

Editorial.

By Tony Cook.

Every few months we get the media drumming on about the forthcoming “Super Moon”. Most amateur astronomers tend to cringe when they hear this term as we simply observe the Moon any time, and not usually when it is especially low on the horizon or close to Full Moon – though there are exceptions. So this month I thought I would come up with some reasons why the Super Moon should be relatively unimportant to most people, just in case our readers ever get the chance to set the record straight with the media, or friends and family, who are caught up in this frenzy. According to Encyclopaedia Britannica, the name “Supermoon” was devised by an astrologer Richard Nolle in 1979 and is defined to be when the Moon is within 10% of perigee, whether it be New Moon or Full Moon. He seemed to think that it would lead to more earthquakes and bad weather on Earth, whereas in fact there has never been any scientific proof for this. The only thing of significance is that the tidal range on the sea is bigger during lunar perigee. It should be said however that benign deep quakes on the Moon do occur more frequently closer to perigee.

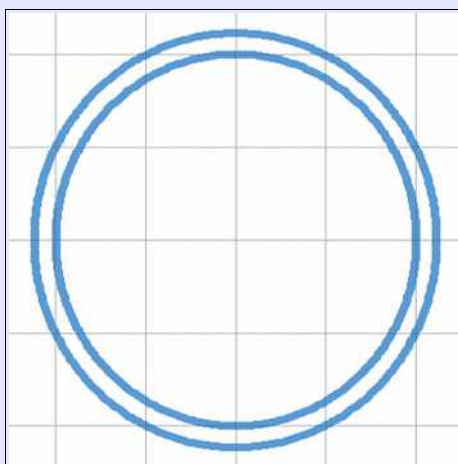


Figure 1. The circles here represent the relative angular sizes of the Moon as seen at perigee (closest point to Earth), versus the smaller angular size at apogee (furthest point from Earth).

The second point is that it is often claimed that the Moon looks significantly bigger during Super Moon. There are three factors that must be taken into consideration here.

(1) the difference between the Moon’s furthest and closest point to Earth only lead to a size change of 11.6% - figure 1 illustrates why this is simply not very exciting. For something about half a degree across in the sky, people would need a pretty good eyesight/memory, or measuring capability, to notice this.

(2) The media are always showing pictures of the Moon on the horizon, but in fact this is not a good time to observe

the Super Moon as you are one Earth radii (6371 km) further away than some observer who has the Moon at the zenith in their sky (See Fig 2). There is also a psychological Moon Illusion effect (Fig 3) coming into play when the Moon is closer to the horizon, with trees or buildings nearby, making it look big relative to these compared to when it is high in the sky away from any reference objects. But of course we have this effect at any time the Moon rises or sets, whether it is at perigee or apogee.

(3) The last point the media sometimes make about the Super Moon is that it is a lot brighter. There is some truth in this in that it is 25% brighter, though if observed on the horizon, this increase in brightness is easily absorbed by the atmosphere. But again even with the Moon high in the sky, would people really notice a 25% change in brightness – I suppose under dark night time conditions, any extra light can help you see better in the dark.

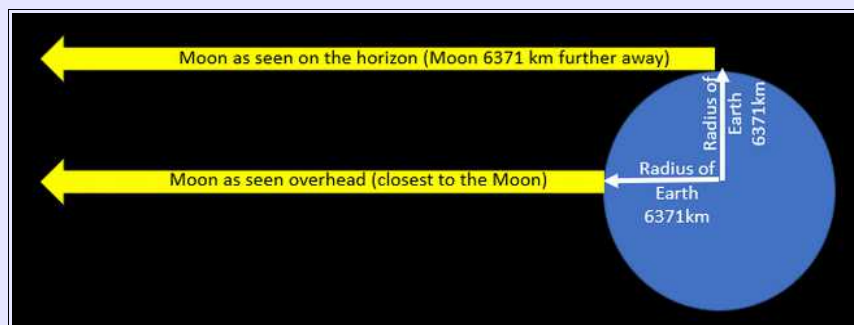


Figure 2. Diagram to illustrate the fact that when the Moon is on the horizon, it is 1 earth radii, or 6371 km further away than an observer with the Moon directly overhead.

I hope these arguments can be of help to some of you who may wish to counter these Super Moon “non-events” that make it onto the news and get people excited unnecessarily.

Finally, just three of quick snippets of space news. Firstly, NASA’s Capstone mission to cis-lunar space was launched on 28th June, from New Zealand and will investigate orbital dynamics and communications for the future planned Lunar Gateway space station. Secondly Korea’s Danuri, or Korea pathfinder Lunar Orbiter, will launch on 2nd August – it will take about a month to arrive. We should be especially interested in this as it’s carrying a camera that can see inside permanently shadowed craters at the lunar poles and is 100x more sensitive than the NASA LROC cameras. It may see ice or frost on the surface of these dark interiors, but could maybe potentially detect scattered light from charged electrostatically levitated dust particles on the interior edges of crater shadows. The spacecraft also carries a polarimeter and a magnetometer. Finally, NASA’s long-awaited unmanned Artemis 1 unmanned orbital mission, may launch between 29 Aug and 6 Sep.

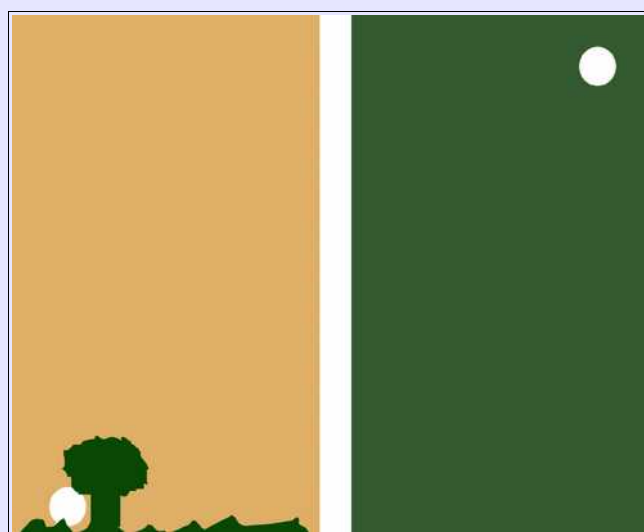


Figure 3. The Moon illusion effect – note that this looks better in real life than in a diagram. (Left) The Moon looks bigger to the brain if it has some reference objects on the horizon. (Right) When it is high up in the sky, without any reference frames nearby, the brain thinks it is smaller. In fact there is no real size change noticeable to the human eye.

Letters – Communications have been received from the following:
Lunar Atlases by Tony Cook

Barry Watts (Beacon Hill Telescopes) phoned to ask about lunar atlases for observing. Below is a list of ones I know about that are suitable for use at the telescope (I have excluded those that are large e.g. Times Atlas of the Moon), though there maybe others:

Atlas of the Moon by Antonin Rukl (Ed. Dr T.W. Rackham divides the Moon into 76 sections and includes a very detailed airbrushed map in each section at fixed effective illumination. This seems to retail at under £40 for used books. There is a pocket version: Moon, Mars and Venus (Concise Guides in Colour) which is also worth hunting for on E-Bay and is cheaper.

The Hatfield Lunar Atlas (Anthony Charles Cook) - this divides the Moon up into 16 sections and provides images under 4-6 different illumination conditions. The modern edition 2012 and 2014 are digitally augmented to bring out more detail in the original Commander Henry Hatfield plates. Pre-2014 editions (by Henry Hatfield and Jeremy David Cook) were printed on glossy paper, but the modern day publishers (Springer) decided to use traditional paper. Various guides on how to observe, and useful appendices are included along with selenographic colongitudes for each image. The current new price appears to be over £40 for the ordinary and SCT versions of the atlas.

The Clementine Atlas of the Moon by Bussey and Spudis, is perhaps the most detailed atlas, as it uses Clementine spacecraft imagery, but taken under Full Moon conditions - so please bear that in mind. The Moon is divided up into 144 map sheets. Also included is a computer generated shaded relief map for each of these sheets. This seems to retail at just under £30 new and uses glossy paper.

21st Century Atlas of the Moon by Charles Wood and Maurice Collins utilizes computer visualizations generated from the LTVT program to produce realistic shaded relief views of the surface mostly at one fixed illumination. Other image inserts of selected areas are at different illumination angles. It is printed on glossy paper. In addition there are limb charts, a map of the far side and some specialized areas. The atlas seems to retail at just under £25 for new copies.

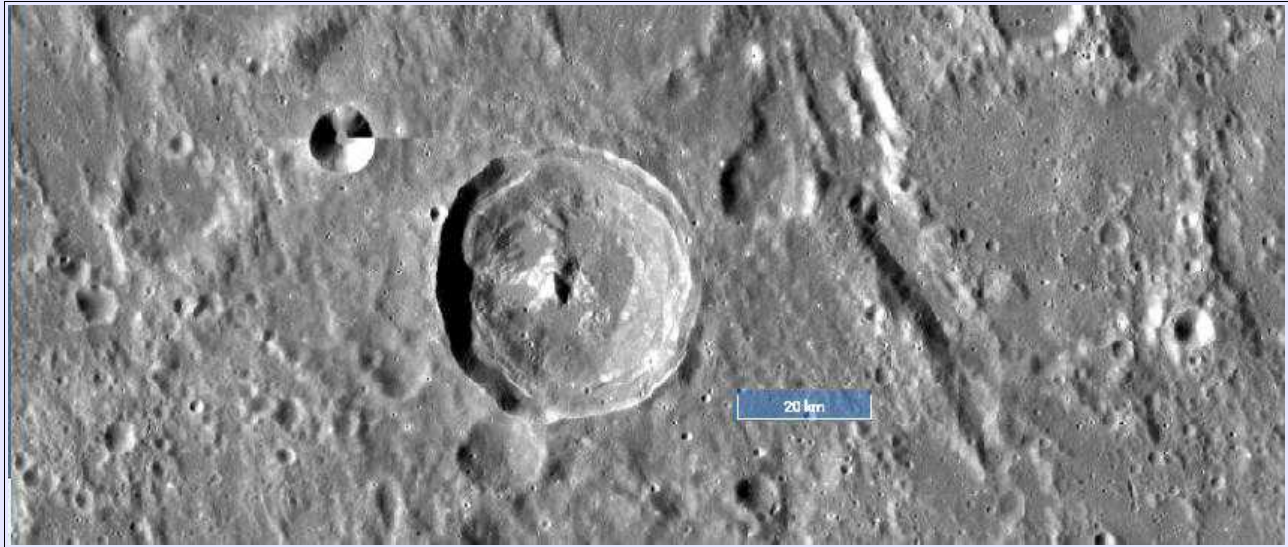
Herschel Crater by Peter Anderson

Concerning the LGC article in last month's circular: Page 35 at the base. The crater Herschel. - I believe that the dark rectangular area was located near Herschel and not J. Herschel. If you look at the top image in figure 3, you will see around half a crater width to the upper right, a darker rectangular (almost square) area. The lighting is such that it is not particularly dark, but it is a little darker than its surroundings and quite obvious. For convenience, the image is attached below. Possibly some further comment could be made on this.



Tony Comments: Well done, I had not spotted that! But let us check the original report: “On 2015 Sep 25 UT 03:28-03:40 D. Davis (Albany, OR, USA, Questar telescope used, x80 and x120, seeing 6, transparency), saw a very black rectangular feature along the western side of Herschel and slightly to the north. the effect was first noticed at 03:28-03:32 and it was checked again at 03:37-03:40. The length was ~4x the width and it was roughly 80-100 km long by 15-20km wide...”. The images were by UAI observers Fabio Verza and Valerio Fontani. Herschel is 39 km in diameter, which would make the square crater about 12 km x 9 km – so this cannot be the same crater as it is too small, the side ratio is not right, and it is on the east, not the west of Herschel. The proposed solution at J. Herschel is much more appropriate.

Nevertheless it is an interesting feature that Peter found just east of Herschel and it can be seen in the NASA LROC Quickmap image below:



It is just speculation, but it may be a crater that has been modified by the adjacent diagonal large impact ejecta scour mark (there are lots of other near-parallel scour marks elsewhere in this region of the Moon, or perhaps the rectangular crater is some form of secondary crater from a nearby larger crater? Or maybe it was an ancient volcanic vent that poured lava into the scour mark depression?

The Viscardy Photographic Lunar Atlas and Harold Hill.

By Nigel Longshaw.

I was interested to read James Dawson's account of the Viscardy photographic lunar atlas in the June circular and in particular his reference to Harold Hill in connection with the book. At the time Harold sadly passed away in 2005 I was fortunate to be in regular contact with the late Richard Baum. Richard and Harold had great respect for each other being eminent in their respective fields and it was through Richard's contact with Harold's son that I was able to secure a box of lunar related items when Harold's effects were being cleared from the house.

Among those items was Harold's copy of the Viscardy Atlas. This atlas was, as rightly suggested by Bill Leatherbarrow, well used by Harold and this is indicated by the absence of the dust cover, splitting of the hinges and internal parcel tape repairs to the spine. Certain images have been cut out of the book and re-taped in by Harold and there are notes throughout the atlas relating to recalculated colongitude values and bookmarks to note particular features of interest to Harold. The book bears the inscription:

To Harold Hill in true esteem, G.Viscardy.

I was already aware that Harold regarded the Atlas highly, as he had mentioned it a number of times during the long period of correspondence I had with him. But perhaps one telling paragraph from his letter to me dated 1995 April 7 is worth quoting in full: -

'...my files contain enough observational material for 3 or 4 Portfolio's [A portfolio of Lunar Drawings, Harold Hill, Cambridge University Press, 1991] more but publishers seem indifferent to the idea of another amateur book on the Moon, citing what has apparently become the standard opinion that the Moon is now passé. Georges Viscardy related the same sorry story from France to me after publication of his Photographic Atlas Guide de la Lune, which I reviewed in the pages of the BAA Journal – he wrote, and I quote from his letter; ' My sole intention was to interest amateurs to study the Moon and not at all to make money, but I realise that I am wasting my time because in France and elsewhere, the Moon is only regarded as 'a musette' – a pastime – for amateur astrophotographers'.

At the time the above seemed very relevant to the state of amateur lunar study, but I think now, particularly with reference to the papers published in the pages of this circular, the amateur is contributing more to our knowledge of the moon than simply 'picture taking'.

As a footnote, in addition to the Atlas itself was a small envelope containing a number of original prints from Viscardy's lunar photographs which he had sent to Harold. It's clear from these that some loss of definition took place in the reproduction of the images in the Atlas as James suggested. The original photographs probably represent the pinnacle of what was achievable with cameras and film of the day. Most of the images are noted as being taken from the Observatoire de Saint-Martin-de-Peille, presumably where Martin Mobberley visited Viscardy in the wonderful video linked to James' article in the June Circular. I have included a number of scans (Figs 1-4) of these original photographs (taken in 1982 and 1983) and whilst, like the images in the Atlas, they cannot compete with modern CCD images, they do form an integral part of the history of amateur lunar observing and are still relevant to the visual observer for purposes of comparing visual impressions. I, like James, greatly admire the Viscardy lunar Atlas, and it will be a constant source of reference for years to come.



Fig.1 Clavius from the Viscardy Photographic Lunar Atlas



Fig.2 Deslandres from the Viscardy Photographic Lunar Atlas



Fig.3 Birt and the 'Straight Wall' from the Viscardy Photographic Lunar Atlas



Fig.4 Triesnecker and Sinus Medii from the Viscardy Photographic Lunar Atlas

Images and comments have been received from the following contributors: Phil Masding, Rod Lyon, Alexander Vandenbohede, Dave Finnigan, Mark Radice, Rik Hill, Leo Aerts, K.C. Paul, Lesley and Maurice Collins, Trevor Smith, Luigi Morrone and Les Fry.

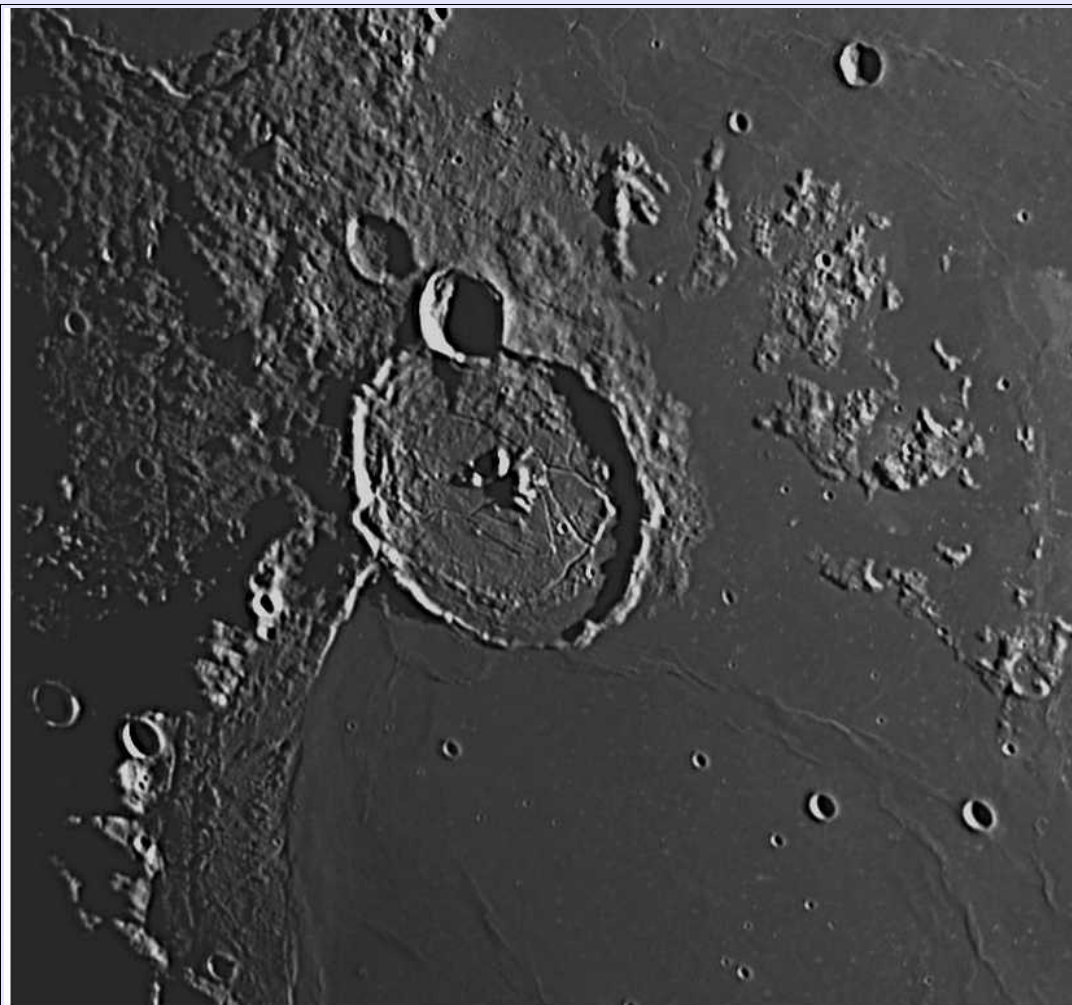
Deslandres.



Deslandres by Phil Masding imaged on 14 June 2022 with a 250mm Meade LX200 and a ZWO ASI 290MM and also use an IR pass filter

Editor Comments: Phil's image shows not only the highly degraded 227km diameter Deslandres but its neighbours Walther, Regiomontanus and Werner. It is the third largest crater on the moon, beaten only by Clavius and Bailly. Deslandres has only a single topographic rim and no trace of a central peak or peak ring. With a depth of only some 2000m, it is abnormally shallow for its size, signifying not only erosion but also probably infilling and uplift. Its floor is domed upwards, and there is a large positive gravity anomaly beneath which suggests a mantle uplift. There is evidence for 'recent' volcanism within the crater, with a small patch of smooth low albedo material hugging the north-eastern rim (visible in Phil's image above the crater chain on the northern floor). The crater Hell, still in deep shadow in the image also has dark mantling deposits over the eastern part of its uneven floor. These olivine/iron rich deposits are highly suggestive of volcanic activity here as well. There is however a possibility that these low albedo deposits are in fact impact melt rich material ejected from Tycho, which is *only* some 350kms away to the south-west. The small crater chain on the northern floor, with Hell H forming its southernmost component, appears to be a basin secondary, but which basin is the parent? The offset central peak of Regiomontanus with its summit crater is very 'volcano' like in appearance and has occasionally been suspected of being one, but sadly the multispectral data shows not a hint of volcanic activity, only plenty of scouring by Tycho ejecta. What do you think?

Gassendi.



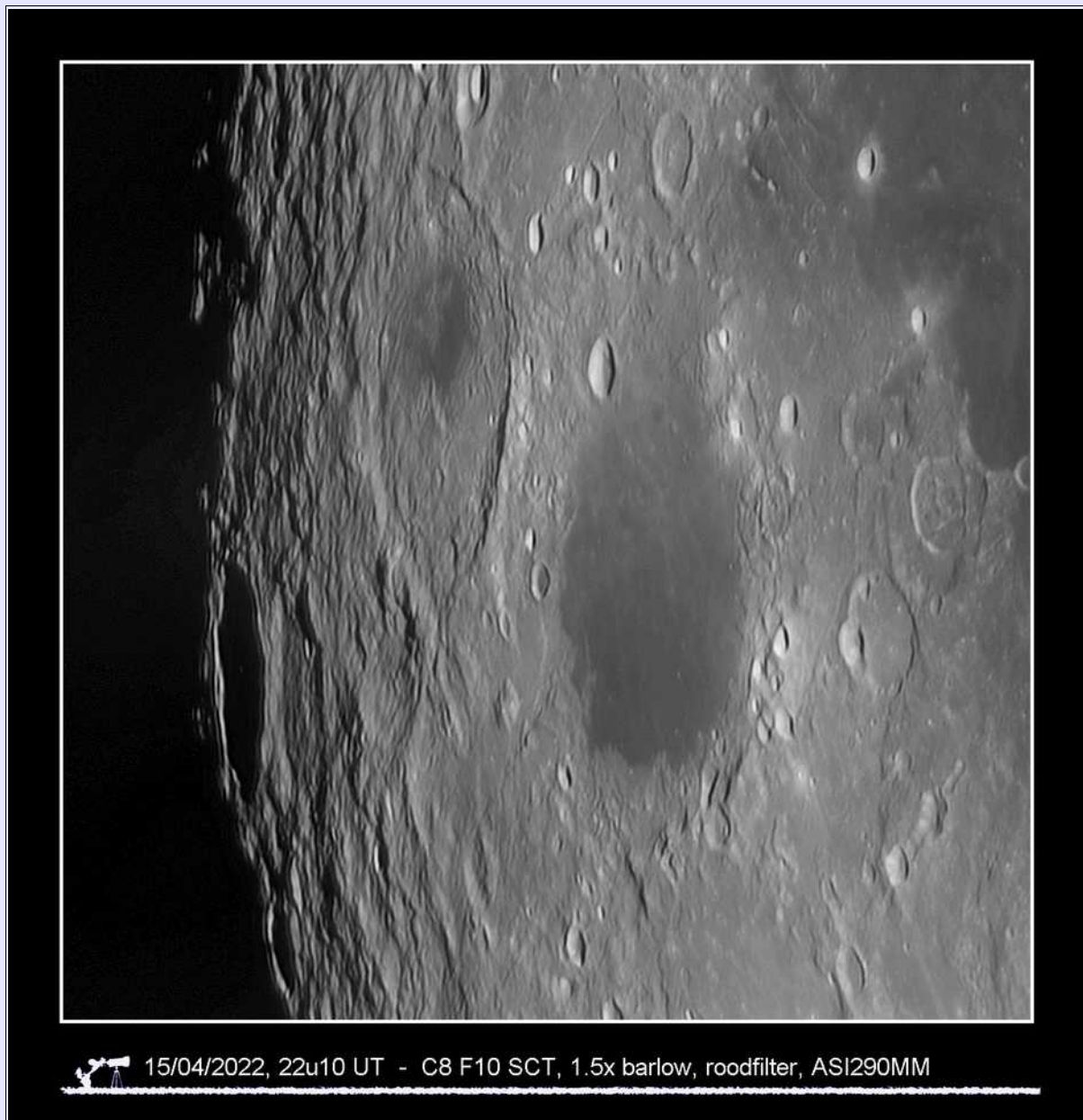
Gassendi 2022.06.10 - 19.59 UT

300mm Meade LX90, ASI 224MC Camera with Pro Planet 742nm I-R Pass Filter.
900/3,000 Frames. Seeing: 8/10, steady.

Rod Lyon

Gassendi by Rod Lyon. Details of date and equipment as noted in image.

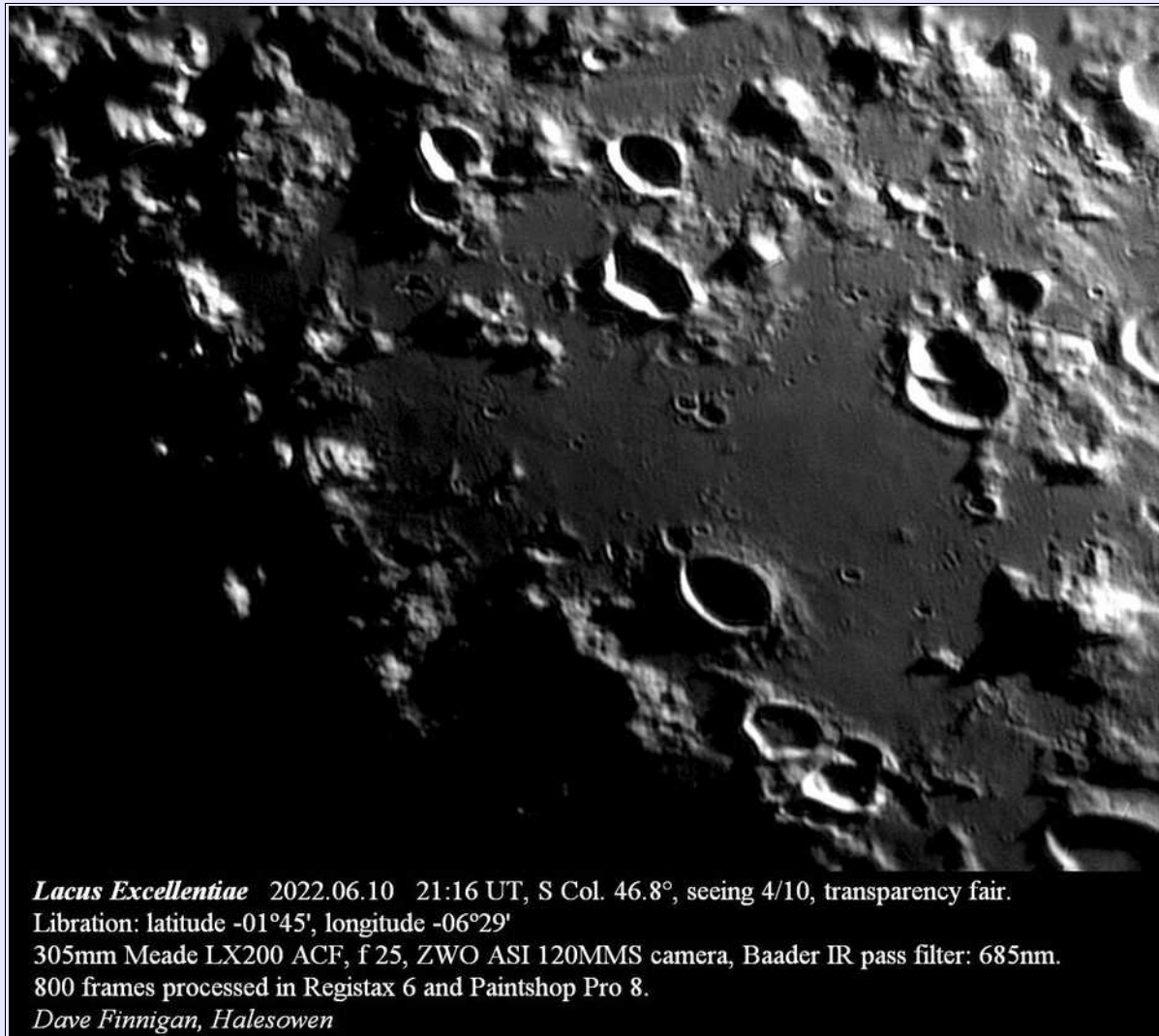
Editor Comments: This fine image of Gassendi (111kms diameter) shows a considerable amount of detail within the crater and on the surrounding terrain. The crater Herigonius (14.8kms diameter) is towards the top of the frame, and some of the components of Rima Herigonius are visible threading their way through the adjacent highland massifs. Gassendi is a Floor Fracture Crater, heavily modified by volcanism, and there is also evidence for extensive volcanism on the adjacent mare and the partially submerged highlands to the east. Many small features that may be vents, cones and possibly even domes can be seen in the LRO Quickmap images of this area, and the mineral overlays show extensive mantling of the highlands by olivine rich, low albedo material that is in all probability pyroclastic in nature. Gassendi itself was at one time occupied by extensive lava lakes, these lakes appear to have drained southwards and towards mare Humorum, but did these lavas drain into Mare Humorum or simply fill up the southern part of the crater? Alternatively did any lavas drain from Mare Humorum into Gassendi? Currently the southern rim is a good 200m higher than the surrounding terrain so the lavas levels would have been much higher in the past. The rim at this low point is draped in what appears to be basalt lavas, so the likelihood is that lava flowed either in or out – or both ways at different times!



Grimaldi and Riccioli by Alexander Vandenbohede – equipment details and time data shown in image.

Editor Comments: Last month we saw an image of Vallis Inghirami by Alexander, here we have another image taken of the Mare Orientale hinterland showing the pre-Nectarian basins Grimaldi and Riccioli. Alexander points out a couple of interesting features, firstly that “*the southern part of Riccioli is filled with the radial facies of the Hevelius Formation/Orientale ejecta.*” Initially the complete floor would have been draped in this material, but later eruption of basalt lavas have flooded the north central floor. These lavas have also inundated many graben on the basin floor showing that their eruption post dated the tectonic effects that created them. The second feature Alexander points out is a tongue of impact melt from the Orientale basin to the south of Grimaldi A (which in this image is in the 9:00 o'clock position close to the western basin edge). Spacecraft images show this as a distinct flow – with an approximately 350m high lobate front, though the flow itself is probably much thicker to the west. The upper surface of the flow is cut by graben, which is no surprise as this must have been emplaced during the course of the Orientale basin forming event, whilst the graben formed as the crust adjusted to the presence of the basin some considerable time after.

Lacus Excellentiae.



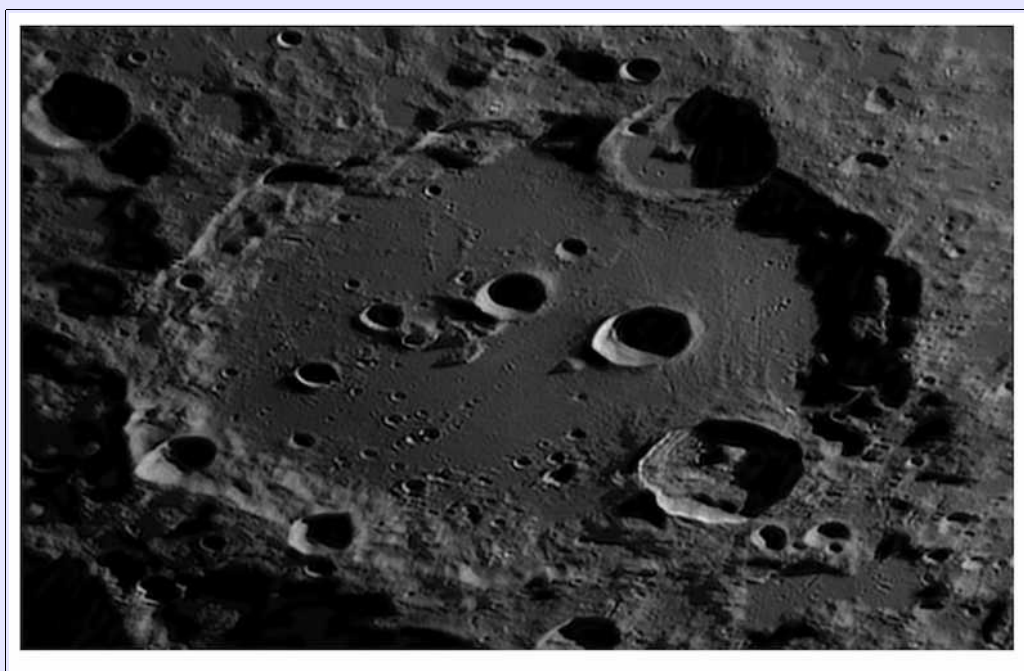
Lacus Excellentiae by Dave Finnigan. Details of image and equipment used shown in the image.

Editor Comments: This rather overlooked area of mare lies to the south of Mare Humorum and probably forms part of the outer structure of that basin. It is however far from being at the same level as the central Humorum basin and is perched some 2500m higher up, and occupies something of a shallow basin, which is particularly noticeable to the east of the crater Clausius, the floor of which is deep in shadow on the western edge of the lacus. The lavas that filled this area have a low titanium content and probably pre date the higher titanium basalts that occupy much of Mare Humorum and some of the nearby mare like patches such as Palus Epidemiarum. Dave's image shows a small dimple on the surface to the east of Clausius, this is marked as a dome on the GLR Group lunar dome map (<http://www.fabiolottero.it/lac/map.htm>) and is a small, 10km diameter, 200m high irregular shaped vent type structure that appears to be partially inundated by later lava flows. The central part of the lacus is remarkably crater free, possibly from a combination of subsidence *and* lava infilling, whilst the crater Clausius appears to be draped in mare type material rich in olivine and iron which might suggest volcanic activity, though lava inundation may also be a suspect. The inner walls of this crater are very rocky in the LRO DIVINER data, with abundant dry debris slides (avalanches in old money). As Clausius is an old crater this rockiness requires a different explanation, and the answer may lie just off Dave's frame to the east, where a broad complex lobate scarp threads its way northwards about half way between Clausius and Hainzel, indicating '*recent*' tectonic activity. So, this may look like a backwater, but there is a lot going on once you delve beneath the surface.

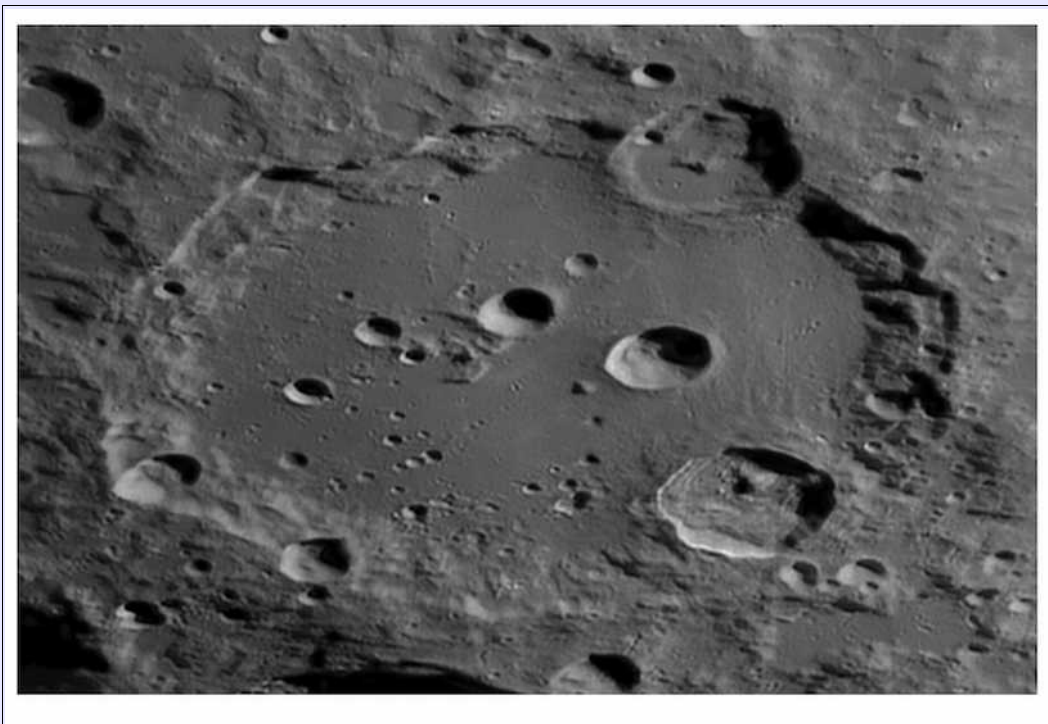
Sunrise over Clavius.



Sunrise over Clavius by Mark Radice (RefreshingViews.com) imaged on 30th May 2022 using a C11 at f20 ASI224MC 784nmIR Filter.



Sunrise over Clavius imaged on 31st May 2022



Sunrise over Clavius imaged on 1st June 2022

Editor Comments: These three images capture the sunrise over Clavius over the course of three consecutive nights, with the interior of the crater becoming visible as the sun clears the eastern rim. Clavius, at a shade over 230kms in diameter, is the second largest crater on the lunar nearside and is of Nectarian age (3.85 Ga), but despite this it is still relatively well preserved. It was the source of some excitement recently when observations made with the NASA Airborne observatory (SOFIA) detected water in the 100-400ppm range in the crater regolith. Temperatures measured during the study ranged from 70°-380°K with the lowest daytime temperatures between 200° and 250°K. So these are the temperatures that the crater floor experienced during the course of this series of images. But under these temperatures the existence of water would be impossible, and the water detected is thought to have migrated into the crater during the course of the lunar night. The study also determined that there were some places that were only illuminated for 10% of the lunar day, including the northern parts of Clavius D, C and L and the outer parts of the southern and western rim. On a topographic point, the middle image of these three show the unusual 'fan' of ejecta spreading north from Rutherfurd which is perched on the southern rim. This type of ejecta pattern might suggest a low angle impact from the south, but this distribution is more likely to be the result of the Rutherfurd impact being on the sloping terrain of the inner wall, a scenario that in some respects will mimic a low angle impact.

Any similar sequences of sunrise over other formations would be informative and very welcome!

Plato to Vallis Alpes



Plato to Vallis Alpes by Rik Hill. Images made from a single stacked 1800 frame AVI using AVIStack2 (IDL) and then further processed with GIMP and IrfanView

Rik Comments: When on the terminator this region catches the attention of all lunar observers. I have imaged it many times at many librations. This was not a particularly favourable libration but many features were well shown in this image. First we have the large crater Plato (104km dia.) on the left side of this image with the dramatic collapse features on its west (left) wall and on the floor you can see 4 of the famed craterlets. To the right are "Plato Rilles" according to Wood in his Atlas of the Moon, but the LROC QuickMap and Virtual Moon Atlas shows them to be smaller rimae south of this. I have used the term Rima Plato to refer to the larger rille for years. Moving further right or east, we come to the magnificent Vallis Alpes at the bottom of which you can see the kilometre wide rima meandering it's length.

In the lower right of this image is the impressive massif Mons Piton (alt. 2250m). There was a spectacular oblique view of this mountain taken by Apollo 15 orbiter looking north with the Montes Alpes in the distance. It is worth looking up (see Fig.1 below image). The crater to the left of this is Piazzi Smith (22km). Then moving further left is and unnamed mountain and beyond this Mons Pico (2400m), every bit as impressive as Mons Piton. It was the subject of a famous drawing by the astronomer James Nasmyth (see Fig.2 below image) .

Lastly we have the Montes Teneriffe south of Plato to the left of Mons Pico, just the tops of gigantic mountains that were flooded by the Imbrium lavas. They are quite a sight in the early morning lunar light.



Fig.1 Oblique view Mons Piton taken by Apollo 15

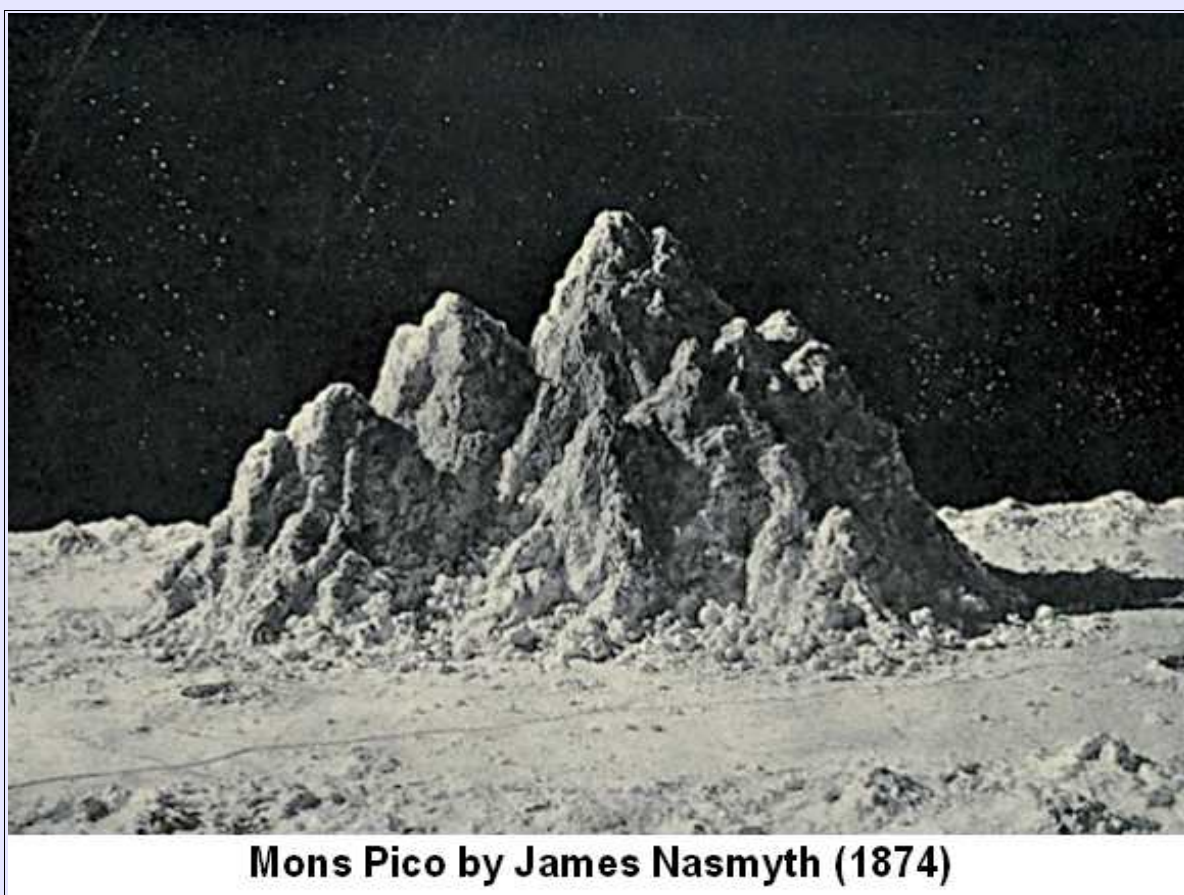
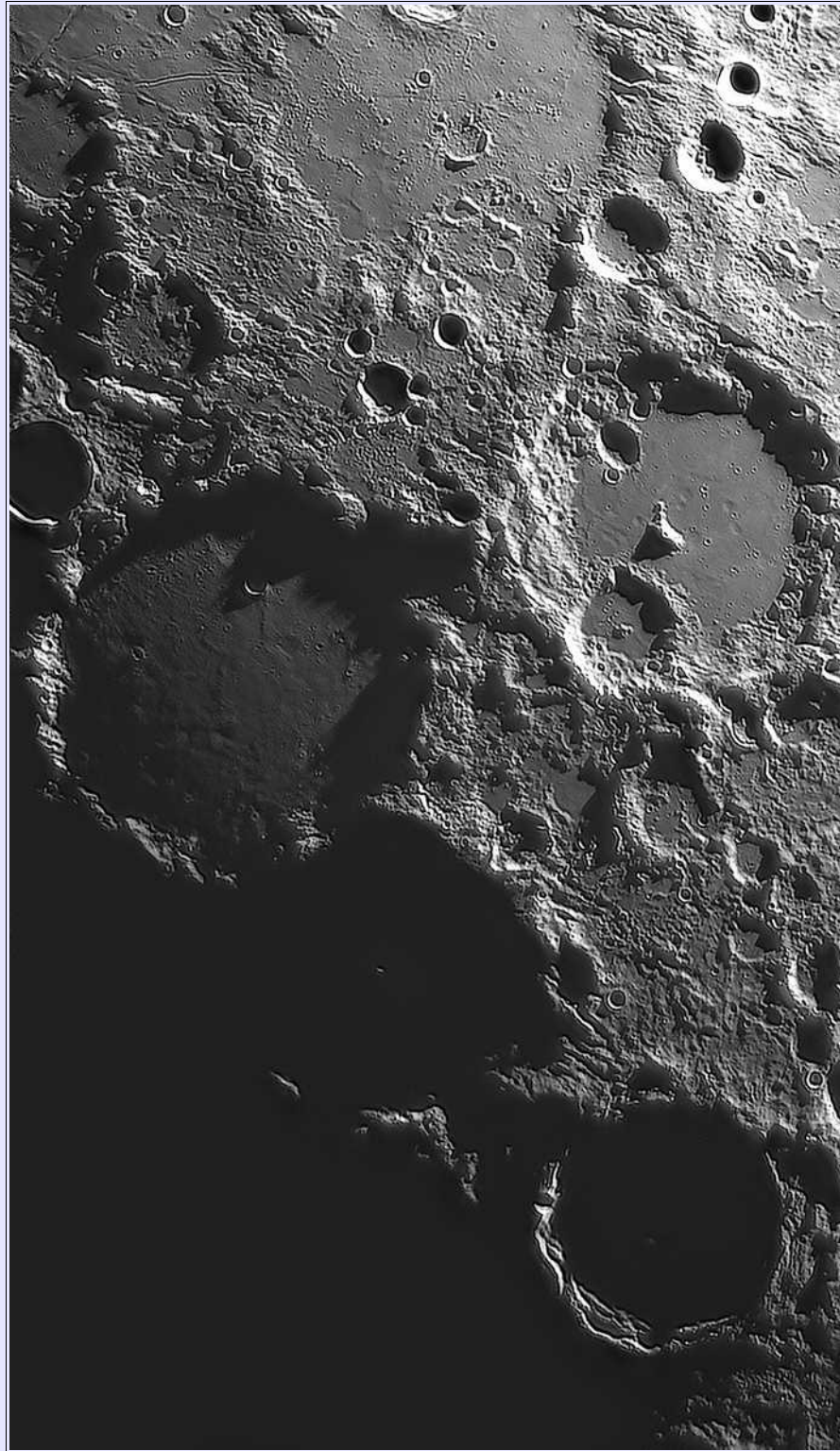


Fig.2 Drawing by the astronomer James Nasmyth (1874). The original caption for this picture states that it is “An ideal sketch of 'Pico' an isolated lunar mountain 8000 feet high, as it would probably appear if seen by a spectator located on the Moon”

Ptolemaeus and Albategnius.



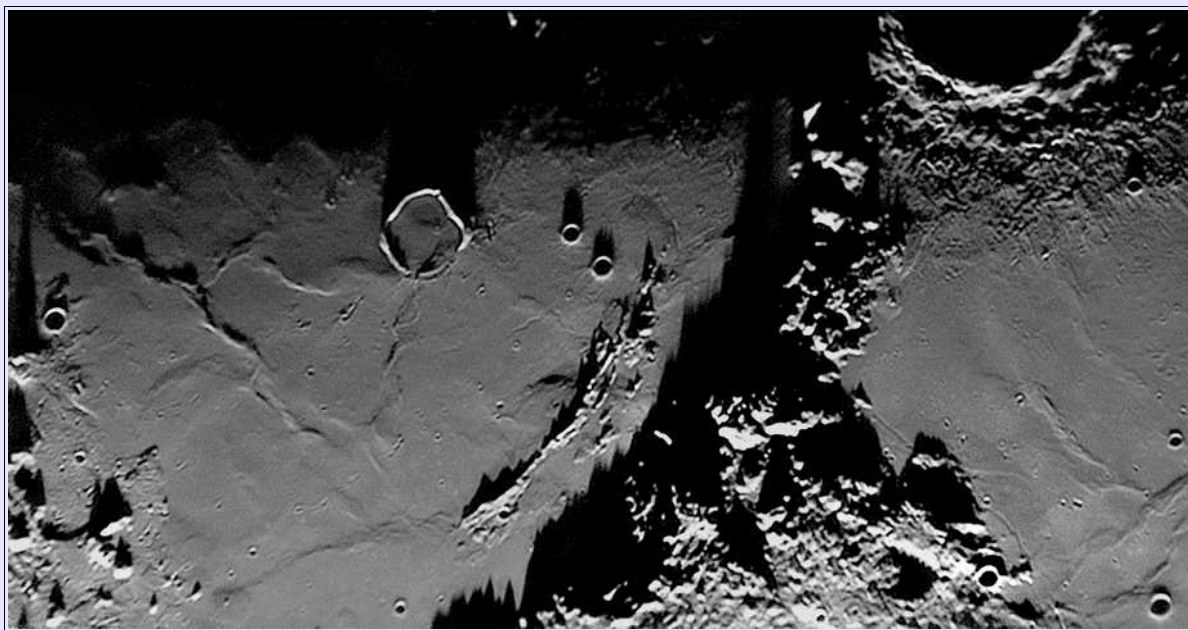
Ptolemaeus and Albategnius by Leo Aerts. Imaged in good seeing conditions on the 8th May 2022 using a Celestron 14" with an Ir filter and webcam ASI 290MM.

Editor Comments: This dramatic image shows a remarkable amount of detail on the floors of Ptolemaeus and Albategnius, most of which appear to be submerged craters. The jury may still be out on whether the material covering the crater floors is lava or basin ejecta, but it is most probably a combination of the two to some degree. Note the central peak summit in Alphonsus is just catching the first rays of the sun, whilst a much fainter spot of light shows where one of the summits of the offset central peak of Arzachel is also intercepting the first rays of the new lunar day.

Wallace.



Wallace by K.C. Paul under early morning sunlight taken with 10" f/6 newtonian reflector + 2.5X barlow + QHYCCD290M camera on 13th Feb2019 at 11h14m UT



This image also by K.C is taken with the same equipment as above but on 4th May2017 at 12h27m UT.

K.C. Comments: The members of this hillock group cast wonderful needle-shaped shadows. What caught my attention is a delicate rille (indicated with arrows) that runs between Eratosthenes D and E, which is a closed pair of twin craters with diameter of 3.8 km. With reference to QuickMap, the rille emerges from a small crater just north of Eratosthenes D. It then runs northwards and passes the western side of Eratosthenes E. It terminates its northward journey at a small crater. The total length of the rille is about 46 km and its width is about 1 km. The wrinkle ridges north of Wallace stands out brilliantly under oblique morning sunlight, as well as the magnificent shadows from Mt. Apenninus.

Moon and Jupiter.

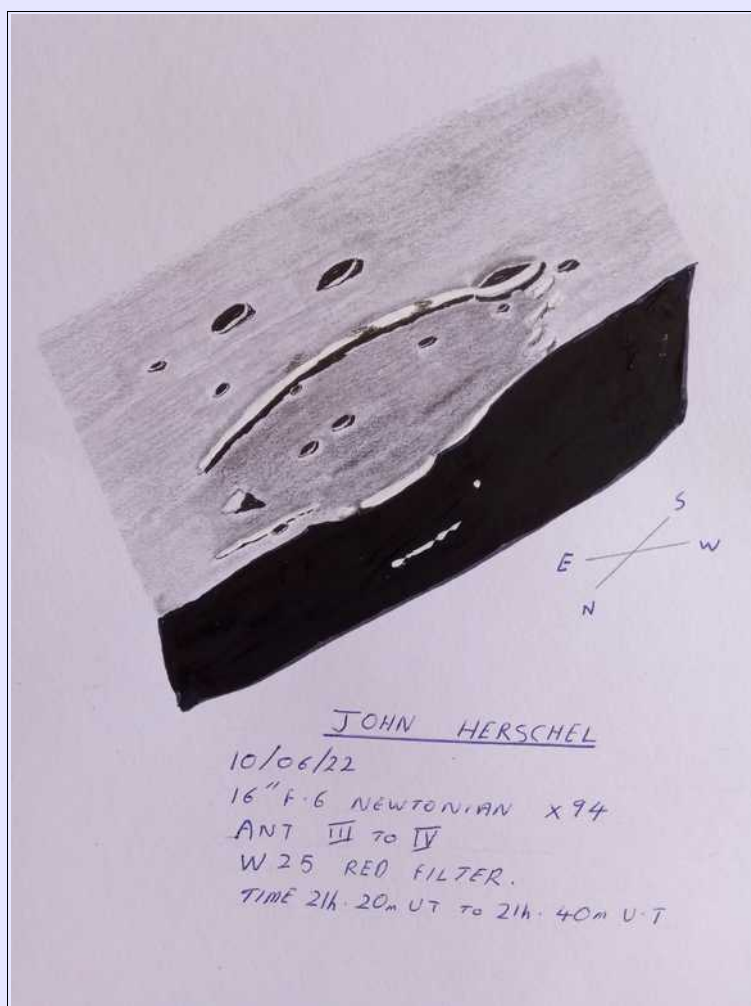


Mobile phone image of the Moon and Jupiter by Lesley Collins and submitted by Maurice Collins.

Maurice Comments: *Lesley took a photo of the Moon right next to Jupiter this morning with her phone. Looked like it had just occulted and come out on the dark side (see enlargement below), but no mention of it in any newsletters looking it up afterwards, so must have been a near miss. No mention of a miss either. I was still asleep but when up I had a look with binoculars and can see Jupiter a couple of degrees away from the eastern limb in daylight. It was a frost this morning so cold out there.*



Enlargement of image of moon shown in right hand panel above.



J. Herschel as drawn by Trevor Smith. Equipment used, time and conditions noted in drawing.

10/06/22. THE LARGE CRATER JOHN HERSCHEL WAS VERY PROMINENT TONIGHT AS IT LAY RIGHT ON THE TERMINATOR. THIS LARGE WALLED PLAIN IS SOME 154 KM IN DIA AND APPEARS VERY ELONGATED DUE TO FORESHORTENING.

THE RIMS TO THE NORTH AND SOUTH ARE EASILY SEEN TO BE VERY FRAGMENTED. THE INTERIOR FLOOR LOOKS TO BE QUITE LEVEL BUT POCKMARKED WITH MANY SMALL IMPACT CRAZERLETS, MANY WERE TOO SMALL TO BE SHOWN ON THE ACCOMPANYING SKETCH.

THIS IS A FASCINATING AREA OF THE MOON AND IF THE LIBRATION IS FAVOURABLE THIS IS A GREAT PLACE TO START A 'TOUR' OF THE MOON'S NORTH POLAR AREA!

Observing notes by Trevor.

Editor Comments: The crater J. Herschel is named after Sir John Frederick William Herschel; British astronomer (1792-1871). Not to be confused with his dad William's crater, which is just plain Herschel.

Hercules-Atlas-Endymion.



Image by Luigi Morrone at 18:32UT on 7th May 2022 using an SCT C14 Edge HD (355mm) Fornax52Mount, ASI174MM, Baader FFC Barlow and Optolong R Filter.

Editor Comments: The pairing of Hercules (68kms) and Atlas (88kms) are a frequent target for imagers, but included here is Endymion (122kms) which if situated more centrally on the nearside would easily rival the lava filled craters Plato and Archimedes. Despite being the smaller crater Hercules is deeper (~3000m) than Atlas (~2500m) as can be seen in this image. The reason is that Atlas is a Floor Fracture Crater (FFC) and has undergone floor uplift as a result of volcanic activity beneath the crater floor. In this case one of the the fractures, running approximately north-south appears to be the focus of pyroclastic eruptions, with vents identified at each end up against the crater walls. This fracture can be seen in Luigi's image just beyond the central peak and sloping from bottom right to top left. This demonstrates that volcanic activity in these FFC's can occur over a very long period of time – suggesting a long lived source of magma and not just a short spurt of activity. Hercules has also been affected by volcanism and has a patch of mare like material up against its northern wall, though there are no signs of anyvents. Though not obvious the floor of Endymion is covered by ray material from Thales which is to the north. The crater floor itself appears to be lava filled, and has some ridge like features which may be wrinkle ridges or lobate scarps, and some unusual features that resemble the enigmatic Ring Moat Domes that have perplexed lunar researchers recently. Three small almost equidistantly spaced craters can be seen on the north-western floor forming an unlikely straight line – a triple impact or just coincidence? To the east of Atlas a small (3km diameter) bright crater can be seen – you can see that it has a Zone of Avoidance to the south-east showing that the impactor arrived at a low angle from that direction – which in this image is from the right hand side of the frame.

11-day Moon.

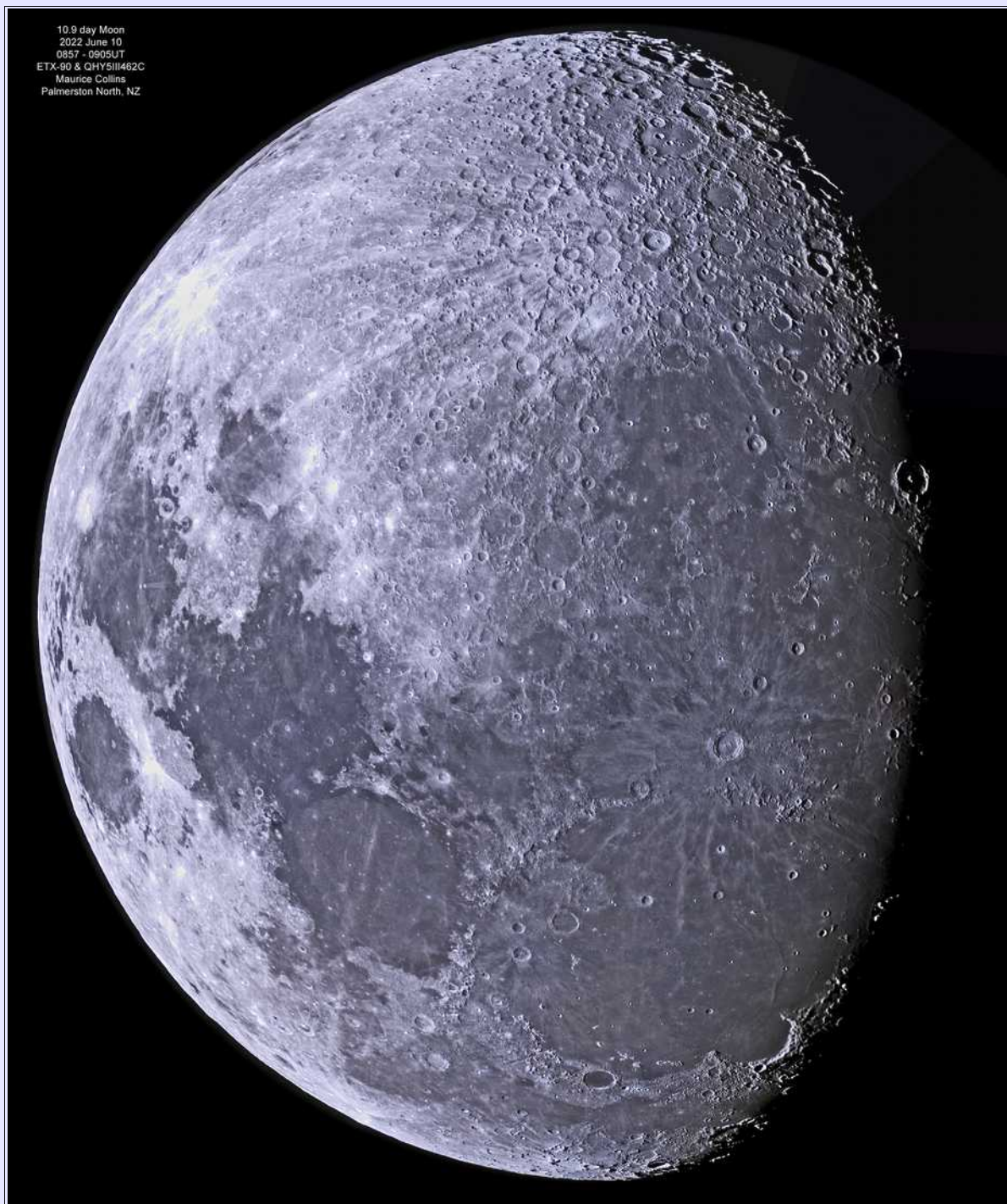


Image by Maurice Collins. Details time, date and equipment as shown in image.

Editor Comments: I have left this image as I received it with north down as it would be seen by southern hemisphere observers, just as a reminder of how surprising the view is to northerners who are lucky enough to see the southern sky from Australia or New Zealand. I must admit to being a bit taken aback by my first view of the moon like this (I really should have known better) but then again, seeing Scorpio or Orion overhead also takes a bit of getting used to. Images such as this have such an abundance of detail it is difficult to know what to focus on – and they provide a superb overview of the main lunar features and their relationships to each other, something we sometimes overlook with high power views of smaller regions.

Triesnecker and Hyginus with Lunar “V”.



Image by Les Fry, details of time, date and equipment included in image.

Editor Comments: This image which records sunrise over Sinus Medii shows the 25km diameter crater Triesnecker set amongst the complex of graben, Rimae Triesnecker. To the east is the 8.6km diameter crater Hyginus, which is not an impact crater but a volcanic collapse feature which has its own associated graben, Rima Hyginus. This graben has a number of circular collapse pits along its length, particularly the northern arm, which look something like peas in a pod under certain angles of illumination. The presence of these graben indicate widespread uplift as a result of subsurface volcanic activity. The uplift is not particularly noticeable even under grazing illumination such as in this image, but can be seen in the various topographic data sets available courtesy of LRO. Les has also captured the clair-obscur lunar V which can be seen towards the top of this image. There are some quite odd crater shapes on this part of the moon, Godin and Agrippa towards the lower left have distinctly non-circular outlines, whilst Ukert – invisible in deep shadow towards the top left of the frame is almost triangular in outline. These anomalous shapes indicates that the crater outlines have been heavily influenced by pre-existing faulting and fracturing that influenced the crater formation and subsequent modification by rim collapse.

More Lunar Eclipse images from the 16th May 2022 have been submitted by Alan Tough, Mike Cabson and Sasha Cook.

Lunar Eclipse (as seen from Chile).



Image by Alan Tough via the iTelescope T70 (remote Observatory), Rio Hurtado Valley, Chile. Equipment: T70 Samyang 135 mm lens (65mm aperture) @ f/3.5, ZWO ASI1600MM camera, Rainbow Astro RST-135 mount. Processing: FITS Liberator and Adobe Photoshop 2022.

Alan Comments: Observing the May 16 Total Lunar Eclipse from Elgin was always going to be a bit of a challenge. When the Moon disappeared into cloud about midway through the first penumbral phase I reverted to 'plan B'. Plan B was to log on to a remote telescope in Chile. This was much more successful! The resultant composite image is made up of two sets of RGB images (taken shortly after the eclipse maximum): 10 seconds per filter for the Moon and 120 seconds per filter for the star field.

Lunar Eclipse Exit.



Lunar Eclipse Exit by Mike Cabson.

Mike Comments: I was fortunate enough to capture a substantial number of images of the recent lunar eclipse from Barbados.

Lunar Eclipse from Spain.



Lunar Eclipse from Torrvieja Spain - taken with a hand held camera by Sasha Cook.

**Basin and Buried Crater Project by Tony Cook.
The Werner-Airy Basin.**

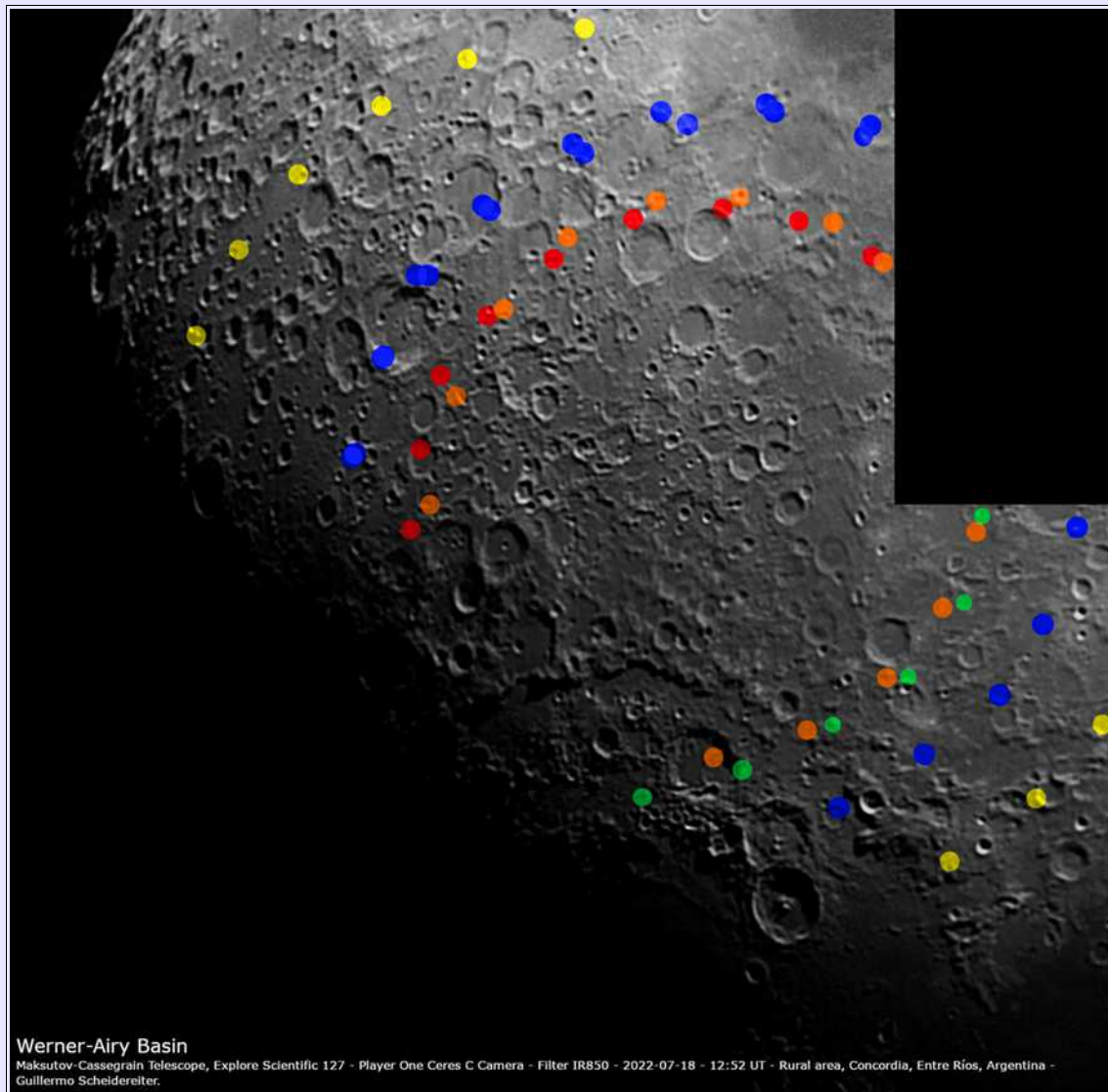


Figure 1. The Werner-Airy impact basins with three proposed rings added by Guillermo Daniel Scheidereiter (LIADA). Note that they had two attempts at estimating the primary and secondary rings, hence the different coloured dots or dot positions. The inner rim is red/green. The second rim is blue and the third rim is yellow.

I was grateful to receive our very first attempted estimate of the basin rings for the Werner-Airy impact basin, from Guillermo Daniel Scheidereiter in Argentina, using an image that they had taken in July. Guillermo had two attempts at estimating the primary and secondary ring, which I have combined in Fig.1. By reverse engineering these to find the lons and lats of each dot, using the NASA LROC [Quickmap](#) web site, I was able to estimate the ring diameters to be: 688 ± 17 km, 1028 ± 89 km, and 1357 ± 50 km. This is at odds though with the values listed by [Liu et al. \(2015\)](#), who give 350, 515 and 765 km diameter rings. Guillermo's 688 ± 17 km diameter ring is the closest to the Liu *et al.* ring diameter of 765 km, and so if my standard deviation estimate was off (it was based upon just 4 transects across the basin), then these maybe one and the same ring?

Looking at Fig.1 there is a hint of the two inner rings that Liu *et al.* mention, though the inner one is more of a circular patch of cratered terrain? Another point to mention is that lunar geology text books say that impact basin ring radii increase in size by $\sqrt{2}$ – neither Guillermo or the Liu *et al.* ring diameters seem to follow this rule – though it may be a rule of thumb rather than a precise relationship?

So as you can see estimates of basin ring diameters are very subjective and tricky. This reminded me a technique

that was used many years ago in [MoonZoo](#), namely by getting lots of people to estimate a basin or crater's rings/perimeters, one can find a mean diameter and by statistical analysis the standard deviation on these. The standard deviation can be used to give a measure of how poorly degraded the rings are. After all if a basin ring is badly damaged, people will come up with wildly different estimates of where it begins and ends. A pristine basin, like Orientale will have sharper edges, and a smaller error on estimations of the diameters of the rings. Anyway like last month I am showing various geophysical datasets for the Werner-Airy basin in Fig 2.

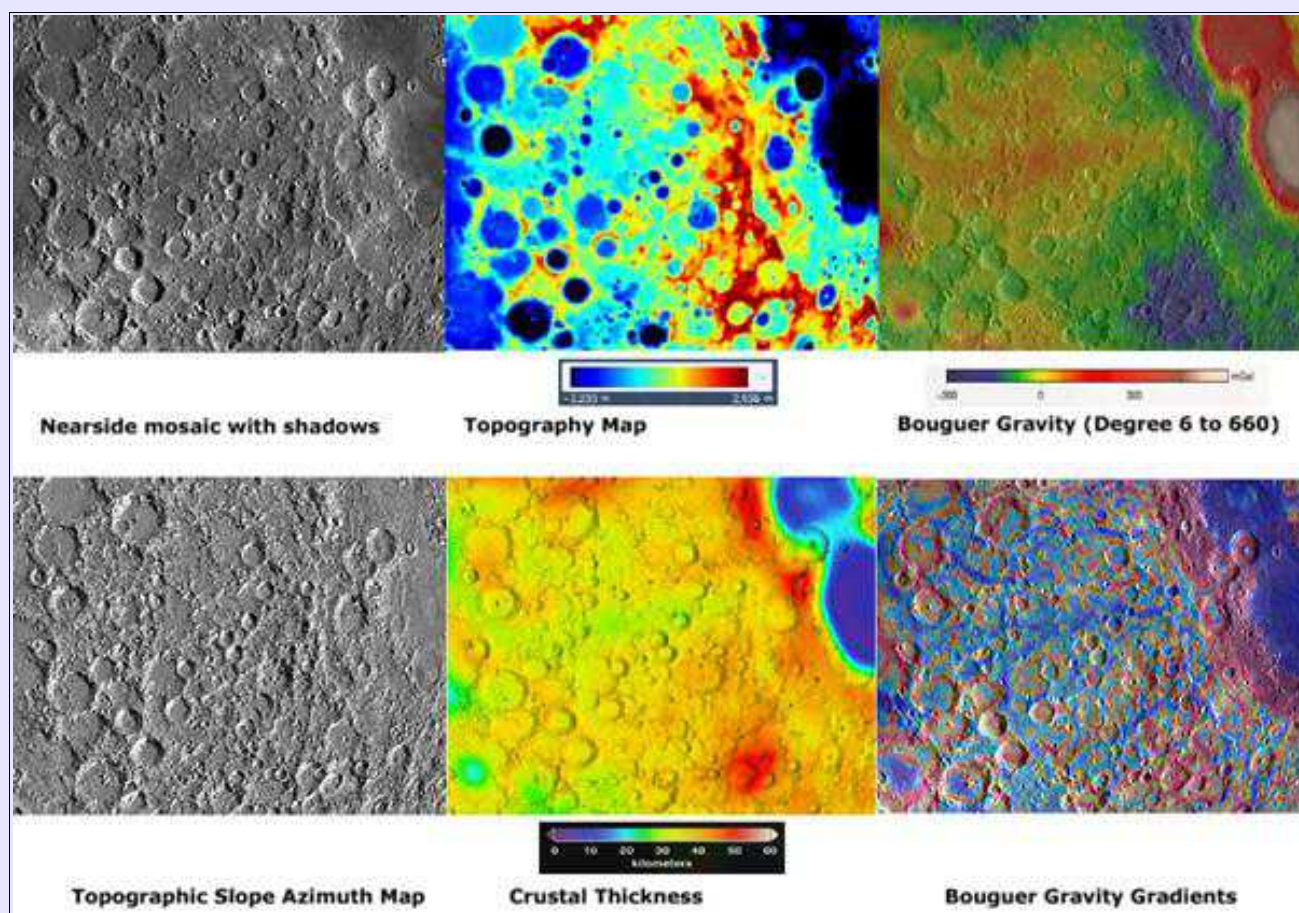


Figure 2. Geophysical datasets for the Werner-Airy proposed impact basin.

The topography in Fig.2 may show perhaps half of a remnant rim, as does the crustal thickness map – though it's odd that this evidence is strongest to the east, which is nearer to the destructive impact forces of the Nectarian basin. The Bouguer gravity data shows no characteristic bulls-eye effect like you get in many basins. However not all basins show this e.g. Tranquilitatis or many pre-Nectarian era basins in general. There is a very faint linear mass anomaly that travels E-W across the floor of the basin though. The slope azimuth plot is peppered with highland craters, but may show slight hints of concentric inward facing slopes – but only if you blur your eyes. The gravity gradient image shows a network of filaments where the gravity isn't changing much. These straddle the floor of Werner-Airy but less so south of the basin.

So to sum up, this looks like Werner-Airy will be a tricky basin to prove and measure rings on. The only safe thing to say is that it is pre-Nectarian in age as the Nectaris basin geology and topography clearly sits on top of part of it. We need more shallow illumination angle imagery on the morning and evening terminators, and for others to have a go on the NASA's Quickmap, drawing out where they think the basin rims are (please provide me with some lon, lat coordinates), then we can get some statistical consensus and update the database.

Please take a look at our website for other lunar impact basins and buried craters that you may want to image: https://users.aber.ac.uk/atc/basin_and_buried_crater_project.htm . I am really keen to gather imagery of the less certain basins, and also for all basins and buried craters in order to find the best selenographic colongitudes to see them at sunrise and sunset.

Lunar Occultations August 2022.

Tim Haymes

Time capsule: 50 year ago: in Vol 7 No.8

[With thanks to *Stuart Morris* for the [LSC](#) archives]

* Miss K Higginson finds some interesting early fade occultations. The earliest being an occultation of Mars seen by Aristotle on April 4th 357BC.

* Mr. P Moore: The Lunar section meeting of 1972 May 20 (Second half) was devoted to the observation of Lunar Occultations. The speakers were: Mr D. Hall, Mr. L.V.Morrison (RGO) and Mr S. Milbourn

* Miss Botley gave a list of fades reported by G.L.Tupan (in *The Observatory*)

* Lunar Occultation Program Report No1 is prepared by Ken Gayner (coordinator)

Observations

Graze occultation of 14 Ceti (ZC 76) on 2022 July 19 @ 0159UT (HBAA #7)

The co-ordinator was successful in observing this graze. (See last circular). The 5.8m star in Cetus grazed the northern cusp at CA 11, with the Moon 65% sunlit.



Fig.1 14 Ceti prior to graze at CA 11 N



Fig-2 Graze path. X marks the spot.

He writes: I set off at 1.20am and arrived at the site location at about 2.10am; the corner of a field. The first event was due at 0259 BST. The location was near Custsdean about 5 miles W of Morton-in-Marsh. The entrance to the field was ungated and the ground solid.

The previous day had reached +35C in the shade but the early morning was a refreshing 17C with a slight breeze. Site Long/Lat 1d 51° 6.8" W, 51d 58' 29.5 N. Height 298m.

The mobile instrument was a Meade SN8 (F4) with 2x Barlow, WAT-910HX video camera at 25 fps (gain 26dB) with the video recorded on a Sony TRV33E DVcam. A GPSBOXPRITE-2u provided the onscreen time stamp in [Fig-1]. Camera and GPS were running from a 12V 4AH Li-ion battery and the EQ6pro mount was connected to the car 12v outlet.

Timings

The first DD at 0159 2.02s UT

Last RD at 0201 9.60s UT

Number of events recorded: 8

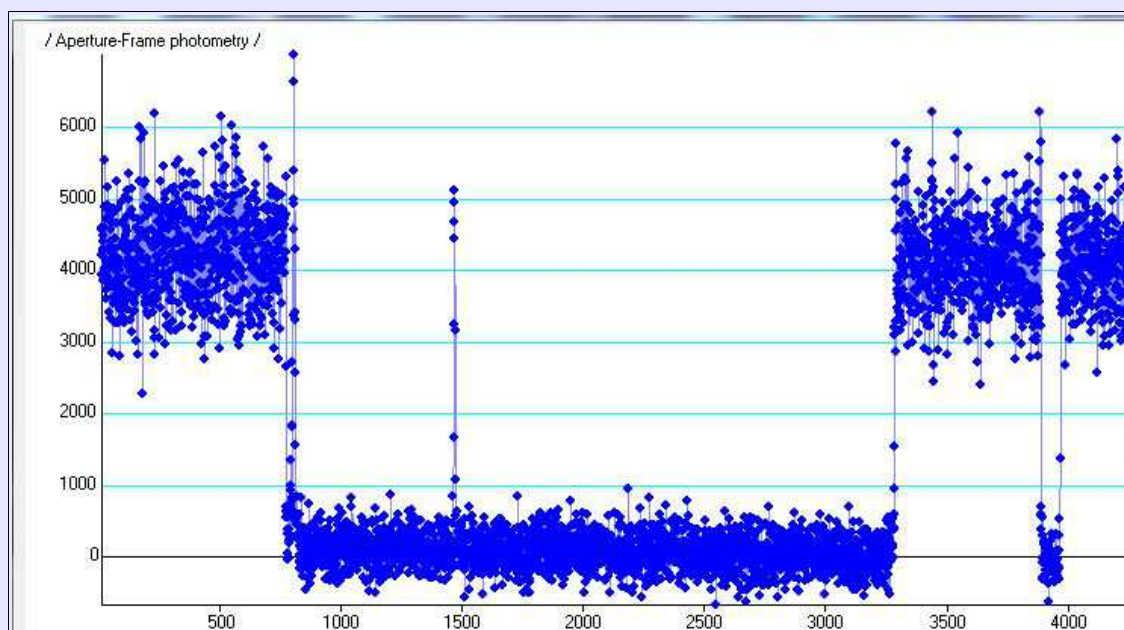


Fig.3 Light curve obtained by playing the AVI through LiMovie with a large photometric aperture (10 pix) at a fixed position. With good polar alignment the aperture stays on top of the star even though it has disappeared. Note: The star appears in a valley at frame 1450.

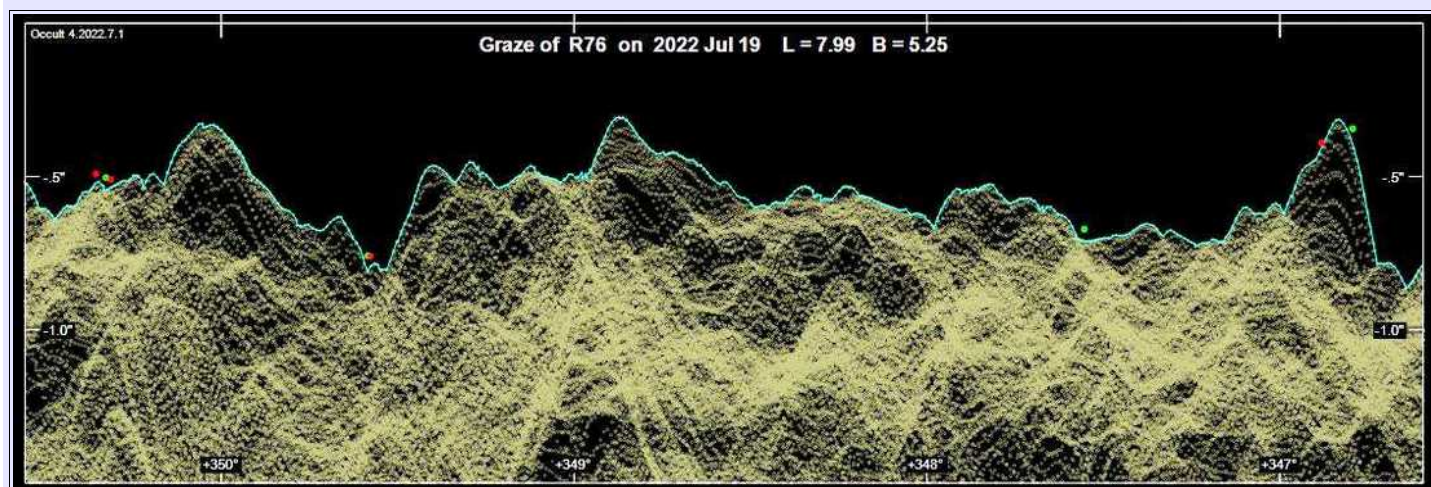


Fig.4 When the contact times are added to Occult4, they can be displayed against the limb profile. Here a red dot on the LHS is the first disappearance (green denotes a reappearance). Times from the tape have been corrected for the fixed “Camera Delay”.

Event of interest – Possible Double Star SAO 109613 (HIP4825)

The SAO 109613 is an unconfirmed double star and there is a reappearance on Aug 15 at 2352UT. An occultation reported in 1980 described the star as two 8.8 magnitude components. Looking at more recent observations in the Occult4 database, I see that Oliver Kloes (DE) and Dave Herald (AU) both observed the star in 2017. Im pretty sure these would have been video observations. They were, and neither reported seeing any double star effects. So here is an opportunity to examine the star at a small Cusp Angle of 14S during a reappearance [Fig.5]. The cusp itself should assist in identifying the reappearance point. The Moon will be bright, so not the best conditions. Please add this to the observing diary.

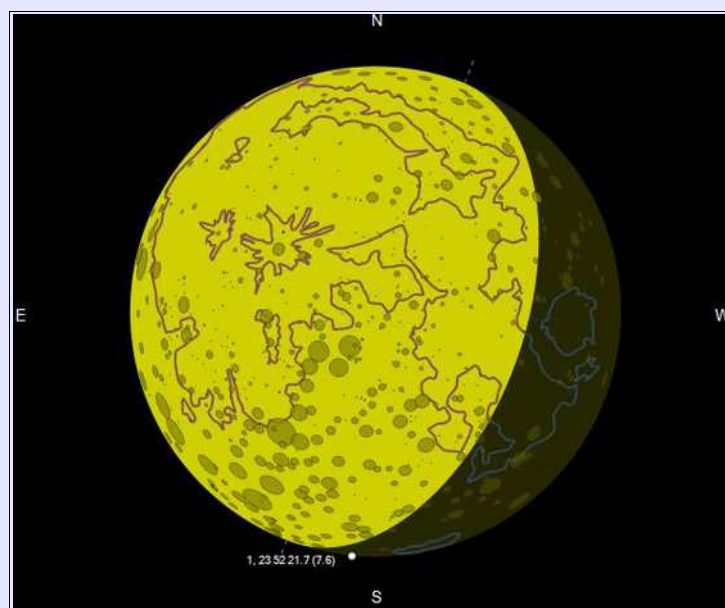


Fig.5

Occultation predictions for 2022 August (Times as other locations will +/- a few minutes)

E. Longitude - 1 18 47.1, Latitude 51 55 40.3. To magnitude r8.0

Moon altitude >7 degrees.

yy	mmm	day	Time	P	Star	Sp	Mag	Mag	%	Elon	Sun	Moon	CA	Notes
		d	h	m	s	No	v	r	ill		Alt	Alt	Az	
22	Aug	2	20	43	9.0	D	1802	K2	7.1	6.5	24+	58	-7	10 255 37S
22	Aug	6	21	41	40.3	D	2290	B0	2.3	66+	108	8	216	29N delta Sco
22	Aug	7	20	54	31	D	184882	A0	8.2	8.2	76+	121	-10	11 192 5S
22	Aug	8	20	31	14.8	D	186250	K5	7.7	6.8	85+	135	-7	10 173 87S
22	Aug	8	22	5	38.6	D	X150546	G8	7.2	7.2	86+	135		9 193 89S
22	Aug	8	22	17	30.8	D	2621	K0	7.5	6.9	86+	136		9 196 73N
22	Aug	8	22	19	39.5	D	186339	K0	7.9	7.3	86+	136		9 197 34N
22	Aug	8	22	31	31.4	D	186361	K5	7.2	6.3	86+	136		8 199 62N
22	Aug	10	21	18	40	m	2965	G2	7.2	6.9	98+	162		9 155 20N
22	Aug	11	22	45	56.3	D	3141	K3	5.8	5.0	100-	174		15 159 36N 35 Cap
22	Aug	13	21	49	14.9	R	165603	G5	8.1	7.5	95-	154		9 119 90N
22	Aug	14	0	33	50.3	R	3438	B3	7.7	7.8	94-	153		26 157 79S
22	Aug	14	1	33	12.4	R	3442	F5	7.9	7.6	94-	152		29 172 74N
22	Aug	15	0	31	16.1	R	128642	M*	7.4	6.5	88-	140		28 141 88N
22	Aug	15	1	51	51.9	R	128661	M0	6.6	5.9	88-	139		34 163 87N
22	Aug	15	22	9	3.6	R	109561	K0	7.9	7.1	81-	128		9 97 36N
22	Aug	15	23	25	11.5	R	137	K2	7.6	6.8	81-	128		20 112 78N
22	Aug	15	23	52	21.7	R	109613	F6	7.6	7.3	80-	127	23	117 14S dbl*
22	Aug	16	1	32	25.7	R	109637	K2	8.0	7.1	80-	127		36 142 63N
22	Aug	16	2	45	16.0	R	157	K0	7.3	6.6	80-	126		41 164 27S
22	Aug	17	1	20	26	m	274	M*	8.2	7.4	71-	115		35 124 14N
22	Aug	17	23	24	2.8	R	93015	K5	8.2	7.4	62-	104		15 87 87N
22	Aug	17	23	29	1.5	R	380	F6	7.3	7.0	62-	104		16 87 73S
22	Aug	18	0	34	10.7	R	93030	F8	8.0	7.4	61-	103		26 100 75N
22	Aug	19	0	52	18.5	R	497	A3	6.5	6.4	51-	91		25 91 74N dbl*
22	Aug	20	1	16	53.7	R	76536	F5	8.2	7.9	41-	80		24 84 88S
22	Aug	22	1	42	19	m	912	B8	7.0	7.0	23-	58		17 68 13N
22	Aug	22	2	13	7.0	R	77905	K7	8.8	7.9	23-	58		21 74 79N
22	Aug	22	3	19	41	m	77974	K0	7.5	6.8	23-	57		31 85 14N
22	Aug	22	3	21	40.7	R	77960	G8	7.7	7.2	23-	57		31 86 62N
22	Aug	22	3	28	16	m	926	B9	7.1	7.1	23-	57		32 87 14N dbl*
22	Aug	22	4	12	54.9	R	77999	A0	8.1	8.0	23-	57	-8	39 96 71S
22	Aug	23	2	12	45	Gr	78914	K2	8.6	8.0	16-	47	15	** GRAZE: nearby
22	Aug	23	4	12	11.1	R	78979	G5	8.1	7.6	15-	46	-8	31 86 41S

Predictions to Aug 31,2022

Key:

P = Phase (R or D), **R** = reappearance **D** = disappearance

m = Miss at this station, Gr = graze near this station (possible miss)

CA = Cusp angle measured from the North or South Cusp.

PA = Position Angle measured from the North though East for a Lunar Eclipse.

Mag(v)* = asterisk indicates a light curve is available in Occult-4

Star No:

1/2/3/4 digits = Robertson Zodiacal catalogue (ZC)

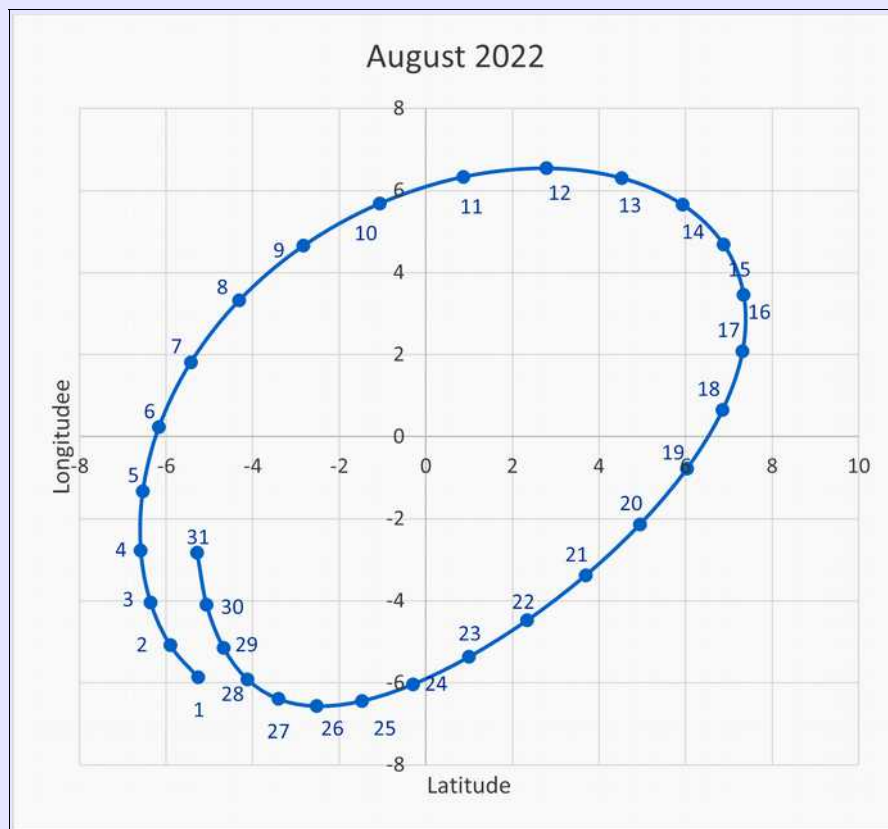
5/6 digits = Smithsonian Astrophysical Observatory catalogue (SAO)

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. Please report timings to Tim Haymes in the Occult4 data format.

*Detailed predictions at your location for 1 year are available upon request. Ask the **Occultation Subsection Coordinator**:* [tvh dot observatory at btinternet dot com](mailto:tvh@btinternet.com)

Those interested in Grazes (only) – please indicate your travel radius in Km, and your home post code.
An aperture of 20cm will be used unless advised to the contrary.



Lunar Libration Diagram August 2022

The unusual case of SAO 158294.
by Peter Anderson.

This story begins in 1836 when John, later Sir John Herschel, recorded this star and first measured its duplicity. He was the son of William Herschel, the discoverer of the planet Uranus and followed in his father's footsteps taking the 18¼" aperture, 20 foot focal length reflecting telescope to the Cape of Good Hope, South Africa. The purpose was to complement the studies of northern sky, and between 1834 and 1838 John observed and recorded the southern heavens. Whilst in South Africa in 1836, John Herschel entertained a visitor, Charles Darwin, who was on his around the world voyage on the 'HMS Beagle'.

At the time he left for South Africa, John Herschel was already quite famous and an unscrupulous New York newspaper 'The Sun' took advantage of the slow communications of the period to perpetrate the infamous 1835 'Moon Hoax'. In six articles they falsely reported his discovery of various forms of life and a flourishing civilisation upon the Moon after improvements using "an immense telescope of an entirely new principle".

In his research John recorded the star we know as SAO 158294 as being a double of magnitudes 8.9 and 9.0 at 4.0 arc seconds separation and position angle 134 degrees, namely to the south-east. This angular orientation meant that on nearly all occasions the companion would be occulted by the Moon some seconds after the primary star. His research details were duly published, ultimately finding their way into catalogues and specifically in this case, the Washington Double Star Catalogue that is currently in use.

The two stars of SAO 158294 were nearly equal in brightness and spaced at a comparable distance apart as the well known double Acrux or Alpha Crucis. As such, the duplicity of the star would be obvious in all telescopes at less than 100 magnifications. The records show that lunar occultation events for this star have been recorded by ten observers on five different occasions. Three were disappearances in September 1977, July 1984, and June 1996 and two were re-appearances in December 1984 and March 2003. Various instruments ranging up to 60cm in aperture were used. On all occasions a companion star was not reported. The occultation on 23rd June 1996 was independently observed by Robert Wilson and myself near Brisbane, Australia and Diana Watson in New Zealand.

I again observed an occultation of this star on 8th July 2022, again as a single star, but this time there was a twist. Instead of 'winking off' instantly as the Moon occulted it - and approximately 1/50 second is a typical duration for such events, there was a very long even fade of not less than half a second.

I am well familiar with observing the lunar occultation of stars, having visually timed them for 47 years, with over 10,000 such events to my credit. Previously I used a 41cm F6 Newtonian at X198 for this purpose, but in 2016 it was replaced by a Celestron 14 using X156. I have examined my original 1996 records and reduced the observation afresh. The 'observed minus calculated' (O-C) reduction of my 1996 observation and those of the 2022 fade are reasonably compatible and do not throw any light on the matter except that a half second duration for the 2022 fade represents an angular distance of close to 200 milli arc seconds (0.2 arc second.)

Under field conditions it is not possible to visually distinguish between instantaneous events and those as long as 1/10 second. If the conditions are poor due to an unsteady atmosphere the obvious effect is that 'blobby' stellar images are produced. The refractive paths through the atmosphere are then quite likely to be distorted resulting in 'quick fades' of up to one sixth of a second. However such a phenomenon is then visible for all events and the necessary poor conditions were not the case on the 8th July. Fading may also be observed during near grazing occultations when the star skims the far northern or southern lunar limbs at a very shallow angle. A fade can on occasion be visible for those very few generally bright stars of large angular diameter, Antares being a stand out example. Diffraction effects also come into play and vary depending upon the physical apparent diameter of the stellar disc. These diffraction effects last no longer than around 1/25 second and may be detected by careful video imaging but not visually.

Other fades lasting 0.2 seconds of time and longer as well as quick stepped disappearances are overwhelmingly attributable to double star phenomena, and I suggest that this is the case in this instance. In addition, the angle and movement of the advancing lunar limb for the 2022 event did not facilitate any substantial lengthening of the

duration of the disappearance - so this is not a significant contributing factor in this case.

When first recorded as a double star in 1836 the separation was stated to be 4 arc seconds but a companion was not detected in those observations made in the period between twenty and forty five years ago. Now, in 2022, in view of the long fade, the star appears to be displaying the presence of a secondary. I postulate that between 1836 and 1977, as viewed from our line of sight, the orbit carried the two stars closer together, so that between 1977 and 2003 they were not distinguishable as separate stars even by the occultation method. In this regard I point out that with the degrading effect of viewing such occultations through our atmosphere, finer detail even if present, can be masked or overlooked, especially if it is not expected.

Then, in the two decades until the recent event in 2022, these stars were again drawing apart and in combination with an appropriate alignment of the angle of the approaching lunar limb the observed fade may have been the result. Unfortunately the naked eye is rather a blunt instrument and what seemed to be a gradual fade in the circumstances, may have contained further information that could have identified the cause as stemming from the occultation of two individual components. If accepting this double star premise, then angular distance represented by the length of a half second fade (0.2 arc seconds) would indicate the order of distance of separation of the two components on that specific alignment of the limb relative to the direction of motion. If the postulated double star was aligned at a different angle to the lunar limb, this same figure could produce a larger angular separation of the components.

Finally, a catalogue error ever remains as a plausible explanation for the failure to observe the secondary star and there are a considerable number of examples that can be provided where the companion star can simply not be found. However in this instance I suggest the definite observed fade supports the original observation of SAO 158294 as a double star.

So we have arrived at rather an unsatisfactory conclusion. A high resolution image of the star may solve the matter if it is revealed to be a close double, and may also help vindicate the original 1836 observation and measurement. As the long fade was a visual observation there is no permanent record to pursue further analysis. So if the star doesn't display its duplicity or some other acceptable explanation is forthcoming, it seems that the matter will remain a mystery, probably until the next occultation event, but a reasonably observable such event does not occur until at least 2033!

Acknowledgment: Special thanks are due to Dave Gault, the International Occultation Timing Association (IOTA) Regional Collector who provided the technical background research into this star and without whose efforts this article would not have been possible.

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Detection and identification of two rilles south of crater Linnè G PART II.

By Raffaello Lena and KC Pau

Introduction

This work is a supplement to a report about two elusive rilles that were found by K.C Pau in the north-western corner of Mare Serenitatis and previously published by the authors in ^[1-2]. Lena temporarily named the rilles as R1 and R2 respectively in the first report ^[1-2]. Recently more data of these rilles has been collected and new tools such as ACT Layers from LROC QuickMap have been employed to identify if the rilles are real. The results agree with our previous work. For future convenient correspondences about these rilles with other observers, K.C Pau now unofficially re-names the rilles Rima Kan 1 and Rima Kan 2 in honor of his wife, who always fully supports his lunar observation.

Rimae Kan is hidden in the north-western corner of Mare Serenitatis and is not very far to the east of Montes Caucasus. Surrounding Rima Kan are many mare ridges (Fig 1). It is not easy to detect these rilles under normal lighting condition, only when they are close to the terminator, and steady seeing seems to be an important factor.

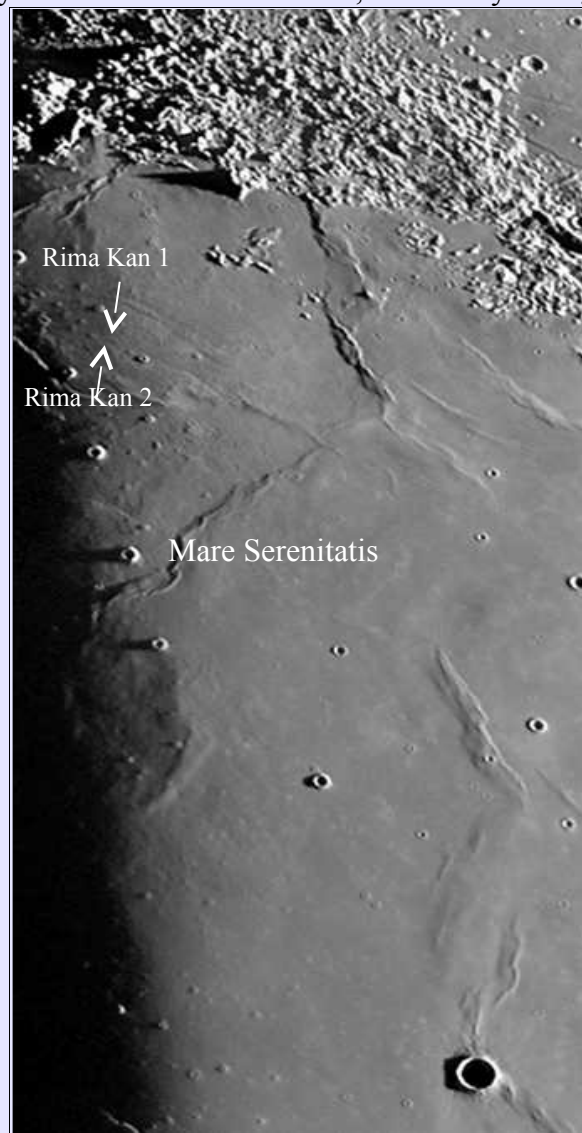


Figure 1: Image taken on May 21, 2018 at 11:49 UT with 250mm f/6 Newtonian reflector at prime focus with QHYCCD290M camera.

From photos taken near the morning terminator, it is found that the western part of Rima Kan 2 seems to end at a piece of highland or probably a cliff which casts a prominent shadow under morning sunlight. The cliff has a long narrow mare ridge linked to its south. But the rille seems to extend westwards after crossing over the raised terrain. The extension is only barely shown on the photo (Fig. 2).

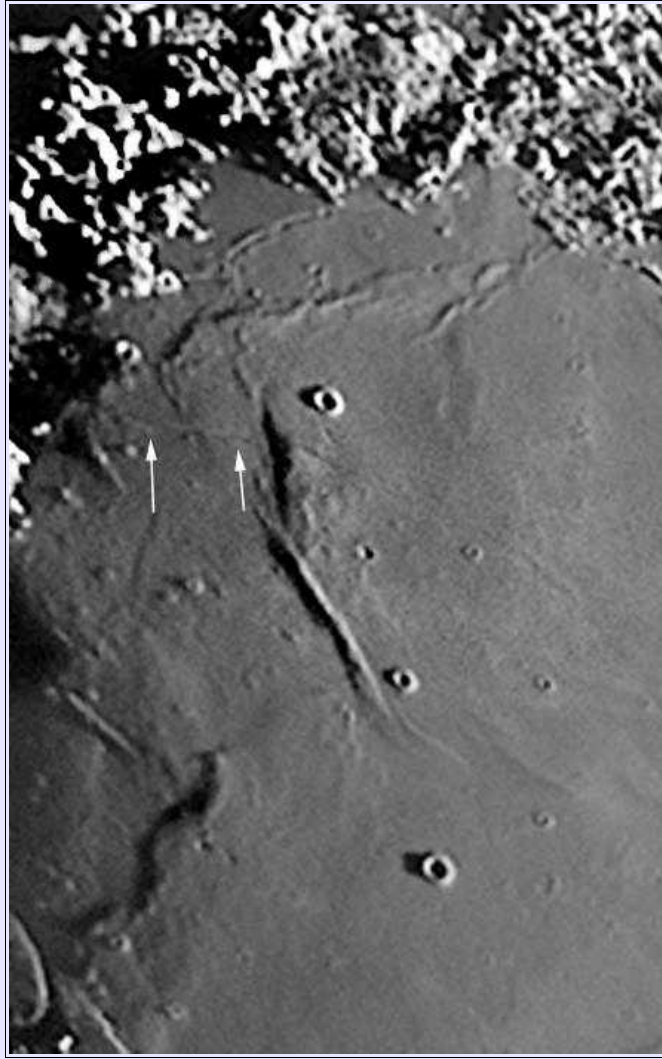


Figure 2: Image taken on April 29, 2020 at 11:27 UT with 250mm f/6 Newtonian reflector at prime focus with QHYCCD290M camera.

Rendered Image using ACT react quick map based on the shaded relief.

The ACT react quick map (<https://quickmap.lroc.asu.edu>) was used to generate synthetic view of selected parts of the LOLA DEM, using the “shaded relief” parameter for several lighting conditions with specific simulation based on date and time in UT. The rendered images display the lunar features under different solar illumination angles when a date/time in UT is selected. Figure 3 shows unequivocally two identified rilles, which appear to be two lunar graben.

Using the ACT-REACT tool, and LOLA DEM, it is possible to determine distances, profiles and depths of several lunar features. At the northern branch, the rille Kan 2 (R2) south of Linnè G is only about 22 m deep, while the southern branch is about 17 m deep (Fig. 4). The average width of the least-disturbed linear sections amounts to ~1,600 m. The rille Kan 1 (R1) is 50 km long while the rille Kan 2 (R2) is about 110 km long. Note that the rille Kan 2 cuts an elevated soil as also detectable in Fig. 3. This relationship suggests that the rille is younger than the ridge.

Discussion and geologic context

Lunar rilles can have different origin. A graben can form by the dropping downward of a linear block between two parallel faults. On the other hand, sinuous rilles are volcanic lava tubes and channels. Linear and concentric rilles are tectonic cracks generally associated with stresses related to impact basins. Linear rilles are also interpreted as depressions formed over rising of magma, called dikes. The dikes rise through regions where a horizontal stress is extensional, making it easier for the dike to push aside the surrounding rocks. The Sirsalis rille, a linear rille, is one of the longest lunar graben, about 380 km long, for which is identified an origin due to rising magma by a dike ^[3].

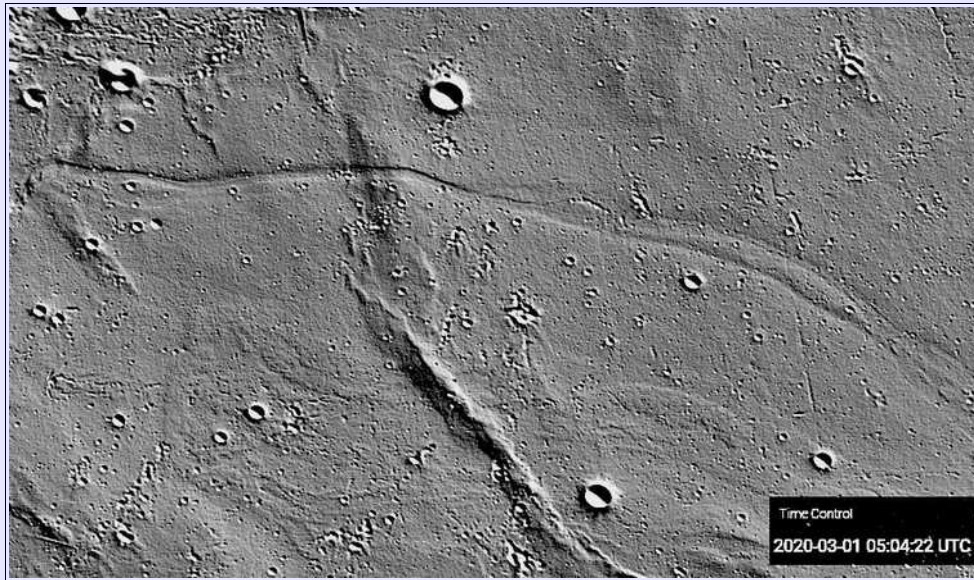


Figure 3: specific simulation based on ACT react quick map shaded relief. The rendered image displays the appearance of two rilles as seen for March, 1, 2020 at 05:04 UT. The resulting rendered image was enhanced in contrast and a high pass filter was applied.

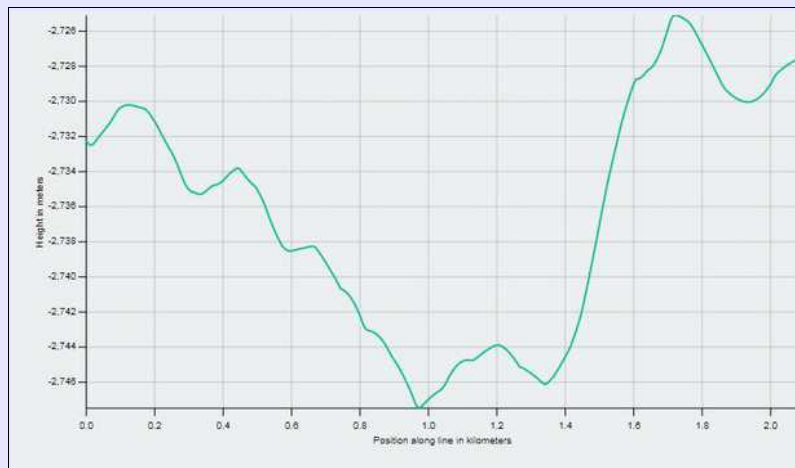


Figure 4: Cross-sectional profile of the rille Kan 2 (R2), derived with the ACT-REACT Quick Map.

Tectonic origin: for many linear rilles on the Moon, their locations relative to impact basins and their orientation geometries strongly suggest that they are graben produced by large-scale tectonic stresses^[4]. Filling of the circular impact basins, such as Imbrium, Serenitatis and Crisium, by mare basalts caused central loading of the lithosphere, flexure, and the formation of circumferential graben at locations around the basins; the radial distance of graben formation is a function of the load magnitude and the elastic lithosphere thickness. Thus this mechanism could be the origin of two concentric rilles under investigation.

Intrusion of dikes: the presence of volcanic features associated with various lunar linear rilles is evidence that at least some linear rilles are graben whose formation is related to the shallow intrusion of dikes^[3]. Mare volcanic eruptions are fed from source regions at the base of the crust or deeper in the lunar mantle. According to Wilson and Head^[3], some dikes intruded into the lower crust while others penetrated to the surface, being the sources for extensive outpourings of lava. Thus the surface manifestation of dike emplacement in the crust is dependent on the depth below the surface to which the dike penetrates. Wilson and Head state that if a dike does not propagate near the surface but stalls at greater depth, the strain will be insufficient to cause any dislocation near the surface. If a dike propagates at intermediate depths the strain will cause extensional deformation, eventually leading to graben formation. On the contrary, if a dike propagates at shallow depth and gains surface access at some points, a subsequent lava effusion will occur and the surface manifestation of the dike will be a fracture. Depending on the magma density relative to the density of the crust and the mantle, and also on the stress state of the lithosphere, some dikes erupt at the surface while others penetrate to depths shallow enough to produce linear graben.

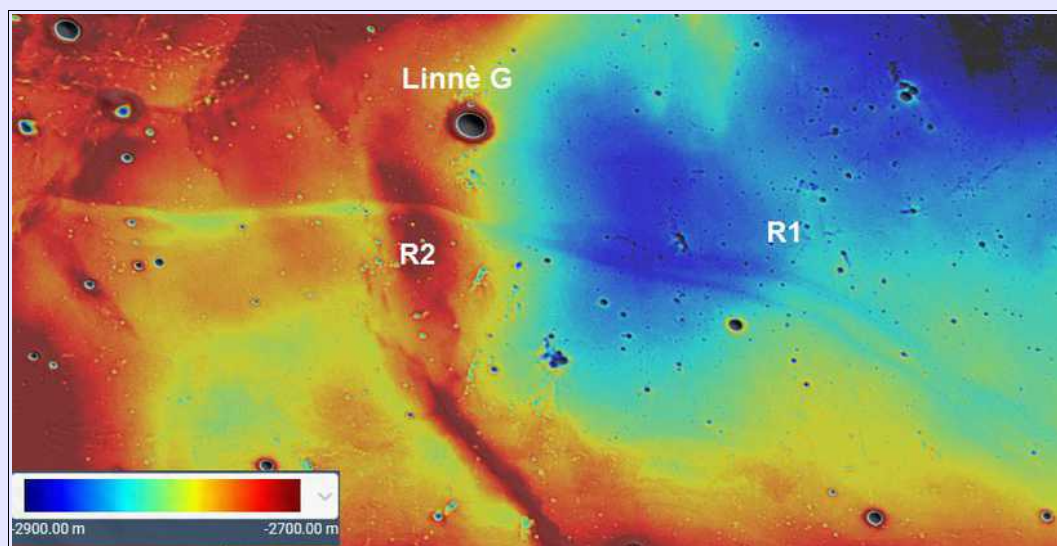


Figure 5 displays the region under analysis using the digital elevation model.

Bouguer gravity anomalies and crustal thickness: the analysis of the gravity data is a useful approach for characterizing the subsurface crustal and interior structure of a planetary body. Grail dataset obtained by the ACT Quick Map LRO (<http://target.lroc.asu.edu/da/qmap.html>) has been used for Bouguer gravity mass anomaly^[5] and for crustal thickness^[6]. Figure 5 displays the gravity anomaly of the examined region. Gravity anomaly mass concentrations are concentrated in the examined region including Linné G and the two rilles. The gravity anomaly is shown in red color (Fig. 5) and is obtained from the GRAIL GRGM900C gravity model after subtracting the gravity resulting from topography assuming a density of $2,550 \text{ kg m}^{-3}$. Consequently these data also indicate variations in thickness of the crust. If the density of the crust is assumed to be uniform, then the gravity anomalies visible in the Bouguer gravity map can be explained by variations in the thickness of the crust. Highs in gravity indicate places where the mantle is closer to the surface, and hence where the crust is thinner. The gravity anomaly indicates the presence of magma chamber at low depth.

Wilson and Head propose that lunar linear rilles like Rima Sirsalis and Rima Parry V are the surface manifestations of dikes which have not reached the surface but propagated to shallow depths of 1–2 km, showing that these dikes were capable of producing surface stress fields leading to the development of graben with widths of 1–3 km^[3]. Note that the average width of the least-disturbed linear sections of the examined rilles discovered by Pau amounts to ~1,600, thus in accord with the derived values for Rima Sirsalis.

Conclusion

Our new data show very clearly there are two long and elusive rilles, oriented roughly radially with respect to Mare Imbrium. In order for igneous dikes to form, the lunar lithosphere would also have to be under extension, and thus this tectonic regime is conducive to both dike and graben formation. Based on the methodology used here, we cannot distinguish between graben formation with or without dike intrusion, as both processes have the potential to produce all of the geomorphologic characteristics of normal faults described in this study. Likely both mechanisms can have

occurred, including dike propagation in the subsurface. It once again shows that with today imaging technology, there is still a chance for amateurs to study elusive features on the moon. In combination with high-resolution images, such investigations might greatly extend our present knowledge of the processes occurred on the Moon.

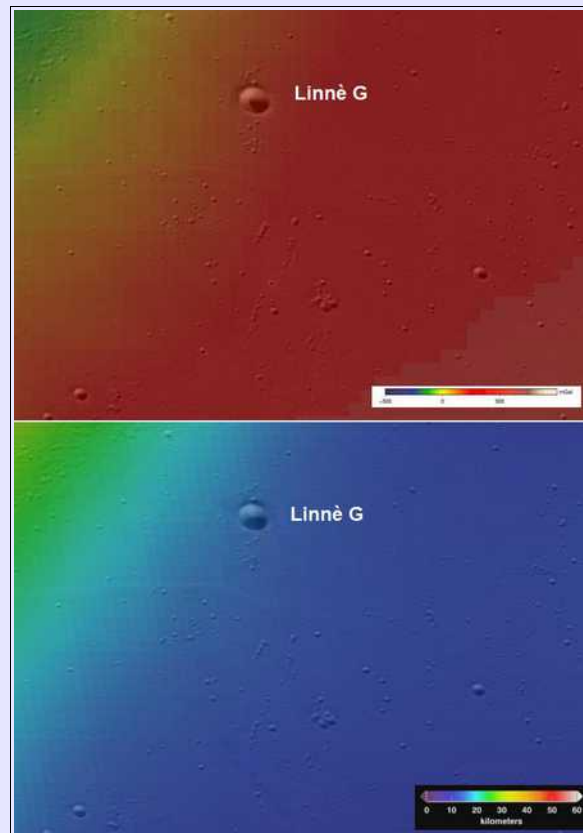


Figure G: (Top) Bouguer gravity gradients of the examined region. (Bottom) GRAIL crustal thickness map at 16pixels/degree. It includes shaded relief of surface features.

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Rilles and Ridges. By Barry Fitz-Gerald.

The wrinkle ridges found in most lunar maria are widely believed to represent tectonic features that formed as the mare surface buckled under compressional forces. These forces were generated as the central part of the mare sagged downwards under the accumulated weight of the infilling basalt lavas, giving rise to the 'MASCONS' discovered during the Apollo missions. The standard wrinkle ridge model has these compressional forces fracturing the crust to form low angle thrust faults, with the wedge of maria above the fault over-riding that beneath producing, a local crustal thickening along the strike or line of the fault.

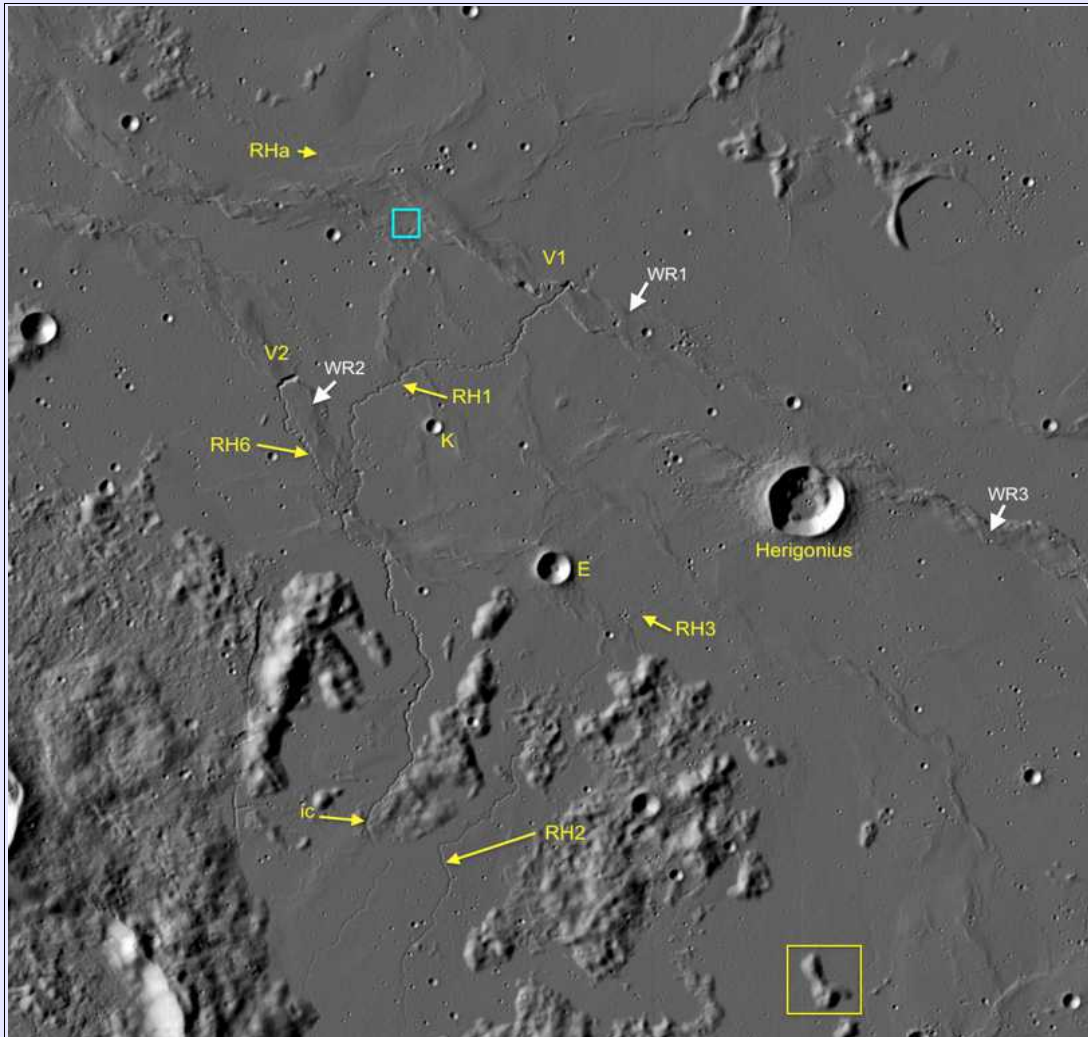


Fig.1 The Herigonius Rille system as seen with the LRO Quickmap with the 'TerrainHillShade' layer enabled. Elements of Rima Herigonius are labeled RH1,2,3 and so on, V1 and 2 are vents from which RH1 and RH6 emerge, RH7a is a suspected sinuous rille and 'ic' represents an area of 'incised channel'. Wrinkle ridges are shown as WR1-3. Feature in yellow box is shown in detail in Fig.11. Feature in blue box is shown in detail in Fig.10.

Wrinkle ridge formation appears to have occurred over a protracted period, with research now indicating that the ridges formed some considerable time *after* the basins filling lavas had erupted^[1]. Consequently the deformation involved solid layers of basalt lava with, in all probability intervening regolith layers, which had formed as each flow was exposed to millennia of meteoritic bombardment and 'gardening'.

There have however been some suggestions that wrinkle ridges formed on a solidified lava crust floating on top of a lower bed of still molten lava^[2]. This effectively de-coupled the solid surface crust from the lava beneath, allowing it to deform under localized compressional forces. This obviously contradicts the recent view that a considerable period of time elapsed between the eruption of the mare lavas and the onset of ridge formation. So whilst the modern view sees wrinkle ridges form by the faulting and compression of solid piles of basalt lava, the somewhat older idea sees them as something more comparable to the buckling of a chilled surface on a lava lake.

It appears that the tectonic model has won the day and the involvement of volcanism does not figure significantly today's views of wrinkle ridge origins. There is however some evidence for a correlation between volcanism and wrinkle ridge formation in some areas at least. I recall several discussions with Keith Abineri regarding this possible connection during his studies of the Herigonius Rille and the shared view that such a link may have existed^{[3][4]}. At the time our only resource for studying the area was a set of Lunar Orbiter IV images on 35mm slide film, which were viewed under a binocular microscope. Of course the resolution and illumination angle limited interpretation considerably, but now with an embarrassment of riches by comparison we can re-visit these areas in high resolution and with the advantage of variable illumination images and terrain elevation/slope data.

The area comprising the Herigonius Rille system that so interested Keith is shown in Fig.1, which is a LRO Quickmap rendition with the 'TerrainHillShade' layer enabled. This shows a number of rilles labeled 'RH' for Rima Herigonius, with a number following, a designation used in a previous regional study^[5]. Gassendi is just out of the bottom left of the frame, but you can get your bearings from the location of the Eratosthenian aged crater Herigonius. As can be seen the rilles appear to flow from north to south and towards Mare Humorum. There are a couple of what appear to be prominent source vents (V1 and 2) that straddle two south-east to north-west trending wrinkle ridges (Fig.1 WR1 and WR2). The apparent location of these of these vent locations *on* the wrinkle ridges is at the least suggestive of a link between them.

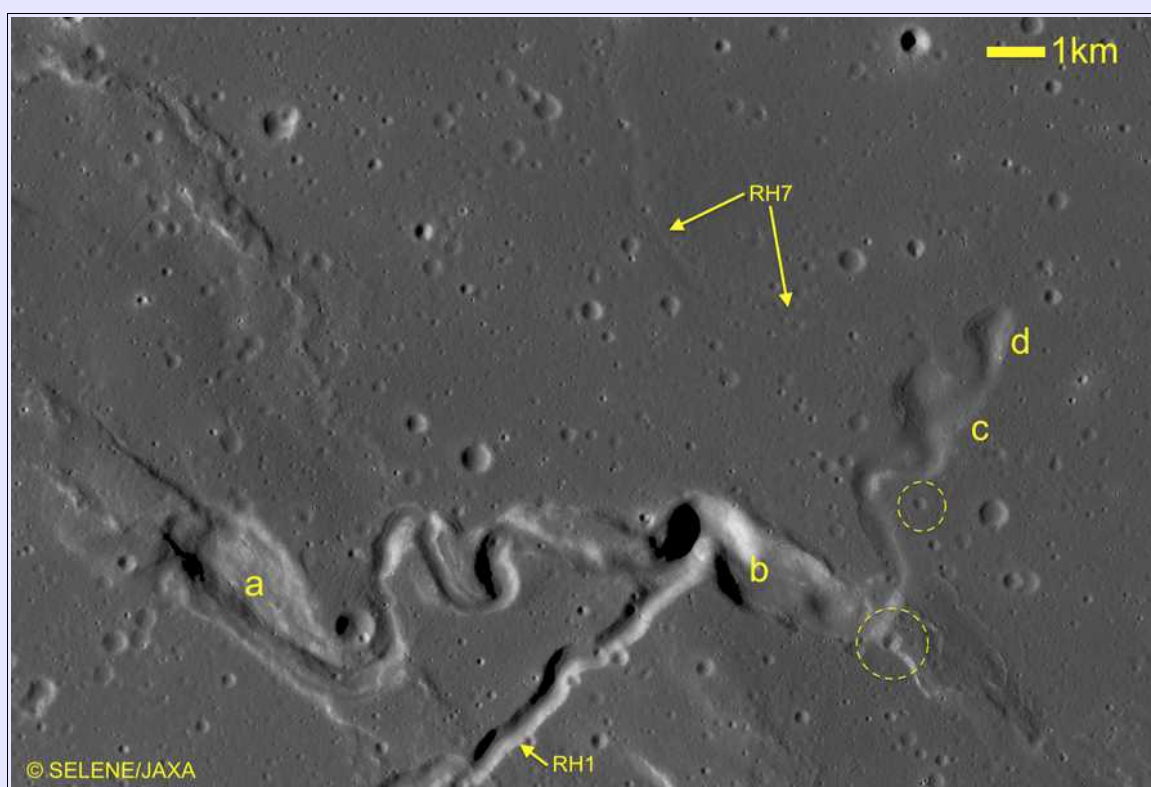


Fig.2 Detailed view of V1 with various sub-structures referred to in the text. The extremely shallow RH7 contrasts with the deeply incised RH1, but the difference may be due to extensive lava flooding to the north of the wrinkle ridge. Features in dashed circles shown in detail in Fig.14. The wrinkle ridge is WR1 in Fig.1.

Rima Herigonius 1 (RH1) appears to originate in a Vent 1 (V1) which is a complex series of interconnected pits that lie along the north-west to south-east trending wrinkle ridge WR1 that rises some 200m above the mare surface and is (at this point) approximately 9km wide (Fig.2). A 200m deep elongate pit 'a' on the western margin of WR1 links to another approximately 200m deep pit 'b' on the eastern margin, via a short section of sinuous rille that straddles ridge summit. These features ('a' and 'b') appear to be vents in their own right, an interpretation base on their depth and the fact that they are the sources of sinuous rilles. RH 1 emerges from pit 'b' and strikes towards the south-west, crossing the summit of WR1, then descending onto the mare surface. Pit 'b' also has a smaller sinuous rille emerging from its eastern end which then expands into a couple of shallower pits 'c' and 'd' on the mare to the north. Pit 'c' in turn gives rise to a rather subdued RH7, which meanders its way towards the north-west. Fig.3 shows this indistinct rille RH7, and one might be tempted to interpret its inconspicuous appearance as being the result of age and erosion, but it is more likely that RH7 has been partially drowned by ponding lavas to the north of WR1, and is probably contemporaneous with the volcanism that produced RH1.

Pit 'a' and the short section or rille between it and 'b' appear to be somewhat distorted as does the eastern end of pit 'b'. Also, the course of RH1, as it heads south away from the southern side of WR1 appears to be slightly offset with a slight kink, again suggesting deformation. This deformation is probably down to the same forces that produced WR1, indicating that these volcanic features formed before or at the same time as the ridge was being squeezed up. It is possible that the various pits that make up V1 were active at different times, with activity switching from one to

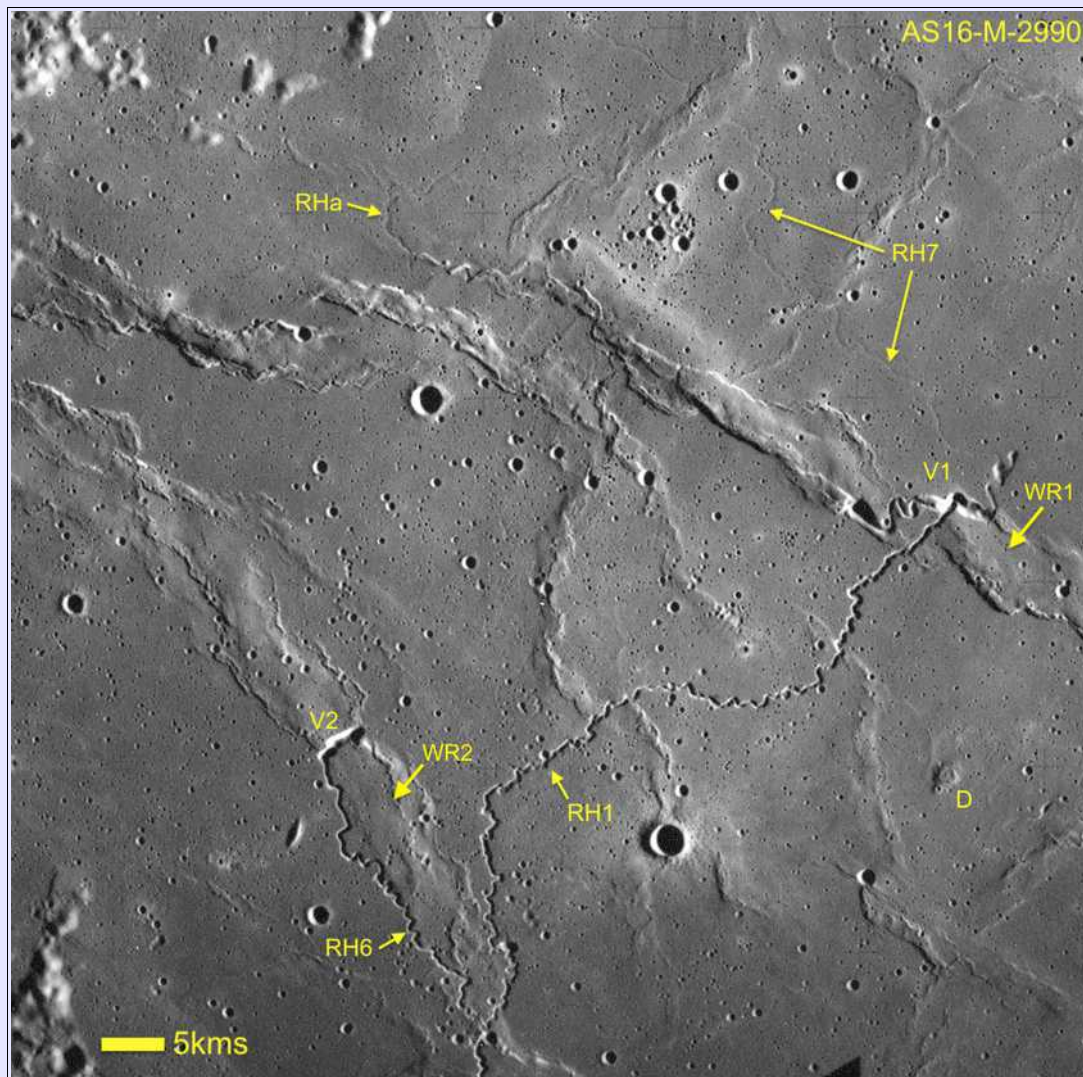


Fig.3 Apollo 16 image of the Herigonius rilles. Note the very low visibility of RH7 which may be the result of lavas ponding to the north as opposed to draining away down the rilles as occurred to the south through RH1.

another. From the morphology and degree of distortion, 'a' might be the oldest, followed by 'b' and 'c' and 'd' the youngest. As noted above the rather subdued appearance of 'c' and 'd' might be the result of ponding of high titanium basalts and they may represent the final active pits in the vent complex. Is it possible that this change in vent activity occurred as WR1 formed? A topographic profile through V1 and along the crest of WR1 shows that the vent area is actually elevated above the general ridge surface and in something of a bulge, but that the central part of the bulge is depressed. This could be interpreted as being the result of the injection of magma beneath the surface of WR1, with the central depression forming as a result of deflation the lavas erupted through the various pits making up V1.

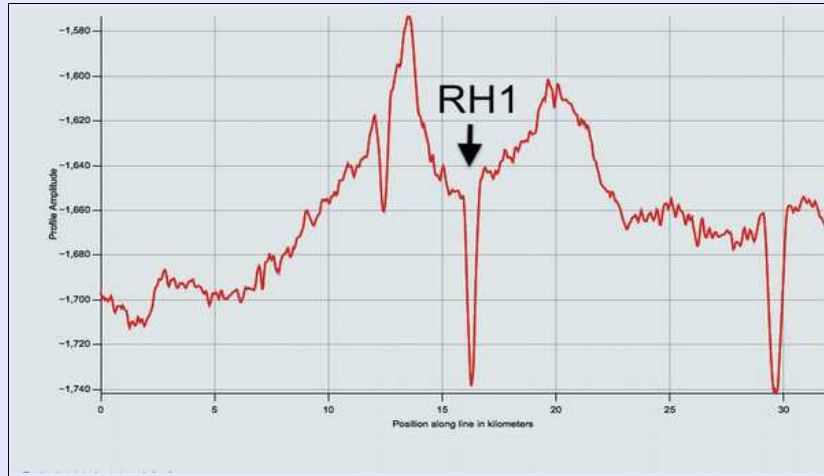


Fig.4 Topographic profile along the crest of WR1 on which V1 lies, and running through the vent complex.

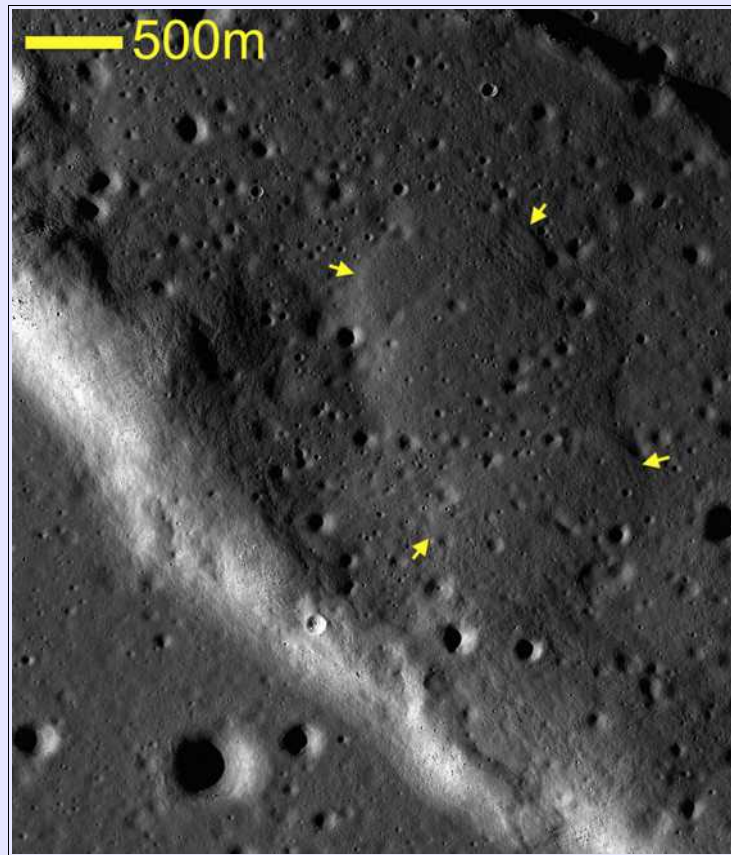


Fig.5 A small suspected lava flow on the crest of WR1 that hosts V1, which lies some 20kms to the east. Lobe fronts are shown with yellow arrows.

There are one or two odd features along the crest of WR1 that *may* be short lava flows, one of which was identified in a previous study^[5] and which might support the hypothesis that lavas were injected into the body of the ridge. This particular structure, 20m high and 2.5km long (Fig.5) could well be such a flow – it has lobate fronts and a raised surface which fits the bill, but alternative explanations may exist. Moving on to Vent 2 (V2) we have a more convincing case of a vent intimately associated with a wrinkle ridge WR2 (Fig.6). The wrinkle ridge here is some 7kms wide and 60m high, whilst the depth of V2 is some 200m. RH6 emerges from V2 and flows south-eastwards, apparently skirting the western margin of WR2. Given the fact that the floor of V2 is some 200m below the adjacent mare and shows little in the way of distortion, this might suggest that in this case WR2 came first and V2 after, an idea supported by the above observation that RH6 hugs the western margin of WR2, as if its course was influenced by its presence. Interestingly another topographic profile along this ridge shows that the surface around V2 is elevated in a bulge and that the centre, where we find V2, is also depressed (Fig.7).

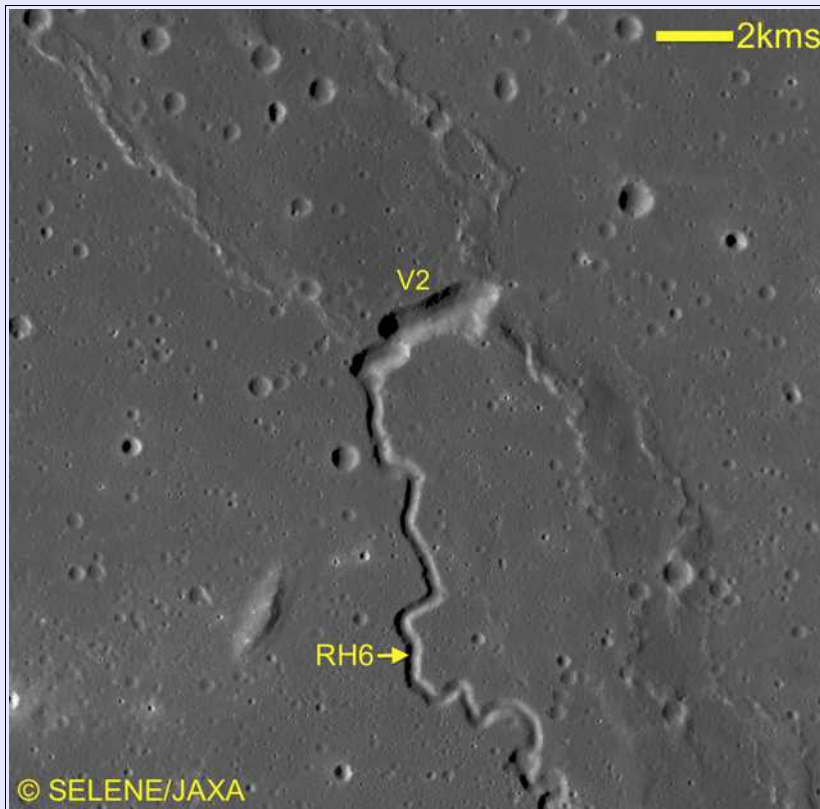


Fig.6 SELENE image of V2 straddling WR2 and RH6 which emerges from its western end. Note the second order ridges either side of WR2 apart from where RH6 runs alongside it.

One curious point regarding these volcanic features relates to the smaller second-order ridges that can be seen along the edges of WR1 and 2. In the case of V1, both pits 'a' and 'b' lie on top of these marginal ridges (Fig.2), whereas in the case of V2 the western marginal ridge to the south of V2 is actually replaced by RH6. Could this suggest a link between these smaller ridges and the lavas erupting at the surface? If the modern interpretation of wrinkle ridges is applicable here then this is unlikely as these smaller ridges are the result of nearly horizontal surface deformation and the positions of the pits of V1 would be coincidence and course of RH6 simply the result of the lava stream hugging the edge of WR2. If however intrusion of lavas has occurred beneath the wrinkle ridge surface then a connection is at least feasible in some way.

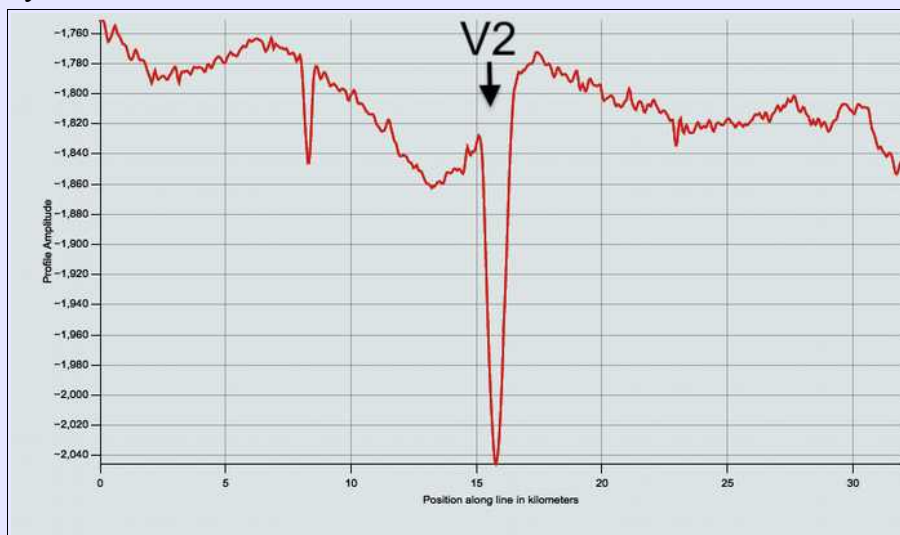


Fig.7 Topographic profile along WR2 showing the raised area surrounding the vent and the central depression.

Previous studies suggested that the obscure RH3 originated amongst the basin rings of Mare Humorum^[5], and then flowed northwards where it was obscured by the ejecta from Herigonius. There is evidence however that this rille originates somewhere near the wrinkle ridge WR3 that Herigonius sits upon, and that the formation of that crater

obliterated the source vent. This would be a third example of a rille originating on a ridge in this area, but unfortunately positive proof of this is not now visible.

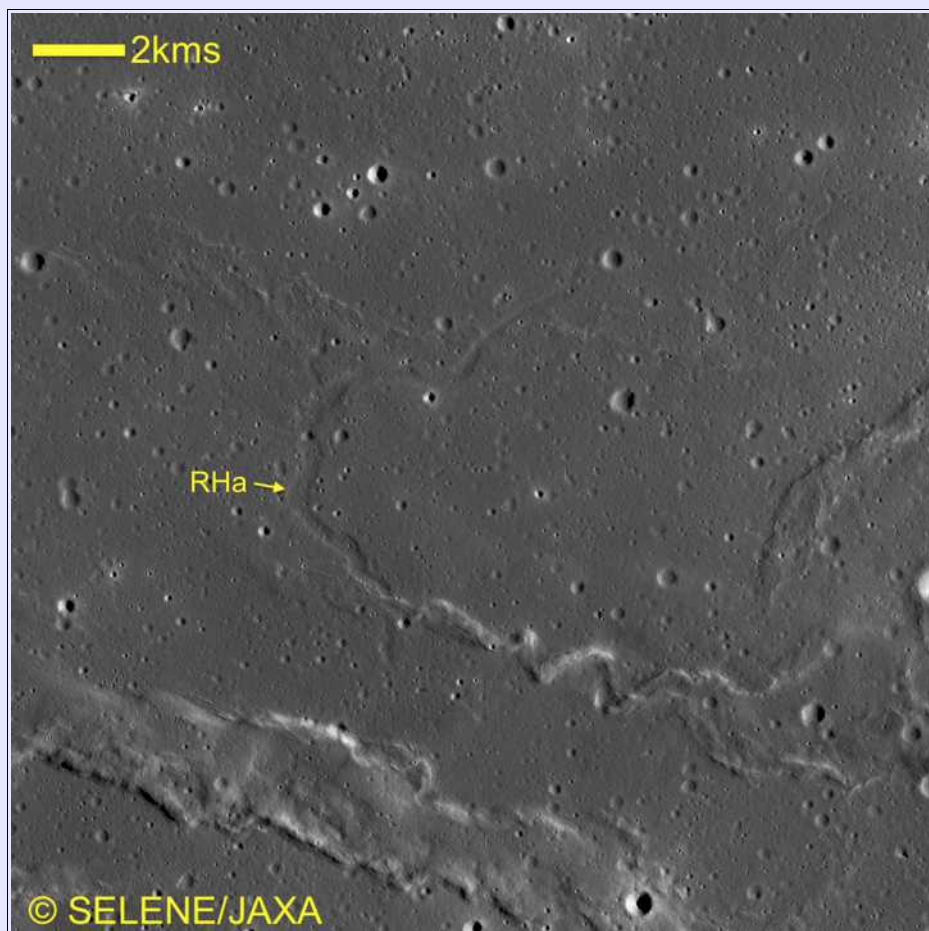


Fig.8 SELENE image of RHa as it emerges from the ridge like structure at the extreme western end of WR1.

An interesting example of a ridge/rille hybrid structure can be seen some 50kms to the west at the extreme end of WR1. Here a sinuous narrow ridge, approximately 600-700m wide and 60m high, transforms into a short 12km long sinuous rille like structure (RHa Fig.3). This narrow ridge appears to form the western tail end WR1, which narrows progressively in this direction before becoming indistinct beyond the emergence of RHa. The rille RHa is quite shallow, around 15m deep and some 450m wide (Fig.8). These dimensions are comparable to RH7 and it is possible that this subdued topography is again the result of flooding by lavas which inundated the mare to the north of WR1. The summit and flanks of the ridge are conspicuously bouldery, indicating relatively 'recent' ground movements, but this bouldery surface becomes smoother and more featureless as the ridge transforms into the rille (between sections b and c in Fig.9). So what exactly is going on here – is the rille emerging from the ridge or is this just a coincidence, where a pre-existing rille is partially obliterated by a ridge that formed at a later stage?

Some 20kms to the south-east of the start of RHa and on the flank of a smaller, adjacent ridge is a structure that appears to be a collapse pit with a short rille emerging from it (blue box Fig.1 and Fig.10). The elongate pit is approximately 150m long by 10m deep and 400m wide, and the rille that comes off it only about 5kms long. What exactly is going on here is not clear, as the rille itself appears have been distorted by the formation of some of the smaller ridges in the area, but a provisional interpretation is that of a small vent which gave rise to a small sinuous rille that has subsequently been distorted by localised ridge formation and general surface deformation. Whilst not certain, this structure is another one that suggests some form of volcanism associated with a ridge and eruption of magma from beneath its surface.

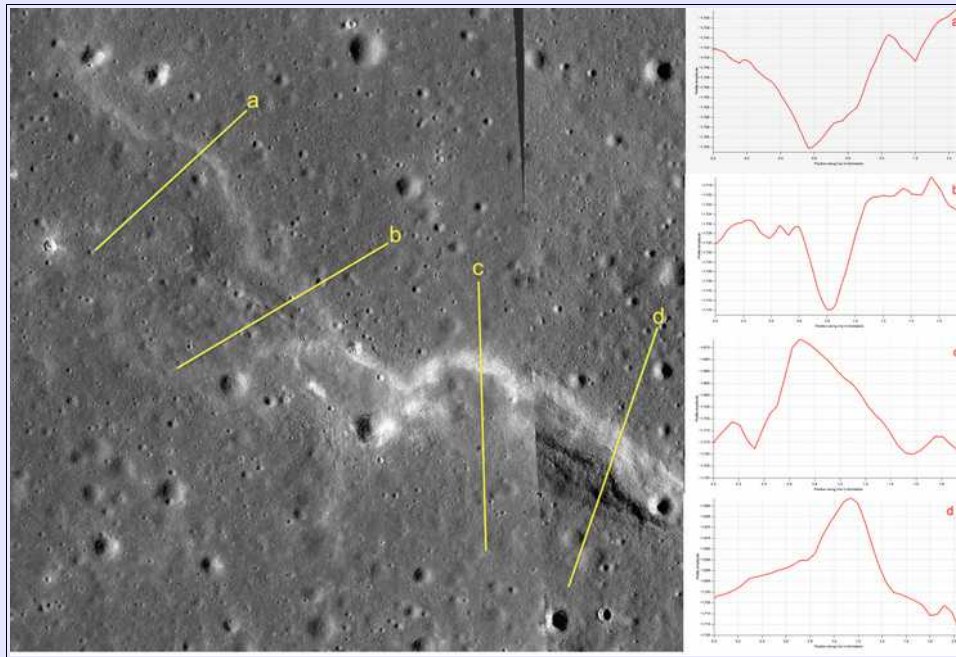


Fig.9 Topographic profiles (a-d) across RHa and the ridge from which it appears to emerge. Note the sharp bouldery crest of the ridge becomes smoother and featureless between b and c.

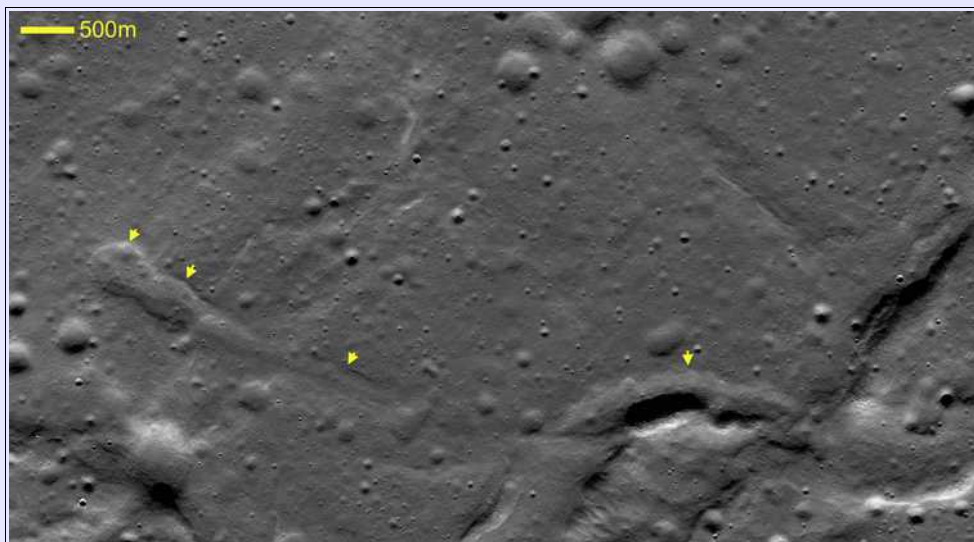


Fig.10 A possible vent and short sinuous rille located on a WR to the east of RHa (blue box Fig.1). Note how the rille appears to be distorted and possibly truncated by the small ridges towards the right if the frame.

The relationship between these rilles and wrinkle ridges has led to the hypothesis that volcanism was responsible for the formation of both types of features^[6]. Of course this contradicts the modern view that the rilles formed much later on a completely solid mare surface. As already noted there have been suggestions that wrinkle ridges may have formed by the deformation of a solidified crust of lava overlying a still molten layer below. Is there any evidence that this type of situation existed in the past?

Around the margins of some of the highland massifs in this area, the presence of a 'high tide' mark has been suggested which marks when the mare level was much higher, but that its level subsequently dropped leaving the tide mark high and dry^[5]. Of course these rims might be explained as being debris aprons formed of loose regolith from slopes above, a common observation on the highland edge. Some of these 'rims' do however appear to be enriched in material of a mare composition as well as having a similar albedo, suggesting that the 'high tide' interpretation may be correct (Fig.11).

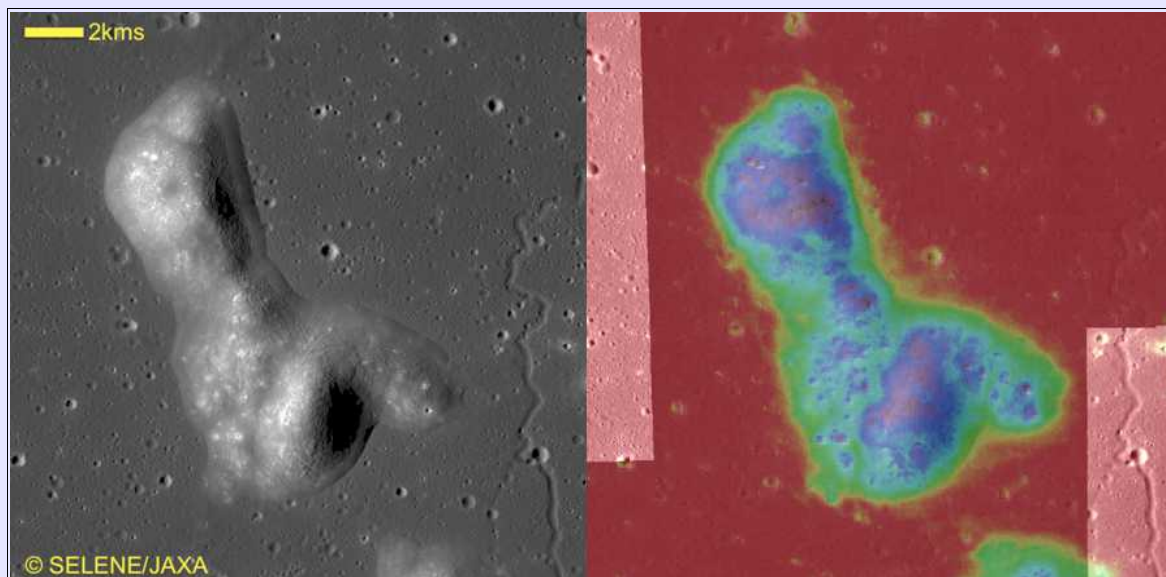


Fig.11 Highland massif identified in yellow box Fig.1. The left image from SELENE shows a well defined 'rim' around the base, the right image shows the FeO abundance with red being highest abundance, grading through yellow then green to finally blue the lowest. Note that the 'rim' has a high abundance of iron, consistent with the 'high tide' interpretation.

Another more convincing indication of a higher lava level can be seen where RH1 cuts an incised channel through a promontory of a highland massifs (feature ic in Fig.1). RH1 can be seen to skirt the western edge of the massif as it approaches the promontory (Fig.12), but it then ascends *over* the promontory instead of skirting *around* the massif edge, which appears to be a case of lava flowing uphill. The bed of RH1 within this valley is elevated above the adjacent mare surface, in the case of point 'a' in Fig.12 this is a height difference of 9m which would have involved the lavas forming RH1 to flow uphill if no other factors were involved – clearly an unlikely situation. To the south of the massif, RH1 is shallower and narrower than at point 'a' as if the flow of lava from the north was reduced in volume and its erosive capacity cut dramatically.

One possible explanation for this observation, that is consistent with the solidified crust hypothesis, is that when RH1 first formed from lava erupting from V1, the mare surface was higher, possibly by several 10's of meters, and had developed a solid crust over which RH1 flowed and into which it cut downwards. At this time the highland promontory would have been submerged, with the surface crust floating several meters above it. RH1 would have therefore flowed *above* the highland massif on this floating surface. Subsequently, as the mare level fell, the level of the crust *and the base of* RH1 would have also dropped, until RH1 began cutting into the slowly exposed highland bedrock, carving itself a deep valley as the level of the mare continued to drop. At some point, the mare level dropped so far that the southwards flow of lava through the valley was cut off, starving the section of RH1 to the south, whilst lavas continued to flow along the northern section towards the now blocked valley.

Being unable to flow further south, these lavas may have over spilled the rille and ponded on the adjacent mare surface to the north of the promontory. This might seem a bit of a stretch of the imagination and maybe a little contrived, but one observation supports the idea. Fig.13 shows a Diviner Normalized Soil Temperature image of the area, with reds indicating higher and blue lower temperatures. This correlates with the degree of rockiness, as larger soil components retain their heat more effectively throughout the lunar night compared to finer components due to the volume/surface area relationship. As can be seen, the section of RH1 along the western margin of the massif (black double headed arrow) is far less rocky than the northern parts of the rille. This might be consistent with lava flooding as the molten material overtopped the channel as a result of the blockage to the south. This flooding would mantle any rocky exposures along the edges of the channel which gives the northern parts of RH1 their extremely rocky signature. So the evidence for a mare level higher in the past is certainly present if open to debate.

So, whilst the modern view of wrinkle ridges as being the result of thrust faults appears to leave little in the way of an opportunity for volcanism to be involved, wrinkle ridges forming as a shrinking crust of lava bends and buckles might provide an opportunity for lava to become involved. One factor that might have an effect is the temperature of the basalt layers being deformed. In the case of a mare composed of solid layers of basalt (maybe with intervening regolith layers) faulting would be likely as the rocks failed under compression by brittle fracture – producing the low

angle thrust faults thought responsible. But in the case of a surface crust, whilst being solid it would also be warmer and more ductile than cold rock layers. Consequently it might be less likely to form faults through brittle fracture but instead develop folds as the slightly plastic crust deformed.

It is known that voids can form in some terrestrial rocks, when horizontal layers are compressed to form folds^{[7][8]} and if the same applied on the moon and the ridges potentially developed open channels within their structure, then this might provide routes for lavas from beneath to migrate upwards and along the body of the ridge. But could such spaces exist in wrinkle ridges? Fig.14 shows a feature in eastern Mare Serenitatis, some 60kms to the south of Posidonius that might partially answer this question. This has been described as a lava channel^[9] but it is possibly better explained as being a wrinkle ridge, that developed a longitudinal roofed void, and that this roof subsequently collapsed to leave an open channel that looks superficially like a sinuous rille. In this example it is also notable that the transition from 'open channel' to the 'ridge like' section at the southern end, looks uncannily similar to the same transition in RHa where the ridge becomes the rille. Might this be the result of a similar process – a roof collapse into a void space beneath? There is even a small blob of material emerging from the southern rim that has been interpreted as a small lava flow, which if true could be an interesting observation.

Of course even if lavas found there way into a wrinkle ridge they would still require some driving force to cause a surface eruption. If V1 and V2 for example originated over vents that reached down into the crust (and their location on the ridges was just coincidence), then the force driving the eruption would be the same as that in any other eruption, the ascent of pressurised magma from deep within the crust and the exsolution of volatiles due to pressure release as the lava neared the surface. On the other hand if the lavas emerged from a sub-surface vent beneath a ridge and then travelled *within* it through subsurface voids and channels, then the pressure might no longer be sufficient to drive a high volume eruption of lava of the sort required to produce a sinuous rill. Additionally the volatile content of the lavas would presumably have been lost during their ascent, leaving none to power the explosive excavation of a vent.

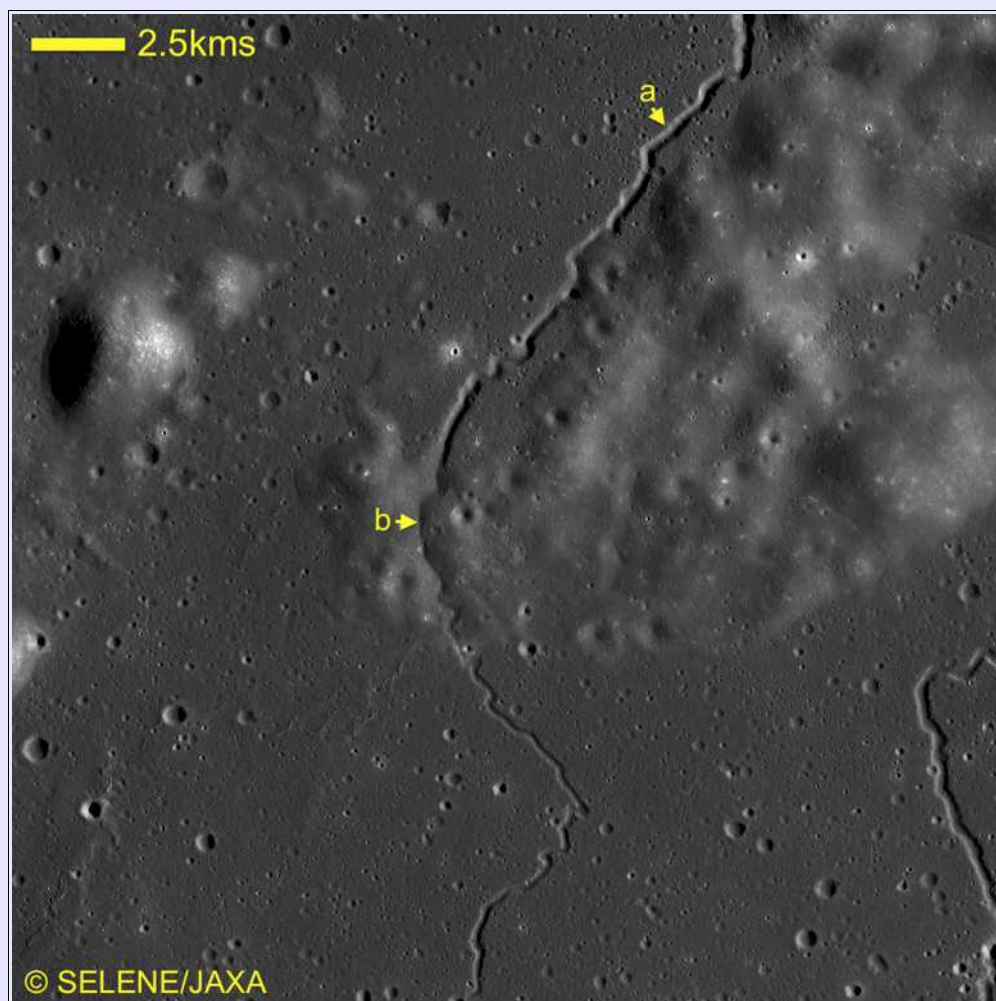


Fig.12 Selene image of RH1 where it cuts through an elevated highland promontory to produce an incised channel ('ic' in Fig.1) Note the reduced width/depth of RH1 to the south of this promontory.

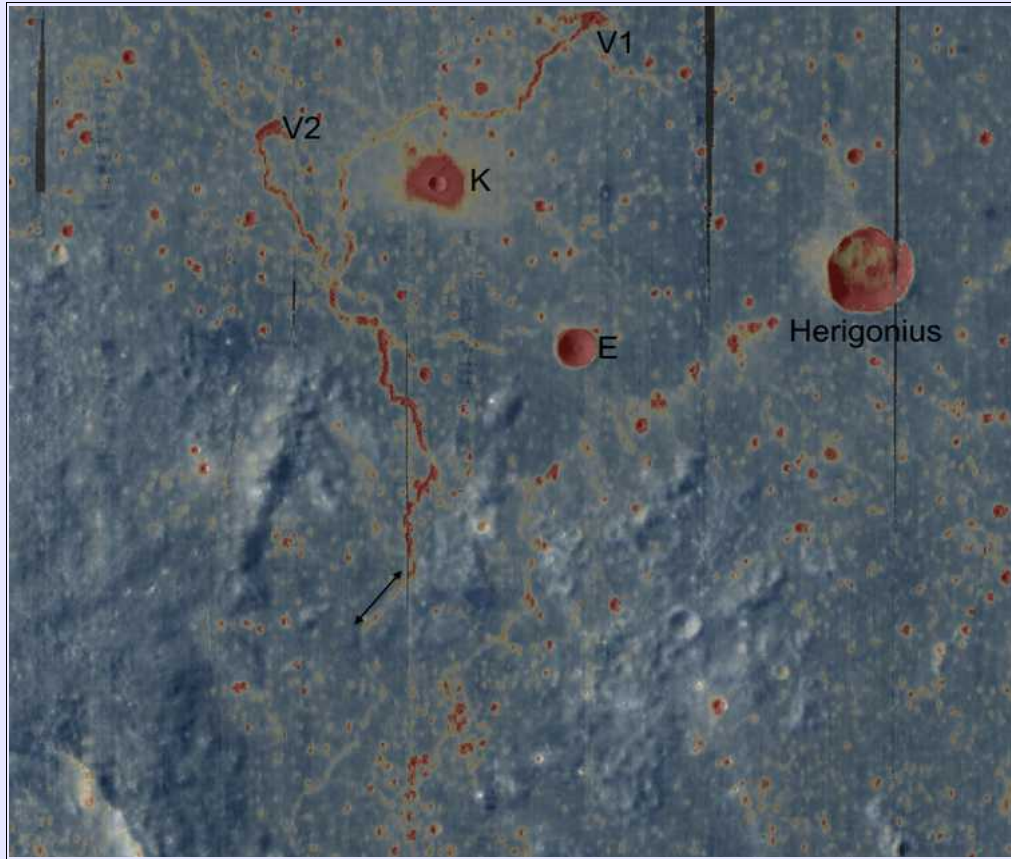


Fig.13 Diviner Normalized Soil Temperature image of the area shown in Fig.11. Red colouration indicated warm temperatures and hence a rocky substrate and blue a cooler temperatures and a finer substrate. The double headed black arrow shows the section of RH1 that hugs the western edge of the massif – note that it is not red as is the northern part of the rille but blue indicating a much less rocky nature.

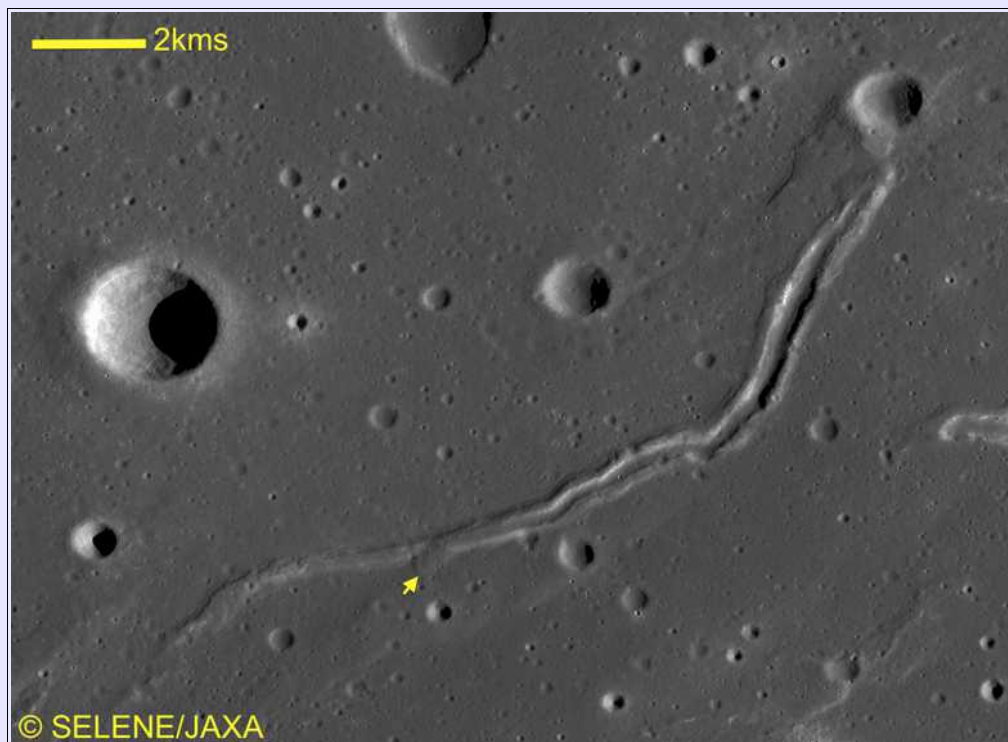


Fig.14 A possible example of a 'collapsed' wrinkle ridge in Mare Serenitatis that *may* have formed by the collapse of the roof of a longitudinal void that formed as the surface layers of lava buckled under compressional forces. Yellow arrow shows a small structure that has been interpreted as a small lobate lava flow.

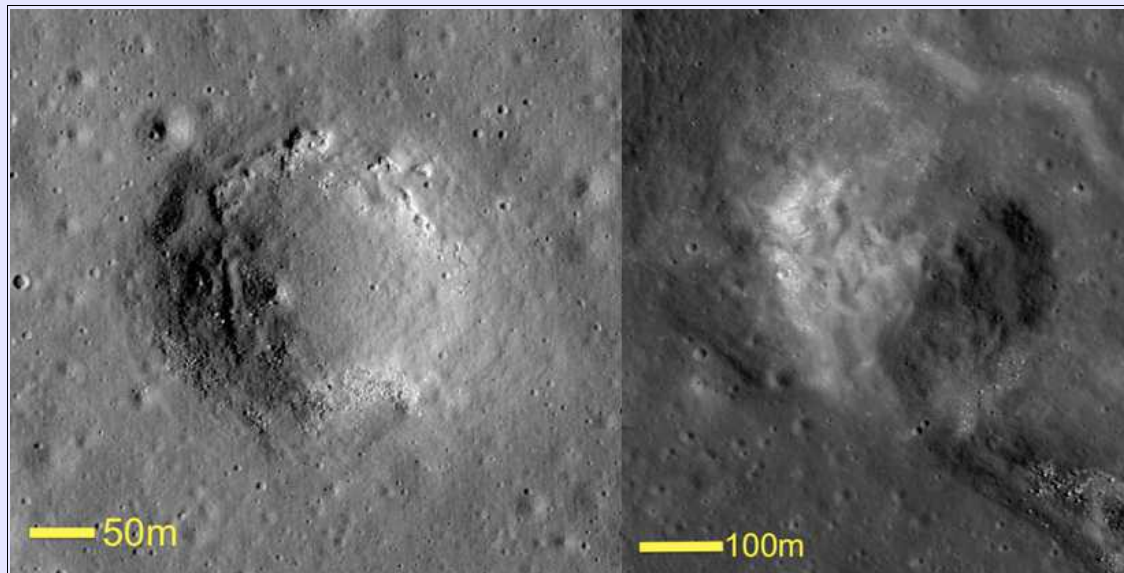


Fig.15 Two small craters near V1 (see Fig.2) that show surface modification similar to that seen in IMP's and possibly indicating gas release from beneath the surface.

It is however possible that as the lava crust subsided, it compressed the still molten lavas remaining beneath, producing the pressure needed to drive an eruption – rather like squeezing toothpaste out of a tube. Alternatively periodic eruption from the original sub-surface vent *into* the molten layer beneath the crust might have pressurised the magma body, but whether this would be sufficient to generate a surface eruption elsewhere is a moot point. The observation that both V1 and V2 are associated with a broad bulge in the ridge might indicate inflation of the ridge with injected magma which then vented to the surface producing the sinuous rilles seen. Also if V1 and V2 were collapse structures and not explosively derived vents, this might render the absence of a lava volatile gas content redundant. Having said that Fig.15 shows two small craters in the vicinity of V1 that show some hints of surface modification that could be due to gas release producing features seen in Irregular Mare Patches (IMP's). If this interpretation is correct then gasses may well have been present and involved in the eruptive activity associated with these vents.

In conclusion, it appears from a survey of the sinuous rilles and wrinkle ridges in the Herigonius region that these structures may have formed more or less at the same time and as a result of lavas invading and then erupting from within the wrinkle ridges. This may have occurred on a solid floating crust of basalt that formed over an underlying still molten layer of magma. This molten layer and its crust was not static, but reached higher levels before subsiding, leaving high tide marks and incised sinuous rille channels on some highland massifs. This might be viewed as something of a unique circumstance, and not a general model for the formation of wrinkle ridges or sinuous rilles, but other examples of this peculiar hybrid ridge/rille configuration can be found which suggests that this type of activity might be more widespread^[10]. There are mechanisms known on earth for generating voids within folded or contorted layers of rock, but whether this can occur on the moon and whether such voids could serve as magmatic conduits is pure speculation. The coincidence in location of the ridges and the apparent sources of the rilles is highly suggestive of a link between the two, at least in some circumstances and suggest that the formation of wrinkle ridges is not solely the result of thrust faulting of cold layers of mare basalt.

Acknowledgements:

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

Selene images courtesy of Japan Aerospace Exploration Agency (JAXA) at: <http://l2db.selene.darts.isas.jaxa.jp>

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LUNAR GEOLOGICAL CHANGE DETECTION PROGRAMME.

By Tony Cook.

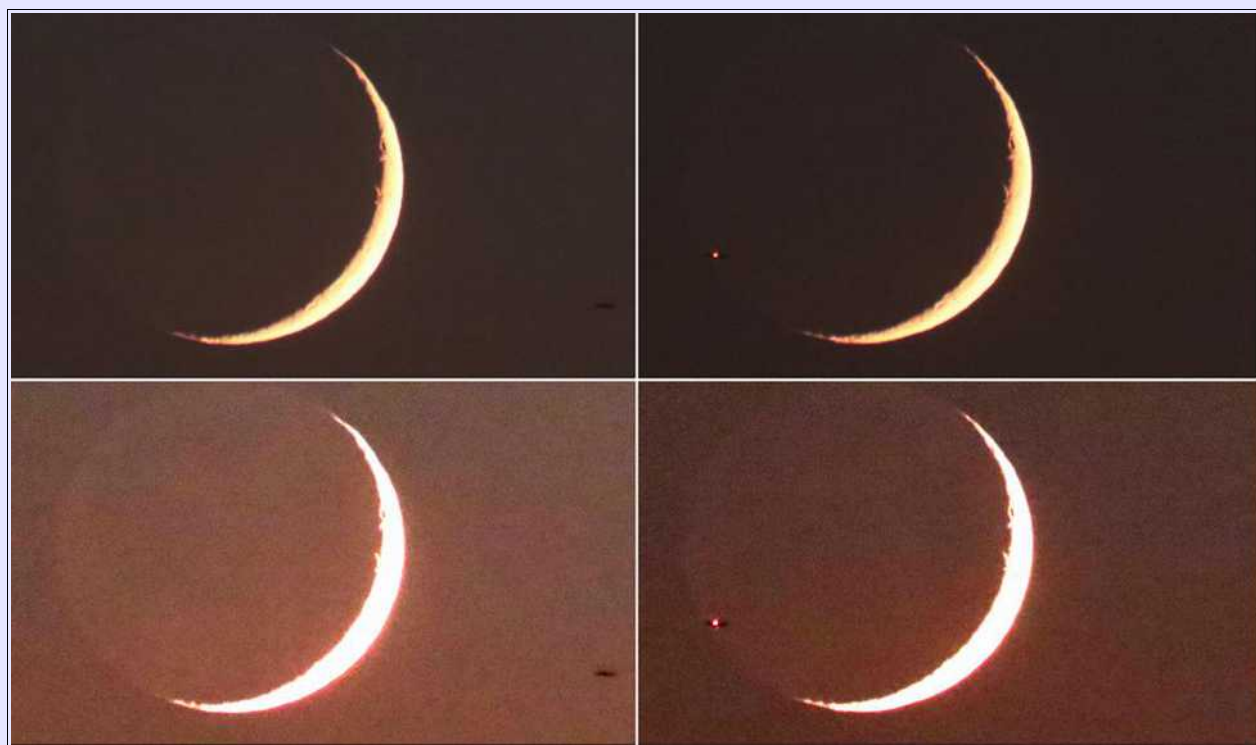


Figure 1. The Moon as captured by Malcom Porter on 2022 Jul 01 UT 21:49. Top images are two images taken close together in time. The bottom images have been contrast stretched.

TLP reports: No reports were received for July, though a curious image was submitted by Malcolm Porter (Kent, UK) of a red flash on the Moon's SW limb (See Fig 1 – top right). An adjacent reference image can be seen in Fig 1 (Top Left), without any flash of light. Lunar impact flashes can sometimes be red in colour, especially if they are low temperature impacts. However, investigation soon revealed, after a bit of contrast enhancement, that the flash was just a navigation light from an aircraft (Fig 1 – bottom right), and the aircraft itself appeared in silhouette, against the sky, on an adjacent frame (Fig 1 – bottom left). Readers should be on the look out for this effect as it is quite frequent at small lunar phases, when the Moon is a crescent and low down near the horizon. What is happening here is that we are looking through a much longer path length of atmosphere, near the horizon, so there is more chance of aircraft, birds, satellites etc, being caught flying past the line of sight to the Moon.

Routine Reports received for June included: Alberto Anunziato (Argentina – SLA) observed visually: Aristarchus, Langrenus, Mare Crisium, and Torricelli B. Maurice Collins (New Zealand – ALPO/BAA/RASNZ) imaged: Clavius, Delambre, Gassendi, Mare Serenitatis, Plato, Theophilus and several features. Anthony Cook (Newtown – ALPO/BAA) videoed earthshine and the dayside of the Moon in visible light, SWIR (1.1-1.7 microns), and also in the thermal IR (7.5-15 microns). Valerio Fontani (Italy – UAI) imaged: earthshine. Les Fry (West Wales, UK – NAS) imaged: Aliancensis, Cassini, Catena Abulfeda, Curtius, Hipparchus, Manilius, Rimae Theaetetus, Stofler, Triesnecker and Werner. Rik Hill (Tucson, AZ, USA – ALPO/BAA) imaged: Linne and Rupes Recta. Trevor Smith (Codnor, UK – BAA) observed: Aristarchus, Langrenus, Messier, Plato, and Proclus. Franco Taccogna (Italy – UAI) imaged earthshine. Aldo Tonon (Italy – UAI) imaged: Aristarchus, Copernicus and Hermann D. Luigi Zanatta (Italy – UAI) imaged Aristarchus.

Analysis of Reports Received:

Earthshine: On 2022 Jun 01 UAI observers Valerio Fontani and Franco Taccogna took up the following lunar schedule challenge:

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: atc@aber.ac.uk

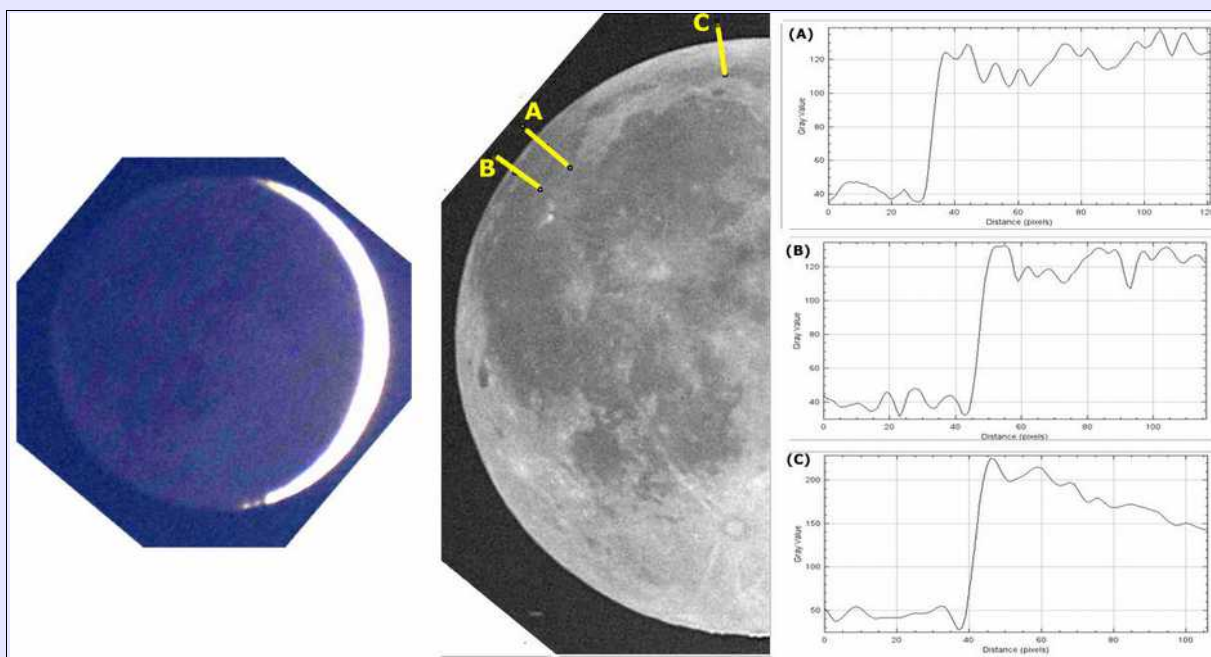


Figure 2. Earthshine observations made UAI observers on 2022 Jun 01 with north orientated towards the top. **(Left)** Image by Valerio Fontani at UT 19:38. **(Centre)** Image by Franco Taccogna at 19:43 UT with three brightness cross sections: A,B,C. **(Right)** Corresponding brightness cross sectional profiles for A,B and C.

The idea behind Prof Hoffmann’s conjecture is that when the Sun is almost behind the Moon – as close as to New Moon as is observationally possible, then if there were any dust clouds above the lunar surface (suspended electrostatically or due to impact ejecta) then right on the limb of the Moon, on the night side, you might be able to detect forward scattering of the sunlight, just over on the far side. This should result in a light arc around the earthshine limb. Fig 2 (Left), taken by Aldo in twilight, shows no obvious arc around the limb, nor at first does Franco’s longer exposure image (Fig 2 – Centre). However if we look again at Fig 2 (Centre) and examine the three cross-sectional brightness profiles on the right of Fig 2, there is slight evidence for blips (local maxima) in brightness going from the blackness of space to the earthshine. – these might infer a light arc around the limb?

Now, before we get too excited, a couple of points that might offer simpler explanations. (1) It is possible that either in the software, or the CCD camera electronics, some sharpening may have occurred, and as a result one gets “ringing” effects on dark/bright boundaries, giving a faint light arc around the limb of the Moon. (2) Certainly on the NW limb of the Moon there is a bright highland area on the far side which sometimes comes into view with appropriate libration – so it is possible the slightly brighter limb we are seeing in brightness profiles A and B could be from this?

So how could we tell the difference? Well if the dust cloud was present, and at an altitude of a km or more, then the arc would be slightly outside, and not inside the limb of the Moon. Secondly, time lapse imaging might reveal some changes over time, especially near more dusty areas of the Moon. Thirdly, the effect may be strongest at higher latitudes as the light has more chance of being near grazing incidence here, especially at the poles – but we also have to be careful of topography here which sticks out above the terminator. So more work needs to be done on this observational method, especially time lapse imaging. If anybody is interested in reading Prof Hoffmann’s 2017 EPSC abstract then click [here](#).

Mutus F: On 2022 Jun 04 UT 05:27-05:31 Maurice Collins (ALPO/BAA/RASNZ) captured a Lunar Schedule request of this crater:

BAA Request: Can you see, or image, 4 points of light in the shadowed floor of the crater? How do these change in appearance over time? Please send any images, or sketches, to: atc@aber.ac.uk

This actually refer to a report by Robert Spellman:

On 2005 Jan 15 at UT 01:25 R. Spellman (Los Angeles, CA, USA, 8" reflector) observed 4 bright points of light on the crater Mutus F? - see Rukl Atlas page 175, chart 74. If his identification of the crater was correct then he could see no structures in the crater that would yield this effect. It could well be that the 4 bright points are just 4 high peaks on the rim catching the first rays of the Sun.

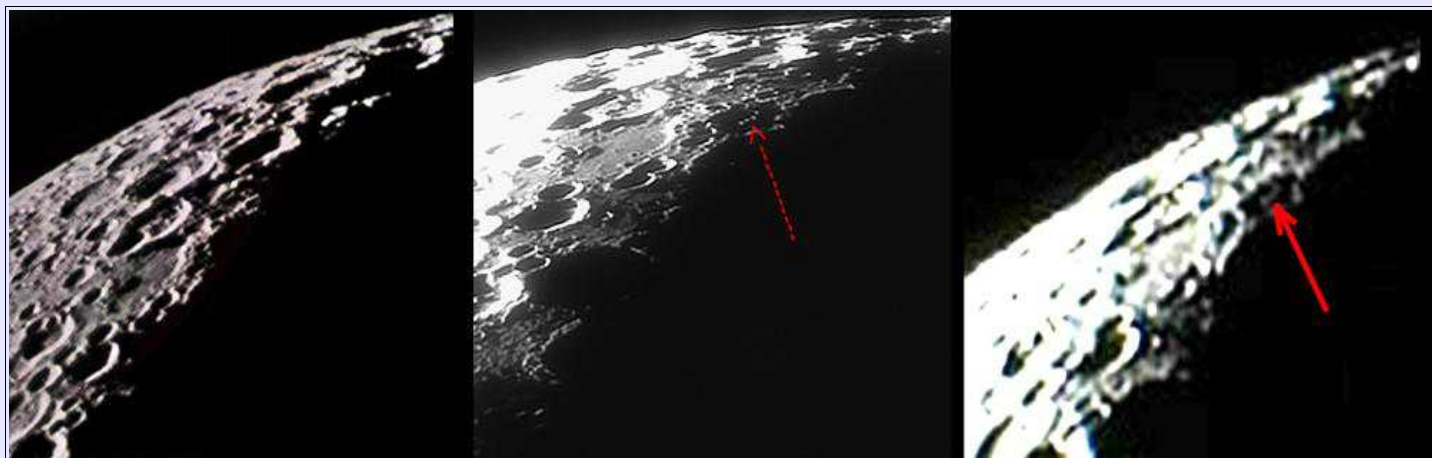


Figure 3. The Moon in the vicinity of Mutus F and orientated with south at the top. **(Left)** An image by Maurice Collins taken on 2022 Jun 04 UT 05:27-05:31. **(Centre)** An image by Robert Spellman taken on 2005 Jan 15 UT 01:25 with an arrow indicating a “string of pearl” effect. **(Right)** An image by Maurice Collins from 2011 Sep 02 UT 08:49-09:07 with an arrow locating where the “string of pearls” effect would be.

Maurice’s image (Fig 3 - Left), taken in 2022 does not show any illuminated region compared to the original image (Fig 3 - Centre) by Robert Spellman, hence was slightly too early in terms of sunrise conditions. However, looking through the archives, he did image the area on 2011 Sep 02 (Fig 3 – Right) and certainly record an illuminated area where Robert Spellman detected his string of bright spots. In fact, we have already covered this in the 2020 May [newsletter](#) and eliminated it as a TLP, but had yet not removed it from the Lunar Schedule programme – as we were interested to see how these spots developed. Maurice’s 2022 image puts a constraint on one end of the selenographic colongitude range, and this has now been updated in the Lunar Schedule programme.

Aristarchus: On 2022 Jun 04 UT 22:45-22:50 Alberto Anunziato (Argentina – SLA) observed visually this area under a similar lunar phase to the following report:

On 1975 Dec 08 at UT18:00-20:40 P.W. Foley (Wilmington, Kent, UK, 12" reflector, x60-x624, seeing II, slight mist) found Aristarchus to be less well visible than features such as: Grimaldi, Reiner, Darwin/Byrgius, Kepler, Plato and Sinus Iridum. Earthshine was exceptionally good tonight and was orange/red in colour. Photographs were taken and these confirmed the apparent dullness of Aristarchus. ALPO/BAA weight=2.

Alberto, using a 105 mm. Maksutov-Cassegrain (Meade EX 105, magnification x154) commented that Aristarchus was on the night side and could not be seen in earthshine, only the outline of the mare edges. Although Aristarchus is often bright in earthshine, when the libration is right, and less earth-lit illuminated slopes are facing away from us, it can appear darker. We shall leave the weight at 2 for now.

Alpetragius: On 2022 Jun 08 UT 04:10 Rik Hill (ALPO/BAA) was imaging the Rupes Recta area, but just caught the southern end of Alpetragius crater, under similar illumination to the following report:

Alpetragius 1958 Nov 19 UT 22:00-22:05 Observed by Stein (Newark, New Jersey, USA, 4" refractor) "Shadow anomaly. Portion of shadow vanished, replaced by lighter shade. At 22:05 gradually darkened & was normal in 20 sec." NASA catalog weight=3. NASA catalog ID #704. ALPO/BAA weight=2.



Figure 4. Alpetragius orientated with north towards the top. **(Left)** An image by Rik Hill, taken on 2022 Jun 08 UT 04:10. The image has been rotated and Alpetragius is just on the edge, as indicated by the red arrow. **(Centre)** An image by Brendan Shaw (BAA), taken under similar illumination on 2015 Jan 28 UT 20:12. **(Right)** An image by Mike Brown (BAA), taken under similar illumination, on 2009 Apr 03 UT 18:43.

This crater has four TLPs associated with it, three of which were by Barnard in 1889 concerning: “*Shadow of CP diffused & pale. Entire inside of crater seemed filled with haze or smoke*”, and the fourth by Stein in 1958, again shadow related. As is often the case, when observations are submitted to me, they are either of a specific lunar feature from the TLP predictions/lunar schedule web sites, or are just for reference and may contain the whole feature of interest or perhaps just part. The latter is the case for Rik’s image (Fig 4 – Left). Nevertheless, it is useful in that we can see that everything looked normal in the southern part of the shadow captured in 2022. Looking for similar illumination images from the past, we have an image by Brendan Shaw from seven and a half years ago (Fig 4 – Centre) and an even earlier image by Mike Brown (BAA) from more than 13 years ago. None of these can be said to show anything unusual in the shadow. The Barnard observations were made with a sizable 36” telescope at Lick observatory. The 1958 TLP observation was made with a smaller 4” refractor, and was relatively short in duration. We should certainly keep a watch on this crater over selenographic colongitude ranges of 13° to 25°, which covers the span of those past four TLP – this should include visual observations, as well as CCD, in case the effect is seeing related? The ALPO/BAA TLP weight will be increased from 2 back up to 3.

Plato: On 2022 Jun 08 UT 21:25-21:40 Trevor Smith (BAA) observed visually this crater a few minutes after a $\pm 1^\circ$ similar illumination and topocentric libration to the following report:

Plato 1932 Apr 15 UT 06:57 Observed by A.V. Goddard & friend (Portland, Oregon, USA, 16" telescope, S=G steady) "Sudden appearance of a white spot like a cloud of steam (in appearance only), and in less than a minute it had spread in a NW direction, until it almost reached the rim of the crater" NASA catalog weight=4. NASA catalog ID #403. ALPO/BAA weight=4.

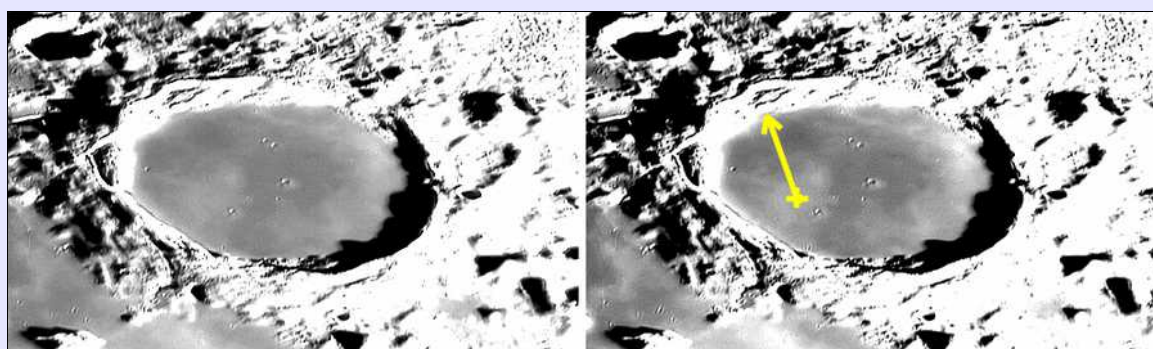


Figure 5. Plato as imaged by Maurizio Cecchi (UAI) on 2014 Nov 02 UT 17:35 and orientated with north towards the top and slightly to the right. **(Left)** The original image but contrast stretched to bring out detail on the floor. **(Right)** The same image but with a cross added to show the location of the 1932 sudden white spot, and an arrow to indicate the approximate direction of travel of the expanding cloud.

Trevor (BAA) was also using a 16” reflector and commented: “...*observed visually this crater under similar illumination and topocentric libration to the following report “I looked and just saw the central craterlet as a whitish ‘spot’. Some 20 km to the west was a whitish smudge which came and went with the seeing (Ant IV). No other detail was visible on the floor of Plato and I think it was simply one of the normal whitish patches which are usually present!”*. The reason why the 1932 report was given an ALPO/BAA weight of 4 was because two observers were involved, the scope was large (like Trevor’s), the seeing was good, no other craterlets were seen on the floor, there was a sudden change and the effect expanded until it reached the rim of Plato. Just for reference, Fig 5 (Left) is a similar illumination image, a few minutes outside the $\pm 0.5^\circ$ observing widow predictions. This certainly shows some

light albedo markings which could give the impression of cloud on the floor of the crater, but the sudden appearance and cloud expansion are not normal. The original report by Goddard, published in the 1932 edition of [Popular Astronomy](#), vol 40, p316, actually gives a coordinate of the appearance of the white spot at 10°W, 51°N, and assuming the distance to the rim was 50 km (See Fig 5 – Right) and “less than .a minute” could be anything from 30 sec to 59 sec, then the velocity of the cloud would have been anywhere from 0.8 to 1.7 km/s. So, what I am wondering here is whether this was a glancing blow impact from the south east, and then the expansion of the ejecta cloud on a north westerly direction? If so, it may be difficult to find the crater without a before and after image, but possible candidates would be elongated or double, have rocky rims, and may show an ejecta pattern towards the NW though this would probably be very subtle and you might want to divide two images of the same area at different phases in order to enhance this?

Aristarchus: On 2022 Jun 10 UAI observers: Aldo Tonon and Luigi Zanatta imaged this crater for the following Lunar Schedule request:

ALPO Request: On 2013 Apr 22 Paul Zeller noticed that the two closely spaced NW dark bands in Aristarchus had some (non-blue) colour to them. Can we confirm his observation of natural colour here? Ideally you should be using a telescope of 10" aperture, or larger. Please send any high resolution colour images, detailed sketches, or visual descriptions to: a t c @ a b e r . a c . u k

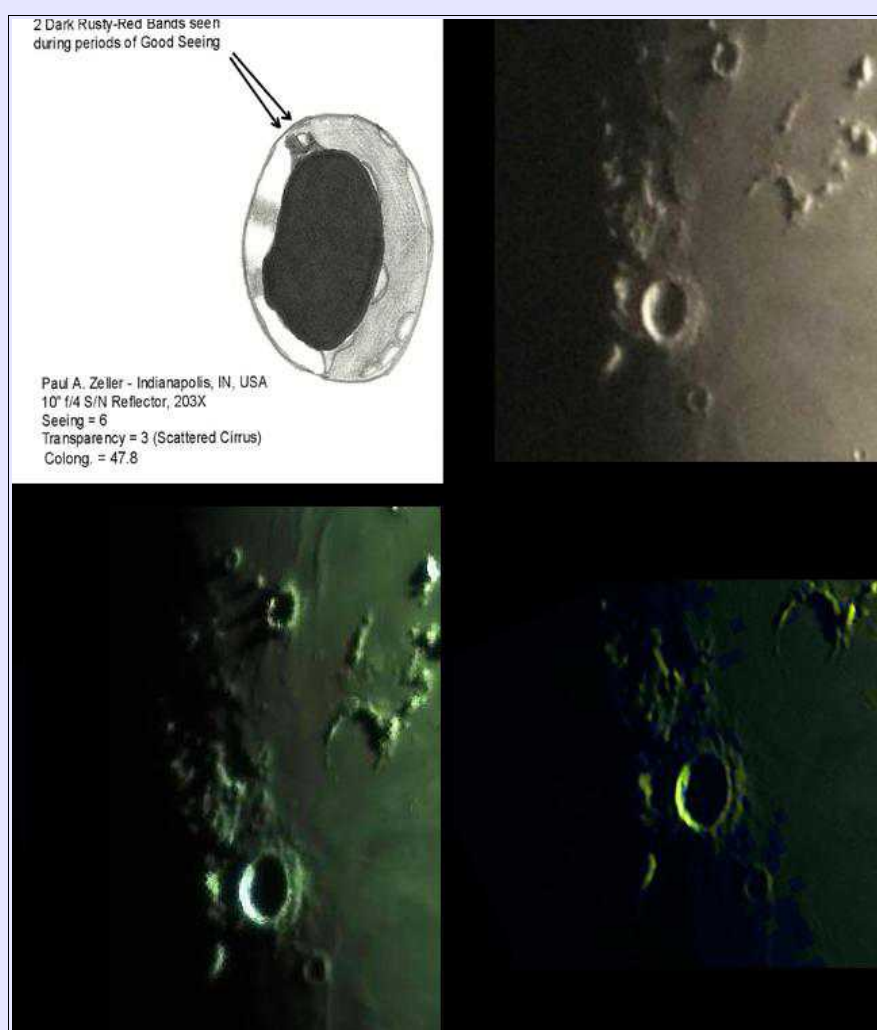


Figure 6. Aristarchus orientated with north towards the top. **(Top Left)** A sketch by Paul Zeller from 2013 Apr 22 UT 01:43. The text on this sketch has been re-orientated to comply with north towards the top. **(Top Right)** An image by Paul Zeller made on 2013 Apr 22 UT 02:37 with colour saturation increased to 60%. **(Bottom Left)** An image by Luigi Zanatta (UAI) made on 2022 Jun 10 UT 22:35 with colour saturation increased to 60%. **(Bottom Right)** An image by Aldo Tonon (UAI) made on 2022 Jun 10 UT 22:59 with colour saturation increased to 60%.

As we can see from Paul Zeller’s sketch (Fig 6 – Top Left), the rusty red bands sit on the NW rim on the border between the illuminated rim and the shaded north rim. Alas Paul’s attempt to capture these in an image did not

succeed as the resolution was not good enough. Luigi and Aldo have since tried, with higher resolution, under similar illumination, but again the resolution is not quite enough to detect the rusty red colour here – assuming it was natural? This is despite having the colour saturation in their images increased. We shall leave the weight of this observation at 1 for now. This TLP has been covered in previous newsletter in: [2013 Jun](#), [2017 May](#), [2018 Oct](#), [2021 Jan](#) and [2021 Mar](#).

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 . By re-observing and submitting your observations, only this way 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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