BAA Lunar Section
British Astronomical Association
Director: Bill Leatherbarrow

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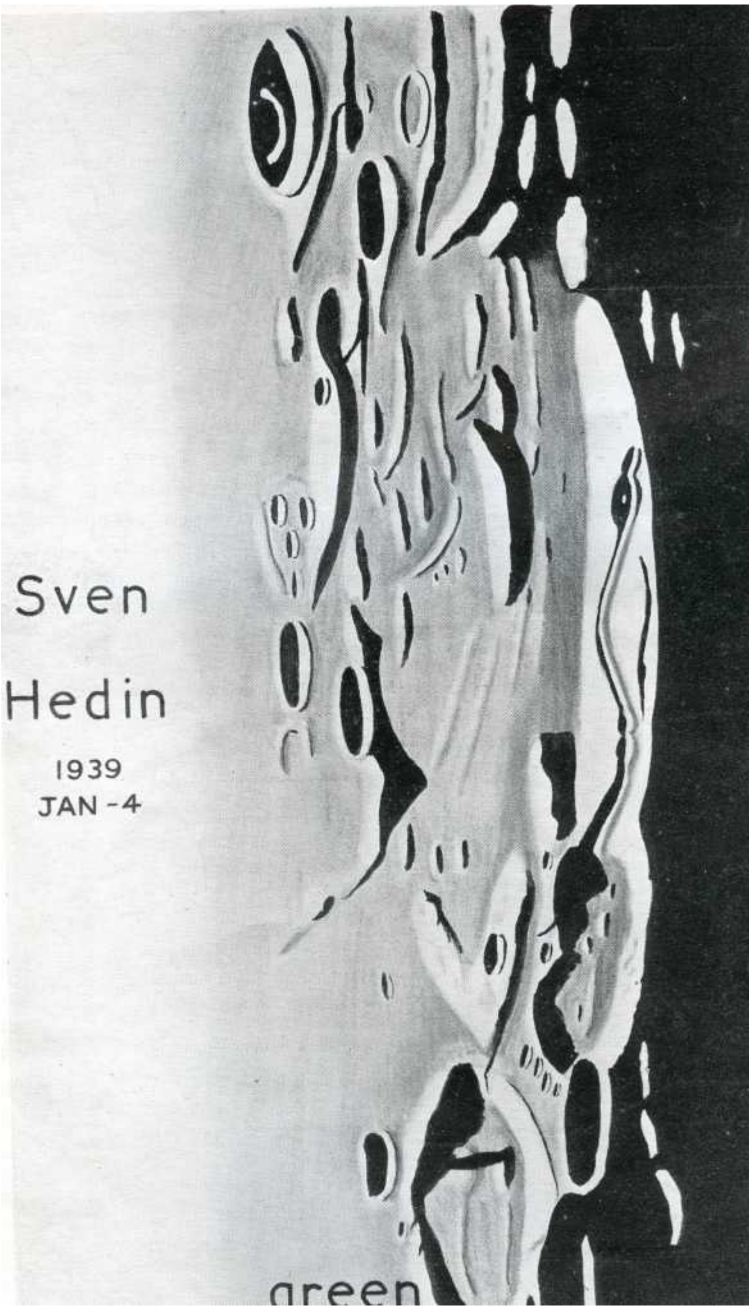
FROM THE DIRECTOR

The decades before the advent of the Space Age were a golden period for the amateur lunar observer. So many unresolved problems of lunar topography presented themselves for investigation by the skilled eye at the telescope, and the archives of our Section, such as for example the past issues of the Section bulletin *The Moon* (available for download from the Section website), are eloquent testimony to the achievements of those years.

The western limb areas (east in those pre-IAU convention days) attracted an inordinate amount of attention. Observers were drawn to exploring the nature of the so-called Miyamori Valley (discussed by Nigel Longshaw in the December 2018 issue of *Astronomy Now*), trying to determine the nature of the Sirsalis Rille's passage through the crater De Vico A, and exploring the elusive limb crater Einstein (known unofficially as Caramuel at that time) - to cite but three examples. One particularly intractable problem was posed by the ancient crater Hedin, located just to the north of Riccioli, whose topographical complexity and proximity to the lunar limb made accurate mapping very difficult.

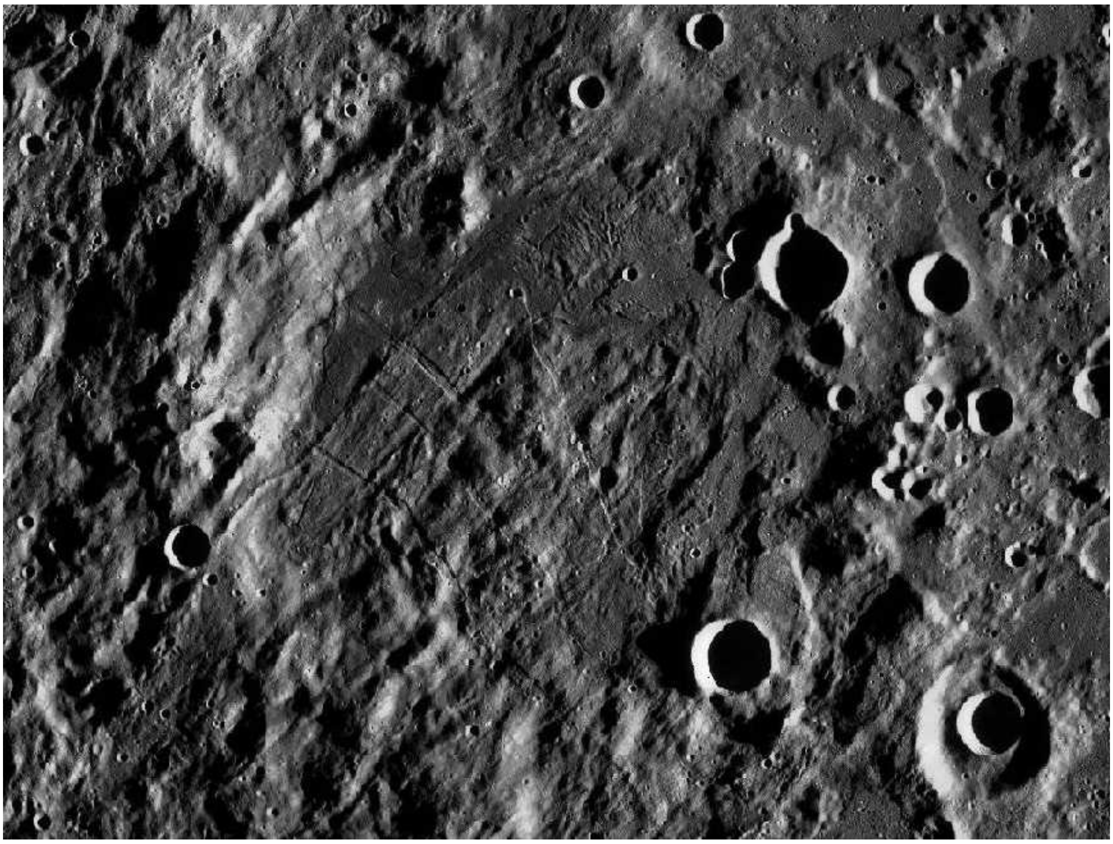
The earliest sustained attempts to map Hedin (known then as Sven Hedin) were by members of the British Astronomical Association's Lunar Section during the period leading up to World War II. Those efforts were led by a young and very gifted observer, Samuel Morris Green, using a home-made 12-inch (300mm) reflector. Green's drawings compare well with modern telescopic imagery, but of course they cannot compete with results from LROC.



Hedin, drawn by S. M. Green in 1939, south up (BAA Lunar Section)

Green's results were summarised in a *Memoir* of the BAA Lunar Section, published in July 1950, but tragically the young observer did not live to see the fruits of his labours. Educated at Bromsgrove School and the University of Liverpool, Green qualified as a doctor and joined the Royal Army Medical Corps at the start of 1944. Planning was already underway for the D-Day landings and on 25 January 1944 Green wrote to the then-Director of the BAA Lunar Section, T. L. MacDonald, saying: 'I am expecting to be in the continental bust-up when it comes off ... I doubt whether I shall be able to send you [anything further] for some time to come'. His words were prophetic: he was killed in action on 6 June 1944, the first day of the Normandy landings. He was 23 years old.

Modern spacecraft imagery shows that Hedin is blanketed in Orientale ejecta material, its floor a jumble of clumpy deposits scored by parallel linear rilles. The best LROC images show that the floor is intruded upon from the southwest by a gigantic tongue of material that appears to have come from the general direction of the Orientale basin.



Hedin imaged by Lunar Reconnaissance Orbiter.

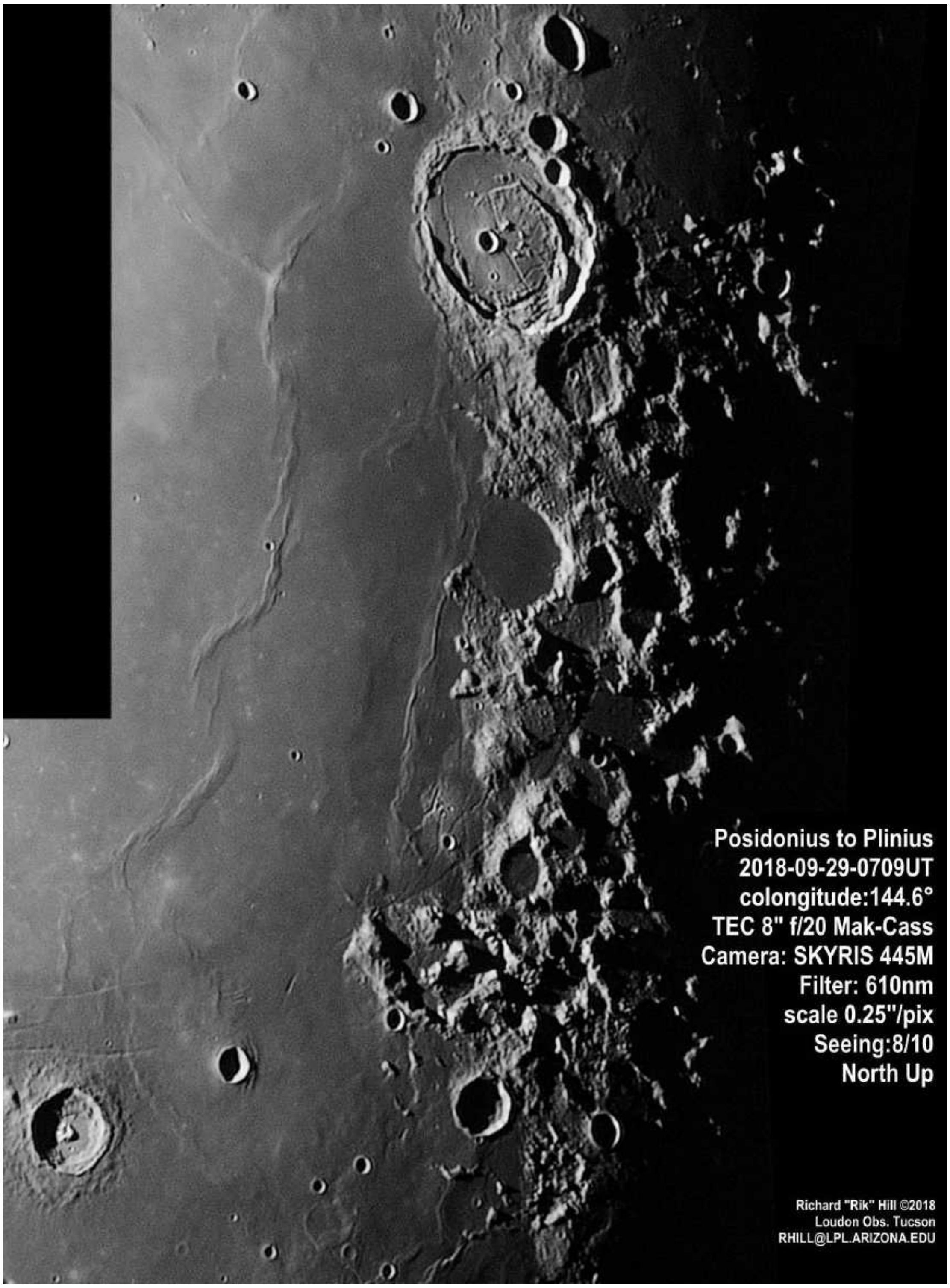
The problems that intrigued Green and our other predecessors in the Lunar Section might indeed be settled now, but Hedin is still worth a telescopic visit. In fact, very few decent telescopic images of it exist even today – a task perhaps for the winter months!

Bill Leatherbarrow

OBSERVATIONS RECEIVED

Images have been received from the following members: Maurice Collins (New Zealand), Dave Finnigan, Rik Hill (USA), Phil Shepherdson, Bob Stuart, and the Director.

Rik Hill has submitted several images, including this fine study of the area around Posidonius.

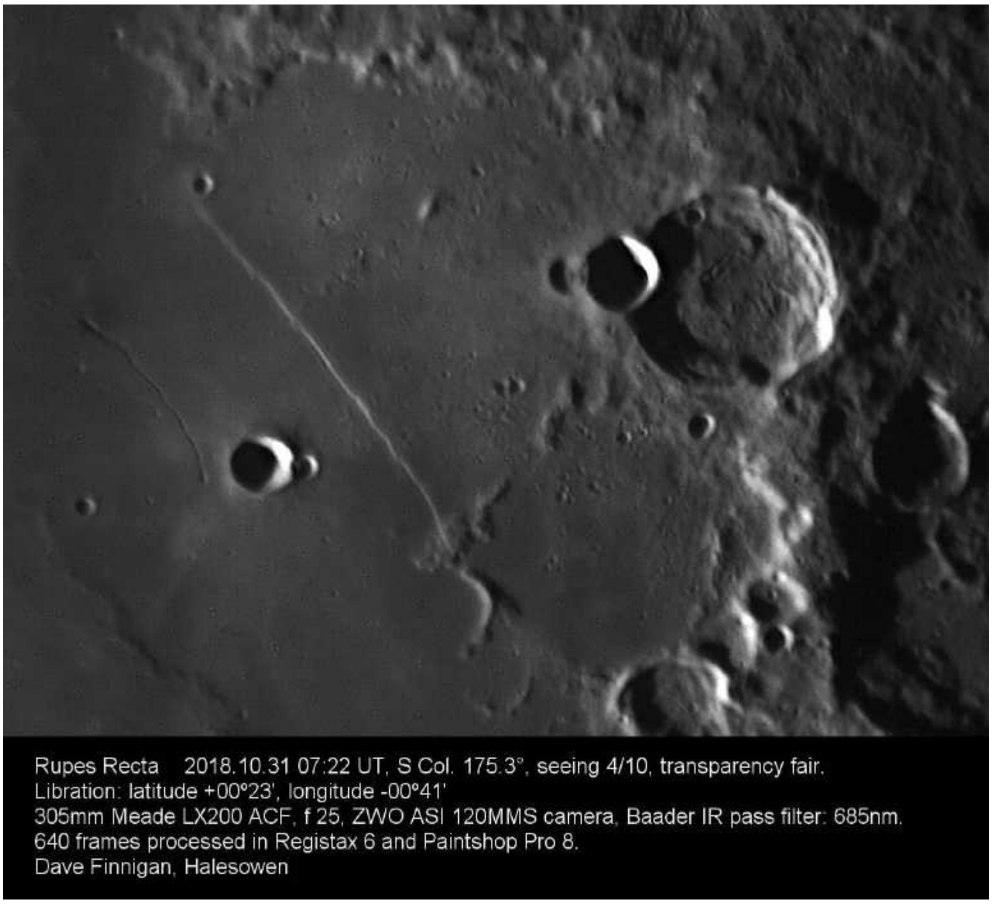


Rik writes as follows:

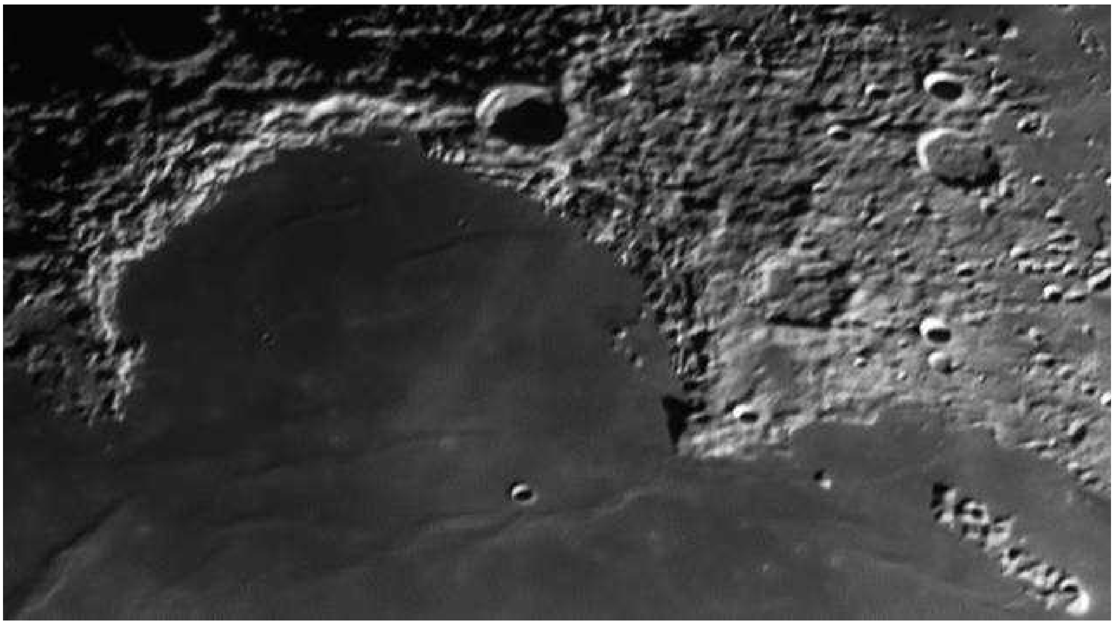
‘A spectacular view of the waning moon terminator dominated by the 99km diameter crater Posidonius at top with the magnificent Rimae Posidonius and the rim of a totally flooded crater on the floor inside the main crater walls. Adjacent to the south wall is the crater Chacornac (53km) with a floor heavily faulted and crossed by rimae. It is older than Posidonius and Mare Serenitatis to the left. Further south is the cirque that is Le Monnier (63km) with the wrinkle ridge Dorsa Aldrovandi that looks like it's pouring out of Le Monnier. It runs for 124km south, down the coastline on the shores of Mare Serenitatis. It ends at a curious cluster of three mountains that are the site for the Taurus-Littrow Apollo 17 base. The landing site is just off the northern tip of the middle mountain which was named South Massif. The oval crater just above these mountains is Littrow (32km) and to its left is a small crater Clerke (7km). Note the system of unnamed rimae surrounding this latter crater and the spectacular east-west fault just south of Littrow.

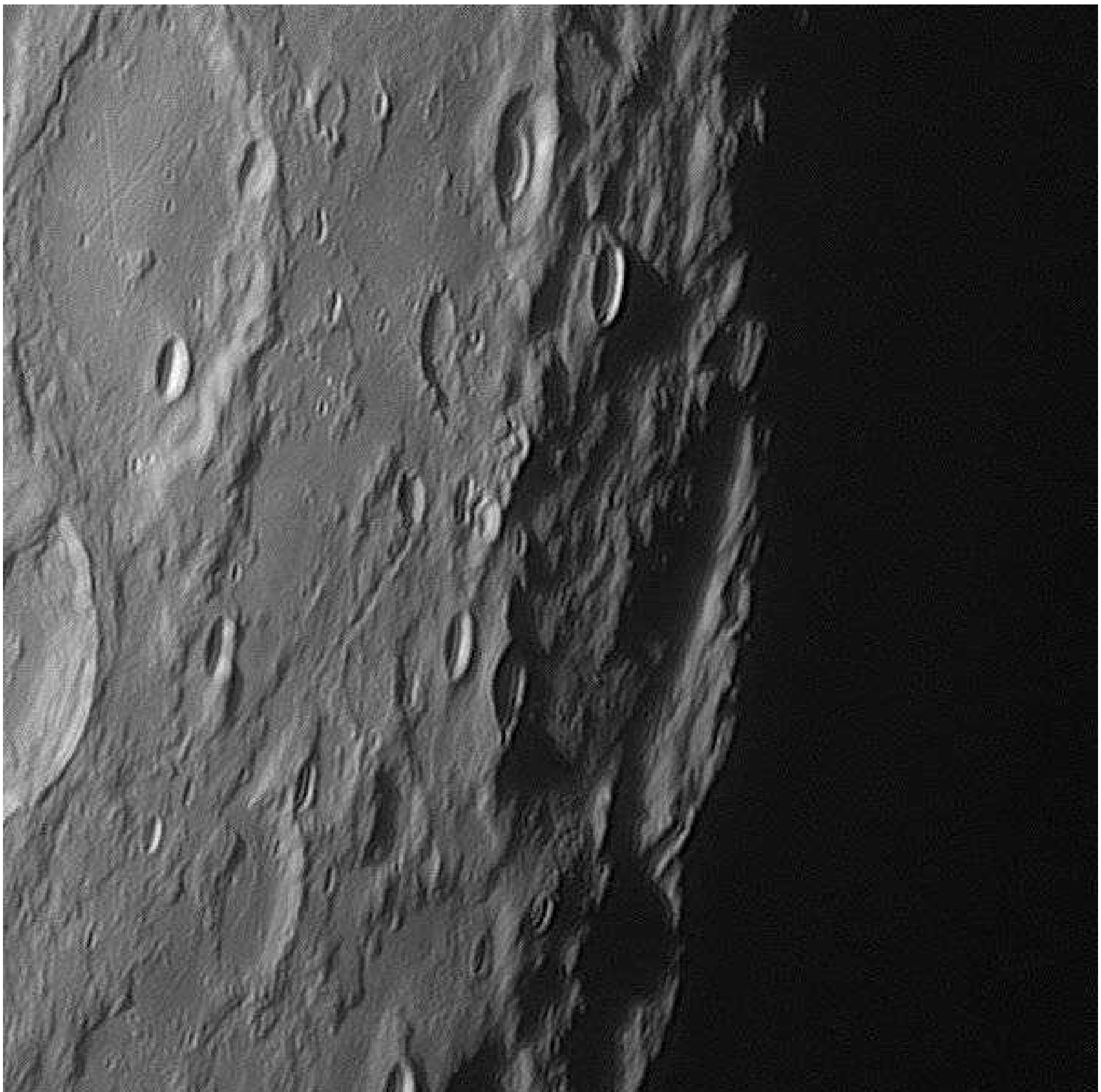
Below the Apollo 17 site is the crater Vitruvius (31km), deep in shadow, and to its left is the smaller Dawes (19km) with a couple little ridges on its right (east) side. Farther on is the crater Plinius (44km) surrounded by its hummocky ejecta blanket and the nice graben-like Rimae Plinius to the north. One last thing is the largest thing in the image. One branch starts from Plinius and the other from Dawes and moving north they merge to form the great Serpentine Ridge (as I learned it in the early 1960s) now known as Dorsa Smirnov and runs all the way up Serenitatis to north and west of Posidonius.'

Dave Finnigan took this fine image of the Rupes Recta area on 31 October 2018.



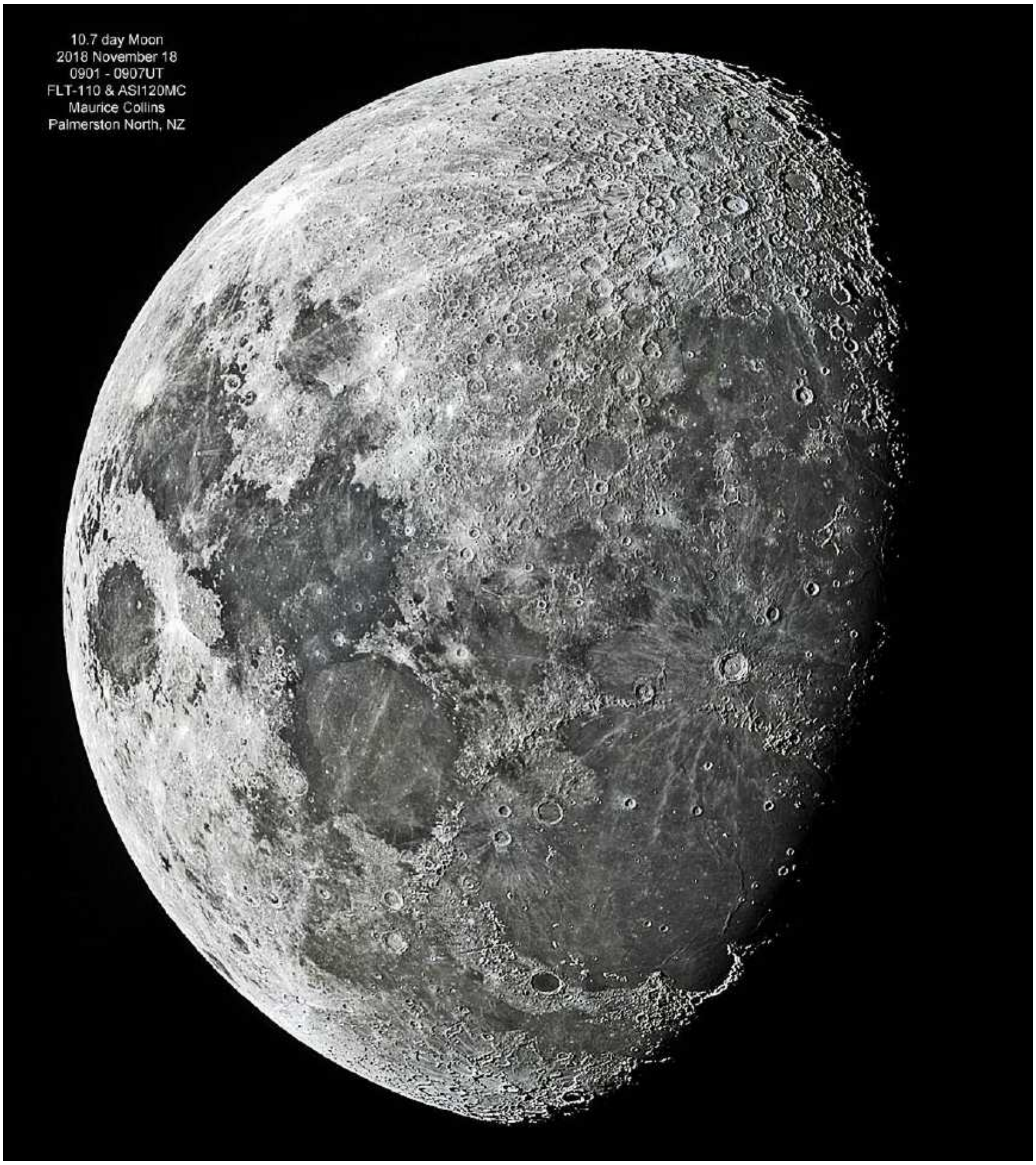
Bob Stuart has submitted an excellent image of the Sinus Iridum, taken on 18 November 2018 at 19.27 UT.





The above image of Hedin was taken by the Director on 21 November 2018 at 21.25 UT, using an OMC300 Mak-Cass. Seeing conditions were unsteady (Ant III-IV), but it is nevertheless worthwhile comparing this image with Samuel Green's sketch earlier in this Circular. It is presented here with south up to facilitate comparison – a comparison that invites admiration of Green's skills as an observer.

Maurice Collins captured this sharp image of the waxing gibbous Moon on 18 November 2018, taken from New Zealand so south is up.



LUNAR MAGMATIC FOAMS AND IRREGULAR MARE PATCHES

Barry Fitz-Gerald

Magmatic foams appear to have become something of a miracle cure to a number of geological conundrums that have been kicking around the academic literature for a while. In the lunar environment magmatic foams are believed to form as basaltic lavas approach the surface in vertical dykes from deep within the crust. The release of volatiles from magma is believed to play a major part in explosive lunar volcanism, with carbon monoxide being a major component, forming at depth in a reaction involving graphite and metal oxides. Water however (which may exist in lunar lavas at concentrations of several hundred parts per million) comes out of solution at much shallower depths and produces a froth or foam that is 95% bubbles [1]. This foam is now implicated in the production some of the most enigmatic features on the lunar surface, irregular mare patches or IMPs. The most well known IMP is the D-shaped structure Ina in Lacus Felicitatis just north-east of Mare Vaporum. This small depression measuring some 2.8 x 1.8kms was first identified from Apollo imagery, and is notable for its peculiar morphology of smooth semi rounded mounds set in a depression amongst lower hummocky and rocky terrain (Fig. 1). Ina is located on the summit of a low shield volcano some 30kms in diameter and 400m high.

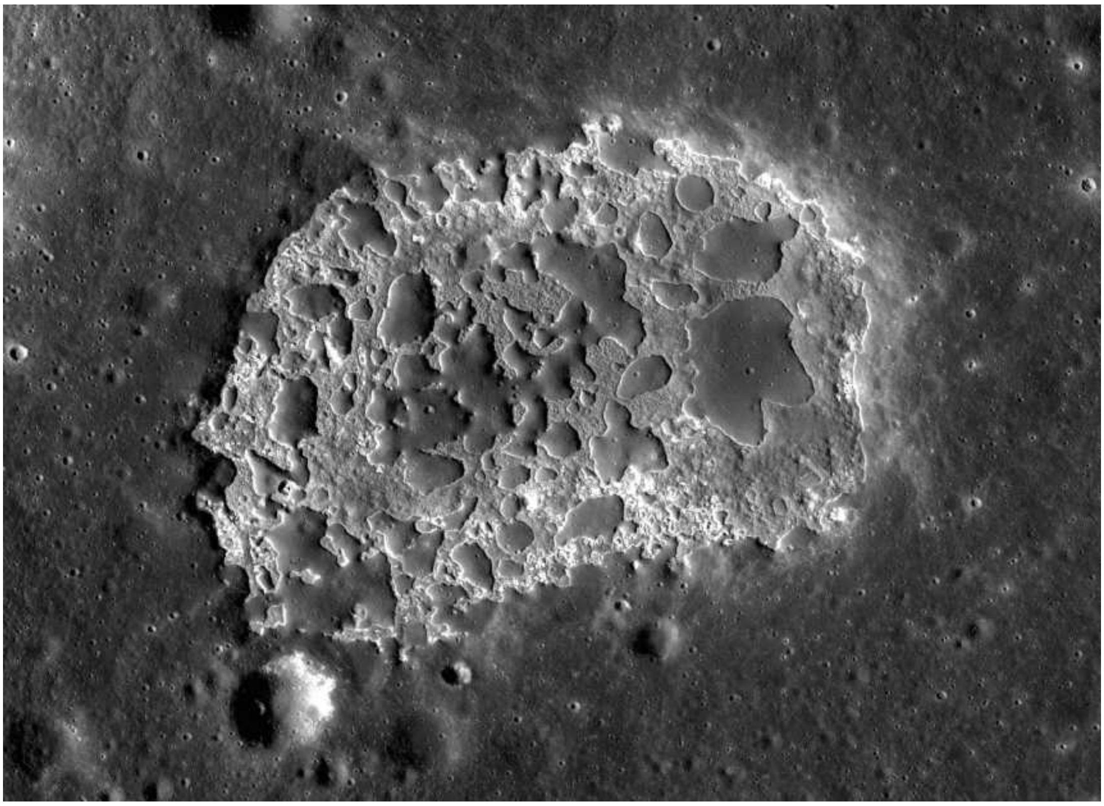


Fig. 1 LROC image of Ina showing the smooth mounds and immature and rocky floor

Ina is not alone in having this peculiar topography and a large number of IMPs have been identified [2] varying in size from Ina, the largest, down to small patches a few tens of meters across. All are found within the maria, which is taken as a strong indication that they are related in some way to basaltic volcanism. What these IMPs have in common is their youthful appearance, with fresh profiles, low optical maturity and a low number of superimposed impact craters. One hypothesis suggested an age of 10 million years, and formation by the release of volcanically or radiogenically derived gas, which essentially blew the fine regolith away to reveal the underlying blocky and immature rock [3]. It was even possible, according to this hypothesis, that the process was still ongoing. An alternative mode of origin suggested that the smooth mounds within Ina could be explained as inflated lava flows, essentially pre-existing lava flows that have been pumped up by the injection of younger lavas into them, a process observed in terrestrial volcanic lava flows [4]. The very young age for Ina and other IMPs of 10 million years has been modified upwards to 100 million by tweaking the various theories of how they formed, but these theories mostly categorise IMPs as some form of exotic basaltic volcanism [2].

The formation theories for Ina and other IMPs such as Rima Sosigenes all gave, what was in lunar terms, embarrassingly young ages for these features, as the orthodox models of lunar thermal evolution had mare volcanism ceasing between 2.9 and 1 billion years ago at the most recent [5]. But into this rather nasty paradox came magmatic foams, an elegant and credible remedy to the young age problem posed by IMPs.

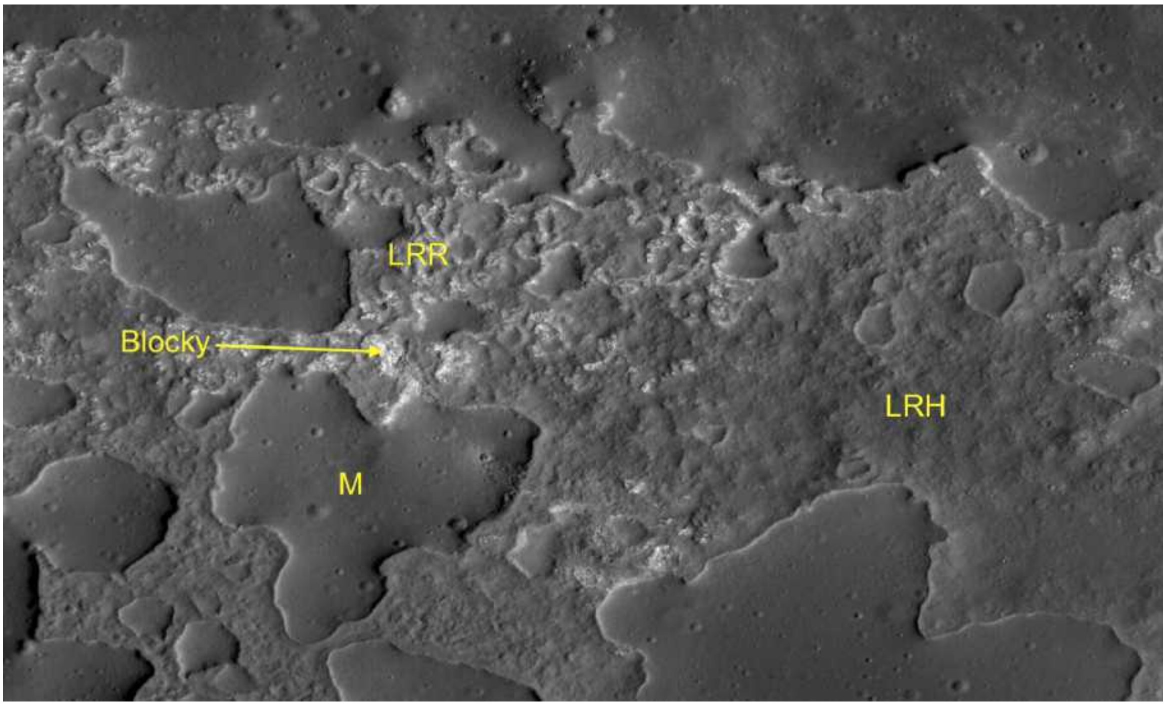


Fig. 2 LROC Observation M119815703R of a section of the eastern floor of Ina showing the blocky, high albedo floor and the Low Relief Ropy (LRR) and Low Relied Hummocky terrain (LRH) that forms the floor of the depression. Note the light cratering on the mounds (M) and the subdued appearance of those craters, with the exception of the crater to the bottom left of centre.

A good starting point for understanding the magmatic foam explanation is Ina itself, which will also serve as an example of other large IMPs. Fig. 2 is an LROC-NAC close up of Ina showing the mounds (M) which are quite smooth with only a few subdued craters which, lack the halo of ejected boulders typical of small craters on the mare. There are exceptions however, such as the crater to the right of the M in Fig. 2 which shows that the impact has excavated solid rock – an observation to be recalled later. The mounds rise some 20m above the general floor, and have quite steep margins (~14°-39°) which suggests material of some strength [6, 7]. Surrounding the mounds and forming the floor of the depression is low relief terrain termed LRR (ropy) or LRH (hummocky) [6]. Bright blocky terrain is exposed at the lowest levels, particularly around the margins of Ina. These blocky areas frequently take the form of narrow sinuous lanes, giving the floor a distinctive squiggly look. The magmatic foam hypothesis proposes that these lower units form the surface of a lava lake which formed within the crater of an ageing shield volcano. As the eruption that formed the volcano progressed, the style of eruption changed from a fire fountain 'Hawaiian' phase to a more explosive 'Strombolian' phase. The difference between the phases is influenced by the rate of magma ascent and the affect this has on the release of volatile gasses, but the end result is that during the 'Strombolian' phase a lava lake accumulates within the summit crater, which subsequently develops a solid surface crust over the molten lava below [1]. This crust will be disrupted by later explosive activity, being highly fragmented with lots of interstitial spaces and voids. Eventually this solidified but porous crust becomes a continuous layer over the last dregs of the lava beneath as any explosive activity dies away. It is at this point that the magic of the magmatic foam occurs.

As noted above, water in lunar magma comes out of solution at shallow depths and is thought to produce a foam with bubbles forming 95% of the volume. These bubbles are so small that they can stay intact against surface tension, producing a stable foam which accumulates beneath the crust of the solidifying lava lake. Simultaneously the lower parts of the dyke are being constricted by elastic forces within the crust. This forces the foamy magma upwards through the numerous cracks in the lava lake crust to erupt as highly viscous flows onto its surface.

In the vacuum of space the bubbles forming the outermost part of the flows explode producing an outer skin of fragmented lava shards, whilst the bubbles deeper down remain intact. As this lava is extremely viscous the flows do not travel far from the vents, but accumulate as low mounds. This highly vesicular lava (more bubble than rock) has been compared to an aerogel, which would absorb the energy of impacts and inhibit the formation of normal craters, producing instead the subdued and rubble free craters we see on the mounds. Additionally, the highly fragmented and porous solidified lava lake bed would cover a network of voids and spaces into which fine surface material would drain, especially when disturbed by seismic events such as moonquakes or nearby impacts. This would expose fresh material at the surface produce an anomalously youthful appearance, with few impact craters and surfaces with a low optical maturity. As a result of these processes the inconveniently young ages of IMPs go away, and the Moon can revert to being ancient, cold and dead. Of course the rubbly halo around the fresh crater pointed out in Fig. 2 is rather a fly in the ointment for this line of reasoning, suggesting that magmatic foams, whilst being ingenious might not be the whole story.

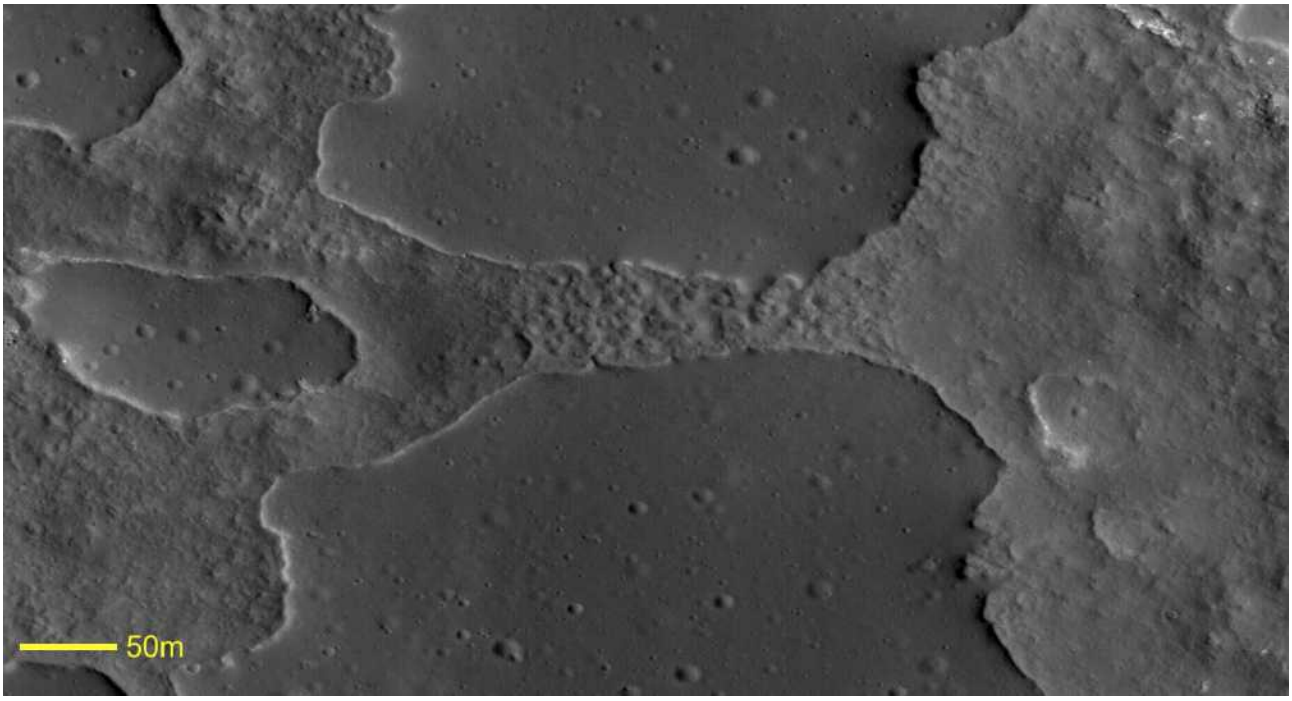


Fig. 3 LROC Observation M119815703R showing the LRR like terrain between two large mounds on the eastern floor of Ina. Note the dense concentration of pits which make up the LRR terrain (middle of frame) and the scalloped edges to the mounds on either side. The LRH terrain either side of the LRR is several meters higher (approx 8m to the west and 18m to the east) than the pit field and may be regolith which has been re-deposited by venting gas.

The magmatic foam scenario has received a lot of attention in the past couple of years, but other researchers, looking at the thermal properties of IMPs have concluded that one of the most parsimonious explanations is removal by outgassing [8]. Also Ina is just one of many IMPs which exhibit a variety of morphologies and whose formation is still subject to speculation – so, are they all the result of the same or differing processes? The outgassing hypothesis is less of a threat to the orthodox view of lunar volcanism, as radiogenically derived gas production would be an on-going process, with the detection of Polonium 210 from lunar orbit indicating the release of Radon within the last 60 million years [9]. Of course the association of IMPs with volcanic settings and structures offers less comfort for the standard model as it implies some form of relatively recent residual activity in the form of volcanically derived gas formation and release.

The analysis of the mounds, which is an important part in most interpretations of IMPs makes no mention of some rather telling clues regarding their formation which can be seen on some NAC images. Fig. 3 is a small section of the north-eastern floor of Ina, it shows two large mounds, each approximately 12-15m high with their edges defined by a moat-like depression some 2m deep and 10m wide. The lobate margins are obvious – which probably led to their interpretation as lava flows, but what is more significant is the small scale scallops visible along these margins, giving them a somewhat 'nibbled' appearance. This is not a morphological feature that should form in a lava flow however viscous, as the outward pressure would produce convex (bulging outwards) flow fronts, and any smaller scale 'breakouts' of lava would also have convex margins. These convex scallops appear to be the result of the mound margins being eroded due to the removal of material from the edges inwards. This is rather like a retreating coastline being incised into bays where erosion is rapid leaving headlands in between.

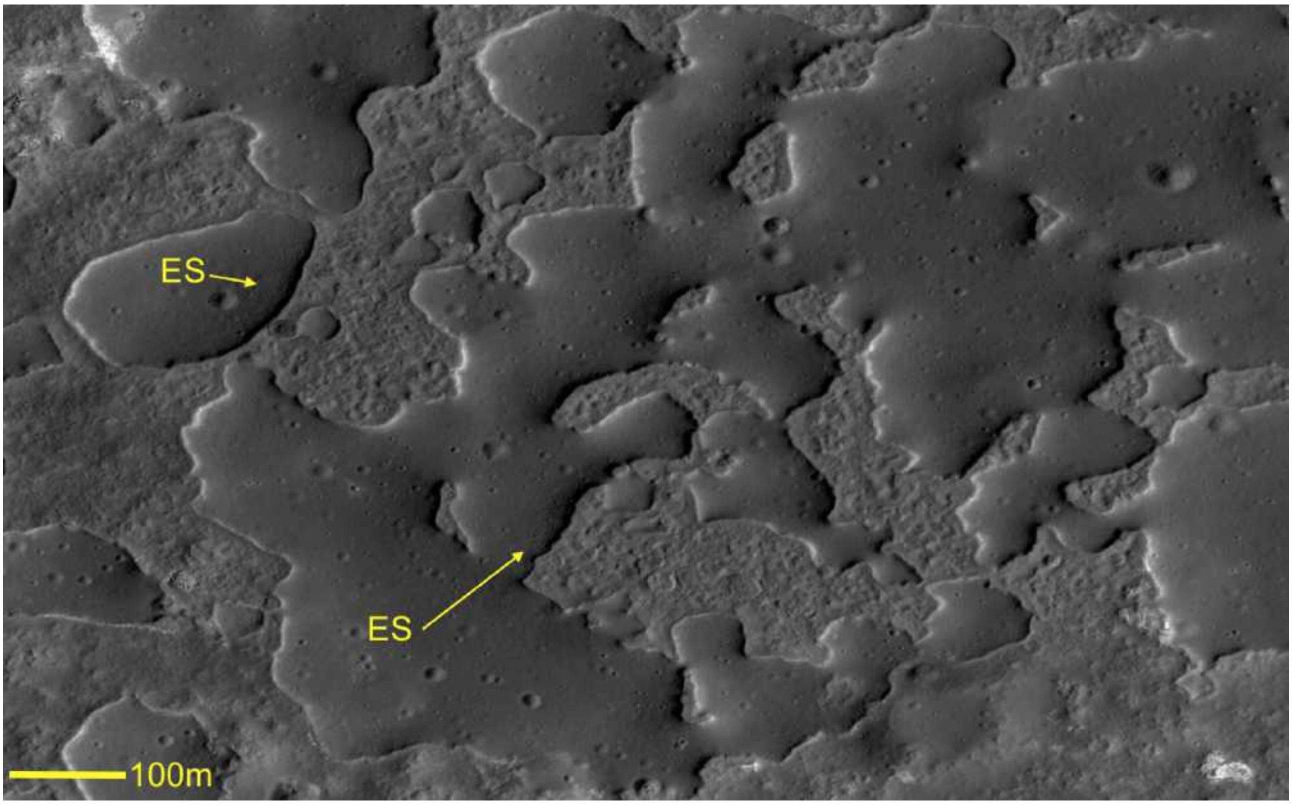


Fig. 4 LROC Observation M159915707R section of the northern floor of Ina showing extensive LRR type terrain associated with the highly scalloped margins of a large irregular mound. Areas of elephant skin texture (ES) indicate the slumping of loose, unconsolidated material off the mound slopes. Note the small depressions within the mounds which probably represent the initial phases of gas venting which will eventually enlarge and coalesce with other depressions, eventually eroding the mounds from within.

The terrain between these two mounds, and between the scalloped margins, consists of a field of crater-like pits producing a texture similar to the LRR terrain noted above. These pits are in the region of 10m in diameter. This particular area has been commented on previously as probably indicative of gas release [10]. The pitted field is lower by some 10-20 meters than the smoother LRH terrain immediately to the east and west. The mound edges to the east and west also have fewer scallops, suggesting a link between the pits and the scallops. The gas release interpretation of these pits seems highly plausible, with the scallops being produced as the mounds are eroded by gas erupting from beneath the Ina's floor. The pitted appearance is consistent with experimental patterns produced in gas-solid fluidized bed experiments, where gas is forced upwards upward through a layer of dry granular material [11, 12], which results in a surface patter rather like that of a waffle, a series of adjoining square cell-like pits with intervening raised walls.

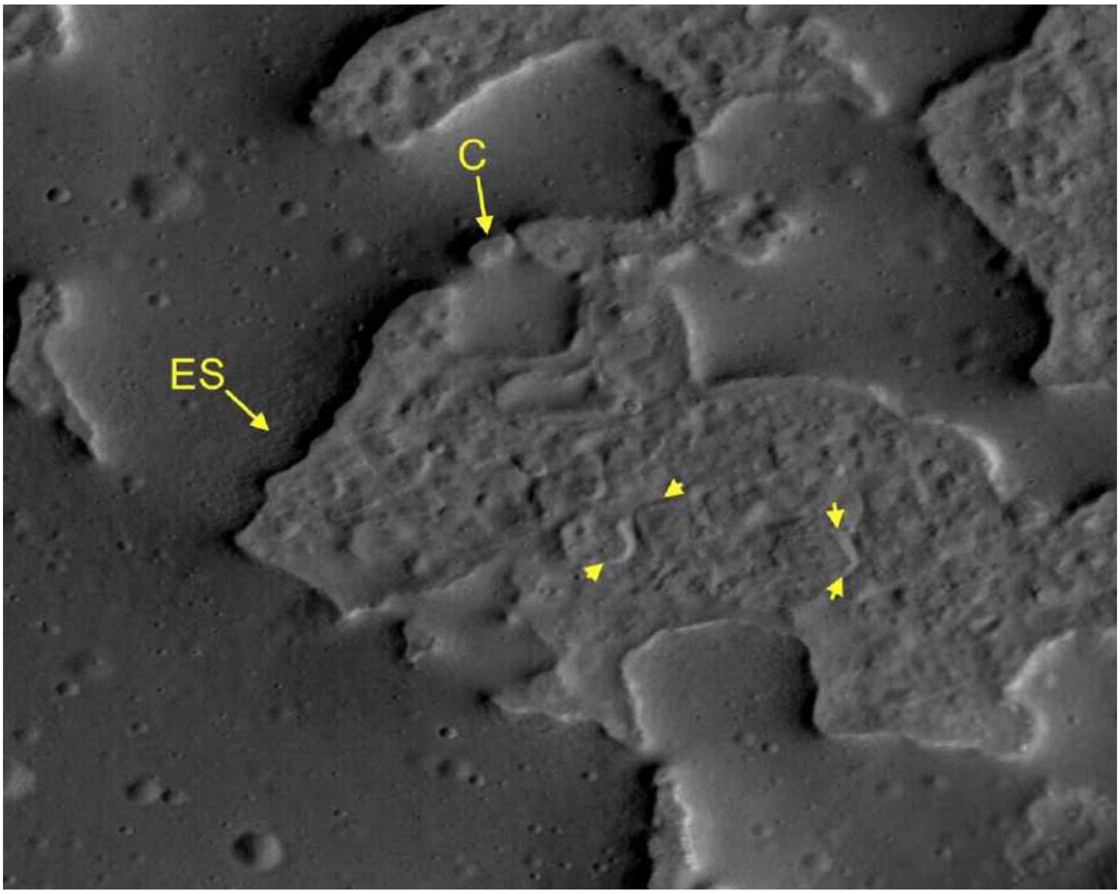


Fig.5 Detail from LROC Observation M159915707R (shown in Fig.4) Elephant Skin texture to the mound edges indicates mass movement of unconsolidated material downslope. Note the 'ropy' elements on the floor (yellow arrows) consist of interlinked ridges which form the rims of the pits. Note the incipient scallop to the edge of the mound at C, where pit formation and regolith erosion is isolating a small mound island from the parent mound.

Fig. 4 shows another section of Ina, where a large irregular mound is interspersed with LRR and LRH terrain, and as can be seen the scalloped mound edges are well developed adjacent to areas of LRR. The actual 'ropy' part of the LRR appears to consist of ridges surrounding individual pits where they abut or actually overlap other pits. This suggests that LRR terrain is composed of overlapping gas release pits, possibly where recent erosion by vigorous release gas has occurred. Experimental fluidized bed experiments produce a highly regular surface pitting, but here the points of gas release are static, and the ascending columns of gas constrained. In reality the gas release points might well move as new routes up through the regolith are developed and then exploited, producing a more chaotic arrangement of pits compared to that seen in the lab.

The mounds also exhibit 'elephant skin' texture where loose material is slumping down slope rather like terrestrial soil creep. This would be consistent with loose unconsolidated material blown from the floor by the erupting gas being re-deposited on the mounds and then slumping off the steeper slopes (Fig. 5). On the surface of the mounds such material would form an effective drape over any impact craters, reducing the visibility of the larger ones and obliterating the smaller, thus skewing age estimates based on crater counts. It would also cover any boulders ejected from these craters, giving the impression that the substrate was not solid rock or regolith. In short, there is ample evidence in this superficial morphological tour to support the gas release hypothesis, and little to indicate the eruption of lavas, foamy or otherwise.

As mentioned, there are numerous other lunar IMPs, but it is likely that there are a large number of smaller examples that have not yet been identified. If gas release is the correct mechanism behind their formation, IMPs will form a spectrum of morphologies related to the amount and energetics of that release. At one end will be IMPs created by low volume transient gas releases and at the other vigorous and prolonged outgassing which was responsible for Ina and the larger representatives of the class. An possible example of an IMP at the low volume end of the spectrum can be seen on the flanks of a dome that Raf Lena and I described recently [13], and named Ya1 after the nearby crater Yangel.

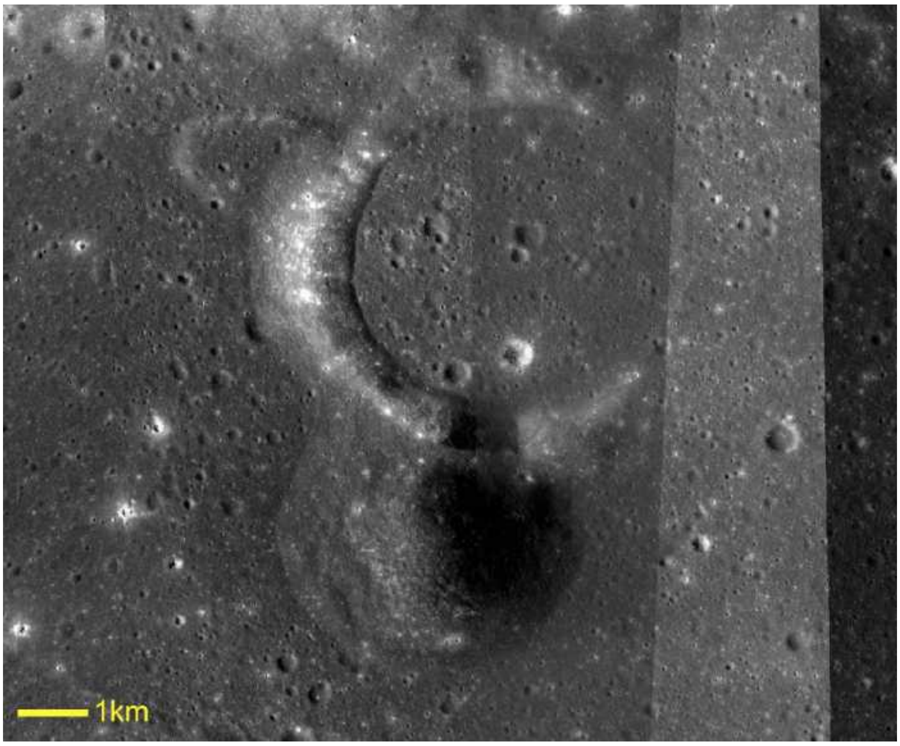


Fig.6 The dome Ya1 located in north Mare Vaporum. Note two dark patches on the inner wall of the crater which the dome appears to have partially overgrown. The dome is tilted to the east.

Ya1 is approximately 600m tall and 5kms in diameter (Fig. 6) and shows pretty convincing evidence of effusive volcanism. In addition some features are present which may be evidence of gas venting, and therefore related to IMP formation. IMPs have been identified on the Manilius 1 and 2 domes some 100kms to the south-east of Ya1 and the magmatic foam model has been used to explain IMPs associated with the Cauchy-5 dome [14], so the association between domes and IMPs is not new. The lower flanks of Ya1 are composed of an annulus which is the result of mass wastage of material – it is more prominent on the western flank, as the whole dome has tipped to the east as a result of subsidence. I originally divided the slopes of Ya1 in to three zones I, II and III, with zone II having extensive lighter patches formed where a darker surface layer appears to have slumped down-slope (Fig. 7). I initially thought this might represent mass wastage, an interpretation that was bolstered by the relatively steeper slope here of 16° compared to 10° for the lower slopes. The presence of extensive pyroclastic deposits on the dome would suggest that the dark stuff is optically mature volcanic deposits. Slumping is present on these flanks and large chunks of zone II have slumped down into zone I. You can see the evidence for this in the rather wavy border between the two zones as shown in Fig. 7.

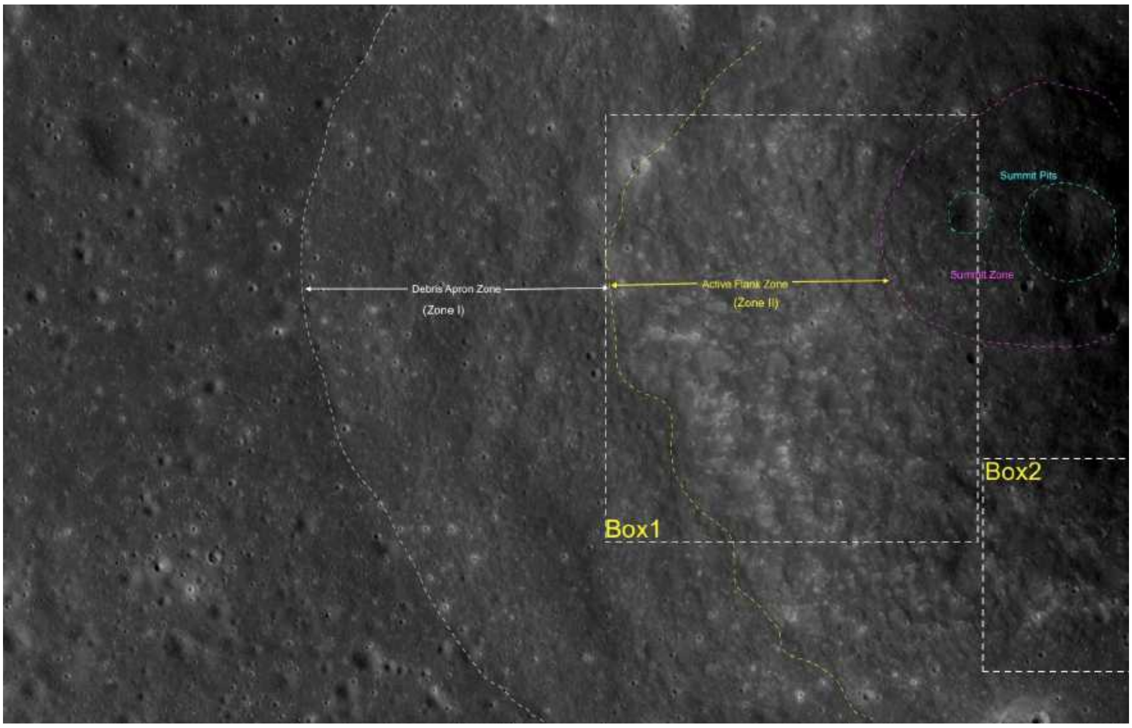


Fig. 7 LROC NAC image of the western and southern part of Ya1 showing the Debris Apron Zone I above which is an Active Flank Zone II within which suspected IMP like activity has occurred. Area within Box 1 is reproduced in Fig.8 and Box 2 in Fig.9. Note the large slumps of Zone II down in to Zone I in the bottom left corner of Box.1

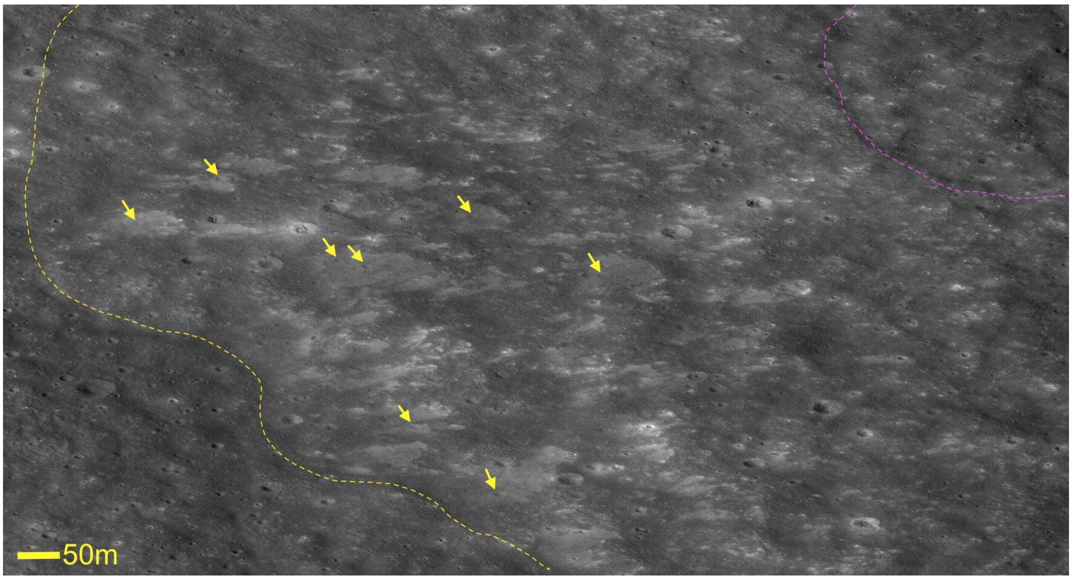


Fig. 8 LROC Observation M168183822LC showing the western Active Flank Zone of Ya1 with numerous lighter coloured areas where the darker surface deposits have been removed by suspected IMP activity. Yellow arrows show positions of relict craters on these light patches. These would have been obliterated if these were slump features.

The light patches are however not slumps, but appear to have formed where the darker surface has been removed by a less destructive process that has left traces of pre-existing craters behind as shallow relict structures on the now exposed lighter under-layer. The light patches give this 'Active Flank Zone' a distinctly etched appearance. There are no boulder trails or streaks of dark material extending down-slope as would be the case with mass wastage (Fig. 8) and the patches themselves are shallow and not deeply incised into the surface.

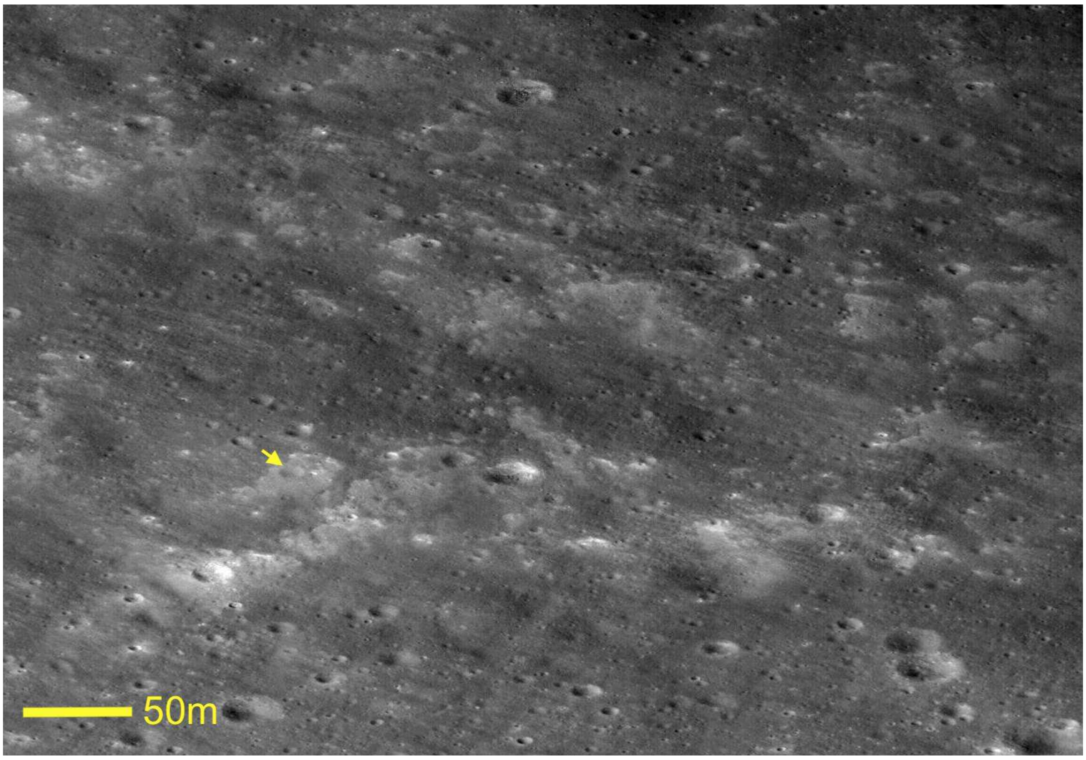


Fig. 9. LROC Observation M168183822RC showing the southern Active Flank Zone II of Ya1with bright patches, clearly incised up-slope margins and relict crater (yellow arrow).

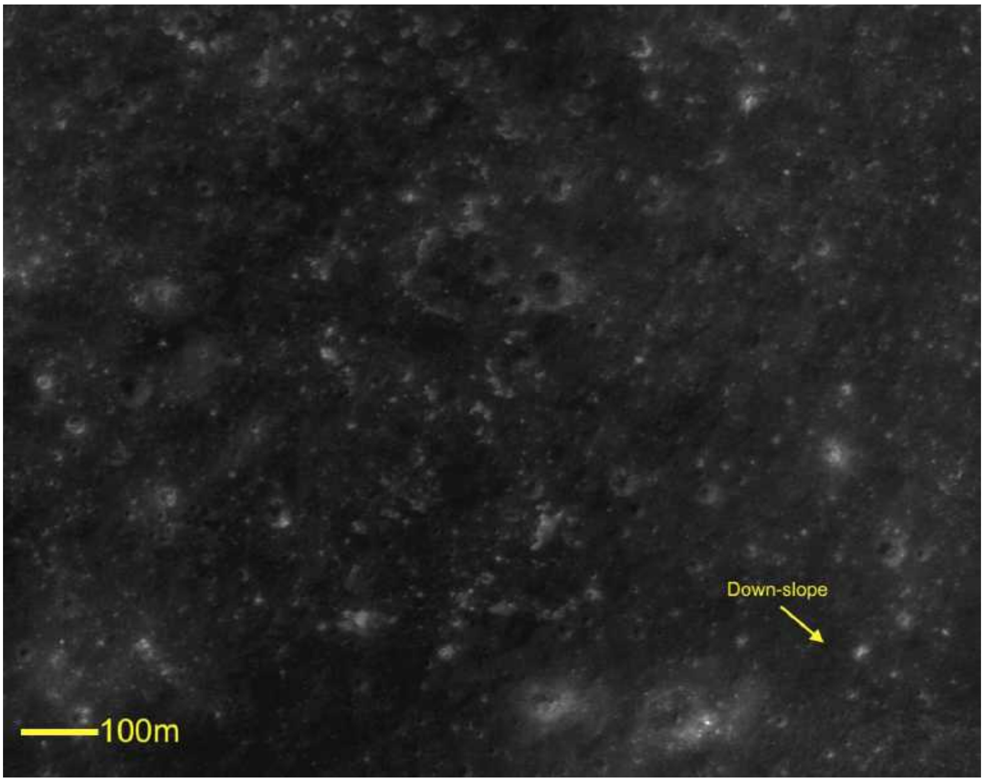


Fig. 10 LROC Observation M1208347443L of the eastern flank of Ya1 showing IMP like features.

The southern side of Ya1 also has light patches within this 'Active Flank Zone', which again show relict craters within them, a lack of evidence for mass wastage streaks and well developed sharp up-slope margins. Some of these light areas are more deeply incised than on the western flank, with the up-slope margins being particularly well defined (Fig. 9).

There are further patches of possible IMP activity on the eastern flank of Ya1, with the same morphology as seen on the southern flank (Fig. 10) with the upper margins of the light patches appearing more incised than on the western flank. A final possible area of activity can be seen within a small area of pyroclastic material on the inner wall of the crater immediately to the north of Ya1. Within this patch features typical of small IMPs can be seen, with the lighter underlying layers contrasting strongly with the darker surface (Fig. 11). This suggests that the IMPs activity is more recent than the deposition of the pyroclastic deposits.

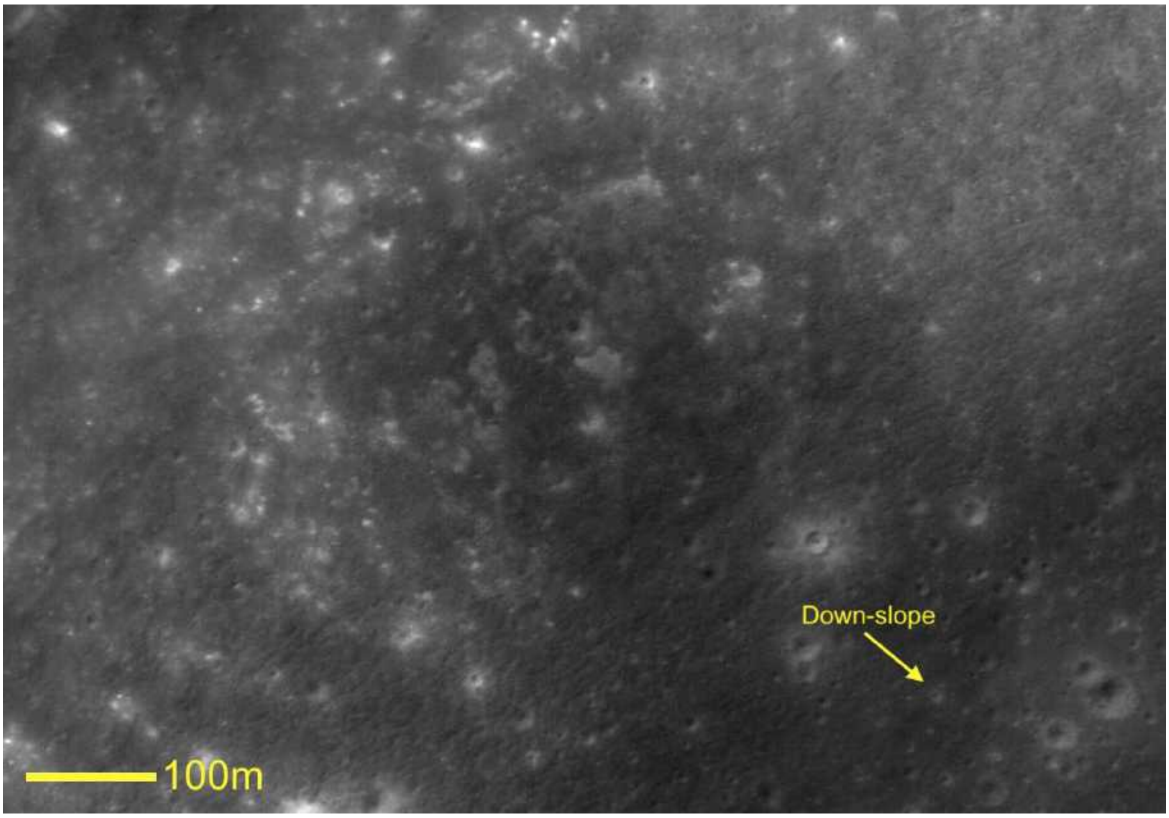


Fig. 11 LROC Observation M168183822LC showing IMP like features penetrating a dark patch of possible pyroclastic material on the inner wall of the crater immediately north of Ya1.

A process that could adequately explain these features is volcanic outgassing from fissures opening on to the flank of Ya1, allowing escaping gas to blow the darker regolith away. This would effectively remove a surface layer but preserve intact the craters that had already formed on this surface and penetrated down into lighter, optically immature deposits. This would not produce debris trails or downslope streaks, as mass wastage would. The light patches generally have distinct up-slope margins, and irregular, feathery down-slope margins, and whilst this is consistent with mass wastage the preservation of relict craters is not.

Supportive evidence for the IMP interpretation given above can be seen by comparison with a spectacular (and apparently unnamed?) caldera-like structure approximately half way between Tobias Mayer B and Bessarion V (Fig. 12). This structure appears to be the result of extensive volcanic activity and is draped in pyroclastic deposits. It also has some unequivocal examples of IMP activity along the southern rim where the north facing escarpment (slope ~ 5°) is etched with light depressions with the same morphology that we see on Ya1 (Fig. 11). The up-slope margins are in this case are even more distinct, suggesting the removal of a greater depth of material and not just a superficial veneer, but despite this the similarity is quite striking (Fig. 13).

If the interpretation of these light patches on both Ya1 and on the slopes of the caldera are correct and the result of outgassing, it would suggest that the gas responsible was volcanic in origin, as both are volcanic structures. Both are however clearly pre-mare in age, Ya1 is embayed on all sided by the lavas of Mare Vaporum and the caldera has been breached and flooded by flows of southern Mare Imbrium.

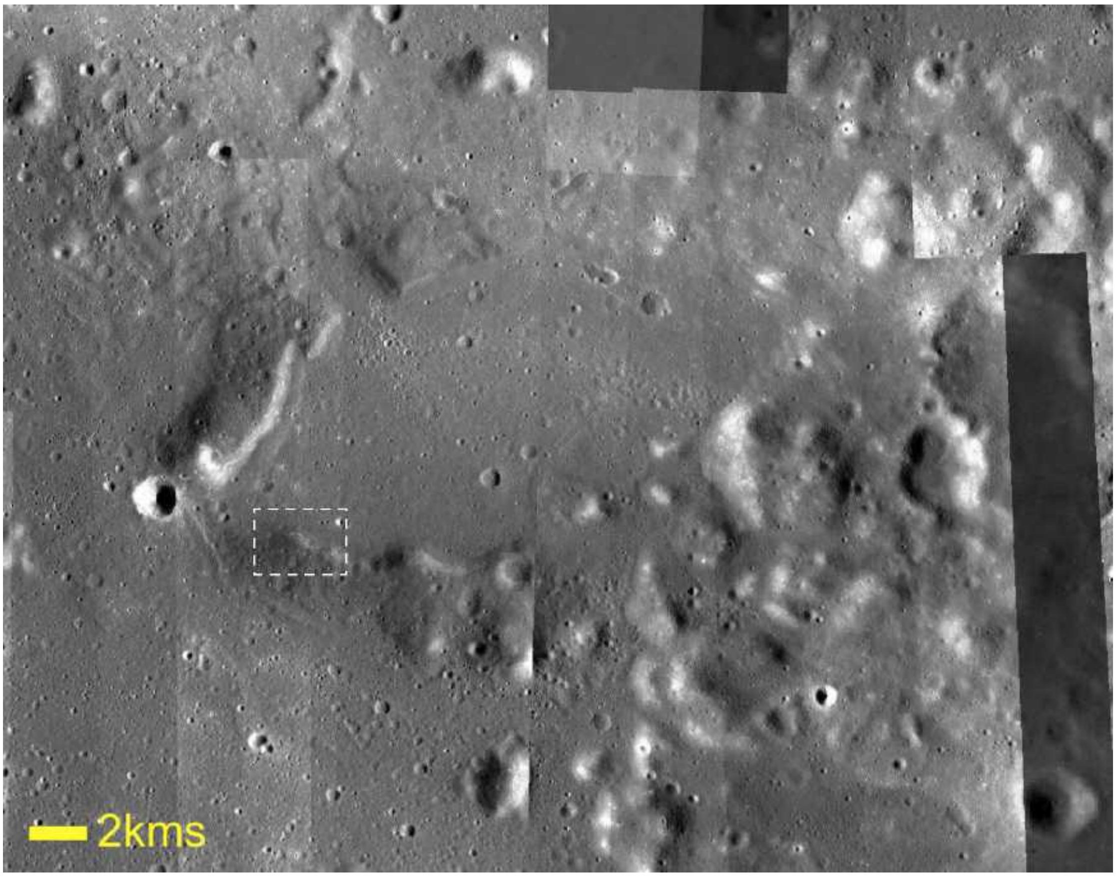


Fig.12 Caldera like structure at centred at Lat 14.664 Long -33.702, Note the dark pyroclastic deposits draping the rim and extensive mare flooding. IMP's are well developed along the southern rim. White boxed area is reproduced in detail in Fig.13.

So both structures are pre-mare in age, yet they host features (IMPs) which are believed to be relatively recent (on the lunar geological timescale) in origin. The pyroclastic deposits associated with both areas are also probably pre-mare in age and therefore much older than the IMPs, a conclusion supported by the observation that the IMPs appear to be eroding through these older deposits as shown in Fig. 11.

Volcanoes release gas, but this tends to happen when they are active, not when they become extinct. But here we have two apparently extinct volcanic structures which seem to have been venting gas after the volcanic activity that formed them had ceased. This would imply one of three possibilities, the first being that the two examples were not truly extinct but still active, albeit on a very minor scale, which would suggest an inordinately long period of activity. The second possibility is that fissures and fractures beneath these geological structures were exploited by gases produced much more recently in lunar history, in which case the occurrence of IMPs is related to the subterranean structure of these volcanoes, and not related to their former volcanic activity. This of course leaves the question of where those gases came from. The location of IMPs within the maria might indicate that the volatiles responsible were produced during the formation of the mare themselves. But if IMPs are as young as they are believed to be, much younger than the maria, this would not be the case. Could the gasses have been confined in a sub-surface reservoir only to be released long after the mare volcanism died away? The third possibility is that the presence of IMPs on these volcanic structures is just a coincidence, and there is no relationship structural or otherwise.

Of the three I think the second is the most likely, as IMPs are frequently found around the periphery of small craters, and craters have well developed concentrically arranged faults, which could act as conduits for escaping gas. IMPs are also associated with fracture zones such as Rima Sosigenes, which would provide ample routes for gases from within the crust to escape to the surface. Volcanoes would similarly have an associated sub-surface plumbing system from which the lavas that formed them originally erupted. All of these could be potential routes that could be exploited by escaping gasses.

IMPs are a diverse group of landforms, and this may be related to the amount and vigour with which the gases that formed them erupted. The presence of IMP features on Ya1, which have not previously been identified, suggests that there may well be more examples of these features waiting to be found. Their origin remains open to debate but I suspect that the magmatic foam theory, however ingenious is not the correct solution.

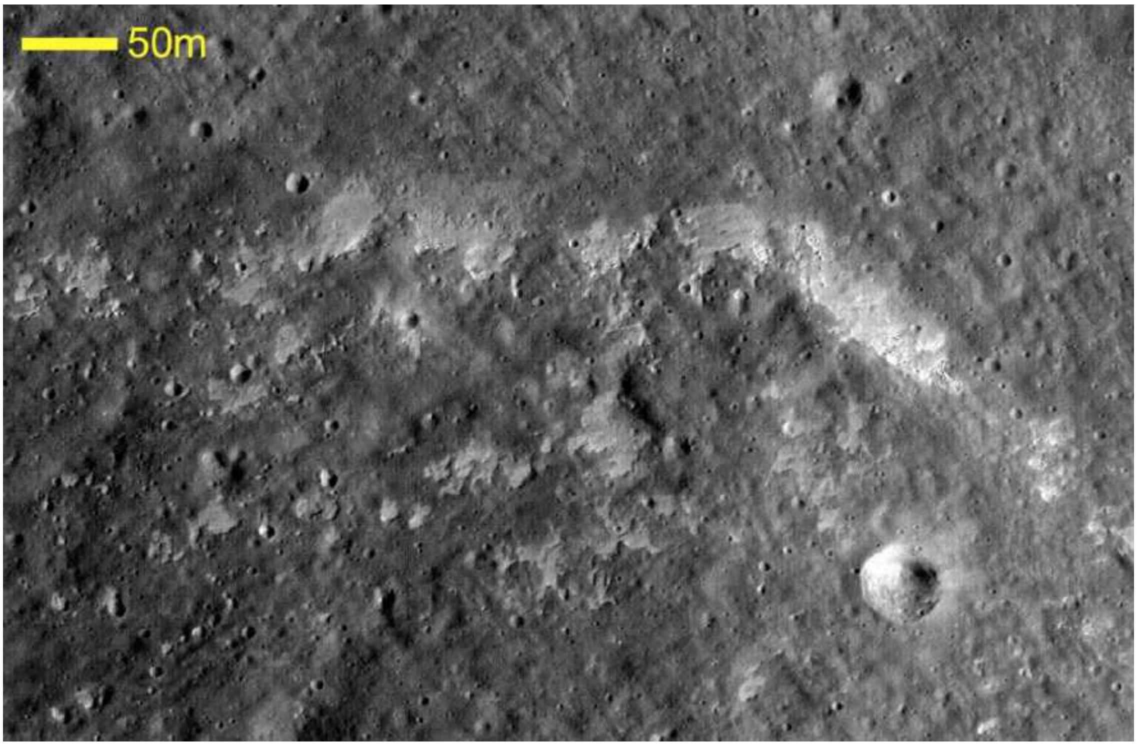


Fig.13 LROC NAC image of the area shown within box in Fig.10. The slope is etched by light toned depressions which have sharp up-slope margins and feathery down-slope ones.

Barry Fitz-Gerald.
barryfitzgerald@hotmail.com

Acknowledgement:

Images from LRO courtesy of NASA/GSFC/LROC, School of Earth and Space Exploration, Arizona State University. (http://lroc.sese.asu.edu)

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LUNAR DOMES (part XXV): Mersenius P dome

Raffaello Lena

In this issue I will describe a dome located at longitude 47.84° W and 19.88° S, inside the crater Mersenius P. Mersenius and Mersenius P are two craters superimposed on the Humorum basin. The inferred history of the Humorum basin is similar to that of the Imbrium basin, but the more subdued topography and the larger density of craters on the rim of the Humorum basin suggests that it is older than the Imbrium basin. Different lithological units, included in USGS lunar geologic map I-495, are apparent in Mare Humorum: the Humorum basalts have been mapped as 4 distinct units, Ipm1 through Ipm4.

As Mersenius and Mersenius P are superimposed on the Humorum basin, patches of mare material are present around two craters (Fig. 1).

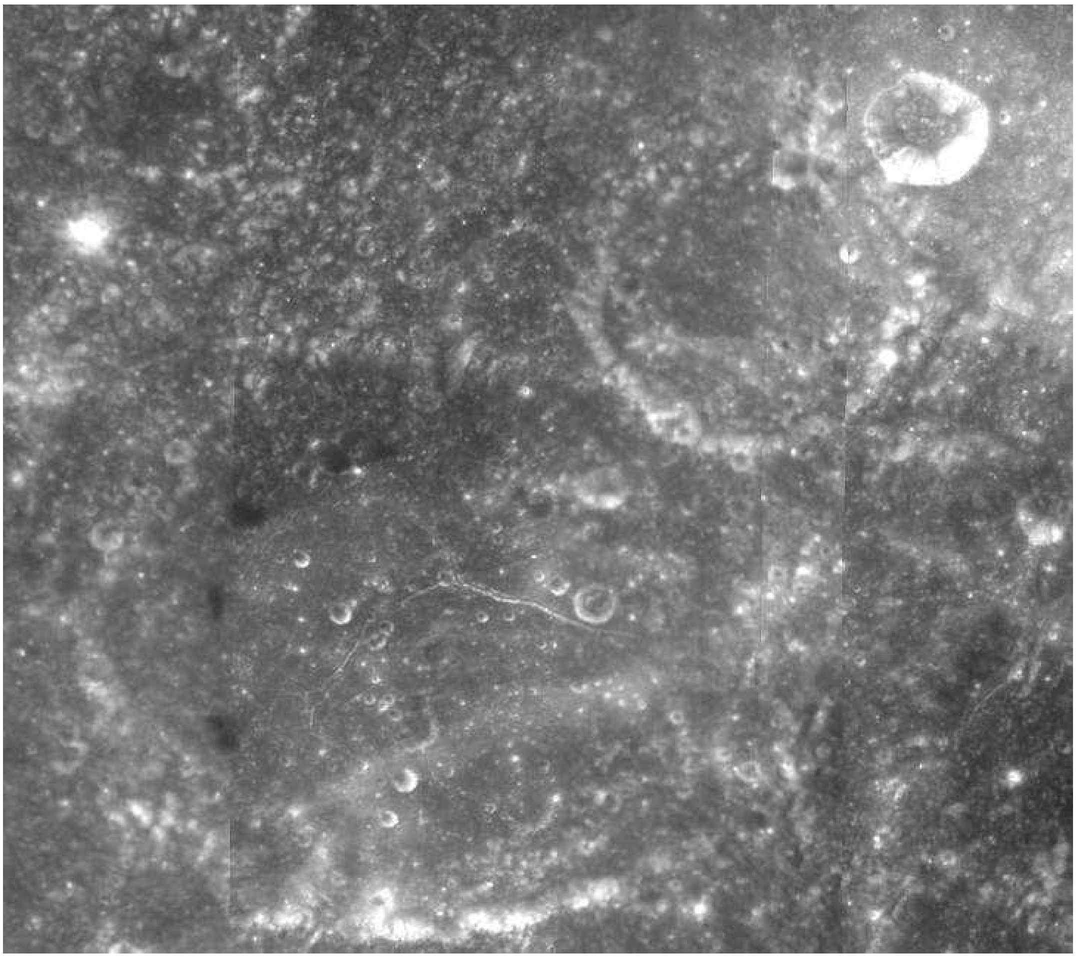

Figure 1. Clementine 750 nm imagery, of the examined Mersenius region.

Martin et al. [1] describe the presence of pyroclastic deposits in this area which might be the exposed remnants of regional deposits that have subsequently been partially covered by crater ejecta.

The floor of Mersenius crater, draped by highland material, is characterised by its domical appearance with the presence of several thin rilles: it is a typical Floor Fractured Crater (FFC) and the Clementine image shows small dark halos (Fig. 1), which have been spectrally characterized as lunar pyroclastic deposits (LPDs) by Gaddis et al. [2]. Possibly the floor of the crater Mersenius has been raised under the pressure of the lunar magma, which filled in the crustal fractures formed by the impact that excavated the crater. Uplift of crater floors is commonly ascribed to magma intrusion, indicating the presence of a large intrusive body in that region.

A raised floor is also detectable in Mersenius P, and is well detectable in CCD images taken under low solar illumination angle. The dome, termed MeP1, was detected in an image taken by the author on November 9, 2008 at 21:15 UT using a 180mm Maksutov-Cassegrain telescope (Fig. 2).

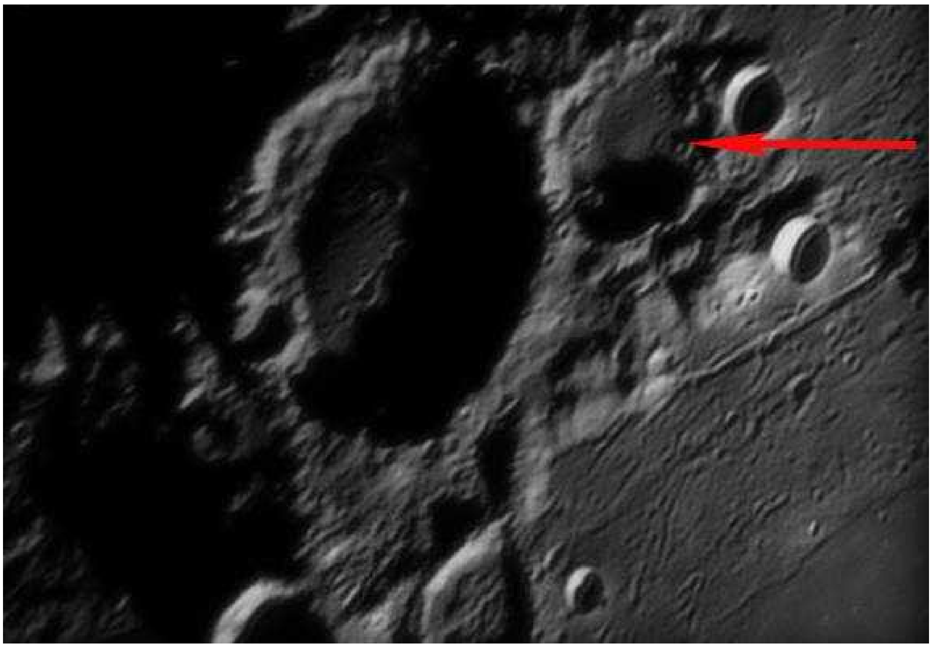

Figure 2.Mersenius P dome (MeP 1) shown by the red arrow. Image by the author.

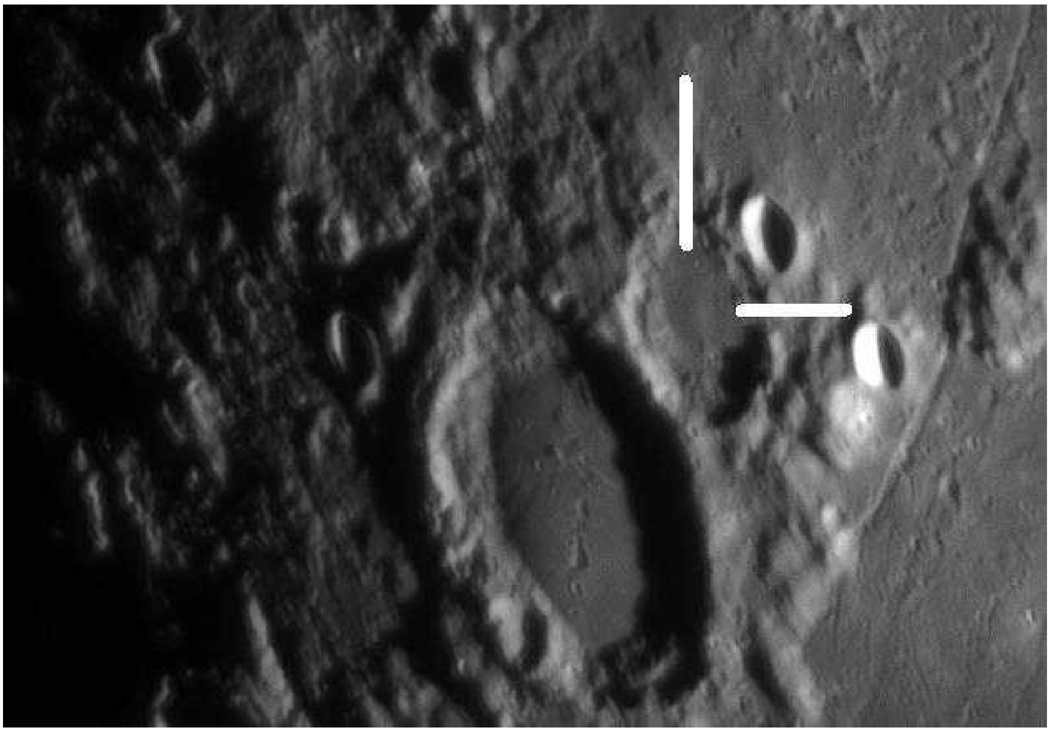

Figure 3. Mersenius P dome (MeP 1) image by Rafael Benavides.

Another image of the dome, by Rafael Benavides, is shown in Fig. 3. It was taken on January 9, 2017 at 22:13 UT with a C11 telescope.

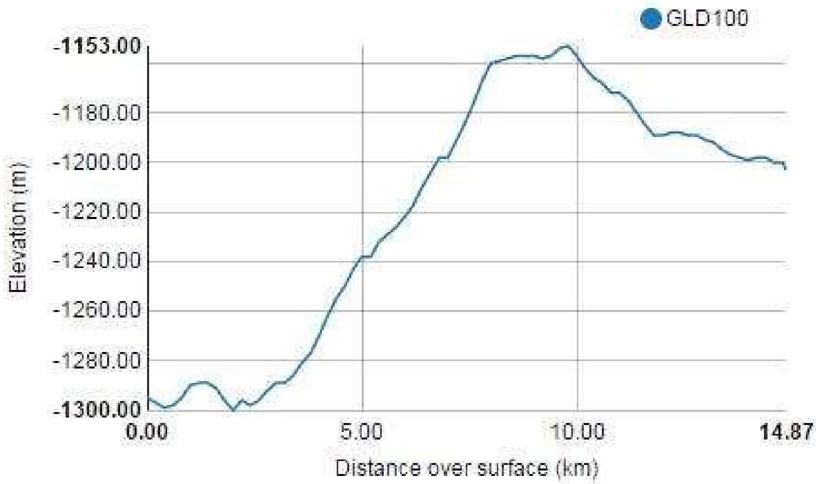

Figure 4. Cross-sectional profile in E-W direction of the dome MeP1. See text for detail.

Morphometric data are obtained relying on a photoclinometric analysis [3-4] and using the GLD100 dataset [5]. The effective height of the dome was obtained by determining elevation differences between the summit of the dome and its surroundings. This leads to a dome height of 140 ± 15m, yielding an average flank slope of 1.29° ± 0.10°. Assuming a typical form factor of f = 1/2, the estimated volume amounts to 8.4 km³. Its diameter is determined to 12.4km ± 0.5km.

The GLD100 dataset indicates a tilt of the soil: Mersenius P dome is 50m high on a side and 145m high on the other side, which is its maximum elevation from lowest point (Fig. 4). Based on the circularity of the dome, the origin is likely attributed to an effusive phase. Fig. 5 displays the Clementine color ratio imagery and reveals that the surface of the dome spectrally appears red. The Clementine UVVIS spectral data of the dome MeP1 reveal a 750nm reflectance of R_{750} = 0.14948, a low value for the UV/VIS colour ratio of R_{415}/R_{750} = 0.58488, indicating a low TiO_2 content, and a weak mafic absorption with R_{950}/R_{750} = 1.08716.

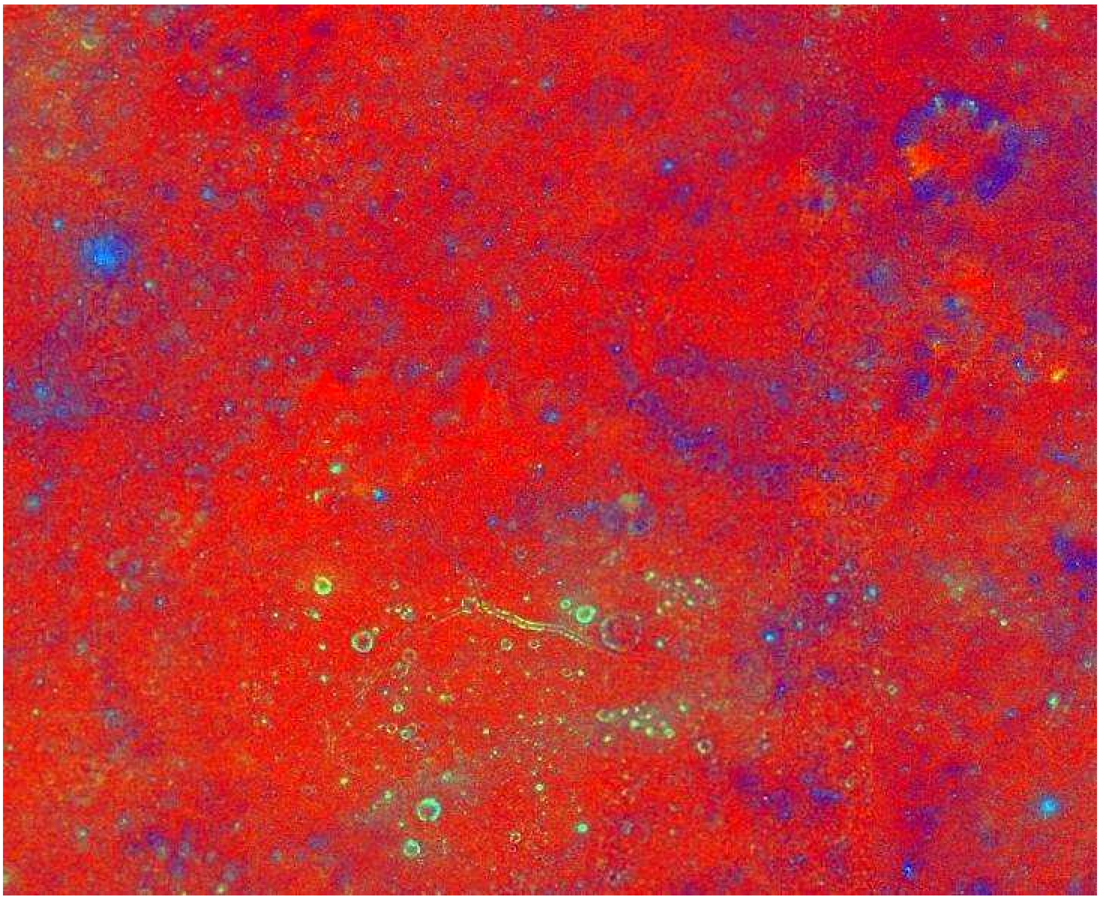

Figure 5. Clementine color ratio imagery.

Based on the spectral and morphometric data, the examined dome belongs to class C_2, assuming an effusive origin. The rheologic model yields for the examined dome an effusion rate of 119 m^3/s. It formed from lava of viscosity of 4.4 x 10^6 Pa s, over a period of time of 3.4 years.

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OCCULTATION NEWS   January 2019   Tim Haymes

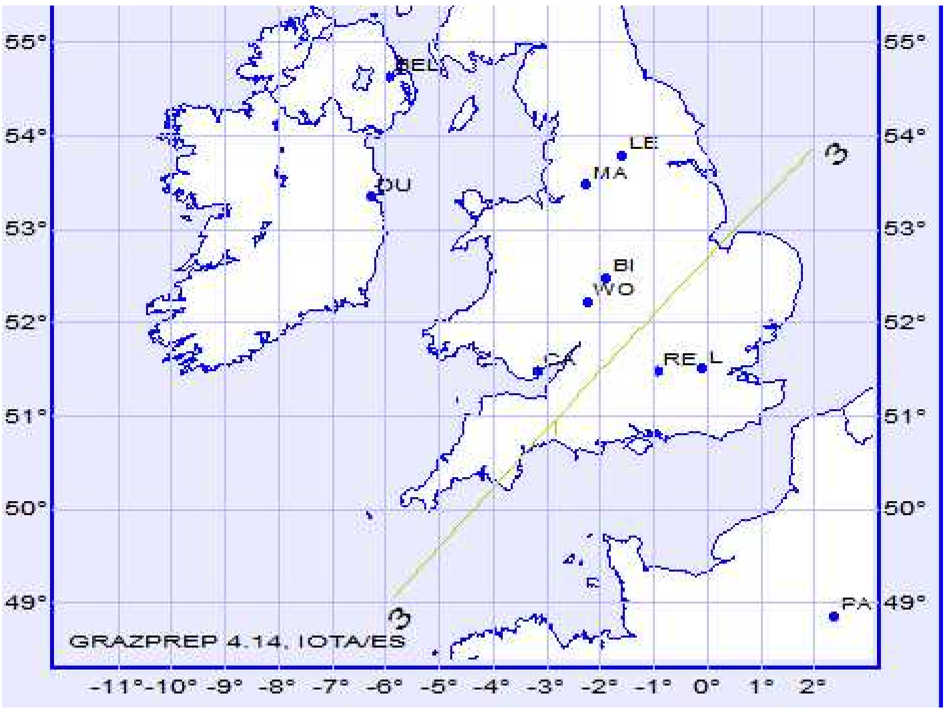
104 Tauri double star

Following the request for observation in the 2018 December issue, Tim Haymes, Alex Pratt and Phil Denyer attempted to observe the occultation predicted for Dec 21st. Unfortunately no observation was possible at any of the stations owing the poor weather conditions. It was to be very challenging at 99% illumination. Our luck ran out !

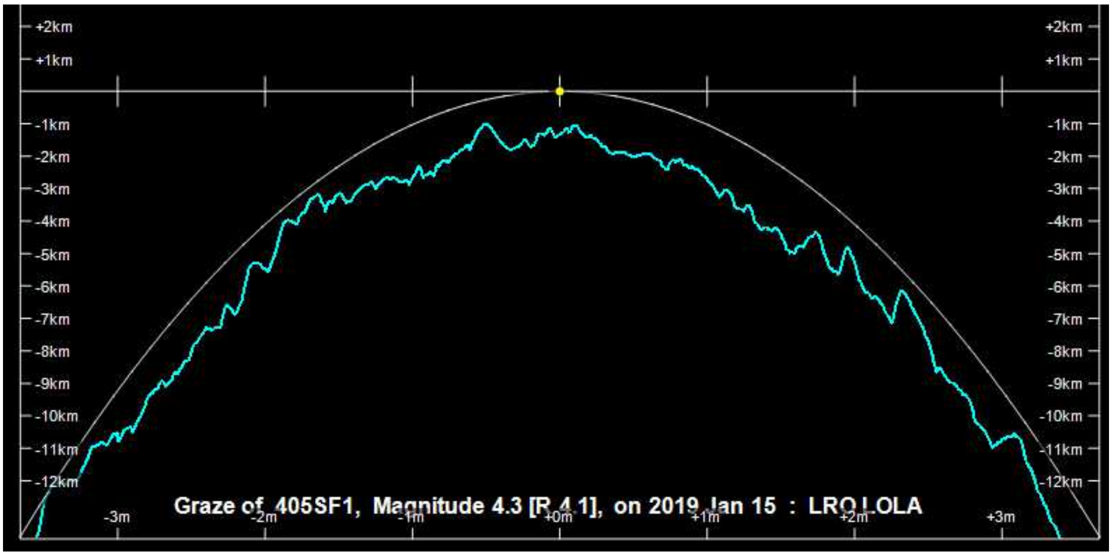
Graze Occultation of mu Ceti, 2019 January 15th 1700 UT

This Northern limit graze is on the *bright* lunar limb, and isn't included in the 2019 BAAH for this reason. However it is a magnitude V4.3 slightly red star (R4.1) and with good conditions and equipment, could be observable. Contact me at the address in the footer.

Circumstances for the Northern Limit graze:
SAO 110723 (Z405). The path is near: Exmouth, Chard, Swindon, Wellingborough, Peterborough, Long Sutton, and places in-between.
At Swindon: Cusp angle -7N, Sun Alt -6, Moon Alt/Az 41/136 UT 1702



Path of the graze (number 3)



Above: Limb profile for the Northern limit. The graze zone is between 0.5 and 2 Km inside the mean lunar limb.

The prediction for this was published in the Journal *for* Occultation Astronomy (JOA) 2019-1 available to members of the International Occultation Timing Association (IOTA) via the Europian sub-section IOTA-ES.

New members are always welcome.
http://www.iota-es.de/membership_howto.html

There are free issues of JOA: http://www.iota-es.de/joafree.html
Take a look !

2019 January predictions for Manchester.
W. Longitude 002d 15’, Latitude +53 25’, Alt. 50m;

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 o	Notes
19	Jan	2	5	29	3.1	R	159503	F5	9.0	8.7	13-	43		6	127	45N	
19	Jan	10	17	45	22.0	D	3356	B8	5.8	5.8	18+	50		20	212	55N	74 Aqr dbl*
19	Jan	11	20	35	46.9	D	146869	G5	8.8	8.4	27+	62		10	243	56S	
19	Jan	12	17	6	39.3	D	128739	A0	7.4	7.4	35+	72	-7	33	180	81N	
19	Jan	12	21	1	37.2	D	60	K2	6.9	6.1	36+	73		16	242	74S	
19	Jan	13	22	9	47.5	D	109787	K0	7.6		46+	85		17	250	64S	
19	Jan	13	22	11	1.5	D	109783	G5	7.3	6.7	46+	85		17	250	75N	
19	Jan	14	19	14	53.4	D	291	G5	6.8	6.2	55+	96		42	194	70N	dbl* dT +0.2s
19	Jan	14	23	0	12.7	D	110334	F2	7.8	7.6	56+	97		20	254	77N	
19	Jan	16	17	16	46.4	D	526	G5	6.7	6.2	75+	119	-8	38	123	64S	
19	Jan	16	20	14	7.9	D	93570	F8	8.6	8.3	75+	121		51	182	62N	
19	Jan	16	23	3	50.0	D	93617	F8	8.7		76+	122		39	237	71N	
19	Jan	17	17	6	9.5	D	94019	K5	6.7	5.8	84+	132	-6	33	106	60S	
19	Jan	17	19	2	50.8	D	94047	F0	7.9	7.7	84+	133		47	136	39S	
19	Jan	17	19	43	57.7	D	705	K0	7.9*	7.2	84+	133		51	149	35S	
19	Jan	17	23	52	5.1	d	94120	G0	8.5*	8.2	85+	135		43	238	71N	
19	Jan	18	17	15	34.2	D	94670	A2	8.1	7.9	91+	146	-7	28	94	86N	
19	Jan	18	17	43	38.0	D	94684	B9	7.2		91+	146	-11	32	100	35S	
19	Jan	18	19	2	13.9	D	94723	K0	7.8	7.0	92+	147		43	118	54S	
19	Jan	18	19	59	1.1	D	856	K5	8.1	7.2	92+	147		50	133	84N	
19	Jan	18	22	26	0.5	D	77528	K0	8.1	7.6	92+	148		57	189	84N	
19	Jan	18	22	44	29.7	D	77541	G0	8.6	8.2	92+	148		56	197	76N	
19	Jan	18	22	49	15.8	D	873	F2	7.6	7.4	92+	148		56	199	75S	
19	Jan	18	22	55	32.6	D	77547	K0	7.1*	6.3	93+	148		56	201	83N	
19	Jan	18	23	43	0.1	D	77585	K2	8.6	7.9	93+	149		52	219	81S	
19	Jan	19	1	4	36.3	D X	7726	K0	8.3*	7.5	93+	149		43	243	50S	
19	Jan	19	1	58	46.2	D	892	B9	6.7	6.7	93+	150		36	256	82S	

19 Jan 19	2	26	58.4	D	894	G0	4.4	4.1	93+	150		32	262	76S	Chi-1 Ori dbl*
19 Jan 19	3	3	25.9	D	77726	K5	7.7	6.7	93+	150		27	269	62N	
19 Jan 19	18	31	23.8	D	78632	G5	7.4*	6.9	97+	160		31	96	35S	
19 Jan 19	20	1	32.8	D	78698	F8	7.2*	6.9	97+	161		43	116	69S	
19 Jan 19	20	10	35.5	D	1031	A0	7.1	7.0	97+	161		44	119	17S	
19 Jan 19	23	8	53.6	D	78796	A0	8.4	8.4	98+	162		58	182	33S	
19 Jan 20	0	38	40.2	D	1051	K1	6.6		98+	163		53	217	58N	
19 Jan 20	1	42	48.2	D	78896	B8	7.4	7.5	98+	163		47	237	87S	
19 Jan 20	4	3	1.2	D	78993	A2	7.8	7.8	98+	165		27	269	85S	
19 Jan 20	4	54	35.6	D	79030	G	7.6*	7.3	98+	165		20	278	44S	
19 Jan 20	4	57	54.9	D	1077	G3	4.0*	3.5	98+	165		19	279	37S	zeta Gem dbl* dT +0.14s
19 Jan 21	4	6	59.8	D	1223	F8	7.7*	7.4	49E	179		35	256	71U	
19 Jan 21	4	37	54.0	D	97590	A0	8.5*	8.5	1E	179		30	262	55U	
19 Jan 21	5	3	51.6	R	1223	F8	7.7*	7.4	0E	179		26	268	75U	
19 Jan 21	5	32	12.6	R	97590	A0	8.5*	8.5	0E	179		22	273	62U	
19 Jan 21	20	10	28.8	R	98190	F0	7.3*	7.1	99-	170		25	93	74S	
19 Jan 21	20	43	33.8	R	98207	G5	8.0	7.5	99-	170		30	100	89N	
19 Jan 21	22	18	39.1	R	1340	A0	6.6	6.6	99-	169		43	121	29N	
19 Jan 21	23	1	15.1	R	1343	M4	6.3	5.5	99-	169		47	134	66N	
19 Jan 22	3	55	47.1	R	1362	K3	7.2	6.6	99-	167		42	237	70N	78 Cnc
19 Jan 22	20	53	9.1	R	1459	G5	7.4*	6.9	96-	156		20	92	90N	
19 Jan 22	23	19	13.7	R	98914	A1	8.0	7.9	95-	154		39	124	46N	
19 Jan 22	23	38	3.4	R	98917	A3	8.5	8.3	95-	154		41	129	89S	
19 Jan 23	4	23	20.5	R	1493	F7	6.5		94-	152		42	225	57S	34 Leo dbl* dT -0.5s
19 Jan 23	7	27	31.9	R	1506	G0	7.0	6.7	94-	151	-6	18	267	36S	
19 Jan 23	22	34	54.9	R	1596	A2	7.2*	7.1	89-	141		22	104	80S	
19 Jan 24	3	8	34.3	R	1613	F5	8.1	7.9	88-	139		46	181	72S	
19 Jan 25	3	17	10	m	1741	K0	7.1	6.7	79-	125		40	167	7S	
19 Jan 25	5	20	35.3	R	119237	K5	8.5	7.8	78-	124		38	205	41N	dbl* dT +0.1s
19 Jan 25	5	49	36.2	R	119239	K2	8.1	7.5	78-	124		35	214	27S	
19 Jan 25	6	21	48.4	R	119242	K0	8.5	8.0	78-	123		32	222	55S	
19 Jan 26	2	18	49.6	R	X125132		7.6	7.4	69-	112		28	137	59N	dbl* dT -1.9s
19 Jan 26	2	18	49.6	R	1856	F5	6.8		69-	112		28	137	59N	dbl* dT +1.9s
19 Jan 26	2	59	38.7	R	139070	A2	8.0	7.9	68-	112		31	148	9N	
19 Jan 28	2	12	51.1	R	2089	G5	6.7	6.2	47-	87		7	119	51N	
19 Jan 28	3	43	8.6	R	158736	K0	8.4	7.7	47-	86		17	139	48N	
19 Jan 28	5	23	0	R	158766	G0	8.4	8.1	46-	85		24	163	14S	
19 Jan 28	6	15	21.3	R	158781	F8	8.7	8.5	46-	85		25	177	43N	dbl* dT -0.12s
19 Jan 28	6	27	47.5	R	158780	G5	8.1	7.6	46-	85		25	180	68N	
19 Jan 29	6	46	32.3	R	2224	K4	7.9	7.1	35-	73	-11	21	173	81S	
19 Jan 30	5	56	34.9	R	2361	B2	4.2	4.1	26-	62		13	150	82N	chi Oph
19 Jan 31	5	35	47.4	R	185258	F0	8.6*	8.4	18-	50		5	135	27N	
19 Jan 31	5	51	59.2	R	X 42183	F2	8.8*	8.6	18-	50		7	139	45N	
19 Jan 31	5	52	50.4	R	185255	K0	8.6*	8.1	18-	50		7	139	66N	
19 Jan 31	6	48	6	M	2498	F2	4.4*	4.2	18-	50	-10	11	151	9S	Xi Oph
19 Jan 31	6	49	14	Gr	2498	F2	4.4	4.2	18-	50	-10	10			** GRAZE: BAAH #3
19 Feb 7	18	52	7.7	D	146721	F5	9.0	8.7	7+	31		7	246	84N	

Notes on the Double Star selection:

Doubles are selected for this list from Occult 4, where the magnitudes of the pair are not more than 2 magnitudes different, the fainter comes is brighter than mag 9,and the time difference(dT) is between 0.1 and 5 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. Negative CA = bright limb
Dbl* = This is a double star worth monitoring.
Mag(v)* = asterisk indicates a light curve is available in Occult-4
Star No:
2/3/4 digits = Zodiacal catalogue (ZC) but referred to as the Robertson catalogue (R)
6 digits = Smithsonian Astrophysical Observatory catalogue (SAO)
X nnnnn, Xnnnnnn. X denotes a star in the eXtended ZC catalogue

Detailed predictions at your location for 1 year are available upon request.
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LUNAR GEOLOGICAL CHANGE DETECTION PROGRAMME 2019 Jan

Tony Cook

A Happy 2019 to our readers – let us hope for a lot of clear sky and ample opportunities to observe! This month we are still playing catch up due to teaching duties at University distracting me from Lunar Section activities. So, will just be summarizing observations received and undertaking scarcely little analysis this month as we have used up more pages than normal in this newsletter. Next month I will publish a table to show how the weights have changed of any past TLP covered by the repeat illumination observations.

Reports have been received from the following observers for October: Jay Albert (Lake Worth, FL, USA - ALPO) observed: Agrippa, Aristarchus, Plato, Poisson, Proclus, Ptolemaeus, Ross D and Theophilus. Francisco Alsina Cardinali (Argentina - AEA) imaged Eudoxus, Mare Crisium, Maskelyne, Maurolycus, and Proclus. Maurice Collins (New Zealand – ALPO/BAA/RASNZ) imaged: Alphonsus, Aristarchus, Clavius, Copernicus, earthshine, Gassendi, Mare Nectaris, Proclus, Schiller, Tycho and took some whole Moon images. Marie Cook (Mundesley, UK – BAA) observed: Aristarchus, Kepler and Plato. Walter Ricardo Elias (Argentina – AEA) imaged Promontorium Agarum, and the South Pole. Valerio Fontani (Italy – UAI) imaged Aristarchus, Cichus and Copernicus. Desiree Godoy (Argentina – AEA) imaged Biela and Manzinus. Leo Mazzei (Italy - Gruppo Astrofili Montagna Pistoiese/UAI) imaged Cichus and Copernicus. Robert Stuart (Rhayader, UK – BAA) imaged: several features. Franco Taccogna (Italy – UAI) imaged Aristarchus, Cichus and Copernicus. Aldo Tonon (Italy-UAI) imaged Aristarchus and Montes Teneriffe. Gary Varney (Pembroke Pines, FL, USA – ALPO) imaged: Aristarchus, Doppelmayer, Janssen, J. Herschel, Mare Tranquillitatis, the South Pole, and several other features. Fabio Verza (Italy – UAI) imaged Aristarchus. Ivor Walton (Cranbrook, UK – CADSAS) imaged Theophilus, Tycho and several features. Luigi Zanatta (Italy - UAI) imaged Aristarchus.

Reports have been received from the following observers for November: Alberto Anunziato (Argentina – LIADA) observed: Aristarchus, Geminus, and Proclus. Marie Cook (Mundesley, UK – BAA) observed: Aristarchus. Maurice Collins (New Zealand – ALPO/BAA/RASNZ) imaged: Copernicus, Sinus Iridum and took some whole Moon images. Walter Ricardo Elias (Argentina – AEA) imaged: Alphonsus, Alpetragius, Censorinus, Eratosthenes, Plato, Proclus and Tycho. Valerio Fontani (Italy – UAI) imaged Montes Spitzbergen. Rik Hill (Tucson, AZ, USA – ALPO/BAA) imaged Copernicus, J. Herschel and Gruithuisen. Nigel Longshaw (UK – BAA) observed Mons La Hire. Leonardo Mazzei (Italy - Gruppo Astrofili Montagna Pistoiese/UAI) imaged Mons Spitzbergen and the Full Moon. Robert Stuart (Rhayader, UK – BAA) imaged: Agatharchides, Clavius, Copernicus, Encke, Gassendi, Hainzel, Lambert, Longomontanus, Mare Cognitum, Mare Nubium, Palus Epidemiarum, Plato, Ramsden, Reinhold, Sinus Iridum, and several features. Franco Taccogna (Italy – UAI) imaged: earthshine, Eratosthenes, Torricelli, Montes Spitzbergen, Plato, the Full Moon, and several features. Aldo Tonon (Italy – UAI) imaged Torricelli, Gary Varney (Pembroke Pines, FL, USA - ALPO) imaged Mare

Crisium and several features. Derrick Ward (Swindon, UK – BAA) imaged Agrippa, Plato and Pytheas.

News: The Chinese have launched a mission to the Moon involving a lander/rover to the far side and a relay satellite placed in a halo orbit around a Lagrange point. The lander is due to touch down on 2019 Jan 03 (or later?). At one point it was discussed putting a lunar impact flash camera onto the relay satellite to monitor the Moon's night side, however I am unaware whether this got the go-ahead or not?

If any readers are interested there is some Europlanet software to which can be used to look for impact flashes on the Moon using recordings of AVI video. This is available from: http://users.aber.ac.uk/atc/alfi.htm. The software is different to the existing Lunar Scan program, but it is intended as a freeware project which will be built upon and improved.

TLP reports: No TLP were observed in October or November.

Routine Reports: Below are a selection of reports received for October and November that can help us to re-assess unusual past lunar observations – if not eliminate some, then at least establish the normal appearance of the surface features in question:

Promontorium Agarum: On 2018 Oct 13 UT 22:54 Walter Ricardo Elias (AEA) imaged this region under similar illumination, to within ±0.5° to the following Patrick Moore report:

Prom. Agarum 1995 Feb 05 UT 18:10-19:20 Observer: P. Moore (Sussex, UK, 15" reflector) - obscuration seen - Antoniadi II seeing, and Moon high up. BAA Lunar Section report. ALPO/BAA weight=3. **[REF 12]**

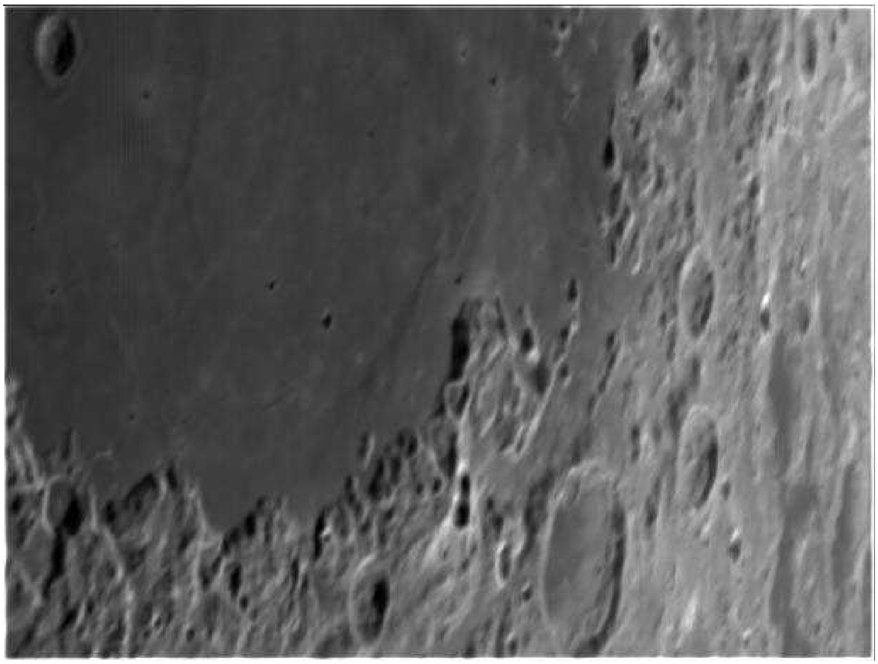

Figure 1. *Promontorium Agarum in Mare Crisium as imaged by Walter Ricardo Elias (AEA) on 2018 Oct 13 UT 22:54. Orientated with north towards the top.*

Alas we do not have any sketches from Patrick Moore on the observation from 1995, but at least we now have a good image of what the area would normally look like in Fig 1, and you can judge for yourself whether there is anything resembling an obscuration there. Many thanks to the skills of Walter for capturing this for us.

Biela & Maskelyne: On 2018 Oct 16 UT 00:40 Desiree Godoy (AEA) & 01:10 UT Francisco Alsina Cardinali (AEA), imaged these two regions under similar illumination, to within ±0.5° to the following report:

Biela, Maskelyne 1969 May 23 UT 02:32-03:00 Observed by Skinner, Perez, Barry, Bernie, Madison (Edinburgh, TX, USA) described in NASA catalog as: "Bright W.rim & 2 spots on N. & SE rim had blink (red -- Trident MB device) & event was in progress at start of obs. Saw nothing without image tube. Could not focus camera so no photos. Blink had ceased when image tube was replaced. Temporary bright reddish spot nr. Mask. photographed, (Apollo 10 watch). 17" reflector used. NASA catalog weight=5. ALPO/BAA weight=5. **[REF 13]**

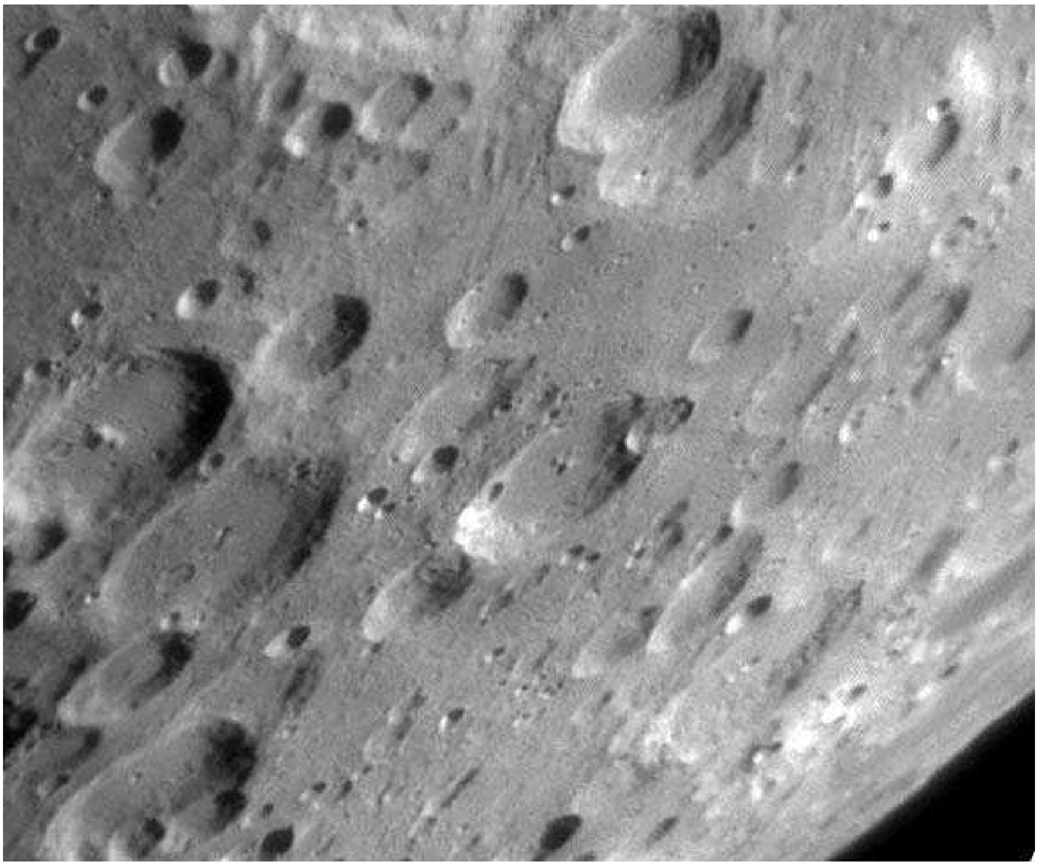

Figure 2. *The crater Biela (centre) in an image orientated with north towards the top. Monochrome image captured by Desiree Godoy (AEA) on 2018 Oct 16 UT 00:40.*

Figure 3. *The crater Maskelyne (centre) in an image orientated with north towards the top. Monochrome image captured by Francisco Alsina Cardinali (AEA) on 2018 Oct 16 UT 01:10.*

Although neither Fig. 2 nor 3 are in colour, at least we now have good reference images to compare the original TLP descriptions against thanks to these AEA astrophotographers.

Agrippa: On 2018 Oct 18 UT 01:00-01:35 Jay Albert (ALPO) observed/imaged, and Gary Varney (ALPO) imaged this crater under similar illumination, to within ±0.5° to the following report:

Agrippa 1961 Oct 18 UT 00:43-01:00 Observed by Bartlett (Baltimore, MD, USA, 5" reflector x180, S=2-3, T=5) "Shadow of c.p. remained greyish, wall shad. normal black. Not due to seeing as wall & landslide shad. not affected. Not caused by refl. sunlight because other similar obs. showed different aspects." NASA catalog weight=4. ALPO/BAA weight=2. NASA catalog ID #750. **[Ref 14]**

Figure 4. *Agrippa and Godin, orientated with north towards the top, taken on 2018 Oct 18 by ALPO observers.* ***(Left)*** *Taken at 01:26UT by Jay Albert.* ***(Centre)*** *Taken at 01:56UT by Gary Varney.* ***(Right)*** *Taken at 02:15 UT by Jay Albert.*

Jay, using a Celestron NexStar Evolution 8" (Transparency=3, seeing 5-6 out of 10) observed visually from 01:00-01:35UT and noted that the shadow of the central peak, whilst small, had a core that was as black as the shadow of the interior eastern wall. The central peak's shadow was slightly less intense at the edges. Cellphone photos attempted (Fig. 4 – Left and Right). Magnifications of 185x and 290x were used for the visual observing. Gary Varney (ALPO) captured a whole Moon image in between these two times at 01:56 UT, also using a cellphone at the eyepiece (Fig. 4 – Centre).

Torricelli B: On 2018 Oct 18 UT 07:32-07:49 Maurice Collins (ALPO/BAA/RASNZ) imaged this area under the same illumination, to within ±0.5°, as the following 1989 report:

On 1989 Jun 12 at UT 21:18-22:25 G. North (Herstmonceux, UK, Coude, seeing=V) noted at 21:18UT that Torricelli B was "barely visible"- possibly this was seeing related. M. Cook (Frimley, UK, 8" reflector, seeing=IV) found Torricelli B to be extremely dull - impossible to judge shadows on floor in contrast to Cens." Holmes (Rockdale, England, UK, 8" reflector, seeing=II-III) at UT21:30 also found Torricelli B difficult to find at magnifications less than 200x. Cameron comments that "Dulling is common on it at high Sun but illumination doesn't seem to be the cause or related". The Cameron 2006 catalog ID=365 and weight=5. The ALPO/BAA weight=3. **[REF 15]**

Fig. 5 shows that Torricelli B was not especially bright, and could be regarded as dull (Fig 5), though to be sure we need to compare this to other images taken under similar illumination, and where possible topocentric libration.

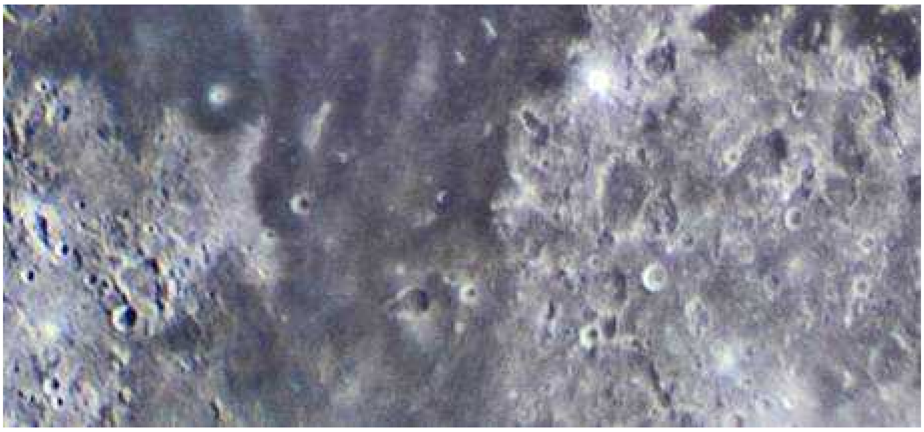

Figure 5. *2018 Oct 18 UT 07:32-07:49 – Torricelli B is the small crater at the centre of the image. This image is from a larger mosaic of the whole Moon captured by Maurice Collins (ALPO/BAA/RASNZ). The image is orientated with north towards the top. Image colour saturation has been increased to 50%.*

Copernicus: On 2018 Oct 18 two repeat illumination events occurred which were covered by UAI observers. Similar illumination (to within ±0.5°) for the 2006 Jun 05 event spanned approximately 18:50-20:50 UT and similar illumination (to within ±0.5°) for the 1990 Apr 04 event spanned approximately 20:15-21:30UT:

On 2006 Jun 05 G. Burt made a drawing over a period of 30 minutes. Upon examining drawing, and comparing with photos made under similar illumination was struck by the abnormality of a small white blob in the north east corner of the shadowed floor. There should be no raised topography between the wall and the central peaks that could give rise to this. The making of the sketch overlapped with an earlier drawing made by Rony de Laet (Belgium) which did not show this blob. Subsequent attempts to find sketches/images at very similar illumination angles have failed to show the blob in the north east corner of the shadowed floor. ALPO/BAA weight=3. **[REF 16]**

On 1990 Apr 04 at UT 21:30-21:50 B. LeFranc (France?) reported observing a white flame effect in Copernicus crater (sketch made) - though Foley comments that the actual location was east of the crater. The Cameron 2006 catalog ID=398 and the weight=2. The ALPO/BAA weight=2. **[REF 17]**

A selection of the images that the UAI observers made are shown in Fig. 6 along with the 2006 sketch by Geoff Burt. For the 2006 event you can see previous repeat illumination observations in the 2013 Mar and 2018 Jan newsletters. For the 1990 event, we have covered this in the 2016 Jan newsletter. The 19:33 and the 20:23 UT images are fairly close in terms of similarity to Geoff Burt's sketch. The 20:56 UT image by Valerio Fontani has the most similar illumination for the 1990 report, but alas we have no sketch in the archives from that TLP.

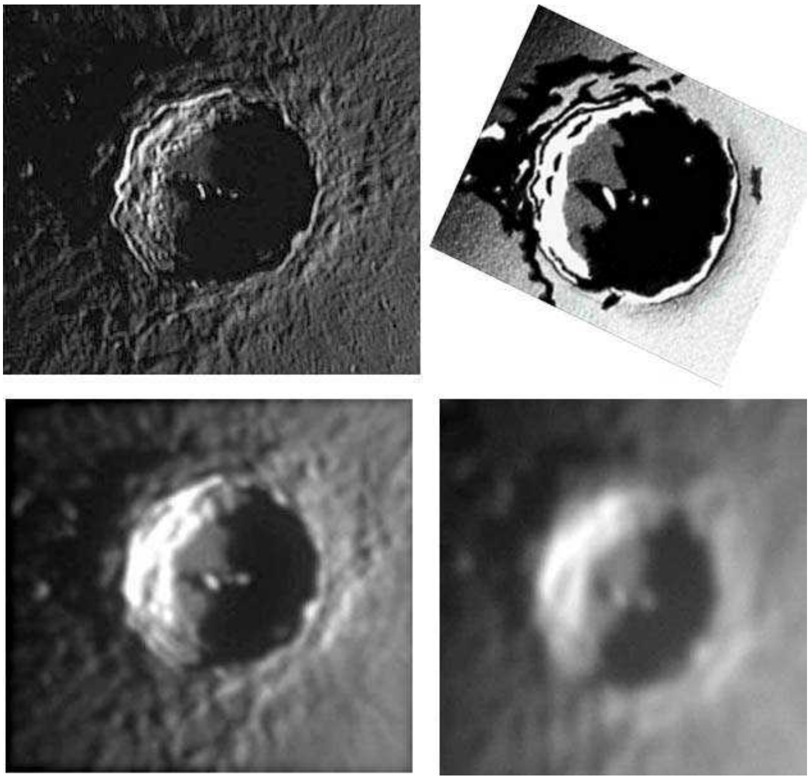

Figure 6. *Copernicus orientated with north towards the top.* ***(Top Left)*** *An image taken by Franco Taccogna (UAI) on 2018 Oct 18 UT 19:33.* ***(Top Right)*** *A sketch made by Geoff Burt (SPA) on 2006 Jun 05 UT 21:00-22:00.* ***(Bottom Left)*** *An image by Leo Mazzei (Gruppo Astrofili Montagna Pistoiese/UAI) made on 2018 Oct 18 UT 20:23 under worsening observing conditions.* ***(Bottom Right)*** *An image by Valerio Fontani (UAI) made on 2018 Oct 18 UT 20:56 made under difficult observing conditions.*

Plato: On 2018 Oct 19 UT 19:50-20:00 Marie Cook (BAA) observed this crater visually under similar illumination conditions (to within ±0.5°) to the following report:

Plato 1969 May 26 UT 20:30-21:05 Observed by Farrant (Cambridge, England, 8" reflector, x160, S=G) "Had misty portion of SW(ast. ?) floor from 2030-2105h at which time it was gone. Clearly seen, had ill-defined boundaries & was an easy obj. to see. Alt.=33 deg. (Apollo 10 watch)." NASA catalog weight=3. NASA catalog ID No. 1148. ALPO/BAA weight=2. **[REF 18]**

Marie comments that the crater was sharp and clear. A thin shadow was seen close to the wall. The floor was normal and no misty patch was seen.

Aristarchus: On 2018 Oct 20 UAI observers imaged Aristarchus under similar illumination (to within ±0.5°) to the following two reports:

Aristarchus 1966 Jul 29 UT 03:40 Observed by Simmons (Jacksonville, FL, USA, 6" reflector x192, S=7, T=4-5) and Corralitos Observatory (Organ Pass, NM, USA, 24" reflector + Moonblink) "Spot on S.wall vis. only in red filter, brightness 8deg. Slightly brighter than surrounding wall. No confirm. Says it might be part that reflected better. Not confirmed by Corralitos Obs. MB." NASA catalog ID #968. NASA catalog weight=1. ALPO/BAA weight=1. **[REF 19]**

On 1982 Sep 29 at UT 05:52UT D. Louderback (South Bend, WA, USA, 8" reflector, x240) saw approximately 7-8 diameters from Aristarchus (72W, 15N) a star-like point on the dark side - uncertain if this was on the limb or inside the disk of the Moon. Cameron 2006 catalog ID=185 and weight=1. ALPO/BAA weight=1. **[REF 20]**

***Figure** 7. Aristarchus as imaged by UAI observers on 2018 Oct 20, orientated with north towards the top. **(Top Left)** 19:22 UT imaged by Franco Taccogna. **(Top Centre)** 19:45 UT imaged by Fabio Verza. **(Top Right)** 20:18 UT as imaged by Luigi Zanatta. **(Bottom Left)** 21:17 imaged by Valerio Fontani. **(Bottom Right)** 21:26 UT imaged by Aldo Tonon.*

The repeat illumination conditions for the above two reports spanned the time range of approximately 18:45-20:45 and 19:35-23:25 on 2018 Oct 20. The corresponding observations are shown in Fig. 7. I wonder if the 1982 observation was due to an occultation?

Plato: On 2018 Oct 26 UT 21:25 Ivor Walton (CADSAS) imaged this crater under the same illumination conditions (to ±0.5°) to the following spectroscopic report:

Plato 1965 Sep 13 UT 07:20 McCord (Mt Wilson, CA, USA, 60" reflector with spectrograph) - "Line depth ratio in spectra a/b (H), c/d (K) were abnormally high compared with 23 other areas, but not quite as pronounced as other areas on other dates." NASA catalog weight=5, NASA catalog ID #895. ALPO/BAA weight=5. **[REF 21]**

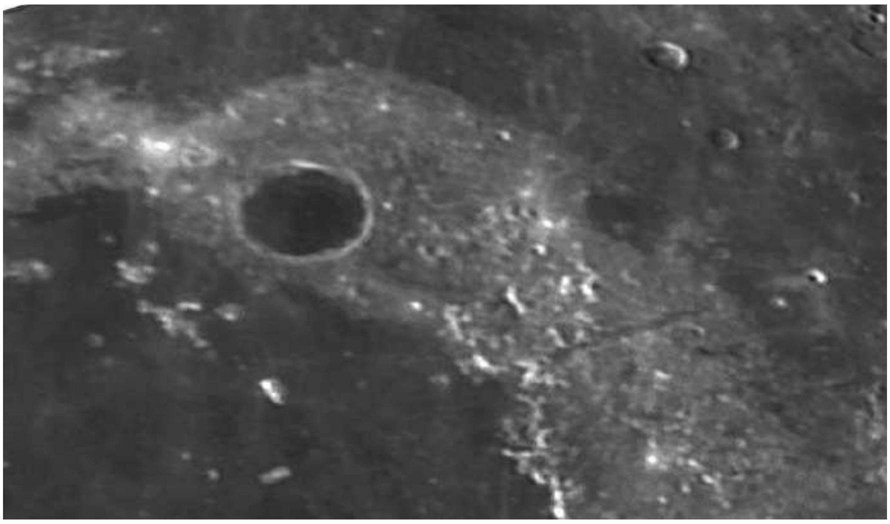

Figure 8. *Plato, from a larger image, by Ivor Walton (BAA) as imaged on 2018 Oct 26 UT 21:25 and orientated with north towards the top.*

Although Fig. 8 cannot help us spectroscopically, it does at least show what the crater would have looked like at the time the 1965 observation was made. Please be aware that solar absorption line filling/shallowing in lunar reflection spectra maybe explained by 'inelastic scattering of sunlight with a small wavelength shift' – see Potter, Mendall and Morgan (1984), which in turn is related to the surface temperature - which of course is high at local lunar noon.

Alphonsus and Plato: On 2018 Oct 30 UT 08:28 Robert Stuart (BAA) took a monochrome image of the Moon during daylight hours here in the UK which was under similar illumination (±0.5° to the following two TLP reports:

On 1958 Dec 02 at UT 06:00 an unknown observer detected a TLP on the Moon (Alphonsus). The reference for this is from Palm, 1967 Icarus. The Cameron 1978 catalog ID=709 and weight=0. The ALPO/BAA weight=1. **[REF 22]**

On 1975 Mar 04 at UT03:46-06:01 P.W.Foley (Wilmington, Dartford, Kent, UK, 12" reflector) observed blueness along the southern wall of Plato. This is a BAA observation. The Cameron 1978 catalogue ID is #1403 and has a weight of 1. The ALPO/BAA weight=1. **[REF 23]**

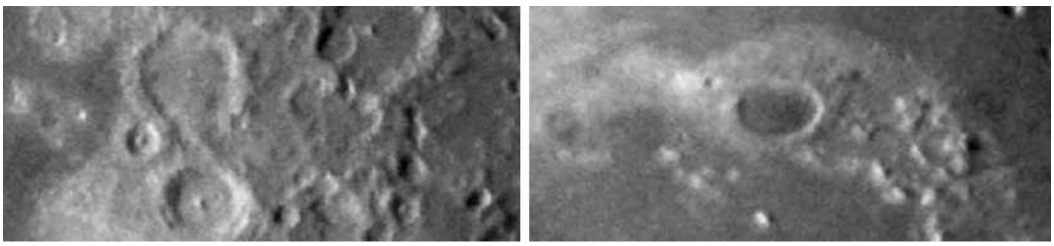

Figure 9. *2018 Oct 30 UT 08:28 – subsections of a whole Moon image by Robert Stuart (BAA) orientated with north towards the top.* ***(Left)*** *Alphonsus.* ***(Right)*** *Plato.*

Although limited by resolution in this day light shoot (Fig. 9}, at least we now have the normal appearances of these craters to compare with.

Torricelli: On 2018 Nov 14 UAI observers: Franco Taccogna and Aldo Tonon, imaged this crater under similar colongitudes to a scheduled repeat illumination request:

ALPO Request: On 2011 Dec 31 Raffaella Braga (UAI) found the north rim or 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. **[REF 24]**

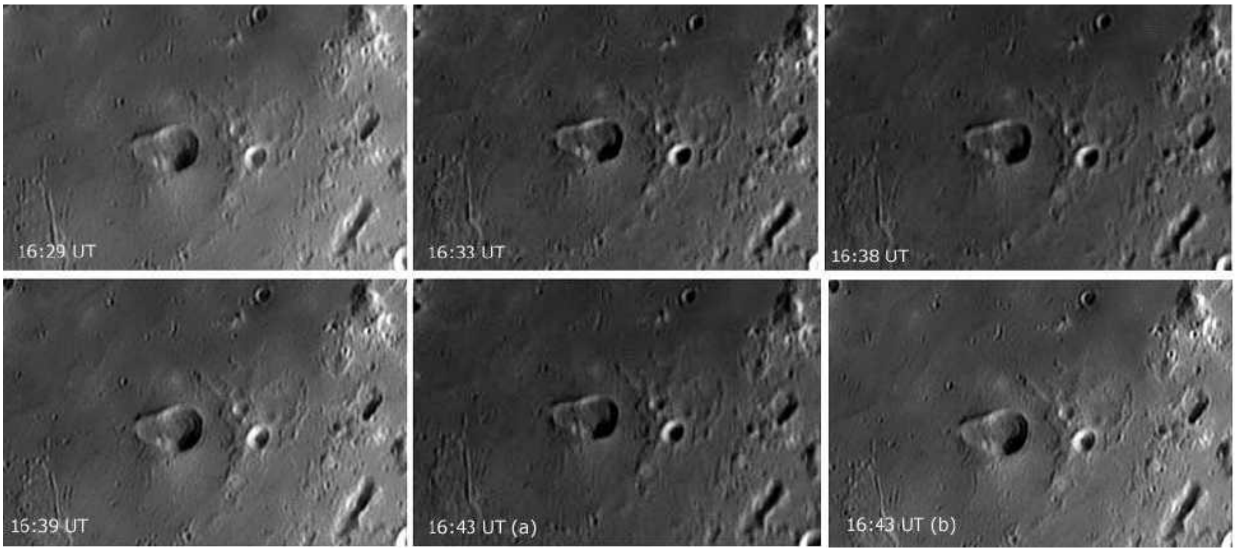

Figure 10. *Torricelli as imaged by UAI observers on 2018 Nov 14 and orientated with north towards the top.* ***16:29 UT*** *by Aldo Tonon.* ***16:33 UT*** *by Franco Taccogna.* ***16:38 UT*** *by Franco Taccogna.* ***16:39 UT*** *by Aldo Tonon.* ***16:43 UT (a)*** *by Franco Taccogna.* ***16:43 UT (b)*** *by Aldo Tonon.*

You can judge for yourself (See Fig. 10) whether the north rim of Torricelli is very bright and varies in brightness in this time sequence. Although similar in illumination, the 2011 observation may differ in viewing angle (topocentric libration).

Montes Spitzbergen: On 2018 Nov 15 three UAI observers imaged this area to see if they could solve whether a suspected lava flooded valley was a sunken valley or simply a couple of semi-parallel wrinkle ridges:

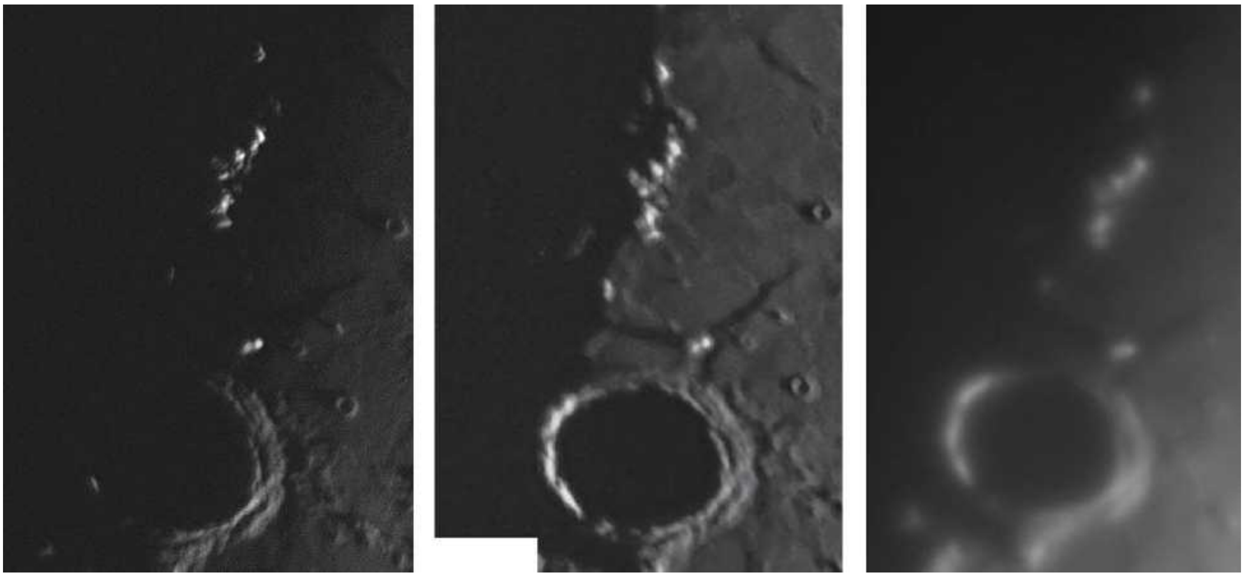

Figure 11. *Montes Spitzbergen are taken on 2018 Nov 15 by UAI members, and orientated with north towards the top.* ***(Left)*** *16:52UT by Franco Taccogna.* ***(Centre)*** *19:49UT by Valerio Fontani.* ***(Right)*** *20:16UT by Leonardo Mazzei (Gruppo Astrofili Montagna Pistoiese).*

Fig. 11 hints at a raised ride SW and NW of Montes Spitzbergen. However, it looks like the start colongitude needs to be adjusted slightly (perhaps by as little as 0.1°) so the area is less in shadow in future predictions.

Eratosthenes: On 2018 Nov 16 UT 23:50 Walter Ricardo Elias (AEA) observed this crater under the same illumination, to within ±0.5° to the following observations from British planetary geologist Peter Cattermole:

Eratosthenes 1954 May 11 UT 20:00 Observer: Cattermole (UK, 3" refractor) "Central peak invis. tho surroundings were sharp". NASA catalog ID #563, NASA weight=4. ALPO/BAA weight=2. **[REF 25]**

Figure 12. *Eratosthenes on 2018 Nov 16 UT 23:50 by Walter Ricardo Elias (AEA), and orientated with north towards the top.*

Walter’s image (Fig. 12) shows a great amount of detail in the crater and three components to the central peak area – no peaks are missing here.

Mons La Hire: On 2018 Nov 17 UT 17:15-17:36 Nigel Longshaw observed this mountain under similar illumination (to within ±0.5°) to the following 1920s era report:

La Hire 1922 Nov 28 UT 22:00? Observer Wilkins (England). NASA catalog states: "Shadow cut thru by white streak (real LTP?. Pickering's atlas shows same phase & col. & shadow is all dark; elong. in peaks are N-S not E-W)" 15" reflector used. NASA Catalog assigns a weight of 4. NASA catalog TLP ID No. #388. ALPO/BAA weight=2. **[REF 26]**

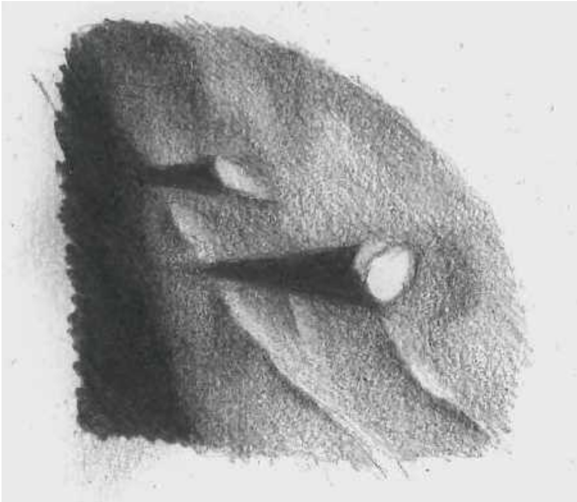

Figure 13. *limited by resolution in this daylight shoot, at least we now have the normal appearances of these craters to compare with.*

Nigel used a 4” refractor at x106 and x260 under good transparency and III-IV Antoniadi scale seeing. Nigel did not see the shadow cut by a white streak, but instead the shadow mostly finished at the ridge to the west, though continued beyond this, to the terminator, as a dark streak (perhaps an optical illusion?). The appearance was similar to what he had seen on 2017 Oct 29 during another repeat illumination observing session.

Pytheas: On 2017 Nov 17 UT 19:29 Derrick Ward (BAA) imaged this crater under the same sun angles, to within ±0.5°, as the following visual report:

On 1982 Aug 29 at UT 02:13-02:30 Robotham (Springfield, ON, Canada, x97 and x160) found that the west rim of Pytheas crater was very bright, especially at lower magnifications, being one of the brightest spots on the Moon. The Cameron 2006 catalog ID=182 and weight=3. ALPO/BAA weight=2. **[REF 27]**

Figure 14. *Pytheas crater on 2017 Nov 17 UT 19:29 taken by Derrick Ward (BAA). Orientated with north towards the top.*

It certainly would appear that west rim of Pytheas (Fig. 14) is very bright – though whether it is one of the brightest spots on the Moon is less certain from this image.

Plato: On 2018 Nov 18 UT 09:11-09:32 Maurice Collins (ALPO/BAA/RASNZ) produced a whole Moon mosaic, and part of this covered the Plato region during the repeat illumination (to within ±0.5°) of the following 1969 report:

Plato 1969 May 26 UT 20:30-21:05 Observed by Farrant (Cambridge, England, 8" reflector, x160, S=G) "Had misty portion of SW(ast. ?) floor from 2030-2105h at which time it was gone. Clearly seen, had ill-defined boundaries & was an easy obj. to see. Alt.=33 deg. (Apollo 10 watch)." NASA catalog weight=3. NASA catalog ID No. 1148. ALPO/BAA weight=2. **[REF 28]**

Figure 15. *Plato taken on 2018 Nov 18 UT 09:11-09:32 by Maurice Collins (ALPO/BAA/RASNZ). Orientated with north towards the top.*

The colour image (Fig. 15) that Maurice took shows the SW quarter of the floor to be lighter than the rest at the time the image was taken, though we cannot tell if this is transient – though my years of observing experience suggest this is unlikely.

Alphonsus: On 2018 Nov 18 UT 18:34 Robert Stuart (BAA) took a large area image mosaic of the Moon under both similar sun angle illumination and viewing angle, to ±1°, to the following report:

Alphonsus 1959 Feb 18 UT 21:00? Observed by Hole (Brighton, England, 24" reflector) "Red patch (Moore in Survey of the Moon says Jan. '59). Moore says, Warner, in Eng. saw it bright red in an 18-in refr. Hedervari & Botha in Hungary saw red patch & several in US (indep. confirm. ?)" NASA catalog weight=5. NASA catalog ID #714. ALPO/BAA weight=5. **[REF 29]**

Bob's image (Fig. 16}, although in monochrome, is a great reference image to compare the Hole TLP report against because both illumination and topocentric libration line up to match what the 1959 observers should have seen if everything was normal in appearance.

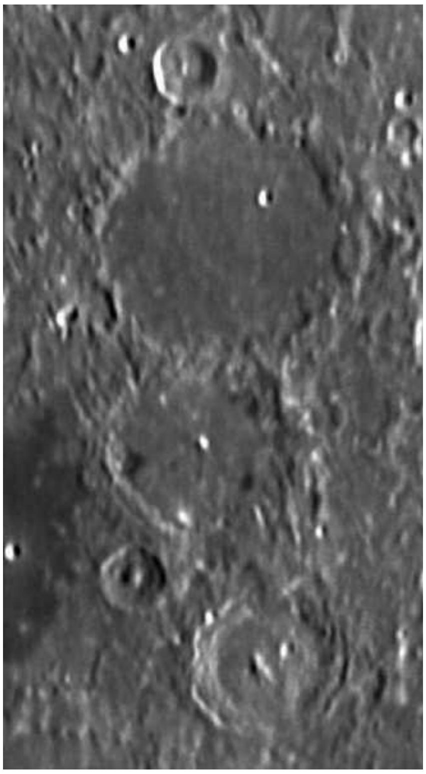

Figure 16. *Ptolemaeus, Alphonsus and Arzachel from a larger image taken by Robert Stuart on 2018 Nov 18 UT 18:34. Orientated with north towards the top.*

Aristarchus: On 2018 Nov 21 UT 18:50-19:10 Marie Cook (BAA) visually observed this crater under the same illumination (±0.5°) to the following:

Aristarchus 1959 Jan 23 UT 06:20 - Observer: Alter (Mt Wilson, CA, 60" reflector x700) "Brilliant blue in interior later turning white. Photos obtained. (MBMW has this entry twice for diff. dates because source gave UT date as 23rd.)" NASA catalog weight=5. NASA catalog ID = #712. ALPO/BAA weight=4. **[REF 30]**

Aristarchus-Herodotus 1964 Sep 20 UT 04:15-04:50 - Observers: Crowe & Cross (Whittier, CA, USA, 19" reflector x390) "Several red spots in area between the 2 craters. No change in phenom. so stopped observing" NASA catalog weight=5 (very good). NASA catalog ID #849. Near Aristarchus 1788 Apr 19 UT 20:00? Observed by Schroter (Lilienthal, Germany) Event described as: "Small area very brilliant & other bright spots". No additional references given. NASA Catalog Event #44, NASA Weight=4. ALPO/BAA weight=1. **[REF 31]**

Marie was observing under moderate transparency and Antoniadi III seeing conditions. She noted no red spots in the area between Herodotus and Aristarchus. There was no blue visible in the interior of Aristarchus, though some atmospheric spectral dispersion on its exterior. The crater basically appeared normal.

Aristarchus: On 2018 Nov 25 UT 03:20-03:46 and 04:08-04:22 Alberto Anunziato (LIADA) observed this crater under three repeat illumination predictions, to within ±0.5°for the following:

Aristarchus 1964 Oct 23 UT 02:35-02:45 Observed by Bartlett (Baltimore, MD, USA, 3" refractor, 133 & 200x, S=3-5, T=4) "South floor region granulated, 6 deg bright with very faint trace of pale yellow color; rest of crater 8 deg bright." NASA catalog weight=4 (good), NASA catalog ID #859. **[REF 33]**

Aristarchus 1983 Oct 23 UT 19:00-01:30 Observer: Foley (Kent, UK, 12" reflector, seeing=II) noticed at 19:00UT an extended bright spot on E wall and extending beyond. This was brighter than other areas of the crater. There was also occasional star-like glistening. Foley comments that the inside of Aristarchus was slightly obscured. The TLP started fading from UT20:30 and finished by 01:30UT. six out of nine independent observers confirmed the effects seen. In total 14 observers observed, 9 reported back and 6 found abnormalities in Aristarchus though all encountered variable seeing conditions - some had spurious colour. Cameron comments that this was one of the best recorded/confirmed TLP events. All CED brightness measurements obtained were very high. Moore, Nicolson and Clarke (5" refractor and 15" reflector, 230-350xseeing III) found the crater to be very bright at 19:11UT through a 5" refractor and there was a blob on the east rim (Bartlet's EWBS?) at 19:14UT. Nicolson also saw a very bright star-like area on the eastern wall but this was not defined as it usually is. The crater was also very bright at 22:43UT using the 15" reflector available to these observers. At 01:07UT they used a Moon blink and discovered that the bright region was bright in blue light and less bright in red - although this was not a detectable blink when switching rapidly between filters. They found that the crater had returned to normal by 01:15UT. M.C. Cook (Frimley, UK, seeing III-IV) observed a large diffuse spot on the east of the crater that was brighter in blue than in red light and the CED device gave a high reading. J.D. Cook (Frimley, UK, seeing III-IV) made a sketch that showed the bright spot extended on the east wall - again the CED reading was high and a lot of detail was visible on the floor. A.C. Cook (Frimley, UK, seeing III-IV) also noted remarkable detail and the bright (as confirmed by CED) blob on the eastern rim. G. North (Sussex, UK, seeing III-II) also confirmed the bright blob on the eastern wall. Wooller found the north west wall was a dirty yellow colour - though no colour was seen elsewhere in or outside the crater. Mosely found the crater to be bright and his sketch revealed the extension of the bright blob on the eastern rim and again a great deal of interior detail. Amery (Reading, UK, seeing III) found Aristarchus to be "a brilliant splash against dulled background in violet filter, especially polarizing filter. CED + polarizer readings high, but not as high as previous night". Mobberley (Suffolk, UK, seeing III-IV) remarked that "spurious colour a total mess around Aristarchus & nothing abnormal seen". A photograph was taken at 20:50UT reveals the bright blob and entire detail. Peters (Kent, UK, seeing III-II) observed Aristarchus with a UV screen from 20:15-21:23UT and commented that although being very bright, there was no variation between white and UV. It was checked with a Moon Blink device and the radial bands were clearly seen in white light, < in blue. The Cameron 2008 catalog ID=233 and the weight=5. The ALPO/BAA weight=4. **[REF 34]**

On 2002 Sep 23 at UT22:45-23:56 C. Brook (Plymouth, UK) noticed that the bands inside Aristarchus varied (UT22:45-22:56) in definition whilst the rim of Herodotus and the rays of Kepler and Copernicus remained sharp. These bouts of variation were 1-2min in duration. At 23:56UT when he checked again the periodic blurring's of the bands were still present. The observer suspected atmospheric effects. M.Cook (Frimley, UK) observed 22:00-22:30 and could see only 2 bands on the west wall - but this may have been because of poor transparency. The ALPO/BAA weight=1. **[REF 35]**

Alberto reported that the crater was extremely bright and the appearance of the bands seemed to vary but with atmospheric seeing. Most of the time it was difficult to distinguish the bands during the first session (Fig. 17 – Left), except at times of good transient seeing. When resuming the observation from 04.08 to 04.22 UT, under better seeing, the bands appeared more defined and four were observed (Fig. 17 – Right). No colour was seen. Everything looked normal.

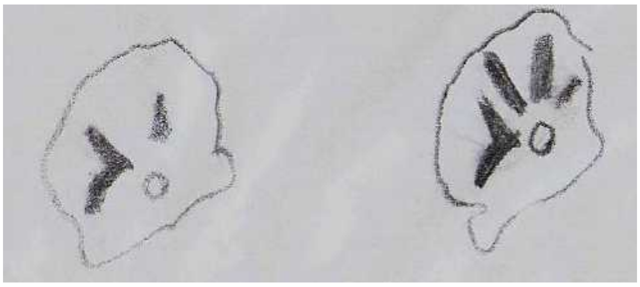

Figure 17. *Aristarchus as sketched by Alberto Anunsiato on 2018 Nov 25. (Left) 03:20-03:40 UT. (Right) 04:08-04:22 UT.*

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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