Observing Crisium 1 (second preliminary report): Is an inflation of the upper surface layers associated with the formation of the wrinkle ridges?

by Raffaello Lena

In a previous note a possible dome, provisionally termed *Crisium 1* (Cr1), has been described. It is detectable in the image taken by Tedorescu on October 3, 2020 at 23:02 UT (see http://www.alpo-astronomy.org/gallery3/var/albums/Lunar/Lunar-Domes/2020-Images/dome%20in%20Crisium%20-%20preliminary%20report-01.pdf?m=1604599104).
A campaign to encourage lunar observers to image Cr1 under waning moon phase was organized and started on November 1, 2020. This was done completely through internet, specifically through the use of e-mails and astronomical forums. The goal of this project was to image Cr1 under low solar illumination angle and to describe the relationship between Cr1 and the nearby topography of the Mare Crisium.

New Observations (November 1-2, 2020)
Fig. 1 displays the image of this second survey taken by Maximilian Teodorescu, from Romania, on November 1, 2020 at 22:03 UT.

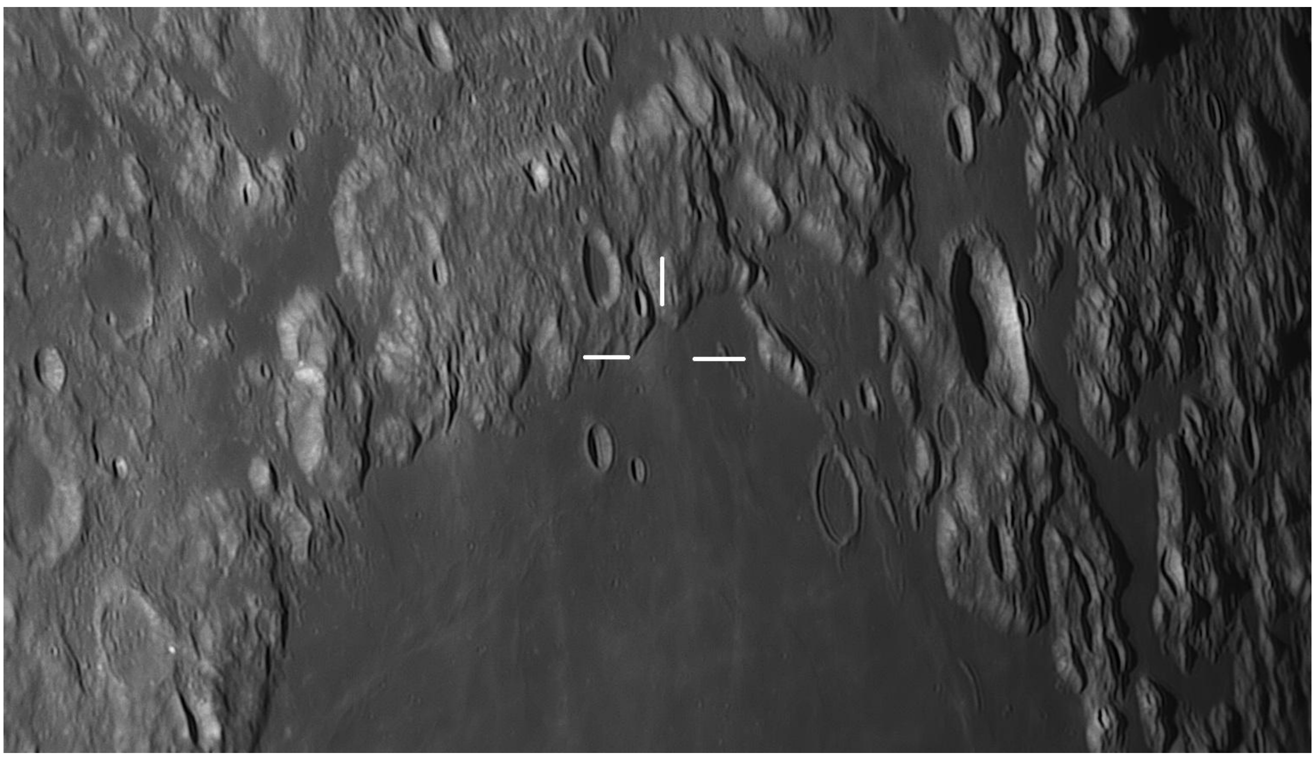

Figure 1: Image taken by Teodorescu on November 1, 2020 at 22:03 UT using a 355 mm Newtonian telescope and ASI 174MM camera.

Another image of this region was made by Pau, from Hong Kong, on November 2, 2020 at 17:27 UT (Fig. 2). The image taken under lower solar illumination angle displays the wrinkle ridges around the examined region.

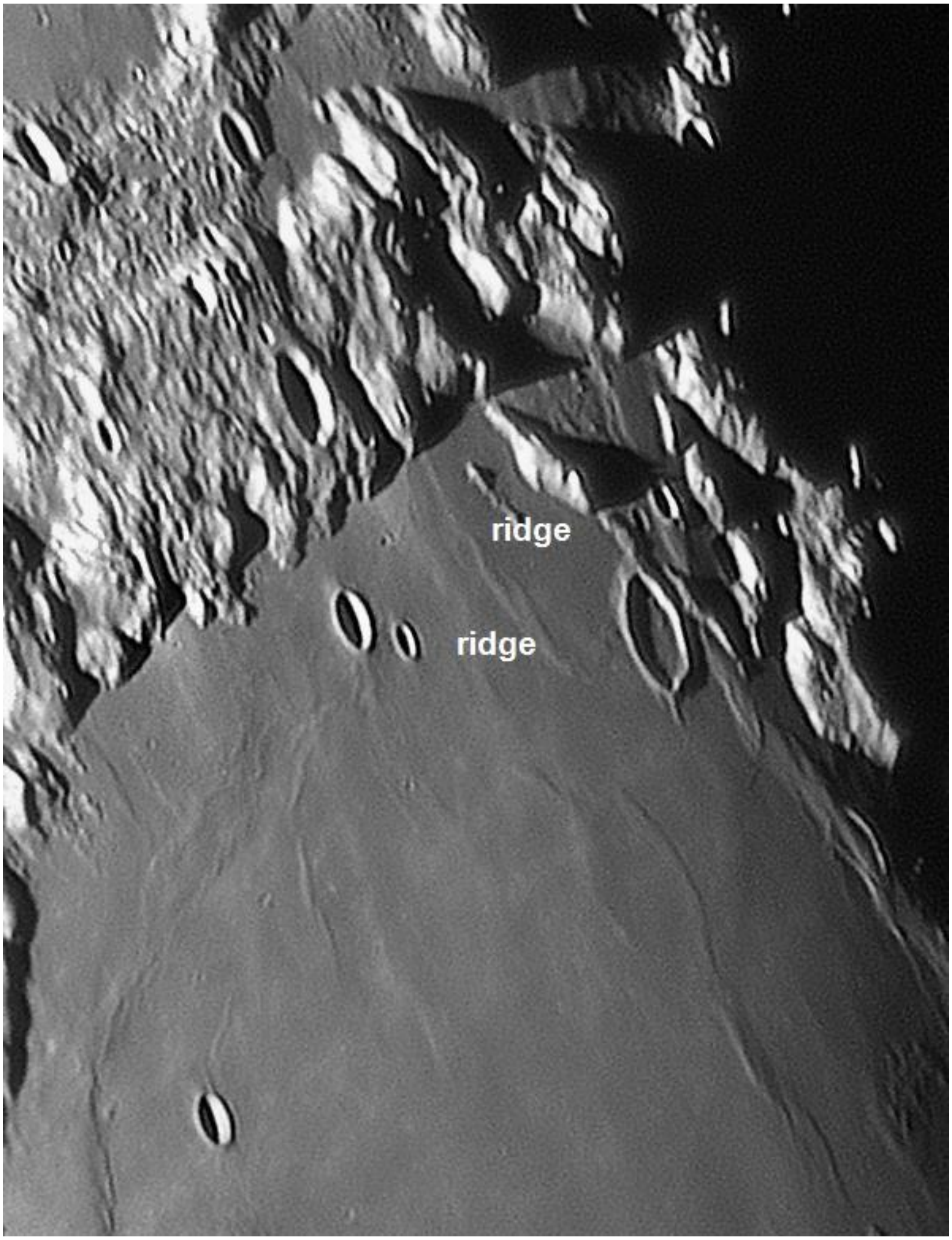

Figure 2: Image taken by Pau on November 2, 2020 at 17:27 UT using a 250 mm f/6 reflector and a QHYCCD290M camera.

Alessandro Bianconi from Italy has imaged Cr1 under lower solar illumination angle (about 3.5°) as shown in Fig. 3. The image was taken on November 2, 2020 at 22:53 UT. Note that under low solar illumination angle the dome surface is partially covered by the shadow of the nearby massif/hills located on the Crisium rim.

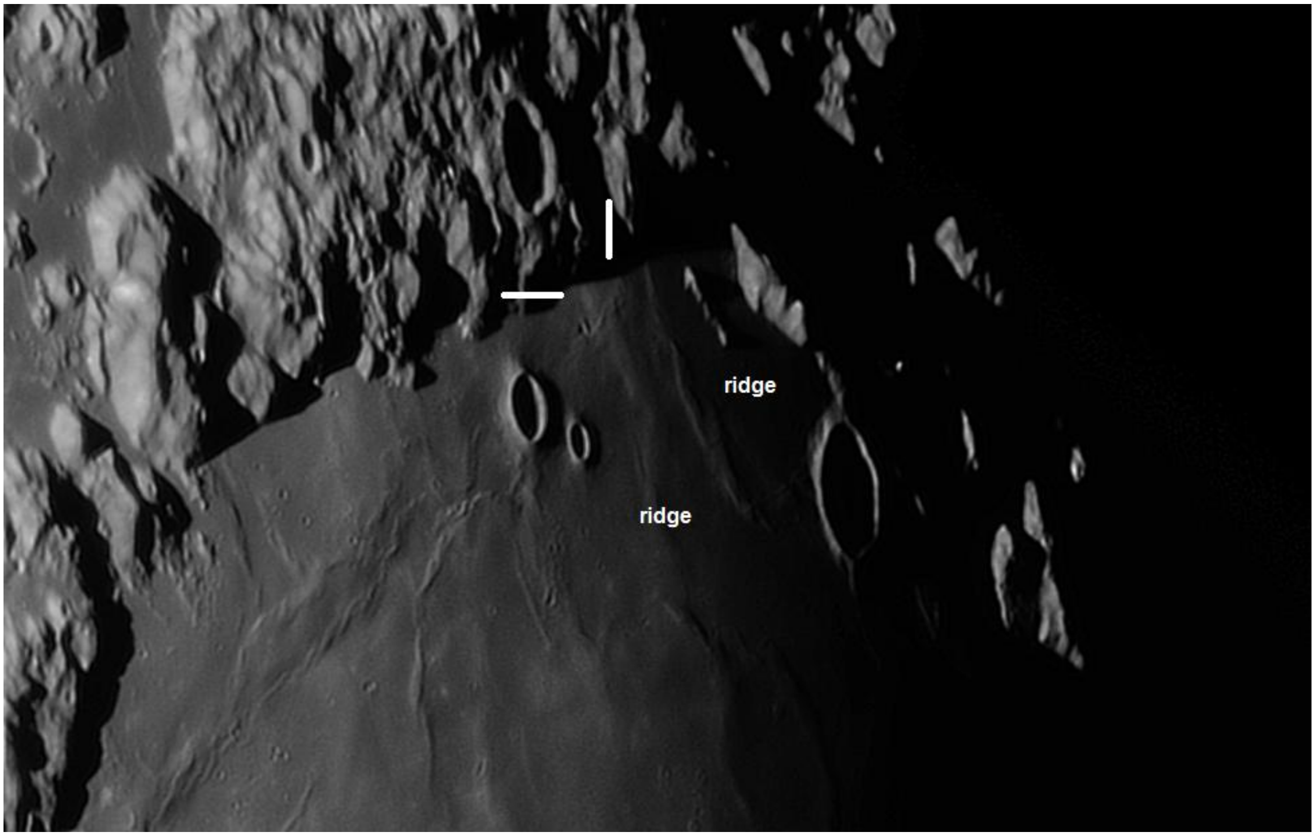

Figure 3: Image taken by Bianconi on November 2, 2020 at 22:53 UT using a C14 HD edge 10Micron GM2000HPSII and ASI174MM.

The recent telescopic images display a connection with the southern ridge when the region is imaged under grazing lighting conditions. Moreover two features like scarps traversing the surface of Cr1 are detectable located in direction SW (see feature A in fig. 8) and NS (see feature B in fig. 8), respectively.

Domes and ridges

Several known lunar domes, examined in the past, are characterized by a connection with wrinkle ridge. Some examples are represented by the dome Grimaldi 1 located in Grimaldi, C16 in the Cauchy region and the dome near Turner. The following figures show these domes (Figs. 4-7).

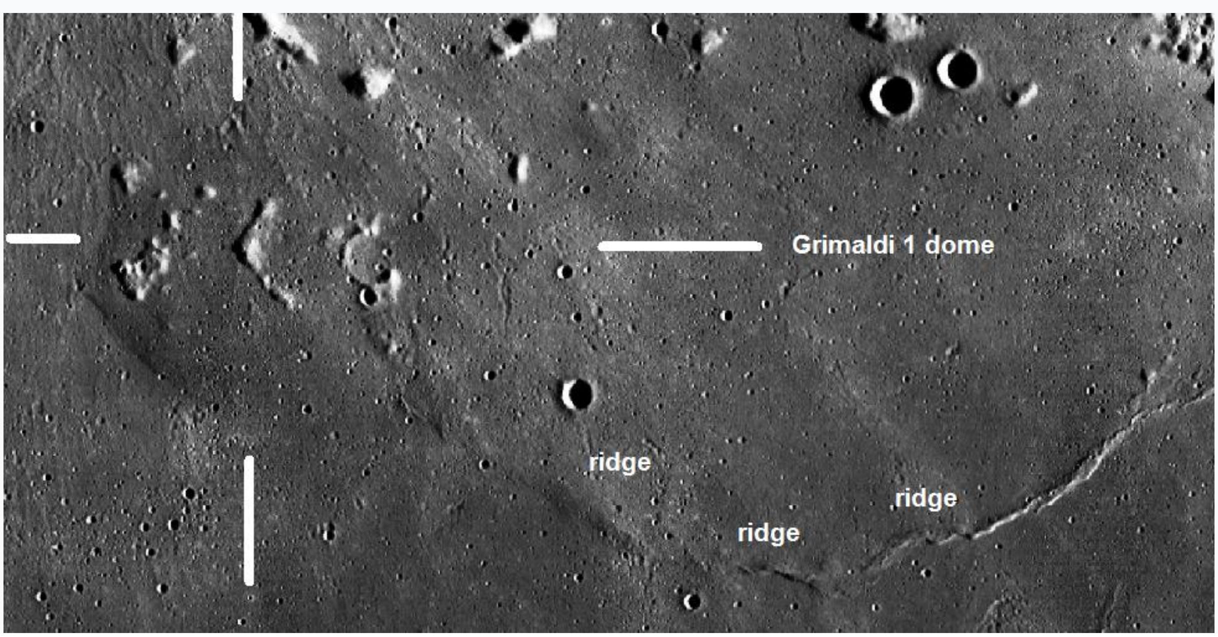

Figure 4: LRO WAC imagery. Dome Grimaldi 1.

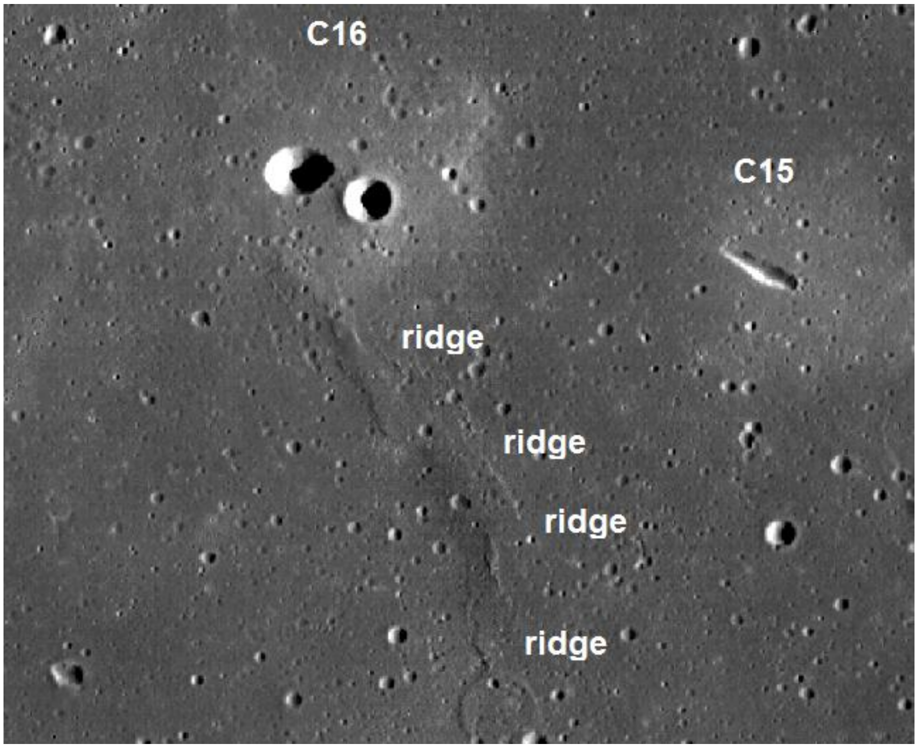

Figure 5: LRO WAC imagery, and the dome C16. The ridge is detectable also in CCD telescopic images in the lunar domes atlas (http://4.bp.blogspot.com/-qr0dWD-NPag/U7btUDmheYI/AAAAAAAAANE/ke9jfz_YUCA/s1600/Cauchyst390.jpg).

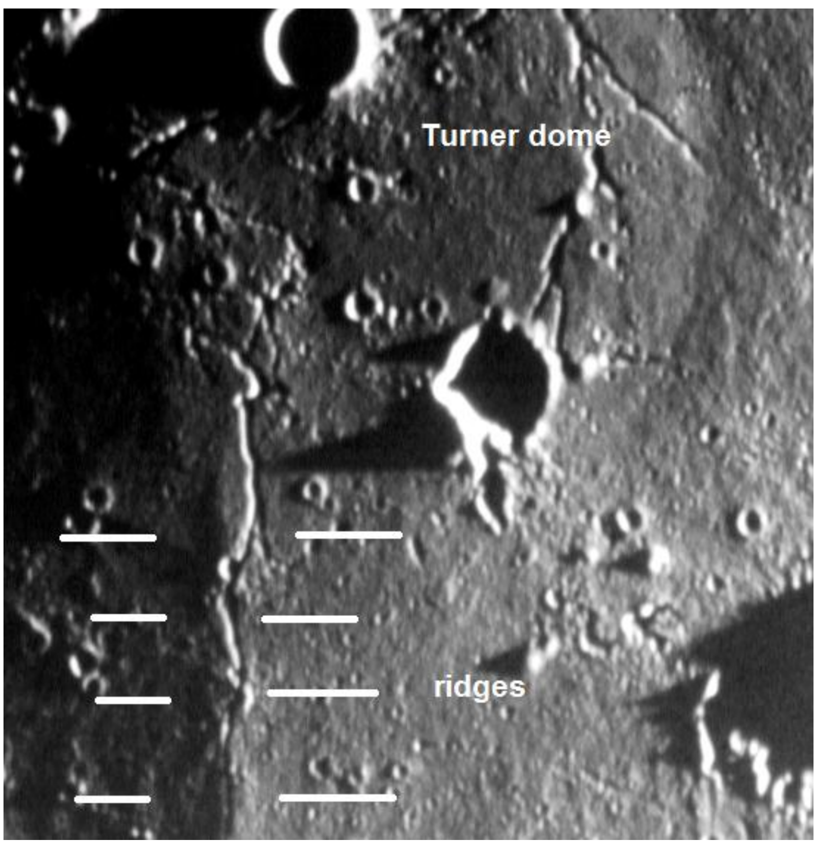

Figure 6: A dome near Turner with associated ridge. Apollo image AS12-50-7438.

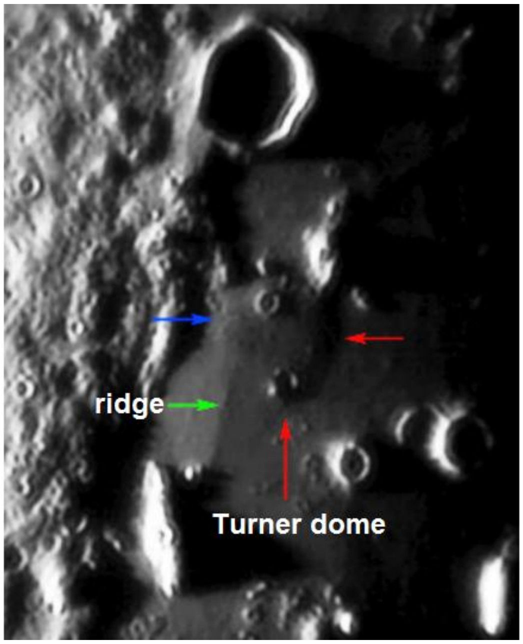

Figure 7: A dome near Turner with associated ridge. Image of the author.

Possibly the structure of Turner extends into the ridge. It would then be the manifestation of a subsurface volcanic dike with sill formation [Lena et al., 2013].

Digital elevation map LOLA DEM

ACT-REACT Quick Map tool was used to access to the LOLA DEM dataset, obtaining the cross-sectional profiles and 3D reconstruction for the examined region (Figs. 8-9).
Based on WAC imagery two low scarps run up through the surface of Cr1 near the elongated crater (Figs. 8-9).
The first feature, labelled as B, is 70-80m high and could be a continuation of another lobate scarp, labelled as A that approaches the dome from the SW. The scarp A is 60-70m high based on LOLA DEM measurements. There is another ridge that approaches the eastern rim of Cr1 from SE (labelled as C in Figs. 8-9).
The scarp B heads off towards the N and the mountain massif that forms the border of the mare Crisium.

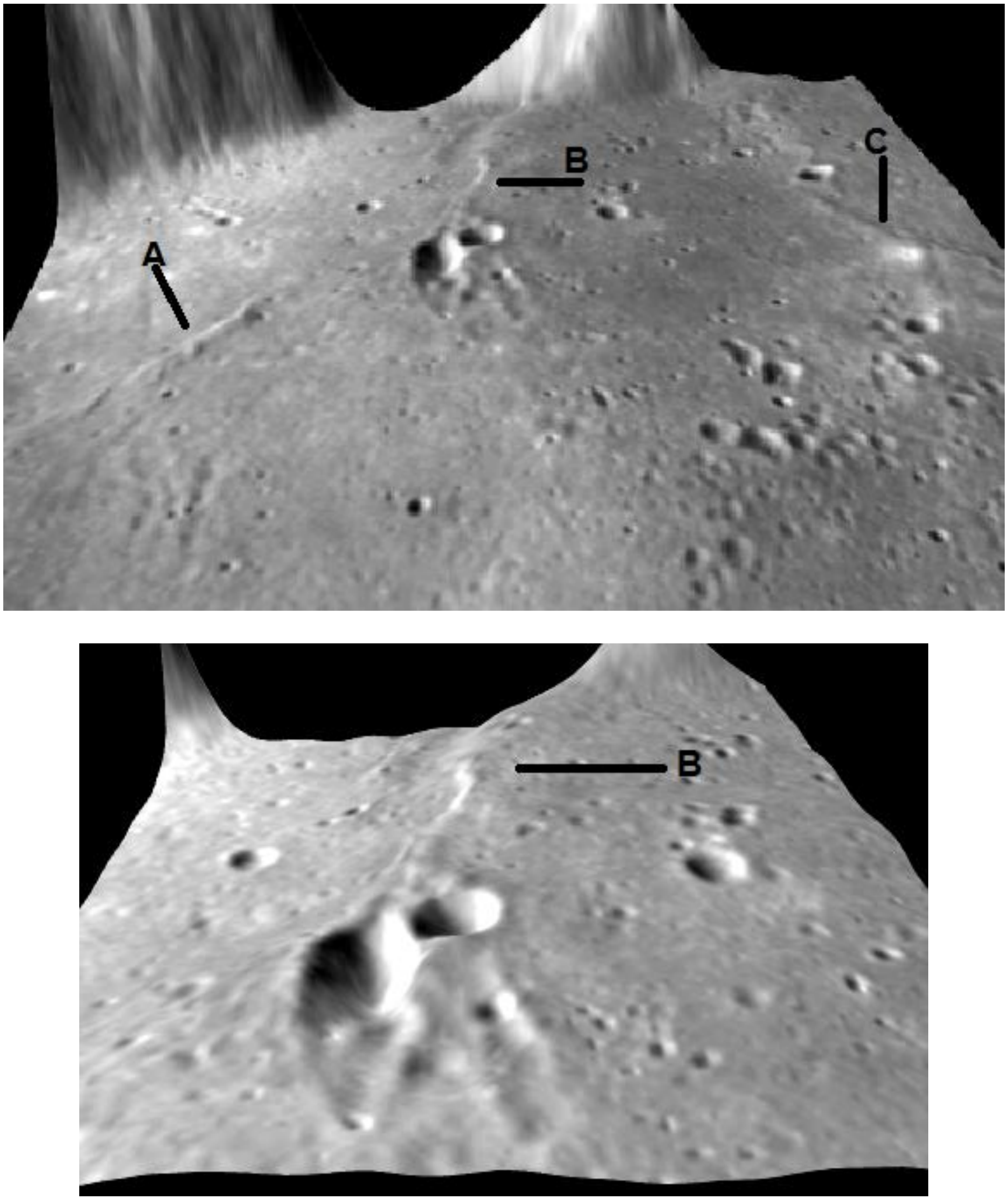

Figure 8: LRO WAC-derived surface elevation. See text for detail.

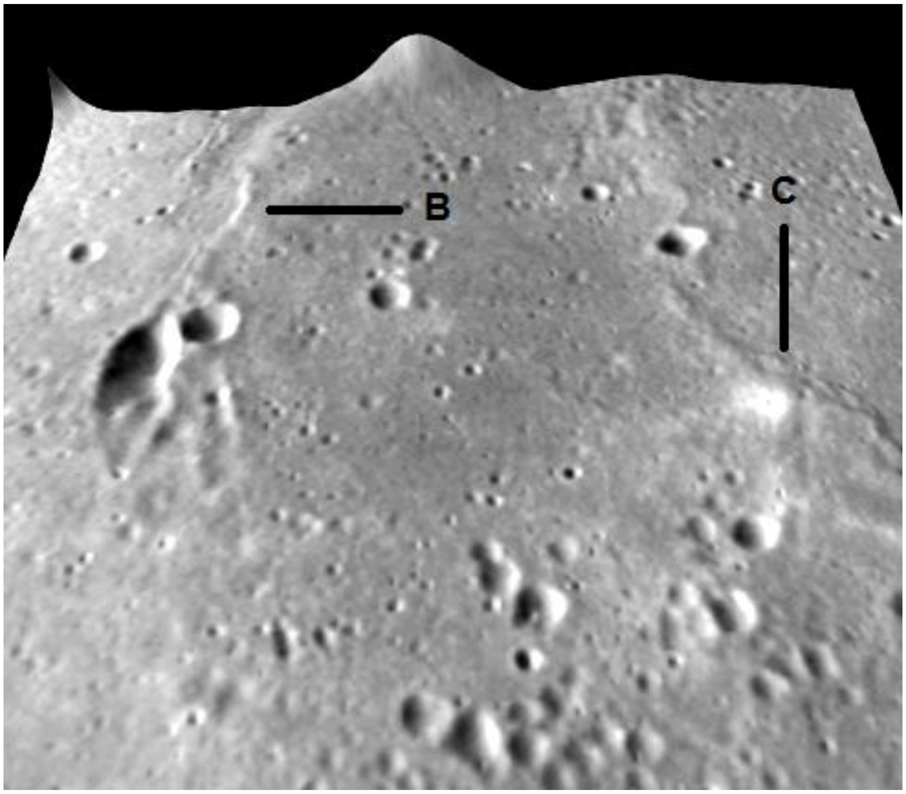

Figure 9: LRO WAC-derived surface elevation.

Along the boundary of the two lobate scarps the feature forms a west facing escarpment suggesting a low angle thrust fault, with the terrain on the eastern side overriding that on the western side (Fig. 9).

Morphometric updated data

Based on new terrestrial telescopic images and the boundary with the mentioned ridges, I have updated the morphometric data without the inclusion of the ridges (and their heights) in the corresponding measurements. This correction yields lower values of the height as shown in Figs. 10 and 11. In the revised measurements the crater Cleomedes F has been used as reference point of the southern rim of Cr1.

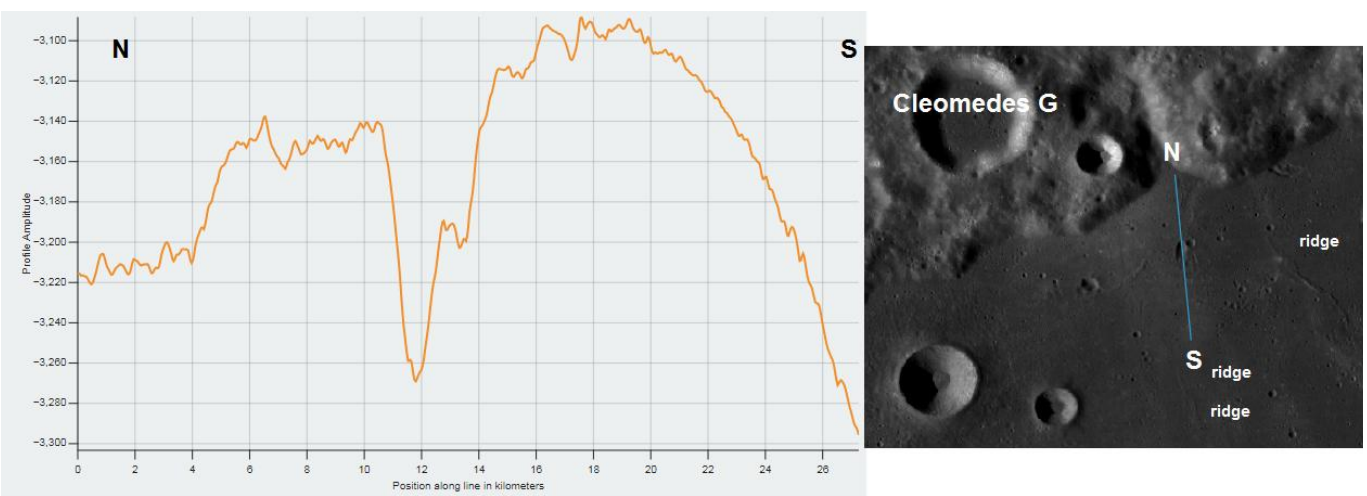

Figure 10: LRO WAC-derived surface elevation in NS direction, excluding the southern ridge to the South of Cr1, as shown in the telescopic images. The height amounts to 160m in NS direction. Note that including part of the ridge the height amount to about 230m as computed in the first preliminary report.

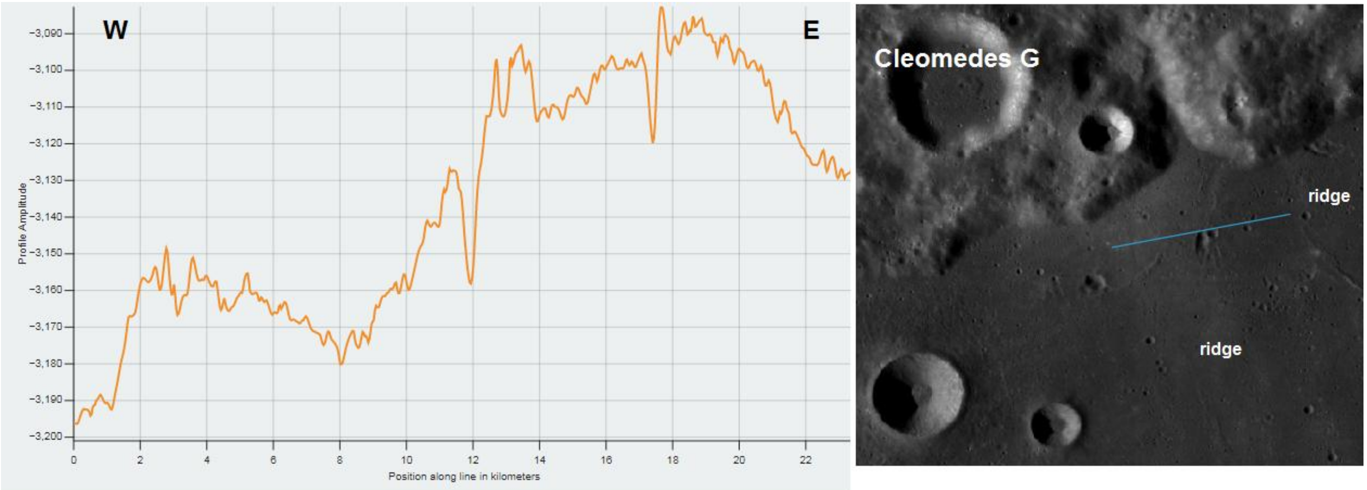

Figure 11: LRO WAC-derived surface elevation in WE direction, based on the boundary shown in the telescopic images. The height amounts to 70m in WE direction.

The outline of a dome can be described by a major axis **a** and a minor axis **b**; thus the dome diameter may be defined as the geometric mean:

$D = \sqrt{\mathbf{a}\,\mathbf{b}}$ and its circularity as c = **b/a,** while the flank slope is defined as slope= arctan (2h/D).
The mean diameter amounts to 24.65km (a=27.0km and b=22.5km) and the circularity is determined to c= 0.83.

Possible interpretation
In the work by Head and Gifford, mare domes of class 4 are associated with mare ridges and arches [Head and Gifford, 1980. Lunar mare domes: classification and modes of origin. Moon Planets 22, 235–257]. The fact that Cr1 is located close to border of impact basin would indicate a formation due to:

1) Magma rise through dikes guided by stress fields resulting from basin subsidence as a consequence of lava loading. The derived morphometric data are compatible with the classification of a C_1 effusive dome but, in this scenario, is not clear the origin of some lobate scarps on its summit (as described in the section *Digital elevation map LOLA DEM*). However lobate scarps and ridges are present in some well known domes, e.g. Mons Rümker
https://agupubs.onlinelibrary.wiley.com/reader/content/1677c5db7e8/10.1002/2016JE005247/format/pdf/OEBPS/pages/bg3.png

Or
2) An up-arching of the central part of Cr1 as result of a next magma intrusion forming a laccolith within the crust. In this scenario, after an effusive phase, a magmatic intrusion occurred creating a west facing escarpment. Based on the circularity (c=0.83) and modelling results Cr1 does not match the properties of putative intrusive domes regarded in previous studies. Another thing that may argue against an intrusive origin for Cr1 is the lack of any sort of extensional fractures (rilles). However it is equally possible that it is could be an intrusive dome where the low pressure did not result in the tensional features usually associated with laccoliths, but these domes of class In2 are more elongated than Cr1 (c>0.8) and characterized by smaller and slightly steeper edifices with diameters of 10–15km and flank slopes between 0.4° and 0.9°.

Or
3) Cr1 can be interpreted as a larger extension of the southern ridge, and thus not an effusive lunar dome.

Or

4) This complex bulge may have formed when magma, or volcanic gases, rose under a lava flow near the surface and inflated it. Thus, based on new acquired data described above, the most likely explanation could be that Cr1 is an inflation of the upper surface layers associated with the formation of the wrinkle ridges that cross the mare margins.

Conclusion

I encourage high-resolution imagery of this area during the next lunation to confirm the hypothesis of an inflation of the surface layers associated with the formation of wrinkle ridges. If any reader has further hypotheses, the debate is welcome (lunar-domes@alpo-astronomy.org). Cr1 is a complex feature and raises quite a lot of questions regarding interpretations of these bulges associated with ridges.

References

1) Head, J. W., Gifford, A., 1980. Lunar mare domes: classification and modes of origin. The Moon and Planets 22, 235-257.

2) Kerr, A. D., Pollard, D. D., 1998. Toward more realistic formulations for the analysis of laccoliths. J. Structural Geology 20(12), 1783-1793.

3) Lena, R., Wöhler, C., Phillips, J., Chiocchetta, M.T., 2013. Lunar domes: Properties and Formation Processes, Springer Praxis Books.