

# **AN UNLISTED DOME NEAR CRATER ARAGO**

## **located at longitude +21.96° and latitude +7.66°**

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Mare Tranquillitatis is situated on the site of an ancient pre-Nectarian impact basin [1]. Arago is a well-known crater located in the western part of Mare Tranquillitatis. To the southwest lies the Manners crater, and to the southeast, the large Lamont formation is situated, which has been submerged by the mare. Lamont is a 75 km wide oval ridge surrounded by a wrinkle-ridge ring approximately 135 km in diameter. It is considered a small multiring impact basin. Moreover Lamont is the site of a moderate-sized mascon [2]. Mascons are associated with impact basins and are believed to be due to the excess mass of mare lavas and/or a rise of the dense lunar mantle under the basin.

Several domes are reported in this region. To the north of Arago lies the large lunar dome Arago Alpha ( $\alpha$ ). A similar-sized lunar dome is located to the west, named Arago Beta ( $\beta$ ). Arago Alpha and Beta have a very irregular profile showing protrusions and possible eruptive vents. Between Arago Alpha and the crater Maclear four well-known aligned domes, 5 to 8 km wide, can be found. These domes have formed in basalts of relatively high TiO<sub>2</sub> content, and they appear strongly blue in the Clementine UVVIS colour ratio image (Fig. 1). The domes Arago Alpha and Beta appear to consist of a mixture between blue and underneath redder lava. 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). New ground-based CCD imagery is currently being studied to examine domes in the Arago region, not identified or well-resolved in Lunar Orbiter photographs and Apollo imagery (see Fig. 2).

Recently this region has been monitored by the GLR group. A low, previously unreported dome has been observed in this area, near Arago Alpha. It is situated at longitude +21.96° and latitude +7.66°. It has formed in basalts of relatively high TiO<sub>2</sub> abundance (see Fig. 1).

For each of the observations, the local lunar altitude of the Sun and the Sun's selenographic colongitude were calculated using the Lunar Observer's Toolkit by H. D. Jamieson. Fig. 3 displays the dome, which was detected by Zac Pujic on May 28, 2005, at 18:10 UT, using a 310 mm Newtonian f/28, a Wratten 25A filter, and a Philips ToUCam CCD webcam (solar altitude = 3.86°, colongitude = 154.30°). The image is oriented with north at the top and west (IAU) to the left.

Another image (Fig. 4) was taken by Jim Phillips on May 28, 2005, at 09:58 UT, using a TMB 8" f/9 apochromatic refractor and an Atik B&W CCD camera (solar altitude = 7.96°, colongitude = 150.16°).

The image shown in Fig. 5 was taken by Paolo Lazzarotti on January 01, 2005, at 01:49 UT, using a 250 mm Newtonian telescope and a Lumenera LU075M CCD camera (solar altitude = 2.68°, colongitude = 155.13°).

An older image in which the dome is apparent (Fig. 6) was taken by Christian Wöhler on July 19, 2003, at 02:40 UT, using a 200 mm Newtonian telescope and a Philips ToUCam CCD camera (solar altitude = 7.74°, colongitude = 150.45°). The dome had not been noticed at that time.

The described dome requires a specific solar altitude to be observed clearly. Preliminary estimations indicate a diameter (E-W direction) of (5.6±0.3) km and a rather low slope; moreover, no black shadow is

cast by the dome even under low solar altitude (see Fig. 5), which confirms its low relief character. As a note of interest, the Apollo imagery and Lunar Orbiter frame, taken under higher solar altitude, do not show this dome.

The height was obtained by determining elevation differences between the summit of the dome and its surrounding on the corresponding 3D profiles derived by photogrammetry and shape from shading analysis [4]. The dome height was measured in the image shown in Fig. 5 as  $(45\pm 10)$  m, yielding a slope of  $0.88^\circ \pm 0.30^\circ$ . Fig. 7 shows the 3D reconstruction results.

Table 1: Properties of the dome located at longitude  $+21.96^\circ$  and latitude  $+7.66^\circ$ , measured in Fig. 4.

Dome	Longitude	Latitude	Diameter (km)	Height (m)	Slope ( $^\circ$ )	Westfall Classification
Dome 1	$+21.96^\circ$	$+7.66^\circ$	$5.6\pm 0.3$	$45\pm 10$	$0.88\pm 0.30$	DW/2a/5f/0
Arago Alpha	$+21.70^\circ$	$+7.56^\circ$	$25.4\pm 0.3$	$330\pm 30$	$1.5\pm 0.3$	DW/3d/5i/7p8p9p
Arago Beta	$+20.07^\circ$	$+6.24^\circ$	$23.6\pm 0.3$	$270\pm 30$	$1.3\pm 0.3$	DW/3d/5i/7p8p9p

In Table 1 we categorize the examined dome using the Westfall scheme [5]. Moreover, this dome is presumably of class IV, using the classification scheme for lunar mare domes introduced by Head and Gifford [6]. However, the dome looks more like a structure which is separate from the nearby ridge, such that it might also be a separate shallow class III dome. In Table 1 we also report the height and slope measured for Arago Alpha and Beta. Interestingly the obtained results strongly suggest that previous estimates of the Arago Alpha and Beta heights, given by Brungart [7], are wrong. Brungart compiled a catalogue of 261 domes reporting their coordinates, diameters, heights, slopes, and morphological characteristics. For Arago Alpha and Beta he reports under the entries 3 and 4 a height of 700 m and 800 m with an average slope of  $5.5^\circ$  and  $6.0^\circ$ , respectively. Our results indicate a lower slope of  $1.5^\circ\pm 0.3^\circ$  and  $1.3^\circ\pm 0.3^\circ$ , respectively.

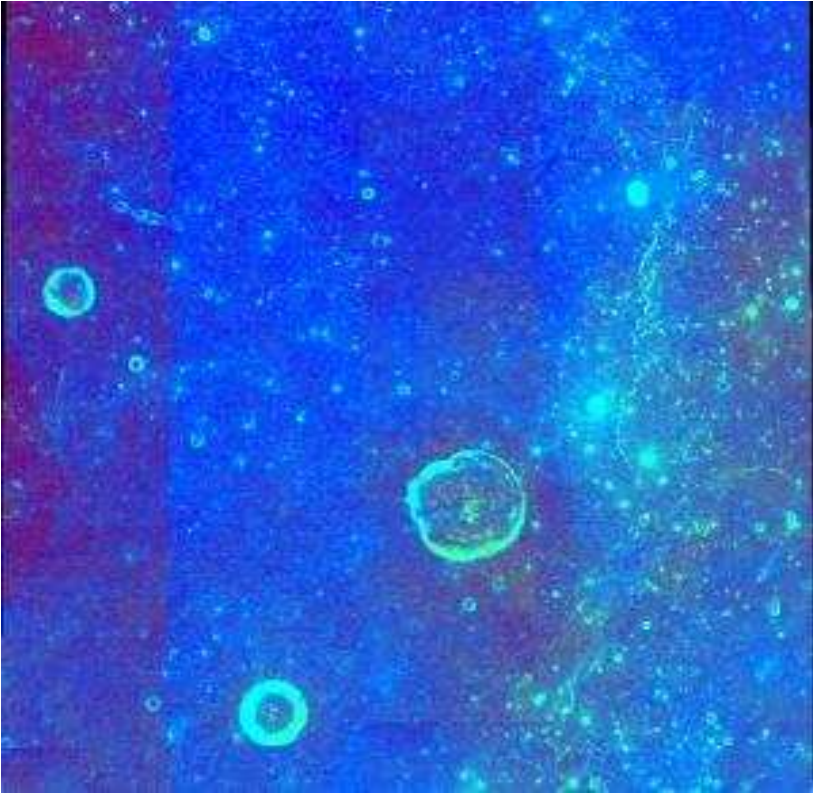
The height of Arago Alpha was measured in the image shown in Fig. 5 as  $(330\pm 30)$  m. The height of Arago Alpha was also computed from a visual observation by Raffaello Lena (Fig. 8). This observation was carried out on November 10, 2002, at 18:00 UT using a 100 mm  $f/15$  refractor (solar altitude =  $1.48^\circ$ , colongitude =  $339.89^\circ$ ). According to Ashbrook [8], the average slope of the dome flank is equal to the solar altitude when  $x = 0.25$ , where  $x$  is the fraction of the dome diameter that is covered by black shadow. A hemispherical shape of the dome is assumed. The height  $H$  of the dome was then calculated by  $H = r (\tan s)$ , where  $r$  is the radius of the dome and  $(\tan s)$  the tangent of the average slope angle when the dome is  $\frac{1}{4}$  covered by black shadow (as it is the case here). It turns out that the summit of Arago Alpha is 310 m higher than the surrounding plain, with an average slope of  $1.48^\circ$ . This result is in clear agreement with the photogrammetry and shape from shading analysis.

Any observations that readers can make about the previously unreported dome described here will be gratefully received for our GLR survey ([lena@glrgroup.org](mailto:lena@glrgroup.org)).

Future observing schedules of the GLR group are being planned to investigate different lunar domes on a case by case basis. It is hoped that by eliminating many of the less reliable measurements and reports, we will be left with a core set of observations upon which more reliable statistical analysis can be performed.

## References:

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- [3] D. Rajmon, P. Spudis, "Distribution and stratigraphy of basaltic units in Mare Tranquillitatis, Proc. Lun. Plan. Sci. Conf. XXXII, paper 2156, 2001.
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- [5] J. Westfall; "A Generic Classification of Lunar Domes", J.A.L.P.O., July 1964, vol. 18, no. 1-2, pp. 15-20.
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- [7] D. L. Brungart, Air Force Institute of Technology Wright Patterson Air Force Base, Ohio, July 15, 1964.
- [8] J. Ashbrook, JALPO, vol. 15, no. 1-2, 1961.



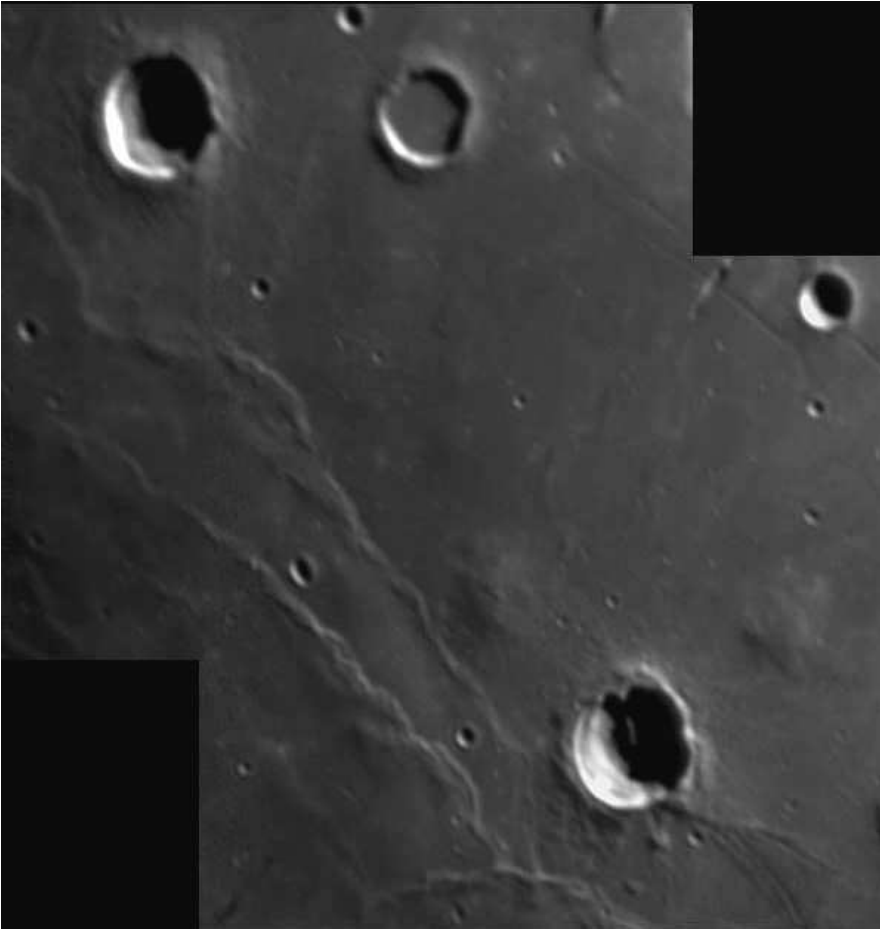
**Figure 1**



**Figure 2**



**Figure 3**



**Figure 4**

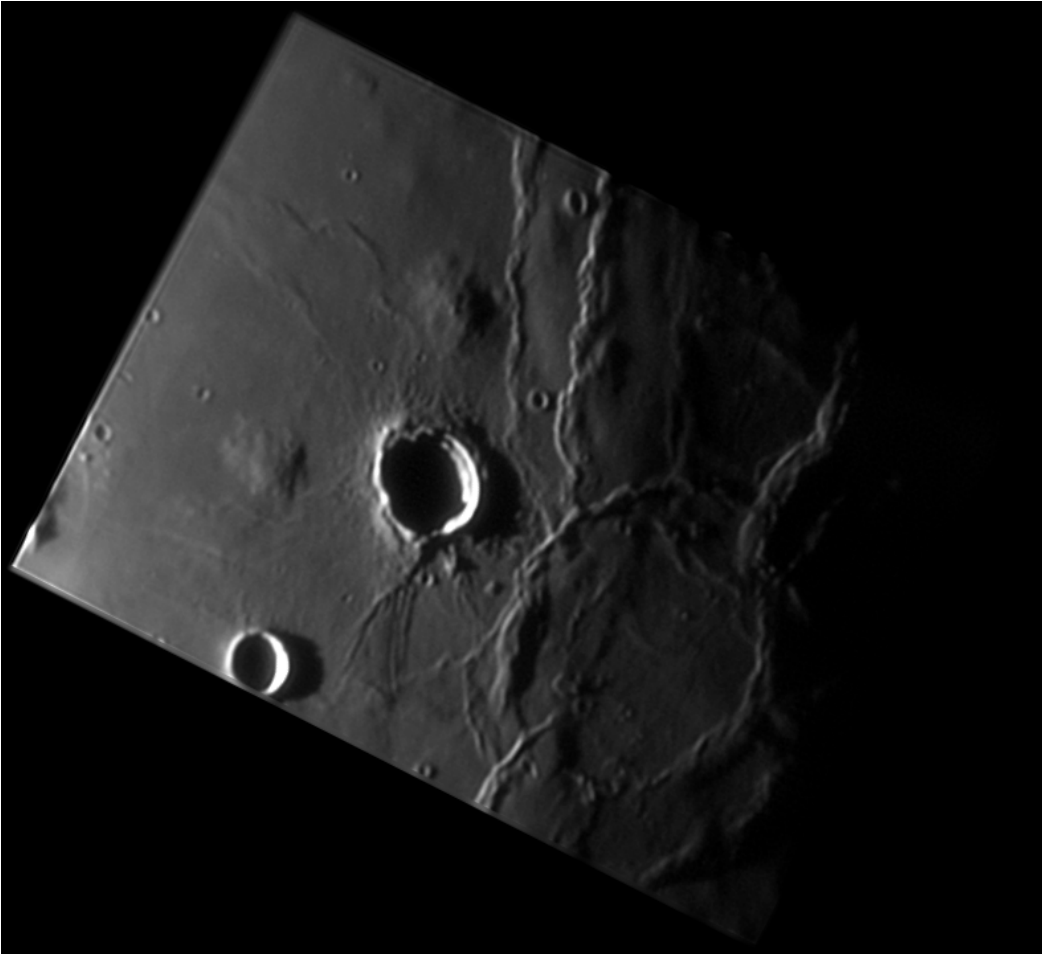


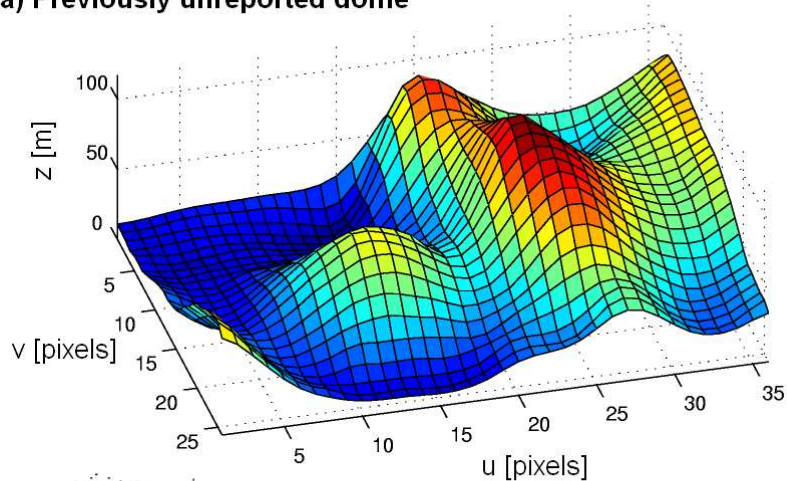
Figure 5



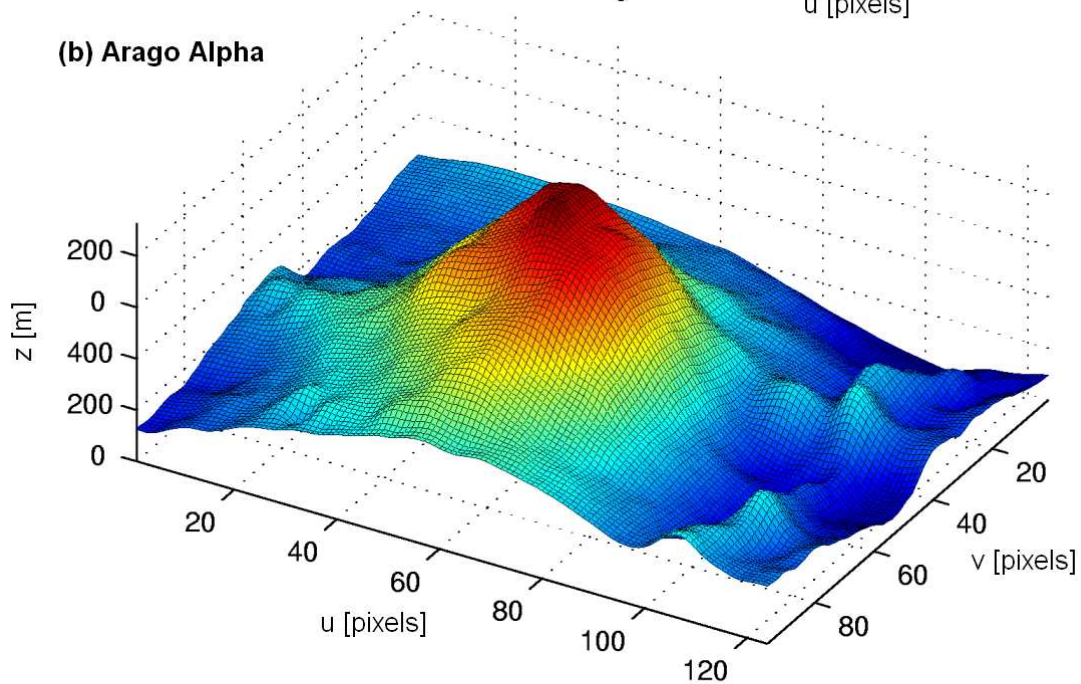
**Figure 6**

pixel scale:  
328 m per pixel

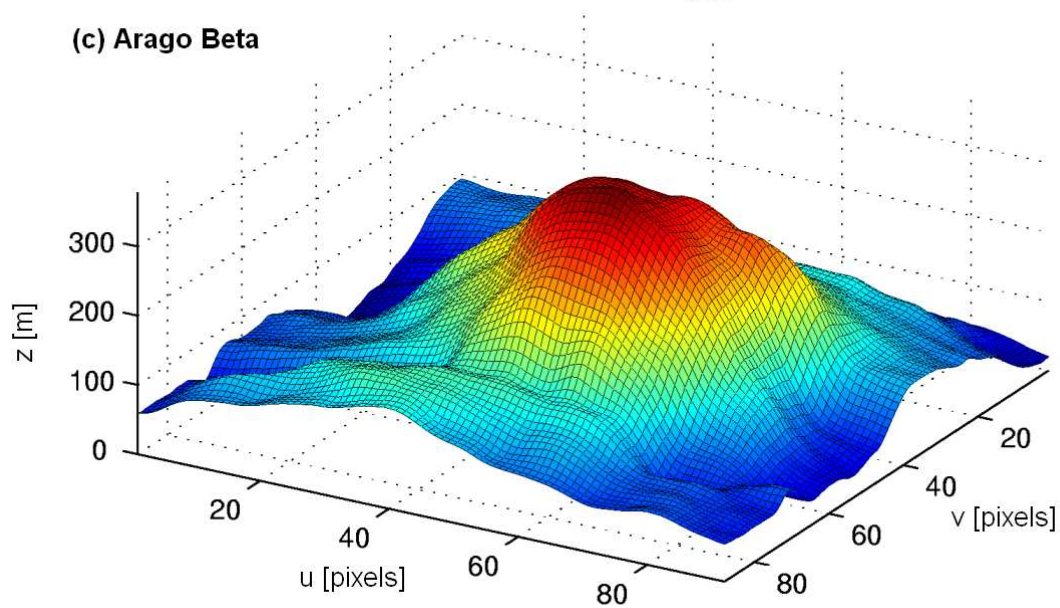
**(a) Previously unreported dome**



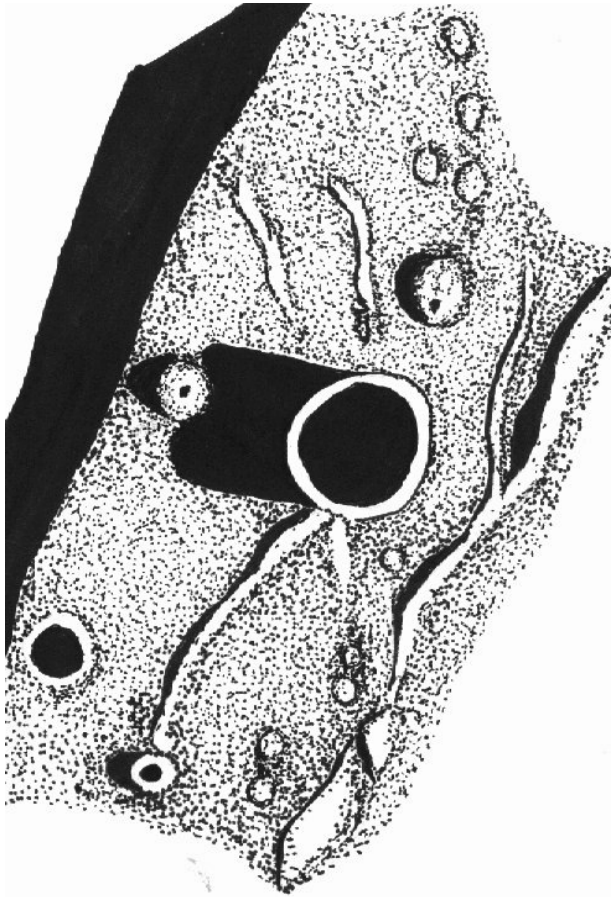
**(b) Arago Alpha**



**(c) Arago Beta**



**Figure 7**



**Figure 8**