Lunar Section

British Astronomical Association

Director: Bill Leatherbarrow

LUNAR SECTION CIRCULAR

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Earthshine and the Crescent Moon from Flagstaff, Arizona

8 March 2021, AP-155 f/7 refractor and Canon 6D camera (Klaus Brasch)

FROM THE DIRECTOR

A combination of a few clear nights, the Moon's higher elevation in the evening sky and some favourable libration conditions has resulted in a welcome uptick in the number of observations submitted in recent weeks. Even more pleasing is the fact that many of these observations have been focussed on particular objectives and conditions. In this issue Paul Abel, Director of the Mercury & Venus Section, writes about his experiences observing the Aristarchus Plateau using different colour filters, and several observers have taken advantage of the favourable southerly and south-westerly librations during February to produce images of the Orientale Basin and the mountains of the South Polar Region.

This issue also includes interesting geological contributions from Barry Fitz-Gerald and Raf Lena. Space is therefore at a premium, so I shall keep these opening comments brief and close by wishing you clear skies for the next lunation!

Bill Leatherbarrow

OBSERVATIONS RECEIVED

Drawings and images have been submitted this month by the following observers:

Paul Abel, Leo Aerts (Belgium), Klaus Brasch (USA), Maurice Collins (New Zealand), Daryl Dobbs, Dave Finnigan, Clyde Foster (South Africa), Mike Foulkes, Rik Hill (USA), Chris Hooker, Rod Lyon, Luigi Morrone (Italy), Mark Radice, Phil Shepherdson, Alexander Vandenbohede (Belgium), George Whiston, and the Director.

Because of pressure on space, as well as the concentration on certain areas in this month's issue, I have had to be particularly selective in deciding what to include. Apologies to those whose work does not appear in this issue; I shall do my best to include as much as I can in future issues.

THE ARISTARCHUS PLATEAU – Some Filter Observations

Paul Abel

Recently, the Director suggested that I might observe the Aristarchus Plateau to see if I could detect any colour. This region of the Moon contains many interesting features, and in Figure 1 I have given a chart of the plateau showing some of the most prominent features found within it.

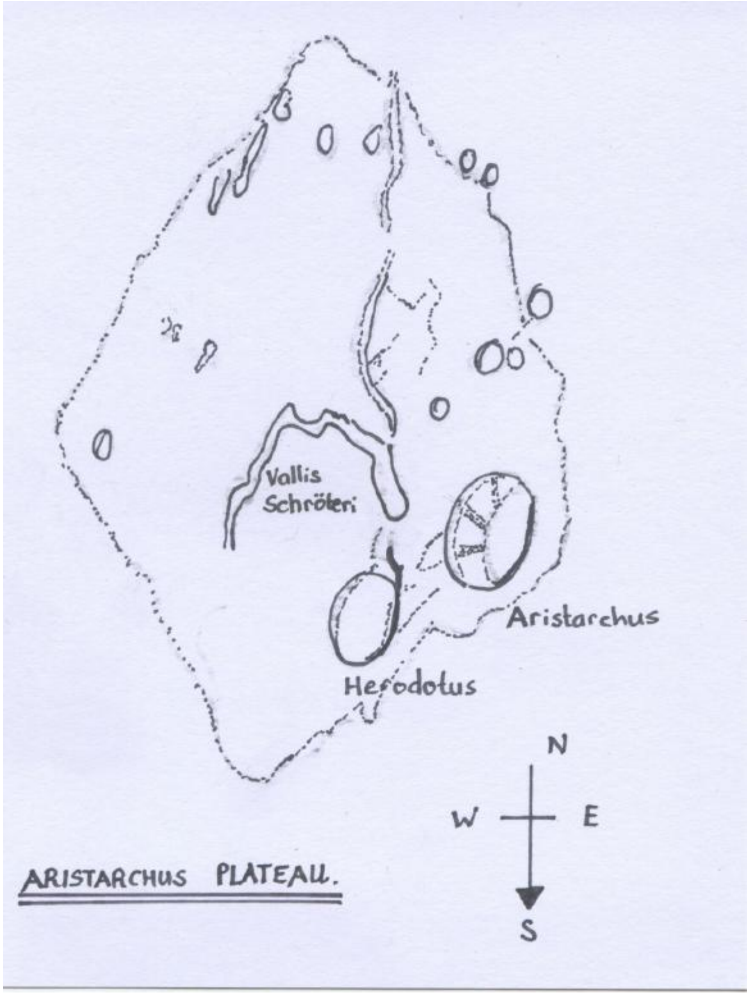


Figure 1: A chart of the Aristarchus Plateau drawn by the author using NASA's 'Dial-a-Moon' free software. The chart shows the orientation of the plateau on 2021 February 25 at 2100UT.

The Plateau is named after the brilliant crater found within its boundaries. Aristarchus crater is the brightest crater on the lunar surface - it has twice the albedo of any other feature and can often be seen faintly glowing in the Earthshine when the Moon is in the waxing crescent stage. It is a large formation, some 40km in diameter and has an estimated depth of 2.7km. An interesting feature of Aristarchus is that the walls contain bands which radiate out from the floor of the crater.

Nearby, just to the south-west lies Herodotus crater whose inner floor has been flooded with dark lava. Herodotus is slightly smaller, some 35km in diameter and just 1.5km deep. To the north of both craters is the magnificent Schröter Valley – the largest sinuous rille on the lunar surface.

On 2021 February 25th, the feature was well placed for observation and so I decided to observe the entire region with a series of optical filters. For those unfamiliar with filters, the idea behind them is very simple – they allow some wavelengths of light to pass through, while stopping others. Each filter is assigned a unique number (called the Wratten Number) which can be found printed on the side. The filters themselves screw into the base of the eyepiece barrel and most telescopes usually come with a set. They have been used in the Mercury and Venus Section for many decades as they allow one to observe a variety of phenomena and cloud markings which are not always so apparent in ordinary white or integrated light (IL).

In the event, 2021 February 25th was clear, and I used my 305mm (12”) Newtonian to observe the feature – a power of x115 seemed to be suitable. The results of the observations are given in table 1. Essentially in IL, I was able to detect some vague orange colour but it was hard to pin down and seemed to occur in patches rather than a uniform colour.

The whole feature was notably darker in W47 – a strong violet filter. Again the feature wasn't uniformly dark; rather there were a number of darker patches and dark spots. This may tie in with the work of Robert Wood who in 1911 photographed the area in UV and discovered that it looked unusual.

The greatest surprise was the application of the W21 (orange) filter: in this light the bands of Aristarchus became much darker, perhaps the darkest I've ever seen them. They were also incredibly well defined in contrast to the view of them with the W47 where they were notably harder to see!

This is the first time I have engaged in filter work for lunar observation, and after obtaining these results, it seems to me that this might be an interesting line of observation to follow; in effect investigating the response to certain features and formations when observed through different filters. It is certainly something I intend to try in future!

UT	Filter	Remarks
2103	None	The whole region is quite easy to identify – a dark rhomboid shape set against the brighter lunar regolith. A vague hint of orange colour was present but not in a uniform way. Rather, it seemed as though there were patches of colour present in an ill-defined way.
2106	W15 (Yellow)	Interesting – similar view to IL. The feature is still quite prominent but not as obvious as in IL.
2109	W21 (Orange)	Very interesting! The features seems slightly darker in places, however the bands of Aristarchus are notably darker! This is probably the best view of them I've ever had. It is remarkable how much darker and more clearly defined they are in this filter!
2112	W47 (Violet)	Whole region is much darker in this filter! The floor of Herodotus is probably the darkest thing (other than shadows) that I have ever seen on the lunar surface. The whole region seems to contain darker spots. The bands inside Aristarchus are much harder to see in this filter.
2114	W80A (Light blue)	Dark patches within the plateau still present but the effect is not as pronounced as in the W47 filter. The bands in Aristarchus are now easier to see than in the W47 filter.

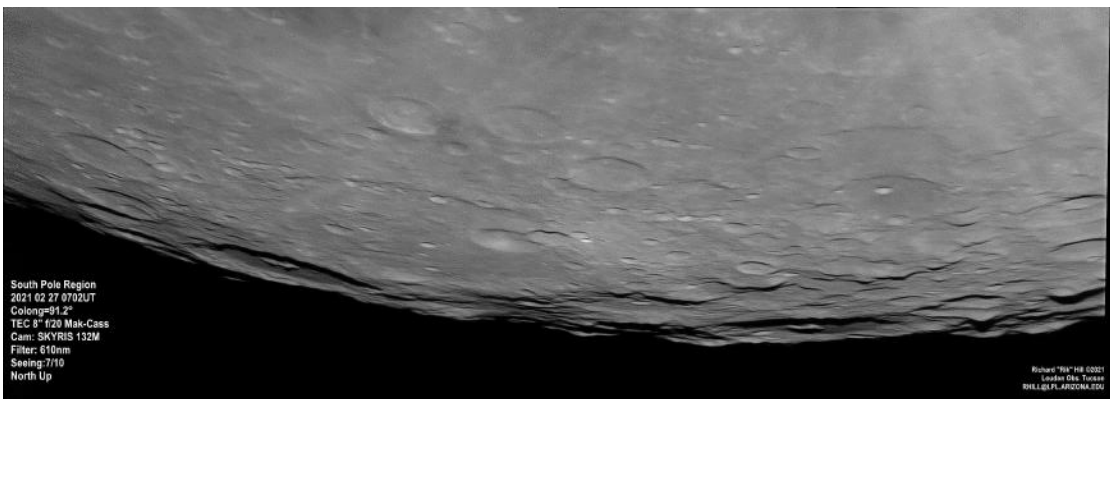
Table 1: Results of observations of the Aristarchus Plateau made with a 305mm Newtonian Reflector, x115 with various filters on 2021 February 25.

Rik Hill imaged the Aristarchus Plateau on the same date as Paul's filter observations, albeit at a different UT, given Rik's location in Arizona. The circles on his image (below) delineate the limits of the plateau.

SOUTH POLAR REGIONS

A favourable libration towards the end of February 2021 encouraged several members to submit images of this notoriously difficult region, where identification and interpretation of topographic features are severely hampered by extreme foreshortening. One can only admire the efforts of visual observers of the past, such as Ewen Whitaker and Harold Hill, who produced charts of the region without the help of modern imaging techniques.

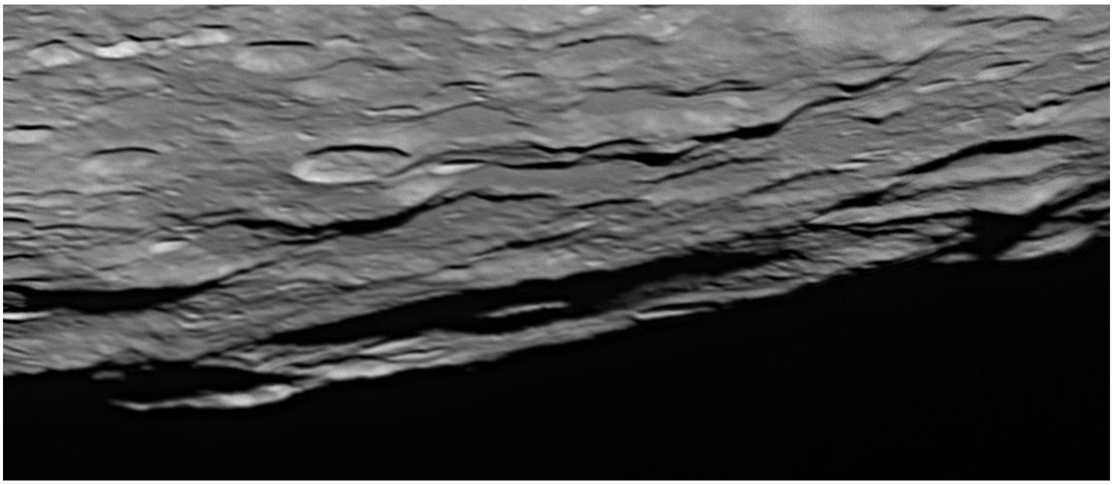
Rik Hill produced an overview of the area on 27 February, along with the following analysis of the major features visible.



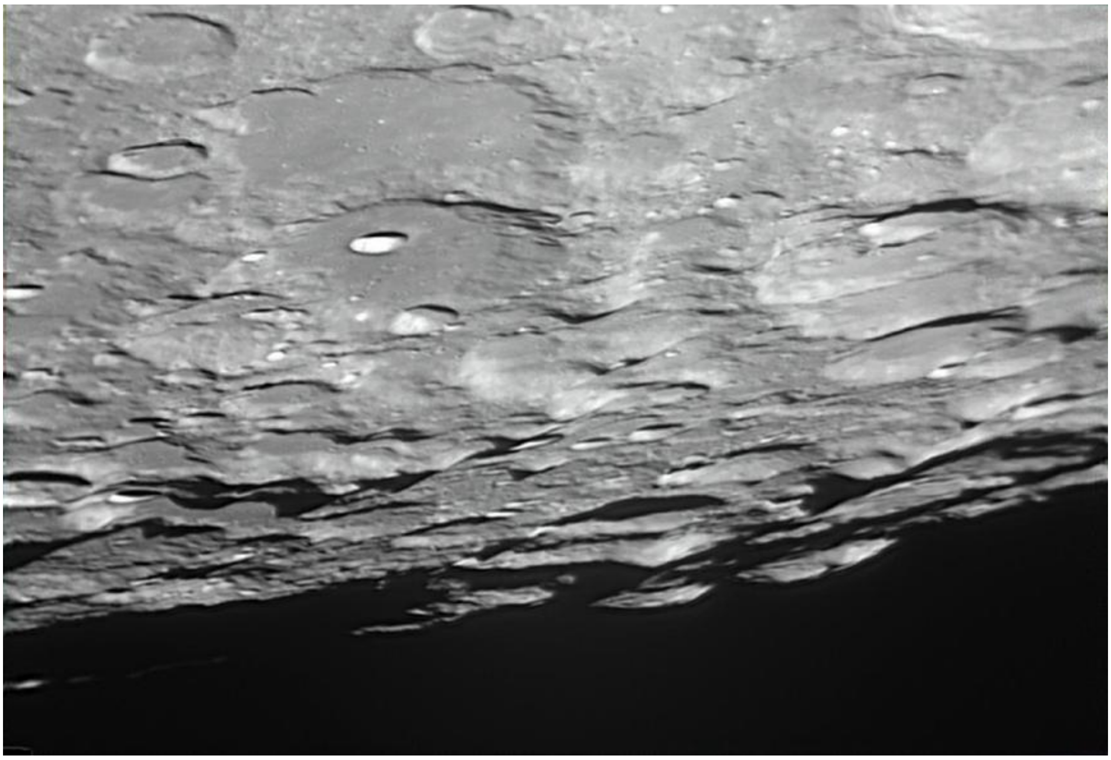
‘A recent favorable libration gave me a nice look at some South Polar features. The South Pole itself is essentially the right edge of the image. Just inside of that edge you can see a large mountain on the limb. This is "M5" on the Whitaker map of the S. Pole. Just to the left of it is "M4" and in front of that mountain is "M3". The large crater left of that is Drygalski (168km dia.) with a nice central peak. This crater is only occasionally in view when the libration is just right. Above and left of Drygalski is Le Gentil (116km) with a smaller crater on the floor by the near wall and a nice large mountain in the foreground. Behind Le Gentil is another smaller shadow filled crater, Boltzmann (76km), very rarely seen but we get a glimpse here, my first. Even further left we see another monster crater with a clear central peak, Hausen (172km).

Above Hausen, halfway to the upper edge, is a much smaller but clear crater with a small central peak, Zucchius (66km). Another clear slightly larger crater is to the right, Kircher (75km) and between them and a little above the similar-sized Bettinus (73km). These are almost always in view if the lighting is right and can act as markers to Drygalski and Hausen.’

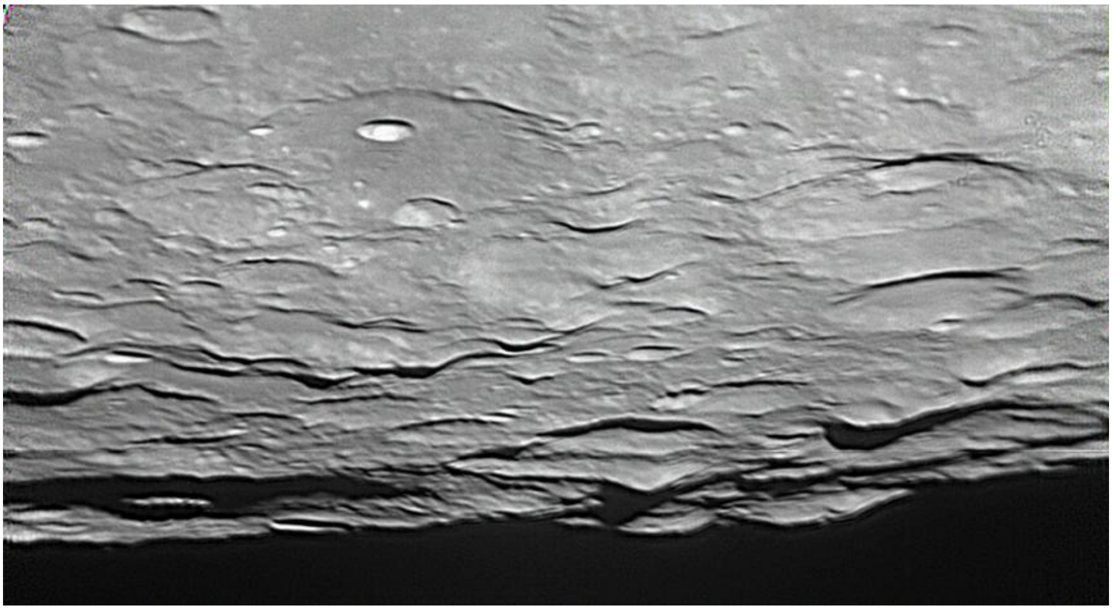
Chris Hooker also captured a favourable view of Drygalski on 26 February 2021, using a 10-inch (250mm) Newtonian.



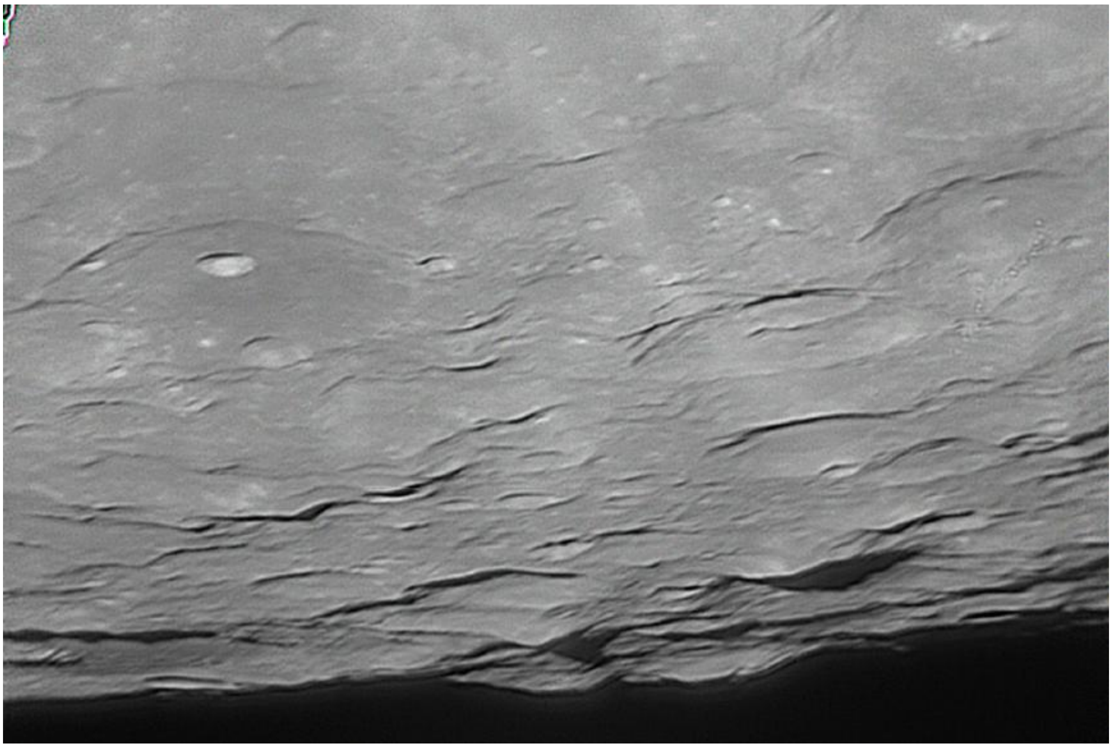
Mike Foulkes, Director of the Saturn, Uranus and Neptune Section, managed images of the South Polar Region on consecutive evenings (25, 26 and 27 February 2021), using a C11. The movement of the mountain shadows in azimuth is clearly visible from night to night.



South Polar Regions, 25 February 2021 (Mike Foulkes)

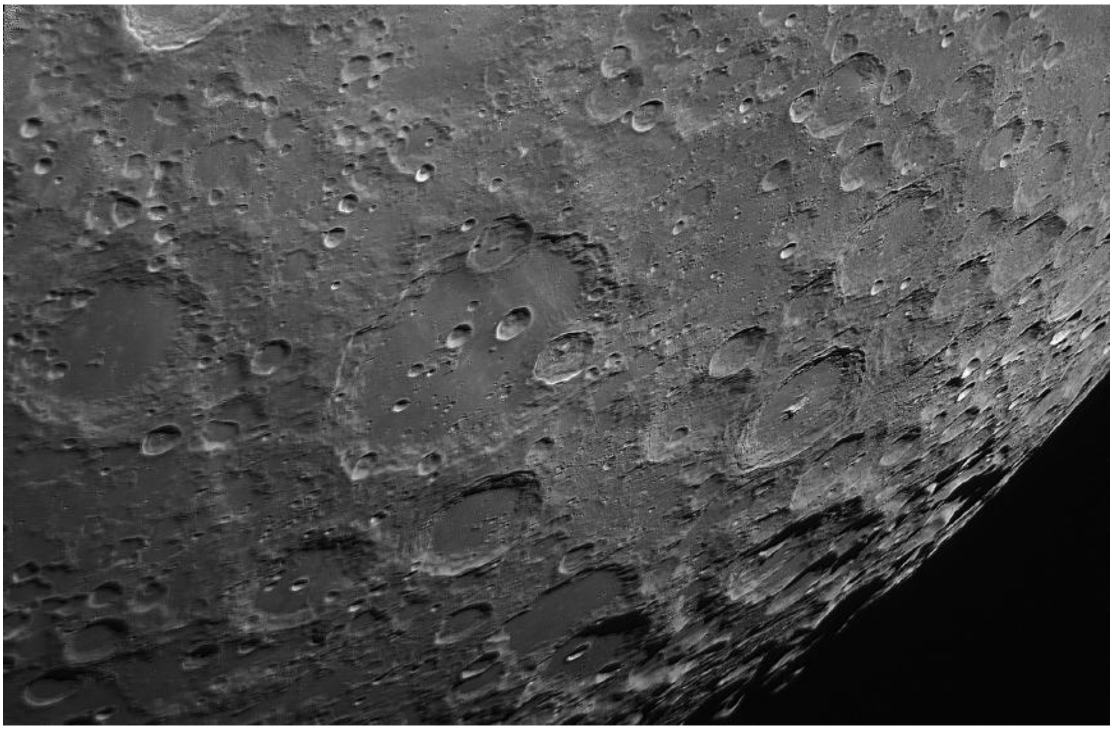


South Polar Regions, 26 February 2021 (Mike Foulkes)



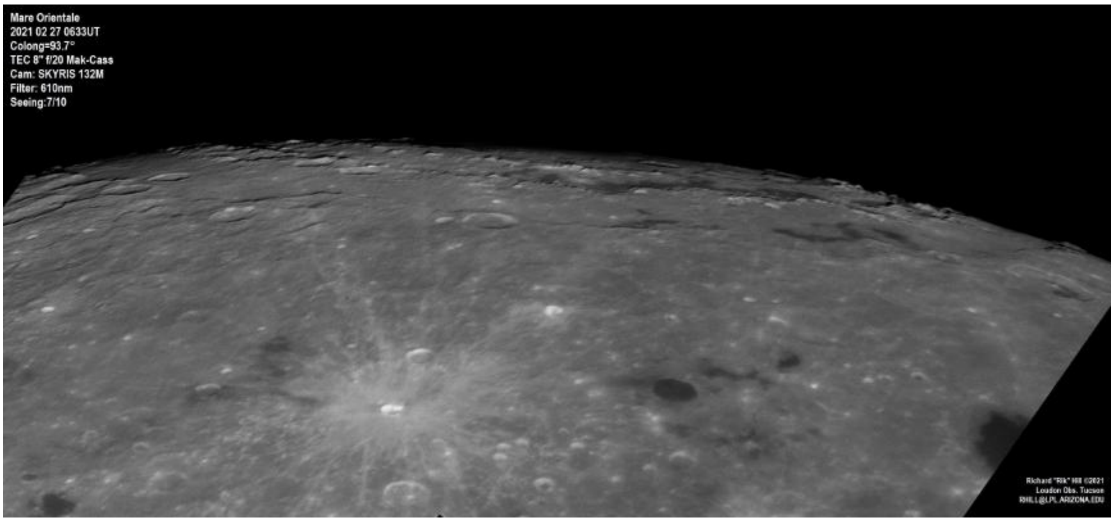
South Polar Regions, 27 February 2021 (Mike Foulkes)

Leo Aerts captured a more general view of the southern uplands on 23 February 2021, using a C14.



THE ORIENTALE BASIN

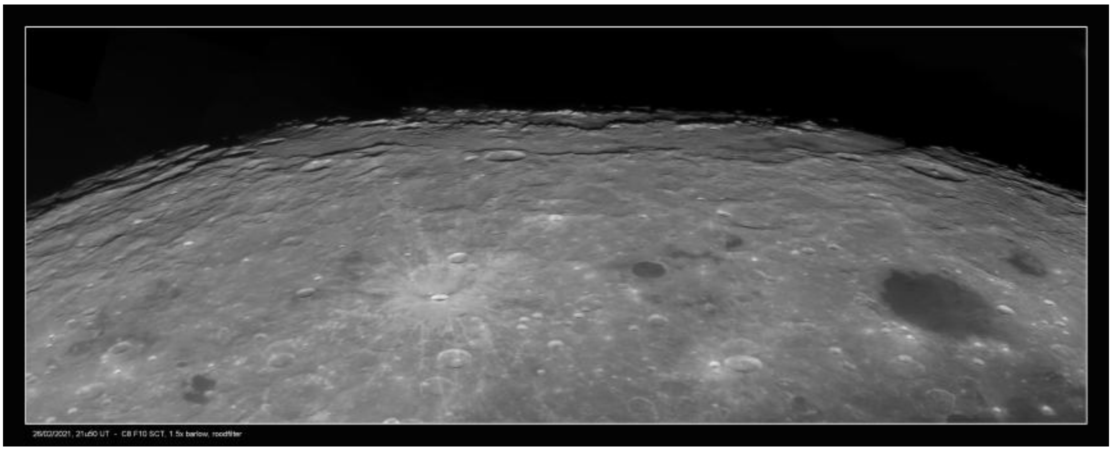
Libration also favoured the western limb during February and this allowed clear views of the eastern rings of the Orientale impact basin. Once again, **Rik Hill** has supplied a useful annotated overview of the area, captured on 27 February 2021.

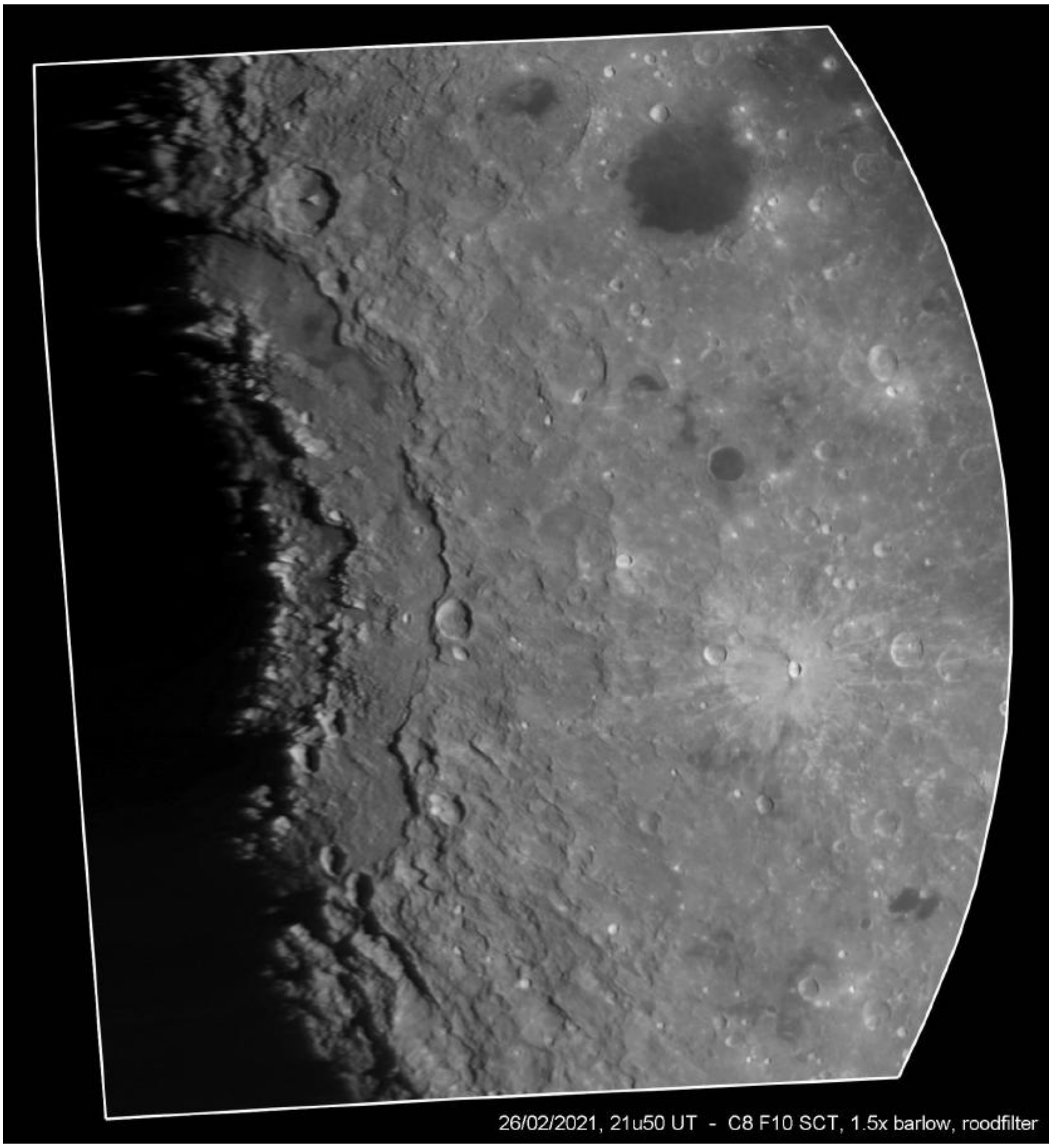


‘Good views of Mare Oriental or the Orientale basin are not frequent for Earth-bound observers. This last February was a good opportunity and I made the best of it taking this montage 6 AVIs stacked into 6 images and assembled with Microsoft ICE software. But seeing the basin in even the best Earth-based images takes a little work.

The dark crater just below center of the image is Cruger (48km dia.) with Lacus Aestatis the small sinuous dark region to the right of it. The partial dark area on the right edge is Grimaldi (228km). The bright rayed crater is Byrgius A (19km) with Byrgius (90km) just above it in the rays. Above this, halfway to the limb, is Eischstadt (51km) and left of that is the smaller Krasnov (43km). These last two craters sit on a scarp called Montes Cordillera that goes off to the right of Eichstadt to an "S" shaped region called Lacus Autumni. The Montes run clear across this image from just above the crater Schlüter (92km) on the right edge of this image, to the twin craters Shaler (49km) and Wright (41km) near the left edge. These Montes are the outer "walls" of the Orientale basin. Up above Eichstadt you'll see another sinuous dark marking, Lacus Veris that winds in and around the sparkling peaks of Montes Rook that extend right and left forming a concentric inner wall to this huge basin, the largest impact feature on the Moon.’

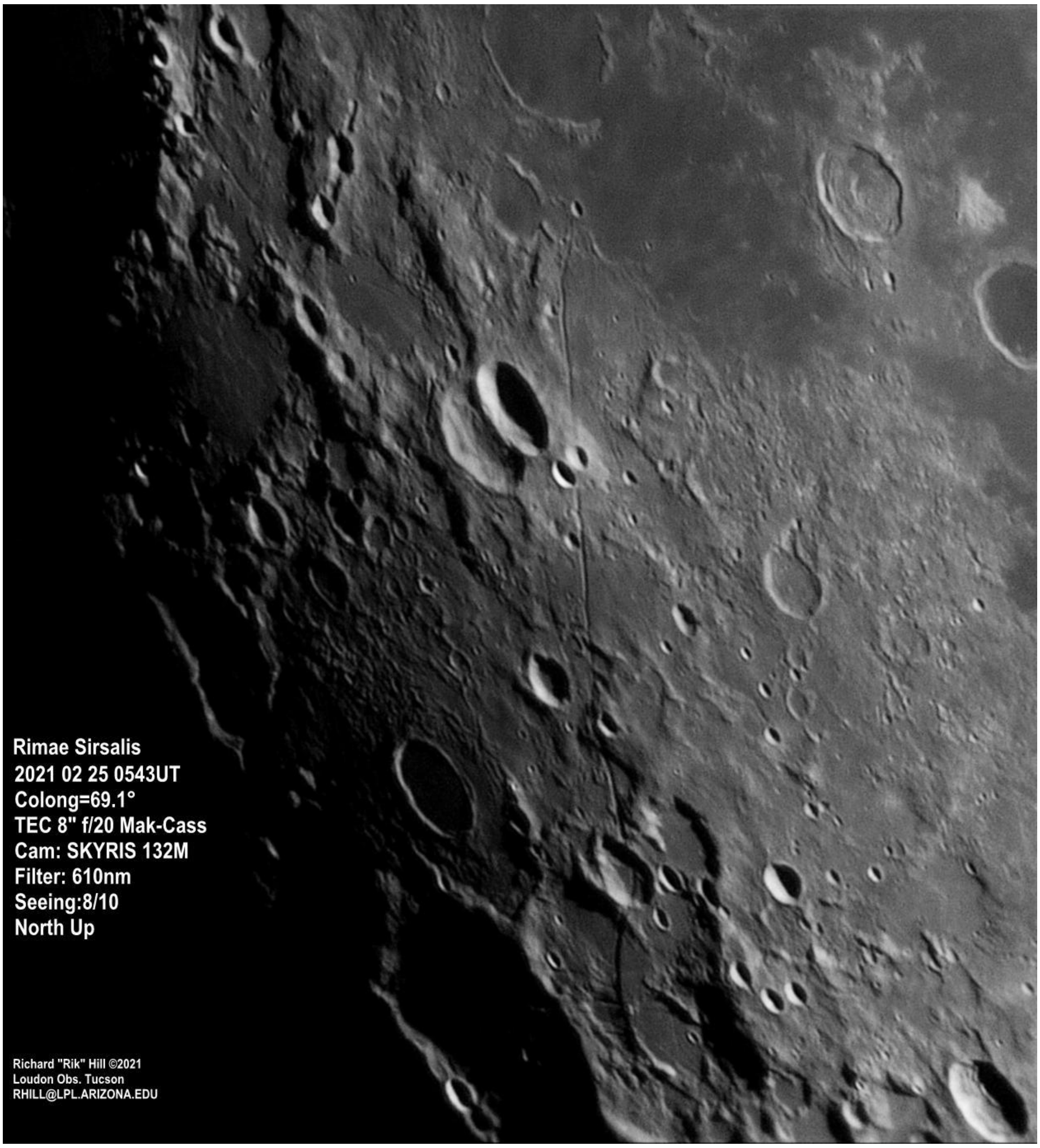
Alexander Vandenbohede imaged the Orientale Basin on 26th February 2021. His original image is given below, along with a spectacular rectified version that reminds me of the images produced by Bill Hartmann at Gerard Kuiper’s Lunar and Planetary Laboratory in the early 1960s. Those images were produced by projecting photographs onto a white globe and then photographing the limb areas from above, whereas now computer software can do the job much more efficiently. Hartmann’s images were the first to reveal properly the multi-ringed nature of the Orientale Basin – a feature that is even more striking on Alexander's superb image.





THE SIRSALIS RILLE

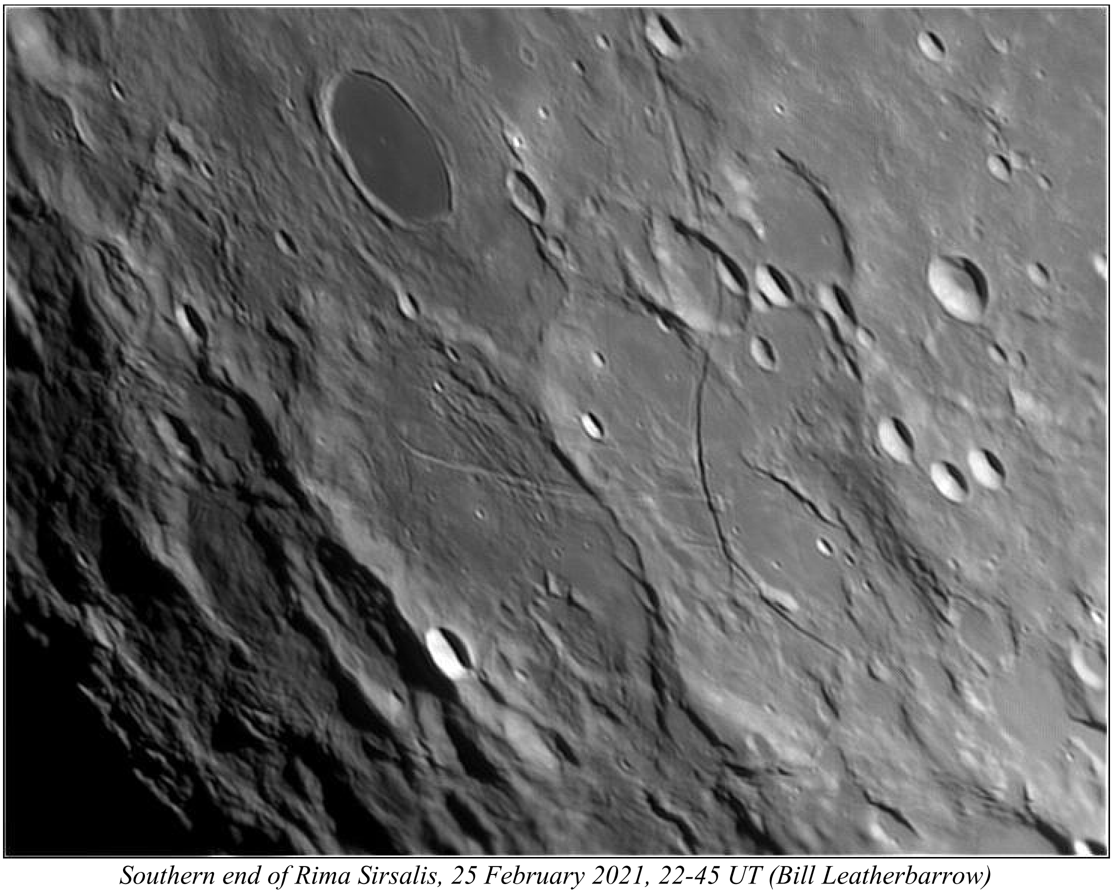
Rimae Sirsalis, perhaps the finest system of linear rilles on the lunar surface, was also favoured by libration during late February, although it is further from the limb and therefore easier to observe than either the South Polar regions or the Orientale Basin. Once again, **Rik Hill** was in the right place at the right time and has sent in the following image and report.



Rik writes: 'One of the longest systems of cracks on the Moon can only be seen as the Moon approaches the full phase. This is the Rimae Sirsalis that runs vertically right up the middle of this image from the curved lower end where it crosses Rimae Darwin and cuts right through the middle of the crater De Vico A (32km dia.) on its way north. The rimae are a series of graben-like trenches as seen in LROC QuickMap. They continue north past the twin craters Sirsalis itself (43km) and the crater it sits on Sirsalis A (48km). Note that the rimae pass through a pair of small craters just south of Sirsalis, Sirsalis F on the left (13km) and Sirsalis J on the right (12km). Both of these craters sit on top of the rimae making their relative ages younger than the rimae. The main rima terminates at the small crater Sirsalis K (7km) to the north. However just north of Sirsalis K is a large ring crater Sirsalis E and in its southern wall you can just make out a notch that is part of the larger rima which must have been buried by the lavas that formed during the flooding that created this portion of Oceanus Procellarum. This becomes quite clear again when looking at the QuickMap.

Before leaving this area, a few more landmarks need to be pointed out. The large shadow-filled crater at the bottom of the image is Darwin (134km) and above it another much smaller shadow-filled crater, Crüger (48km) one of the stepping-stones to Mare Orientale when it is visible. In the lower right corner of this image is the crater Henry Freres (43km) and in the upper right is the shallow crater Hansteen (46km) with its system of rimae to the south, and about half of the dark-floored crater Billy (48km) showing on the right edge. Between them notice the white triangular peak of Mons Hansteen.'

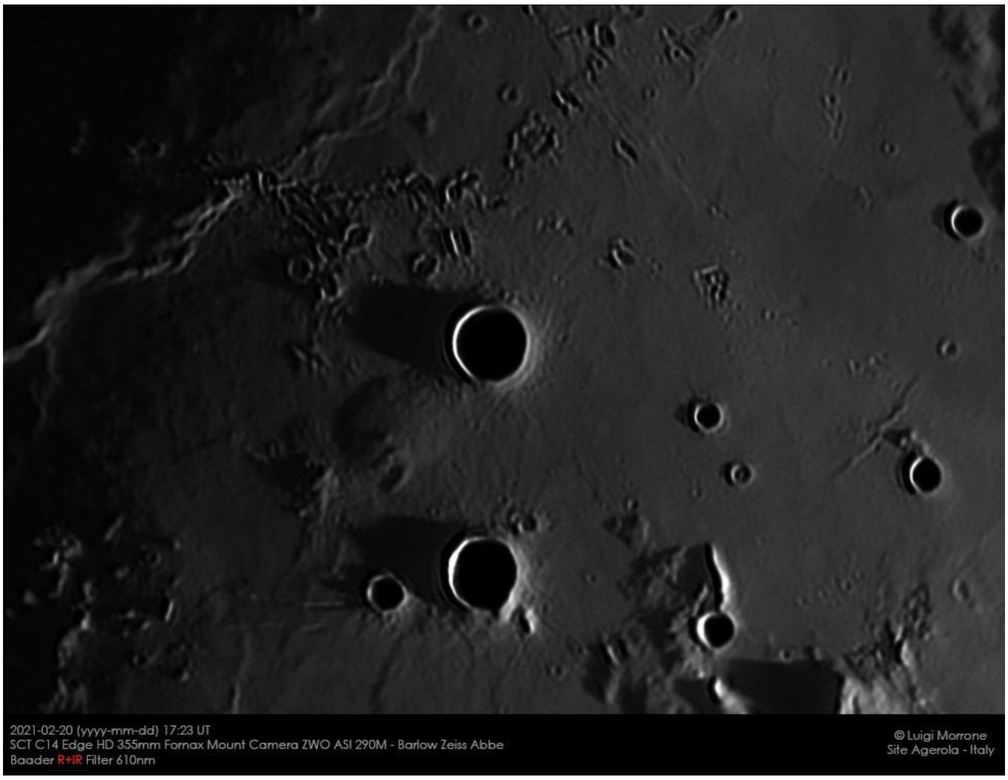
The Director imaged the southern end of Rimae Sirsalis on the same date, albeit at a later UT. This image shows the nature of the rille's passage through the crater De Vico A and its termination in a spur to the east of Darwin. The former used to exercise lunar observers in the 1950s and 1960s, with some arguing that the rille tunnelled under the walls of De Vico A. Modern imagery shows that this is not the case!

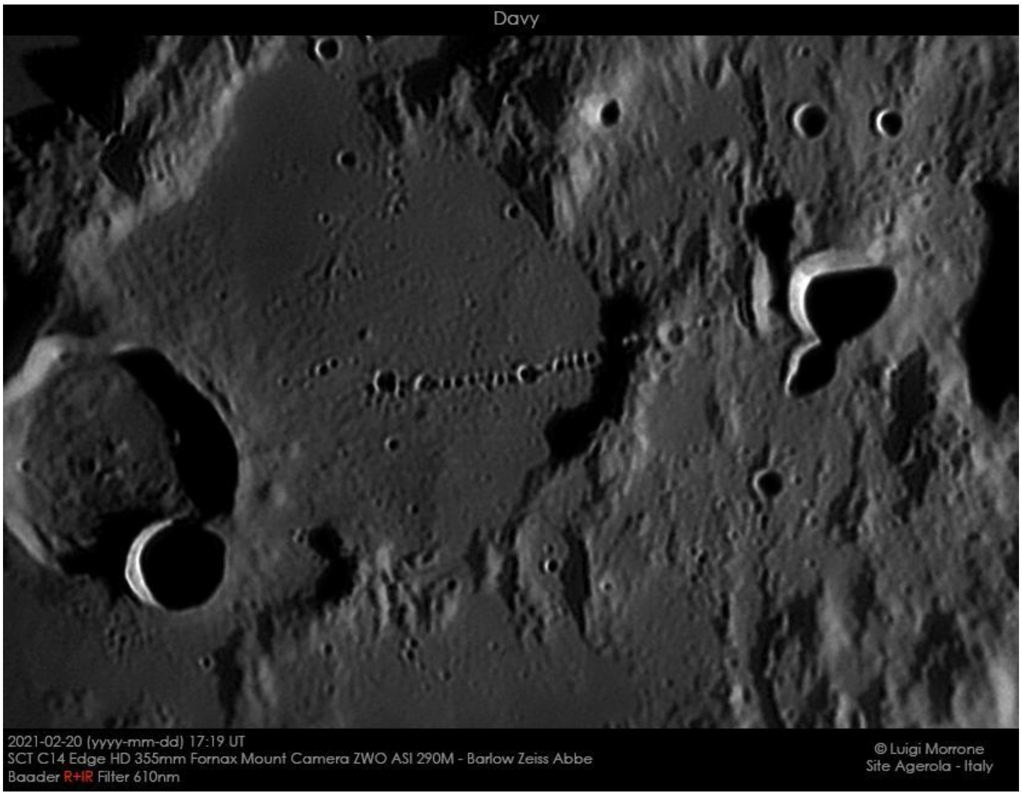


Southern end of Rima Sirsalis, 25 February 2021, 22-45 UT (Bill Leatherbarrow)

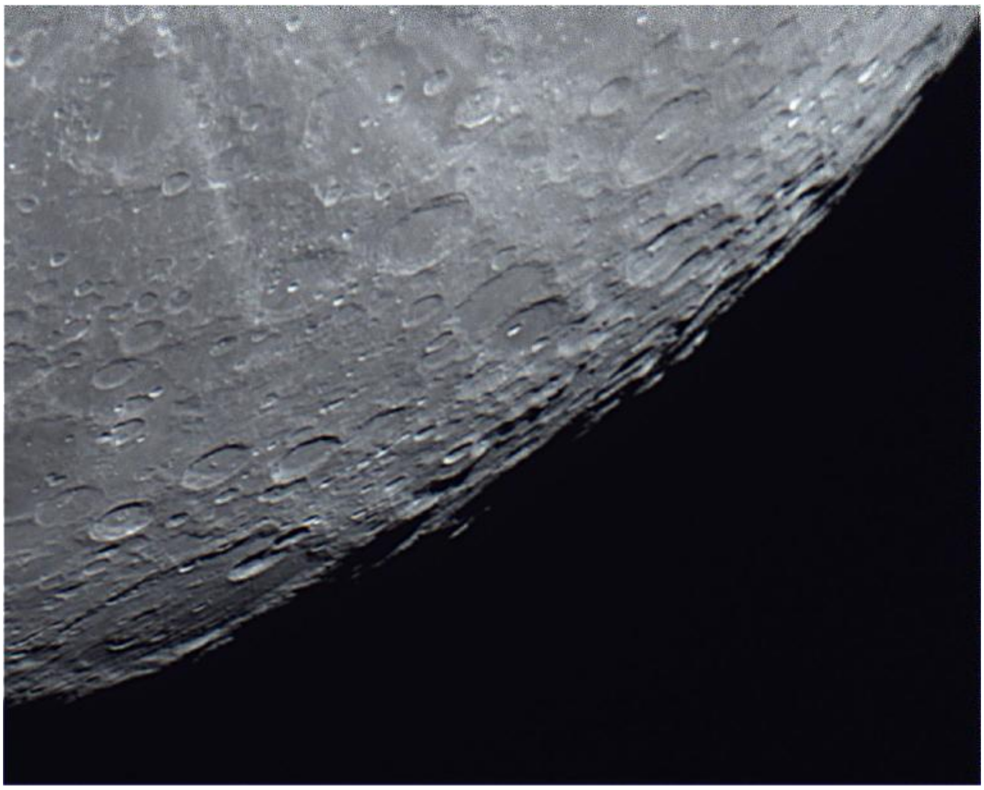
IMAGES GALLERY

Luigi Morrone has submitted the following images, showing domes near Gambart C and the Davy crater chain.

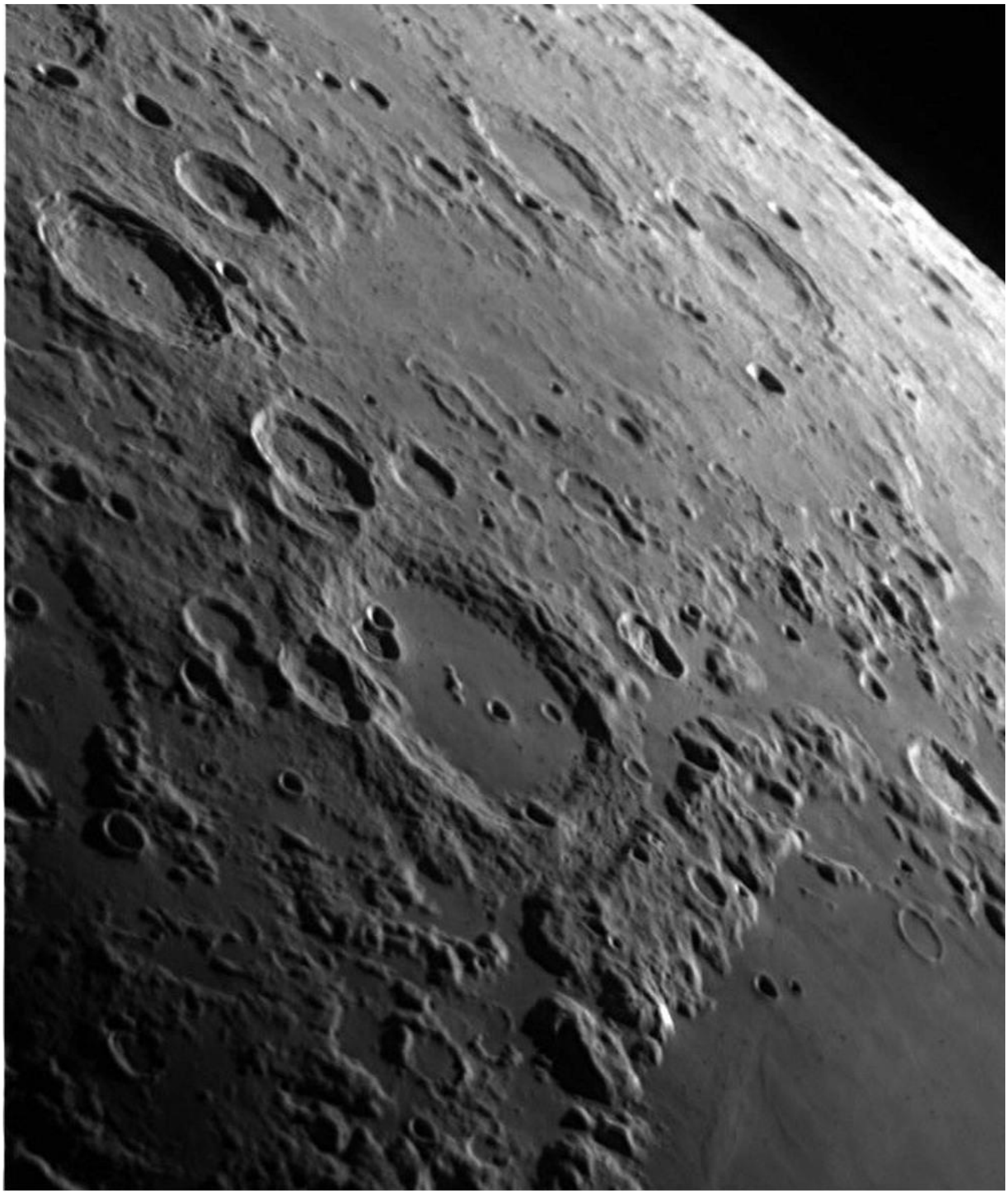




Schickard 2021.02.25 20:31UT, S Col. 76.4, seeing 4/10, transparency good.
Libration: latitude -05°21', longitude -05°20'
305mm Meade LX200 ACF, f 25, ZWO ASI 120MMS camera, Baader IR pass filter: 685nm.
800 frames processed in Registax 6 and Paintshop Pro 8.
Dave Finnigan, Halesowen



Bailly, 25 February 2021, 20-09 UT, 250mm spec. (Phil Shepherdson)



Cleomedes & Geminus to NW. 2021.03.17 - 18.27 UT
300mm Meade LX90, ASI 224MC Camera with Pro Planet
742nm I-R Pass Filter. 300/3,000 Frames. Seeing: 7/10.
Rod Lyon

LUNAR DOMES (part XLVI): Meton dome Raffaello Lena

In this issue I will describe a possible lunar effusive dome located on the floor of Meton, on typical light plains material. The selenographic position of the described lunar dome on the floor of the crater Meton, which is termed Meton 1, is 19.40° E and 73.14° N (Fig. 1).

Nearside craters such as Meton, Barrow, and Goldschmidt display rim topographies showing evidence of lineated troughs associated with the Imbrium basin. The light plains in Meton are mapped as light, fairly smooth, flat to locally undulatory surfaces in USGS map I-1062. This region consists of a surface type with typical highland characteristics as well as a second one with similarities to mare. The second type is mainly found close to the basaltic plains of Mare Frigoris, leading to the assumption that cryptomaria may be hidden under the light plains material. However, the existence of cryptomare units has not been verified so far by a detection of dark-haloed impact craters. Meton is located near the northern lunar limb, and is viewed from a low angle and foreshortened (Fig. 1).

Before the Apollo 16 mission in April 1972, light plains were thought to be mostly volcanic in origin. Apollo 16 astronauts John Young and Charles Duke landed their Lunar Module on the light plains Cayley Formation at a landing site named Descartes (-8.97º latitude, 15.5º longitude). They expected to sample ancient lunar volcanic rocks, but found instead breccias (rocks made up of rock fragments cemented together).

The differences between the maria and highland smooth plains deposits were more ambiguous in regions where the Clementine data had gores and the albedo of the maria is elevated (i.e. Mare Frigoris and eastern Imbrium basin). Light plains are defined as smooth, flat, maria-like deposits that are higher in albedo (reflectance) than the smooth, flat, dark maria. Light plains cover about 9.5% of the lunar surface, while the maria cover about 16%.

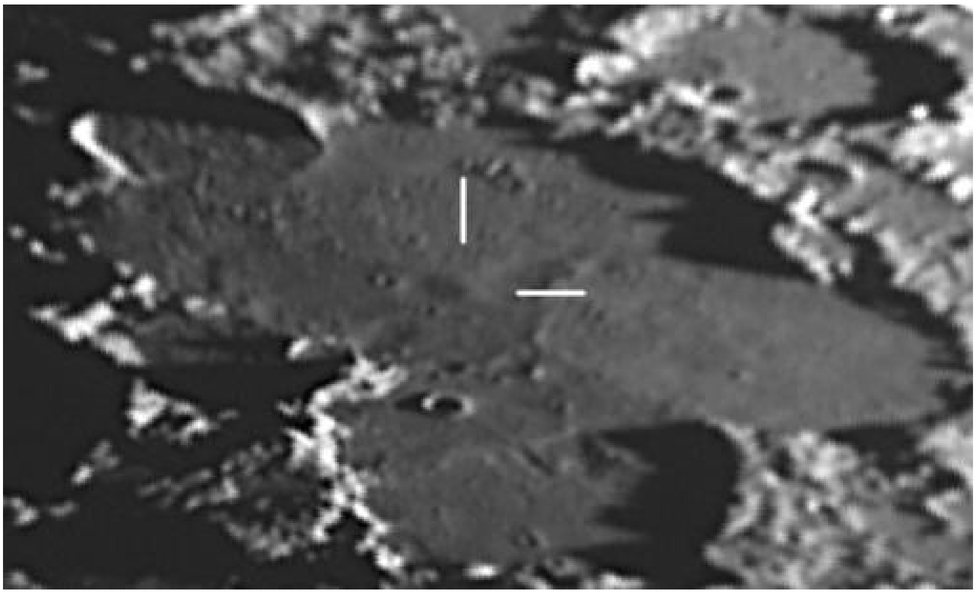


Figure 1: Telescopic image of the dome Meton 1, acquired on June 28, 2009, at 20:40 UT by Jim Phillips.

Spectral interpretations showed that the highland light plains are not mare basalt, but are composed of significantly more feldspathic, non-mare material (Spudis & Schultz, 1983). Conversely, some known non-mare volcanic units, such as the Apennine Bench Formation (a deposit of post-Imbrium KREEP basalt), contain light plains. These interpretations do not rule out alternate origins for a subset of highland smooth plains, including impact melt or volcanic origins (effusive or pyroclastic).

Another image of Meton 1, recently acquired by Luigi Morrone, is shown in Figure 2.

Figure 3 displays the examined region as imaged by WAC of the Lunar Reconnaissance Orbiter (LRO). Note that Meton consists of several merged crater rings that have been flooded with lava, forming the remnant of a walled plain.

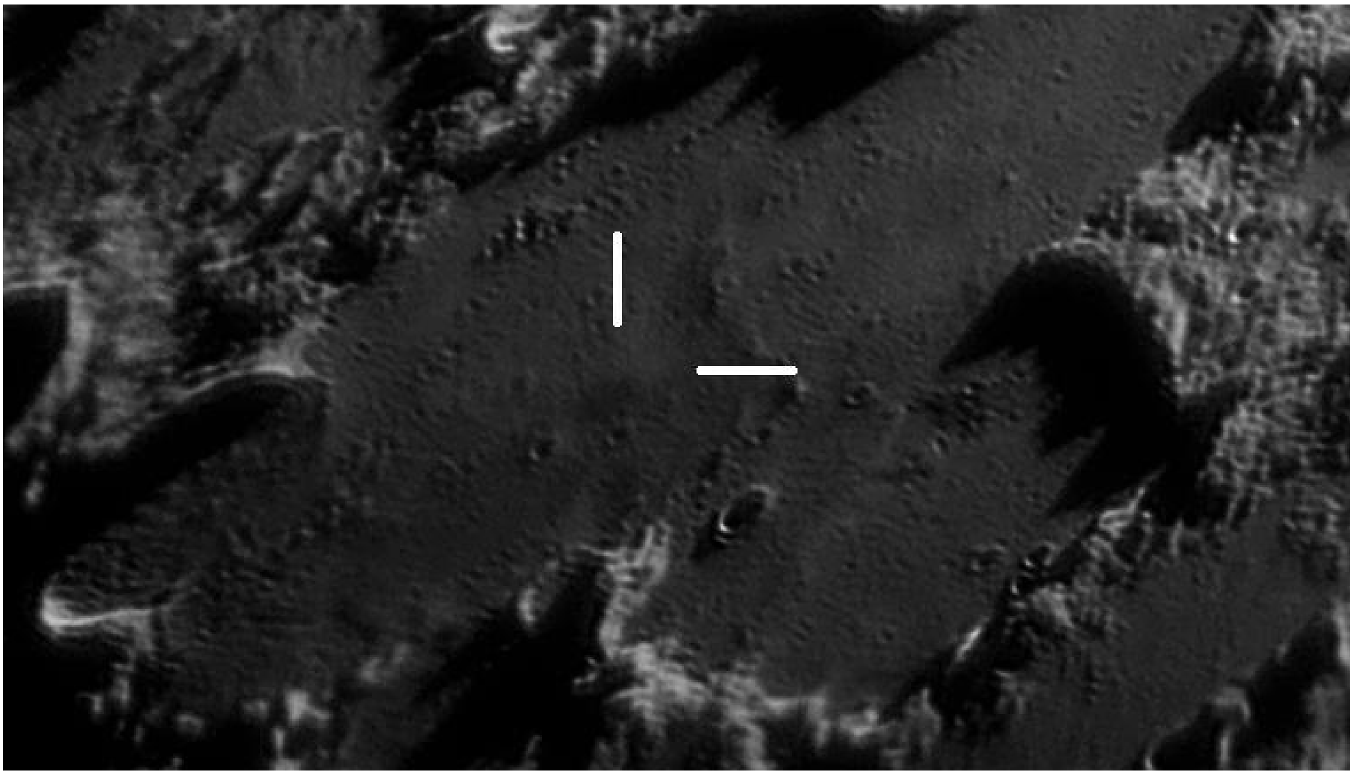


Figure 2: Telescopic image of the dome Meton 1, acquired on December 21, 2020 16:40 UT by Luigi Morrone.

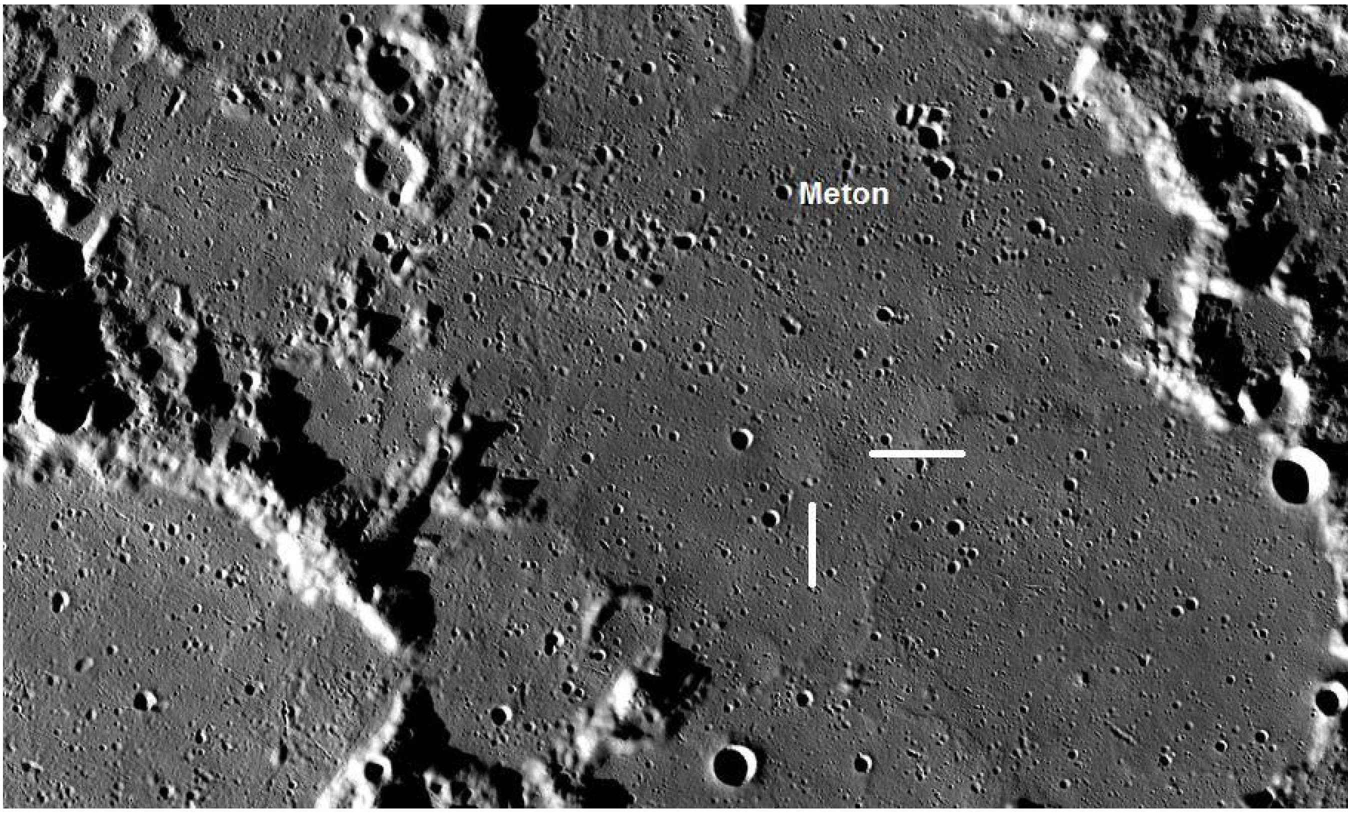


Figure 3: WAC of the Lunar Reconnaissance Orbiter (LRO).

The dome diameter corresponds to 14.5km and its height to 90m, resulting in an average flank slope of 0.71°; the dome volume amounts to 4.5 km³.

Fig. 4 displays the DEM of Meton 1 obtained using the telescopic image of Fig. 1 and photoclinometry and sfs approach (Lena et al, 2013).

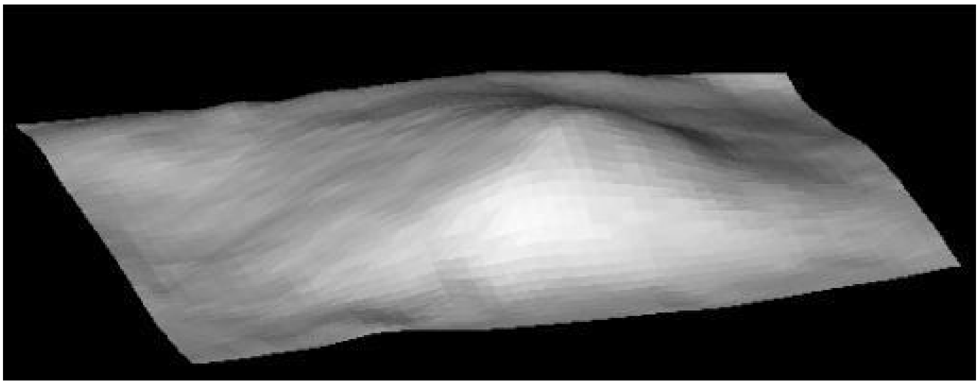


Figure 4: Local DEM of the dome Meton 1. The vertical axis is 20 times exaggerated.

The ACT-REACT QuickMap tool was used to access the LOLA DEM dataset, allowing us to obtain the cross-sectional profiles for the examined dome (Fig. 5).

Note the agreement of the measurements carried out on the CCD telescopic image and the LOLA DEM.

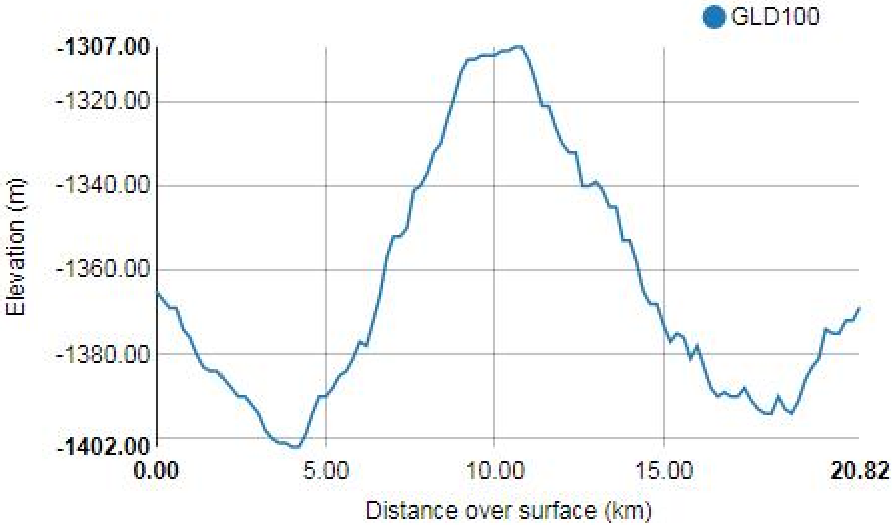


Figure 5: LOLA DEM dataset and cross-sectional profiles for the examined dome Meton 1.

Accordingly, the rheologic model (Wilson and Head, 2003) yields a magma viscosity of 1.4 x 10^4 Pa s, an effusion rate of 1900 m $^3s^{-1}$ and duration of the effusion process of 0.07 years. Based on the viscoelastic dike model a magma rise speed of 7.3 x 10^{-3} ms^{-1}, a width of the feeder dike of 7.7m and a length of 34km is inferred. According to its morphometric properties, the viscosity of the dome-forming magma and the dike geometry, Meton 1 resembles lunar mare domes of class C_1 with a tendency towards class B_2 suggesting a volcanic origin of the light plains material.

The rheologic modelling results indicate that the dome was formed by low-viscosity lava and the origin of the dome material is in the lower lunar crust.

The basalts of Mare Frigoris, as well as the surrounding highland and light plains material, are characterised by exceptionally large amounts of Mg-rich rock material.

The composition of the dome forming lava is not typical of mare basalt due to its high Al and low Fe and Ti content (Lena et al., 2010). Hence, these results would suggest the occurrence of a possibly non-mare volcanic episode in the region north of Mare Frigoris.

References

[1] Lena, R., Wöhler, C., Phillips, J., Chiocchetta, M.T., 2013. *Lunar domes: Properties and Formation Processes*, Springer Praxis Books.
[2] Wilson, L., Head, J.W., 2003. 'Lunar Gruithuisen and Mairan domes: rheology and mode of emplacement'. *J. Geophys. Res*. 108 (E2), 5012–5018.
[3] Lena, R., Wöhler, C., Phillips, J., Berezhnoy, A. 'An effusive lunar dome in the light plains of the crater Meton'. 41st Lunar and Planetary Science Conference (2010).
[4] Spudis, P. D. & Schultz, P. H. 'Some Geochemical and Geophysical Implications of Very Old and Very Young Lunar Mare Volcanism'. *LUNAR AND PLANETARY SCIENCE* XIV, P. 737-738. Abstract.

HAROLD HILL'S BASALTS

Barry Fitz-Gerald

The noted lunar observer Harold Hill identified what he though might be basaltic lava flows to the south of the crater Vieta and recorded their location in two superb drawings which appeared in his *Portfolio of Lunar Drawings* [1]. One of these is reproduced in Fig. 1. Two features which he named sheets A and B were recorded between the craters Vieta and Lacroix which he considered likely to be lava flows, with sheet B appearing to be superimposed on sheet A. He noted that no actual fronts were detectable at the edges of these sheets, and that any finer detail on the surface of these 'flows' would probably require a greater aperture instrument than the 10-inch reflector he was using.

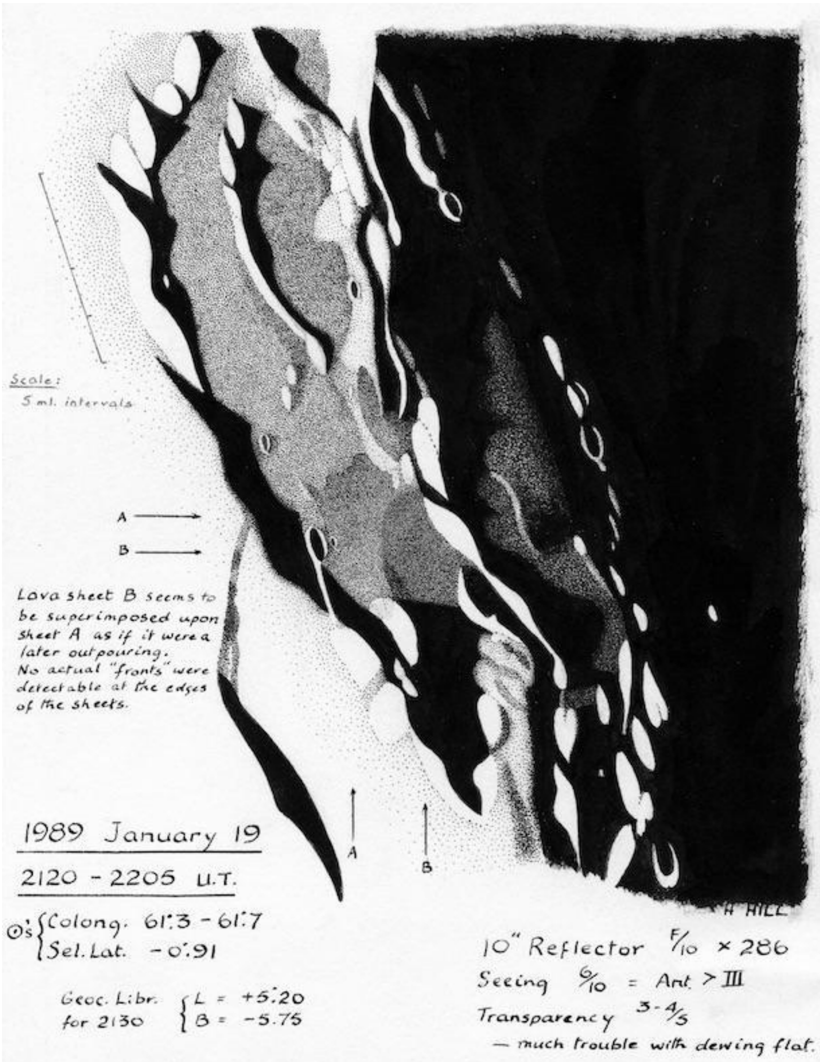


Fig. 1 Drawing by Harold Hill of 'Basaltic areas south of Vieta' showing the location of what he tentatively identified as lava sheets A and B. Note the drawing shows south up as opposed to the remainder of the images below which are north up. Courtesy of Bill Leatherbarrow and BAA Lunar Section.

We can narrow down the area where sheets A and B were recorded as being between Vieta Y and Fourier N by comparing his drawings with the LROC-Wide Angle Camera (WAC) imagery shown in Fig. 2 which covers the area studied by Hill and its wider environs. What can be seen in this WAC image is that much of this area is dominated by 'light plains deposits' such as the large featureless patch between Fourier and Drebbel E. These plains are thought to probably represent basin ejecta deposits emplaced during the formation of the major basin such as Orientale and Imbrium.

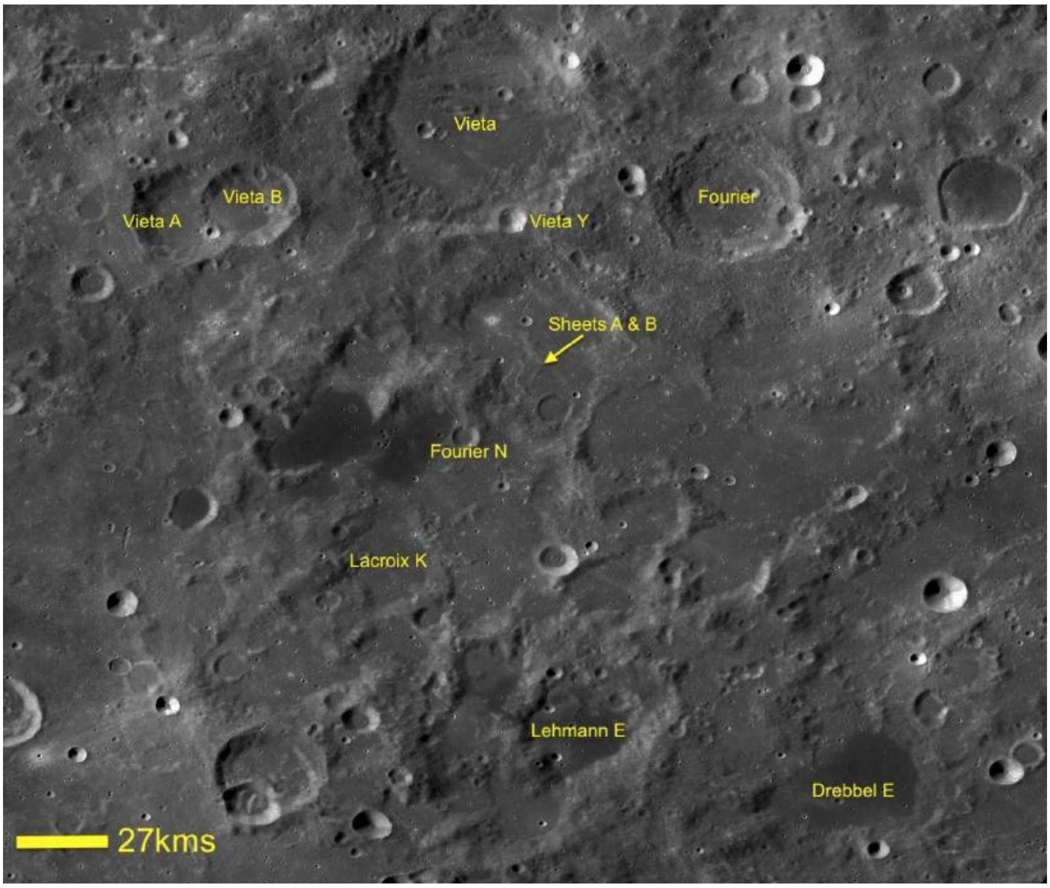


Fig. 2 LROC WAC image of Hill's 'basaltic lava areas south of Vieta. Note the widespread 'light plains' deposits and the restricted lower albedo patches of Drebbel E, Lehmann E and the 'butterfly' shaped patch to the west of Fourier N. The area within which Harold Hill's 'sheets A and B' were observed are also shown.

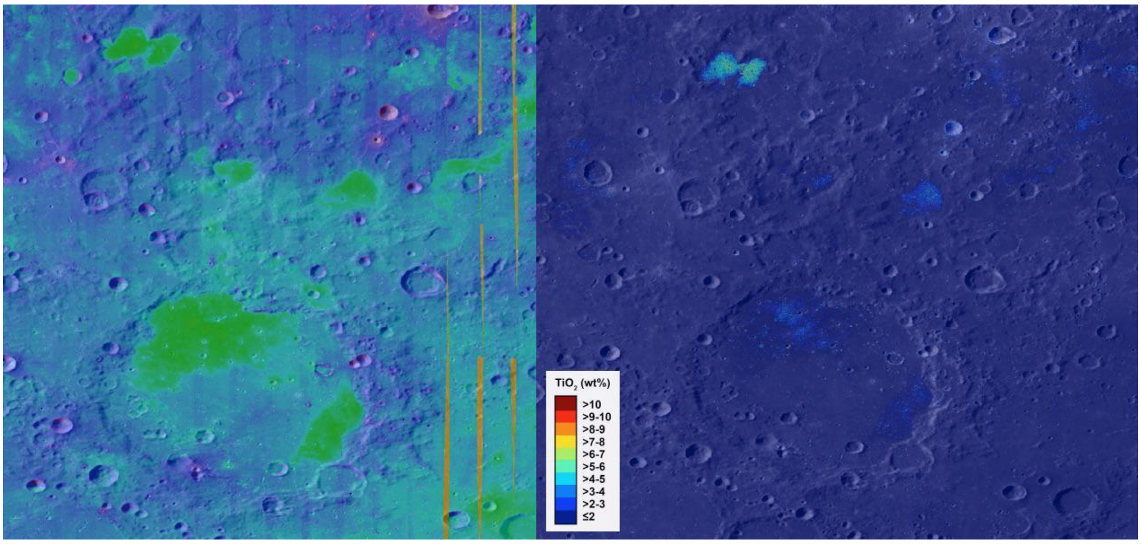


Fig. 3. Left: Abundance of FeO (wt %) mosaic from Quickmap showing the iron-rich composition of the low albedo areas including the mare units within Schickard which is towards the bottom of the image, and Right: TiO2 abundance in wt% for the same area. Note the higher percentage within the 'butterfly' shaped basalt unit.

These smooth, relatively high albedo plains contrast with a number of lower albedo areas, particularly a 'butterfly' shaped patch to the west of Fourier N and the features designated Lehman E and Drebbel E (these may be extremely degraded highland craters but that is not obvious). These low albedo patches are similar in appearance to the mare-like deposits on the eastern and western floor of Schickard, with a high abundance of iron (Fig. 3) consistent with basalt lavas. The lavas within the 'butterfly' shaped area have a highest titanium content of these basaltic patches and are compositionally closer to mare basalt in Mare Humorum.

These mare units appear to represent lava lakes where molten basalt accumulated within topographic lows, ancient crater floors or basins set within higher terrain. This is shown in Fig. 4 which follows a line through the 'butterfly' patch, Lehmann E and Drebble E in turn (following a rather dog legged course). As can be seen these basaltic areas correspond to low points in the terrain, a not unsurprising observation. As we will see however, this does not mean that the lavas erupted in the same places

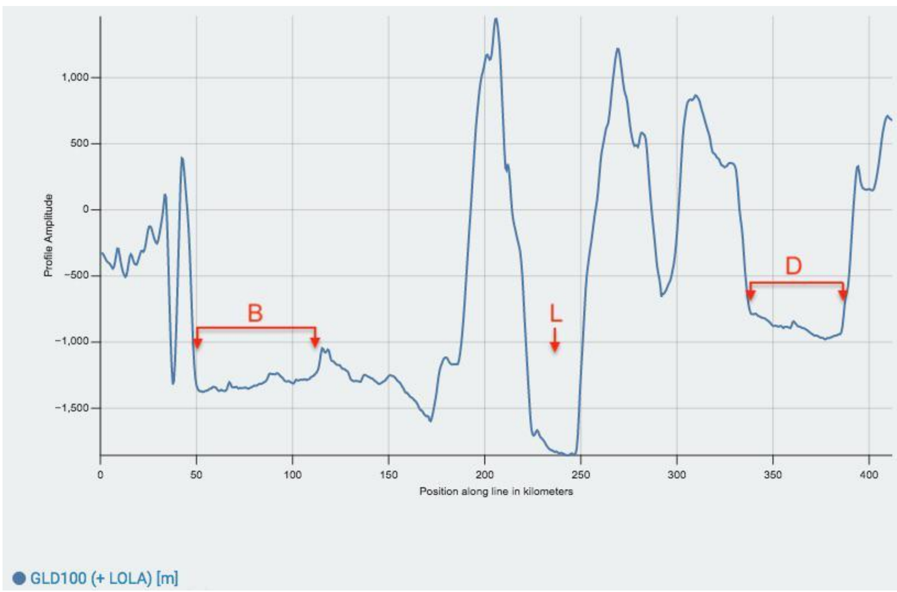


Fig. 4 (previous page) A transect through the 'butterfly' patch (B), Lehmann E (L) and Drebble E (D) showing that each of these areas are within topographic lows surrounded by higher terrain.

Whilst these low albedo areas are basaltic in nature, the area between Vieta Y and Fourier N and where Hill identified sheets A and B is in contrast composed of smooth light plains deposits dominated by highland (plagioclase rich) lithologies, which is consistent with their being basin ejecta and not volcanic rock (Fig. 5). These plains form the floor of what are either highly degraded craters or highland basins. By comparing Fig. 1 with the WAC image shown in Fig. 5, it is possible to say that Hill's sheet A corresponds to the eastern floor of this area whilst sheet B corresponds to the western floor. Unfortunately there is no evidence for extensive lava flows which would correspond to either sheet A or B. Harold Hill was however a careful and experienced observer and so features within this area clearly gave a very strong impression of separate and possibly overlapping sheets.

One possible contributing factor might be the presence of a small patch of dark possibly basaltic lavas or pyroclastic deposits, hugging a highland promontory along the northern 'rim' (Fig. 5). These deposits might well suggest the presence of a vent somewhere here, but there are no obvious candidates. The presence of this darker material, despite being limited in extent, may well contribute to a detectable difference in albedo between the eastern and western floors leading to the impression of separate flows. The visibility of this dark area may also be emphasised by the presence of a small extremely young crater nearby that has excavated very bright olivine rich ejecta from what is probably a cryptomare unit (ancient lava flow) buried beneath these light plains.

Another possible factor is that the western floor is approximately 200m lower compared to the eastern. The eastern floor is also tilted slightly towards the east (Fig. 6) which might result in a contrasting appearance across the feature under low angle illumination. Running north-south across floor are three en-echelon west-facing scarps. The westernmost of these is visible as a short lobate scarp on nearby highland slopes, suggesting that it is a tectonic feature resulting from movement along a low-angle thrust fault. Whether the other scarps are similar tectonic features is not clear, but they do not appear to be volcanic in origin. Their position however corresponds to the apparent contact between sheets A and B in Hill's drawings which might suggest that these also contributed to the appearance of adjacent flows.

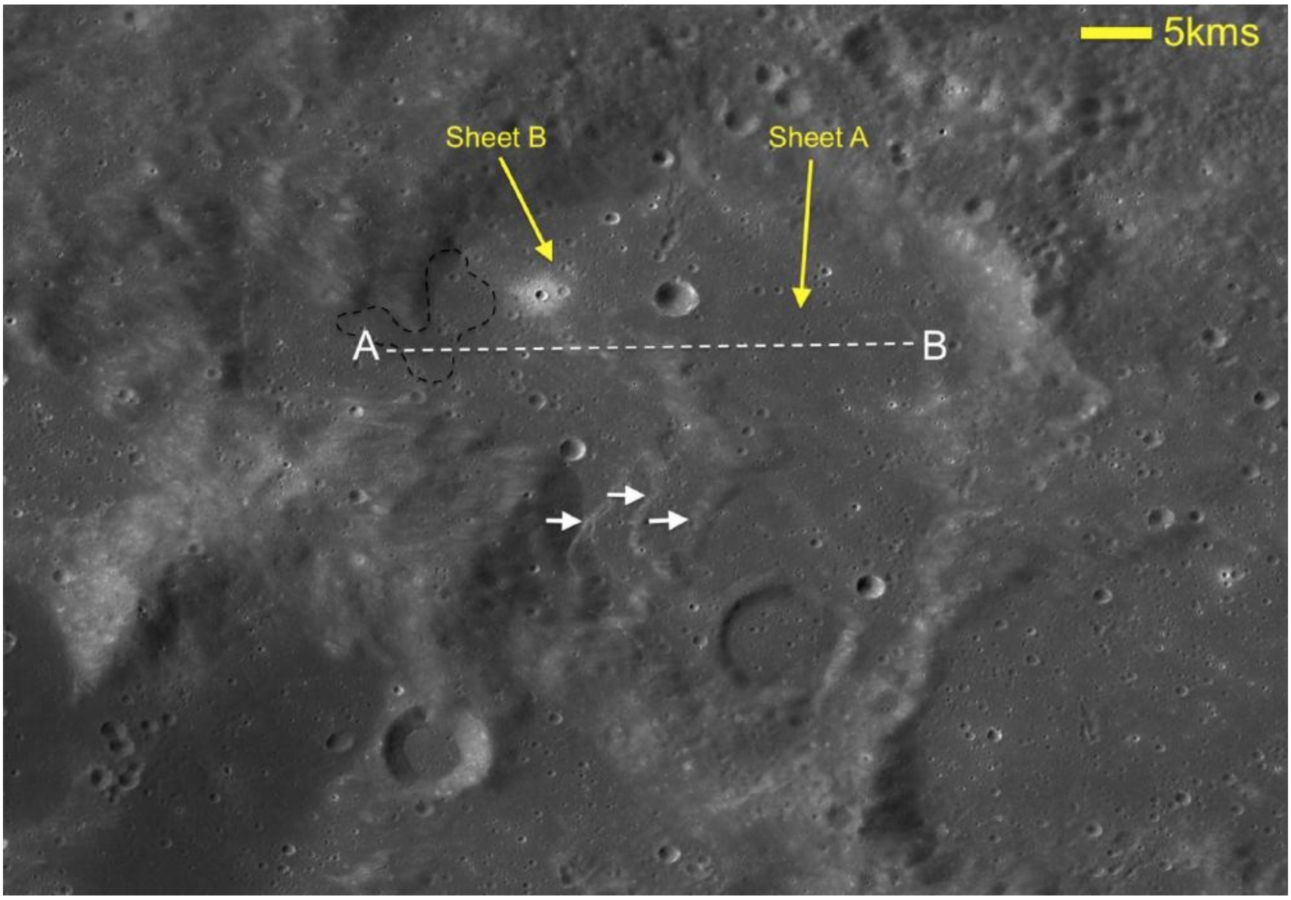


Fig. 5 WAC image of the area within which Harold Hill identified two possible lava sheets showing the sections of floor which probably correspond to these sheets A and B. The topographic profile along line A-B is shown in Fig. 6. White arrow indicates scarp-like features between the lower western floor from the higher eastern floor. Black dashed line shows a small area of possible basaltic lavas surrounding a promontory on the northern shore. Note the very bright very young crater nearby.

Whether any of these factors played a part in Hill's interpretation is obviously now just speculation, but some of features described within this area could well have contributed to the impression of separate overlapping flows.

Moving on to firmer basaltic ground, the 'butterfly' shaped patch (Fig. 7) appears to occupy two or more adjoining ancient craters. The larger of the two craters is separated by a low ridge with a superimposed cluster of secondary impact craters, several in the 1km size range. The floor of the larger western crater is roughly 100m lower in elevation than the eastern and is a conspicuous telescopic target. The floor is covered in low albedo basalts with relatively high titanium content that probably overlay (as do probably all of the basaltic units described here) light plains deposits. This mare unit represents a former lava lake, with evidence for this visible as a 'high tide' mark perched some 60m above the crater floor and most conspicuous along the northern shore. This shows the original maximum level of the lava lake before it subsequently fell as the lavas cooled and contracted or drained away elsewhere. A small wrinkle ridge is also visible near the southern shore, a further indication that the level of the lava lake dropped over time. The conspicuous high albedo rim of a 2.5km diameter impact crater can be seen on the northern part of the floor. This was probably submerged beneath the lava surface but re-emerged as the level fell, with the bright bouldery rim representing a fragmented veneer of basalt.

The surface is crossed by a number of fault like fractures (Fig. 6) which may have formed as a solidified crust on the lake surface was disrupted by movement within a still molten layer beneath. The floor is also domed slightly upwards, possibly suggesting further volcanic activity after the lake had completely solidified.

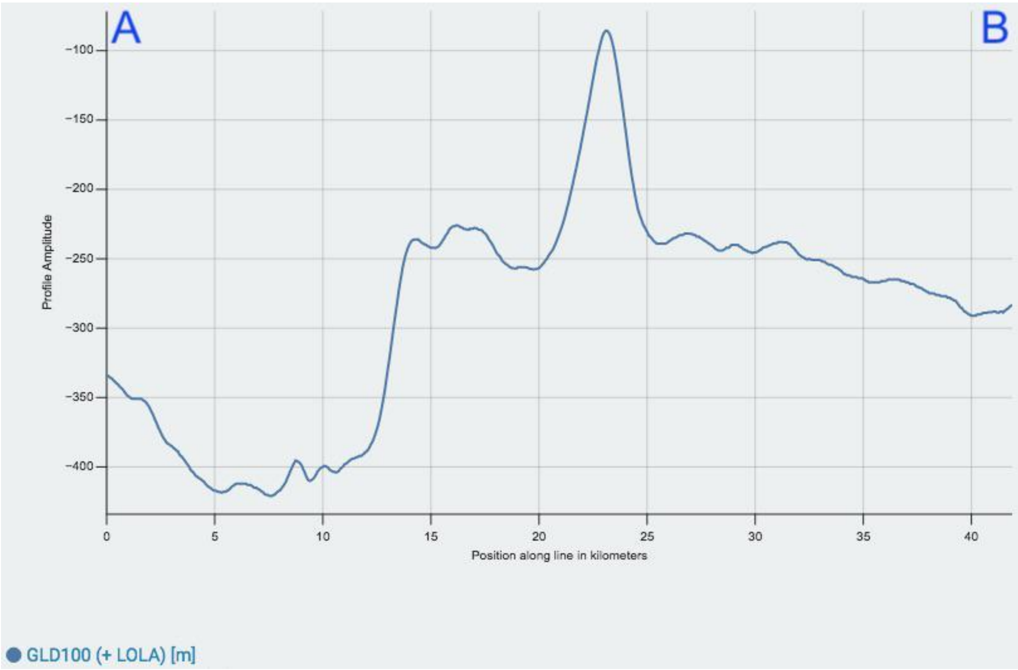


Fig. 6 Topographic profile across line A-B in Fig. 3. Note the deeper western floor to the depression and the tilting of the eastern floor towards the east.

Along the southern shore, a line of three possible volcanic cones or vents can be seen. The westernmost cone is the most prominent, measuring approximately 1.5kms in diameter and with an elongate summit crater some 50m deep. Another possible vent is located more centrally on the western floor. These vents must have formed once the lava lake solidified or at least developed a solid crust, and possibly at the same time that the crater floor was domed upwards, suggesting a protracted period of volcanic activity within this relatively small area.

The eastern crater floor has a rectangular patch of basaltic lava occupying its western part, whilst the higher eastern part is covered in light plains. Within this mare patch is a peculiar feature with a vaguely 'swastika' like radiating pattern of short fractures or very short sinuous rilles. It is extremely tempting to interpret this as some form of volcanic structure as the floor here is also slightly inflated in a low dome like swelling. The presence of the spidery fracture/rille pattern on top of an inflated area is suggestive of volcanism. There are also a number of oddly rectangular craters within this feature which may represent collapse pits – features sometimes encountered in volcanic settings.

Pinning down the source of the basalt lavas within these craters is tricky. The vents on the western floor are potential sources, but if they were the only ones, the lavas would have had to flow uphill to reach the more elevated eastern part of the 'butterfly'. As already noted the vents are on top of the lava lake surface so were probably active after the lake was formed. So maybe another source existed on the eastern floor and the suspected volcanic structure with the spidery arrangement of fractures is an obvious candidate. Support for this idea can be seen in the form of an approximately 60m deep channel that cuts across the southern part of the ridge between the craters, and slopes downwards from east to west (Fig. 8).

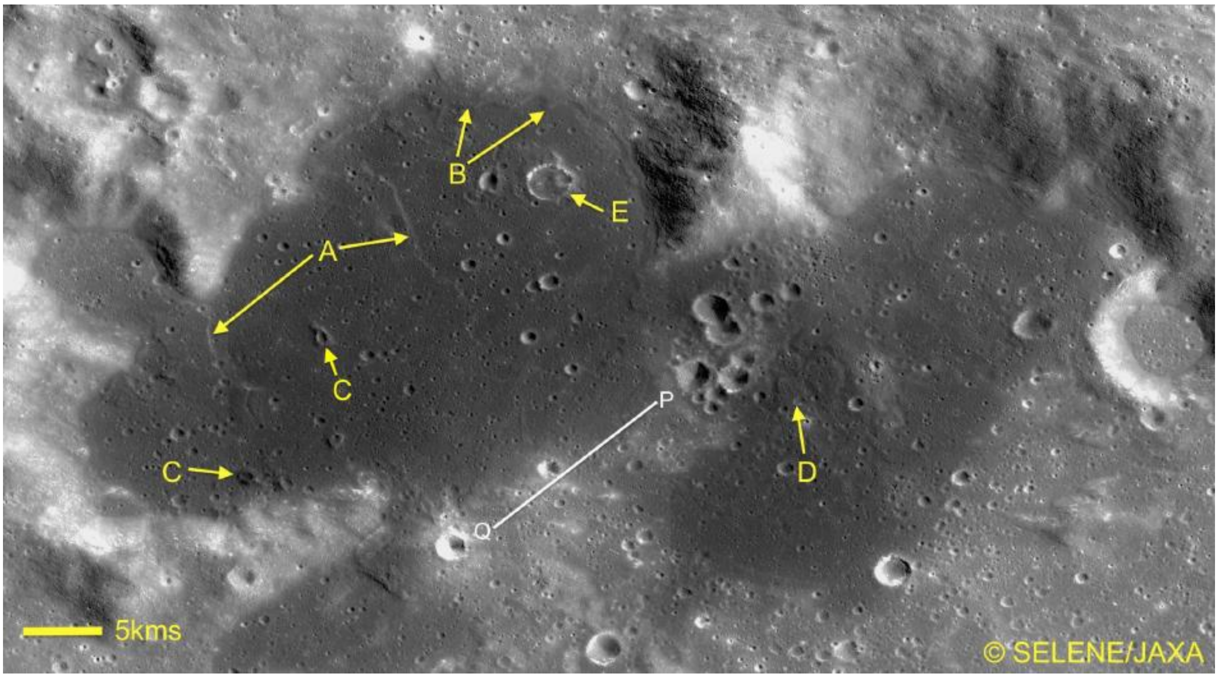


Fig. 7 SELENE view of the 'butterfly' shaped mare patch consisting of a western and an eastern topographic low. These may represent ancient degraded craters. A – fractures in the basalt surface of the former lava pond, B – high tide mark around edge of pond, approximately 60m above the general surface, C – possible volcanic cones or vents, D – radiating arrangement of short fractures or rilles. E – partially submerged impact crater. Topographic section along line P-Q is shown in Fig. 6

This may represent a channel carved by lavas that erupted within the eastern crater and then flowed downwards into lower, western crater. If the western crater was originally much deeper than the eastern one, it is possible that quite a depth of lava accumulated here as it drained out of the higher eastern crater. This would explain the presence of features such as the high tide mark, fractures and wrinkle ridge in the western crater, and a lack of such features in the east.

The irregular 'crater' Lehmann E is another ancient crater or highland basin filled with mare type lavas, which are in this case of a lower titanium content when compared to those already discussed. Immediately to the west of Lehmann E and separated from it by a high ridge is another ruined crater, the floor of which is some 1000m higher in elevation than the floor of Lehmann E (Fig. 9) This unnamed crater is mostly draped in light plains material but also contains a distinct dark lava flow of basaltic composition.

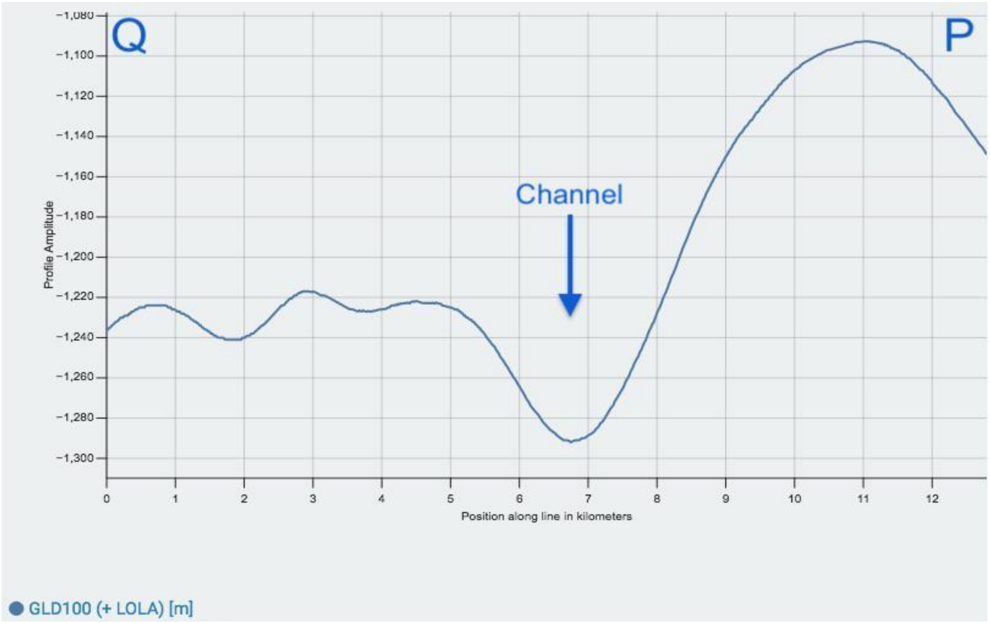


Fig. 8 Topographic profile along line Q-P in Fig. 5 showing a possible lava channel along the southern margin of the butterfly shaped mare feature.

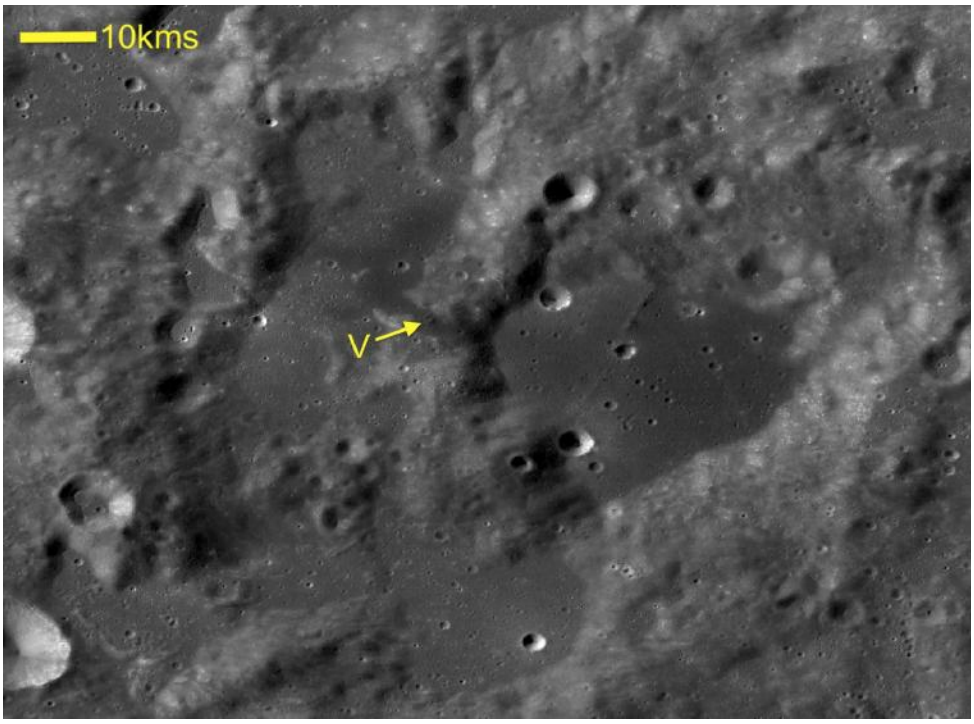


Fig. 9 LRO WAC image of Lehmann E and adjoining un-named topographic low which is some 1000m higher . Note the breached cone or vent (V) on the western rim of Lehmann E and the linear feature crossing its floor in a NNE to SSW direction.

There is no ambiguity as to the source of this lava flow or the lavas in Lehmann E, as they can be traced back to a vent perched on the crest of the intervening ridge. This is quite unusual as it might be natural to expect ascending lavas to follow the shortest route through the crust to the surface and therefore erupt at the lowest possible point topographically such as on a crater floor. In this case the rising magma bypassed the floor of Lehmann E, and continued upwards a further 1300m to erupt on this ridge. This shows that outpourings of lava can occur on higher terrain and then flow down to accumulate in topographic lows. In the present case the lavas that erupted from the vent flowed west and down some 150 – 200m into the unnamed crater and east and down 1300m onto the floor of Lehmann E (Figs 10 and 11). The lavas flowing into the unnamed crater resulted in a small but conspicuous dark flow that stands out against the light plains that cover the crater floor. This flow is easily seen telescopically as a thin thread-like feature. The lavas that flowed down into Lehmann E were more extensive covering much of the floor.

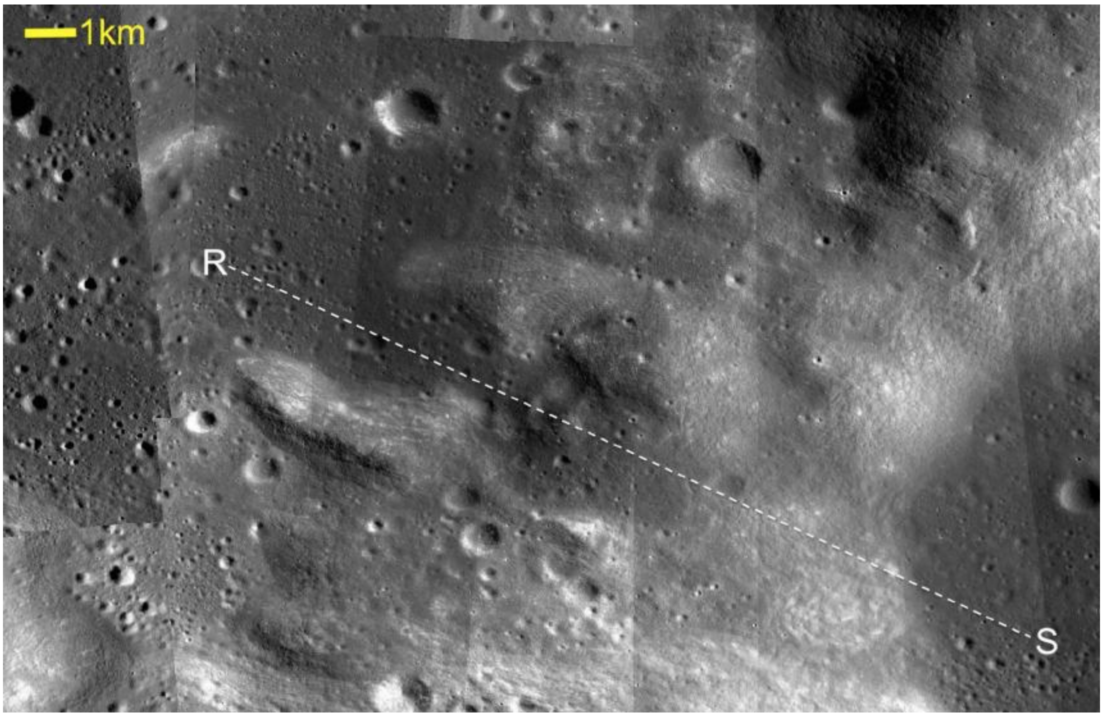


Fig. 10 Detail of the western rim of Lehmann E showing the vent on its crest and low albedo lava flows heading off downslope to the east and into Lehmann E and westwards into the higher, un-named depression. The topographic section along line R-S is shown in Fig. 9.

The vent, which is probably better described as a breached cone is some 1.5kms in diameter, with the breach in the rim to the north. Its position on the very crest of the rim of Lehmann E can be seen in the topographic data (Fig. 11). A further volcanic feature can be seen on the floor of Lehmann E in the form of a small ridge (~ 40m to 80m high) which stretches from the northern to southern 'rim' in a NNW-SSE direction. This may represent a fissure along which volcanic eruptions have taken place.

Drebbel E is slightly more crater-like than the features we have discussed so far, with a curved western rim, and a floor draped in basalt lavas of a similar composition to those in Lehmann E (Fig. 12). The most significant feature within Drebbel E which is probably connected with the eruption of the lavas is a 10-15km long ridge which actually appears to be the crest of a much larger but low 'dome' like structure. The total height of this 'dome' including the ridge crest is some 100m, but the width of the feature at about 15kms means that the slopes are extremely shallow, and only in the region of 2° or so (Fig. 13). Unfortunately there are no obvious lava flows visible in Drebbel E, and so whilst it is possible to speculate that this 'dome' is the source of the surrounding lavas, there is no direct link as we see in Lehmann E.

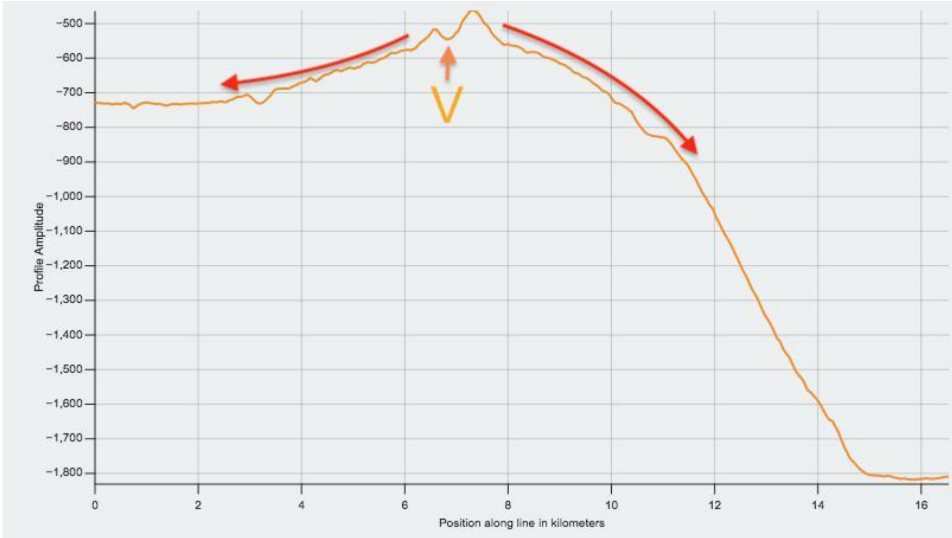


Fig. 11 Topographic profile along line R-S in Fig.8 showing the location of the vent on the rim of Lehmann E. Red arrows indicate direction of lava flows from the vent.

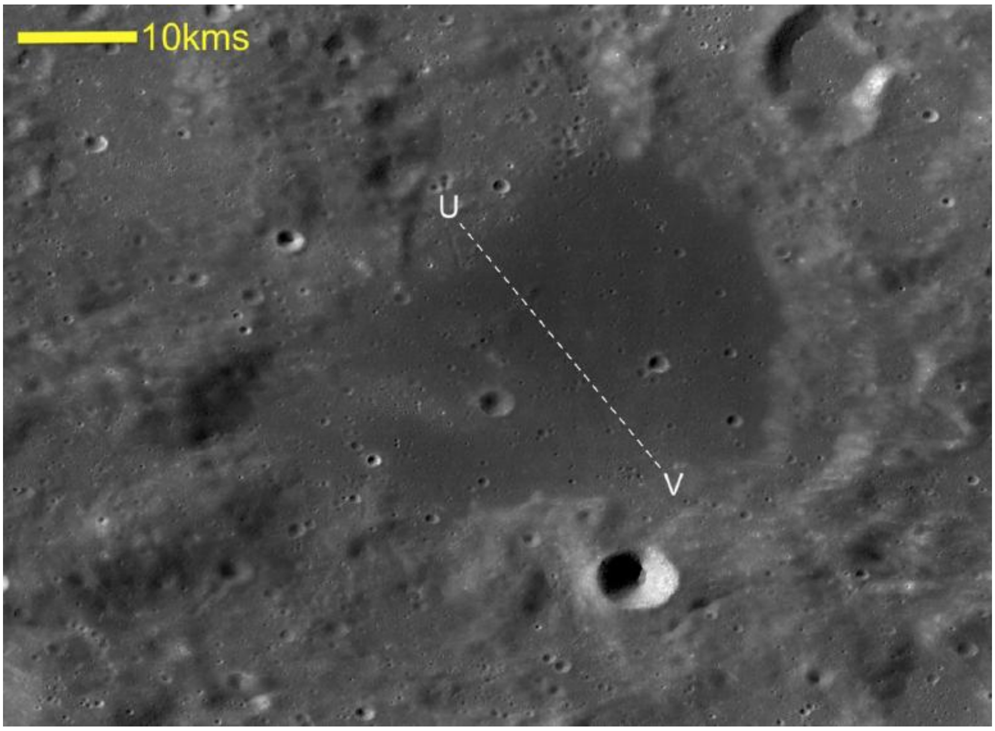


Fig. 12. Drebbel E. Topographic profile along line U-V is shown in Fig. 11.

So whilst Hill's sheets A and B do not appear to be lava sheets but light plains deposits of impact origin, there are several areas of basaltic flows mostly concentrated within topographic lows surrounded by elevated highland type terrain. These lows are likely to represent a palimpsest landscape of ancient degraded craters draped in a smooth veneer light plains deposit, much of which probably derived from the Orientale Impact event. There are many such basaltic areas along this western limb, with the crater Schickard harbouring extensive deposits, some of which at least seem to have originated from a volcanic centre in or around the crater Lehmann.

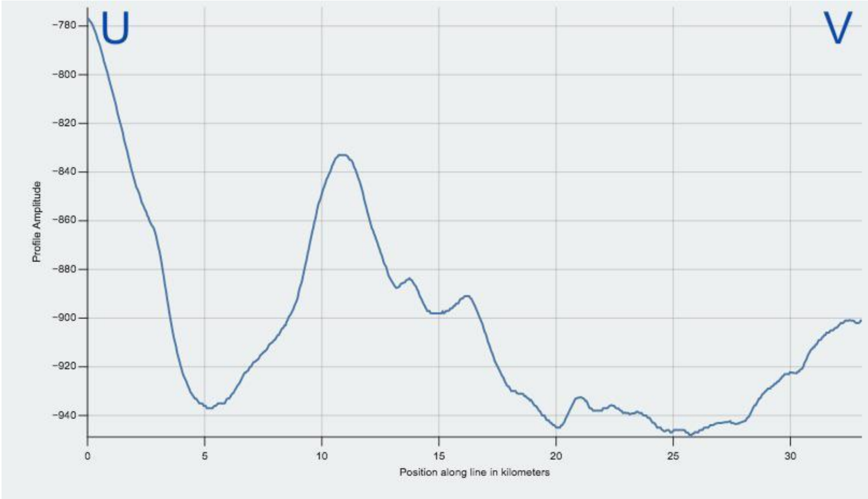


Fig. 13 Topographic profile along line U-V in Fig. 10 showing the dome-like structure on the floor of Drebbel E. Note the height is in the region of 100m but the width some 15kms – giving a real slope of approximately 2°. The summit crest is slightly steeper than the flanks at a breathtaking 3°.

Taking a slightly wider view and using the GRAIL free air gravity data from the LRO Quickmap site we can see that the area we have been looking at may lie within an ancient and largely invisible impact structure, somewhere in the region of 250kms in diameter which would make it slightly larger than Clavius and in the peak-ring basin category. Portions of a northern and south eastern rim can be (maybe with the eye of faith) seen in the form of arcuate positive anomalies where the elevated topography contributes to the gravity variation, whilst at the centre of the structure a negative anomaly can be seen between Lacroix A and Lacroix K, with a further one beneath Lehmann E.

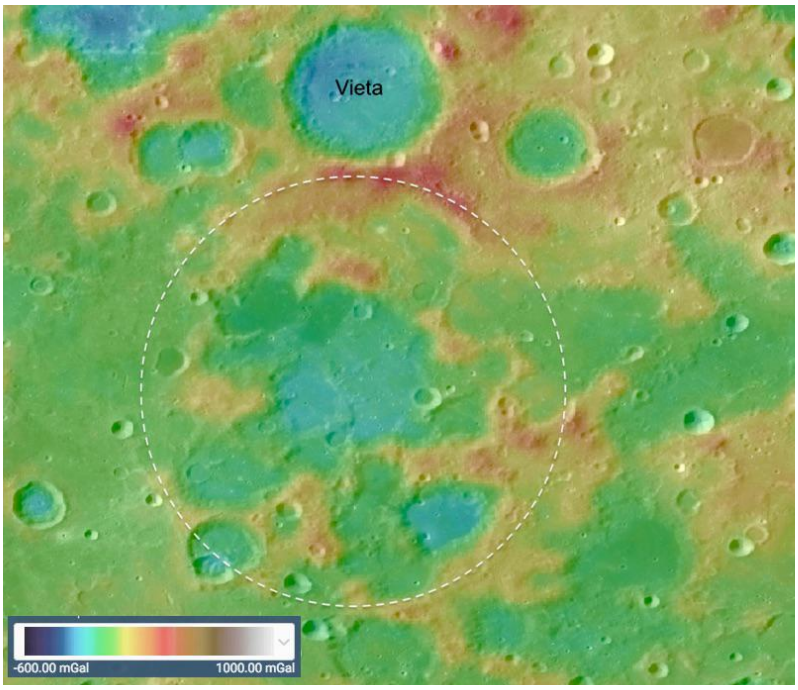


Fig. 13 GRAIL free air gravity overlay for the region under discussion showing the presence of a possible 250km diameter impact basin. The data shows gravity disturbances which include contributions from both the surface relief and any sub-surface interfaces, so the suspected rim shows up as a series or red/yellow arcs along the white dotted circle which is the outline of the original structure. Note the negative gravity anomaly within the central part of the structure.

If this is an ancient basin, then it would probably be of pre-Nectarian age. The fact that the basalt eruptions filling the butterfly shaped feature and Lehmann E occurred outside the central part of the suspected basin (as indicate by the gravity data) might suggest some relationship between subsurface structures such as faults and fractures and the route followed by ascending lavas. Drebbel E lies outside this suspected basin, but there is probably no shortage of crustal fractures beneath this ancient highland area that have been followed by ascending lavas to the surface.

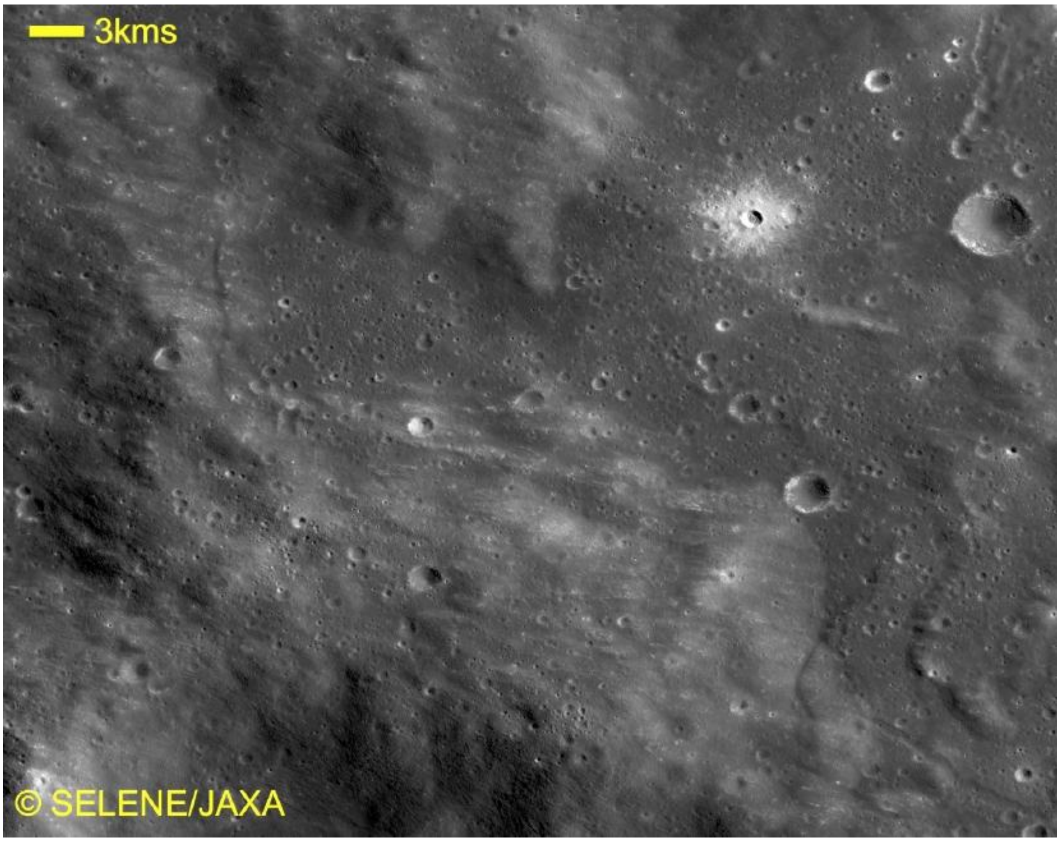


Fig. 14 Image of the highlands just north of the 'butterfly' shaped lava lake showing the streaky appearance of the slopes. Note the streaks are not parallel to each other over the whole area but rather follow the strike of the individual slopes.

A final thought on this particular area is the rather odd appearance of the highlands, with many of the slopes etched with bright streaks such as those immediately north of the dark 'butterfly' shaped feature (Fig. 14). Initial thoughts suggested that these are ray material from Byrgius A or some other young crater but these streaks are not radial to any impact craters, and instead follow the strike of the slopes (i.e. parallel to the slope) rather like the ripples that form in turf on steep hillsides. LRO images show that the streaks are actually composed of lines of boulders and loose rocky material that mark innumerable small terrace-like breaks in slope. The bouldery lines are clearly relatively youthful in lunar terms, and an unusual feature on highland slopes. Could these be tectonic in nature – the result of moonquakes destabilising the slopes? When Apollo era seismic data were re-evaluated [2] the western limb was found to have experienced recent clusters of shallow moonquakes (particularly around the crater Crüger), could these streaks be indicative of ongoing tectonism? Are these streaks visible telescopically and have any unusual illumination effects been observed in this area in the past? I would be interested to hear if anyone has made any relevant observations.

Acknowledgements:

LROC images reproduced by courtesy of the LROC Website at http://lroc.sese.asu.edu/index.html, School of Earth and Space Exploration, University of Arizona.

Selene images courtesy of Japan Aerospace Exploration Agency (JAXA) at:

http://l2db.selene.darts.isas.jaxa.jp

References:

1. Hill, H. (1991) *A Portfolio of Lunar Drawings*. Cambridge University Press

2. Watters, T.R., Weber, R.C., Collins, G.C. *et al.* 'Shallow seismic activity and young thrust faults on the Moon'. *Nat. Geosci.* **12,** 411–417 (2019). https://doi.org/10.1038/s41561-019-0362-2

LUNAR OCCULTATIONS April 2021 Tim Haymes

Time capsule: 50 year ago:
[With thanks to *Stuart Morris* for the LSC archives.
https://britastro.org/downloads/10167]

- Lunokhod-1 resumes its science program and switches on the TV cameras. Sunrise over the lunar horizon was photographed.
- Lunar Occultations: Timings were received from D.Hall (Leicester), P.J.Young (nr Leeds)and R. Middleton (Colchester).

  NB: Only Mr Hall's observations appear in the global Occult4 database. His observations state the PE used.

Reports Received

Brian Mills was set up to observe the Graze Occultation of 52 Geminorum on March 22nd from home. He says: 'I recorded the D and R (possibly) of ZC1099 last night from around 4.7km inside the mean graze line'. The observation was recorded by video at 25 fps with time insertion.

It good to hear reports of graze occultation attempts - Thank you.

Features of Occult4 Tim Haymes

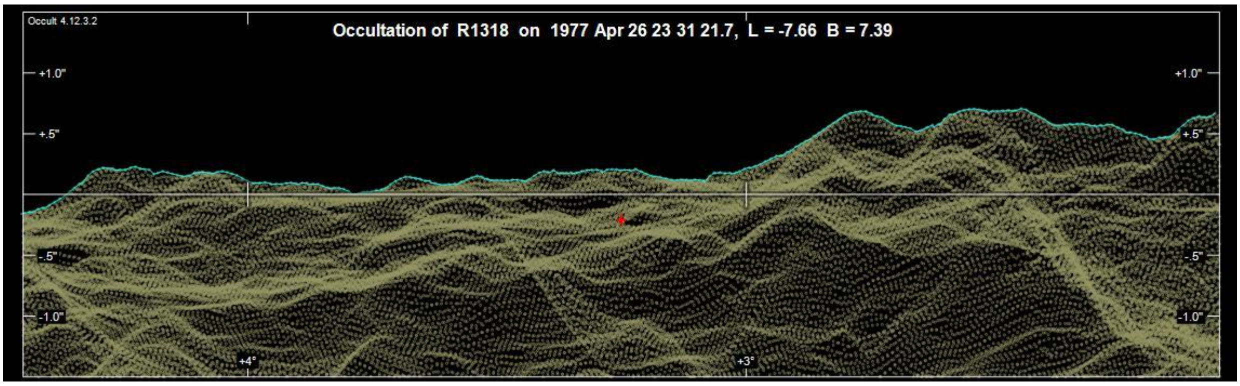
This is prediction and analysis software developed and maintained by Dave Herald (Marrumbateman, AU).

The database of occultation times is extensive – it contains all known measurments. Selecting Lunar Observations and **view/analyse** historical Occultations 1623-now, the user can query on an observer name or star.

Once a list is obtained the action 'Create Report' will display a virtual report format from which the star can be plotted on the lunar limb. The report will include all the observations at a particular address. For example P. Young has two timings made at Shoreham–on-Sea. (I searched for 'Young'). With this report the **Reduce&Plot** command will re-analyse the observation and produce O-C data using our current knowledge and limb profiles. Once this stage is done, right-click on the line to plot the star against the limb.

The sequence of actions is:

Search for observer or star
Highlight the observation(s) of interest
Create report
On the report page (Observation Editor) use [Reduce and Plot].
The quality data is then presented.
Highlight a line (one observation)
Right-Click [Plot event against profile]



P. Young's Observation used in the example. The computed star position is inside the limb.

Bright Star Occultations in April 2021 (UK)

Apr 15, 20 35 58s DD omega Tau
Apr 27, 21 45 35s RD nu Lib
Apr 30, 2 54 8s RD theta Oph

String of events in Gemini on April 18th

Five events are predicted for the evening of the 18th. Observers should also see fainter stars this evening, and a potential for a good haul, weather permitting. The fainter stars are mag 9-10 with the Moon presenting an Earthlit limb. Good hunting.

Occultation predictions for Northern Oxfordshire in 2021 April.

E. Longitude - 1 18 00 , Latitude 51 55 00, Alt. 119m; Moon Alt>5 degrees
Some fainter predictions are omitted near Full Moon.

y	m	day d	Time h	m	s	P	Star No	Sp	Mag v	Mag r	% ill	Elon	Sun Alt	Moon Alt	Moon Az	CA	Notes
21	Apr	1	2	28	14.8	R	159441	F8	8.0*	7.8	84-	133		18	170	41S	
21	Apr	1	2	43	27.6	R	159450	G8	8.8*	8.4	84-	133		18	173	46S	
21	Apr	1	3	30	59	m	159469	K5	8.9*	8.2	84-	133		18	185	11S	
21	Apr	2	3	8	1.5	R	184586	F5	8.3	8.0	75-	120		14	166	67N	
21	Apr	2	3	46	14.6	R	2407	F3	7.0	6.7	74-	119		15	175	58N	15 Oph
21	Apr	4	3	48	10.5	R	187311	G5	8.6	8.0	53-	93		6	150	81S	
21	Apr	14	20	27	57.1	D	505	A0	7.1*	7.1	6+	29		9	285	60S	

21	Apr	15	20	27	13.8	D	76533	K2	8.4	7.8	12+	40		19	279	54N	
21	Apr	15	20	35	58.1	D	628	A3	4.9	4.8	12+	40		18	281	30N	omega Tau
21	Apr	16	21	2	36.7	D	76977	B9	8.5	8.4	19+	51		23	279	34N	
21	Apr	16	22	7	26.5	D	77019	F5	7.9	7.6	19+	52		13	290	87N	
21	Apr	17	20	59	28.8	D	77833	K5	8.8	8.1	27+	62		32	271	41N	
21	Apr	17	23	8	57.5	D	920	B9	8.7	8.6	27+	63		13	293	37S	
21	Apr	18	20	36	23	M	78827	A*	7.4	7.2	36+	73		43	256	3N	
21	Apr	18	21	46	59.1	D	78885	A3	7.6	7.5	36+	74		33	270	75N	
21	Apr	18	22	7	17.8	D	78898	A0	7.9	7.8	36+	74		30	274	81N	Dbl*
21	Apr	18	22	40	27.7	D	78918	K0	8.3	7.7	36+	74		25	280	68N	
21	Apr	18	22	48	7.8	D	78924	F5	8.0	7.7	36+	74		23	281	78N	
21	Apr	19	20	36	14.6	D	79708	F8	9.0	8.8	45+	85		50	241	68S	
21	Apr	19	21	3	54.2	D	79724	K0	7.8	7.0	46+	85		46	249	57N	
21	Apr	19	21	36	8.1	D	79739	F0	7.1	7.0	46+	85		41	256	69N	
21	Apr	19	22	14	25.6	D	79740	F2	8.5	8.3	46+	85		35	264	8S	Dbl*
21	Apr	20	0	13	14.8	D	79804	G0	7.4*		47+	86		18	286	78S	Dbl*
21	Apr	20	0	18	39.3	D	1195	B8	6.8*	6.9	47+	86		17	287	63S	
21	Apr	20	21	20	17.0	D	80395	K0	8.9	8.3	56+	97		49	237	72S	
21	Apr	20	22	23	25.7	D	80417	K0	8.7	8.2	56+	97		40	253	55S	
21	Apr	20	22	48	33.7	D	80425	K0	8.6	8.0	56+	97		36	258	46S	
21	Apr	22	0	50	52.0	D	98751	G5	8.3	7.7	68+	111		23	270	70N	
21	Apr	22	20	38	9.3	D	1544	M2	5.4	4.5	76+	121	-12	52	182	89N	46 Leo
21	Apr	22	21	30	46.3	D	99179	K5	8.6	7.8	76+	122		50	202	65S	
21	Apr	22	23	9	48.2	D	99202	A2	7.8	7.7	77+	122		41	233	36N	
21	Apr	23	2	1	43.8	D	99250	M0	8.7	7.9	78+	124		16	270	87N	
21	Apr	23	20	39	49.8	D	118843	G0	8.5	8.2	85+	135	-12	46	164	35N	
21	Apr	23	20	58	0.5	D	118854	K0	8.9	8.4	85+	135		46	171	80N	
21	Apr	23	21	6	16.1	D	1659	K0	6.7	6.0	85+	135		47	174	69N	
21	Apr	23	22	44	26	M	118880	K2	8.3	7.6	86+	135		44	207	5N	
21	Apr	24	0	25	9.5	D	118905	K0	7.9*	7.4	86+	136		33	235	61N	
21	Apr	24	1	23	53.9	D	1673	K0	8.2*	7.6	86+	137		25	249	74S	
21	Apr	25	0	3	52.0	D	119369	A3	8.8*	8.7	93+	150		35	213	53S	
21	Apr	25	0	37	30.3	D	1781	M*	7.6*	6.8	93+	150		32	222	59S	
21	Apr	25	2	39	32.5	D	119422	G5	8.7	8.4	94+	151		16	250	46N	
21	Apr	26	20	55	19.5	D	2028	G8	6.5*	5.9	100+	176		17	133	55N	96 Vir
21	Apr	27	21	33	45	M	2160	A1	6.4	6.3	99-	169		10	133	19S	22 Lib
21	Apr	27	21	45	34.8	R	2159	K5	5.2	4.4	99-	168		11	135	84S	nu Lib
21	Apr	29	0	26	37.0	R	2327	G3	6.7	6.4	95-	153		14	160	47N	
21	Apr	29	1	24	58.6	R	184263	A2	9.0	8.8	94-	153		16	173	51N	
21	Apr	29	2	46	44.5	R	184296	K1	8.4	7.8	94-	152		15	192	75N	
21	Apr	30	2	37	34.8	R	2499	K3	6.4*	5.6	87-	138		13	176	49N	
21	Apr	30	2	54	8.3	R	2500	B2	3.3*	3.4	87-	138		13	180	67N	theta Oph
21	Apr	30	2	58	6.6	R	185327	A5	8.5*	8.4	87-	138		13	181	54N	
21	Apr	30	3	31	43.0	R	185346	A2	7.3	7.2	87-	138	-9	13	188	77N	
21	May	1	1	45	39.7	R	186770	K2	7.6	6.8	79-	125		7	151	89S	
21	May	1	1	59	53.3	R	186780	A0	8.5	8.5	79-	125		8	154	83S	
21	May	1	3	7	57	Gr	2673	A3	6.3		78-	124		16	**	GRAZE	nearby
21	May	1	3	22	1.8	R	186845	A0	8.7	8.7	78-	124	-10	11	172	23S	
21	May	1	3	24	3.1	R	2673	A3	6.3		78-	124	-10	11	172	28S	
21	May	1	3	28	52.7	R	X157068		8.5	8.3	78-	124	-10	11	174	65S	Dbl*
21	May	1	3	28	54.6	R	2669	A7	6.4		78-	124	-10	11	174	66S	Dbl*
21	May	4	3	32	5.1	R	3141	K3	5.8	5.0	46-	86	-8	6	136	58S	35 Cap

Prediction to May 5th

Notes on the Double Star selection:

Doubles are selected from Occult 4, where the fainter companion is brighter than mag 9.0, and the time difference(dT) is between 0.1 and 10 seconds. **Please report double star phenomena.**

Key:

P = Phase (R or D), **R** = reappearance **D** = disappearance
M = Miss at this station, Gr = graze nearby (possible miss)
CA = Cusp angle measured from the North or South Cusp. (-ve indicates bright limb)
Dbl* = A double star worth monitoring. Details are given for selected stars.
Mag(v)* = asterisk indicates a light curve is available in Occult-4
Star No:
1/2/3/4 digits = Zodiacal catalogue (ZC) referred to as the Robertson catalogue (R)
5/6 digits = Smithsonian Astrophysical Observatory catalogue (SAO)
X denotes a star in the eXtended ZC/XC catalogue.

The ZC/XC/SAO nomenclature is used for Lunar work. The positions and proper motions of the stars in these catalogues are updated by Gaia.

Detailed predictions at your location for 1 year are available upon request.
Occultation Subsection Coordinator: occultations at stargazer dot me dot uk
Tim Haymes, LS Coordinator (occultations)

LUNAR GEOLOGICAL CHANGE DETECTION PROGRAMME

Tony Cook

Introduction: Observations received in the past month have been divided into three sections: Level 1 is a confirmation of observations received for the month in question. Every observer will have all the features observed listed here in one paragraph. Level 2 will be the display of the most relevant image/sketch, or a quote from a report, from each observer, but only if the date/UT corresponds to: similar illumination (±0.5º), similar illumination and topocentric libration report (±1.0º) for a past TLP report, or a Lunar Schedule website request. A brief description will be given of why the observation was made, but no assessment done – that will be up to the reader. Level 3 will highlight reports, using in-depth analysis, which specifically help to explain a past TLP, and may (when time permits) utilize archive repeat illumination material.

TLP reports: No TLP reports were received in February.

Level 1 – All Reports received for February: Jay Albert (Lake Worth, FL, USA - ALPO) observed: Aristarchus, Furnerius, Plato, and Stevinus. Alberto Anunziato (Argentina - SLA) observed: Censorinus, Eimmart, Lyell and Proclus. Massimo Alessandro Bianchi (Italy – UAI) imaged: Aristarchus, Lichtenberg, and several features. Maurice Collins (New Zealand – ALPO/BAA/RASNZ) imaged: Aristarchus, Bürg, Mare Humorum, Mare Nubium, Theophilus, and several features. Daryl Dobbs (Risca, UK - BAA) observed: Eimmart and Manilius. Walter Elias (Argentina – AEA) imaged: Alphonsus, Curtis, Montes Apenninus, Pickering, and Proclus. Fernando Ferri (Italy) imaged Torricelli. Les Fry (West Wales, UK – NAS) imaged: Aristoteles, Atlas, Byrgius, Cleomedes, de La Rue, Delambre, Drygalski, Fracastorius, Glushko, Gutenberg, Hausen, Hercules, Jansen, Lacus Autumni, Lacus Lenitatis, Manzinus, Mare Humboldtianum, Mare Nectaris, Maurolycus, Messier, Montes Taurus, Pitiscus, Plinius, Posidonius, Rupes Altai, Sacrobosco, and Schickard. Valerio Fontani (Italy – UAI) imaged: Aristarchus, Lichtenberg and several features. Rik Hill (Tucson, AZ, USA – ALPO/BAA) imaged: Aristarchus, Archimedes, Mare Orientale, the south pole area, Mons Rümker and its surrounds, and Rimae Sirsalis. Davide Pistritto (Italy – BAA) imaged: Aristarchus. Leandro Sid (Argentina – AEA) imaged: Aristarchus. Trevor Smith (Codnor, UK – BAA) observed: Aristarchus, Bullialdus, Eimmart, Gassendi, Lichtenberg, Madler, Mare Humboldtianum, and Plato. Bob Stuart (Rhayader, UK – BAA/NAS) imaged: Longomontanus and its surrounds. Franco Taccogna (Italy – UAI) imaged: Torricelli and several features. Aldo Tonon (Italy – UAI) imaged: Eratosthenes. Gary Varney (Pembroke Pines, FL, USA – ALPO) imaged: Mare Crisium. Ivan Walton (Cranbrook, UK – BAA) imaged Eratosthenes. (Italy – UAI) imaged: earthshine and Aristarchus.

Additional Reports received for December 2020: Walter Elias (Argentina – AEA) imaged: Agrippa, Alphonsus, Aristarchus, Capella, Cassini E, Delambre, Isidorus, Langrenus, Mare Crisium, Mare Nectaris, Maskelyne A, the north polar region, Petavius, Plinius, Posidonius, Ross D, the south polar region, Theophilus and several other features.

Level 2 – Example Observations Received:

Agrippa: On 2020 Dec 22 UT 01:21-01:22 Walter Elias (AEA) imaged and earlier at 00:30-00:44 Jay Albert (ALPO) observed visually this area under similar illumination to the following report:

Agrippa 1966 Nov 19/20 UT 23:58-00:14 Observed by Bartlett (Baltimore, MD, USA, 5" reflector x283, S=4, T=5) "Faint bluish tinge seen at base of NW wall beneath landslip" NASA catalog weight=4. NASA catalog ID #995. ALPO/BAA weight=3.

It is interesting to compare Walter's image (Fig. 1) with Jay Albert's earlier visual report: *'The crater's W wall was sunlit with its rim brilliantly white. The floor was almost completely in shadow except for a thin stretch of floor along the base of the interior W wall. The E facing slope of the central peak was also bright and its peak cast a shadow that extended slightly beyond the shadow covering the floor from the E wall of the crater. There was no "faint, bluish tinge" or other color seen at the base of the NW wall at its base or elsewhere in or around the crater.'* Although Bartlett was using a reflector, it is still possible to get some artificial colour fringes on contrasty edges of the crater, either through chromatic aberration in an eyepiece or if the Moon was low due to atmospheric spectral dispersion – though from Bartlett's locality the Moon's altitude was 31°. Walter's image does show some artificial colour, but does not show blue at the base of the NW wall – in this particular observing orientation of the Moon as seen from Argentina.

Figure 1. *A colour image of Agrippa taken by Walter Elias (AEA) on 2020 Dec 20 UT 01:21-01:22. Agrippa is located just left off and slightly above the centre of the image - north is towards the top. This image is a merge of two images taken at this time.*

Earthshine: On 2021 Feb 13 UT 17:40 Luigi Zanatta (UAI) imaged the earthshine following a BAA lunar schedule request:

BAA Request: Please try to image the Moon as a very thin crescent, trying to detect Earthshine. A good telephoto lens will do on a DSLR, or a camera on a *small scope. We are attempting to monitor the brightness of the edge of the earthshine limb in order to follow up a project suggested by Dr Martin Hoffmann at the 2017 EPSC Conference in Riga, Latvia. This is quite a challenging project due to the sky brightness and the low altitude of the Moon. Please do not attempt if the Sun is still above the horizon. Do not bother observing if the sky conditions are hazy. Any images should be emailed to: a t c @ a b e r . a c . u k*

Figure 2. *Earthshine on 2021 Feb 13 UT 17:40 as imaged Luigi Zanatta (UAI) with north towards the top right.* ***(Left)*** *Original image.* ***(Right)*** *Colour normalized and contrast stretched.*

Dr Hoffmann was originally interested to see if he could detect an arc of light around the limb of the earthlit part of the Moon – potentially from a lunar exosphere perhaps transiently laden with dust from a recent impact? He had found potential evidence for arc-like bright earthlit limbs in low sunlit phase images, but needed further imagery to check up on this. You could get a bright arc around the earthlit limb if dust were at a sufficient altitude to achieve forward scattering of the sunlight from behind the Moon. It should be said though that one can also obtain a light arc around the limb of the earthlit Moon, on the western limb, simply due to libration bringing lighter far side highland material into view. Suffice to say that Luigi's image (Fig. 2) shows no obvious sign of a bright western earthlit limb that is detailed in Dr Hoffmann's abstract: https://meetingorganizer.copernicus.org/EPSC2017/EPSC2017-1014.pdf

Lyell: On 2021 Feb 16 UT 23:15-23:45 Alberto Anunziato observed this crater under similar illumination to the following report:

Lyell 1972 Nov 10 UT 23:43 Observed by Bartlett (Baltimore, MD, USA, 3" refractor x54, x100, x200S=3, T=5) "At apparent centre of floor & edge of morning shadow an elongated, N-S irreg. obj. dull whitish-gray, albedo=4 like a c.p. (photo in Kwasan atlas in 1963 taken at col. 339.3 deg has a faint suggestion of a bright spot in that place- (plate 20) LO IV66 h2 & 73 H2, sun elev. @ 20deg show an even, dark floor with a very small crater right in centre -- unresolvable at earth. Kwasan photo's spot could be an artifact" NASA catalog weight=3. NASA catalog ID #1349. ALPO/BAA weight=2.

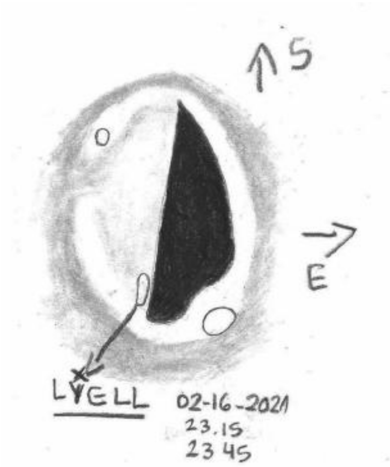


Figure 3. Lyell as sketched by Alberto Anunziato (SLA) on 2021 Feb 16 UT 23:15-23:45. Note that the orientation is as depicted in the sketch and it is in mirror image view.

Alberto found the floor of the crater was half covered in shadow. There were a total of three bright spots, one on the SW part of the rim. Another on the NE rim and the third in the northern edge of the floor – exactly at the edge of the shadows as Bartlett reported. – however not in the centre! The three white spots appeared to correspond to localized topography.

Eudoxus: On 2021 Feb 18 UT 18:15 Maurice Collins (ALPO/BAA/RASNZ) imaged the Moon under similar illumination to the following report from Canada:

On 1988 Nov 15 at 10:07-10:40 UT P. Jean (Outremont, Quebec, Canada, 4" refractor?) saw to the SE of Eudoxus (18E, ~43N) a luminescent area just over on the night side of the terminator - it was cone shapes and coppery in colour. Cameron comments that maybe it was a very low sun angle effect and she has seen something similar, but on the bright side of the terminator. Jean then goes onto comment that at 10:25UT a very dark line was seen south of the cone i.e., east of the terminator. A sketch was provided and P.Foley commented that the cone did not correspond to any terrain. Cameron 2006 Catalog Extension ID=339 and weight=3. ALPO/BAA weight=2.

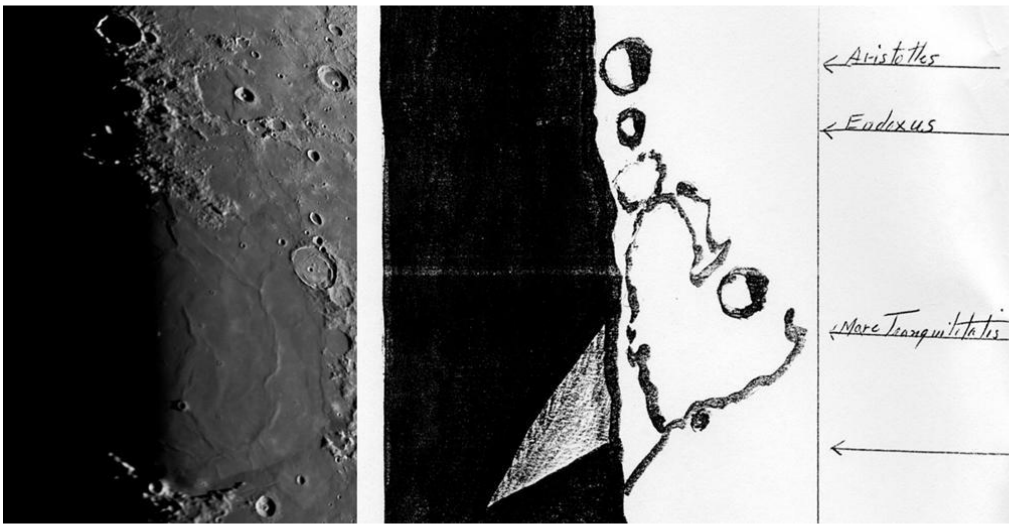


***Figure 4**. Eudoxus-Mare Serenitatis, orientated with north towards the top. **(Left)** An image by Maurice Collins (ALPO/BAA/RASNZ) taken on 2021 Feb 18 UT 08:15. **(Right)** The sketch made by Pierrette Jean on 1988 Nov 15 UT 10:07-10:40.*

Thanks to Maurice's image (Fig. 4 – Left) and comparing it to the 1988 sketch (Fig. 4 – Right) it is clear that the location of the TLP is more 'SE Serenitatis' rather than 'SE of Eudoxus'. Also, the terminator is a little further to the west in the sketch and this could indicate that the time was off by a few hours for the 1988 sketch.

Curtis: On 2021 Feb 19 UT Walter Elias (AEA) imaged Mare Crisium, including Curtis crater under similar illumination to the following Victorian era report:

Williams of the UK, on 1882 Aug 21 at 19:30UT (Moon's age 7.9 days) noticed a spot at least half as bright, and as large as Picard, near to Picard crater. This observation was reported in the Astronomical Register of the Royal Astronomical Society and is not included in the Cameron catalogues. It is one of many measurements of the brightness of this spot for different illumination angles and is one of three outlying brightness points spotted on a graph by Williams. The ALPO/BAA weight=3.

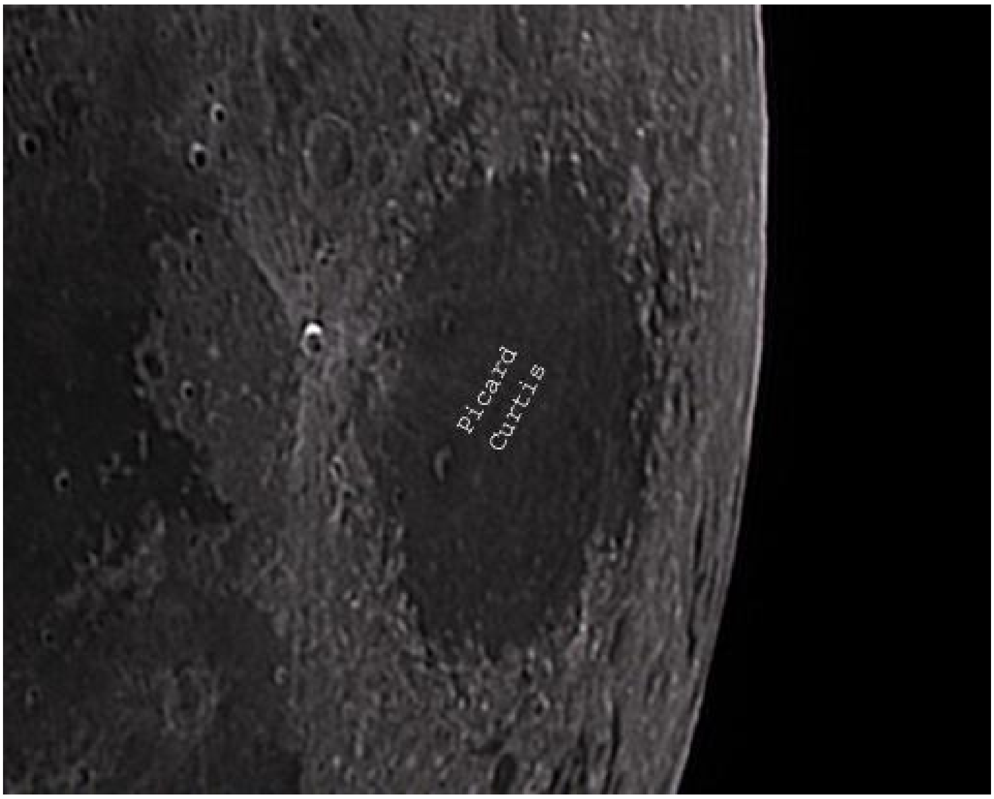


Figure 5. *Mare Crisium as imaged by Walter Elias (AEA) on 2021 Feb 19 UT20:36 and orientated with north towards the top. The location of Picard and Curtis are labelled.*

Eratosthenes: On 2021 Feb 20 UT 19:26 and 19:28 Aldo Tonon (UAI) imaged and at 20:00 UT Ivan Walton (BAA) also imaged the crater for the following lunar schedule request:

ALPO Request: This request comes about because of two observations. Firstly, on 2009 Nov 25 Paul Abel and others detected some colour on the inner west illuminated slopes of this crater. No similar colour existed elsewhere. On 2012 Aug 25 Charles Galdies imaged this crater and detected a similar colour, approximately in the same location, though he also imaged colour elsewhere. It is important to replicate this observation to see if it was natural surface colour, atmospheric spectral dispersion, or some effect in the camera that Charles was using, namely a Philips SPC 900NC camera. The minimum sized telescope to be used would ideally an 8" reflector. Please *send any high- resolution images, detailed sketches, or visual descriptions to: a t c @ a b e r . a c. u k .*

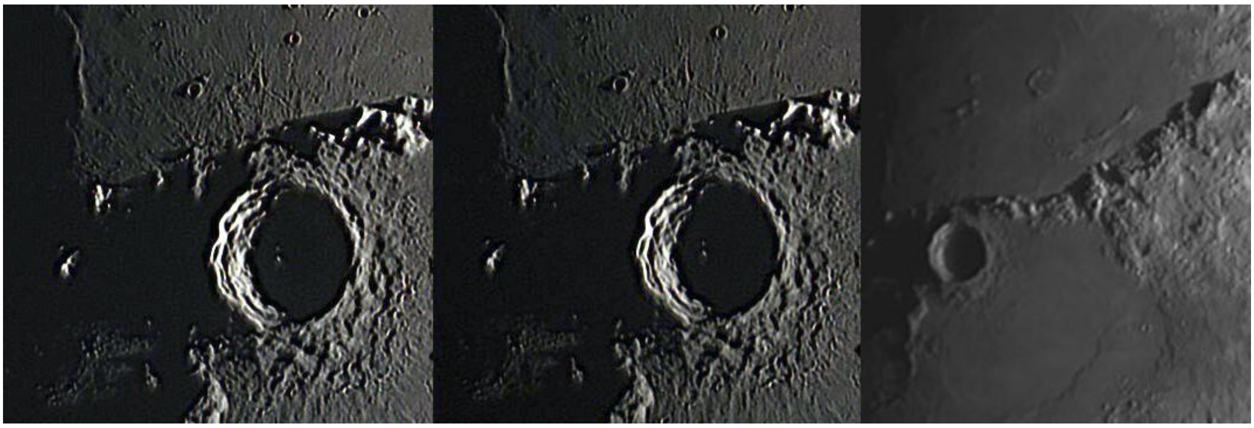


Figure 6. *Eratosthenes as imaged on 2021 Feb 22 and orientated with north at the top.* ***(Left)*** *Colour image by Aldo Tonon (UAI) taken at 19:26 UT, colour normalized and then had its colour saturation increased to 50%.* ***(Centre)*** *Colour image by Aldo Tonon (UAI) taken at 19:28, then colour normalized and then had its colour saturation increased to 50%.* ***(Right)*** *A monochrome image by Ivan Walton (BAA), taken later at 20:00 - provides a useful context image for the area.*

The colour images in Fig. 6 do not show any sign of the orange/brown colour mentioned in the above TLP report. They will however be useful for future work on simulating atmospheric spectral dispersion in order to see if that could have been a cause.

Eimmart: On 2021 Feb 22 UT 19:18-19:42 Trevor Smith (BAA) and at 20:00-20:25 Daryl Dobbs (BAA) observed visually this crater under similar illumination to the following report:

On 1981 Apr 15 at UT06:27-06:40 D. Louderback (South Bend, WA, USA using a 3" refractor x134 and S=4.5-5 and T=5-0) saw a bright spot on the western wall of Eimmart (sketch supplied) have an unusual brightening and shade. Variations occurred over 2-3-minute intervals. Louderback commented that the spot looked like a flare with its apex located at the crater wall and there was some blurring effect on the spot - it decreased in size during the phenomenon. Seeing worsened later. Apparently on the 18th and 19th of April everything was back to normal. Cameron comments that there is no bright spot on the Moon at this location. Lunar Orbiter IV plates 192-3.2 shows evening conditions. Cameron 2006 Catalog Extension TLP ID=130 and weight=3. ALPO/BAA weight=3.

Trevor commented that it took a while to identify the crater as it was close to the NE limb and contrast was poor. He saw a bright glow or spot on top of the craters east rim, but not on the west! Many other bright spots were visible in the general area around the crater. No blurring or variations in brightness were seen.

Daryl Dobbs even made a sketch of the area (Fig. 7). He comments: *'The observer used a small telescope at a relatively low magnification, the crater Eimmart is on the border of the Mare Crisium and the Mare Anguis. With such a high Sun angle over the area there were no shadows and a lot of glare, I used a neutral density filter which helped me familiarize myself with the area. The first thing which is apparent is a very bright fan-shaped ray system pointing westwards towards the Mare Crisium, this was determined to be the crater Eimmart A which is situated on the rim of Eimmart. With no shadows to aid identification at x 133 it was very difficult to* *determine the outline of Eimmart. The Mare Anguis is a small irregular Mare with many dark patches, the bright fan-shaped rays were very conspicuous and I'm sceptical if any white spot could have been observed on the western wall of Eimmart as the bright fan-shaped rays from Eimmart A were equal in brightness to Proclus nearby. With the increase of magnification, it was still very difficult to make out the outline of Eimmart, however a feature below and too the north caught my attention as a likely candidate for the observation above.*

This feature was a small bright spot with a darker area above and to the South East, this darker area along with the white spot gave the impression of being roughly the same size as Eimmart, and with a small telescope and lack of shadows for surface relief could easily be confused with it. The bright spot had an uneven outline which was sharper at a higher magnification, further investigation determined this to be the crater Eimmart G, the dark area was determined at a higher magnification as being dark Mare material. Looking in The Hatfield Photographic Lunar Atlas *shows plates 3a, 3d and 4a matches the view I had through the eyepiece.*

Cameron above notes in the Lunar Orbiter IV plates shows evening conditions, I wonder if this indicates there were shadows in the pictures, if so I can't see how this would be useful as it is my belief we are dealing with a misidentification of the crater Eimmart and the observer spotted with a small telescope at low magnification the very bright spot which marked the location of Eimmart G, they could have been fooled by the outline of the darker patch of Mare material resembling the expected outline of the crater Eimmart.

The observation mentions it looks like a flare with the apex on the crater wall, this could be a description of Eimmart A's bright rays which seem to converge at a point. If the Moon was low on the horizon atmospheric conditions could cause either Eimmart A or Eimmart G to give the impression of variability, both features Eimmart A and G are young craters with a very bright ray system and ejecta blanket, I find it difficult to see how the observer could have spotted a white spot on Eimmart's western wall as this feature would have been covered with the bright ejecta blanket ray system of Eimmart A. I'm also wondering if the observer got East and West mixed up, if they have, I don't think it would have made much difference as Eimmart A ray system and ejecta covers that part of the crater too.

I strongly suspect a misidentification between Eimmart and an existing feature Eimmart G caused by low magnification and lack of surface shadows. Using a neutral density filter on all the eyepieces did substantially help in identifying the craters in the area as they are so close to the limb with a very high sun angle. Eimmart G is roughly in line with the shore line of the Mare Crisium and the rough terrain, however Eimmart and Eimmart A is in line with the Mare Crisium, at x133 this was not easily apparent, but higher magnification the relative positions of the craters could be seen helped by the ND filter.'

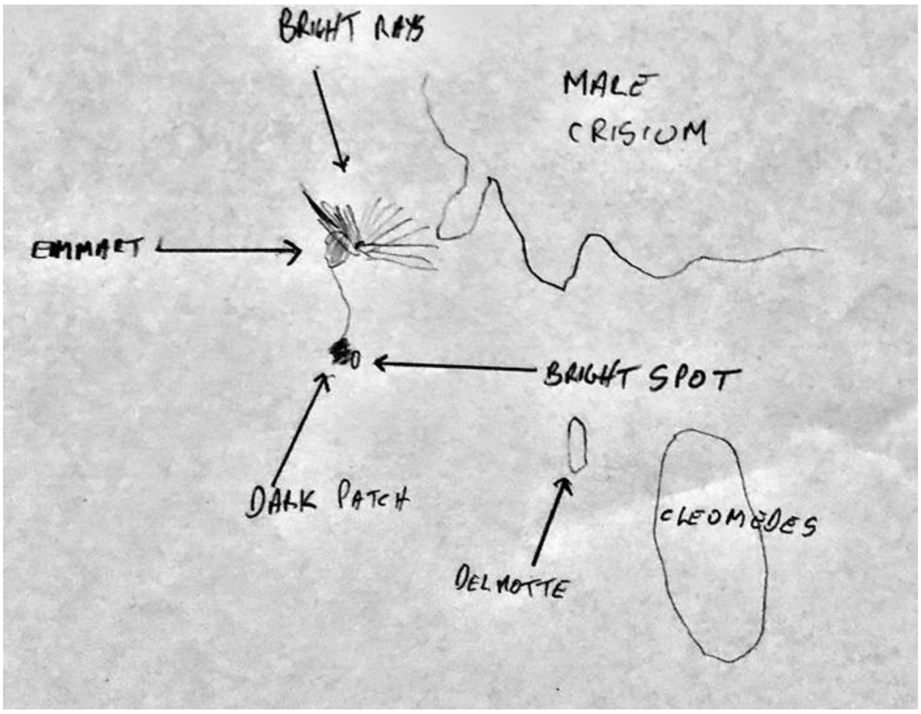


Figure 7. *A sketch map of the area around Eimmart made by Daryl Dobbs (BAA) on 2021 Feb 25 UT 19:28-20:13 and orientated with north towards the bottom.*

Aristarchus: On 2021 Feb 24 UT 00:09, 00:11 and 00:16 Leandro Sid (AEA) imaged this crater under similar illumination to the following repeat illumination events:

Aristarchus, Schroter's Valley, Herodotus 1881 Aug 07 UT 00:00? Observed by Klein (Cologne, Germany, 6" refractor, 5" reflector) "Whole region between these features appeared in strong violet light as if covered by a fog spreading further on 7th. Examined others around & none showed effect. Intensity not altered if Aris. placed out of view." NASA catalog weight=4 (high). NASA catalog ID #224.

Aristarchus 1981 Mar 17 UT 22:40-23:25 Observed by Moore (Selsey, England, 15" reflector, seeing III) "Aristarchus very bright according to Crater Extinction Device and a coloured blink detected" BAA Lunar Section TLP report. ALPO/BAA weight=1.

Figure 8. *Aristarchus as imaged in colour by Leandro Sid (AEA) on 2021 Feb 24 and orientated with north towards the top.* ***(Main Image)*** *Taken at 00:16UT.* ***(Inset Image)*** *Taken at 00:09.*

There is a hint of light blue to Aristarchus in Leandro's image (Fig. 8), but this is normal natural colour, and certainly not the strong violet light reported in 1881. Without using a CED or digital number values in the image, Aristarchus looks visually quite bright – or rather contrasty compared to other craters – but this is all relative – so the brightness for the 1981 report maybe to be expected. Re-reading Patrick Moore's original report, there is mention of a filter #9 which if a Wratten filter would be yellow. There is no mention in his report of using red/blue filters to detect a Moon blink – so the Cameron catalog report may be incorrect in this respect?

Aristarchus: On 2021 Feb 24 UT 04:55 Rik Hill (ALPO/BAA) imaged the crater under similar illumination to the following two reports:

Aristarchus: 1985 Dec 25 Louderback observed that the south west wall was a creamy deep yellow. There was also strong fluorescent blue on the west wall of the Cobra Head - Schröter's Valley area and this was similar to the violet glare seen on Aristarchus at times. Violet was seen between Aristarchus and the Cobra Head. Seeing conditions were poor. Brightening of a point near C occurred roughly every 10-15 seconds and lasted 0.5 sec - (Cameron concludes that this was not due to the Earth's atmosphere). A 0.2 step drop in brightness was seen on point A (twin spots). Point C had reduced by 0.6 steps. Elsewhere was stable in brightness. Cameron 2006 catalog ID=281 and weight=4. ALPO/BAA weight=3.

Vallis Schröteri 1893 Jan 30 W.H. Pickering noted variations in vapor column rising from the Cobra Head feature (seen on several nights in succession) and also in the visibility of craterlets A, C, F. Sunrise +2d. (time est. fr. gives colongitude). Cameron 1978 catalog ID=279 and weight=3. Pickering was observing from the southern station of Harvard University in Arequipa, Peru.

Figure 9. *A monochrome image of Aristarchus taken by Richard Hill (ALPO/BAA) on 2021 Feb 24 UT 04:55 and orientated with north towards the top.*

Rik's image (Fig. 9) is a useful context image for the Louderback report, though the monochrome nature precludes us from examining the colour aspects of the 1985 report other than being useful for simulating atmospheric spectral dispersion effects to see if these might have been the cause. For the Pickering report, if my memory serves me correctly it was something to do with seeing the area around the head of Vallis Schröteri appearing blurred – giving rise to the appearance of a vapor cloud effect – more than likely a combination of the natural appearance of the topography here at this colongitude and atmospheric seeing effects. Anyway, Rik's image is a useful calibration picture of what the area should normally look like under good conditions and can be used to simulate effects of blurring by the atmosphere, to try to explain what Pickering saw.

Aristarchus: On 2021 Feb 24 UT Davide Pistritto (BAA) imaged the crater for the following respective ALPO Lunar Schedule request and repeat illumination/libration predictions:

ALPO Request: Does the Aristarchus area look "invisible" through a blue filter? Use a telescope of at least 8" aperture. Any visual descriptions, sketches, or colour images should be emailed to: t o n y . c o o k @ a l p o - a s t r o n o m y . o r g

1996 Jun 28 UT 21:04 F. Ferri and D. Zompatori (Anzio), using a 20cm f/6 reflector, reported that (translation) "Using a blue filter the area was invisible". This is a UAI observation from Italy. ALPO/BAA weight=1.

Figure 10. *Aristarchus as imaged by Davide Pistritto (BAA) on 2021 Apr 24 and orientated with north towards the top.* ***(Left)*** *Taken at 19:43 in red light.* ***(Right)*** *Taken at 19:42 in blue light.*

Davide's images (Fig. 10) show a view of Aristarchus that is sharper in red light than blue, but in blue light, by no means does the description of the interior match that of the 1996 TLP. Once can expect slightly lower resolution in blue light because the contrast is lowered due to Rayleigh scattering in our atmosphere, but of course this can vary with transparency/other types of scattering in our atmosphere.

Lichtenberg: On 2021 Feb 26 UT 20:29 UAI observers: Valerio Fontani and Massimo Alessandro Bianchi, imaged the crater in colour and monochrome respectively for the following BAA lunar schedule request:

BAA Request: An important historical TLP sketch of this crater, and its surrounds, made by Richard Baum back in 1951 seems to have the wrong UT? It is very important that we establish what the UT and date of this observation actually was. In this prediction we are seeing if his date was off by 1 day. Please email any sketches, monochrome, and especially colour images to: a t c @ a b e r . a c. u k

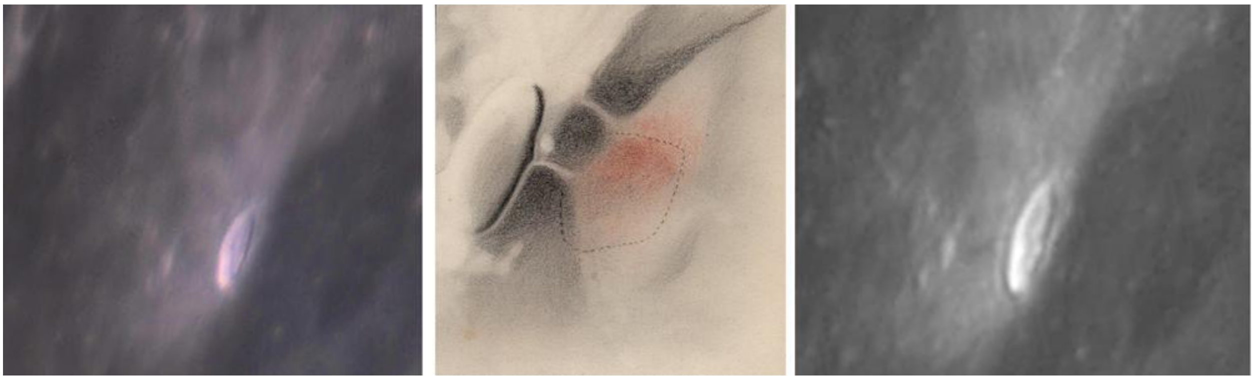


Figure 11. *Lichtenburg orientated with north towards the top.* ***(Left)*** *As imaged in colour by Valerio Fontani on 2021 Feb 26 UT 20:29 with colour saturation increased to 50%.* ***(Centre)*** *The original Richard Baum (ALPO/BAA) sketch with a quoted date and UT of 1951 Jan 21 UT 18:19-19:39.* ***(Right)*** *As imaged in monochrome by Valerio Fontani on 2021 Feb 26 UT 20:29.*

Interestingly a visual observation by Trevor Smith (BAA) made on 2021 Feb 25 UT 21:00-21:20 matched the similar illumination to the date and UT given in the original Richard Baum report. Trevor comments: *'Lichtenberg is a small (21km) crater and is very foreshortened due to its close proximity to the north/west limb. Tonight, it was half in shadow and very close to the terminator. No small red spot was seen and everything else appeared normal!'*. Clearly as you can see from the original sketch in Fig. 11 (Centre), the crater is not half in shadow, and so the date given in Richard Baum's log book must be wrong. Figs 11 (left & Right) by UAI observers show that the shadow is right for an anticipated/corrected colongitude range and so the date may have been 1951 Jan 22 instead of the 21st. However, there is much else different between the sketch to the east of the crater in comparison with the digital images which leaves us with a real big puzzle? Another possibility could be that Richard's times were in fact GMAT – probably unlikely but we have another request in the lunar schedule web site to investigate this.

Plato: On 2021 Feb 26 UT 01:30-02:00 Jay Albert observed this crater visually under similar illumination to the following to report:

Plato 1937 Jul 22 UT 06:20 Observed by Haas (Alliance, Ohio, USA, 12" reflector?) "Floor distinctly greenish, but was gray on June 23, 1937 at 0430 & col.84 (normal?)" NASA catalog weight=4. NASA catalog ID #421. ALPO/BAA weight=3.

Jay used a Celestron NexStar Evolution 8" SCT, at x226 and x290, under poor magnitude 2 conditions, although his seeing was good at 7-8/10. Jay found Plato to be fully sunlit with no shadows – the walls formed a bright ring. The central and S craterlets and the N pair were all visible. He found the crater floor was its usual dark shading and there was no greenish colour seen to the floor No color was seen in or around the crater either and there were no signs of any obscurations.

Level 3 - In Depth Analysis:

Again, this month I am out of time to do some full in-depth analysis into some of the above reports left in the level 2 category. However, I was provided with a nice write-up by Fernando Ferri, using 16-bit largely unenhanced CCD images for the report below, that I have edited – though most of the words are his. I have also added some images from Franco Taccogna, which have been Registaxed, but are of slightly higher resolution. As you will see the conclusion is largely the same.

Torricelli: On 2021 Feb 18 UT 18:36-18:56 Fernando Ferri (BAA) and at 18:36-18:51 UT Franco Taccogna (UAI) imaged the crater for the following lunar schedule request: and I have used most of the words in his report, with a few modification…:

ALPO Request: On 2011 Dec 31 Raffaello Braga found the north rim of Torricelli to be very bright at the start of the observing session but dimmed considerably later. He was not sure on the normal appearance of this crater, hence why it is really important to establish this by re-observing under similar illumination. Minimum telescope aperture required: 3", and try to use a refractor if possible. Please send any high-resolution images, detailed sketches, or visual descriptions to: a t c @ a b e r . a c. u k .

Fernando remarks that Raffaello Braga is an experienced lunar and planetary observer, former director of the UAI Lunar section. He made his 2011 Dec. 31 observation using a 115mm refractor. For this lunar observation request Fernando used an 8” Celestron SC telescope with a Televue 2x barlow with IR cut filter and acquired 30 sec videos with a ZWO ASI 224 camera in the 20 minutes time window. The sky was clear of clouds but the seeing was poor, judged IV Antoniadi as a mean, during the observing session. Some thin cloud veils were noted at the end of the session. Eleven RGB AVI format video files were processed, stacking the same small number of frames without any detail enhancement and gain adjustment. The result of each stack was saved as a separate 16-bit TIF file. Visually Fernado did not note any significant variation of the northern rim albedo (Fig. 12) but in order to try a more quantitative approach he did some raster analysis on the images taken:

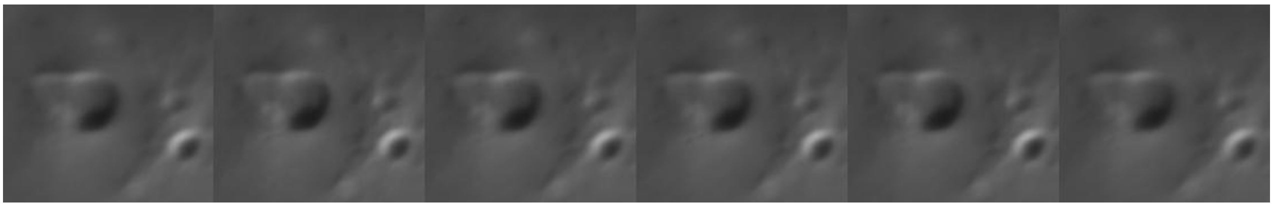


***Figure 12:** Torricelli crater images acquired by Fernado Ferri (BAA) in the requested observing time window on 2021 Feb 18 UT 18:36-18:56. No apparent large albedo variation is present (north is up).*

To try to exclude changes caused by atmospheric condition variations Fernado compared the brightness values of the northern rim of the Torricelli crater to a reference area out of the crater (Torricelli A), sampling the images taken at 18:36 UT and 18:56 UT along a line profile (Fig. 13). The green channel was used.

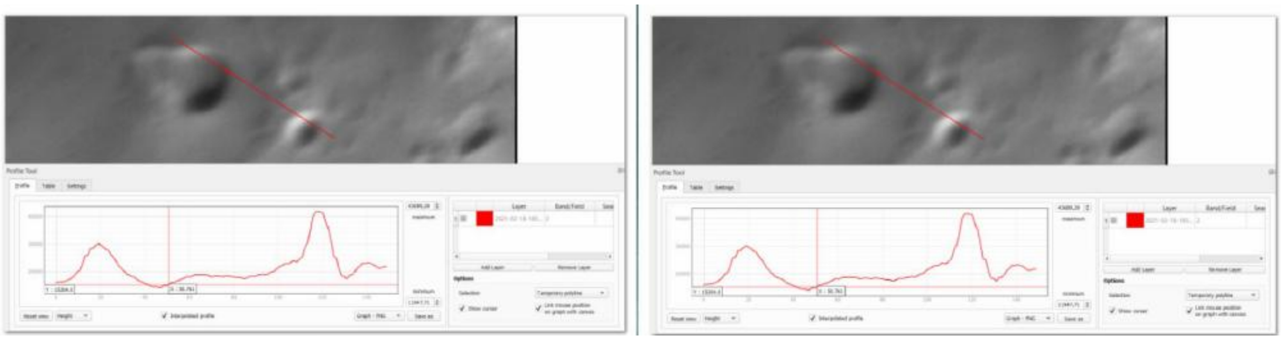


Figure 13. *Raster or DN values (green channel) sampled along a line between Torricelli north rim and Torricelli A: to the left 18:36 UT, to the right 18:56 UT, (north is up). Images by Fernado Ferri (BAA).*

The pixel (DN) values on the graphs of Fig. 13 showed no significant variation between the start and end of the requested time window, confirming the visual observation. Another check was made sampling the pixel values of 2 points on Torricelli north rim and 1 point on Torricelli A rim (Fig. 14).

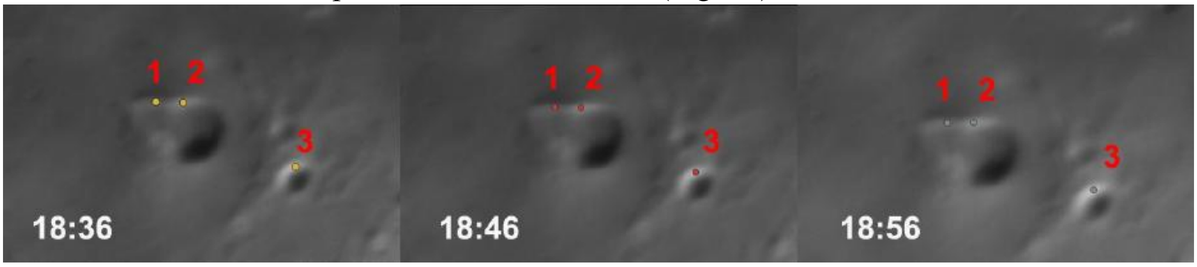


Figure 14 *Points selected for pixel value sampling on 3 images taken at 10 minutes intervals. Images by Fernado Ferri (BAA).*

This analysis was made on the single RGB channels. In Fig. 15 the G channel variation graph was shown, the R and B channels gave similar variation trends. The variations showed a general small decreasing trend and were almost within the standard variation of the mean value. This behaviour was probably caused by a slight change of the sky transparency. No large variation was visible in this data.

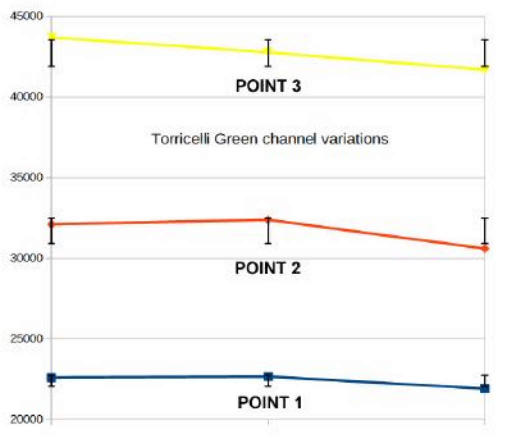


Figure 15. *Pixel value (DN) variation of the sampling points for the 3 images taken at 18:36, 18:46 and 18:56 UT. Time is the x axis, pixel values are the y axis. The range of y axis for each of the three data points over time are also shown as error bars. Graph by Fernado Ferri (BAA).*

The above analysis result (Fig. 15) showed that no apparent large albedo variation was present during the observation of Torricelli of 2021 Feb 18 UT 18:36-18:56 with similar illumination conditions to the 2011 TLP observation made by Raffaello Braga.

I also received some images of the crater from Franco Taccogna (UAI), taken with a 20cm f/5 Newtonian (Barlow APO x3) and show a sequence of his images here (Fig. 15). Franco's images have been processed via Registax. Again, no obvious signs of brightening on the rim can be seen, athough the 18:50 image appears dimmer, presumably due to a change in transparency, and this is born out by a crude brightness profile I have plotted in Fig. 16. Alas there was no available time do do a full analysis. So neither Fernando's nor Franco's image sequences came up with anything to suggest what was seen in 2011 was normal. Brightness changes do occur but these can be a combination of transparency and atmospheric seeing conditions (affecting bright sharp edges/points more so than regional areas).

Figure 16. *Torricelli as imaged by Franco Taccogna on 2021 Feb 28 with an ASI 120 MM camera and a R#21 filter. North is towards the top. (Far Left) 18:36 UT. (Left) 18:43 UT. (Right) 18:50 UT, (Far Right) 18:51UT.*

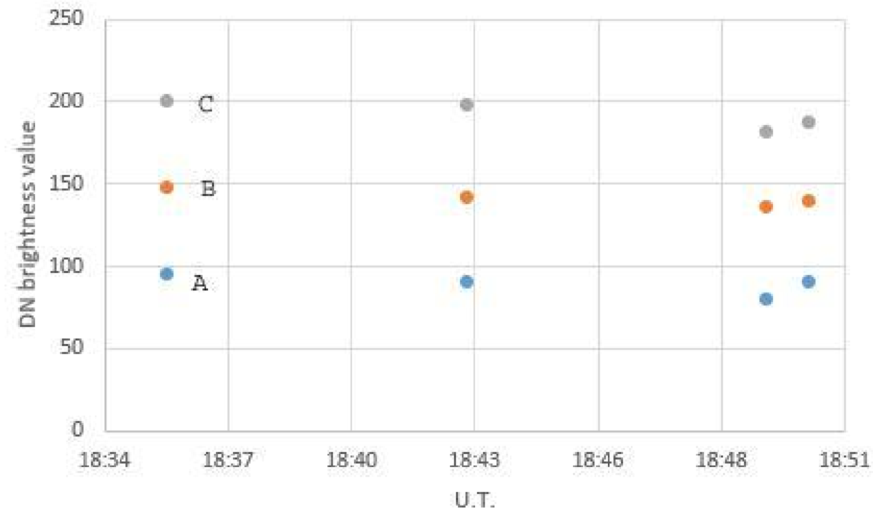


Figure 16. *Brightness measurements from Framco Taccogna's images in Fig 15 for the same three points on the craters as shown in Fernando Ferri's image in Fig 14. No error bars shown.*

Fernando would like to highlight that 16-bit images with no compression and processing enhancement can be analysed in a quantitative or semi-quantitative way in order to obtain more useful and reliable information and data for albedo variation studies such as the ones related to transient lunar phenomena. This is absolutely true, the photometry is more precise and you can cover a greater range brightness levels from the dark terminator to a brightly lit ray crater – certainly more than the 256 grey levels in a monochrome 8 bit image. Most modern cameras use 16 bits. However, if the photon noise (square root of the number of photons per pixel), atmospheric point spread function, atmospheric scattering are taken into account then one cannot reliably obtain 16-bit resoulution or 1/65536 of a level of brightness going from white to black – but it will probably be better than 1/256 for 8-bit images. I think the take-home point to make here is please keep on sending in your images for lunar schedule requests and repeat illumination. But consider moving from JPG (lossy) format to TIF or PNG (non-lossy compression) as JPGs can introduce artefacts in non-contrasty areas and close to edges. Definitely keep the original images – just in case we need to do further work and need higher photometric resolution!

General Information: For repeat illumination (and a few repeat libration) observations for the coming month - these can be found on the following web site: http://users.aber.ac.uk/atc/lunar_schedule.htm . Only by re-observing and submitting your observations can we fully resolve past observational puzzles. To keep yourself busy on cloudy nights, why not try 'Spot the Difference' between spacecraft imagery taken on different dates? This can be found on: http://users.aber.ac.uk/atc/tlp/spot_the_difference.htm . If in the unlikely event you do ever see a TLP, firstly read the TLP checklist on http://users.aber.ac.uk/atc/alpo/ltp.htm , and if this does not explain what you are seeing, please give me a call on my cell phone: +44 (0)798 505 5681 and I will alert other observers. Note when telephoning from outside the UK you must not use the (0). When phoning from within the UK please do not use the +44! Twitter TLP alerts can be accessed on https://twitter.com/lunarnaut .

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