## Searching lunar domes in Mare Crisium: the dome Crisium 1 located near Cleomedes G (preliminary report) <br> by Raffaello Lena

Lunar domes are the best evidence of volcanic activity in the moon. Most have very low angle of inclinations, only a few degrees at most. This makes domes similar to earth's shield volcanoes formed by outpouring of magma from a central vent (effusive eruption) [1-3].
Over the past few years only one dome near the Yerkes crater has been identified and studied [3]. Yerkes 1 is characterized by the presence of rilles in the summit. It has a height of $110 \pm 20 \mathrm{~m}$, a flank slope of $1.36^{\circ} \pm 0.20^{\circ}$, and a volume of $4.8 \mathrm{~km}^{3}$ (see also our map http://crisiumdomes.blogspot.com/).The Crisium basin is of Nectarian epoch, while the mare material is of the Upper Imbrian epoch [4].

Maximilian Teodorescu, from Romania, has imaged another dome located at coordinates of $23.35^{\circ} \mathrm{N}$ and $58.37^{\circ} \mathrm{E}$. The examined dome-named Crisium 1 (Cr1)- is clearly detectable in the image taken on October 3, 2020 at 23:02 UT (Fig. 1).
Another image of this region made by Pau on the same day, October 3, 2020 but at 15:14 UT is shown in Fig. 2.


Figure 1: Image taken by Teodorescu on October 3, 2020 at 23:02 UT using a 355 mm Newtonian telescope and ASI 174MM camera. The examined lunar dome-termed Cr1- is marked with white lines.


Figure 2: Image taken by Pau on October 3, 2020 at 15:14 UT using a 250 mm f/6 reflector and a QHYCCD290M camera.

Another image of Cr1 was made by Guy Heinen on March 22, 2019 at 23:08 UT (Fig. 3).


Figure 3: Image taken by Heinen on March 22, 2019 at 23:08 UT using a Schmidt Cassegrain 235mm.

A possible vent of 3.4 km diameter and 160 m deep is present on the summit (see Figs. 1-3 showing the terrestrial telescopic images and Fig. 4, which displays a WAC image). The image of Fig. 4 is shown in cylindrical projection, deleting the foreshorting.


Figure 4: LRO WAC imagery. The dome under study is marked with white lines. The image is shown in cylindrical projection, thus deleting the foreshorting. On the summit of Crl are present some wrinkle ridges and a possible vent (under investigation).

## Morphometric properties: digital elevation map based on telescopic imagery and LOLA DEM

Generating an elevation map of a part of the lunar surface requires its three-dimensional (3D) reconstruction. A well-known image-based method for 3D surface reconstruction is shape from shading (SfS). It 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 for deriving 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 [3]. The SfS method requires accurate knowledge of the scattering properties of the surface in terms of the bidirectional reflectance distribution function (BRDF).
The height h of a dome is obtained by measuring the altitude difference in the reconstructed 3D profile between the dome summit and the surrounding surface, considering the curvature of the lunar surface. The average flank slope $\zeta$ was determined according to: $\zeta=\arctan 2 \mathrm{~h} / \mathrm{D}$. The uncertainty results in a relative standard error of the dome height $h$ of $\pm 10$ percent, which is independent of the height value itself. The dome diameter D can be measured at an accuracy of $\pm 5$ percent. The 3D reconstruction of the dome Cr 1 obtained using terrestrial telescopic images is reported in Figs. 5-6.


Figure 5: 3D reconstruction of Cril based on terrestrial telescopic image of Fig. 1 by photoclinometry and SfS analysis. The vertical axis is 15 times exaggerated.


Figure 6: 3D reconstruction of Cril based on terrestrial CCD image of Fig. 2 by photoclinometry and SfS analysis. The vertical axis is 25 times exaggerated.

The examined dome has a base diameter of $24.5 \pm 0.5 \mathrm{~km}$. The height of Cri1 measured on the images shown in Figs. 1 and 2 amounts to $215 \pm 20 \mathrm{~m}$ and $225 \pm 20 \mathrm{~m}$, respectively. Using the image of Fig. 3 the derived height amounts to $230 \pm 20 \mathrm{~m}$.

ACT-REACT Quick Map tool was also used to access to the LOLA DEM dataset, obtaining the crosssectional profile for the examined dome (Fig. 7).


Figure 7: LRO WAC-derived surface elevation plot of Crl based on LOLA DEM in N-S direction.
The most elevated part of the surface section covered by the DEM (in N-S direction) has a height of $220 \pm$ 20 m , thus consistent with the measurements carried out on the telescopic images, yielding an average slope of $0.98^{\circ} \pm 0.1^{\circ}$.
The edifice volume is determined, assuming a parabolic shape, to $51 \mathrm{~km}^{3}$.

## Spectral data

Spectral data have been obtained using Chandrayaan-1 Moon Mineralogy Mapper ( $\mathrm{M}^{3}$ ) an imaging reflectance spectrometer that can detect 85 channels between 460 to $3,000 \mathrm{~nm}$. The spectrum of the dome (Fig. 8) displays a narrow trough around $1,000 \mathrm{~nm}$ with a minimum wavelength at 975 nm and an absorption band at $2,130 \mathrm{~nm}$, corresponding to a typical High-Ca pyroxene signature, indicating a basaltic composition.


Figure 8: Moon Mineralogy Mapper $\left(M^{3}\right)$ spectra of the examined dome.
The Clementine UVVIS spectral data reveal a colour ratio of $\mathrm{R}_{415} / \mathrm{R}_{750}=0.5713$, indicating a low $\mathrm{TiO}_{2}$ content $<3 \%$.

## Classification

According to the classification scheme for lunar domes [3] Cri1 belongs to class $\mathrm{C}_{1}$. It is the second dome identified in Mare Crisium during our survey after Yerkes1 (Fig. 9).


Figure 9: Image taken by Teodorescu on October 3, 2020 at 23:02 UT using a 355mm Newtonian telescope and ASI 174MM camera. The dome Yerkes 1 is marked with white lines.

Ye1, with its low flank slope and rather low edifice volume, belongs to class $\mathrm{B}_{2}$ [3]. A map of this region including the dome Ye1 is published in our lunar domes atlas (http://crisiumdomes.blogspot.com/). Further analysis is ongoing.

We encourage more high-resolution imagery of this area so we can have more data of this dome, which is under study. Please check also your past imagery and send them to me for the ongoing study (lunar-domes@alpo-astronomy.org).

## References

[1] Basaltic Volcanism Study Project, 1981. Basaltic Volcanism on the Terrestrial Planets. New York: Pergamon Press.
[2] Lena, R., Lunar domes, chapter in Encyclopedia of Lunar Science Editor: Brian Cudnik, 2015, Springer ISBN: 978-3-319-05546-6.
[3] Lena, R., Wöhler, C., Phillips, J., Chiocchetta, M.T., 2013. Lunar domes: Properties and Formation Processes, Springer Praxis Books.
[4] Wilhelms, D., The Geologic History of the Moon, USGS Prof. Paper 1348. Washington: GPO, 1987.

