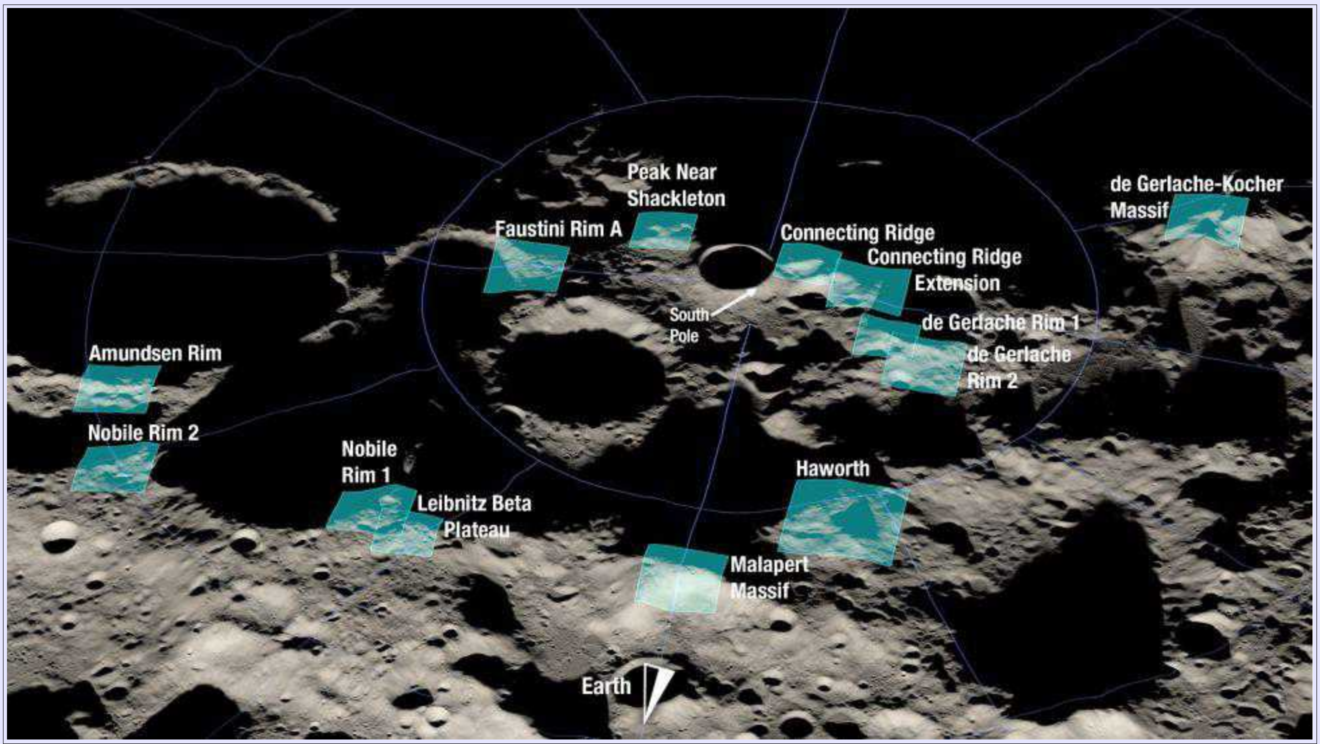

## From the Director.

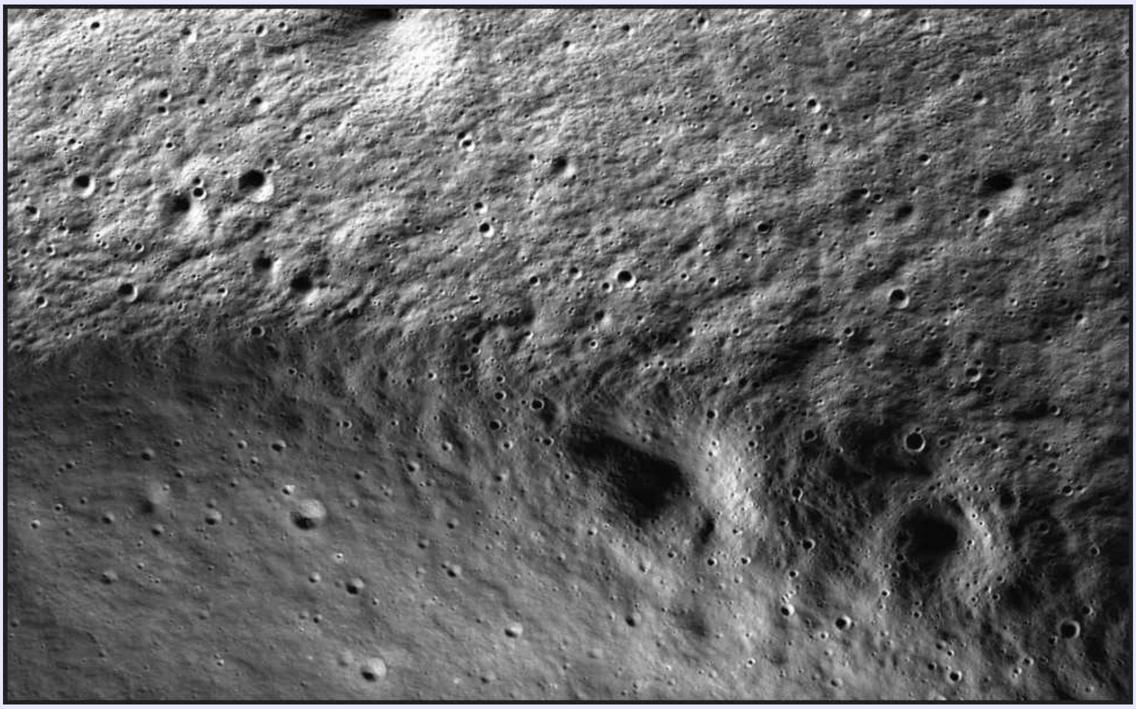



**The Lunar South Pole Area with potential Artemis 3 landing sites mapped out. Taken by the LROC camera on 2023 Mar 03. Image Credit: NASA/GSFC/Arizona State University**

Although the Artemis 2 manned flyby flight around the Moon is not until Nov next year, NASA is hard at work already on planning the next crewed Artemis 3 landing on the Moon, sometime during, or after, Dec 2025. That will of course depend of upon Elon Musk's Space-X getting his Starship rocket, mounted on a 32 engine Super Heavy first stage, launched successfully, checked out and proven to be flight worthy and reliable. A version of the Starship rocket, known as Starship Human Landing System (HLS) has been selected by NASA to land the Artemis 3 crew on the Moon. We should learn, sometime this month, which lucky 4 astronauts will be selected for the 10 day orbital flight. It is also possible that Space-X may send a team of artists on a "dearMoon" mission around the Moon prior to the Artemis 3 landing attempt, but presumably after NASA's Artemis 2 lunar flyby?

Anyway if you were out observing on 2023 Mar 03, please check to see if you have any images of the lunar south pole area, if so it might be of interest to see if you can spot the potential landing sites that NASA has selected for Artemis 3. Alternatively check out imagery you have taken in the past or from the sketches in Harold Hill's "A Portfolio of Lunar Drawings". Note that the side of the Moon facing Earth is at the bottom of the map shown above. These sites have been selected for at least five reasons: (1) a fairly flat, boulder less area that is safe to land on, (2) good illumination from the Sun for much of the time of the anticipated landing, (3) favourable libration to give good direct communication with Earth, during the landing - note that most of the sites are earth-side rather than far-side, because of this requirement, (4) a variety of geology to explore, (5) good traversal access to permanently shadowed areas where ice maybe present and/or areas where ice may just be a short depth below the surface.

Note that all of these sites appear to be on mountain tops plateaus, or ridges, or rims, so one presumes that all surface exploration will be down-hill, initially, and probably fairly quickly. After exploring lowland sites, such as permanently shadowed craters, one could imagine a lot of time would have to be factored in for the climb back up hill again – though it may not be quite as strenuous as on Earth as the gravity is just 1/6$^{th}$. Another odd thing about missions to the south pole is that the Sun will be shining horizontally, so all the shadows of the: rocks and the astronauts themselves, will be incredibly long, unless projected onto a slope. To cope with this the astronaut space suits (AxEMUs) are equipped with 4 powerful lamps at the top of the helmet.



**A ShadowCam image of Marvin crater taken on 2023 Feb 28, with part of the crater in the lower half of the image (Image credit: NASA/KARI/Arizona State University).**

Changing the topic slightly from manned to unmanned mission, Korea's Danuri orbiter, is now successfully taking images inside permanently shadowed areas near the south pole using NASA's ShadowCam. It is 200 times more sensitive than NASA existing LROC NAC camera. ShadowCam is capable of seeing inside shadows using illumination from scattered light from illuminated craters rims and/or using earthshine to illuminate the surface. You can tell this is the case in the image above because if you look closely at crater shadows there is some variation in direction. The illuminated rim is way off of the left side and bottom left of the image, out of view.

Tony Cook.

P.S. Congratulations to our Lunar Domes coordinator: Raffaello Lena, for being co-author on an abstract concerning: *"Spectral and Morphometric Properties of the Fracastorius Crater Lunar Dome"*, at this year's Lunar and Planetary Science Conference.

**Lunar Occultations April 2023.**
**By Tim Haymes.**

**Time capsule: 50 year ago: in Vol 8 No.4**

*L E Fitton: A New TLP Analysis Technique. Red and Blue filters for luminous gas.
*Project Fade: Zeta Cancri is this month's priority, and a known multiple star.

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

**Zeta Cnc ( ZC1236) from the Occult Database**

Observations in 1973 April were recorded by A Savill (Selsey) and G Buss (Bognor). There are two other observations without a name. K Hall (Warrington) made an observation in 1991 November 26.
He observed no double star effects with a 10cm refractor with dark limb visible. With the benefits of Occult4 software we can predict on that night, two possible step events for zeta Cancri of duration 1.7 and 4sec.

**In April:**

The evenings of the 24th and 25th April will see the Moon occult stars in Gemini at a favourable crescent illumination. Here is an excellent opportunity to collect a good number of occultation timings in a few evening sessions. The challenge is "how many" and how to identify the fainter ones not in the list. Certainly those fainter than mag 8.5 will be quite easy with a video camera. A sketch of the limb and any Earth lit features will help in estimating the Cusp Angle, and a note of the approximate star magnitude would help with identification.

**Report Lunar timings:**

Reporting with the program *lunarreport.exe* is simple, but to identify fainter stars the use of the Occult4 is needed. Not everyone wants to install this, so the subsection offers an identification service. Another option would be to request predictions for your location on those days down to magnitude 10.

I can send you a list which would be easier to inspect when many possible star are involved. We need to get the ID correct. There is no auto-analysis in Lunarreport to flag up an incorrect star identification. Occult4 can provide this function with an O-C value.

**Graze of SAO 77837 on April 24**

In the HBAA #3, the graze zone passes near St Austell and Newquay at about 2259UT. The star is magnitude is 6.0 and at the northern cusp.

**Lunar Impacts**

We must not forget the possibility of recording *lunar impacts* when the Moon is high at more sociable hours. The April Lyrids are active over this period and Earth shine should be prominent.

**Comet 29P (S-W 2)**

Currently being studied by the Comet Section (Mission-29P), will be occulted by the Moon on the morning of April 25th around 9am. Not relevant in itself, but somewhat unusual.

**(393) Lampetia on April 28, 0320UT**

IOTA predict an occultation of TYC 5706-09041-1 with duration up to 8 seconds. The UK path and details can be inspected here. https://www.asteroidoccultation.com/2023_04/0428_393_80580.htm

Visual observations are encouraged, since a comparison with video timings would be of interest to the writer. There are some useful mobile phone apps that can be used as a stopwatch and give UT times directly from GPS signals, such as Sat Timer.
Wishing all – good observing.

Tim Haymes.

**Occultation predictions for 2023 April (Times as other locations will +/- a few minutes)**

**Oxford: E. Longitude - 1 18 47, Latitude 51 55 40**
**To magnitude ca 8.5, Moon altitude >7 degrees.**

| yy | mmm | day d | Time h | m | s | P | Star No | Sp | Mag v | Mag r | % ill | Elon | Sun Alt | Moon Alt | Moon Az | CA o | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23 | Apr | 1 | 21 | 40 | 45.8 | D | 1444 | K0 | 7.8 | 7.1 | 83+ | 131 | | 56 | 191 | 52N | |
| 23 | Apr | 1 | 23 | 37 | 1.4 | D | 98813 | F8 | 8.4 | 8.1 | 84+ | 132 | | 46 | 232 | 81S | Mult* |
| 23 | Apr | 2 | 22 | 56 | 15.5 | D | 1553 | A0 | 7.8 | 7.8 | 90+ | 143 | | 49 | 202 | 90S | 78 Leo |
| 23 | Apr | 3 | 0 | 12 | 2.5 | D | 99227 | K0 | 8.2 | 7.6 | 90+ | 143 | | 43 | 226 | 48N | |
| 23 | Apr | 4 | 21 | 43 | 21.0 | D | 119212 | K0 | 7.5 | 6.9 | 98+ | 165 | | 36 | 149 | 51N | |
| 23 | Apr | 9 | 3 | 51 | 24.6 | R | 2206 | K0 | 7.0 | 6.4 | 90- | 144 | | 14 | 201 | 14N | |
| 23 | Apr | 10 | 3 | 34 | 8.6 | R | 2349 | B1 | 2.9 | | 83- | 132 | | 13 | 184 | 55S | sigma Sco |
| 23 | Apr | 11 | 4 | 29 | 52.9 | R | 2505 | K4 | 5.3 | 4.5 | 74- | 118 | -8 | 10 | 184 | 74S | 43 Oph |
| 23 | Apr | 22 | 20 | 8 | 28.9 | D | 612 | A3 | 7.6 | 7.4 | 8+ | 32 | -8 | 19 | 284 | 59S | Dbl* |
| 23 | Apr | 22 | 20 | 8 | 29.8 | D | 76475 | A3 | 7.7 | 7.5 | 8+ | 32 | -8 | 19 | 284 | 58S | Dbl* |
| 23 | Apr | 24 | 19 | 59 | 0.7 | D | 77804 | A0 | 7.3 | 7.1 | 22+ | 56 | -7 | 39 | 266 | 26N | |
| 23 | Apr | 24 | 20 | 8 | 47.7 | D | 906 | K1 | 6.6 | 6.1 | 22+ | 56 | -8 | 37 | 268 | 76S | Mult* |
| 23 | Apr | 24 | 22 | 32 | 5.0 | D | 77927 | A0 | 8.9 | 8.8 | 23+ | 57 | | 16 | 293 | 34S | |
| 23 | Apr | 24 | 23 | 3 | 33.9 | D | 77961 | B8 | 8.6 | 8.6 | 23+ | 57 | | 12 | 298 | 53S | |
| 23 | Apr | 25 | 19 | 58 | 42.1 | D X | 95186 | | 8.6 | 8.5 | 31+ | 67 | -6 | 47 | 254 | 73N | |
| 23 | Apr | 25 | 19 | 58 | 42.1 | D | 78862 | F0 | 8.6 | | 31+ | 67 | -6 | 47 | 254 | 73N | |
| 23 | Apr | 25 | 20 | 16 | 18.8 | D | 78873 | A2 | 7.8 | 7.7 | 31+ | 67 | -9 | 44 | 258 | 89S | |
| 23 | Apr | 25 | 20 | 20 | 41.0 | D | 1056 | B9 | 7.2 | 7.3 | 31+ | 67 | -9 | 44 | 259 | 81N | |
| 23 | Apr | 25 | 21 | 31 | 2.8 | D | 78916 | G5 | 8.4 | 8.0 | 31+ | 68 | | 33 | 273 | 59S | |
| 23 | Apr | 25 | 22 | 35 | 34.6 | D | 78957 | G8 | 7.5 | 7.0 | 31+ | 68 | | 23 | 284 | 52S | |
| 23 | Apr | 25 | 22 | 52 | 27.3 | D | 1067 | K2 | 7.1 | 6.4 | 32+ | 68 | | 21 | 287 | 52N | Dbl* |
| 23 | Apr | 25 | 23 | 57 | 34.4 | D | 1075 | G0 | 8.5 | 8.2 | 32+ | 69 | | 12 | 299 | 62N | |
| 23 | Apr | 26 | 0 | 0 | 58.2 | D | 79022 | K0 | 8.0 | 7.6 | 32+ | 69 | | 11 | 299 | 80S | |
| 23 | Apr | 29 | 22 | 2 | 19.7 | D | 99058 | K2 | 8.5 | 7.7 | 69+ | 112 | | 45 | 226 | 64S | |
| 23 | Apr | 30 | 21 | 26 | 56.7 | D | 99421 | K2 | 8.1 | 7.5 | 77+ | 123 | | 47 | 198 | 45N | Dbl* |
| 23 | May | 1 | 0 | 29 | 57.3 | D | 1613 | F5 | 8.1 | 7.9 | 78+ | 124 | | 27 | 249 | 89S | |

See the December 2022 issue of LSC for an explanation of the table.
*Detailed predictions at your location for 1 year are available upon request. Ask the* **Occultation Coordinator**: tvh dot observatory at btinternet dot com, or the Director.

**Interested in Grazes only? – Indicate your travel radius in Km and your home post code or nearest town. An aperture of 15cm will be used unless advised. More predictions will be generated by this process.**

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## Members Communications.

### E-Mail from Harry Warren on Lunar Mountains

I'm still astonished that generations of astronomers were so badly wrong in what they told us about lunar mountains. We were always led to believe the first explorers would encounter mountain ranges on the moon even more craggy, rugged and jagged than the Alps, the Himalayas, the Rockies, the Dolomites, etc., and then we were suddenly told, in the 1960s, that astronomers had got it completely wrong and that lunar mountains actually resembled nothing more than outsize lumps of plasticine. I don't remember anyone making much of it at the time either.

Tony Cook Replied:
I think the idea that lunar mountains were sharp and craggy came about in two ways, firstly the lunar gravity is about 1/6th that of the Earth, so the mountains could be taller. Secondly a book by Naysmith and Carpenter had some plates of artificial lunar landscapes made from plaster of Paris which were moulded and illuminated supposedly to resemble shadowed views of the Moon. Its possible that the cragginess was due to the nature of plaster of Paris looking craggy. In reality the mountains tend to be smooth as violent impacts and subsequent space weathering have resulted in coatings of ejecta, landslides etc covering up any craggy features. It also might be the case that a lot of crust is fragmented so there may not be contiguous giant pieces of mountains like we have here on Earth.

**Diophantus and Delisle.**
**By Nigel Longshaw.**

The drawing and images, along with Barry's excellent topographical interpretations of Diophantus and Delisle in the last circular created sufficient interest to delve a little deeper into the historical record. Having only passed a glance across these features in the past I had none of my own observations for comparison. But as Barry commented these features have been of interest within the section for rather a long time.

In fact the region attracted the attention of T.G.Elger, first director of the L.S., in 1887 sufficient for him to publish a lengthy description in his column 'Selenographical Notes' in the January 1888 issue of *The Observatory.*

Elger describes the 'ray like' feature observed by Paul Abel, and imaged by Bill Leatherbarrow as a '…*faint light strea*k', visible when the sun has attained an altitude of 4-5 degrees over the region. This he explained extends '*…from a small crater b* [on the northwest of Diophantus] *to the low white plateau a* (alpha) [1] *on the north of the ring plain, and terminating a little east of it*'. '*At this stage of illumination*', he goes on to say '… *the marking has an elongated spindle-shaped form, convex towards the north east*'. This description compares well with Harold Hill's depiction of the streak on page 73 of 'The Portfolio'.

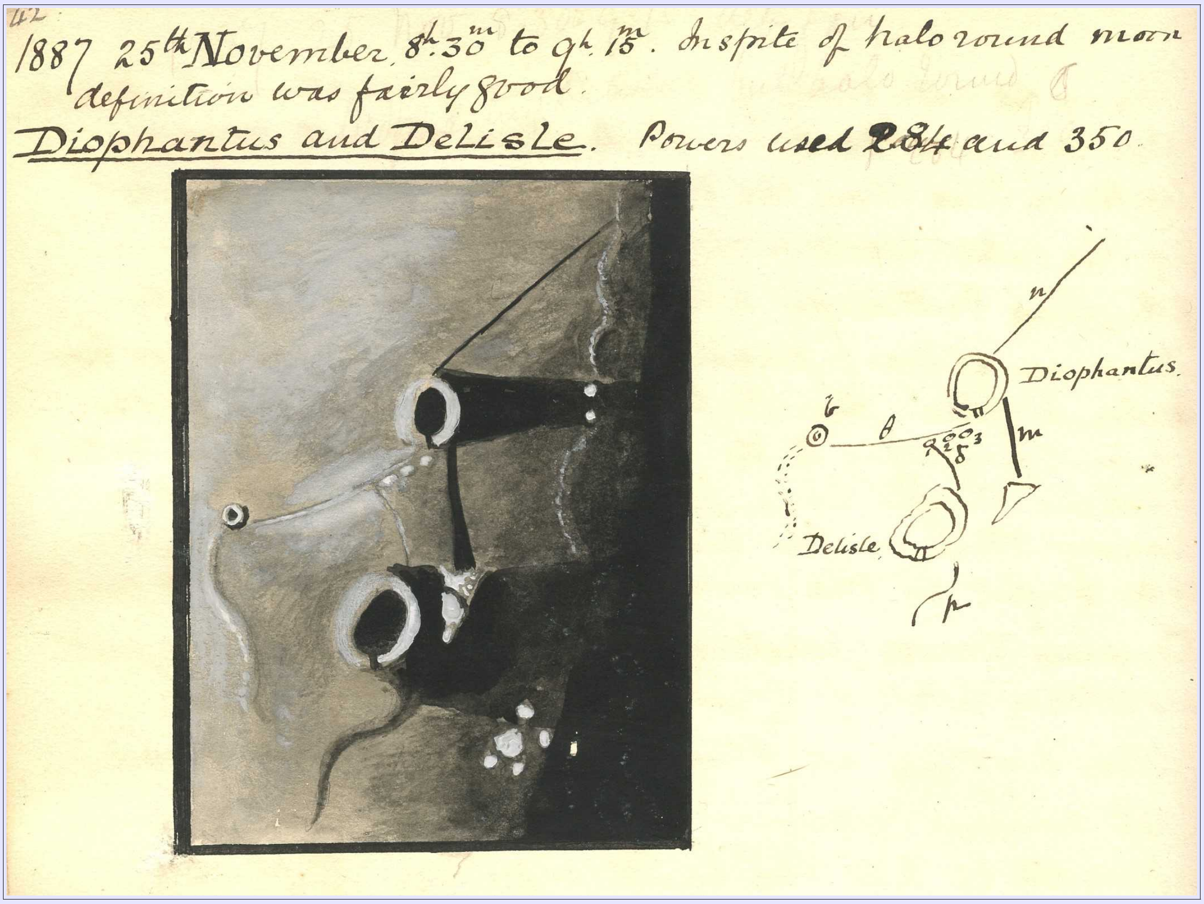


**Fig.1 extract from T.G.Elger's observing notebooks held in the B.A.A. archives.**

However, Elger goes on to say, '*While examining this feature* [light streak] *on the above date* [2] *with powers of 284 and 350 on an 8 ½ inch Claver-reflector, a cleft was discovered on its site running from the north side of Diophantus b, to the north boundary of the shadow thrown by the eastern side of Diophantus*'. In addition, in the location of Neison's 'plateau' Elger records '… *three minute white spots …bordering the northern flank of the cleft*'.

The apparent cleft and 'white spots' recorded by Elger are perhaps suggestive of partial resolution of the 'hummocky' terrain recorded in Bill's images in the last circular and which are described by Barry as '…*a line of secondary craters and their intervening ridges, arranged in an arc to the SW of Delisle, which is their parent* *crater. The fact that the humps and troughs of the secondary craters appear to follow the path of the ray is purely coincidental*'.

Did Elger interpret the partial resolution of this 'hummocky' terrain as a cleft? I have spent more time than I care to recall perusing Elger's drawings, and it does appear in several instances he was apt to depict unresolved and difficult detail as features with a linear tendency. Of course, one is bound to draw comparisons with the Martian canals, and perhaps he made a similar interpretation when he drew a distinct cleft in Vendelinus which created so much controversy when later observers had difficulty in recovering the feature as Elger drew it.

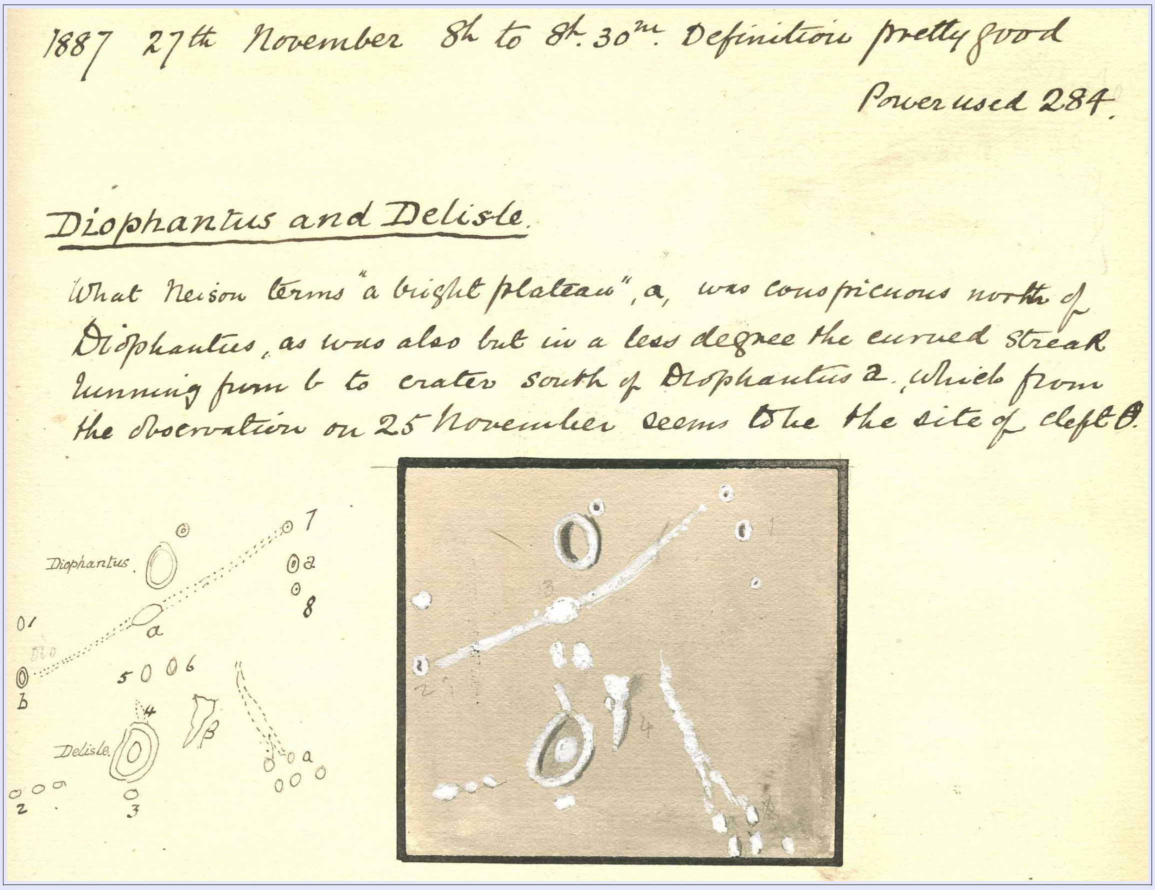


**Fig.2 extract from T.G.Elger's observing notebooks held in the B.A.A. archives.**

If nothing else the above does suggest that to successfully interpret the selenographical record a modicum of the particular observer's bias has to be taken into account.

**Notes:**

1. Here Elger is referring to a feature indicated by E. Neison on the relevant chart of the region in '*The Moon, and the condition and configuration of its surface'* published in 1876. Elger indicates that this feature is not easily seen under sunrise conditions but becomes '…so conspicuous at a later stage'. Harold Hill shows a small ridge in this location.
2. Elger was observing the region on 25th November 1887, between 8hrs and 10hrs.

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**Conjunction from Malta.**
**By Geoff White.**

I saw that T Haymes photographed the alignment of the Moon, Jupiter and Venus but it looks as though the photo wasn't included. I saw the same alignment on both February 21st and 22nd but hadn't thought of sending them to you as the quality of lunar photographs which you do publish are way above my efforts. I've included two photos which I took from our roof in Malta. We live here in the winter.

The image on the left was taken on February 21st at 1725 UT and the image on the right was taken on February 22nd at 1749 UT. Being further south than the UK the three objects are much higher in the sky. They are only snaps, though, taken on my mobile phone.

**Conjunction from Malta.**

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**Conjunction images from West Wales.**
**By Rob Davies.**

**The Moon, Jupiter and Venus on 23rd of Feb 2023. Details Nikon D750 1/2sec, F2.8, ISO 100 at 38mm.**

## Members Images and Drawings.

### Waxing Moon.

**Image by John Axtell using a Canon EOS550D mounted straight into the focuser of a Obsession 15" Classic (an un-driven Dobsonian). Taken on 27th Jan at 19.32, 1/400 sec, ISO 800.**

**Geological Notes:** If you look at this image and squint so that it goes out of focus (alternatively just take your glasses off) you will have a reasonable impression of the view Galileo had using his rudimentary telescope. His drawings which are frequently reproduced show the terminator passing through a conspicuous circular feature below the centre of the disc, this might represent Theophilus, as this crater is so conspicuous on the waxing moon as can be seen in John's image.

**Gassendi.**


**Image by Alexander Vandenbohede with details of equipment, time/date in caption.**

**Geological Notes:** In this image the graben Rimae Mersenius can be seen to the west of Gassendi, running from near the eastern rim Mersenius northwards before apparently disappearing near the small keyhole shaped crater Letronne K. Towards the right of the frame is the somewhat pear shaped Agatharchides, and to the north of it you can see a structure termed 'The Helmet' a patch of raised terrain surrounded by mare lavas. It has a rounded southern edge and a bay to the north and the low terrain forming it has a distinctly reddish hue. The elongate hill catching the sun that juts out into the northern bay is Herigonius $\eta$ and the smaller, apparently double one near the southern edge is Herigonius $\pi$. This area is not an area of highland material but is suspected to be a volcanic feature, composed of more silicic material similar to the terrestrial volcanic rock rhyolite, and of a Nectarian age.

The small (15kms diam) heart shaped crater to the north-east of Gassendi is Herigonius. This crater gives its name to the spectacular sinuous rille Rimae Herigonius which emerges from the wrinkle ridge you can see to the north-west of Herigonius and flows southwards into the mare filled bay to the east of Gassendi. The small patch of highlands that form the eastern side of this bay were informally called the Andreus Hills and are named accordingly on the Rand McNally moon map and its derivatives, the name does not however appear to be an IAU accepted one. The western edge of these hills have a slightly lower albedo than the eastern part, and this seems to be due to deposits of volcanic material that drape the slopes. These originate from volcanic vents that are possibly now submerged beneath the mare lavas.

**Maurolycus and Janssen.**

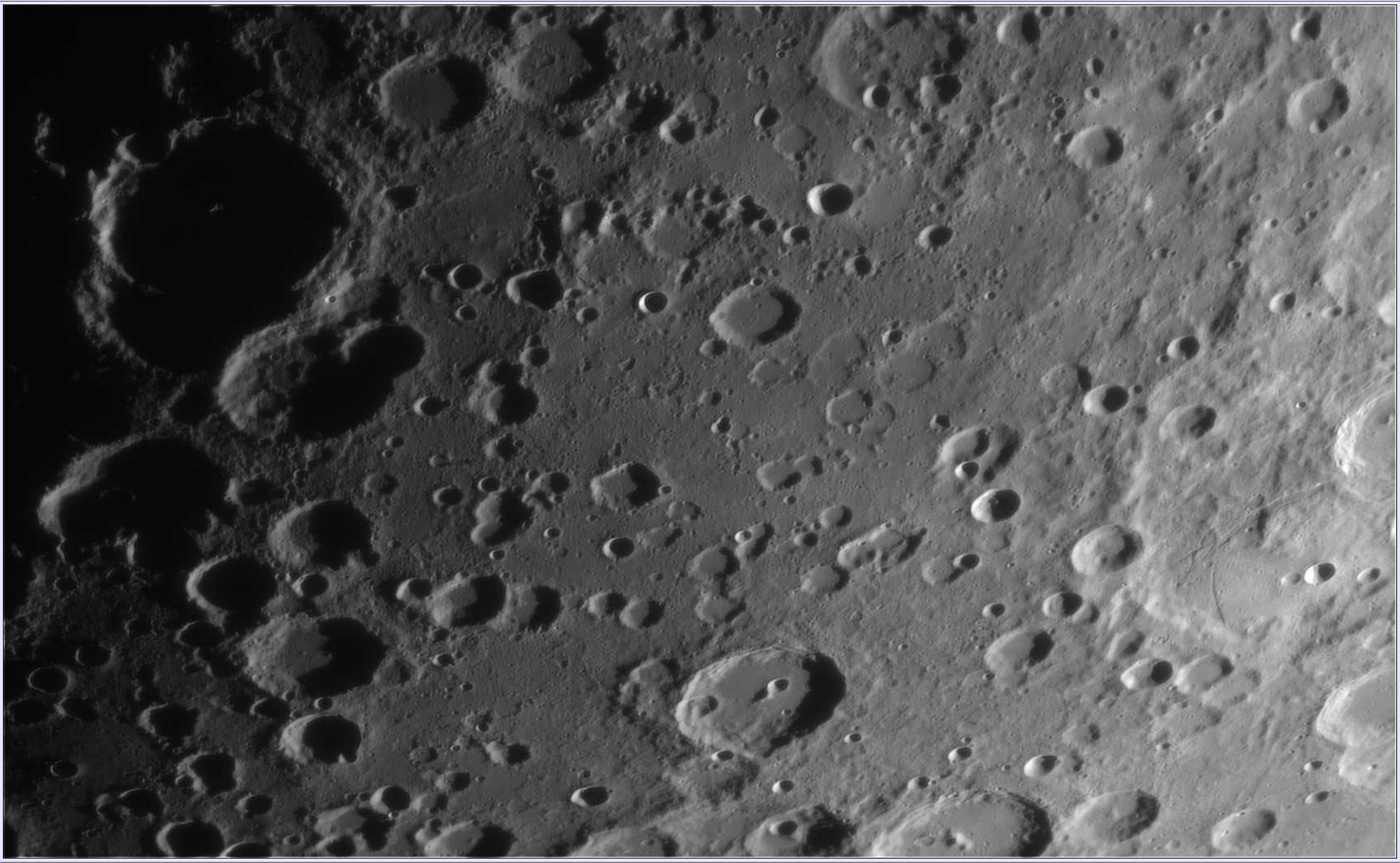


**Image by Bill Leathebarrow taken on 26th Feb 2023 at 1916UT.**

**Geological Notes:** The craters Maurolycus and Janssen, whilst interesting in themselves bracket a part of the southern highlands that appears to be oddly relatively free of large craters, and composed of light plains with a sprinkling of smaller craters, many of which may be basin secondaries. This dearth of big craters might be something to do with the proposed Mutus-Vlacq basin, the central part of which (if it exists) is located just to the west of Pitiscus and north of Asclepi, which is slightly truncated by the lower edge of the frame. The GRAIL gravity data shows a slight thinning of the crust in this area and beneath Asclepi, as well as a positive Bouguer gravity anomaly, which might support the basin interpretation, but there is a distinct absence of any real topographic features that might indicate its presence. If there was an ancient basin here, it might account for the lack of larger craters from early lunar history, as these might be present but obscured beneath the light plains which subsequently filled the low lying basin.

Pitiscus is a crater I try and monitor as often as I can as it was the site of a TLP report that I mentioned in a previous LSC* where I noted that "*An interesting TLP report dates from from September 6th 1981 (01:00 to 01:30 UT) when a bright glowing cloud was photographed on the floor of the crater Pitiscus by Gary Slayton of Fort Lauderdale, Florida using a 8" reflector. As well as being photographed, the event was observed visually and was described as having a grey colouration with a tinge of red*." Despite its rather ancient look there are a surprising number of relatively youthful geological features within the crater including evidence for avalanches off the central peak and lobate scarps which cross the crater floor. You might also notice the rather straight looking southern rim of the crater, you can see that it is parallel to the straight southern rim of Janssen, and both alignments were identified as being part of the hypothesised 'Lunar Grid' system. It is quite possible that these two alignments reflect deep crustal fractures that formed as a result of the cataclysmic impact that produced the South Pole–Aitken basin. The image also shows how the northern part of Janssen is covered by ejecta from the Nectaris basin, which is called, logically enough the 'Janssen Formation', though it is distributed far more widely than just within Janssen.

*Lunar Section Circular Vol. 57 No. 3 March 2020.

**Atlas and Hercules.**

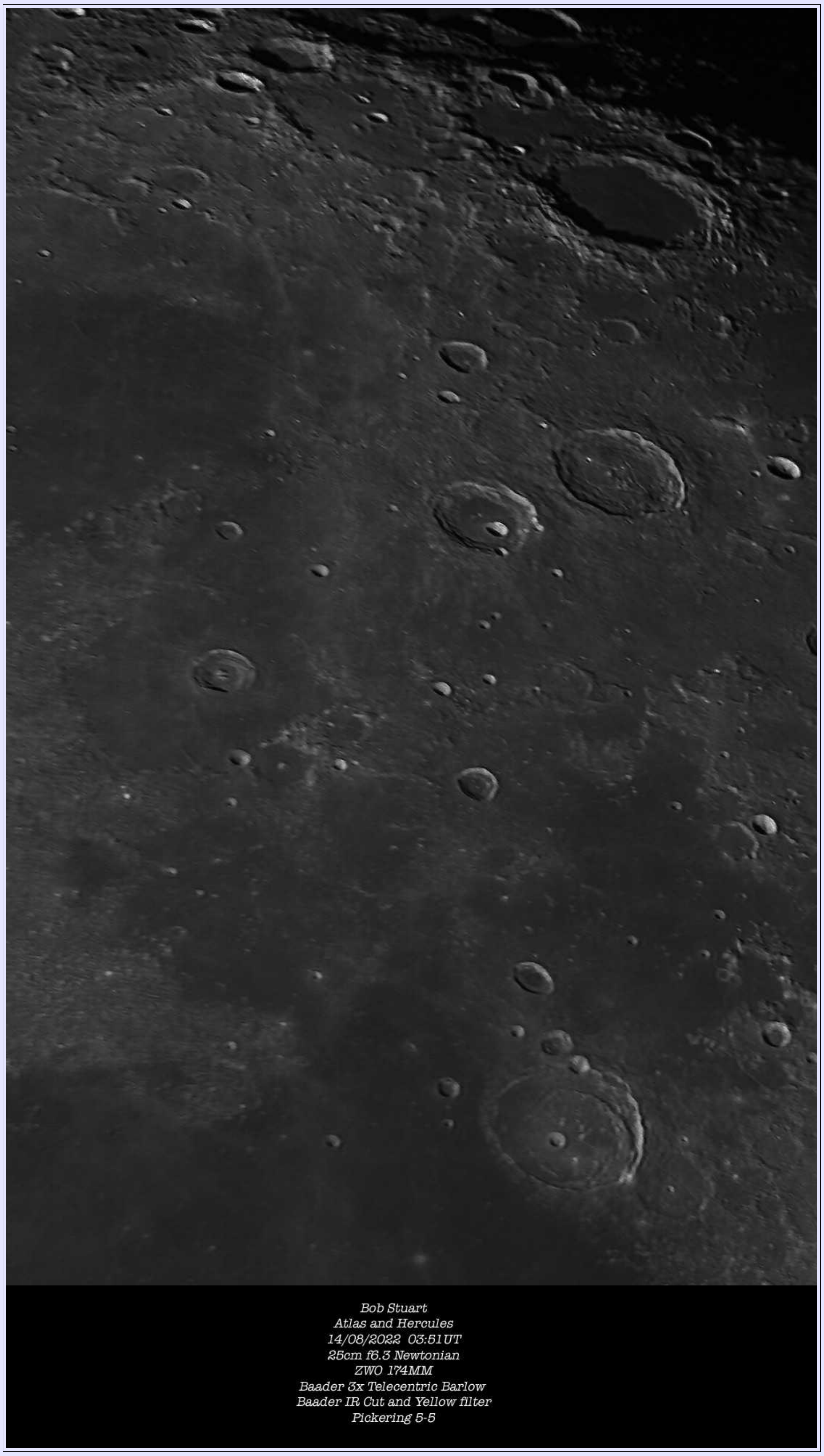



**Image by Bob Stuart with details of equipment and time/date in caption.**

**Geological Notes:** Bob's image stretches from approximately 25°to 65° north, from the northern part of Mare Serenitatis to just beyond the 135km diameter crater De La Rue which has two conspicuous craters on its floor, the larger De La Rue J and a smaller keyhole shaped one to its north which may be a binary impact structure. The light plains covering the crater floor also partially obscure a number of other more ancient craters in the 20km+ diameter size range. Dating probably to the pre-Nectarian it is difficult to tell whether De La Rue is composed of one or more ancient craters, there are some low hills near De La Rue J that may represent part of a peak-ring of a single large crater, but this is uncertain. The crater floor, particularly to the north is draped in bright ejecta from Thales, which is the fresh looking 30km diameter crater perched just outside the north-western rim.

**Heraclitus.**

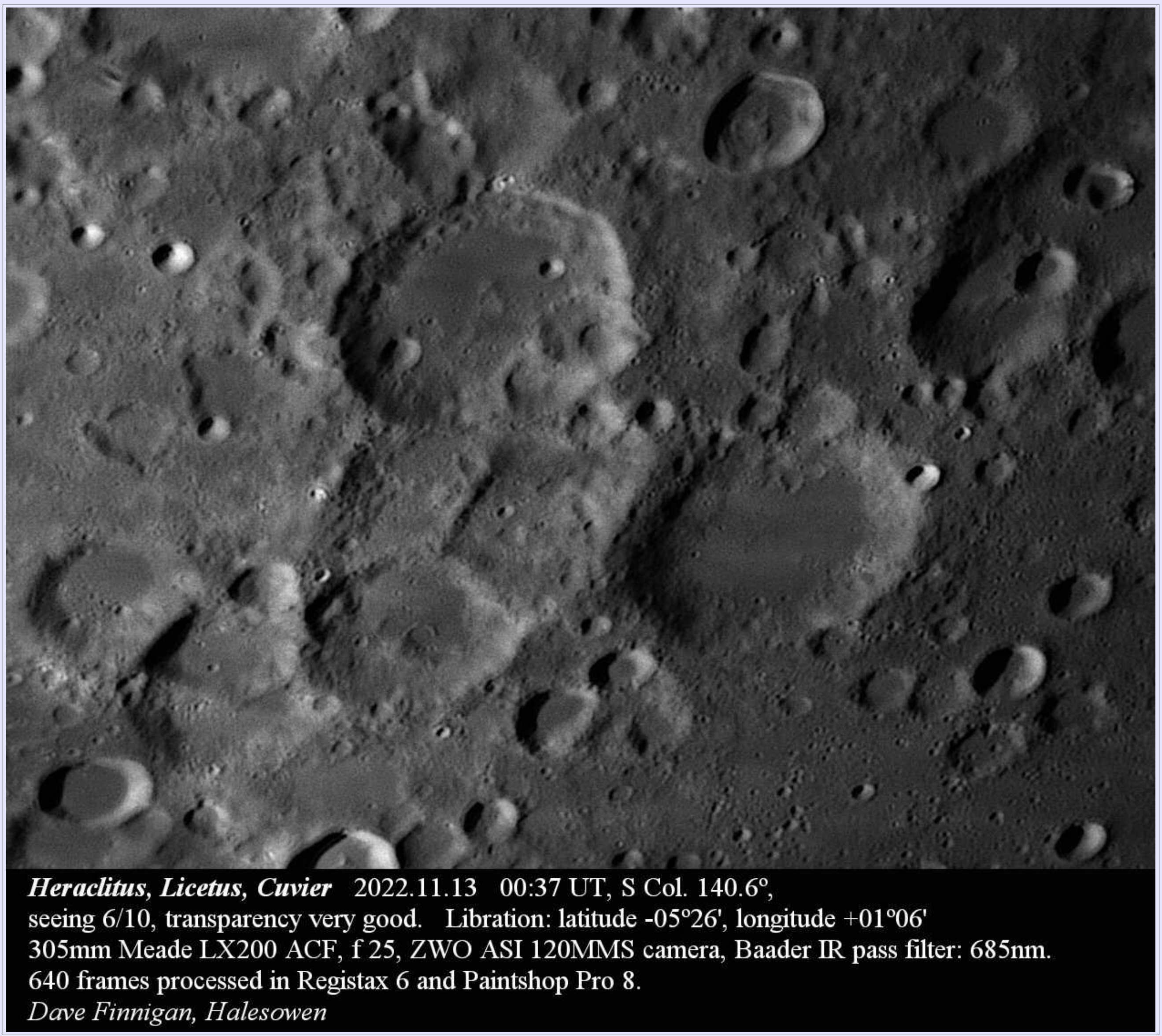



**Image by Dave Finnegan with details of equipment and time/date in caption.**

**Geological Notes:** Heraclitus really is a tricky subject and working out exactly what it is far from easy. Dave's image shows the main crater Heraclitus, with somewhat straight rims and a central ridge all somewhat parallel to each other and orientated NNE-SSW. The northern end of Heraclitus is truncated by Licetus and the southern part by Heraclitus D, with the northern rim of the latter producing a Y shaped ridge where it apparently meets the Heraclitus central ridge. Both Licetus and Heraclitus D are much deeper that Heraclitus itself (~2,500 and 2,000m respectively) suggesting that they are much younger. The most obvious interpretation is that Heraclitus is an ancient, smaller version of the elongate crater Schiller (with its parallel rims and elongate central peak) and that the younger Licetus and Heraclitus D partially demolished the northern and southern ends of the older crater. I am not totally convinced myself that this is the correct interpretation, but in the absence of a more convincing explanation it is probably the most probable one.

There is a lobate scarp running up the western part of Heraclitus and in to the western part of Licetus – these features are believed to be relatively young in lunar terms. In Heraclitus however this scarp is smothered and scoured by Tycho ejecta, so if the 108My age estimates for Tycho are to be believed, these scarps are older, giving you an idea of how young a young lunar feature actually is. Towards the bottom left of the frame is the small (27km diameter) crater Deluc C, which appears to have a smooth mare like floor. This smooth floor is however probably not mare basalt, but an impact melt deposit that originates from the Tycho impact, as this crater is only 350kms away to the NW so well within the range of its ejecta.

**Thebit.**

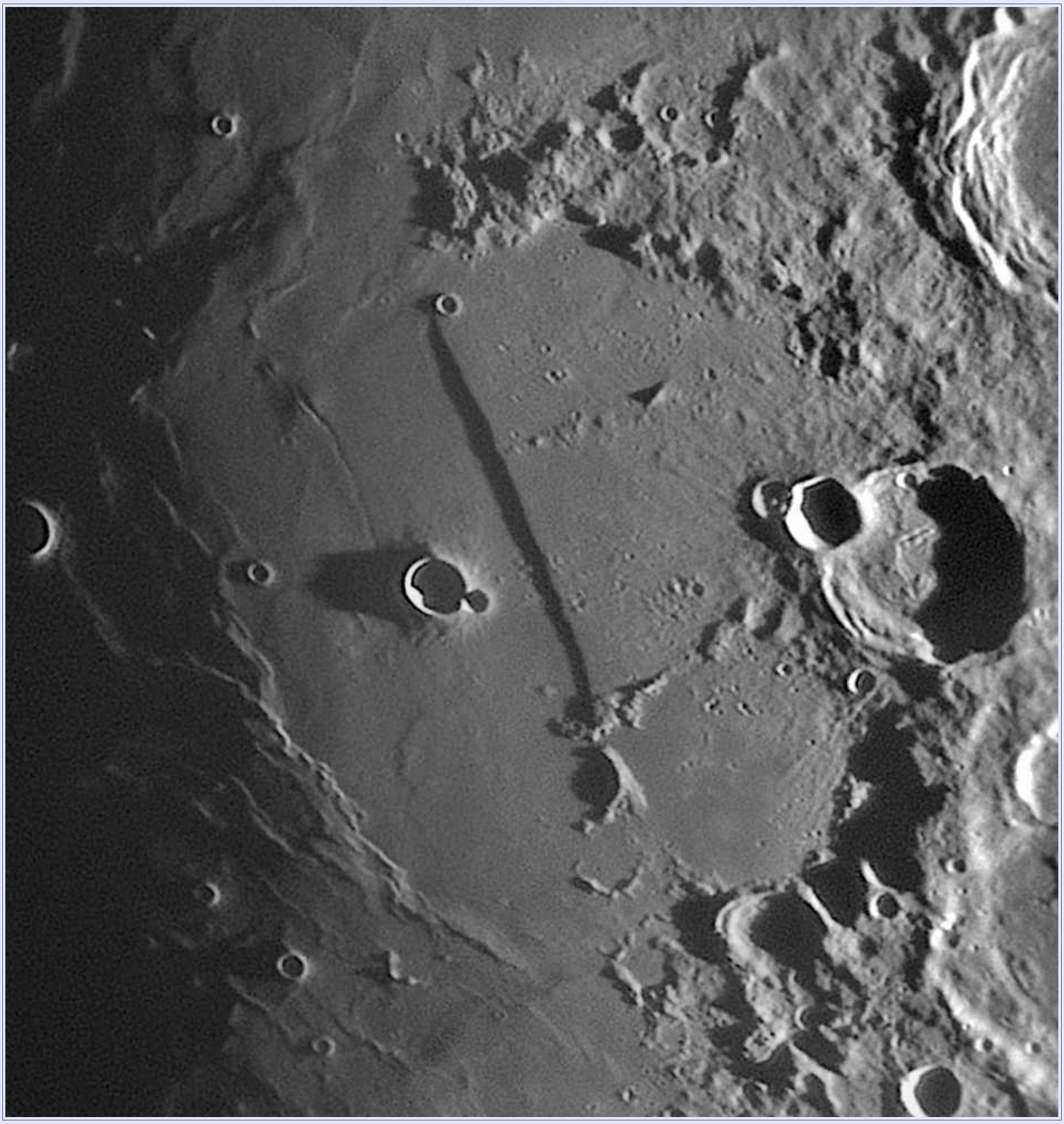
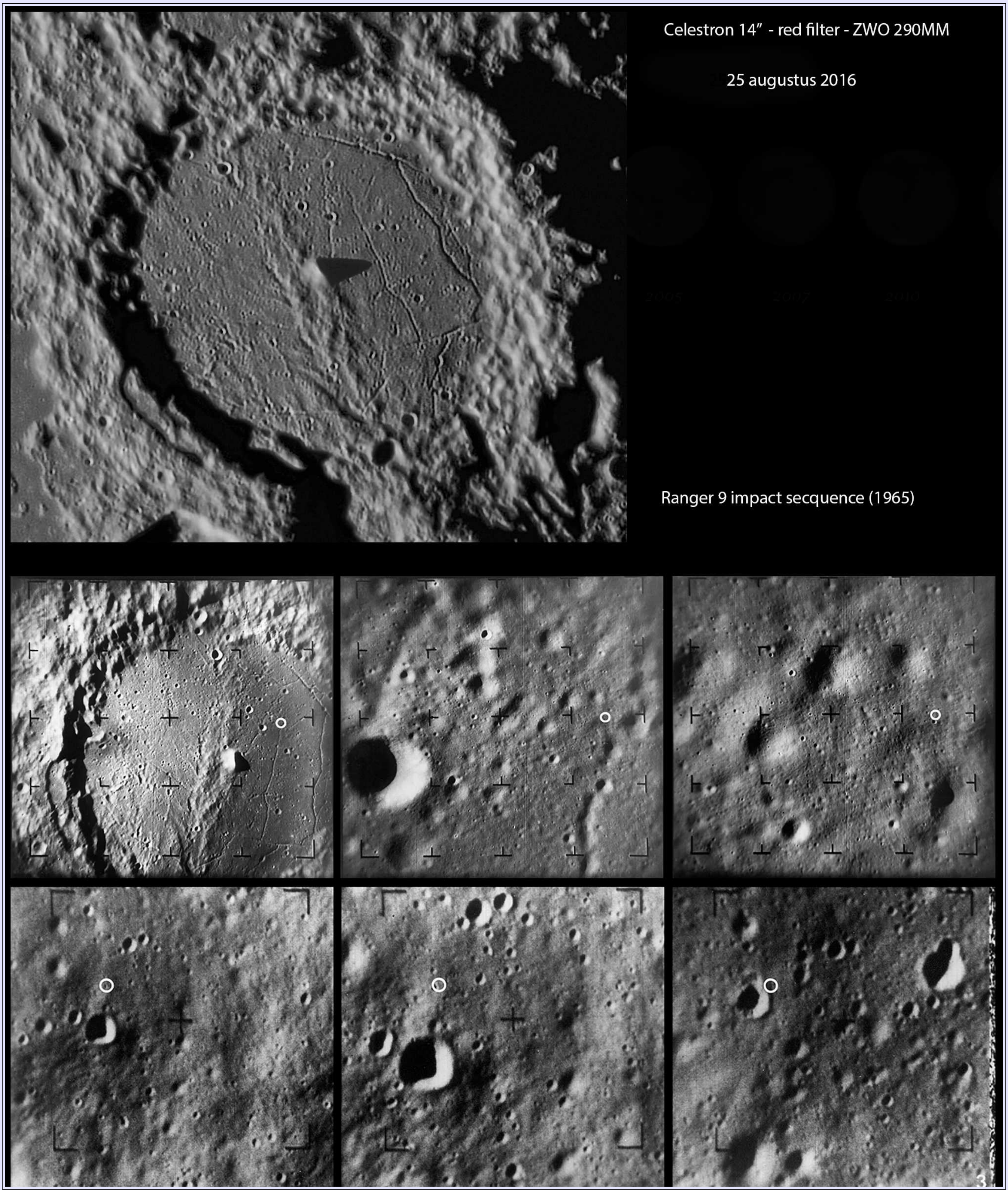


**Image by K.C.Pau taken with a 250mm f/6 Newtonian +2.5X barlow with QHYCCD290M camera.**

**Geological Notes:** This image should be viewed alongside Raf Lena's article later in the LSC regarding the Birt domes and associated deposits. Clearly visible in this image are the accumulations of pyroclastic material around the vents at the northern end of Rima Birt, with the wide cleft of Birt E conspicuous. The southern end of the rima is in the shadow cast by Birt crater, and this image clearly shows how the ejecta encompasses both Birt and Birt A which is a result of them being a binary (simultaneous) impact pair. The same can be said for Thebit A and L which I strongly suspect is another binary pair. The outline of the proposed 'Ancient Thebit' crater can be seen with the eastern rim visible, but the western represented only by a semi-circular arrangement of wrinkle ridges. These ridges appear to be underlain by a positive Bouguer gravity gradient (see the GRAIL overlay in Quickmap) that form part of the roughly hexagonal configuration of gravity anomalies that surrounds the Procellarum basin and which is thought to represent the upwelling of dense magmas into fissures that formed as the lunar globe shrank due to cooling. If this is the case then it might suggest that the 'Ancient Thebit' pre-dates this global shrinkage, with the fissures that formed as a result following the course of even older cracks that formed around the the ancient crater's circumference.

**Alphonsus.**




**Main image by Leo Aerts imaged on August 25th 2016 with a Celestron C14. Lower six images are from the Ranger 9 (1965) image sequence for comparison.**

**Geological Notes:** Leo's image compares very favourably with the first image in the Ranger sequence. The main image by Leo clearly shows the difference between the eastern and western crater floor, with the former being lower and more rugged than the latter, and separated by the central ridge which is composed of ejecta from Arzachel to the south.

**Hipparchus.**

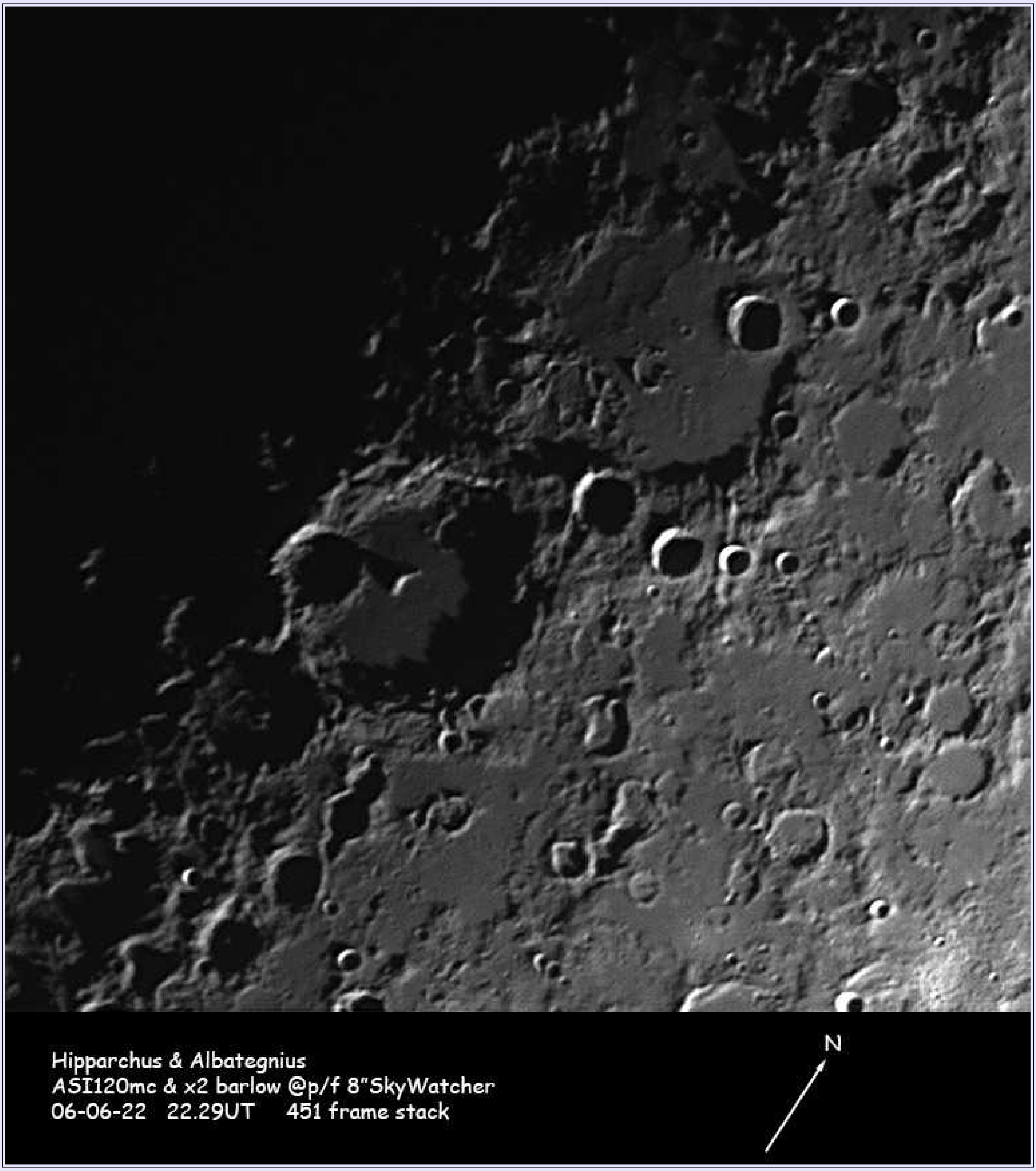



**Image by Les Fry with details of equipment and time/date in caption.**

**Geological Notes.** The 143km diameter pre-Nectarian crater Hipparchus is extremely shallow for its size, with the light plains forming its floor only 1000m or so below the battered remnants of its rim. This is probably as a result of deeply in-filling with ejecta from basin and other younger impacts. The adjacent Albategnius has a distinctly offset central peak, displaced approximately 10kms to the west of the craters geometric centre. Why this is so is something of a mystery but it *may* have something to do a subsurface body of magma to the east of the central peak which shows up in the GRAIL gravity data. The high albedo patch you can see in the bottom right marks the Descartes crustal magnetic anomaly, which is one of the strongest on the Moon (24 nT) and the strongest on the nearside. Elsewhere these anomalies are associated with lunar swirls such as Reiner Gamma where magnetic shielding is thought to prevent space weathering, the same process applies to Descartes, but there is no swirl structure just a high albedo patch.

**Arzachel**

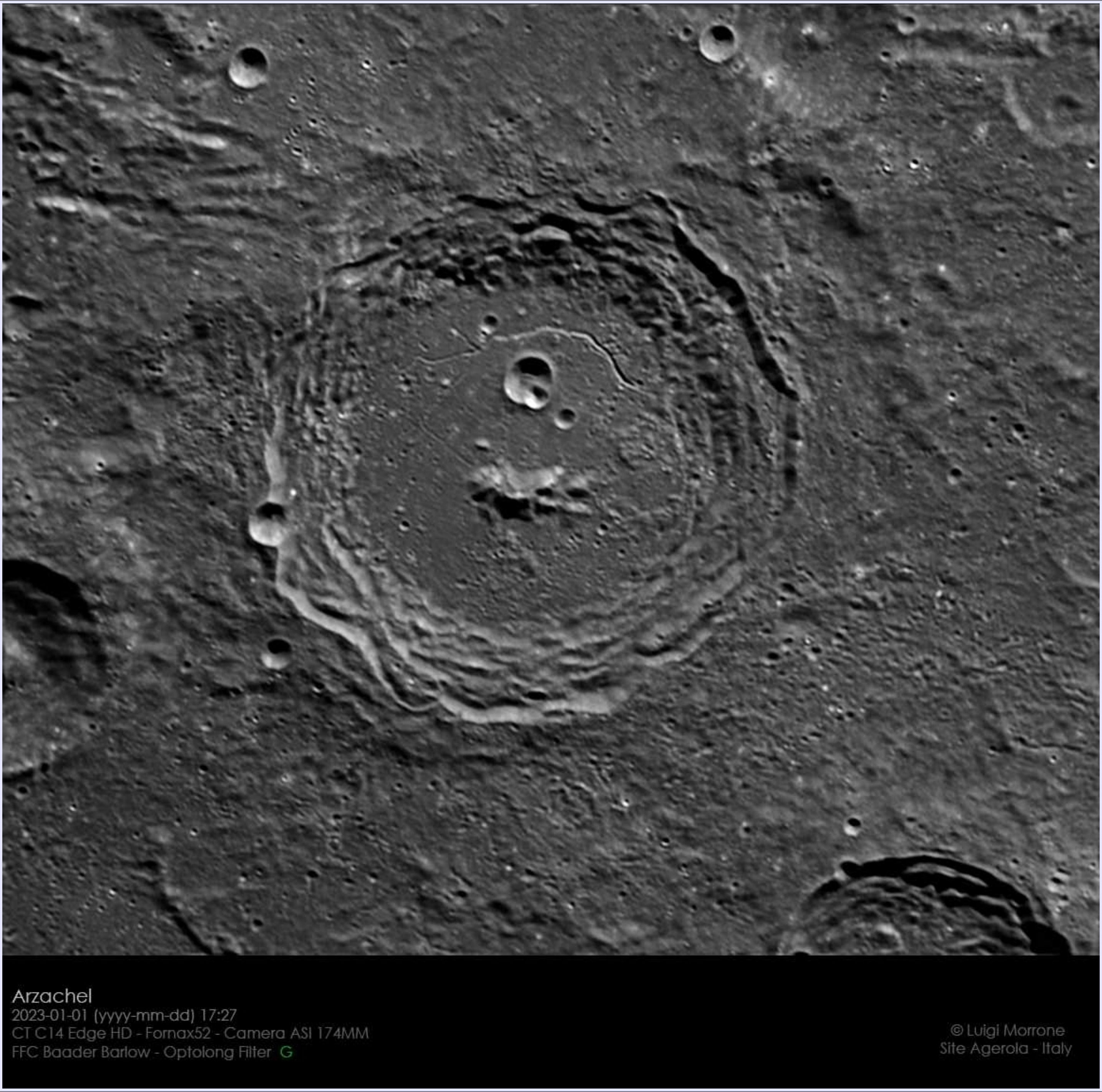



**Image by Luigi Morone with details of equipment and time/date in caption. (North is to the left in this image)**

**Geological Notes:** Another image taken using a Celestron C14 which demonstrates why this telescope is a favourite with planetary imagers! As with the crater Albategnius which we saw in Les Fry's image previously, the central peak of Arzachel is also displaced from the geometric centre of the crater. Again the displacement is to the west, and there is also a Bouguer gravity anomaly to the east of the peak that may be implicated. Arzachel is obviously a Floor Fracture Crater, and it appears that there is an older complex of fractures as well as a younger set which includes the prominent one running approximately parallel to the eastern rim. The crater is about 2,700m deep which might be a tad on the shallow side for a crater of this diameter (96kms) suggesting that the floor has been uplifted – which is why the floor fractures formed. If this is the case it is possible that a slab of the crater floor became detached from the basement and moved not only upwards but sideways under the influence of magma rising from beneath. Notice also that both the central peak here and in Albategnius are rather chevron shaped with the concave side to the east – which might possibly be the result of a lateral displacement of some form.

**Theophilus, Cyrillus and Catharina.**

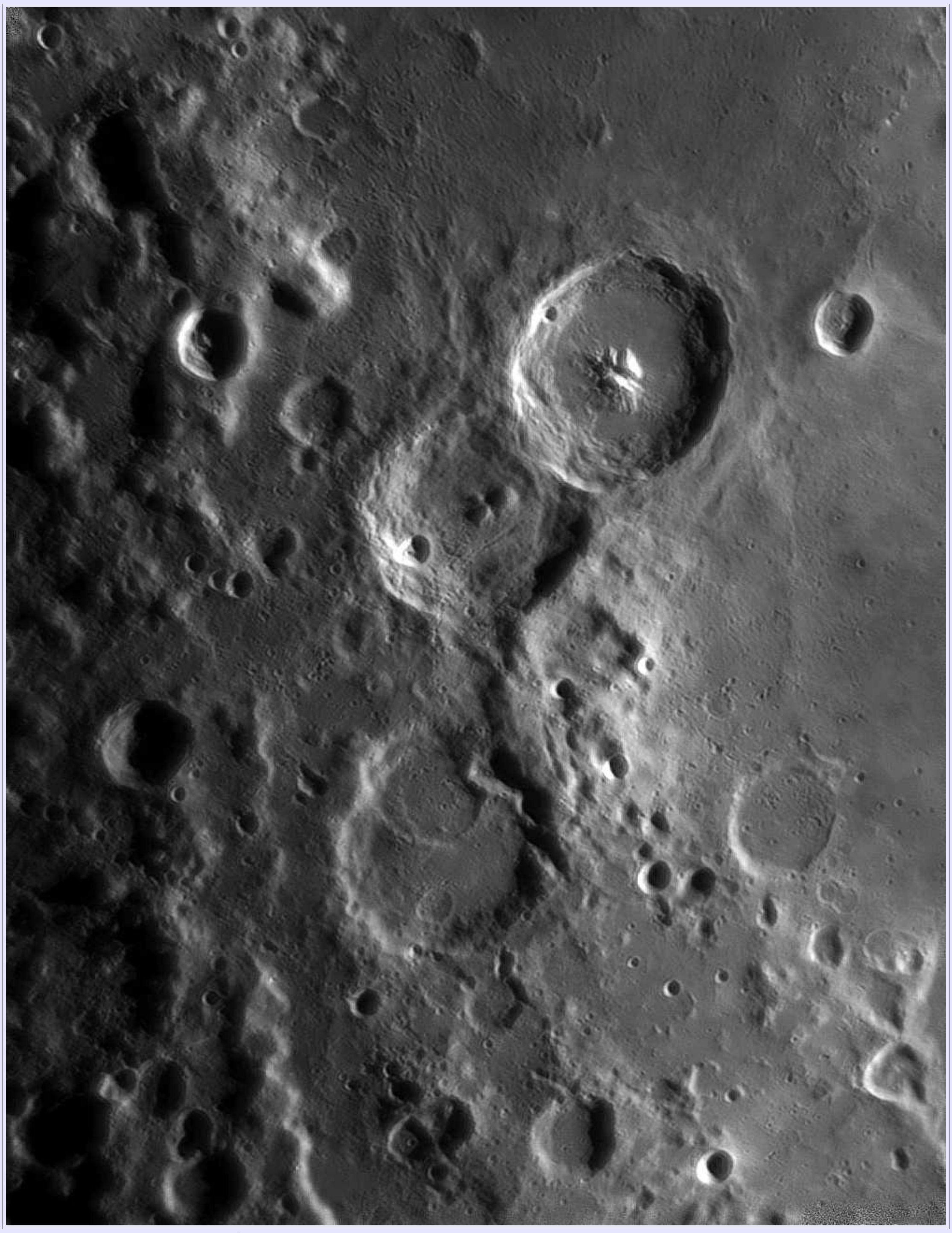


**Image by Ken Kennedy on 26th Febuary 2023 using a Celestron 8 at prime focus (f10, 2000mm) and with a x2 Barlow, so f20, 4000mm f.l.**

**Ken Comments:** *As I had hoped, the high elevation Moon last night was in relatively still air. It makes imaging so much easier as the image isn't jumping about all over the place! The Moon was at a phase of 6.5 days and I used my C8, I tend to use the gain turned quite far down to prevent too much contrast and so the imaging is slower but I tried to get about 4,000 images for each image of SER file with my Altair camera. There was so much detail to see but the three craters Theophilus, Cyrillus and Catharina make a fine triplet. I have attached one image taken at f20 using 1150 stacked images. The other thing which caught my eye was the sun rising on Maurolycus and just shining on the tip of the central peak. Look for it on the terminator about 1/3 way down from the top. This image was taken at f10 using 1250 stacked images. For a change - north is up! When this session ended I found that an auroral display was going strongly so had a turn about of cameras for some quick images.*

**Sea of Tranquillity and surrounding sights.**

**Sea of Tranquillity**
26 February 2023 1942UT
Celestron C11 f20 ASI224MC UV-IR filter
Mark Radice RefreshingViews.com

**Image by Mark Radice with details of equipment and time/date in caption.**

**Mark Comments:** *The Sea of Tranquillity was our target for tonight. In the centre of the view we have the ghost crater Lamont, the delicate outline of a crater buried long ago under the lava floodplains that formed the Sea of Tranquillity. Alongside is the crater Arago and the gentle shield volcanoes Arago alpha and beta. To the south is the Apollo 11 landing sight, marked by the three craters Armstrong, Aldrin and Collins and the nearby Cats Paw. The seeing wasn't the best so I switched to the UV-IR filter and boosted the colour to reveal the differing soils. Most of the surface is blue indicating titanium-rich soils with a few patches of lighter material superimposed.*

More of Mark's astronomical work and imaging tutorials can be seen at his website and You Tube channel [http://www.refreshingviews.com/](http://www.refreshingviews.com/)

## Reiner Gamma.

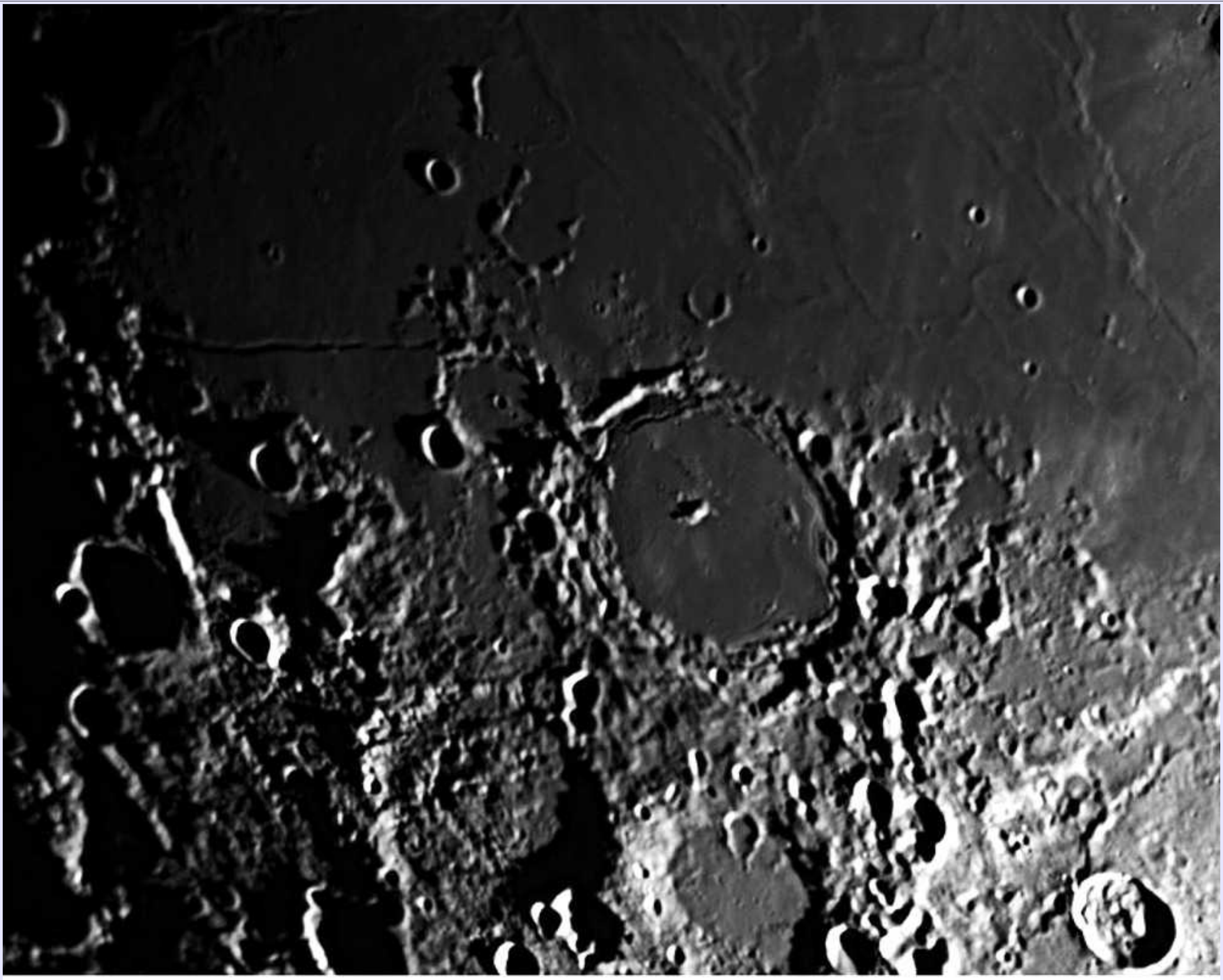

**Image and comments by Rik Hill with details of equipment and time/date in caption.**

*People tend to think that since we have landed on the moon and bombarded our neighbor with countless spacecraft over the last 66 years, that we know all about it now. Nothing could be further from the truth! This is one of the features that represents "lunar swirls", a localized magnetic anomaly in Oceanus Procellarum. The crater in the center of the image is, appropriately, Reiner (31km dia.). At the top, half of the crater Marius (43km) is peeking down. To the left of Marius you can see some of the Marius Hills, the famous field of lunar domes. Then on the left side of this image is the large crater, Cavalerius (60km) still mostly in shadow. Above Reiner, on the terminator, is the crater Galilaei (15km) and roughly halfway between these two and a little left is the crash site of Luna 8. Unfortunately radio contact was lost with that spacecraft after two unsuccessful retro burns and it crash landed on 7 Dec. 1965 (Moscow date).*

*Reiner Gamma has no relief, and is a purely an albedo feature. Oblique views from the Lunar Orbiter 2 cameras show no topography at all, just a stain on the floor of Procellarum. It's magnetic field has been measured from spacecraft altitudes as low as 28km and those measurements have shown it to be one of the strongest magnetic anomalies on the Moon. In the 17th century this feature was identified as a crater that was named Galilaeus to honor Gaiileo. This was honorarium was moved changed to the aforementioned Galilaei after the true nature of Gamma was learned. However, the cause of this and other lunar magnetic swirls is still a tantalizing enigma.*

*This was made from 2-1800 frame AVIs stacked with AVIStack2 (IDL) then assembled with MicroSoft ICE and final processed with GIMP and IrfanView.*

**Pitatus with Rima Hesiodus.**



**Pitatus with Rima Hesiodus to the West 2022.12.02 - 18.28 UT**
300mm Meade LX90, ASI 224MC Camera with Pro Planet 742nm I-R Pass Filter.
750/3,000 Frames. Seeing: 7/10. Rod Lyon

**Image by Rod Lyon with details of equipment and time/date in caption.**

**Geological Notes:** Continuing the theme of offset central peaks, Pitatus is another example with the displacement in this case being towards the NW. It might come as no surprise that there is also a significant positive Bouguer gravity anomaly located to the SE of the central peak, as was the case with Albategnius and Arzachel. That Pitatus is a Floor Fracture Crater goes without saying, the circumferential fractures being amongst the best examples anywhere on the Moon. This image also gives you a sense of the differences in elevation across crater floor, with the north-western quadrant being significantly elevated, whilst the south-eastern quadrant forms a deep bowl shaped depression some 800-1000m deep. Clearly the sub-surface volcanic plumbing and migration of magma beneath Pitatus has resulted in some complex surface movements both up and down.

Another section of the hypothesised 'Lunar Grid' system can be seen heading west from the southern rim of Pitatus, as a faint alignment of topographic elements running parallel to Rima Hesiodus to the north. This feature is quite subtle and probably only visible under very favourable illumination. Could the alignment of this feature and the rima hint at a common origin in a deep, ancient network of crustal fractures?

**Half Moon from Fife.**

**Image by Alan Clitherow on 26th February 2023 using a  a 10” F6.3 Newtonian with the camera at prime-focus.**

**Alan Comments:** I *only rarely take Lunar images but I was so struck by the quality of my local seeing condition on the 26th of February that I had to image the visible phase. As I use a relatively small chipped ASI monochrome planetary camera I had to mosaic together a number of images to get the final result. I was very pleased with the final result from the point of view of detail and hope it is of interest.*

**Mare Crisium.**

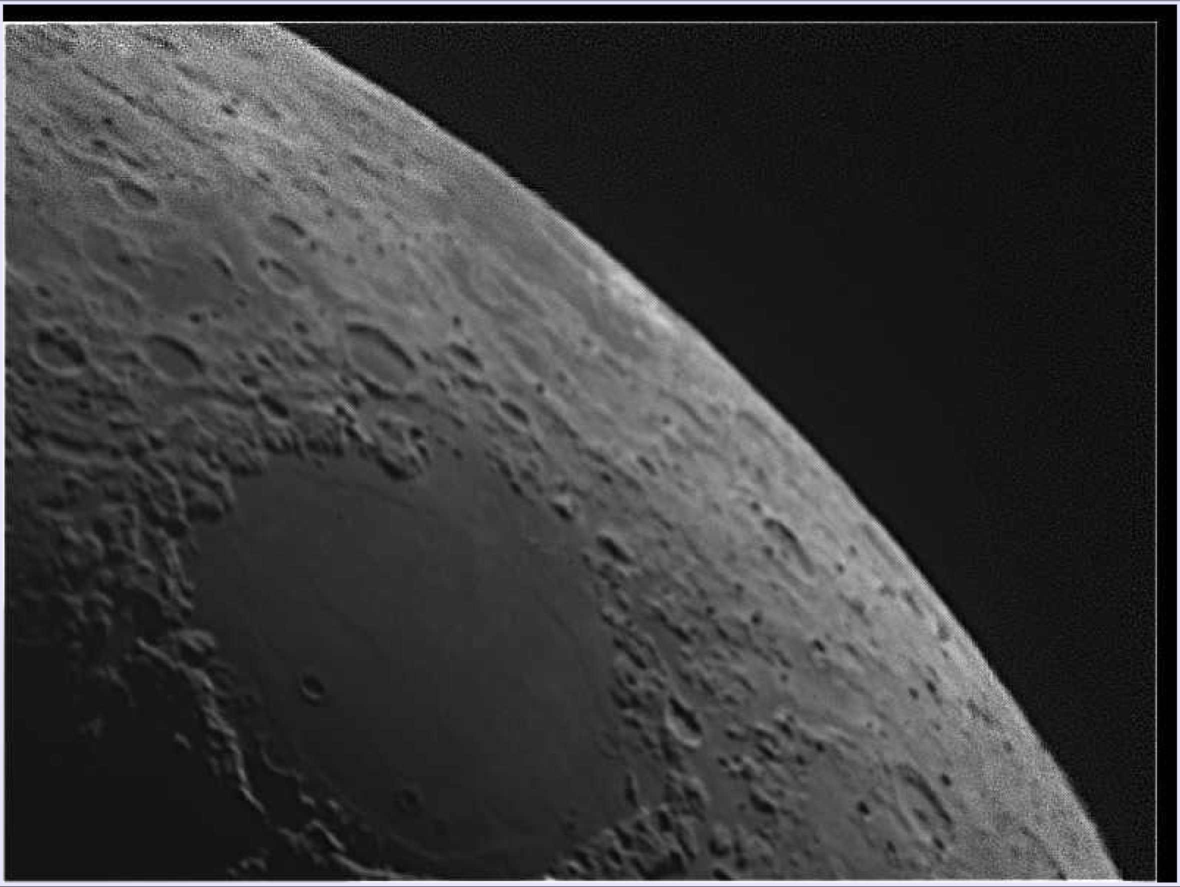
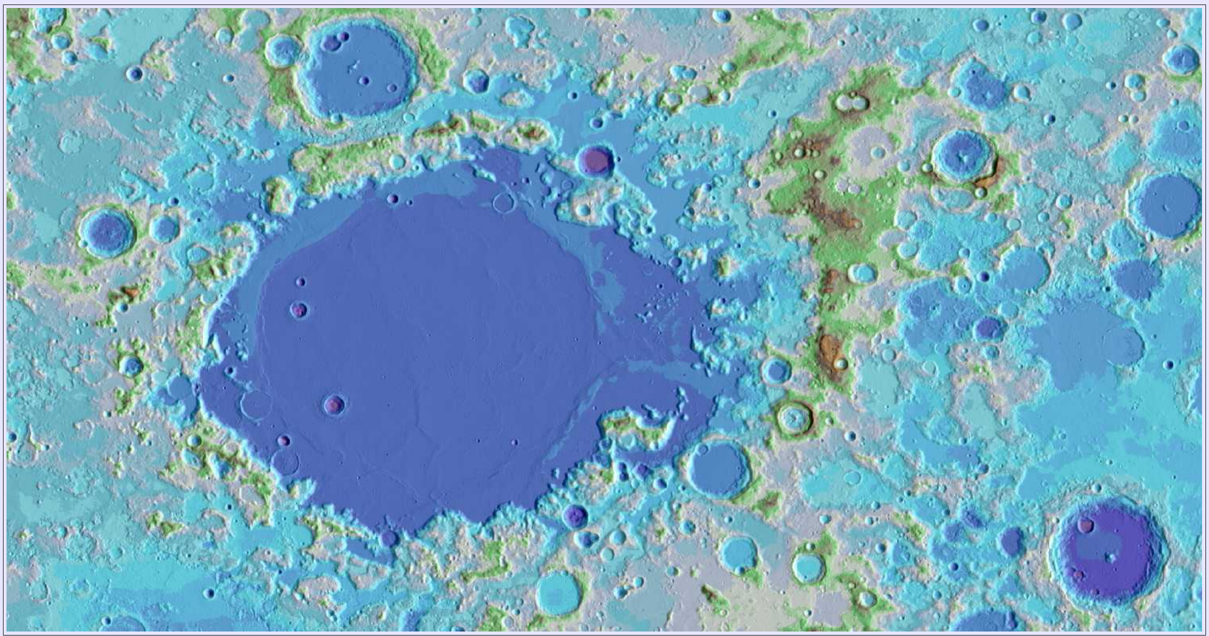


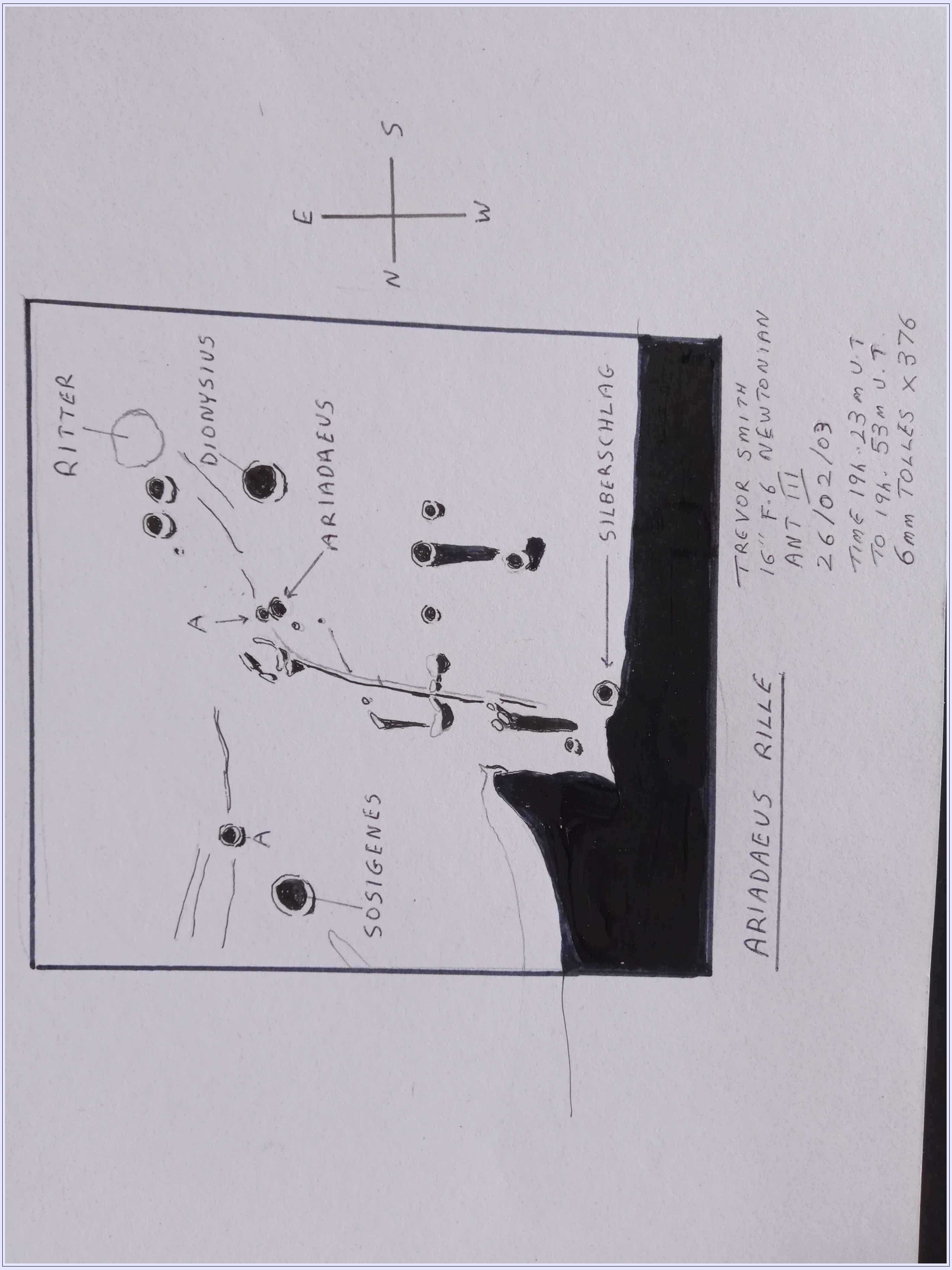
**Image by Phil Shepherdson using a Skywatcher 102mm f13 Mak and ZWO AS1294MC.**

**Geological Comments:** This perspective on Mare Crisium gives you a fairly good impression of why it is believed to be the result of a low angle grazing impact. The basin in elongate along the line of sight (W-E) in this image. To the east, beyond the basin the surface is thought to have been scoured by low angle ejecta, and this resulted in a fan shaped arrangement of ridges and grooves which show up well in the Colour shaded relief map below. The rather descriptive term 'Tomahawk Basin' was coined some years ago to describe the appearance of these low angle impact basins, but I the term is unfortunately not in widespread use*.



* *Arrowhead craters and tomahawk basins: signatures of oblique impacts at large scales. P. H. Schultz and A. M. Stickle. 42nd Lunar and Planetary Science Conference (2011)*

**Ariadeus Rille and Environs.**
**By Trevor Smith.**




Trevor Smith has sent in this drawing of the Ariadeus Rille and surroundings plus comprehensive observing notes. The date of the drawing is 26/03/2023 and not 26/03/2003!

***To view them correctly in Adobe Reader go to the toolbar at the top of the page, select view, then select rotate view, then rotate clockwise. To return to the ordinary view do the same but select rotate Counterclockwise.***

ARIADAEUS RILLE AND ENVIRONS

TREVOR SMITH

I WAS VERY INTERESTED TO SEE THE SKETCH MADE OF THE ARIADAEUS RILLE REGION IN THE FEB L.S.C PAGE 24 BY PAUL ABEL. ALSO THE SKETCH AND COMMENTS OF NIGEL LONGSHAW IN THE MARCH 2023 L.S.C PAGE 3 AND ALSO THE IMAGE BY DAVE FINNEGAN IN THE MARCH 2023 L.S.C PAGE 15 OF THE SAME REGION.

I OBSERVED THIS REGION UNDER QUITE FAVOURABLE CONDITIONS ON 26/02/23 BETWEEN 19h 23m AND 19h 53m U.T. I MADE A SIMPLE SKETCH WHICH SHOWS THE TERMINATOR JUST A FEW KM AWAY FROM THE WESTERN RIM OF SILBERSCHLAG. THE SEEING WAS QUITE GOOD AT TIMES (ANT III AND II IN MOMENTS OF CALM). THIS ALLOWED THE USE OF X376 ON THE 18" F/4 NEWTONIAN (6mm TELES EYE-PIECE). THE WHOLE AREA WAS VERY GRANULATED AND IN THE MOMENTS OF STEADIER SEEING MINUTE DETAIL COULD BE SEEN ON THE INNER SLOPES AND FLOOR OF THE RILLE.

A THIN JET BLACK LINE OF SHADOW MARKED THE LENGTH OF THE INTERIOR NORTHERN SLOPE OF THE RILLE WHILST THE SOUTHERN EDGE STOOD OUT CLEARLY AS A BRIGHT WHITE LINE.

THE SPLIT OR FRACTURE OF THE RILLE (CLEARLY SEEN IN DAVE FINNEGANS IMAGE) AND WHICH LIES SOME 35 KM OR SO TO THE EAST OF SILBERSCHLAG WAS QUITE OBVIOUS. WHAT CAUGHT MY EYE WAS THE SMALL BUT PROMINENT OBSTRUCTION CROSSING THE RILLE FROM NORTH TO SOUTH. THIS CAN BE FOUND SOME 60 KM OR SO FROM THE WEST OF

3

THE CRATER ARIADAEUS. THIS 'OBSTRUCTION' WAS VERY NOTICEABLE AND LOOKED VERY MUCH LIKE AN ARTIFICIAL BRIDGE CROSSING THE RILLE! (ONCE AGAIN, THIS IS WELL SEEN IN DAVE'S IMAGE). ANOTHER 'OBSTRUCTION' OF THE RILLE LIES SOME 40 KM OR SO FARTHER WEST AND IS SEEN TO BE CAUSED BY A MOUNTAIN RIDGE.

THE VERY WEST OF THE RILLE WAS NOT VISIBLE TONIGHT AS IT JUST SEEMED TO FADE AND BECOME LOST IN THE VERY ROUGH TERRAIN AND SHADOWS OF THE LUNAR MORNING TERMINATOR. I HAD HOPED TO OBSERVE THIS REGION THE FOLLOWING NIGHT AS IT WOULD HAVE BEEN WELL PRESENTED BUT HEAVY CLOUD COVER PREVENTED ANY OBSERVING!

THE EASTERN END OF THE RILLE APPEARED TO STOP AT THE OUTER NORTH/WEST RIM OF ARIADAEUS A, THEN CONTINUE ON THE OPPOSITE SOUTH/EAST OUTER EDGE OF CRATER A AND THEN CONTINUE OVER THE MARE TRANQUILLITATIS IN THE DIRECTION OF RITTER BUT NOT ACTUALLY REACHING RITTER. IT APPEARS TO TRAVEL SOME 25 KM OR SO OVER THE MARE BEFORE JUST FADING INTO THE MARE. I MUST ADMIT THAT I AM SOMEWHAT UNSURE AS TO WHETHER THIS LAST 25 KM OR SO IS ACTUALLY A BONAFIDE REMNANT OF THE ARIADAEUS RILLE OR IS IT A DISCONNECTED PART OF THE NEARBY RITTER RILLE SYSTEM?

3

THIS RITTER RILLE SYSTEM WAS QUITE EASY TO SEE TONIGHT BUT IT IS MUCH FAINTER AND LESS PROMINENT THAN THE ARIADAEUS RILLE.

SAID TO HAVE BEEN FIRST SEEN IN 1792 BY THE GERMAN ASTRONOMER JOHANN SCHROTER (1745 TO 1816).

THE ARIADAEUS RILLE IS CERTAINLY ONE OF THE BEST EXAMPLES OF A LINEAR RILLE, PERHAPS SECOND ONLY TO THE ALPINE VALLEY.

HAVING A TOTAL LENGTH OF AROUND 300 KM AND A DEPTH OF SOME 500 M AND A WIDTH OF ABOUT 5 KM IT CAN BE EASILY GLIMPSED IN SMALL TELESCOPES.

I AGREE TOTALLY WITH PAUL ABEL THAT THIS AREA IS VERY COMPLEX AND UNDER LUNAR MORNING OR LATE EVENING LIGHTING THE VIEW CAN BE ALMOST OVERWHELMING.

TREVOR SMITH
CODNOR.
DERBYSHIRE.

**Sinus Iridum.**

**Image by Stuart Wilson taken on 3rd March at 21:25 using c9.25 at f/10 and a ZWO ASI 662MC.**

**Geological Notes:** With a diameter of some 250kms Sinus Iridum would have been an impressive impact basin with possibly a central peak ring, but there is little visible now to indicate the presence of such a structure beneath the Imbrium lavas that flooded into the sinus. There is a small group of hills projecting above the basalt lavas close to the eastern rim, whether these are part of a submerged ring or represent collapsed rim material is debatable.

Mons Gruithuisen Gamma and Delta are visible as smooth rounded hills to the west of Promontorium Heraclides. These steep sided volcanic domes are composed of a silicic lava more akin to granite than the ubiquitous basalts that form the majority of lunar domes. They are steep sided because the lava that make them up was much more viscous than lunar basalts (which are about as viscous as heavy engine oil and 10 time less viscous than terrestrial basalts) and oozed out and solidified close to their eruption vent. Lavas of this type frequently produce explosive eruptions as gas contained in the lavas cannot escape in a sedate manner as it would from a runny basalt – hence events like the Mt St.Helens eruption. Fine geological structure visible in LRO images suggest the same happened here with explosive and non explosive phases of eruption building up the steep sided domes.

The domes are classified as 'Lunar Red Spots' due to their unusual spectral character, so related to 'The Helmet' shown in Alexander Vandenbohede's image in this LSC. They also exhibit an enhanced Thorium anomaly, a feature shared with a number of other 'red spots'. The domes post date Sinus Iridum, and are believed to have formed simultaneously somewhere between 3.8 and 3.7 billion years. This is older than most of the domes we are used to seeing in the mare which sit on top of the more recent mare basalts.

## Lunar domes (part LXIV): Birt domes and pyroclastic material.
**By Raffaello Lena**

In a previous note, published in LS circular, I have described the domes in Birt, which are two domes bisected by two rilles (Lena, 2019). These two domes, named as Birt 1 and 2, are located in Mare Nubium, near the elongated crater Birt E. It is likely the vent of Birt 1.

An elevation map of the examined volcanic domes is reported in Fig. 1.

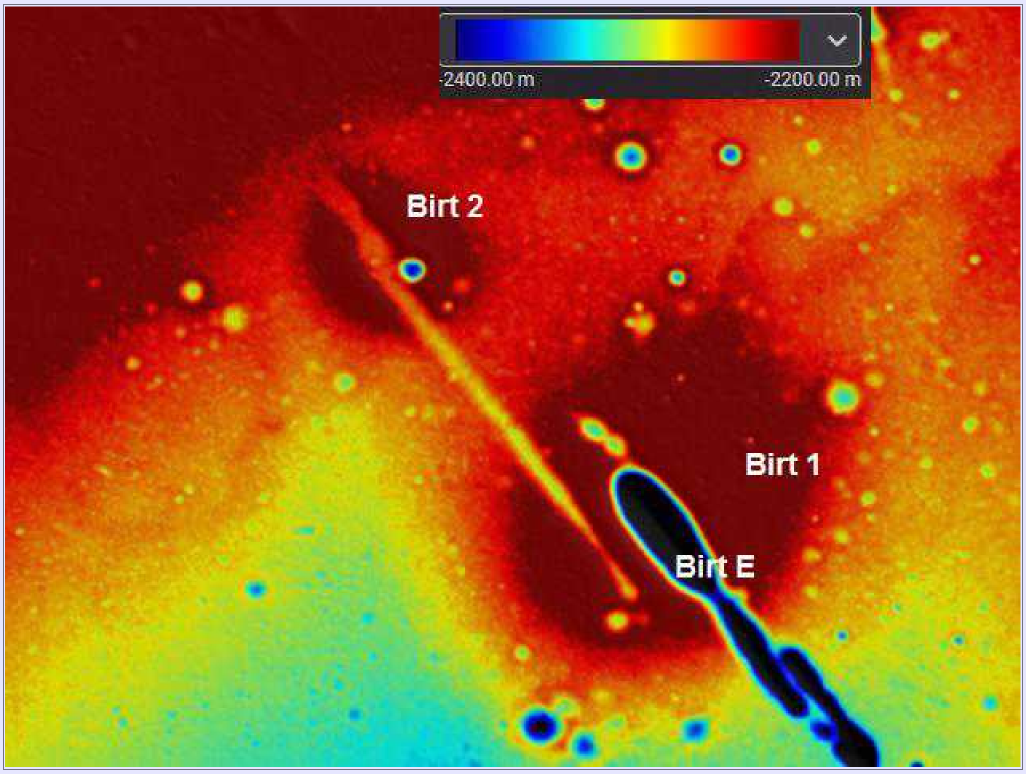



**Figure 1: Elevation map on the DTM of Birt 1 and Birt 2. The association of two rilles with the domes is strongly indicative of volcanic origin.**

The dome diameters of Birt 1 and Birt 2 amount to 16.0 and 7.8km, respectively. The height of the dome Birt 1 is determined to be 160 ± 20m, resulting in an average slope of 1.22° ± 0.10°. The height of the dome Birt 2 amounts to 70 ± 10m, yielding a slope of 1.03° ± 0.15°. The dome volumes are determined to 17.3km³ and 1.3km³ for Birt 1 and Birt 2, respectively. The dome Birt 1 belongs to class $C_1$, while Birt 2 belongs to class $C_1$ with a tendency towards class $C_2$ due to its smaller diameter and lower edifice volume (Lena et al., 2013; Lena, 2019).

### Ground based telescopic imagery
A telescopic image of the examined region is shown in Fig. 2. The image was taken by Carmelo Zannelli on the evening of January 1, 2023 at 17:58 UT in good seeing conditions using a Telescope Astrofaktorja DK20" F/27. The soil around two domes shows a different albedo.

### Albedo
Birt E is a small deposit associated with a linear rille. Possible pyroclastic mantling surrounds the crater Birt E. The concentric nature of the deposit suggests that this is the likely source for at least some of the dark mantle material (Fig. 3). The Color map is obtained as described by Sato et al. (2014).

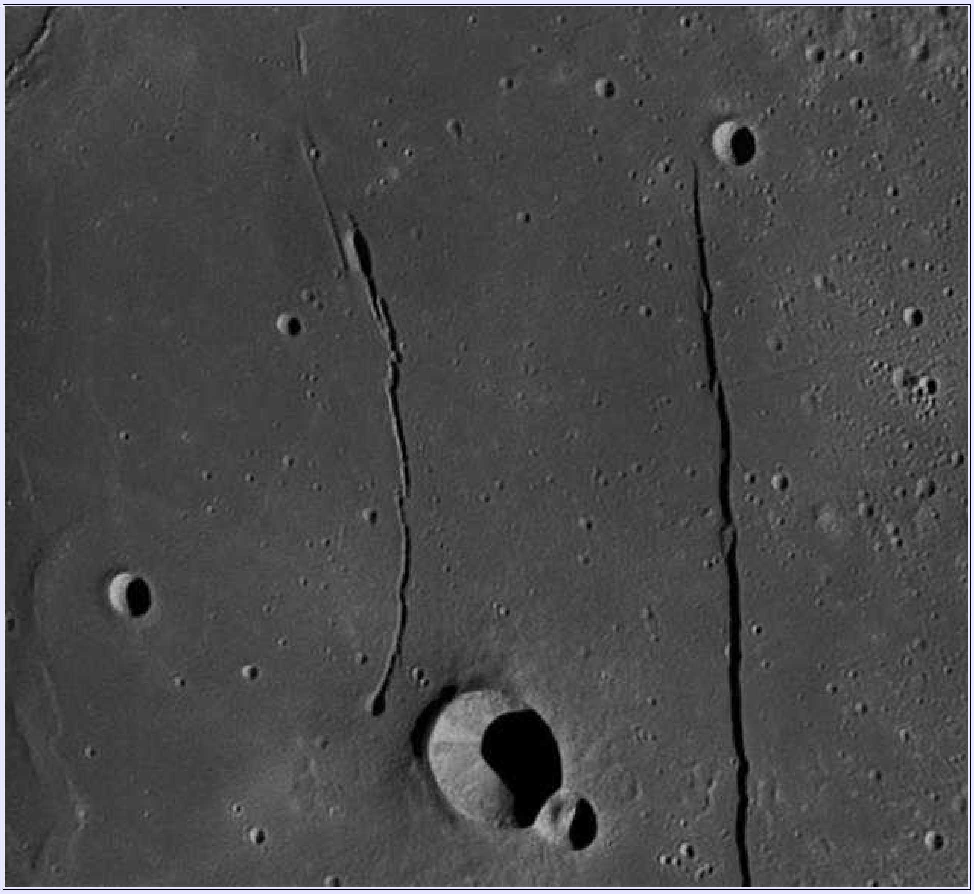


**Figure 2: Rima Birt and two domes. Image made by Carmelo Zannelli. In the image two vents are detectable and located on the summit of two examined domes.**

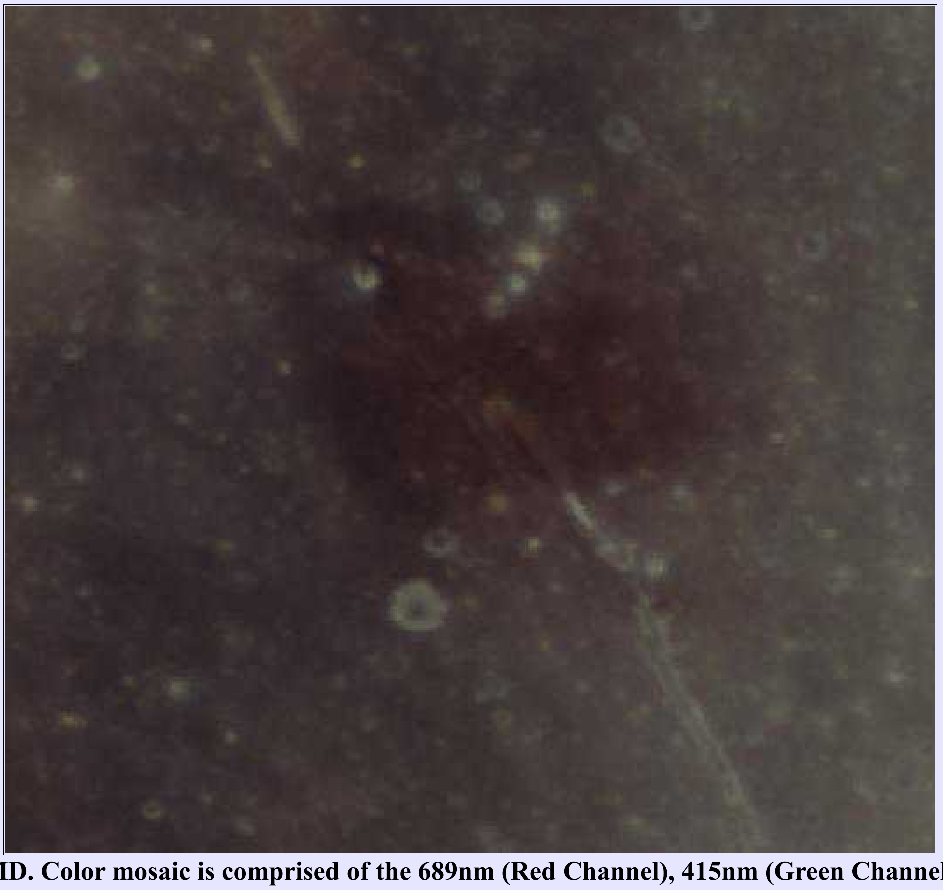


**Figure 3: Birt E DMD. Color mosaic is comprised of the 689nm (Red Channel), 415nm (Green Channel), and 321nm (Blue Channel). Color map described in Sato et al., 2014.**

In the Clementine color ratio composite image (Fig. 4), this deposit appears orange, suggesting lower titanium abundance than the surrounding bluer mare deposits.

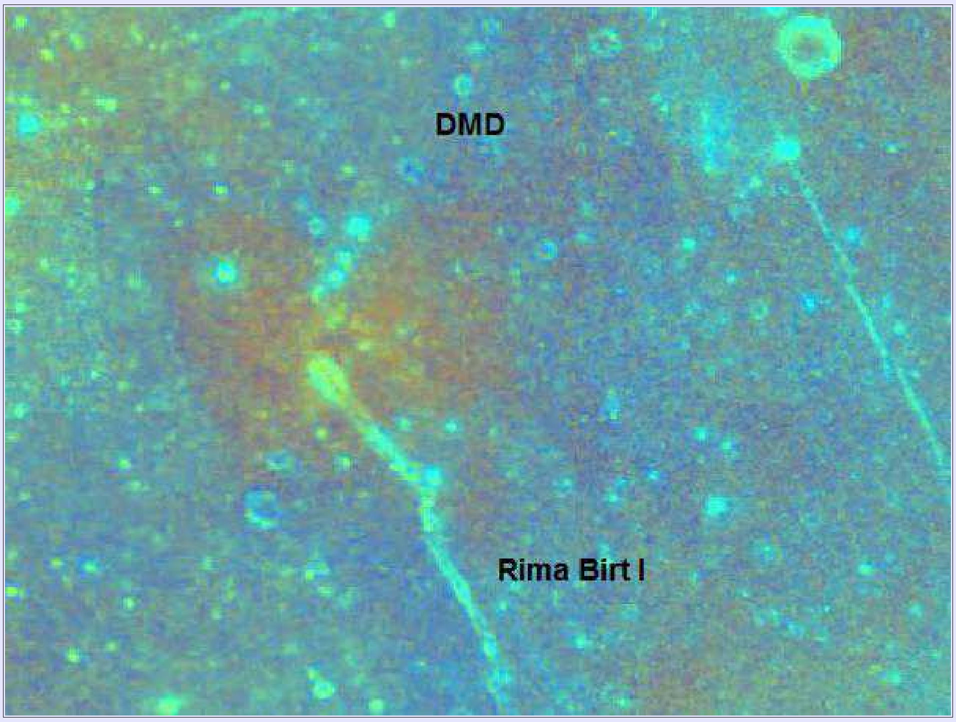



**Figure 4: Clementine color ratio image. Channel Ratio Red = 750nm/415nm Green = 750nm/950nm  Blue = 415nm/750nm.**

The Birt E pyroclastic deposit may be a late-stage volcanic deposit formed by the release of volatiles during cooling of residual magma after emplacement of the regional mare basalt flows (Gustafson et al., 2012).

**Spectral data**

In this study I used the approach described by Besse et al. (2014) based on the $M^3$ spectral data of recognized DMDs including mineralogical evidence indicative of the presence of volcanic glasses.

Pyroxenes have two absorption bands, one centred near 1000nm and another near 2000nm; these band centres move to longer wavelengths as Ca and Fe substitute for Mg. Olivine has a complex absorption band centred beyond 1050nm that moves as Fe substitutes for Mg (Besse et al., 2014 and references therein). Significant amounts of olivine in lunar volcanic deposits will broaden the pyroxene absorption at 1000nm and shift it to longer wavelengths, while the 2000nm band remains fixed. Because olivine lacks a band at 2000nm, the 1000nm absorption in olivine-rich lunar deposits will be strengthened relative to the 2000nm band.

The presence of Fe-rich volcanic glasses in lunar soils causes broad and shallow absorption bands because of the amorphous structure of the glasses (Besse et al., 2014). The 1000nm band centre of lunar glass is generally shifted to longer wavelengths when compared to pyroxene, and the 2000nm band centre to shorter wavelengths. Thus, the 1000 and 2000nm band centre positions of lunar glasses will typically appear close together than those of pyroxenes.

***Band  center at 2000 nm***

This parameter was derived from standard processing and calibrated level 2 of $M^3$ data. The 1000nm band centre of lunar glass is generally shifted to longer wavelengths when compared to pyroxene, and the 2000 nm band centre to shorter wavelengths. Fig. 5 displays the derived values for the Birt deposit, which range from 1950nm to 2050nm.

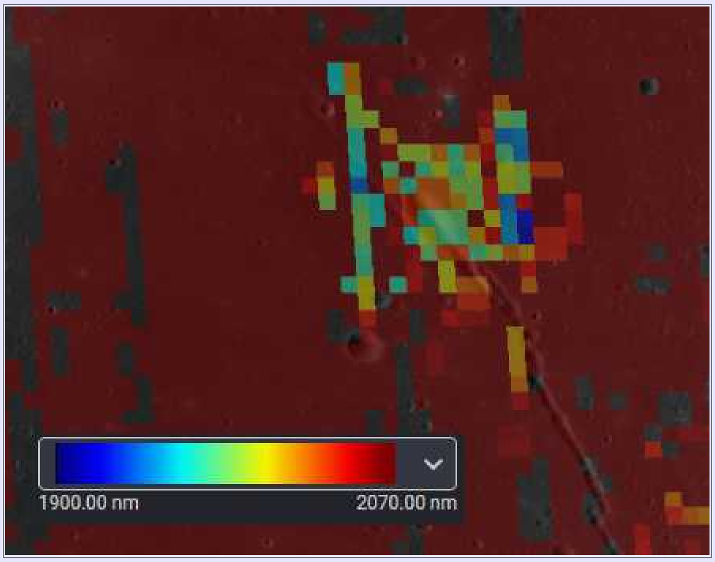



**Figure 5: Center of the 2000nm spectral absorption band, sensitive to pyroxene composition. Shorter-wavelength band centers are associated with glasses. To minimize the effects of noise, only pixels with band depths greater than 0.05 are shown.**

### *M³ Spectral data*

From the M³ observations, the Birt DMD exhibits different mineralogy. The change in position and shape of the absorption is also consistent with the presence of volcanic glass. These results are confirmed by the spectra reported in Fig. 6. The 1000 and 2000nm band locations are shifted to longer and shorter wavelengths, respectively, and attributed to volcanic glass contribution.

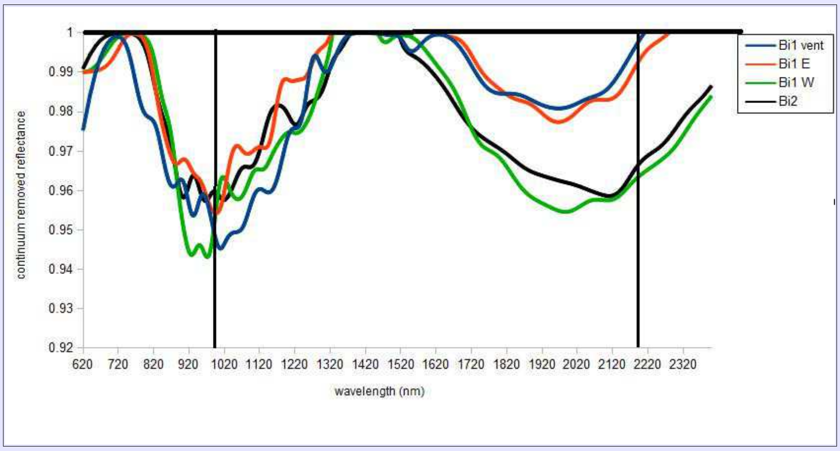



**Figure 6: M³ spectra obtained for several regions. Note the broad 1000nm absorption band. Orbital period OP2C1. The vertical lines display the 1000nm and 2200nm bands center.**

As shown in Fig. 6, the 1000nm band is wide suggesting that a component such as volcanic glass or olivine may be present.

Although the wider and shifted 1000nm absorptions could also be attributed to the presence of olivine in some of these deposits, the shift to shorter wavelengths of the 2000nm absorptions and the relative strength of the 2000nm band are indicative of the presence of volcanic glasses signature (Besse et al., 2014). Table 1 displays the absorption bands center derived for the sampled regions.

| Feature | 1000nm band | 2000nm band |
|---|---|---|
| Birt1 (vent) | 1020 | 1980 |
| Birt1 east | 1009 | 2010 |
| Birt 1 west | 1049 | 2020 |
| Birt 2 | 1020 | 2130 |

**Table 1: Absorption bands centre for Birt pyroclastic deposit. The presence of volcanic glass in a spectrum is considered to be the strongest evidence in support of a pyroclastic origin.**

Besse et al. (2014) describe the Birt E deposit with a 1000nm band at 1050nm and 2000nm band at 2030nm, in accord with the analysis reported in this note by the author.

***Contribution of Volcanic Glasses***

A cluster of possible DMDs with band positions very close to the orange glass is used as a criterion to characterize them as DMDs (Fig. 7). Based on this diagram the Birt deposit is plotted halfway between the orange glasses and the mare basalts.

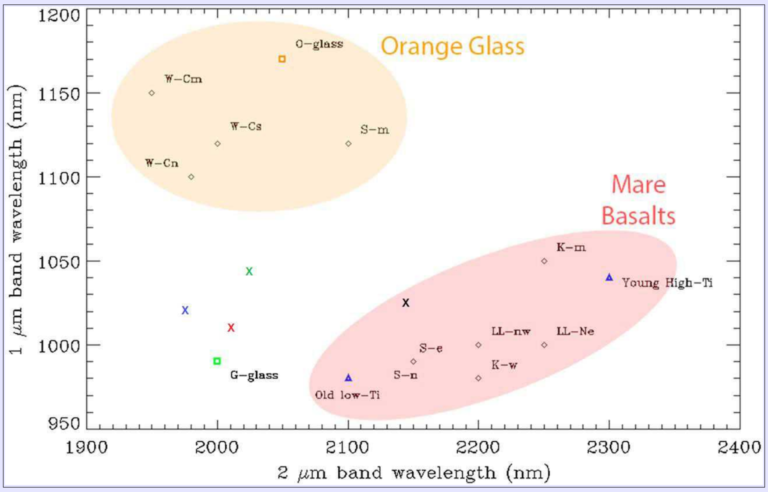



**Figure 9: Diagram of the band position at 1000 and 200nm. Adapted by the work of Besse et al. (2014).**

Hence, the examined pyroclastic deposit displays a glass signature mixed with mare basalt signature.

**Geologic events**

The plausible interpretation is that lava melt tracked up a fault in this region, bowed up the surface, and fractured it, resulting in at least two rilles. Parts of the intruded magma reached the surface, thus forming the domes at the northern end of Rima Birt, Birt 1 and 2. Possibly two rille segments formed as a surface expression of two separate dikes. In a subsequent phase, an explosive activity occurred, originating the pyroclastic deposit spectrally characterized by the presence of volcanic glasses intermixed with basalts.

**Mineralogical Composition**

Based on the spectral data the pyroclastic deposit has been identified and including the presence of volcanic glasses signatures intermixed with basalts (Fig. 10). For this study I have also derived abundance maps in wt% of FeO, clinopyroxene, orthopyroxene and $TiO_2$ content created from topographically-corrected Mineral Mapper reflectance data acquired by the JAXA SELENE/Kaguya (Fig. 11).

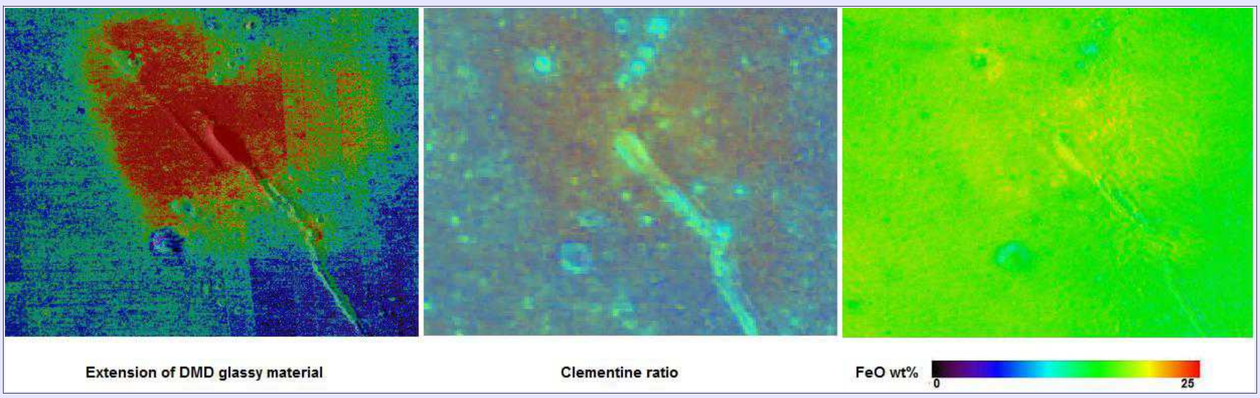



**Figure 10: Extension of the pyroclastic deposit and comparison with the Clementine map and the derived FeO abundance in wt%.**

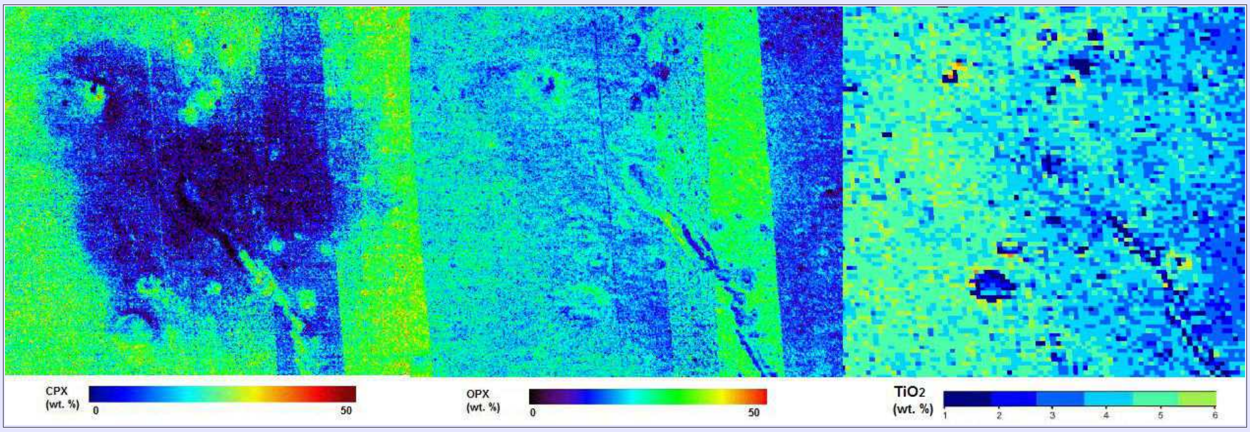


**Figure 11: (left) clinopyroxene (CPX), (middle) orthopyroxene (OPX), (right) $TiO_2$. Derived abundance maps in wt%.**

The pyroclastic deposit displays a FeO of 18.0-21.0 wt %, like the nearby mare units. The $TiO_2$ varies from 2.0 wt % to 5 wt % (near Birt 2).

The deposit shows an enhanced abundance of orthopyroxene (from 16.5 wt % to 30.0 wt %) and a lower abundance of clinopyroxene (1.0-11.0 wt %) if compared with nearby mare units (26.3-38.0 wt %). Furthermore the lower clinopyroxene content is detected in the deposit suggesting the presence, in the examined region, of volcanic products of different composition (Fig. 11). The composition of the Birt domes is the same of the inferred mineralogy of the deposit confirming that the explosive activity occurred as a late-stage volcanic phase.

**References**

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Gustafson, J. O., J. F. Bell III, L. R. Gaddis, B. R. Hawke, and T. A. Giguere (2012), Characterization of previ-ously unidentified lunar pyroclastic deposits using Lunar Reconnaissance Orbiter Camera data, J. Geophys. Res.,117, E00H25,doi:10.1029/2011JE00389

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Sato et al., 2014, J. Geophys. Res. Planets, 119, 1775–1805, doi:10.1002/2013JE004580

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**<u>Basin and Buried Crater Project.</u>**
**<u>By Tony Cook.</u>**

No emails or observations have been received specifically about impact basins or buried craters this month, so I thought that I would take the opportunity to specifically address how one goes about picking a buried crater from the on-line catalog, trying to confirm the best selenographic colongitudes to see it at sunrise or sunset, and how to measure its position and diameter.

**Step 1 – Find a buried crater in the catalog:**

## Table 2 – Buried Craters

| Version: | 2022 Jul 05 |
|---|---|

| Crater | Far/Near Side | Lon | E/W | Lat | N/S | Diam (km) | Status | Age | Col-SR1 | Col-SR2 | Col-SS1 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| QCMA 1 | N | 17.9 | W | 74.4 | N | 48 | Proposed | | | | |
| PFC 39 | N | 23.6 | W | 66.6 | N | 60 | Uncertain | | | | |
| QCMA 2 | N | 9.8 | W | 63.7 | N | 146 | Proposed | | | | |
| PFC 38 | N | 18.9 | W | 63.4 | N | 36 | Uncertain | | | | |
| QCMA 3 | N | 23.6 | W | 62.1 | N | 82 | Proposed | | | | |
| PFC 37 | N | 27.6 | W | 61.8 | N | 40 | Uncertain | | | | |
| PFC 40 | N | 9.7 | W | 61.1 | N | 39 | Uncertain | | | | |
| QCMA 4 | N | 1.7 | W | 58.9 | N | 167 | Proposed | | | | |
| QCMA 5 | N | 11.4 | E | 58.3 | N | 121 | Proposed | | | | |
| QCMA 6 | N | 20.2 | E | 55.7 | N | 181 | Proposed | | | | |
| PFC 49 | N | 68.0 | W | 55.6 | N | 56 | Uncertain | | | | |
| QCMA 7 | N | 31.4 | W | 55.4 | N | 101 | Proposed | | | | |
| QCMA 8 | N | 6.0 | W | 54.3 | N | 143 | Proposed | | | | |
| PFC 51 | N | 28.3 | W | 53.5 | N | 38 | Uncertain | | | | |
| PFC 11 | N | 43.5 | W | 52.7 | N | 40 | Uncertain | | | | |
| QCMA 9 | N | 1.9 | W | 52.6 | N | 34 | Proposed | | | | |
| QCMA 10 | N | 21.4 | E | 51.8 | N | 65 | Proposed | | | | |
| PFC 13 | N | 9.4 | W | 51.7 | N | 100 | Uncertain | | | | |
| PFC 10 | N | 73.6 | W | 48.8 | N | 128 | Uncertain | | | | |
| QCMA 11 | N | 30.5 | E | 48.7 | N | 129 | Proposed | | | | |
| QCMA 13 | N | 60.2 | W | 47.8 | N | 114 | Proposed | | | | |
| PFC 22 | N | 55.0 | E | 47.7 | N | 98 | Uncertain | | | | |
| Ancient Newton | N | 8.4 | W | 47.3 | N | 125 | Uncertain | | | | |
| QCMA 14 | N | 55.6 | W | 47.3 | N | 92 | Proposed | | | | |

**Figure 1. The top of the table of suspected buried craters from the basins and buried craters website: https://users.aber.ac.uk/atc/basin_and_buried_crater_project.htm .**

The first thing you need to do is to look at the table on the basins and buried crater web site (Fig 1). You can pick any crater – but it is more helpful to pick one that hasn't been measured i.e. there are blank cells in the table that we need to fill in. As you can see, currently there are a lot of unfilled cells as we have just started!

The buried craters are sorted by latitude amount, but look at the N or S (next column to the right) to see which hemisphere they are in. If you plan to observe and take images, or sketch at the eyepiece, then pick one that will be on either the sunrise or sunset terminator on the lunar near side. Alternatively if its cloudy then you can use your old archive images, VTLT (Virtual Terminator Lunar Toolkit) software or the LROC NASA/ACT Quickmap website.

The crater names can sometimes seem strange such as PFC and QMCA, followed by numbers. The QMCA stands for Quasi-Circular Mass Anomalies. These are essentially found by looking for circular or elliptical arcs in free-air gravity and Bouguer anomaly data as well as gravity gradient versions of these datasets. PFC stands for Partly Filled Crater and have already been visually identified to some extent. The QMCA and PFC's have come from a Geophysical Research Letters paper by A.J. Evans et al. (2016): "Identification of buried lunar impact craters from GRAIL data and implications for the nearside maria". You will find the QMCA's more of a challenge to locate, if visible at all, but are worth looking for in case Evan's *et. al.* didn't spot some clues that you spot?

**Step 2 – Finding the crater on the Moon:**

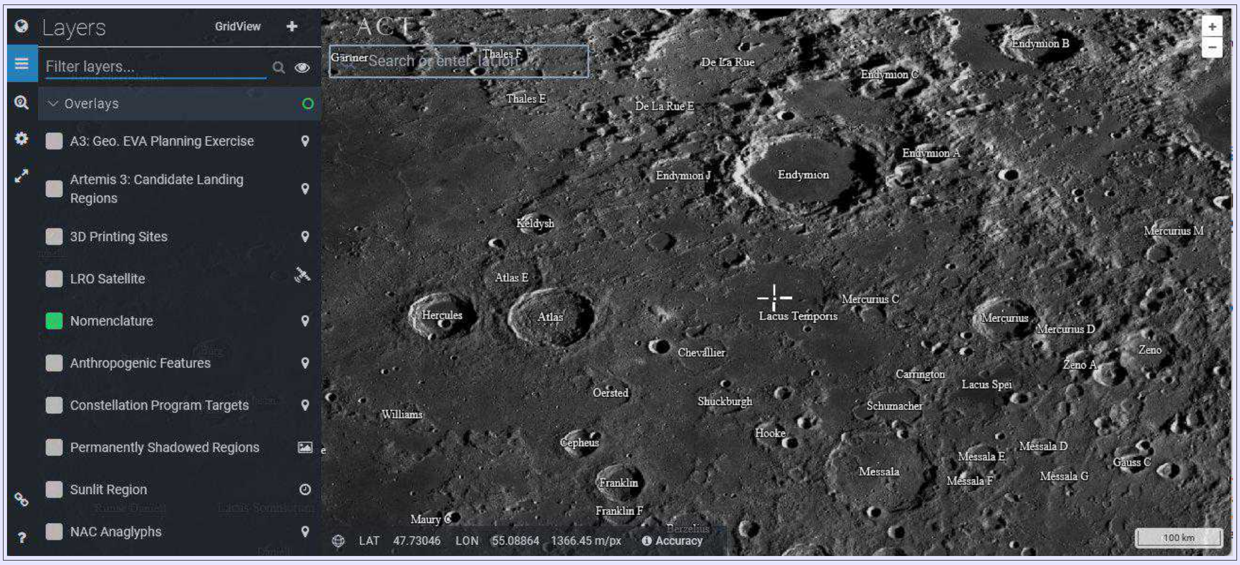



**Figure 2. Searching for the approx. location of PFC22 on NASA's Quickmap website: https://quickmap.lroc.asu.edu The white cross indicates the published location in the table.**

You have three choices here: (1) use an atlas with lon/lat grid lines, (2) use the cursor, with lon/lat readout, on LTVT (https://github.com/fermigas/ltvt/wiki ) to search for it virtually, or (3) use the cursor, with lon/lat readout, to look for it on the LROC NASA/ACT Quickmap website.

As, by definition, the crater is buried, or highly degraded, it is unlikely that you will see it on the atlas, LTVT or LROC Quickmap, but the important thing is to find neighbouring features that you can recognize that you can use as landmarks or sign posts to help you look for the buried crater in question. In the case of PFC22 we see that it lies on the northern part of Lacus Temporas, and has other signposts such as Endymion to the north, Atlas and Mercurius to the west and east, and Shuckburgh to the south.

**Step 3 – Finding the best visibility sunrise/sunset selenographic colongitudes:**
This is relatively straight forward, you just need to pick a selenographic colongitude that corresponds to the longitude, treating west as positive. So for PFC22 which has a quoted longitude of 55.0˚E, the selenographic colongitude at sunrise would be 360˚-55˚=305˚. The sunset colongitude would be 305˚-180˚=225˚. You should observe for a few hours after local lunar sunrise and a few hours before local lunar sunset, in order to find the time that the buried crater is most easily seen – if at all? LTVT can help you with these times. As to when you find the buried crater is best visible – this is going to be very subjective. Its best that we receive lots of observations and then an average or range or selenographic colongitudes can be derived and added to the database.

If you don't fancy observing, then LTVT by itself can simulate the appearance of the surface and you can test out lots of selenographic colongitudes until you find the buried craters best appearance at sunrise or sunset.

**Step 4 – Measuring the longitude and latitude and diameter of the crater:**
This should utilize NASA's Quickmap web site, or LTVT, and/or whatever imagery you have taken, to find the rim of the crater, or whatever parts are left of it. In the NASA Quick map tool. You can place some points on the rim (see Fig.3), and then when you have finished just click on "Download CSV" on the bottom right corner. Please make sure you have a uniform distribution of points and not all bunched up in one area. The resulting file: *"features.geojson"* looks horrible (Fig 4), but you can clearly see the longitudes and latitudes of the points you measured on the rim. You could take an average of longitudes and average of latitudes, to find the centre of the crater, or just email it to me and I'll computer the longitude, latitude and best fitted diameter for you and then add it to the database.

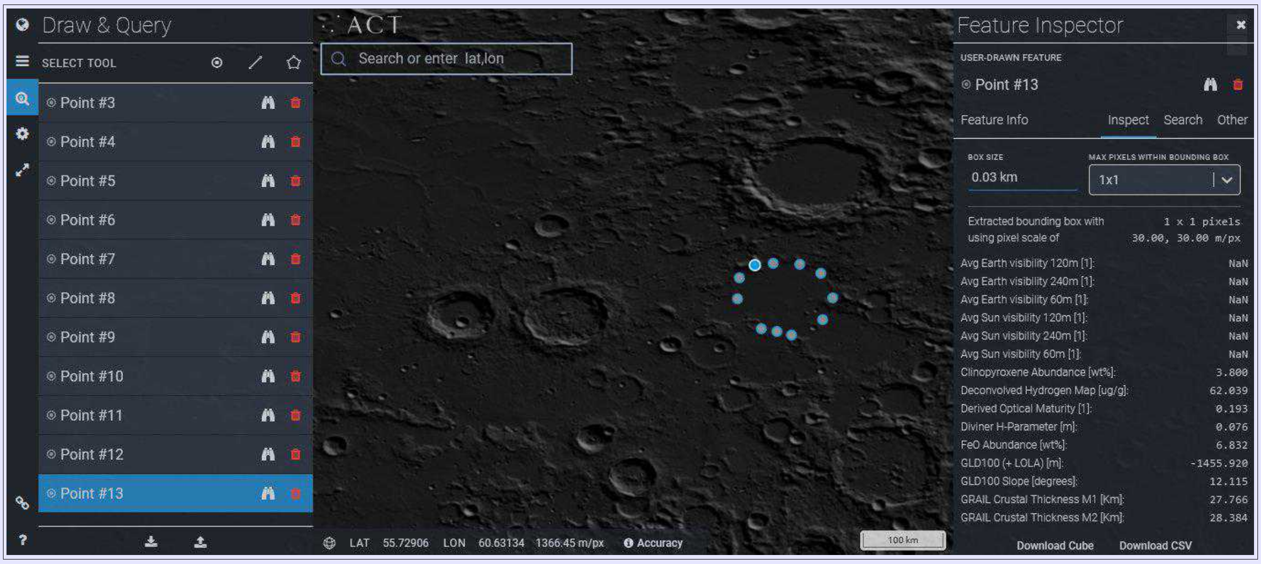



**Figure 3. Using the "Draw and Query – Point Tool" to measure the rim of a buried or degraded crater.**

{"type":"FeatureCollection","features":[{"type":"Feature","geometry":{"type":"Point","coordinates":[54.59295541843199,49.39777084624839]},"properties":null,"id":3},{"type":"Feature","geometry":{"type":"Point","coordinates":[55.89976899052947,49.35270830927951]},"properties":null,"id":4},{"type":"Feature","geometry":{"type":"Point","coordinates":[56.93620734081368,48.90208293959072]},"properties":null,"id":5},{"type":"Feature","geometry":{"type":"Point","coordinates":[57.5220203214091,47.685394441431]},"properties":null,"id":6},{"type":"Feature","geometry":{"type":"Point","coordinates":[55.494206157809565,45.83783042570697]},"properties":null,"id":7},{"type":"Feature","geometry":{"type":"Point","coordinates":[54.00714243783657,46.15326818448912]},"properties":null,"id":8},{"type":"Feature","geometry":{"type":"Point","coordinates":[52.925641550583485,48.67677025474632]},"properties":null,"id":9},{"type":"Feature","geometry":{"type":"Point","coordinates":[52.83551647664573,47.64033190446212]},"properties":null,"id":10},{"type":"Feature","geometry":{"type":"Point","coordinates":[54.77320556630751,46.01808057358249]},"properties":null,"id":11},{"type":"Feature","geometry":{"type":"Point","coordinates":[57.02633241475144,46.60389355417791]},"properties":null,"id":12},{"type":"Feature","geometry":{"type":"Point","coordinates":[53.691704679054425,49.307645772310636]},"properties":{"selected":true},"id":13}]}

**Figure 4 The "features.geojson" file for the points measured in Fig 3.**

Alternatively if you just want to attempt to measure the diameter you can use the Draw & Query / Path (or line) tool on Quickmap (Fig 5). This time place one point on one side of the crater, and then double click on the opposite side. It then tells you the length of the line i.e. diameter of the crater. Take at least 2 transects through the crater and take an average. If you take several measurements you can obtain both an average and a standard deviation (Using Excel) and the latter will give you an uncertainty on the crater rim, potentially telling us how eroded it is – though be careful because if the crater is elliptical this would also show up in the standard deviation. If in doubt just send me some diameter measurements and I will do the calculations myself.

**Step 6 – Looking for other evidence for the crater:**

The NASA Quick map web site has a whole host of remote sensing datasets and imagery that you can investigate. Try going through as many of these as possible, using the available layers to see if anything lines up with the crater rim, or secondary ejecta craters. I sometimes find the SLDEM2015 Azimuthal plot, found under the LRO LOLA option, can be useful, and more so: TerrainHillshade (with a zenith illumination angle of more than 85 deg) under the ACT layers (Experimental). But you can also look at gravity data, rock abundance maps etc. Indeed, PFC22 shows up exceedingly well in the mineralogical Clementine colour ratio map in Fig 6 (look at the location where the diameter transects were in Fig 5). But you will have to experiment to see which layer works and which doesn't.

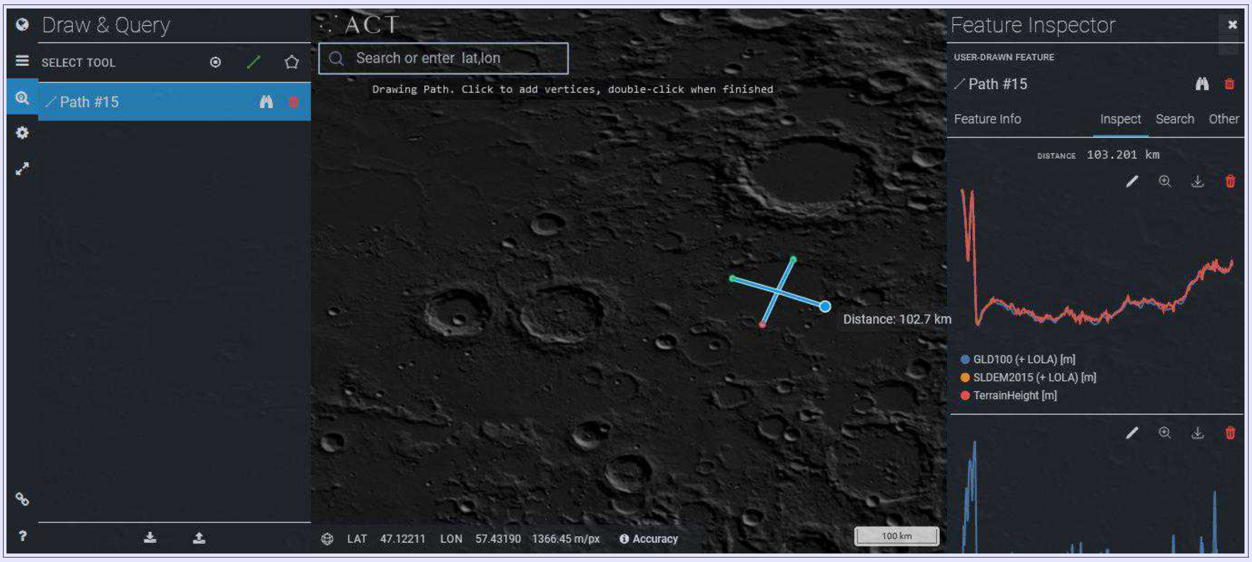



**Figure 5 Measuring crater diameters with NASA's Quickmap web site.**

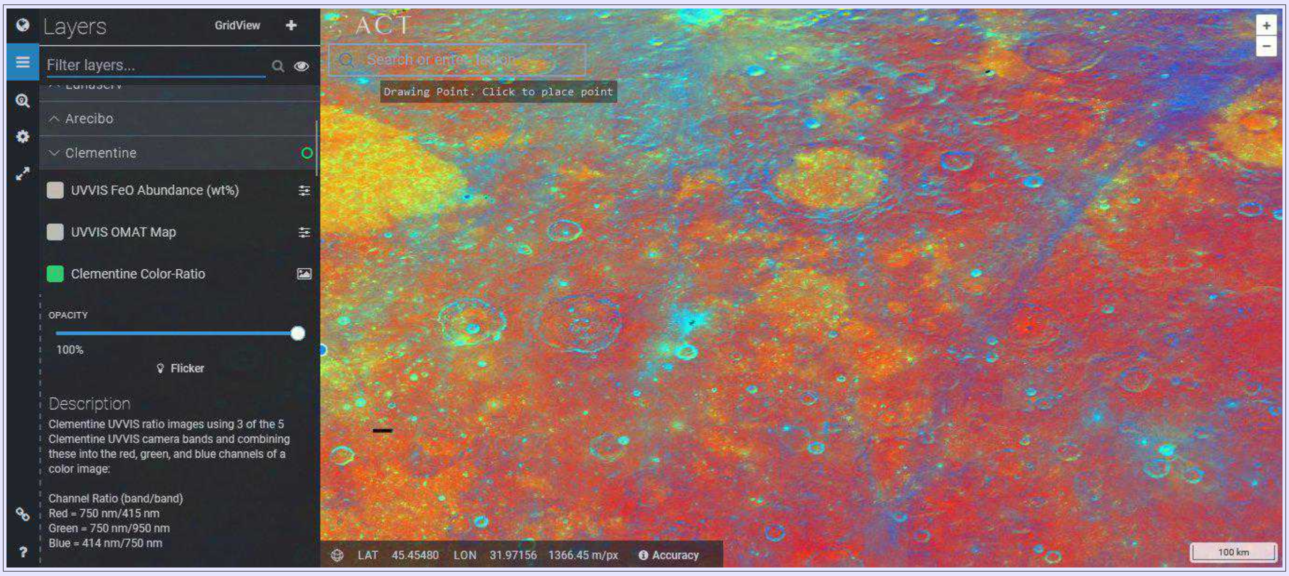



**Figure 6 The "Clementine Colour Ratio" layer from NASA's Quickmap web site.**

**Step 7 – Report:**

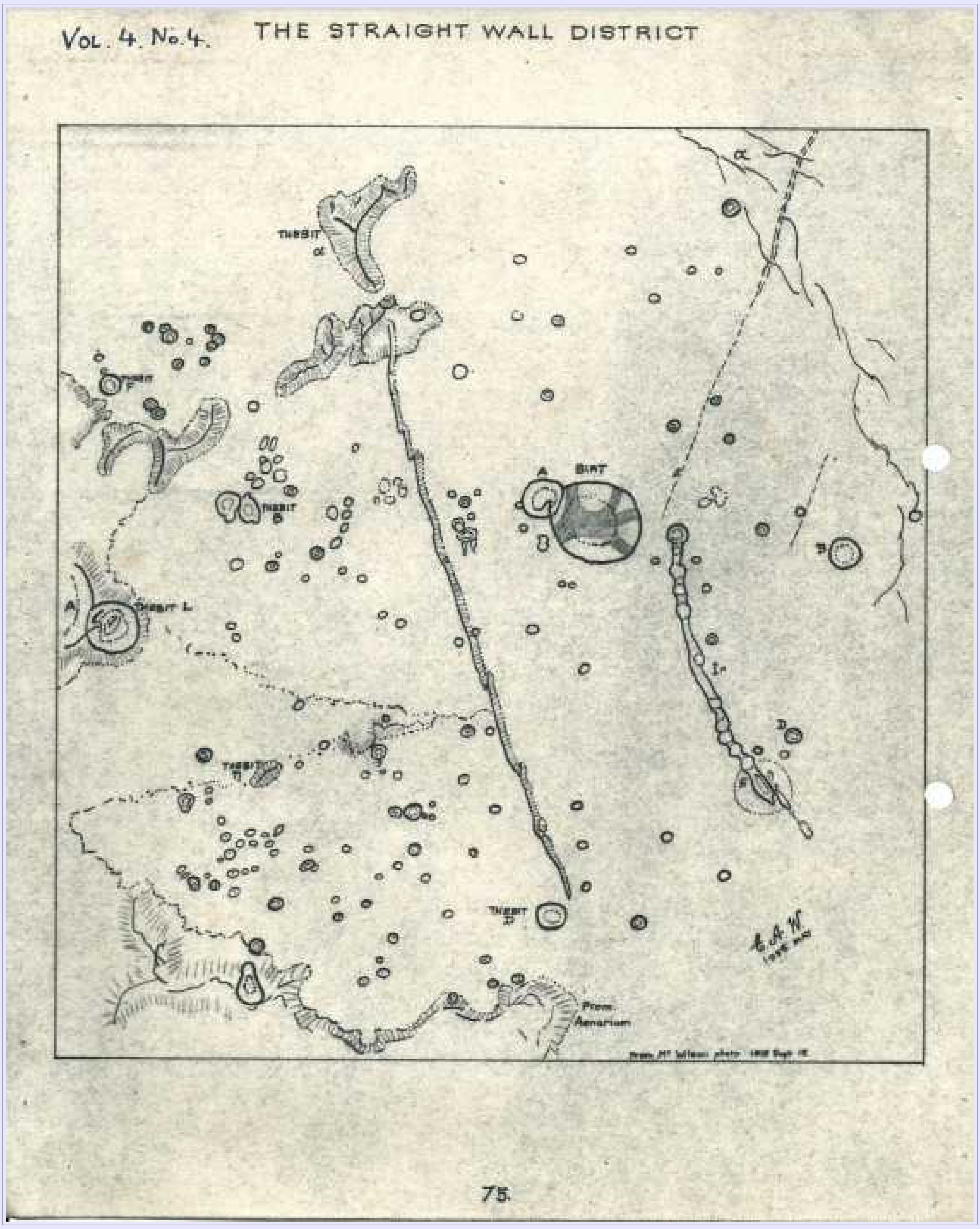
Don't just keep your findings to yourself, please email them to me e.g. images, sketches, screenshots from VTLT or the Quickmap website and some text in the email of what you found and measured. I look forward to reporting this and updating our database.

If you think that you have discovered a new impact basin, or unknown buried crater, please check whether it has been found previously on the following web site, and if not email me its location and diameter so that I can update the list.

https://users.aber.ac.uk/atc/basin_and_buried_crater_project.htm.

**From the Archive.**

**The Straight Wall and District by E.A.Whitaker, The Moon. Vol.4 No.4, June 1956.**




**Note North is UP.**

This is telescopic drawing, but a chart based on Mt Wilson photographs created by E.A.Whitaker for visual observers to use as a template and on to which they could add additional features viewed through the the eyepiece. Whitaker produced a number of these charts with the same intention, and these can be found in other issues of 'The Moon' available in the BAA Lunar Section archive. The detail shown here is worth comparing with that visible in K.C. Pau's image and the image by Carmelo Zannelli in Raf Lena's article in this LSC. The features in this chart appear to be fairly accurately portrayed, but the level detail recorded seems to be exceeded by that in Zannelli's image taken using a 20” Dall Kirkham telescope. Some features such as the two parallel lineations trending NE to SW and represented by dashed lines in the chart are not visible in LRO images (or the two images in this LSC) but it might not be wise to dismiss any such features too hastily without examining other images taken under varying illumination.

**Delisle and Diaphantus – recent volcanism?**
**By Barry Fitz-Gerald.**

Well, not exactly *recent* volcanism in terrestrial terms but possibly in lunar terms at least! After the flurry of interest in Delisle and Diaphantus in recent LSC's, including the article by Nigel Longshaw in this issue, I have looked at some of the suspected domes reported in the area of these two craters. The main problem with identifying dome like structures, by which I mean *bona fide* volcanic structures in this area, is that the mare surface, particularly west of the crater pair, is dominated by numerous swells and troughs associated with a complex of north-south orientated wrinkle ridges that run between the Aristarchus plateau and Sinus Viscositatis. Some of these *may* be volcanic but many, possibly most of these recorded by previous observers are probably not.

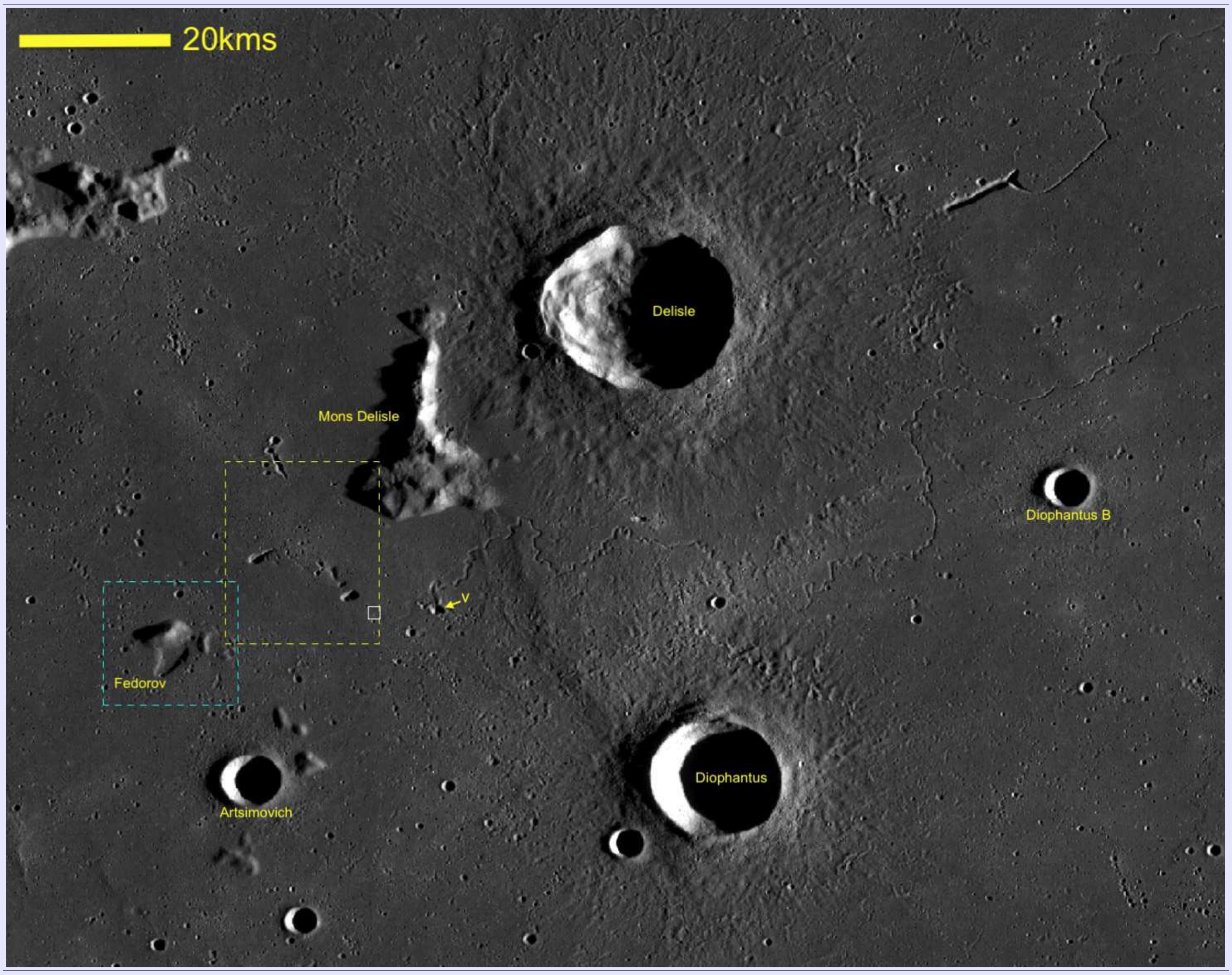



**Fig.1 LROC WAC image of the Delisle and Diaphantus area. Features in the boxes are discussed below.**

There is however a small cluster of more likely volcanic features to the SW of Mons Delisle (Fig.1), as well as other features that suggest late stage volcanism in this area of a slightly rarer form. To set the scene however, the 25km diameter Delisle is slightly older than the 17.5km diameter Diophantus, though both are of Eratosthenian age, and between 3.2 to 1.1 billion years old. The terrain between the craters is elevated above the rest of the mare, with the western edge of this area defined by a curving scarp running between the western rim of Diophantus and the south-eastern tip of Mons Delisle. This feature is probably tectonic in origin and post-dates the emplacement of the mare lavas in the area, as a sinuous rille that runs between Delisle and Diaphantus climbs up and over it, something that would not have been possible if it was present when the lavas forming the rille were flowing.

This rille is quite interesting in its own right, appearing to emerge from an approximately 200m deep vent (V in Fig's 1 and 2) which has unfortunately been straddled by a cluster of secondary craters from Diophantus making interpretation difficult. This is significant because it dates the rille to a period *before* the formation of Diophantus, and indeed other sections of the rille are also smothered by ejecta from this crater, as well as from the much younger Samir.

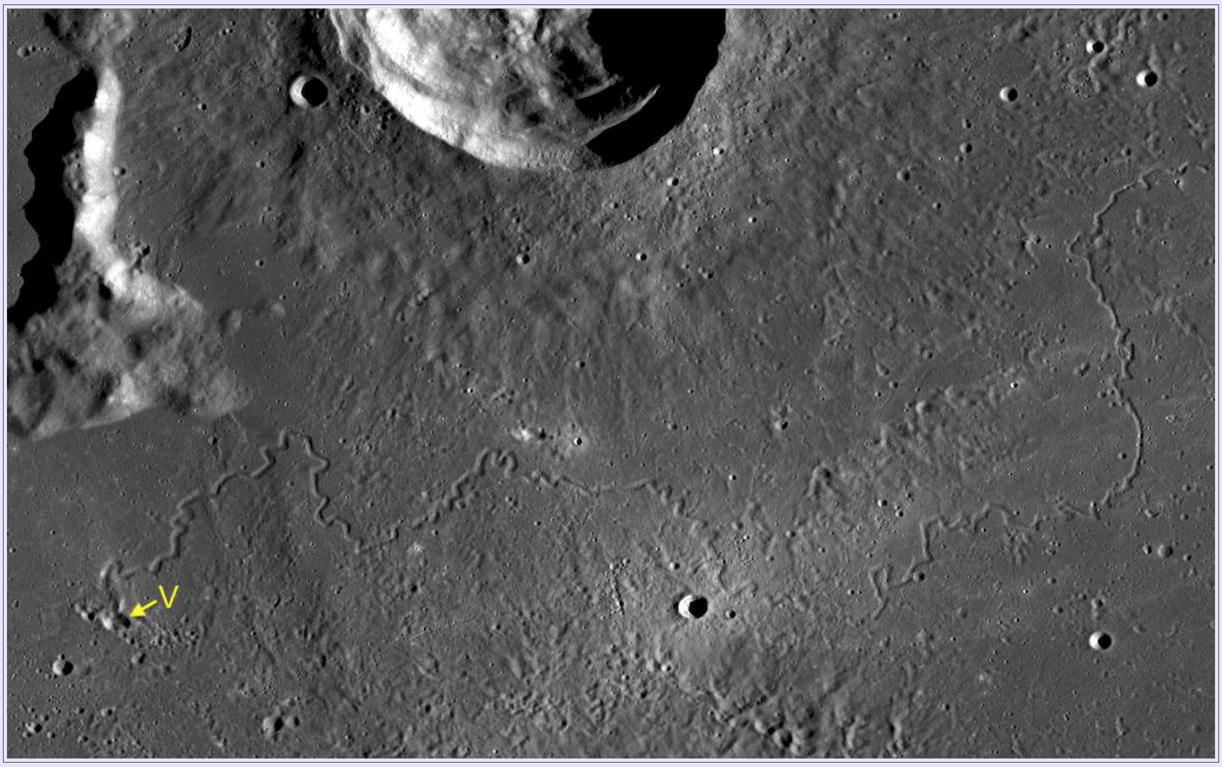



**Fig.2 The sinuous rille that runs between Delisle and Diaphantus post-dates the former but pre-dates the latter. Note how its course snakes around the ejecta of Delisle, which would have formed an obstruction it flowed around. Note that the possible vent (V) is at a lower elevation that the stretch of rille between the two craters, showing that the elevation of this terrain occurred after the rille had formed, as lava will not flow uphill. Image courtesy SLENE/JAXA**

This rille appears to drain towards the east and north towards Mare Imbrium, and is surrounded by faint side branches and tributaries in its 'lower' reaches around Diophantus B, suggesting it formed an extensive shallow lava flood, but with the bulk of the lavas flowing within the rille. The rille peters out just before it reaches a prominent lava flow, part of a complex of prominent flows that originate somewhere in the vicinity of Euler and flow northwards towards the Imbrium basin (Fig.3).

Of course the more prominent Rima Delisle also flows eastwards from a elongate vent to the east of Delisle and may pre-date that crater. There is a minor Thorium anomaly to the west of Mons Delisle that might be implicated in this volcanism, but nothing as intense as the nearby anomalies associated with the Aristarchus Plateau to the west and Marian to the north. I have not seen any representations of these rilles in any drawings or images of the area, so am unsure whether they would be visible in anything other than large apertures with very favourable seeing.

Moving on to dome like features, there are two possible candidates to the SW of Mons Delisle that have been recorded by numerous observers. Two examples of these observations are shown in Fig.4 with drawings made by B.T Doherty in 1963 and R.F. Rogers in 1966, but a scan through back issues of The Moon will reveal many more. Comparing the drawings with the spacecraft images it would appear that both observers recorded the domes, albeit with slightly different positions, whilst Rogers appears to have recorded the presence of possible vents on the summits. The domes themselves are extremely subtle features, only a few tens of meters high and with extremely shallow slopes and diameters of 13-15kms. As can be seen if Figs.1 and 5 they are barely perceptible in the imagery, and even with the Terrain Slope option in LRO Quickmap enabled (which can highlight slight topographic features and slopes) they are still difficult to spot. This shows the clear advantage of visual observations in detecting these extremely low amplitude features.

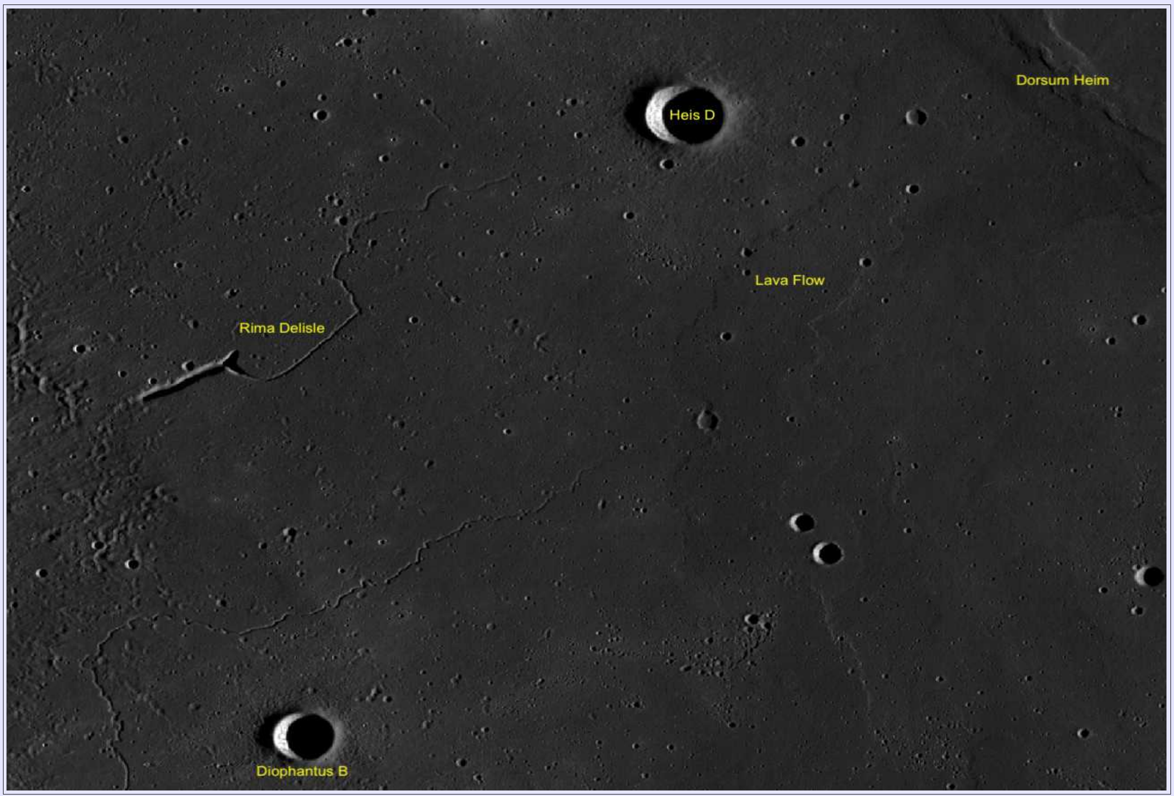



**Fig.3 Rima Delisle and the lower reaches of the sinuous rille that flows between Delisle and Diaphantus. Also shown is a lava flow with a prominent flow front.**

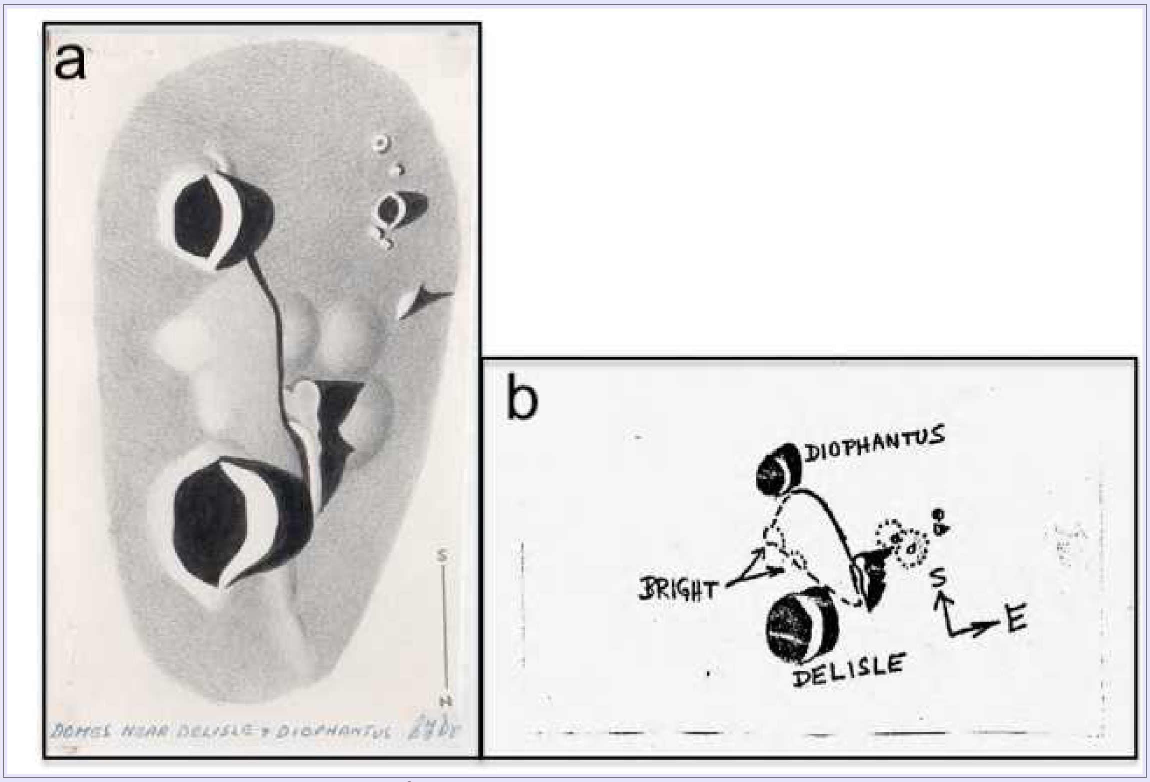



**Fig.4 Drawings by B.T Doherty made on the 26th November 1963 from The Moon, Vol.12 No.3 (a) and by R.F. Rogers on 27th August 1966 from The Moon, Vol.15 No.2. Note <u>north is down</u> in both drawings.**

Vents are present, but their positions might suggest something other that two individual domes, and what might actually be present is an a single structure in the form of a single swelling with an undulating surface and a number of separate vents. It is possible that this complex might also be related to the pit which is the possible source of the sinuous rille discussed above, and that all of these features share a common source of magma beneath the surface.

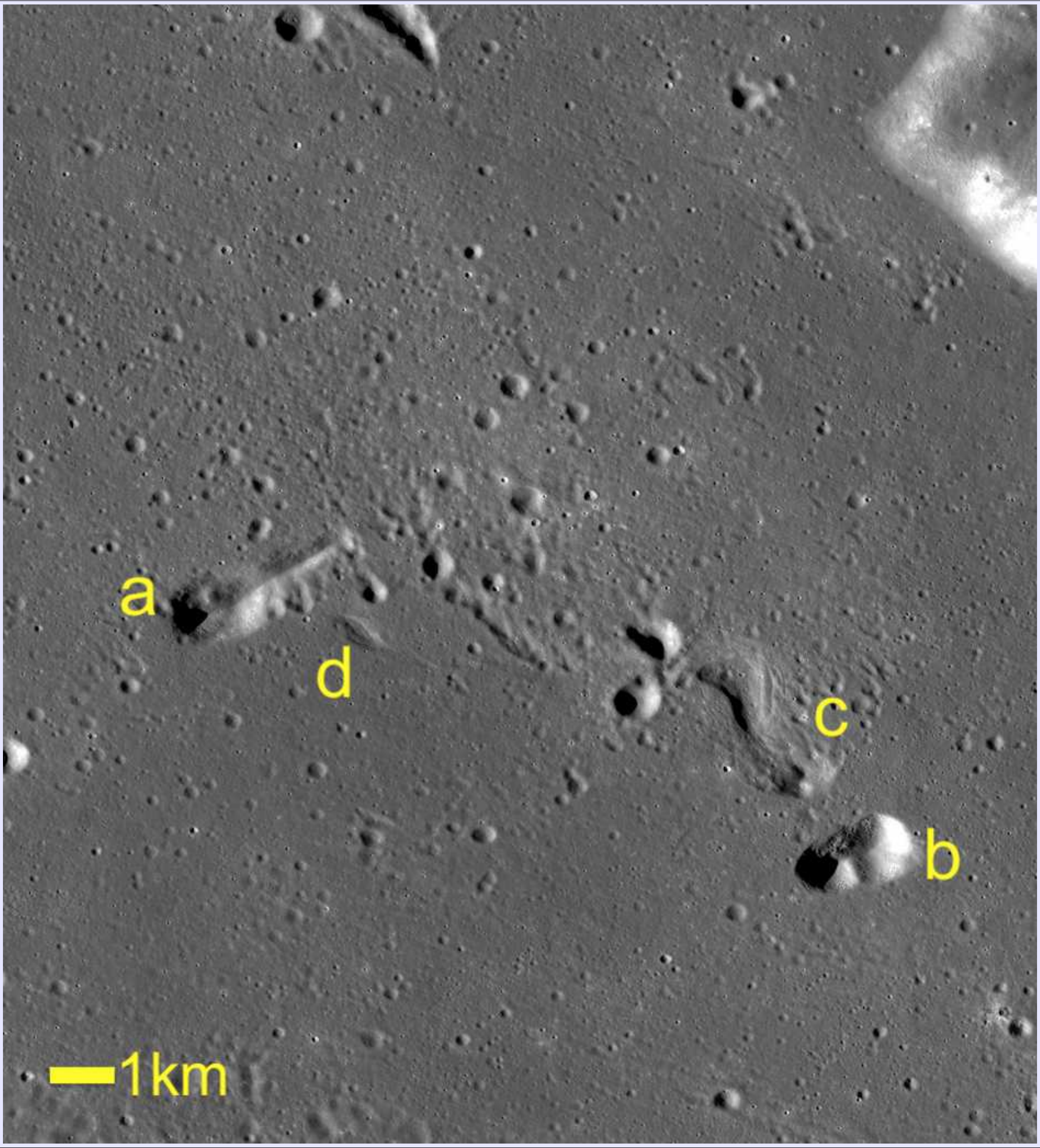



**Fig.4 The summit area of the suspected domes outlined in the yellow box in Fig.1. Note the possible eruption vents a and b and possible collapse pits c and d. Image courtesy SLENE/JAXA**

Fig.4 shows the vents along the summit of this complex, and as can be seen they are quite different in shape and morphology, with the two labeled **a** and **b**, being rimless craters, between 1 and 3kms long and between 250 and 300m deep. They both have relatively rocky interiors with b being the most rocky with bouldery deposits and exposures visible in its walls. These two may be vents from which explosive eruptions have occurred, with **b** being the most convincing candidate. The pits marked **c** and **d** are much shallower features and have rather distinctive edges consisting of concentric ridges and fissures. These may represent collapse features that formed as the underlying magma was erupted leading to the surface collapsing into the emptying chamber below. The two distinctive types of pits certainly suggest a different but possibly related formation process.

Possibly the most interesting feature related to volcanism in this area is however even more subtle in nature, and can be located in the small white box in the lower right corner of the yellow box in Fig.1 and shown in glorious LRO NAC detail in Fig.5. This small area of mare surface, which appears to be speckled with ejecta from Diophantus, shows quite a mottled appearance with irregularly shaped patches of a lighter material showing through where a darker surface layer appears to be missing. The edges of the lighter patches are quite ragged, and are clearly not impact structures or the product of mass wastage as they are not on slopes of any significance.

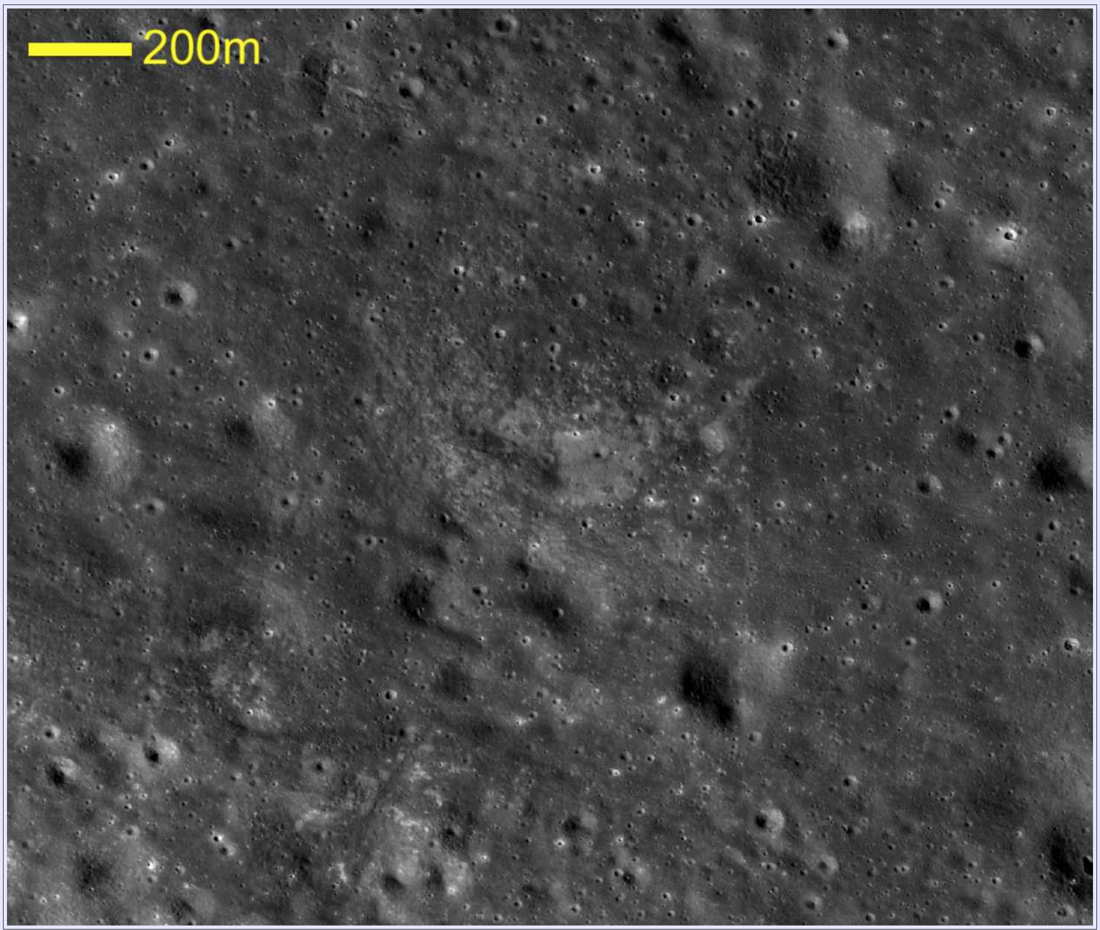



**Fig.5 LRO NAC image if the area in the small white box in Fig.1 showing irregularly shaped lighter patches of possible iIMP activity where the darker surface material has been eroded by gas venting from beneath.**

This area is, I suspect, an example of what I have previously called an immature Irregular Mare Patch or iIMP to distinguish it from the more well known Irregular Mare Patches or IMP's*. There have been a number of hypotheses suggested to account for IMPs which count Ina as its most well known example, these range from lava flows that have been inflated by the injection of gas or the eruption of a frothy lava, but the most likely explanation by a country mile is that they represent areas where the regolith has been eroded away by gas escaping from beneath the surface. As these features seem to cluster in volcanic areas the likely culprit is volcanic gasses which vent to the surface, presumably having originated from magma bodies within the crust. As the gas escapes from the surface it blasts the fine regolith fractions away from the surface leaving coarser material behind. This removes the older, darker space weathered surface and exposes fresher, un-weathered sub-surface material. In the case of IMP's such as Ina the level of erosion is sufficient to produce distinct depressions with a bright boulder rich substrate (representing the material exposed by the venting gas) on which rounded mounds of smooth darker (representing material not yet removed and likely covered in redistributed fine regolith particles) material sit like drops of mercury.

In the present case, the amount of gas release, though locally widespread, has not produced any Ina like depressions, but has just removed the upper layers of mature regolith to expose fresher material beneath. I noted a similar pattern of erosion on the flanks of the dome named Ya1 by myself and Raf Lena in some previous studies, and which appear to be areas where the escape of volcanic gas has eroded the dome slopes in a very unusual and quite unique way for lunar domes**.

These features do not seem to have been described in the academic literature that I have access to, so these remarks are just my interpretation of what is seen in the images. It is also worth noting that this patch of iIMP is aligned with **b** and **c** (Fig.4) and between them and the suspected vent for the sinuous rille (Fig.2) suggesting that they are all the product of one volcanic system with multiple vents and differing products (explosive activity, gas release and flowing molten lava) emerging from them at different times. It is likely that the iIMP patch is the 'youngest' expression of this activity.

Another possible volcanic feature is the crater Fedorov (Fig.6) which abuts the southern edge of a small nubbin of highland that projects some 500m above the mare surface slightly to the west of the dome(s) discussed above. Fedorov which is rimless and some 170m deep is in fact a collapse crater, of probable volcanic origin, and similar to feature **c** in Fig.4, but on a larger scale. It also has the circumferential fissure arrangement noted in feature **c**, suggesting the slumping of the edges of the crater as the ground within subsided.

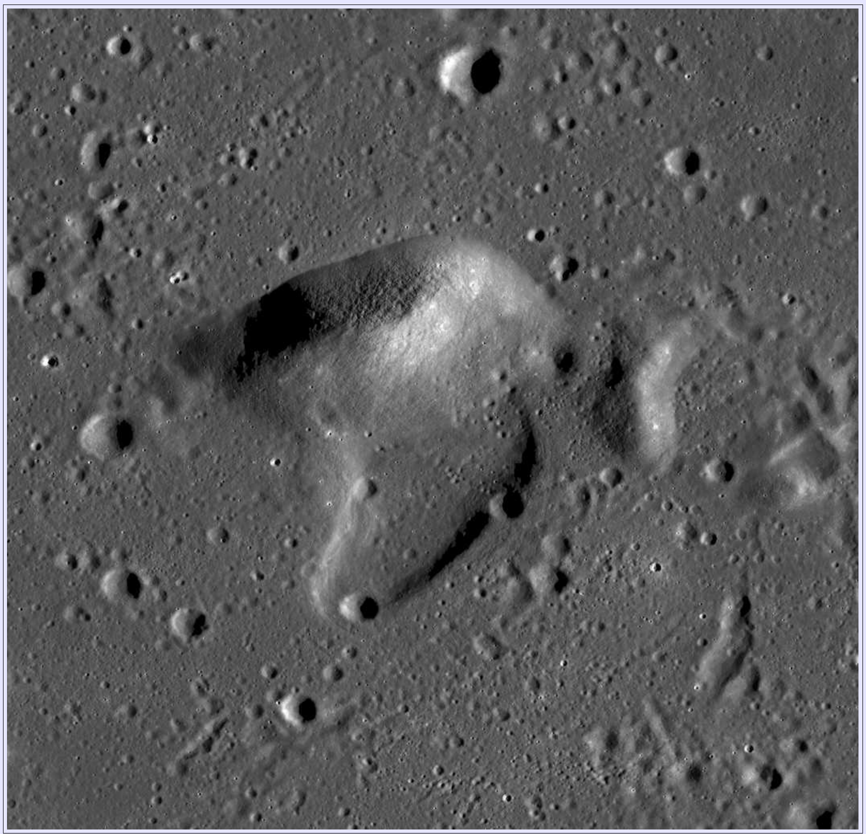


**Fig.6 The crater Fedorov which is more likely to be a volcanic collapse crater than an impact structure. Image courtesy SLENE/JAXA**

Fedorov is only located some 20kms away from the summit of the dome discussed above, and on the edge of a very slight swelling that appears to correspond to the position of all the the features discussed so far (Fig.7). So as previously suggested we might not have a number of discrete domes here but a single large complex, with a somewhat uneven surface that gives the impression of more than one structure. This may be more likely than there being several individual volcanic structures being clustered in a relatively small area.

A number of drawings contained in the back issues of The Moon indicate the presence of a large dome immediately west of Mons Delisle (see Fig.4a and Fig.10 on page 25 of last months LSC). The topographic data in Quickmap however shows that this terrain is quite flat with no surface swelling evident. There is a gentle regional slope from high ground to the south towards the north and the Imbrium Basin (explaining why the large lava flows including the one in seen in Fig.3 flow towards the basin) and this *may* have contributed to the impression of a dome here, but there is nothing in the spacecraft images and data to support these observations.

To summarise, there appears to be a volcanic complex to the SW of Mons Delisle that consist of an extremely low amplitude surface swelling with barely perceptible flank gradients, but which has been recorded by visual observers as two separate domes. This appearance of two domes may not reflect the nature of the complex, which appears to have a number of surface vents, collapse pits and areas of iIMP activity. These may have produced explosive volcanic activity as well as the eruption onto the surface of lavas that carved a sinuous rille which flowed northwards towards the Imbrium Basin, skirting the ejecta blanket of the southern rim of Delisle.

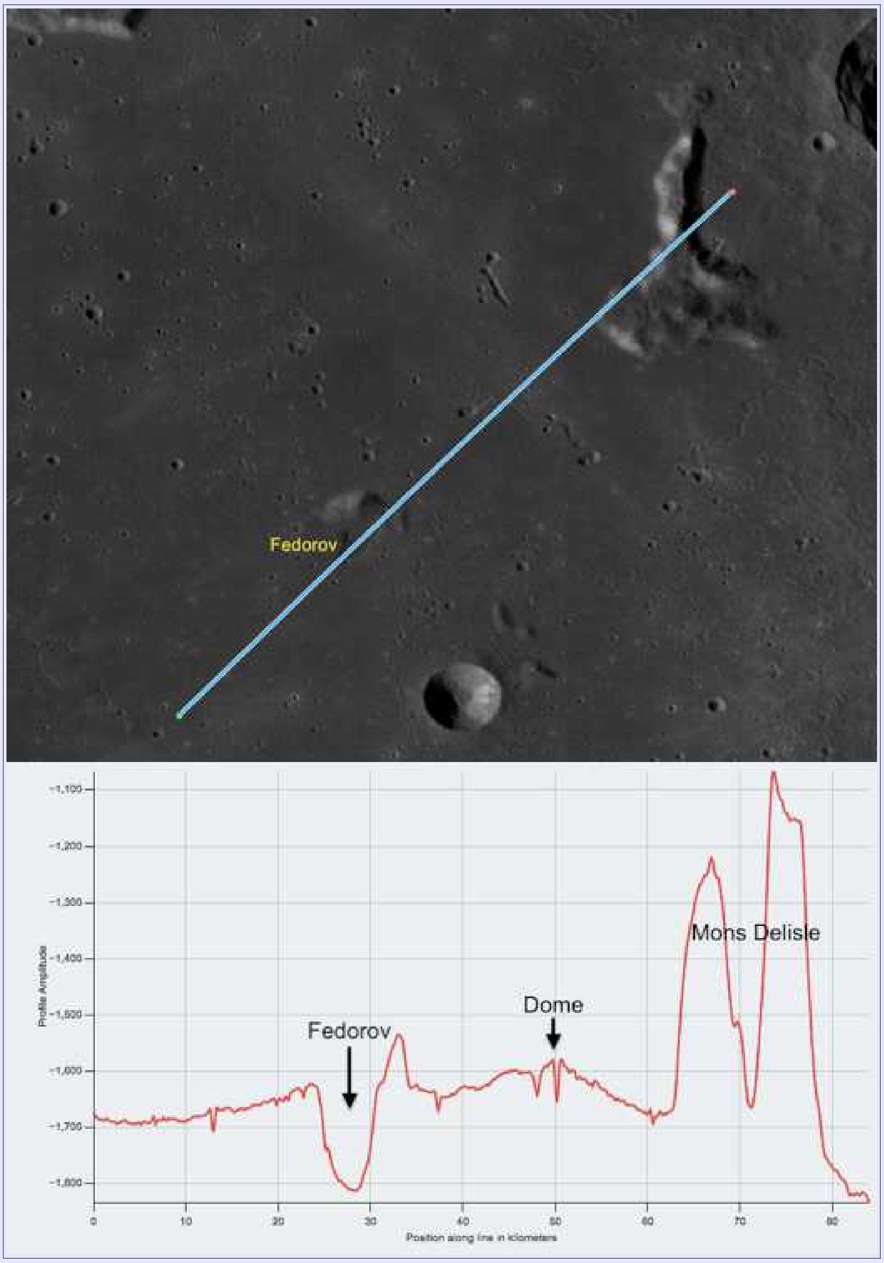



**Fig.7 Topographic section along the blue line in the top panel shows that Fedorov sits on the slight swell that includes the domes identified by visual observers.**

The iIMP may represent the venting of volcanic gasses at the end of the volcanic activity through fissures leading from subsurface magma chambers to the surface, which essentially blew the more mature surface regolith away and exposed lighter, un-weathered material beneath. The draining of the magma from beneath this complex may be responsible for the pits that show evidence of downwards collapse such as Fedorov and those shown in Fig.4. Further exploration of the area using the record contained in The Moon archive and spacecraft images may well reveal more interesting features in this complicated area.


*Lunar Domes (part XLIX): Dome north of Rhaeticus L. Raffaello Lena and Barry Fitz-Gerald. Lunar Section Circular. Vol. 58 No. 7, July 2021

**Lunar Magmatic Foams and Irregular Mare Patches. Barry Fitz-Gerald. Lunar Section Circular Vol. 56 No. 1, January 2019.

**LUNAR GEOLOGICAL CHANGE DETECTION PROGRAMME.**
**By Tony Cook.**


**Figure 1. The LUMIO spacecraft from the opening slide of the LUMIO Scientific Workshop (Image Credits: Politecnico Milano, ESA, ASI)**

**News:** On February 13th, a workshop (See Fig 1) was held by the Italian Space Agency in Rome (and on-line) on the upcoming Italian LUMIO CubeSat mission. LUMIO stands for "Lunar Meteoroid Impact Observer" and is planned to launch in 2025/26 on a 1.5 year mission to a safe halo orbit whereby it can monitor the Moon's far side for impact flashes for 14 days per month. It contains two cameras and a beam splitter. One camera can work in visible light and the other in the near IR – so this would allow for blackbody temperature determination of impact flashes and the ability to automatically exclude cosmic ray events (these would be in one camera image and not in the other at the same location on the Moon). Theoretical predictions suggest that the camera maybe able to capture nearly a quarter of a million impact flashes over its planned lifetime. What is currently uncertain (from the documents that I have seen) is the frame rate of the camera, so it may not be able to do a light curve of the flash over time if the exposure is too long?

Another impact flash related piece of news is that the Greek NELIOTA people (ESA funded impact flash observatory in Greece) have released software that you can use at your telescope, with FireCapture software, to detect impact flashes in real time. Or, you maybe able to run previously recorded video of earthshine through and detect old candidate impact flashes. The software may also work for detecting impacts on Mars and Jupiter as well. If you have the ability to video earthshine at say faster than 10 frames per sec, then please give the software a go by downloading it from the following website: https://kryoneri.astro.noa.gr/en/flash-detection-software/

TLP Reports: No TLPs were observed in February apart from the impact flash videoed from Japan on 2023 Feb 23 – see last month's newsletter.

**Routine Reports received for February included**: Massimo Alessandro Bianchi (Italy – UAI) imaged Herodotus. Anthony Cook (Newtown, UK – ALPO/BAA) imaged: several features in the Short-Wave IR (1.5-1.7 microns) and colour imagery at optical wavelengths. Alan Clitherow (UK – BAA) made a 1st quarter Moon mosaic. Walter Elias (Argentina – AEA) imaged: Aristarchus, Copernicus, Herodotus, Manilius, Mare Crisium Proclus and Timocharis. Les Fry (West Wales, UK – NAS) imaged: Endymion and Lacus Bonitatis. Rik Hill (Tucson, AZ – ALPO/BAA) imaged: Montes Apenninus and Montes Caucasus. Ken Kennedy (Scotland – BAA) imaged: Maurolycus and Theophilus. Jean Marc Lechopier (Teneriffe, Spain – UAI) imaged Montes

Teneriffe. Eugenio Polito (Italy – UAI) imaged: earthshine, Herodotus, Montes Teneriffe, Plato, Sulpicius and Gallus M. Mark Radice (Swindon, UK – BAA) imaged: Mare Crisium, Mare Tranquilitatis, Littrow, Plinius, Posidonius and Triesnecker. Franco Taccogna imaged earthshine.

**Analysis of Reports Received:**

**Herodotus:** On 2023 Feb 02 UAI observers imaged this feature; Massimo Alessandro Bianchi at 17:39-17:42UT and Eugenio Polito, at intervals from 18:27-19:23 for the following lunar schedule request:

***BAA Request: Some astronomers have occasionally reported seeing a pseudo peak on the floor of this crater. However, there is no central peak! Please therefore image or sketch the floor, looking for anything near the centre of the crater resembling a light spot, or some highland emerging from the shadow.***
***All reports should be emailed to: a t c @ a b e r . a c . u k***

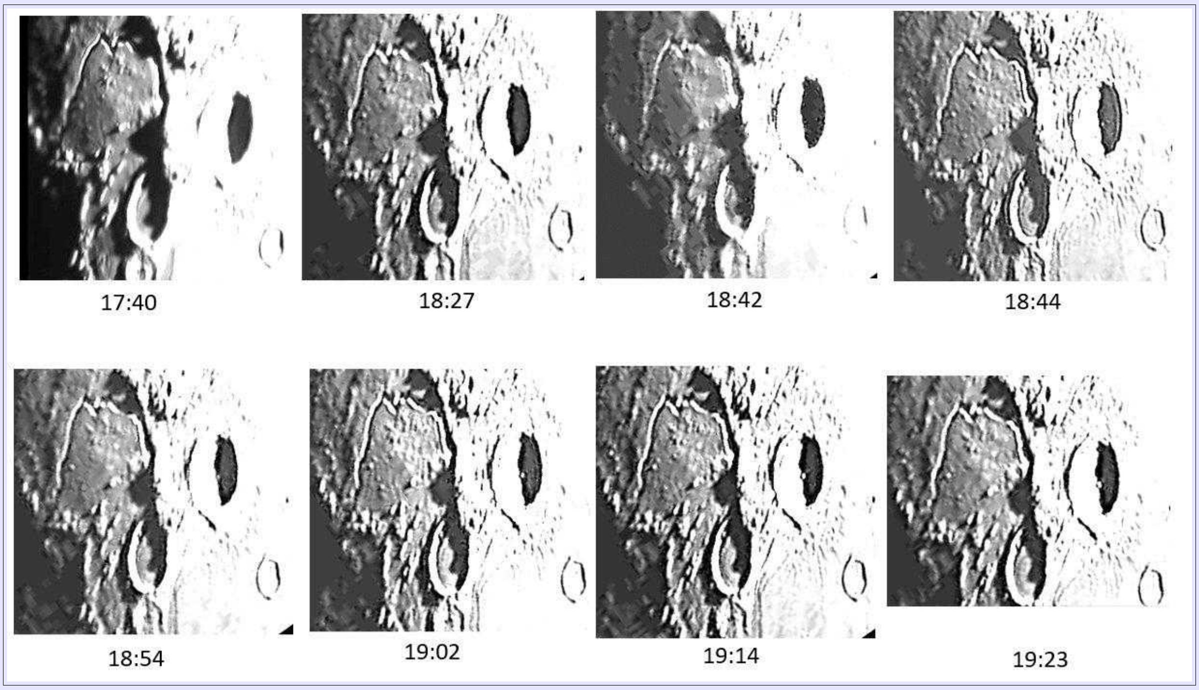



**Figure 2. Contrast stretched versions of images of Herodotus taken by UAI observers on 2023 Feb 02. The times quoted under each image are in UT. The 17:40 image is by Massimo Alessandro Bianchi and the others are by Eugenio Polito.**

At last, we may have some evidence of a central pseudo peak (spot) on the floor of Herodotus, after all these years of imaging! Though, we must be a little careful as pushing the image contrast so high can lead to noise artefacts. To avoid mistaking these noise artefacts, one has to look at trends in the time sequence in Fig 2. Firstly at 17:40 UT we see a small light arc on the NW floor of the crater, this is on all the images, so must be real, but of course is nowhere near the centre. Between 17:40 and 19:02 UT there is a white spot is on the southern part of the floor, sandwiched between the rim and the blob-like part of the shadow. This is known about and has been discussed by Raffaello Lena many years ago and sketched by Peter Grego. It may have faded slightly by 19:23 UT but again that might be related to the contrast stretching? A white spot, slightly NW of the centre is visible in the 18:42 UT image, but the original image had some noise in it, however it may be present in the 18:27 and 18:44 UT images. By 18:54-19:23 UT there is a diffuse light spot that is more central and hugging the dimple in the floor shadow. Indeed, maybe it even consists of two white spots in the 19:23 UT image – but there again that could be image noise for one of them? So, have we found the famous pseudo peak that is sometimes there but mostly not visible, according the Bartlett, Haas, Hill, Firsoff etc? Maybe, though as you can see it is fairly faint, the southern floor spot is brighter – but the observers never mentioned this (only the central spot). Also, would visual observers have really been able to see such faint detail as CCDs can image?

We need more time lapse imagery of the caliber that was shown in Fig 2 to see if the effect repeats itself and identify what sub-solar longitudes and latitudes are needed to see it. Anyway, congratulations to the UAI team for achieving these current time sequence images.

**Aristarchus:** On 2023 Feb 06 UT 02:11 Walter Elias (AEA) imaged the crater under similar illumination to the following report:

***Aristarchus 1989 Oct 13 UT 21:00 Observed by Cook (Frimley, Surrey, UK, 20cm reflector (visual and video) "Aristarchus had what appeared to be outline of a ghost crater on it's eastern side - quite large and bright". Cameron 2006 extended catalog TLP ID No=378 and weight=5.ALPO/BAA weight=3.***

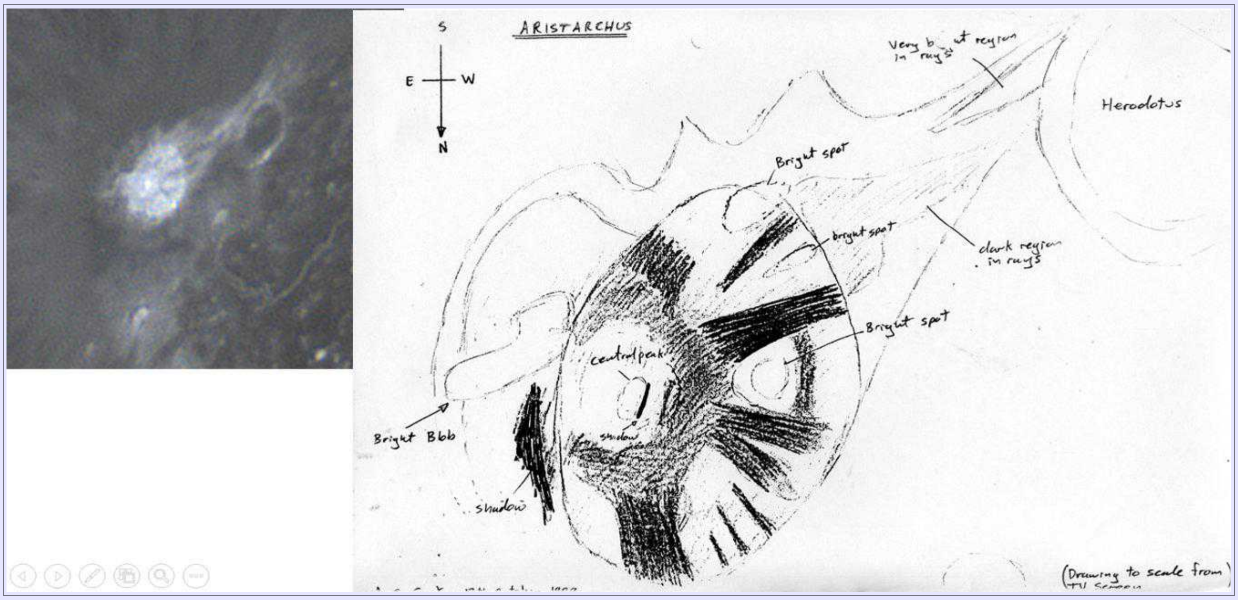



**Figure 3. Aristarchus orientated with north towards the bottom. (Left) An image by Walter Elias (AEA) taken on 2023 Feb 06 UT 02:11. (Right) A sketch made off the TV screen from video feed from the telescope during a TLP seen by Tony Cook on 1989 Oct 13, after the original visual detection.**

The TLP I saw in 1989 was a very interesting one. It was detected visually by myself, and would like to quote from my report: "*On examining Aristarchus my attention was drawn by a very bright blob on the east. This was much brighter than I had ever seen before and was comparable in brightness to the central peak of Aristarchus. Also, a lot of fine detail was seen in and around this blob, including a bright arc to the south east of the crater, (attached to the blob and continued north of this). This was so prominent that it gave the impression that there was a second crater attached to the South East of Aristarchus. I began to set up the CCD video equipment for monitoring of Aristarchus and began operating this at 21:02UT. Unfortunately, the video recorder was in "Play" rather than "Record" mode and this fault was not discovered until some time later. Successful recordings were obtained at the following times: 22:04-22:08 UT, 22:13:10-22:22:26UT, 22:25:02-22:32:12UT. Observations ceased after 22:32UT due to cloud. A drawing of Aristarchus based on the video recordings appears on the next sheet. The bright blob was certainly not as bright on the video than it was at 21:00UT*".

The sketch I made by tracing over the TV screen can be seen in Fig 3 (right). The general appearance is very similar to Walter's image in Fig 3 (Left) in terms of interior detail though the blob on the east exterior, in his image, is not as bright as it was in the 1989 visual TLP nor the CCD sketch i.e. much fainter than the central peak in Walter's image. The ghost crater effect that I saw initially visually, had faded by the time the successful video recording was captured and is not at all visible in Walter's image. We shall leave the weight at 3 for now, but its good that we have a more modern context image.

**Earthshine:** On 2022 Feb 21 UAI observers: Eugenio Polito (17:21 and 17:27 UT) and Franco Taccogna (17:35UT) imaged the crater for the following Lunar Schedule request:

***BAA Request: Please try to image the Moon as a very thin crescent, trying to detect Earthshine. A good telephoto lens will do on a DSLR, or a camera on a small scope. We are attempting to monitor the brightness of the edge of the earthshine limb in order to***

***follow up a project suggested by Dr Martin Hoffmann at the 2017 EPSC Conference in Riga, Latvia. This is quite a challenging project due to the sky brightness and the low altitude of the Moon. Please do not attempt if the Sun is still above the horizon. Do not bother observing if the sky conditions are hazy. Any images should be emailed to: a t c @ a b e r . a c . u k***

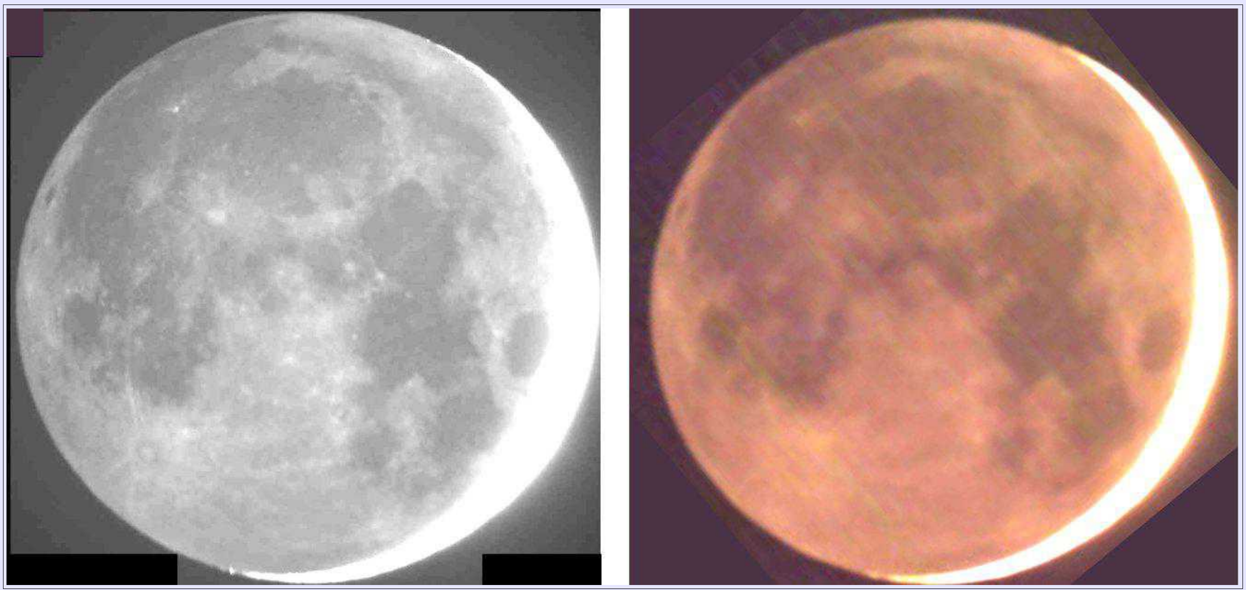


**Figure 4. Earthshine as imaged by UAI observers on 2023 Feb 21. (Left) Taken by Eugenio Polito at 17:21 UT from San Pancrazio Sal. (Italy) using a Skywatcher SkyMax 102/1300 with an ASI 178 MM cameras and a 0.5x focal reducer. (Right) Taken by Franco Taccogna at 17:35 UT from Gravina in Puglia (BA), Italy using an EVO Guide 50 ED (f:240mm) with a ASI 120 MC camera.**

Neither of the images in Fig 4 show an obvious bright rim to the SW-NW limb of the Moon that Dr Martin Hoffmann was suggesting might be evidence of forward scattering of light from a dusty exosphere in his 2017 EPSC conference poster. Now there is a high albedo highland part of the Moon that libration sometimes brings more across onto the nearside of the Moon that might offer an explanation to what was suggested at EPSC back in 2017, but I think we need more examples, closer to New Moon before we can rule this out.

A couple of important points about Fig 4. Eugino and Franco were observing from different locations, and so different observing conditions may explain the variation in colour and detail visible. Secondly note how bright Aristarchus appears like to your eyes  in Fig 4 (Left) – it looks like the brightest feature on the Moon! However, in Fig 4 (Right) it is similar to Kepler and Copernicus. This illustrates perfectly how visual observers may have been tricked in the past into thinking that Aristarchus has varied in brightness in the matter of minutes (14 minutes in the case of the observations above) as it all depends upon what atmospheric observing conditions and imaging resolution and contrast are doing to the seeing disk, or point spread function (PSF). A large PSF will make small contrasty bright features "blur" out into less bright features, hence why Aristarchus appears similar in brightness to nearby Copernicus and Kepler in Fig 4 (Right). Another aspect to consider when visually judging brightness is the background a ray crater is seen against – this is "relative brightness". However, if one takes some CCD digital number (DN) values then in Fig 4 (Left) Aristarchus is DN=209, Copernicus is DN=197, Proclus DN=224, Tycho DN=183, bright Spot near Hell DN=218, and you can quite clearly see that in an absolute sense, Aristarchus is not the brightest feature on the Moon, but in a relative sense (what your eye/brain sees) it could be regarded as the most "contrasty" feature.

**Theophilus:** On 2023 Feb 26 UT 19:30 Ken Kennedy (BAA) imaged this crater under similar illumination to the following report:

***Theophilus 1964 May 18 UT 01:05-01:15 Observed by Dieke (Baltimore, MD, USA, 6" refractor, x125) "Crescent of crimson color on SW between rim & floor. Was not present at 0500, nor did it reappear from 0115 to 0245h" NASA catalog weight=3. NASA catalog ID #812.***

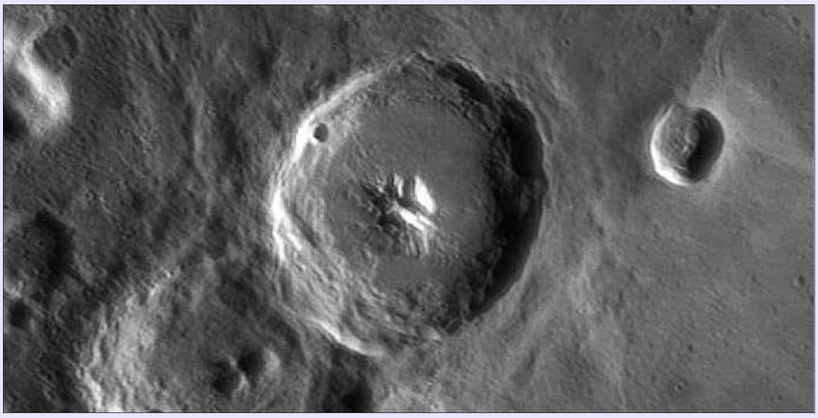


**Figure 5. Theophilus as imaged by Ken Kennedy (BAA) in monochrome and with north towards the top.**

Although Ken's image (Fig 5) is in monochrome, it is a good context image of what the crater should have looked like back in 1964. The only difference of note between the SW area of the crater is that there is a lot more obvious terracing between the SW rim and the SW floor than visible elsewhere in the crater.

**Montes Teneriffe:** On 2023 Feb 28 UAI observers Jean Marc Lechopier observed visually and Eugenio Polito imaged this region according to the following lunar schedule request:

***BAA Request: please image this area as we want to compare against a sketch made in 1854 under similar illumination. However, if you want to check this area visually (or with a colour camera) we would be very interested to see if you can detect some colour on the illuminated peaks of this mountain range, or elsewhere in Mare Imbrium. Features to capture in any image (mosaic), apart from Montes Teneriffe, should include: Plato, Vallis Alpes, Mons Pico and Mons Piton. Please note that we are especially interested in the appearance of the individual peaks of the Montes Teneriffe, when the Moon is at a low altitude e.g. flaring and colours seen. Any visual descriptions, sketches or images should be emailed to: a t c @ a b e r . a c . u k***

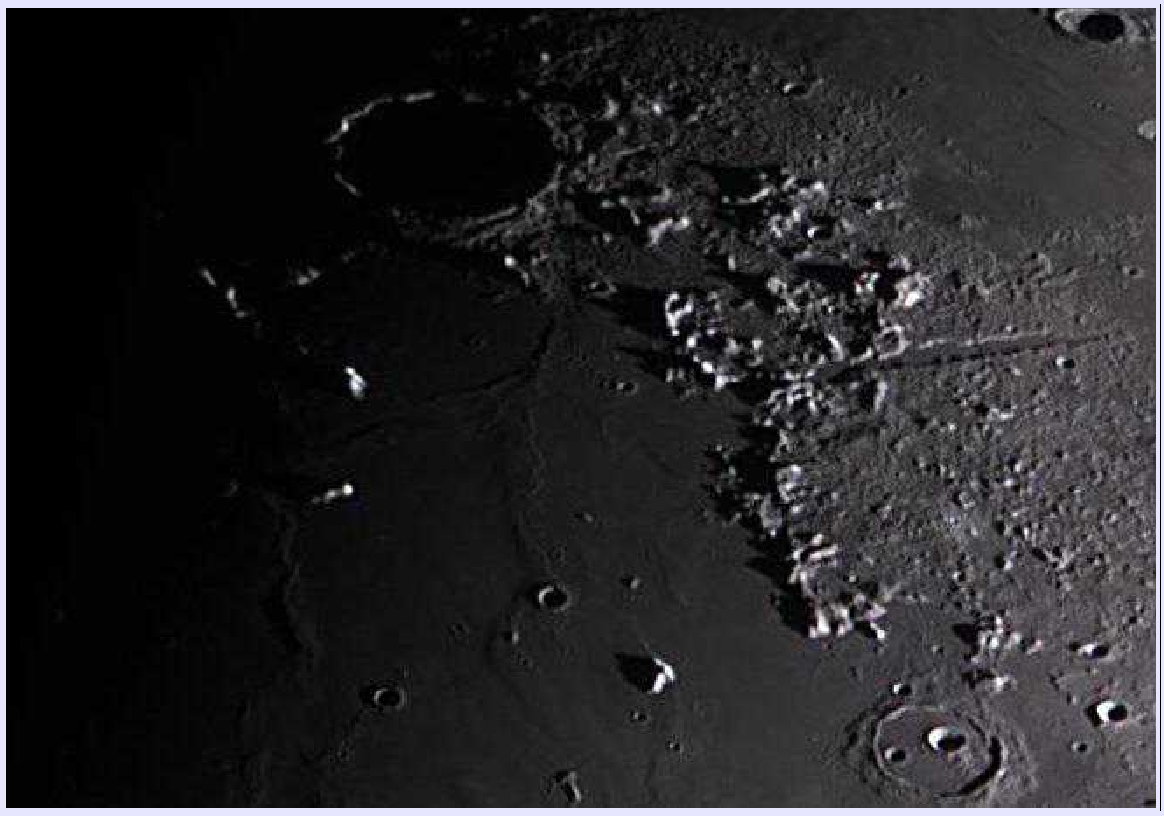


**Figure 6. Montes Teneriffe to the bottom left of Plato as imaged by Eugenio Polito on 2023 Feb 28 UT 19:35 and orientated with north towards the top.**

Jean Marc observed from 21:45-22:15 UT on February 28, 2023 with the SkyWatcher 150/1200ed refractor (x300). Montes Teneriffe Mons had not emerged properly from the terminator. The atmospheric seeing was average i.e. the Airy disk of Polaris was visible but agitated and the first diffraction ring was difficult to detect, but nevertheless the lunar surface through the eyepiece was satisfying to look at with lots of detail. Transparency was very good too. Three peaks of Montes Teneriffe were visible, standing out of the darkness of the night side as very white points, slightly dilated and agitated by the turbulence. This gave the impression that they were being enveloped in a mist (just an effect – not real). The three visible peaks were perfectly white, as indeed were other features in the area. The altitude of the Moon above the horizon was 67° and so no atmospheric dispersion colours were seen, and the peaks did not change colour like they did in the TLP description. Jean Marc focussed their attention on possible perception of colours, due to: instrumental chromaticism, atmospheric refraction or lunar characteristics, but did not find anything.

Just as a reference image, Eugenio captured what we see in Fig 6. You can compare this with other observations of the Montes Teneriffe TLP as discussed in the 2018 Jun, 2019 Feb, 2020 Aug, 2021 Jan, and 2022 Dec newsletters. We shall leave the original TLP report at a weight of 1 for now, and await new repeat illumination reports, maybe at lower altitudes above an observers horizon, in order to see how atmospheric effects might mimic what was described in the original TLP report.

**Sulpicius Gallus M:** On 2023 Feb 28, between UT 20:00 to 20:30 (and one image earlier) Eugenio Polito (UAI) took images of this feature for the following Lunar Schedule request:

***UAI Request: Franco Taccogna (UAI) would like to know at what colongitude range does this feature start to brighten up dramatically. Please send in any images taken with a telescope size of at least 6 inches to: a t c @ a b e r . a c. u k .***

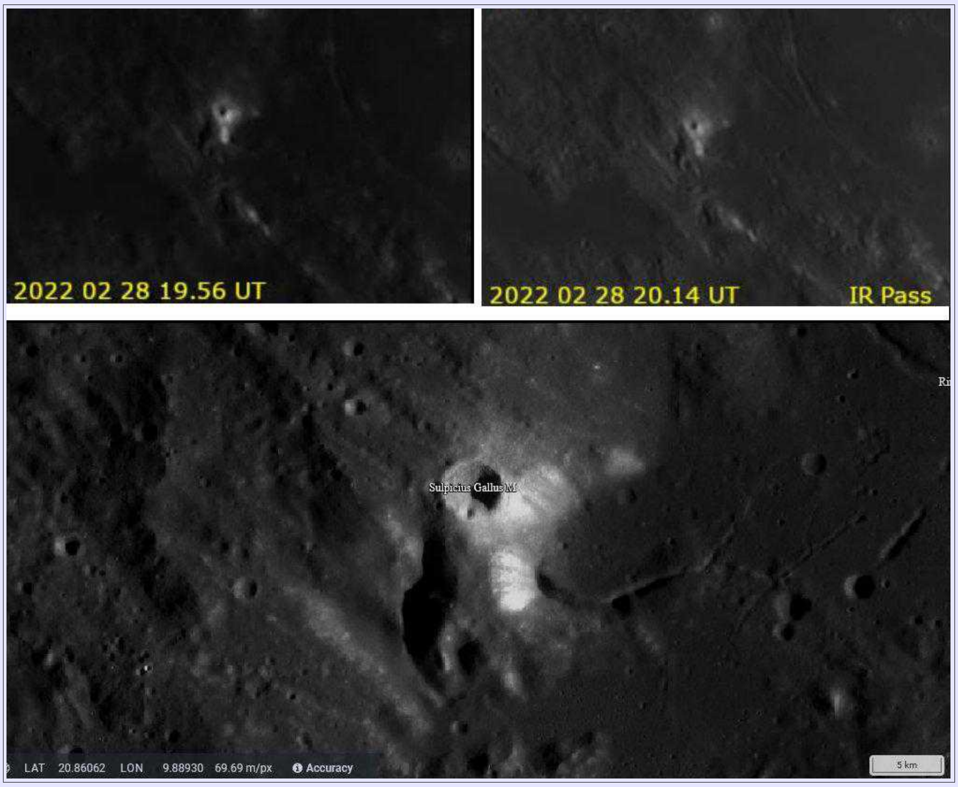



**Figure 7. Sulpicius Gallus M with north towards the top. (Top) Images by Eugenio Polito (UAI), taken on the date and UT as indicated by the text in the images. (Bottom) A NASA LROX Quickmap WAC mosaic closeup of Sulpicius Gallus N**

Although not a TLP, the feature is quite strikingly bright and could cause false TLP reports from untrained observers, so it is important to know when it starts to brighten up. The 19:56UT image (Fig 7 – Top Left) is at a selenographic colongitude of 12.0˚, however I think it is important to have a wider area covered so it can be compared to other bright craterlets. Just out of interest I have enclosed a closeup image mosaic from LROC in the lower part of Fig 7 to show the volcanic and other rilles in the vicinity, which make it quite an interesting area to study.

**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. 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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**Items for the April circular should reach the Director *or* Editor by the 20th April 2023 at the addresses show below – Thanks!**

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