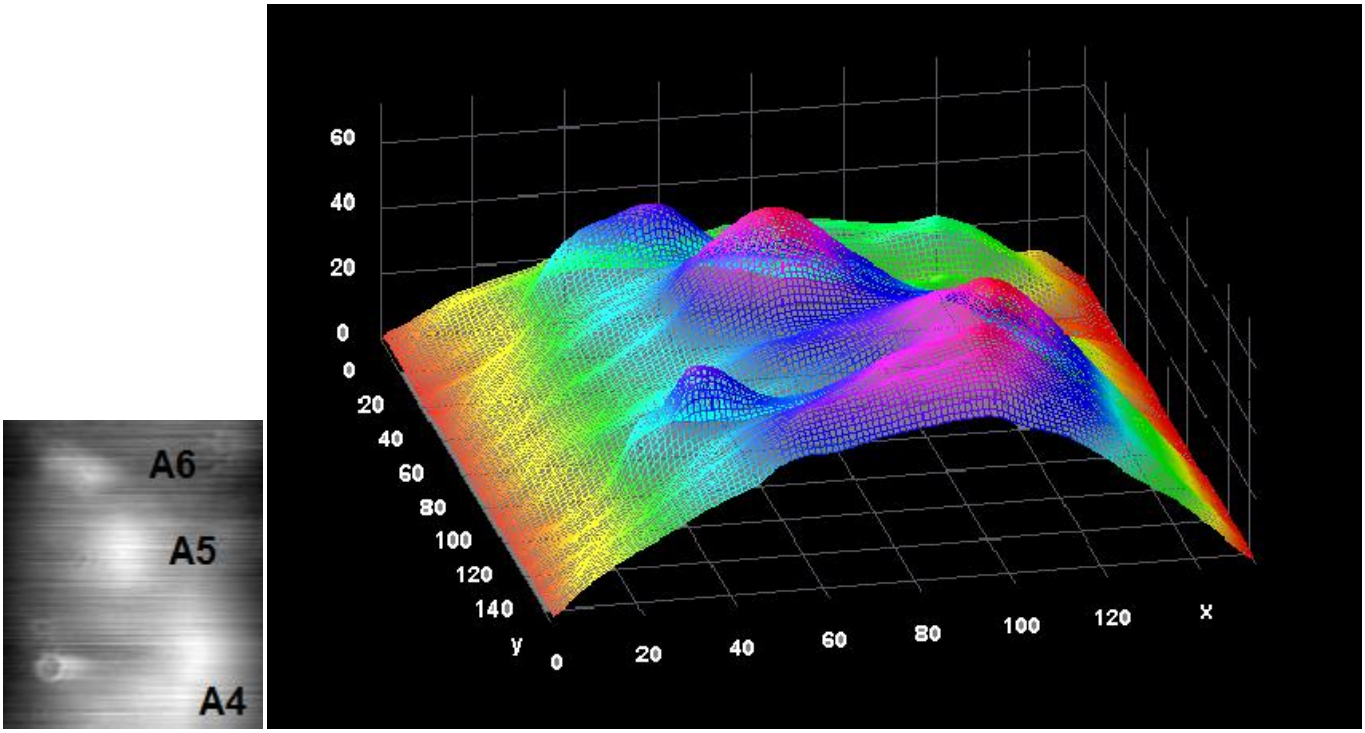

Figure 4: (left) DEM obtained using the telescopic image of Fig. 2. The domes A4-A6 are marked. (right) 3D reconstruction of A4-A6, vertical axis is 30 times exaggerated.

To the north of Arago lie two known lunar domes Arago α (termed A2) and Arago β (termed A3). These two large domes (Fig. 2)- A2 and A3- belong to class D and formed during several stages of effusion, representing non-monogetic domes. The other smaller domes in Arago show lower flank slopes and according to their rheologic properties, belong to class A implying low lava viscosities of about 10^3 Pa s, high effusion rates and very short durations of the effusion process of about 3–4 months.

In another previous work, a dome in Mare Spumans has been identified using LROC WAC imagery and named as Spumans 1 (see link below)
http://www.alpo-astronomy.org/gallery3/var/albums/Lunar/Lunar-Domes/2021/Dome%20in%20Mare%20Spumans.pdf?m=1633191674

It lies at about 26 km south west of the crater Pomortsev.

An image of the dome was taken by Schenck on November, 21, 2021 at 03:16 UT using a C14 f/11 (Fig. 5).

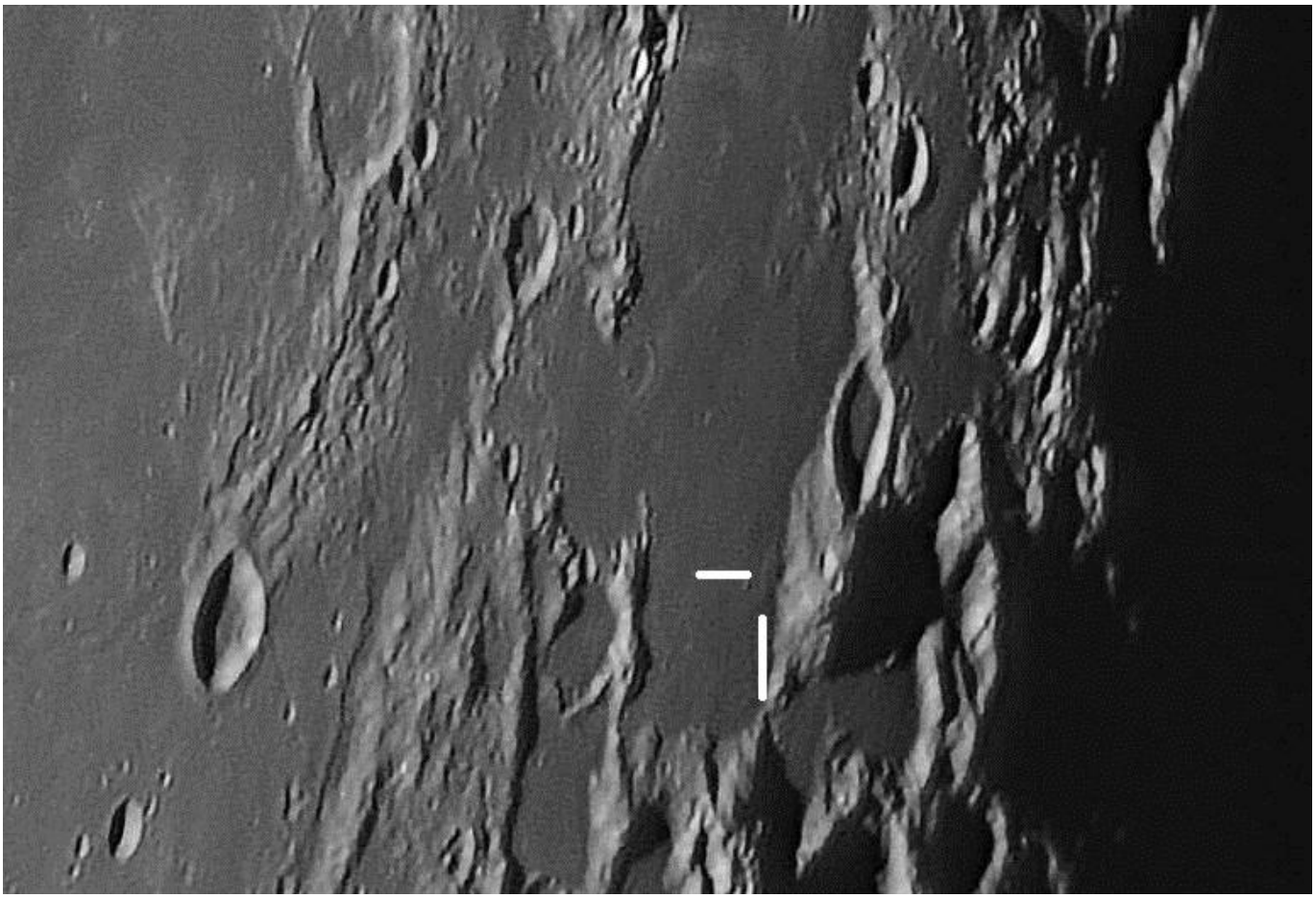

Figure 5: Telescopic image made by Schenck on November, 21 2021 03:16 UT. The dome Spumans 1 is marked with white lines.

I have deleted the foreshortening effect transforming the telescopic image in cylindrical projection**,** using LTVT software package by Mosher and Bondo (Fig. 6).

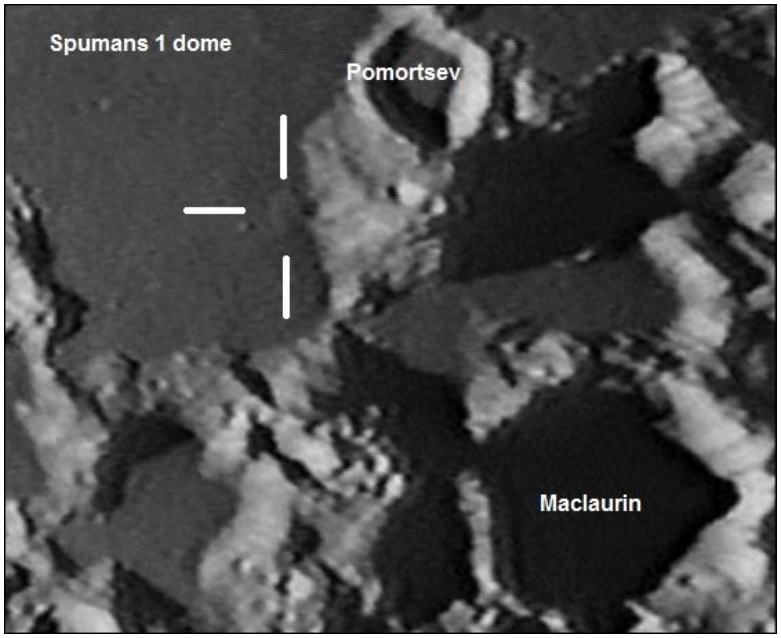

Figure 6: The dome Spumans 1 displays a circular shape. Image in cylindrical projection using LTVT software package.

Inversely, a synthetic image of a dome can also be generated based on an available DEM as seen from a given direction for lighting from some other specified direction. The LTVT software was used to generate synthetic view of selected parts of the LOLA DEM as cylindrical projection deleting, also in this case, the effect of foreshortening (Fig. 7).

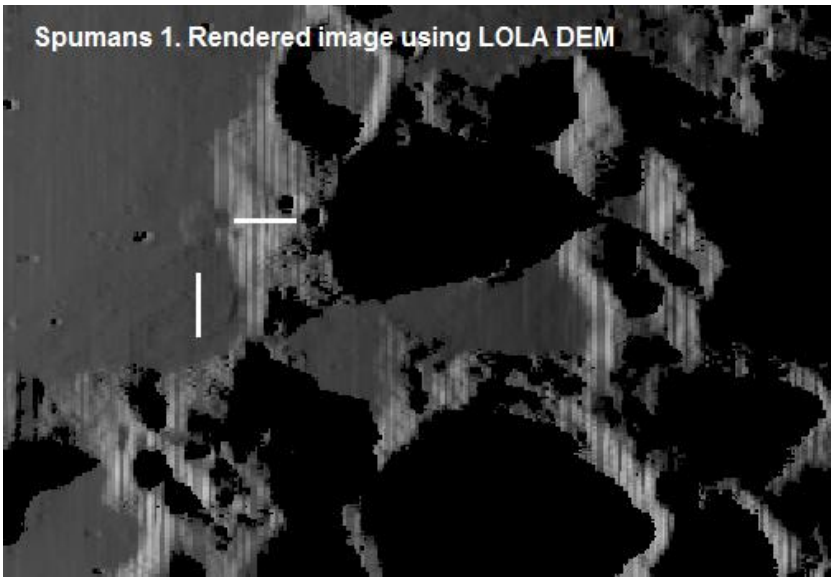

Figure 7: Image simulated based on the LOLA DEM using LTVT, displaying the dome Spumans 1 under the solar altitude of 3.9° as cylindrical projection, thus deleting the effect of foreshortening. The rendered image may be compared with the telescopic image shown in Fig. 6.

Based on the telescopic image, the dome has a base diameter of 8.5 ± 0.5 km. The height, determined using the photoclinometry and SfS approach [2], amounts to 95 ± 10m. A 3D reconstruction is shown in Fig. 8.

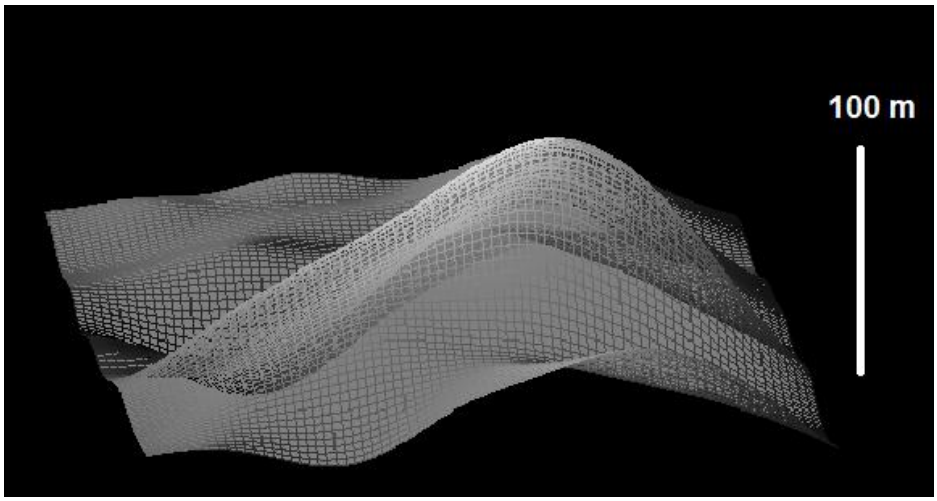

Figure 8: 3D reconstruction of Spumans 1, based on the telescopic image of Fig. 6. Vertical axis is 30 times exaggerated.

The search for lunar domes in the easternmost regions of the Moon can be a goal for amateur astrophotographers and astronomers. I encourage high-resolution imagery of this area using telescopic images, so that we can have more data about the dome Spumans 1, actually under study.

Please check also your past imagery of the Mare Spumans and send them to us for the ongoing study (lunar-domes@alpo-astronomy.org).

References:

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[6] Mosher, J., & Bondo, H., 2006. *Lunar Terminator Visualization Tool (LTVT)*. See: https://github.com/fermigas/ltvt/wiki