The Lunar Observer

A Publication of the Lunar Section of ALPO

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December 2022

In This Issue

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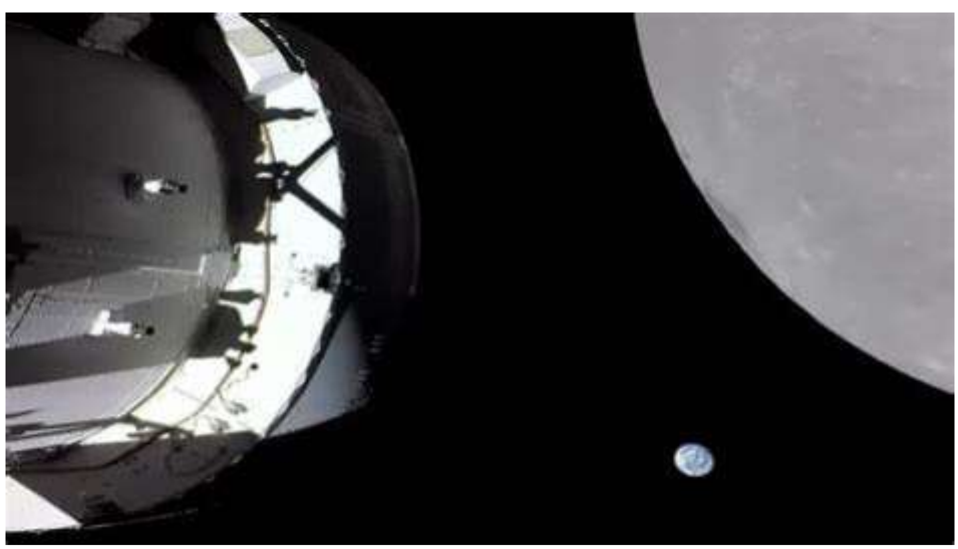
Lunar Reflections

Wishing each of you a very happy holiday season! As I write this, we have a very interesting and active time in lunar observing. The high point is the Artemis I spacecraft which blast off in late November for a 25 day mission around the Moon. If all goes well (at this time, it seems it is), in 2024 four astronauts will fly Artemis II on a mission around the Moon. Then, in a year or two later, astronauts will again return to the lunar surface! These are exciting times! Also, on November 8, 2022 there was a total lunar eclipse that seemed well observed. This brings up our lunar calendar later in this issue. On December 8, 2022 the Full Moon will occult Mars at opposition for parts of North America and Europe.

As we wrap up this year, I thank all who contributed to making *The Lunar Observer* such an interesting lunar newsletter. In the ALPO Lunar Gallery, check out in 2022 the other *The Lunar Observers* that you may have missed plus an index of all that this newsletter covered this past year.

Please remember to look through your files to find lunar observations of the crater Petavius. Please send them to Alberto and myself by December 20th. Until then...

Clear skies,
-David Teske



Lunar Topographic Studies

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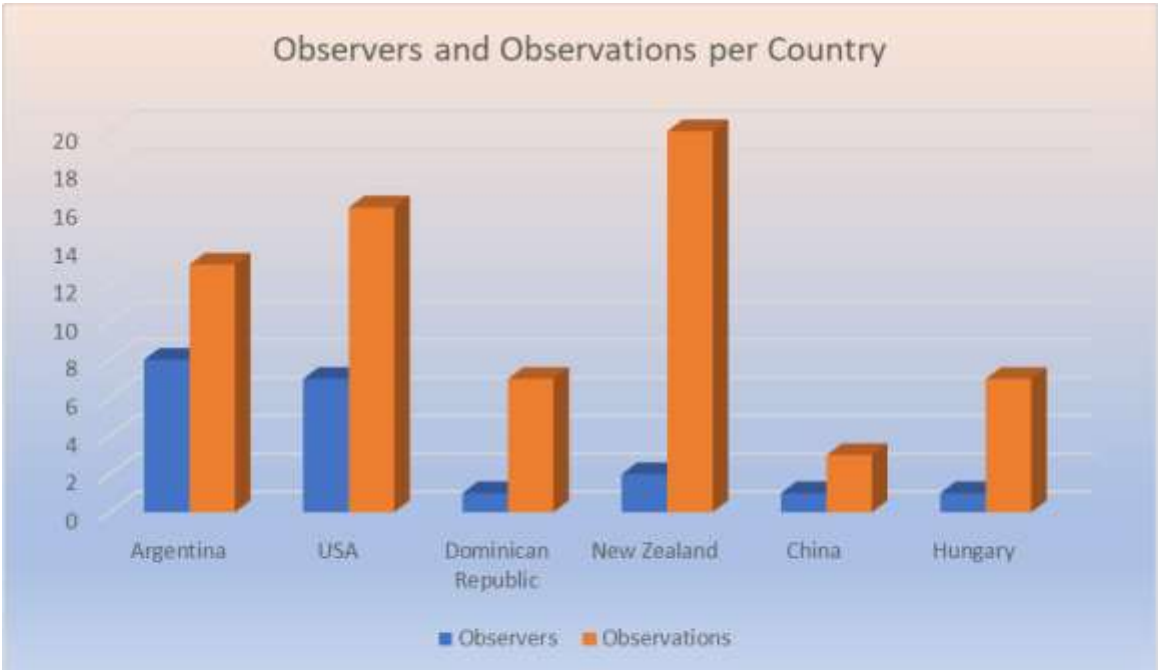
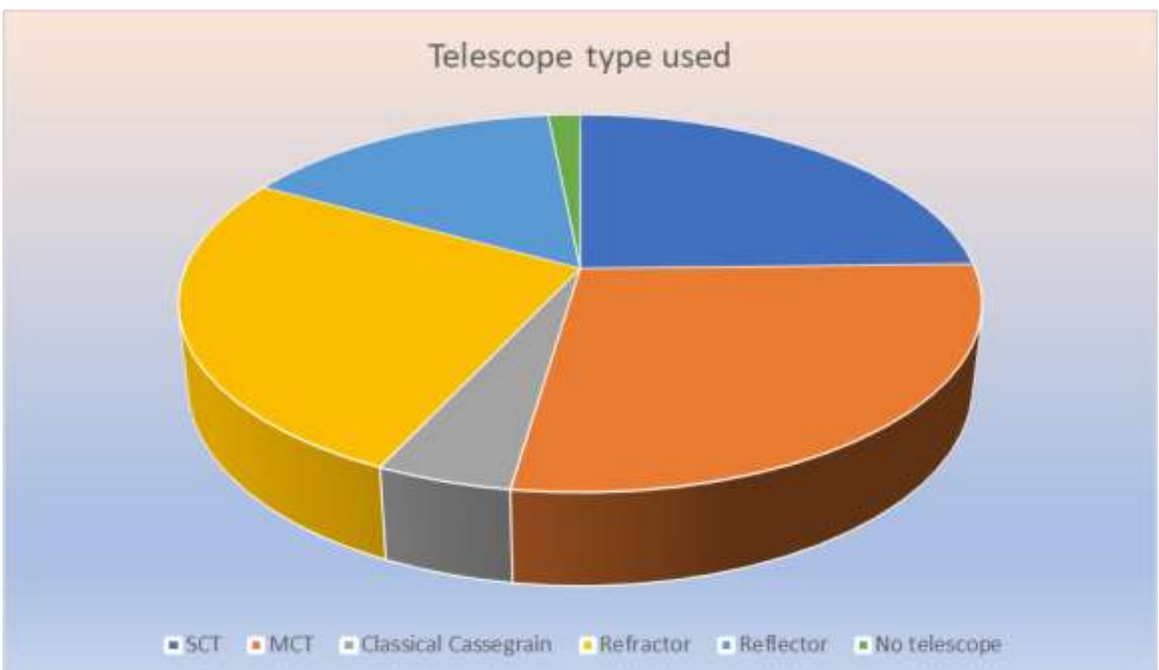
Observations Received

Name	Location and Organization	Image/Article
Alberto Anunziato	Paraná, Argentina	Article and images *The Canals of Aristillus, A Wrinkle ide from Marius to Reiner A* and *The Ridge that Crosses Mons Piton*.
Esteban Andrada	Mar del Plata, Argentina	Image of Herodotus.
Francisco Alsina Cardinalli	Oro Verde, Argentina	Images of Aristillus and Mons Piton.
Maurice Collins	Palmerston North, New Zealand	Images of the 6.9 day old Moon, Copernicus, 9 day old Moon (3) and Lunar Eclipse (6).
Walter Ricardo Elias	AEA, Oro Verde, Argentina	Images of Riccioli and Mare Crisium.
István Zoltán Földvári	Budapest, Hungary	Drawings of Arnold, Montes Rook and Lacus Autumni, Mount Marilyn and Map of Posidonius crater.
Facundo Gramer	AEA Oro Verde, Argentina	Images of Aristarchus and Tycho.
Marcelo Guarda	Santa Fe, Argentina	Images of the Waxing Gibbous Moon and Waning Gibbous Moon.
Robert H. Hays, Jr.	Worth, Illinois, USA	Articles and drawings *Oppolzer* and *Hipparchus X* and Lunar Eclipse timings.
Rik Hill	Loudon Observatory, Tucson, Arizona, USA	Article and image *Brahe's Greatest Hit, Where's Walther?, Gambart* and image of the Total Lunar Eclipse.
Eduardo Horacek	Mar del Plata, Argentina	Image of Herodotus.
Felix León	Santo Domingo, República Dominicana	Images of Cleomedes, Janssen, Geminus, Mare Crisium, Langrenus, Petavius and Theophilus.
Michael Owen	St. Augustine, Florida, USA	Images of Schiller and Northern Mare Imbrium.
KC Pau	Hong Kong, China	Article and images *Peculiar Shadows in the Drawing of Lacus Mortis by Phil Morgan.*
Guillermo Scheidereiter	LIADA, Rural Area, Concordia, Entre	Article *Do You Know How the Moon Originat-*
Michael E. Sweetman	Sky Crest Observatory, Tucson, Arizona, USA	Images of Bullialdus, Clavius and Copernicus.
David Teske	Louisville, Mississippi, USA	Lunar Eclipse timing.
Larry Todd	Dunedin, New Zealand	Images of Aristarchus, Mare Humorum, Mare Humorum, Vallis Alpes, Theophilus, Messier (2), Arago and Kies.
Paul Walker	Middlebury, Vermont, USA	Images of Hadley Rille and Clavius.
Darryl Wilson	Marshall, Virginia, USA	Image of the Lunar Eclipse, Article and images Spectral Angle Mapper, A Hyperspectral Algorithm to Generate Surface Material Maps.

December 2022 *The Lunar Observer*
By the Numbers

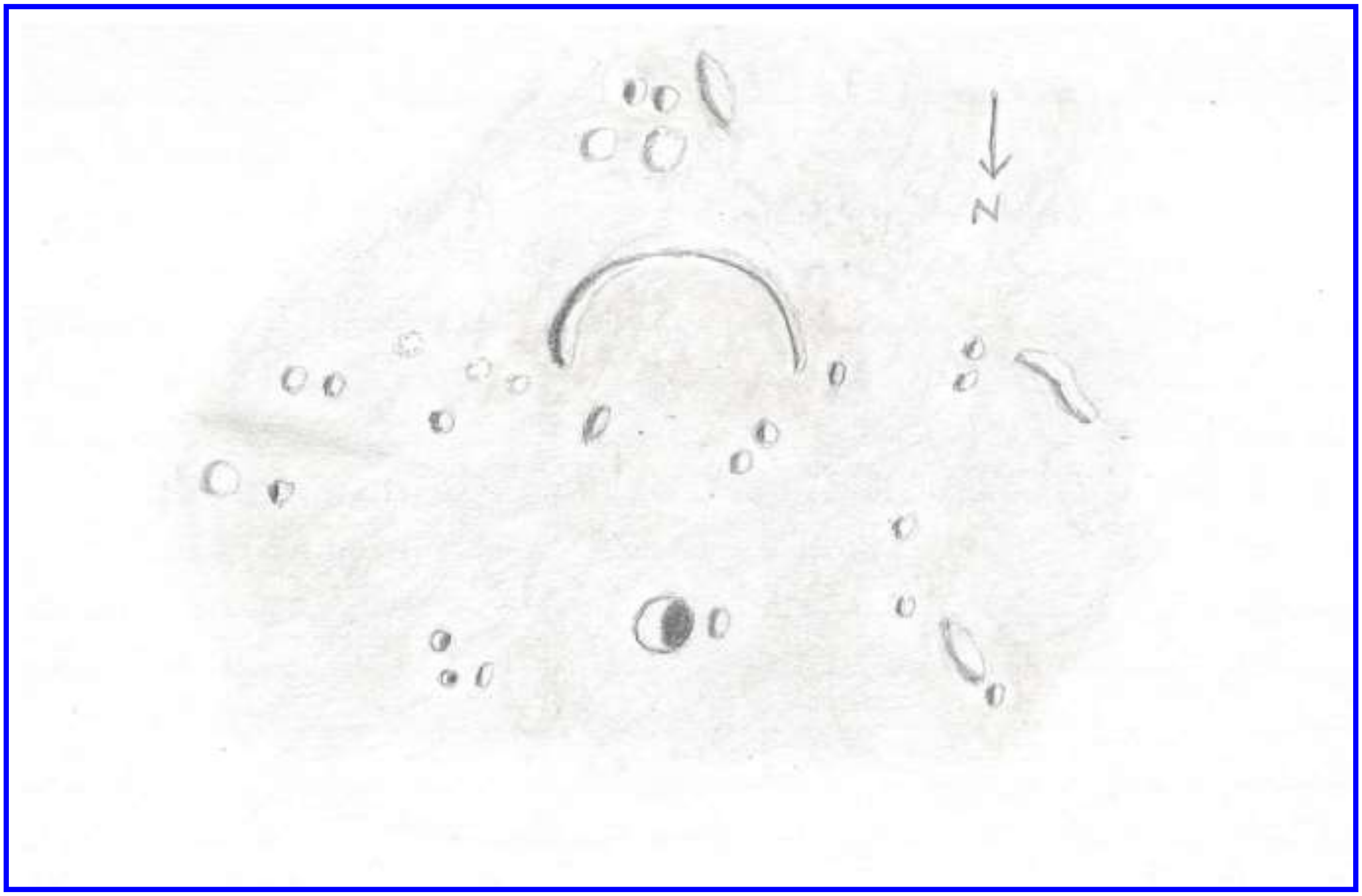
This month there were 66 observations by 19 contributors in 6 countries.





Hipparchus X

Robert H. Hays, Jr.



Hipparchus X, *Robert H. Hays, Jr., Worth, Illinois, USA. 2022 August 18 07:56-08:32 UT. 15 cm reflector telescope, 170 x. Seeing 8-9/10, transparency 6/6.*

I observed this feature and vicinity on the morning of August 18, 2022. This area is within the large broken ring Hipparchus. The main feature of this sketch is a partial crater with only a southern rim. The southeast part of Hipparchus X is relatively wide, but the southwest rim is much narrower. These two parts are connected by only a very thin ridge. This ridge is nearly straight, giving the half crater a flattened appearance. An elongated peak is south of Hipparchus X, and four more hills are just to its east. The southern two of this group are smaller but with darker shadowing than the northern pair. The north rim of Hipparchus X is missing except perhaps for three detached peaks. Hipparchus N is north of Hipparchus X, and a small peak is just to its west. Two tiny pits are east of Hipparchus N. A tiny hill is nearby. The Lunar Quadrant map shows only one crater there, and labels it Hipparchus NA. The southern pit is the larger one, and the letter designation probably refers to it. There are definitely two pits there. A varied group of five peaks is west of Hipparchus X, together with three tiny bright spots. A small peak is just west of Hipparchus X, and two more peaks and a short ridge are farther west. Three more peaks and a mound are west of Hipparchus N.

The Ridge that Crosses Mons Piton

Alberto Anunziato

Mons Piton (IMAGE 1) would be one of the outcrops of one of the rings of the Imbrium basin, just look at its location in the Mare Imbrium. What is not so well known is that a ridge intersects it, not a ridge generated by subsurface thrust fault folding the surface like classic ridges, but rather the surface aspect of the hidden topography of the Imbrium basin ring. Mons Piton is always beautiful to look at, but it is difficult to graphically represent in a drawing the brightness hues that are seen. At colongitude 5.9º, at the moment of observation, near the terminator, the shadows that extend towards the west, with illumination from the east, hide a good part of the 25 km of the total surface that Mons Piton occupies.

Image 1, Mons Piton, *Alberto Anunziato, Paraná, Argentina. 2022 September 03 23:10-23:20 UT. Meade EX105 mm Maksutov-Cassegrain telescope, 154x.*

Lunar Topographic Studies

Two bright bands were observed, one that runs from north to south and the other from east to west, which if we see IMAGE 2 (which corresponds to a very similar illumination, colongitude 12.9º, which allows us to see a little more of our mountain), we perceive that they correspond to the highest areas. These brightness differences are explained by Charles Wood "Piton has variations in brightness similar to bands on the inner walls of impact craters. The dark hues are probably the space-weathered tone of the mountain, and the bright bands are fresh material exposed by small landslides" (http://www2.lpod.org/wiki/February_10,_2005). In IMAGE 1 we see that the ridge that starts from Piton and passes between the small craters Piton A (left, 6 km in diameter) and Piton B (right, 5 km in diameter), despite its low height and smooth relief (that we clearly see in IMAGE 2), presents differences in tonality that indicate how steep or smooth the terrain is and its relative height.

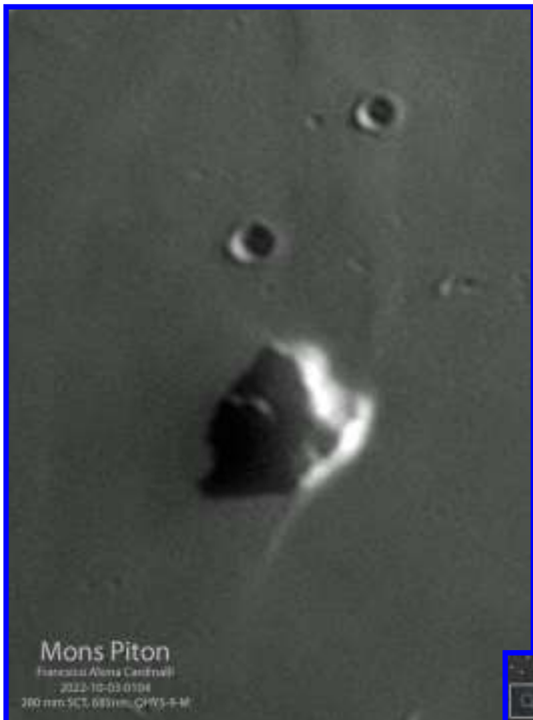


Image 2, Mons Piton, *Francisco Alsina Cardinalli, Oro Verde, Argentina. 2022 October 03 01:04 UT. 280 mm Schmidt-Cassegrain telescope, SBONY IR Pass 685 nm filter, QHY5L-II M camera. North is down, west is left.*

Taking into account that the illumination comes from the east, the brightest right band would correspond to the highest part and the darkest left band the lowest part. This can be verified with IMAGE 3, achieved with the Lunar Reconnaissance Orbiter Quickmap. The orange segment is the wrinkle ridges indicator (according to the Layer Map of Lunar Wrinkle Ridges), as we can see, it indicates a shorter wrinkle ridge than the one that can be seen in IMAGE 1 and 2, but on the right, you can see the profile of the relief of the area not marked as wrinkle ridge on the Quickmap. Clearly the profile of the relief is that of a wrinkle ridge: the left slope is smooth and the right slope is steep and abrupt. The yellow circles indicate the highest point on the map and on the terrain relief. We do not know why the area between Piton A and Piton B is not marked as a wrinkle ridge, when it clearly appears to be.

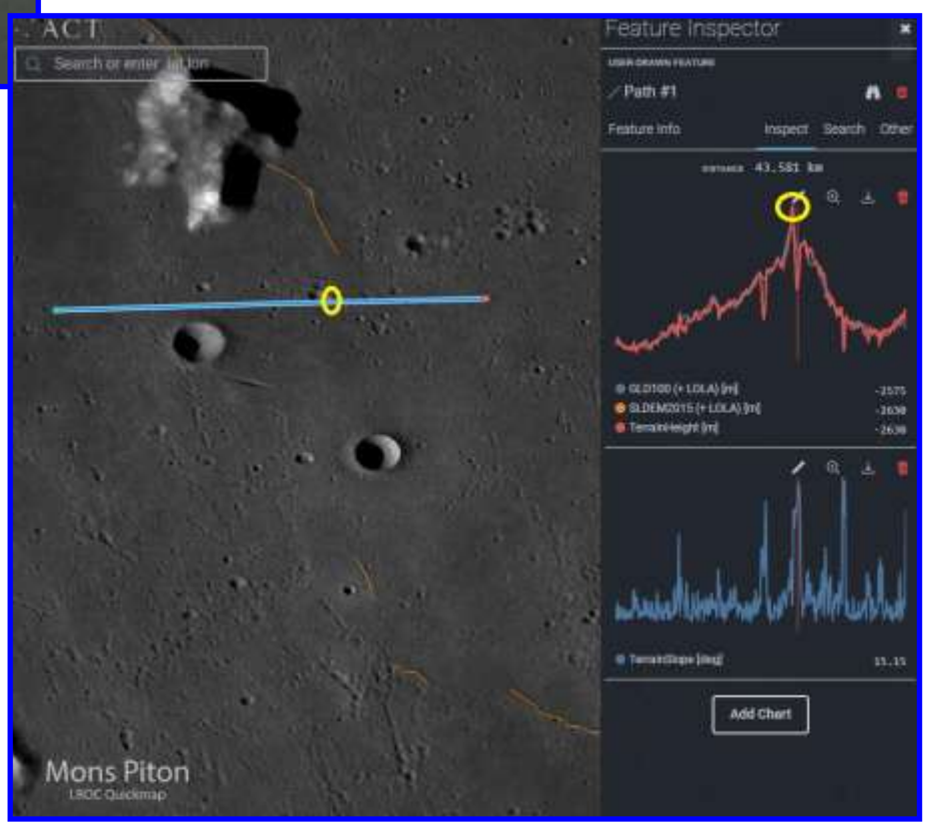


Image 3, Mons Piton, *LROC Quickmap North is up and west is left.*

Brahe’s Greatest Hit

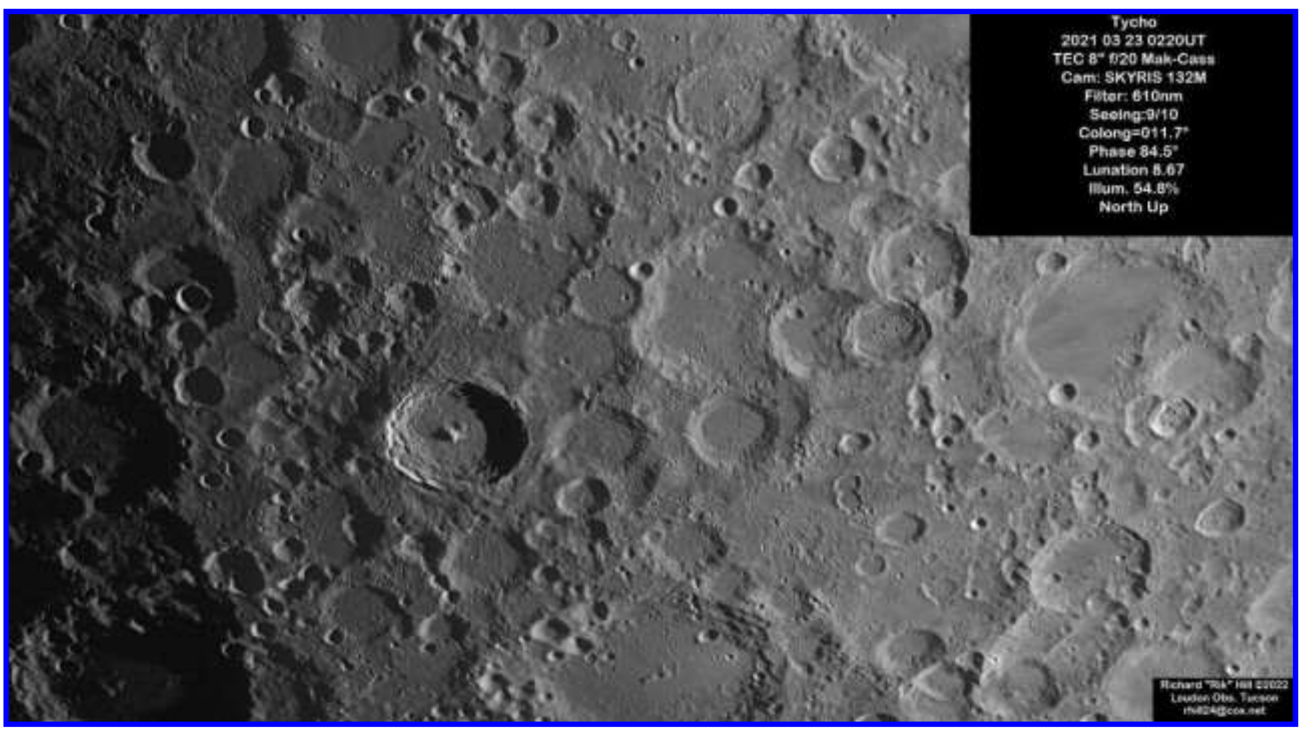
Rik Hill

At the focus of the bright rays that encircle the whole Moon is the young (< 1 billion years old) crater Tycho (88 km dia.) named after the famed astronomer Tycho Brahe seen here just left of center in this image. Prominent in the southern highlands it is a feature most lunar observers learn about early on. You don’t see the rays here because the Sun is just rising on this moonscape while the rays are best seen with high sun, especially at full Moon. But here we can enjoy oft missed features of topography. First notice the region surrounding Tycho about width of the crater diameter where many of the features look soft, almost out of focus. This is from the material that was ejected from the crater during impact. Other material, of larger size, formed secondary craters like the cluster seen just above Tycho. There are more such small fresh craters to the right of the Tycho as well.

The flat-bottomed crater just right of center is Saussure (56 km) and between it and Tycho is Pictet (65 km). Notice how the left half of Pictet is softened by ejecta while the right half is much better defined. Above and further right from Saussure are two overlapped craters Nasireddin (54 km) the lower one and Miller (77 km) the upper. The very large flat floored crater to the right of them is Stöfler (129 km). Here is a place where you can see a bit of the rays from Tycho splayed out on the floor of Stöfler. Once you see them here you can trace them back and see more south of Nasireddin.

The large crater south of Tycho is Maginus (168 km) with its unusual central peak and on its northern wall is Proctor (54 km). On the left side of Tycho, on the edge of this image is Wilhelm (111 km) and below it Is Longomontanus (150 km). Just north of Tycho is the landing site for Surveyor 7, the last in that spectacular series of lunar landers. It began operations on the moon on Jan. 10, 1968 and ended on Feb. 21 from battery failure having sent back over 21,000 images. Before we leave Tycho, one more treat. Notice the trail of secondary craters from the northwest wall of Tycho stretching over two crater diameters farther to the northwest. I have not seen this catena at high sun but it is fairly easy to find at a low sun angle like this image.

While this image has very good resolution, around 1-1.5km, I still did not find the obelisk!



Lunar Topographic Studies

The Canals of Aristillus

Alberto Anunziato

When I was looking for information on Eratosthenes for the previous Focus On, more specifically on W. H. Pickering's observations of the supposed plant or animal life in that crater, I discovered in Walter Haas's booklet (published by ALPO) “Does Anything Ever Happened on the Moon ?”, 1942, the reference to observations of the “Aristillus Dark Bands” (page 10): “On the northwest inner wall of Aristillus is a dark band which extends beyond the rim, where it widens. Pickering observed the behavior of this band and of other marks in the vicinity, he found that the band really consists of two close streaks (“canals”), which are more easily split outside the rim than on the inner wall”. Pickering was an excellent observer (with wild hypotheses), I must confess that I realized what a mediocre observer I am; I had previously observed the dark bands and had not realized that there were two and that they diverged. IMAGE 1 appeared in the October 2016 issue of *The Lunar Observer* with a text in which I told how I had been surprised to see for the first time what I called "a dark band". But in IMAGE 1 you can clearly see that what looks like a dark band starts to split about halfway down the inner rim. Haas says that Pickering “suggest the resolving of inner “canals” as a test of definition”. I read Haas’s booklet several years ago, this work for me preserves the fascination for the last years of the heroic age of selenography (when, according to Pickering, "scarcely any professional astronomers look at the moon now-a-days, it is left wholly to the amateurs”), but it is always pleasant to return to it. I did so to search for old observations of the Aristillus dark bands. In “The lunar crater Aristillus”, the Italian Mentore Maggini makes a thorough analysis of how the bands appear and disappear throughout the lunation, using his observations made from Florence and Arcetri in the years 1917-1920. We can summarize this cycle in these words; “the first duplication of the canal has been seen by me at colongitude 35º on the second step of the circus; observation was very difficult. But at colongitude 39º it had become very evident and beautiful… At colongitude 63º the internal canal become less visible, and the duplication seems to disappear… till 80º of colongitude the canal remains invisible… the configuration just described is maintained till 117º-120º of colongitude, afterwards the duplicity of the canal is no more observable… After 150º the aspect of Aristillus becomes again similar to that described at the sunrise” (pages 143-144).

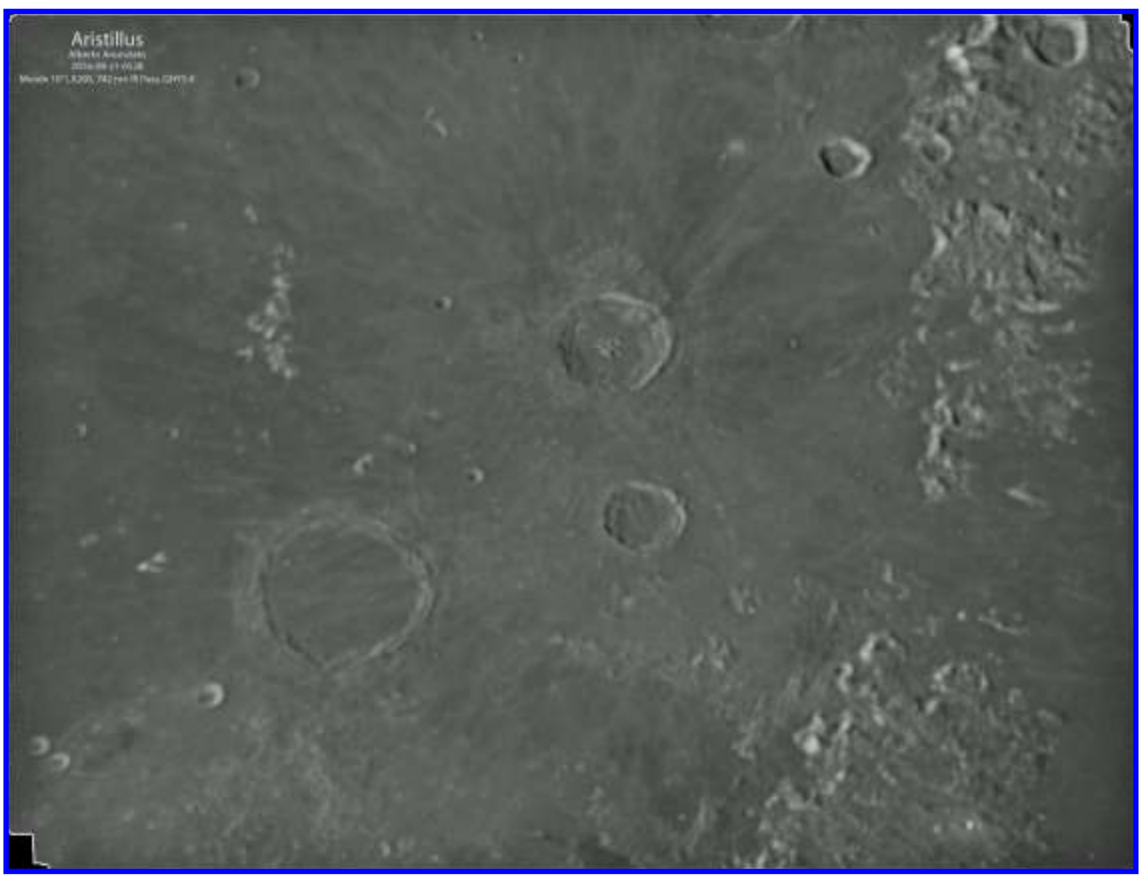


Image 1, Aristillus, *Alberto Anunziato, Oro Verde, Argentina. 2016 August 21 05:58 UT. Meade LX200 10 inch Schmidt-Cassegrain telescope, Astronomik ProPlanet 742 nm IR Pass filter, QHY5-II camera.*

Lunar Topographic Studies

More simply, the dark bands cannot be seen in the oblique illumination of the rising or setting Sun on Aristillus, they can be seen in the vicinity of the full Moon.

The noun "canal" seems to indicate that Maggini shares with Pickering the belief that the dark bands of Aristillus would share their "attractiveness" with the supposed canals of Mars: they would appear at the time of the lunar lunation that “would correspond on the earth to one month before and after the summer solstice. On the other hand, from the observations of Schiaparelli and Lowell the average time when the Martian canals were first seen to duplicate is at solar longitude 25º.8. Without entering on hypotheses, we infer that a factor depending upon the season enters into the internal and external changes of Aristillus” (pages 145/146). It must also be said that Pickering himself, who, in addition to discovering the dark bands, gave them the name "canals", made clear that “The lunar atmosphere… it is not likely however that its density exceeds a few millimeters, and in that case ice when warmed would pass directly into vapor without passing through the liquid form. However, tempting the idea might be, and their appearance certainly suggest it, these canals cannot therefore be irrigating channel either natural or artificial” (“The double canal of the lunar crater Aristillus”, page 575).

Another of the observers cited by Haas, E. C. Slipher, had another hypothesis about these dark marks, they are “shadowed cracks”: “throughout their length they lie at a generally lower level than the adjoining country and frequently appear to form the edge of elevated mesa-like regions, this is particularly true of the markings inside the crater (…) the markings are natural features in the lunar surface made to stand out by unequal illumination. They appear to be mere cracks, perhaps of great depth” (“Markings on Aristillus”, page 78).

Today we know that they are not cracks, as Slipher thought, nor canals, as Pickering and Maggini thought, but that it is a "V shaped dark ray", related to the low angle impact that originated Aristillus, “with the impactor arriving from the south-west. Evidence for this can be seen in the distribution of ejecta” (Fitz-Gerald and Lena, Aristillus: the unusual narrow ribbon of dark material”). In this work the topography of the V-shaped dark ray is specified: “The ray is approximately 30 kms long from its apparent origin at the base of the north-eastern crater wall. The lowermost part of the ray is however in all probability obscured by the impact melt deposits which occupy the crater floor, therefore the total length is likely to be greater. The ray splits into two some 8.5 kms from its origin, with the western arm being wider (approximately 1.3 kms) than the Eastern”. Its origin, according to the authors cited would have occurred “during a late stage in the crater forming process and after the most proximal ejecta had been emplaced. This implies that the material forming the ray was excavated from the deepest part of the transient cavity”. The material that forms “the canals” derive from “an excavation of a localized, deep seated mafic or ultramafic igneous intrusion during the very latest phase of crater excavation. The orientation of the ray would be influenced by the low angle geometry of the impact in the downrange direction”. Finally, the reason why these dark bands, which are like the counterpart of the bright band that seems to come out of Anaxagoras, are divided would be, according to Fitz-Gerald and Lena that “The crater wall has a slope of approximately 13° at this location but the cause of the divergence of the eastern and western components is not obvious. The most likely explanation is blocking of the ray by a slightly elevated topography in its path, giving rise to a shadow effect downrange”.

Image 2, Aristillus, Francisco Alsina Cardinalli, Oro Verde, Argentina. 2016 June 16 05:15 UT. Meade LX200 10 inch Schmidt-Cassegrain telescope, Astronomik ProPlanet 742 nm IR Pass filter, QHY5-II camera.

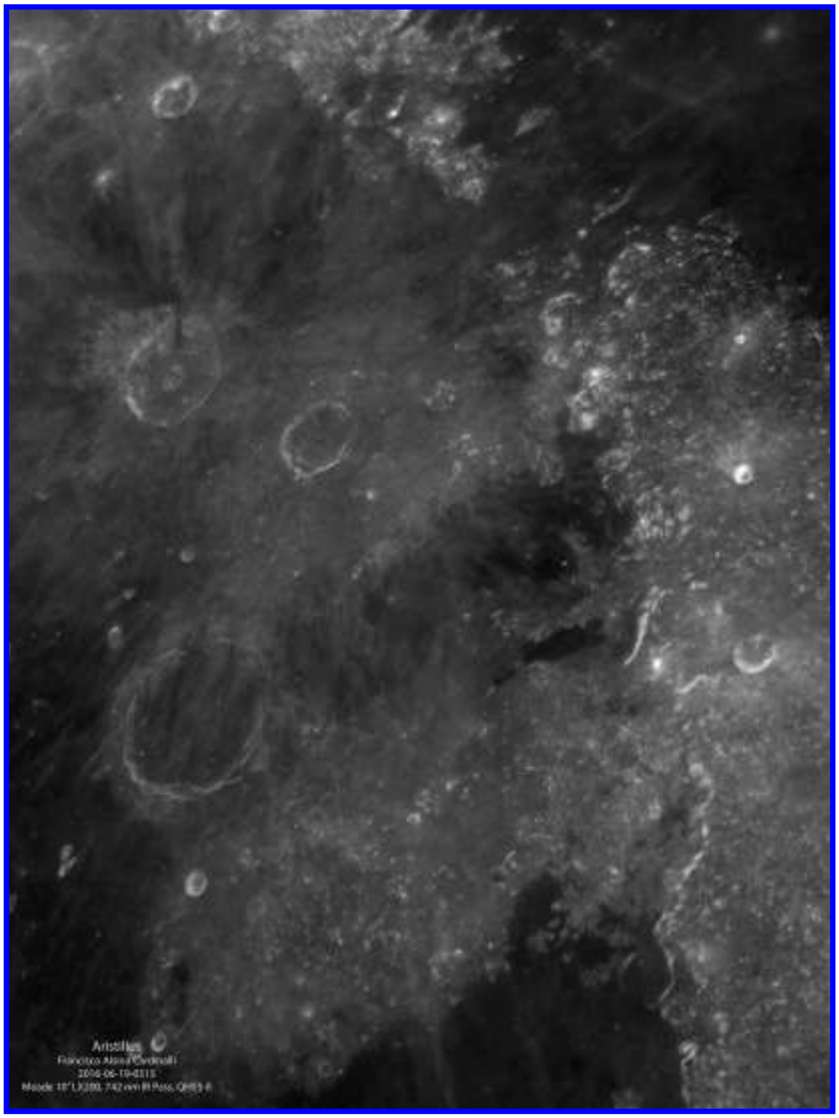


IMAGE 1 was taken in the last quarter (colongitude 127.7º), with 90% illumination, IMAGE 2 was taken in the first quarter, almost full moon (colongitude 77.9º), with 98% illumination, both within the time which would be the most propitious of the lunation to observe the dark bands, with the frontal illumination that made Pickering and his followers dream of some phenomenon on the lunar surface related to the rise in temperature in Aristillus.

We close with words that, although they come from the "madman from Mandeville" (as William Pickering was known), are still furiously current (page 578): "It is the opportunity of the amateur. But it is of no use for him to simply watch these changes for himself. What he should to do in order to be of some use is to make his observations and drawings with care, always recording the times and computing the corresponding colongitudes, and the put his results in print. Let everyone do his share, even if it be but little".

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Lunar Topographic Studies

Gambart

Rik Hill

This overlooked region is southeast of the great crater Copernicus. On the left side of the image is the beautifully terraced crater Reinhold (diam. 49 km). Just above and right of Reinhold is the ring crater Reinhold (24 km) and further on the smaller twin craters Fauth (12 km) and below it Fauth A (8 km). Normally I wouldn't bother with craters of this size but these two figured prominently in the foreground of the famous New York Times "Picture of the Century" on Nov.24, 1966. A restored copy of that Lunar Orbiter 2 image can be seen at donaldedavis.com/2004%20new/COPERNho.gif. I looked these craters up right away in 1966 when I first saw the Orbiter image.

Dead center in this image is another very old ghost or ring crater Gambart (26 km) of pre-Imbrian age (3.85-4.55 billion years old) flooded with ejecta from the many large nearby impacts. Then on the right edge of this image is the crater Mösting (27 km) with Sömmering (29 km) the ghost crater just to the left of it the same age as Gambart as the flooding might indicate. Above these two is the ruined crater Schröter (35 km). Between and above a line between Sömmering and Gambart and are two vertically aligned relatively recent craters of similar size. The upper is Gambart C (12 km) and below it is Gambart B (11.5 km). Between them and just to the left you can just make out 2 of the Domes Gambart, the left one sporting a nice central pit. Another dome can be seen south of Gambart itself by first spotting the small clear crater, Gambart N (5 km) well seen in this image. Below and to the left is a slightly brighter portion of the mare and you may see the small pit there in the center of the bright region in its own dark patch. This is Gambart 1. Look and the curious mountain further south and left. It's has a crater in its summit but it is not volcanic. There are a number of such features on the Moon.

Before leaving this region, be sure to enjoy the hummocky terrain to the southeast of Reinhold. Then above Reinhold you can see a lot of the ejecta and secondary cratering from Copernicus. This is very interesting when on the terminator.

Reinhold to Mösting, *Richard Hill, Loudon Observatory, Tucson, Arizona, USA. 2021 January 17 02:11 UT, colongitude 42.9°. TEC 8 inch f/20 Maksutov-Cassegrain telescope, 610 nm filter, SKYRIS 132M camera. Seeing 8/10.*

Lunar Topographic Studies

A Wrinkle Ridge from Marius to Reiner A

Alberto Anunziato

The western part of Oceanus Procellarum is a dense network of wrinkle ridges. If one looks at the Lunar Wrinkle Ridges Map of the Lunar Reconnaissance Orbiter Quickmap it is almost impossible to locate oneself among so many that run from north to south, clearly all related to the same geological phenomenon. When we are observing visually it is easier to distinguish the most relevant ones. In previous issues we talked about the wrinkle ridge that seems to emerge from Herodotus A, which at the time of the observation documented in IMAGE 1 was seen in all its magnificence, but we prefer to focus on another of the most prominent ridges, the one that runs between Marius and Reiner A.

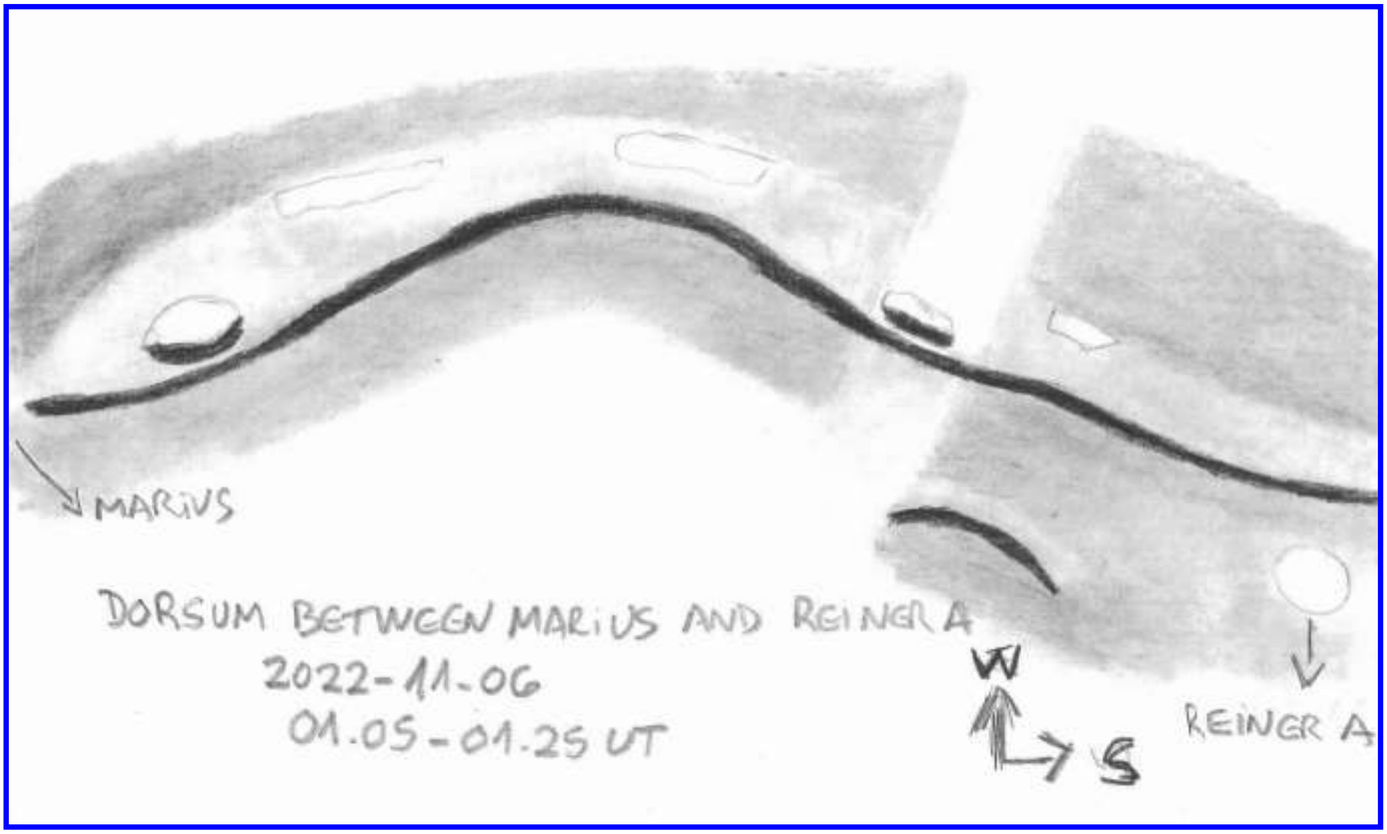


Image 2, Dorsum Between Marius and Reiner A, *Alberto Anunziato, Paraná, Argentina. 2022 November 06 01:05-01:25 UT. Meade EX105 mm Maksutov-Cassegrain telescope, 154x.*

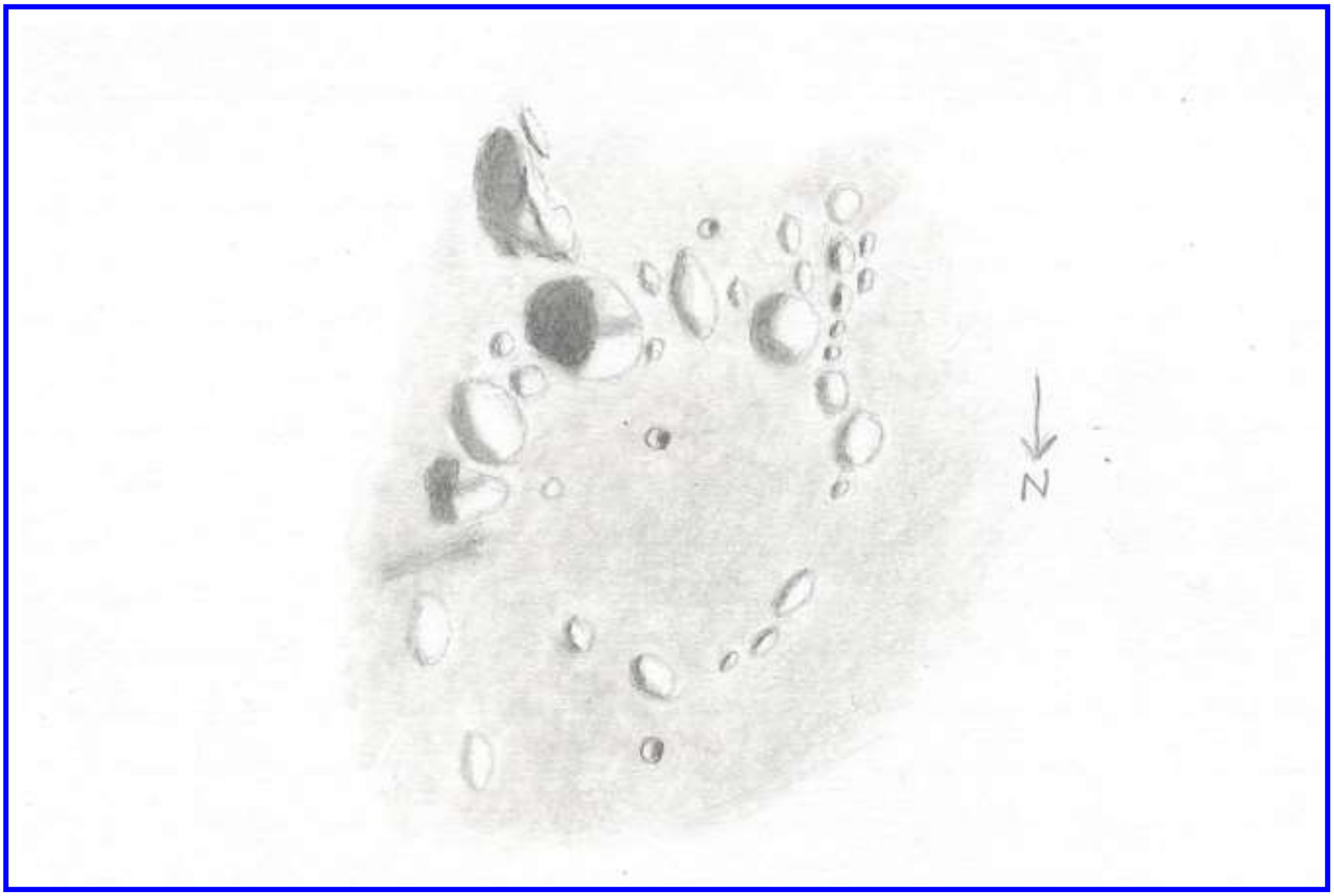
The most characteristic feature of this dorsum is how a ray from Kepler interacts with it. IMAGE 2 was already published in the Focus On report corresponding to the bright ray craters of the northern hemisphere (in the July 2022 issue of our newsletter) and corresponds to the friends of Trapecio Austral, an astronomical group from the city of Mar del Plata, Argentina. It shows the panorama of the area, with Aristarchus and Herodotus on the left and Kepler at the top. In IMAGE 2 we can see how one of the Kepler rays interacts with one of the wrinkle ridges concentric to the west edge of Oceanus Procellarum, especially in the area indicated by the red arrow. I remember seeing on some other occasion how this ray from Kepler seems to "pass over" the wrinkle ridge that we observe.

***Image 2 (left) and image 3 (below), Marius to Reiner A,** Eduardo Horacek-Esteban Andrada, Mar del Plata, Argentina. 2021 August 20 00:22 UT. 150 mm Maksutov-Cassegrain telescope, Canon EOS Rebel T5i camera.*

It is not so common that we can see at the same time two features as evanescent as a bright ray and a wrinkle ridge. It was interesting to take advantage of this wonderful image to compare the topographic details that we observe in IMAGE 1 with those that are seen in IMAGE 3, which is a detail of IMAGE 1. From left to right, from Marius to Reiner A, first we find a considerable elevation (bright and casting shadow) very close to Marius, in IMAGE 1 it is perceived as a bright spot, while in IMAGE 3 it is more clearly perceived that the bright segment is the crest, a kind of "wrinkle ridge on top of another wrinkle ridge", the steepest area of the dorsum. Many times, what we visually observe as a single segment of wrinkle ridge are actually several segments that our vision joins because the resolution of our telescope is not able to separate, this is probably the case with our image, the truth is that in the IMAGE 3 we see how the crest rests on the western end of the arch until about halfway up the ridge, and we see it more complete than in IMAGE 1, in which we recorded only the brightest segments. About halfway through IMAGE 1, when the ridge appears to change from its "up" direction to a "down" direction, it also changes the side of the arch that the crest rests on (left to right, west to east); the two halves are likely to correspond to two different wrinkle ridges. The bright ray from Kepler appears to illuminate the brightest crest segment, with its corresponding shadow. Visually the bright ray looks sharper over the wrinkle ridge than in IMAGE 3. It is easy to deduce that Kepler is older than the concentric dorsa at the edge of Oceanus Procellarum, since its bright rays overlap with the pre-existing topography, we can also deduce how bright Kepler's rays are, which can be seen perfectly in oblique illumination.

Oppolzer

Robert H. Hays, Jr.



Oppolzer, *Robert H. Hays, Jr., Worth, Illinois, USA. 2022 August 19 07:40-08:00; 08:32-08:46 UT. 15 cm reflector telescope, 170 x. Seeing 8/10, transparency 6/6.*

I drew this crater on the morning of August 19, 2022. Oppolzer is a broken crater on the southern edge of Sinus Medii, and has obviously been flooded by it. Oppolzer K is the interior pit south of center, and a small bright spot is to its east. The southern rim of Oppolzer is a varied group of mountains. The largest peak is southeast of Oppolzer K, and a substantial mountain is to its southeast. This ragged feature may be part of the crater Reaumur. An elongated peak is south of Oppolzer K, and an unidentified craterlet is nearby. A large peak southwest of Oppolzer K is nearly surrounded by smaller hills. The mountains of the nominal north rim of Oppolzer are smaller and more scattered than those to the south. Oppolzer A is just north of a relatively large peak. A fairly large hill is east of this peak, and three smaller ones are to its west. These five peaks are quite isolated from those farther south. Two low mounds are northwest of Oppolzer.

Lunar Topographic Studies

Peculiar Shadows in the Drawing of Lacus Mortis by Phil Morgan

KC Pau

Recently, I have a chance to read an article "Faults of Lacus Mortis" written by Phil Morgan in December 2009 issue of BAA LSC. In this article, Mr. Morgan discussed his observation about a small hill that was depicted by Colin Ebdon on 8-9 October 2009 and his explanation about how the fault south-west of crater Bürg turned into a rille. All these discussions are valuable information for me. However, the shadows in his drawing of Lacus Mortis at late sunset really attracted my attention. I noticed a group of peculiar shadows to the south-east of Burg (fig. 1, indicated with white arrows). These shadows gave me the impression that they were projected by objects from the east side of Lacus Mortis as their spires pointed to the west. But, this drawing showed the late sunset view of the lake. Did I misinterpret the drawing? I shared this drawing with other local moon observers and they had the same feeling as mine.

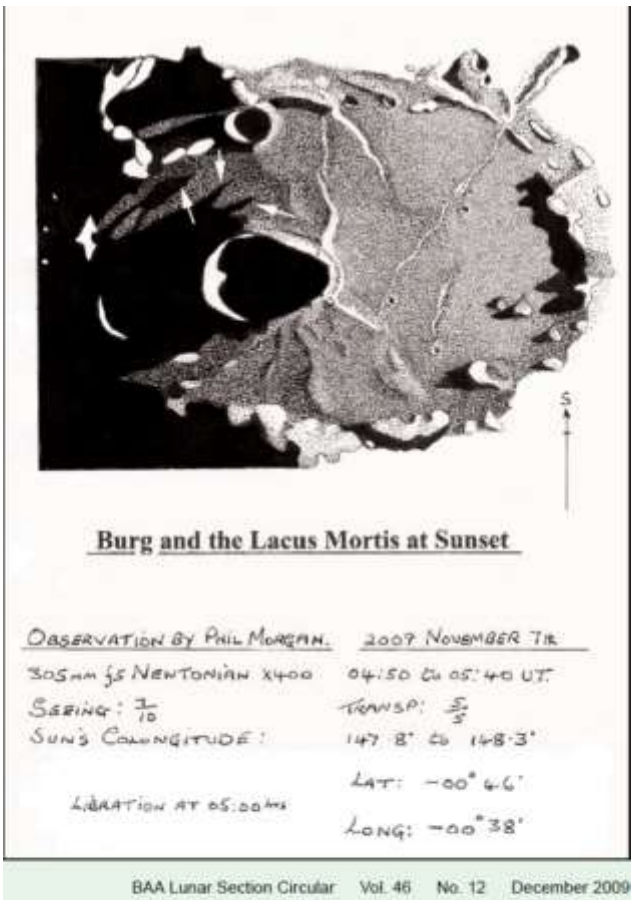


Fig. 1 *Phil Morgan's drawing. The shadows indicated with white arrows seems to be very peculiar*

I first checked with the LROC-Quickmap and it shows the area around the shadows is quite "smooth" and no particular topographical features are located (fig 2).

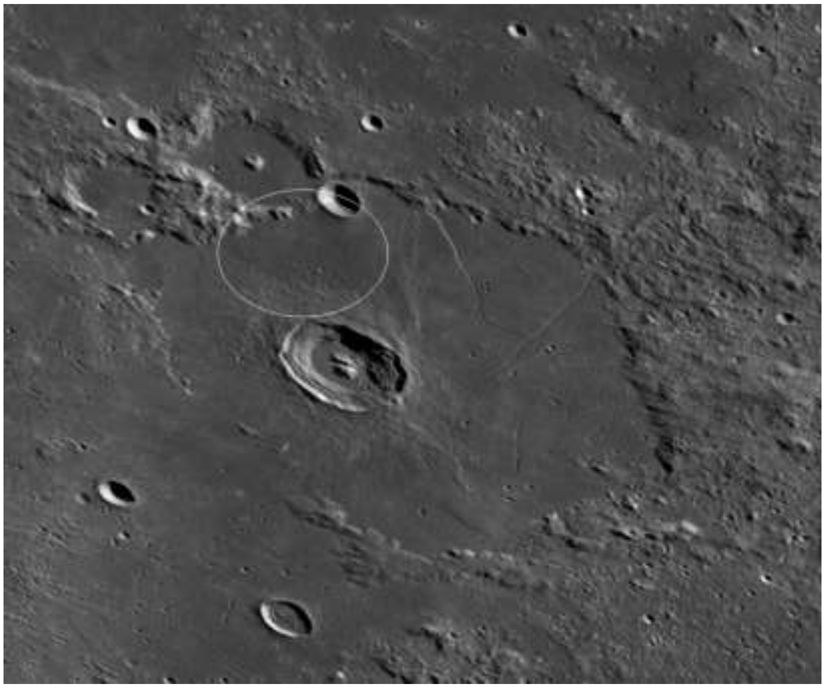


Fig. 2 *Crop from LROC-Quickmap. White circle indicate area where the peculiar shadows shown in Morgan's drawing.*

Then I searched my own moon photo archives and had found some photos of Lacus Mortis (fig. 3, 4 and 5) with the observing conditions quite close to Mr. Morgan's drawing. However, no such peculiar shadows can be identified with these photos. How these peculiar shadows are formed? This question is still wandering in my mind. I anticipate readers of both LSC and LTO may help to solve this mystery.

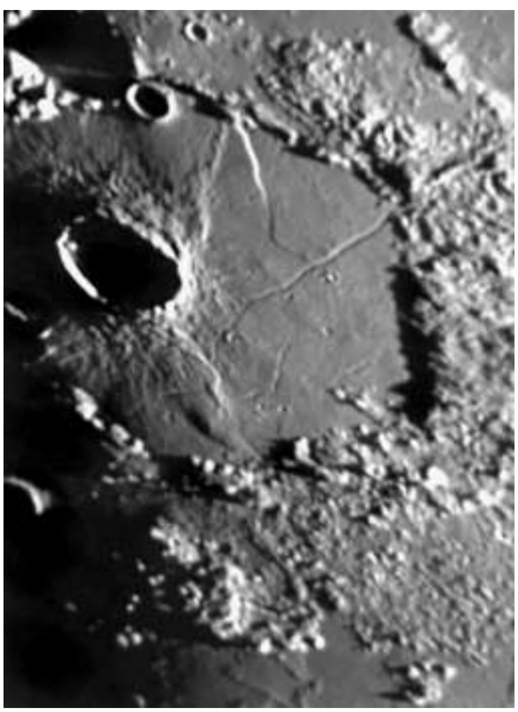


Fig. 3 *Photo was taken on 8 Jan 2007_19h27m UT, colong: 148.4^o*
Lat. Lib: +00^{o}15' Long. Lib: +02^{o}20'

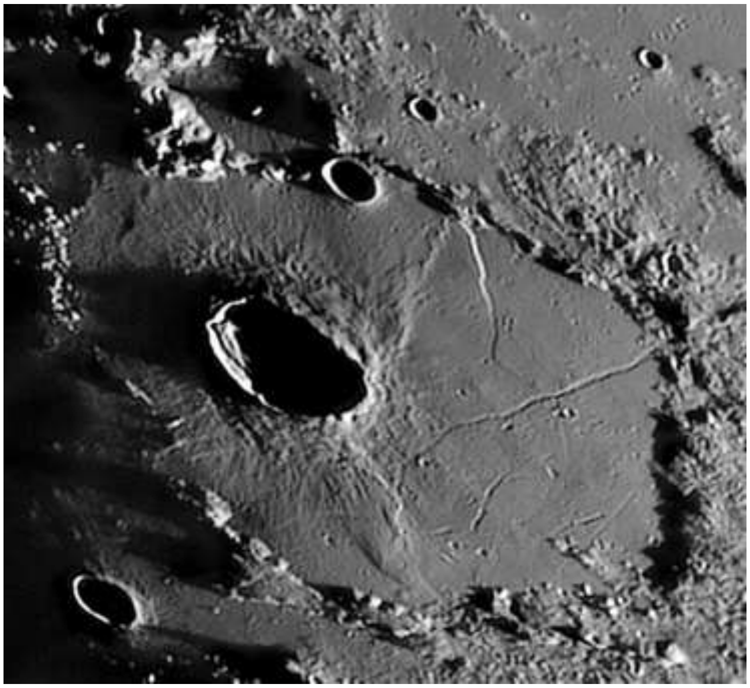


Fig. 4 *Photo was taken on 25 Jan 2019_20h40m, colong"147.8º Lat. Lib: -06º14' Long. Lib: +06º32'*

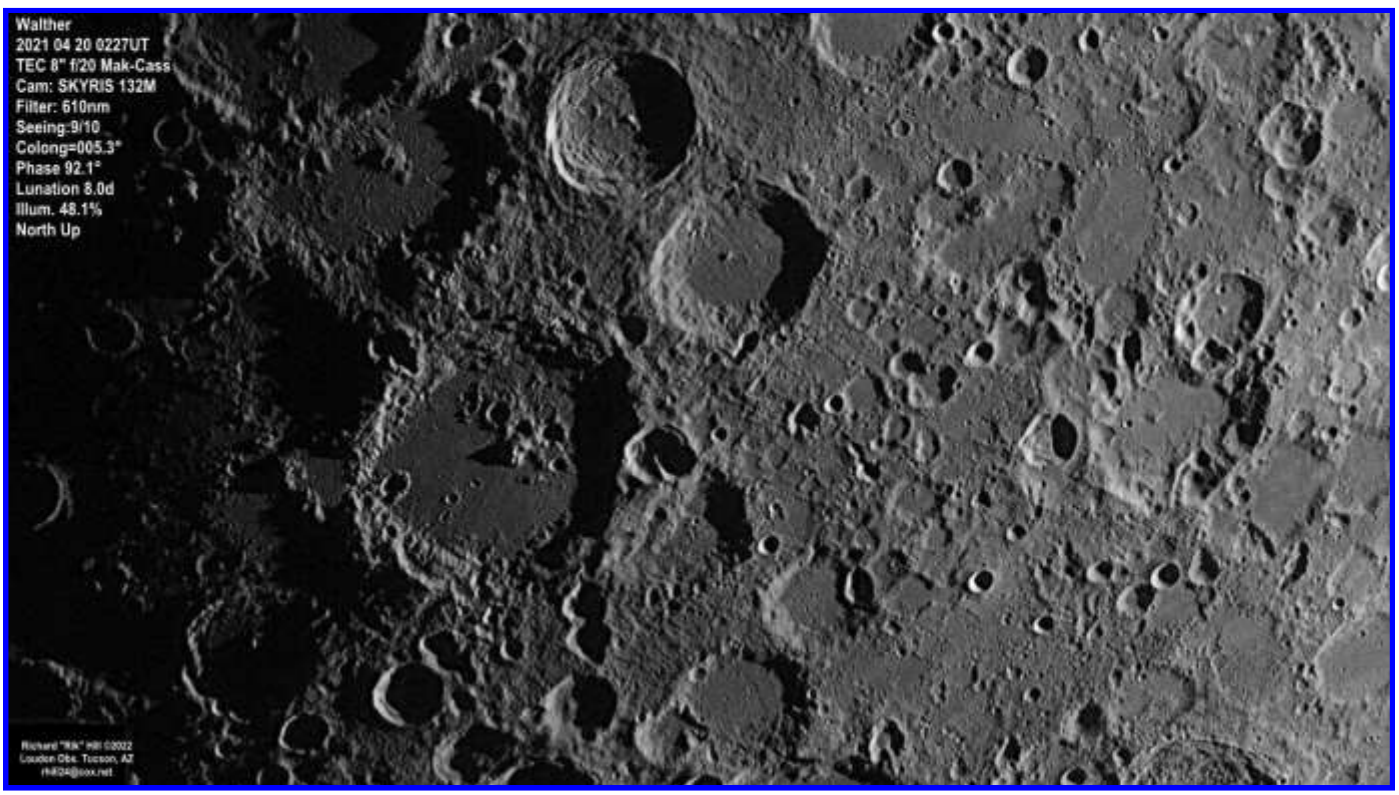
Fig. 5 *Photo was taken on 29 Sep 2018_19h43m, colong"151.3º Lat. Lib: +05º50' Long. Lib: -04º31'*

Where's Walther?

Rik Hill

In the lunar highlands south of the crater Arzachel and the large crater Purbach is the even larger 134 km diameter crater Walther (formerly known as Walter and Valtherus by Riccioli). It is a wonderful old crater of Nectarian age, 3.85-3.92 billion years old, and it shows its age. The walls are badly eroded by later, more recent impacts. In the northeast quadrant of the crater is a curious collection of craters and mountains, the latter may be ejecta from other nearby impacts. Note the nice shadow from the central peak like the shadow from a sundial gnomon on the large flat western floor. North and slightly west (left) from this crater is what's left of another even older crater, Regiomontanus (129 km). It is Pre-Nectarian (3.92-4.5 b.y.o.) and overlain by Purbach, a younger crater to the north. Most of the features in this highland area are Pre-Nectarian. The two smaller craters to the northeast (upper right) are Aliacensis (82km) below with the flat floor and Werner (71km) above, with the nice terracing. Aliacensis is also Nectarian but I have a hunch a little bit younger than Walther, while Purbach is Eratosthenian (1.1-3.2 b.y.o.) and much younger than any of the others.

To the southeast of Walther is a flat floored crater Fernelius (66 km) and above and to the right of it is Kaiser (54 km). The floors of both these craters are peppered with secondary craters of 1-3 km in size. There are a lot of odd shaped craters in this highland area that owe their unusual shapes to their modification by later impacts. Due east of Walther, almost to the edge of the image, is one medium sized crater with a smaller one on its northeast wall. The larger one is Gemma Frisius (90 km) and the smaller is Goodacre (48 km) a name familiar to lunar prowlers. You can spend hours exploring this area and still you will not have exhausted what's available.



Walther, *Richard Hill, Loudon Observatory, Tucson, Arizona, USA. 2021 April 20 02:27 UT, colongitude 5.3°. TEC 8 inch f/20 Maksutov-Cassegrain telescope, 610 nm filter, SKYRIS 132M camera. Seeing 9/10.*

Lunar Topographic Studies

Do You Know How the Moon Originated?

Guillermo Scheidereiter

Of course, dear reader, it is not the objective of this modest article to give an exhaustive answer to the question about the origin of the Moon, how our satellite was born and when. But if it is to your liking and disposition, join me on a brief tour of some of the answers that humanity has tried throughout the centuries, trying to reveal such a deep mystery.

Mythology

It is Homer (8th century BC), one of the first aedos who seems to deal with the birth of Selene, the Moon, to whom he dedicates the XXXII song of his famous Homeric Hymns:

XXXII
TO THE MOON
O soft-spoken Muses, daughters of Zeus Cronida, skilled in song! Teach me to sing the Moon, with open wings, whose brightness comes out of her immortal head, appears in the sky and envelops the earth, where everything emerges very adorned by her dazzling brightness. The dark air shines next to the golden crown and the rays shine in the air when the divine Moon, after washing her beautiful body in the Ocean, dresses herself in garments that shine from afar, harnesses the resplendent stiff-necked horses and accelerates the passage of such steeds with beautiful manes, at night, in the middle of the month, when the great disk is in its fullness and the rays of the crescent Moon become most brilliant in the sky; hint and sign for mortals. Once the Cronida was united with her in love and bed; and, having become pregnant by her, he gave birth to the maiden Pandia, who stood out from her for her beauty among the immortal gods.
Hail, queen, goddess with snowy arms, divine Moon, benevolent, with beautiful braids; having begun with you, I will sing the glories of the male demigods, whose deeds the aed servants of the Muses celebrate with their kind mouth. [3]

In Greek mythology, Gaia, the Earth, is the wife of the first god, Uranus, the sky. Homer writes in Hymn XXX:

I will sing to the Earth, mother of all things, well founded, ancient, that nourishes all beings that exist on earth: how many beings move on the divine land or in the sea and how many fly, all are nourished by your riches. [3]

The allusion made by the minstrel to the "giver" figure of Gea is clear; she has the grace to give life and abundance, wealth, goods, prosperity and ends her song enthroning her in her gift of mother:

Hail, mother of the gods, wife of the starry sky. [3]

From the fruit of Gea and Uranus, Tea is born, a Titaness (deities who reigned over the cosmos before the rise of the Olympians), from which all light comes and to whom Homer gives the name of Euriphaesa, who, together with Hyperion (his brother and god of the heights), they had three children including Selene, the Moon. Sing, Homer, in Hymn XXXI, to the Sun:

So, Hyperion married the glorious Euryphasea, his German sister, who gave him beautiful children: the Aurora, with rosy arms, the Moon, with beautiful braids, and the indefatigable Sun, similar to the immortals. [3]

[1]Artist who, accompanied by a zither, blood historical epics.

Lunar Topographic Studies

And this is how the Moon arises in Greek mythology, as a beautiful daughter of titans. It is fair to say that, in the later Hellenic stage, the goddess Selene is associated with Artemis, daughter of Zeus and Leto, although she is originally the goddess of the hunt, wild animals, virginity, the virgin land, and whose power and popularity, they end up "eclipsing" Selene. A similar association occurs with the Egyptian gods.

Egyptian mythology is based on the pre-eminence of the Sun, embodied in Ra, so it is he who takes center stage in the pyramidal texts, leaving Iah, the Moon god, in the background. In essence, Iah (moon) is the lunar disk, "the white disk" and, similarly to what happens between Selene and Artemis, Iah is related to Osiris, a multifaceted god, associated among other things with crops, vegetation , the floods of the Nile and reproduction and, after his demise at the hands of Seth (his brother), he also becomes the god of death. Iah appears in the Late Period (661-332 BC) and is closely related to Osiris's own death and rebirth. The phases of the Moon would represent the future of Osiris, in such a way that the waning phase explains his mutilation and disintegration by Seth, while the growing phase represents the rebirth of Osiris, the full moon being his return to the splendor of life.

Osiris-Iah. In the head you can see the Moon in its crescent and full phases.
Metropolitan Museum of Art, New York.

However, the beliefs that sustain Egyptian mythology spread and were practiced for more than three thousand years (until Justinian I prohibited it, in the year 535 AD), with multiple variants that explain the diverse iconography of this complex religious system and the intricate identifications and dissociations between its entities. Thus, according to various texts, the Moon is born in the left eye of Horus, son of Osiris, who faces Seth in battle to avenge the death of his father. Specifically, the legend says that, in the contest, Seth seizes the eye of Horus and seriously wounds it, and the god Thoth must intervene to heal the injury (it is appropriate to mention here that Thoth is considered the god of wisdom, knowledge, mathematics and, also, of lunar filiation). Although the evil eye of Horus is removed, the brightness diminishes thus becoming the restored eye, 'udyat', the eye of the night: the Moon.

In Sumerian culture, we also find the Moon personified in the god Nannar, also called Sin, Zuen, Suen, Sinai and Nanna, son of the air goddess Ninlil and the wind god Enlil. In turn, it is presumed that Nannar's wife is the goddess Ningal with whom he had two children: Inanna, goddess of life and fertility (symbolized by the planet Venus), and Utu, god of the Sun and justice. With his children, Nannar, the Moon god, heads a triad of gods who rule the cosmos with absolute dominance and becomes the most important god in the Mesopotamian universe, with significant cults and temples in the ancient Sumerian cities of Ur and Harran, and in Babylon, which shows the relevance that the Moon had for these cultures.

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[2] Eos
[3] Selene
[4] Helios

The image below shows a Sumerian seal found in the Johns Hopkins University Archaeological Museum. In the scene, a man is presented before the god seated on the throne. Although there is no evidence that the deity is a particular god of the Mesopotamian pantheon, the crescent Moon that appears at the center of the scene could be related to Nannar. Such was the importance of this god, that the Moon appears represented in multiple engravings above gods, goddesses and kings.

Sumerian seal, 2112-2004 BC.

In this city of Ur, worshiper of "pagan" deities, where idolatry of the god Nannar reigned, Abraham was born, son of Terah and brother of Nahor and Haran (Genesis 11:26). According to some writings, for Abraham, who believed in Jehovah, who for him was the true god, life was not easy in the city of Ur of the Chaldeans, because there they practiced rites of worship to Nannar, represented by a huge ziggurat, which went against their beliefs. Luckily for Abraham, God gives him the mandate to leave this city (Genesis 12:1-3; Acts 7:2, 3), and this is probably the beginning of the "death" of those old gods. The birth of the Moon in Christian mythology differs considerably from the personifications in deities attributed by other cultures and its role is none other than that of lighting the night. The Moon, like the Sun and the stars, is created by God on the third day of creation. In the book of Genesis, written by Moses, around the year 1500 a. C., it reads:

13 *And it was evening and morning, the third day.* ***14*** *Then God said: "Let there be lights in the expanse of the sky to separate the day from the night, and let them serve as signs to mark the seasons, the days and the years;* ***15*** *"and serve as lights in the expanse of the sky to give light on the earth." And so it happened.* ***16*** *And God made the two great lights. The greater light to light the day, and the lesser light to light the night. And the stars.* ***17*** *And God set them in the expanse of the sky, to give light on the earth,* ***18*** *to rule the day and the night, and to separate light from darkness. And God saw that he was good.*

In the Mayan, Aztec and Inca mythologies, the Moon has a somewhat different birth and, with the nuances of each civilization, a similar story was told in these cultures. The legend is narrated in "*The Florentine Codex. General history of the things of New Spain*", written by the Franciscan missionary Bernardino Sahagún, in the 16th century, who went to Mexico with the mission of evangelizing the natives. Apparently, it all started in a meeting of the gods that took place in Teotihuacán with the aim of defining who would be in charge of illuminating the heavens and the earth. Among the attendees was Tecuciztécatl, who boasted greatness and wealth and longed to become a god and, seeing the opportunity to achieve his goal, offered himself for the task. However, the elder gods of the council decided that he must compete with someone to achieve his end. So, they chose Nanahuatzin, who willingly accepted:

—Ca ye cualli, teteoé, oannechmocnelilique (-Okay, gods, you have done me a favor).

Both had to make offerings and dedicate themselves to worshiping the gods for four days. While Tucuciztécatl's offerings consisted of fine gifts and riches, Nanahuatzin's offerings were humble and revealed Nanahuatzin's modest and simple nature. At the end of the penance period, the gods formed lines through which the candidates were to run and throw themselves into a great bonfire of divine fire that would transform them into gods. Tucuciztécatl was the first; gala dress with heron feathers, conical and vest, he passed between the gods, but when he reached the fire, he felt a scorching heat that prompted him to withdraw and he did not dare to enter the fire. The modest Nanahuatzin, who was dressed only in paper, had no fear and threw himself into the flames. Humiliated and tormented by his lack of courage, Tucuciztécatl followed him and also entered the bonfire. After dawn, two stars came out following the same order in which they had entered the fire, both equally bright. But seeing one of the gods that this was unfair, he hurt Tucuciztécatl's face, through wounds made to a rabbit. And so he remained, with less shine and with scars on his face as up to now. Then, the god of the wind, Ehécatl, manages to push them through the sky and thus, Nanahuatzin, converted into the Sun, crosses the sky during the day and, by order of Tucuciztécatl, crosses the night, converted into the Moon.

Science

The first scientific theory about the birth of the Moon was proposed in 1873 by the French astronomer Édouard Roche (1820-1883) and is known as the simultaneous formation theory. The astronomer formulated that the Moon was formed together with the Earth at the same time, in the same region and with the same materials, which, in turn, would give both stars a similar density. Although it is now known that the Moon shares a similar chemical composition with the Earth, the densities of both have important differences, which inevitably leads to the invalidation of the Roche theory. [5]

Later, in 1882, George Darwin, son of the father of the Theory of Evolution, Charles Darwin, proposed the fission theory, according to which the Earth expelled part of its mass as a result of rapid rotation in the early phases of formation (the Earth would complete a complete rotation in no more than two hours and twenty minutes) [5]. This theory was quite valid, to the point that, in 1925, the Austrian geologist Otto Ampherer suggested that the emerging Moon from fission would causally explain continental drift, which was later refuted because it is currently known that ocean basins such as that of the Pacific, are much more recent than the formation of the Moon [1]. In short, the fission theory also falls into disuse and is objected to due to the differences in the chemical composition between the Moon and the Earth, in addition to not being able to explain the angular momentum of the Earth-Moon system.

In 1910, the American Thomas Jefferson Jackson See (1866-1962), proposed the theory of capture. See's hypothesis maintains that the Earth trapped with its gravitational attraction a body that supposedly originated in an unknown region of our Solar System. This body would have passed close to the Earth and when it exceeded the Roche limit (see link in footnote 6), it fractured and the debris regrouped to form the Moon [5]. This hypothesis became popular until 1980, although it was never clear how the capture mechanism occurred, since this would assume that the early Earth and the body had paths close to and at the same distance from the Sun [5]. In addition, it would have been necessary for the Earth to have an "atmosphere" capable of slowing down the body. On the other hand, it is not capable of explaining certain similarities in chemical composition between both stars. [1]

Another theory that seeks to explain the formation of the Moon is that of accretion or co-formation. This hypothesis holds that the Moon formed together with the Earth around 4.5 billion years ago, as a binary system, from the primary accretion disk of the Solar System [1]. This idea is a particular case of the accretion theory proposed by the Russian geophysicist Otto Schmidt (1891-1956) in 1944, to explain the formation of planets. However, it didn't work either: "The problem with this hypothesis is that it does not explain the angular momentum of the Earth-Moon system or why the Moon has a relatively small iron core compared to that of Earth (25 % of its radius compared to 50 % for Earth)" [1].

[6] Academically trained at the University of Montpellier where he was also a professor, in addition to the theory of lunar formation, Roche carried out other important work related to gravity. Thus, he studied comets, Laplace's nebular hypothesis, the formation of Saturn's rings, and established what is now known as the Roche limit.

Mythology and Science.

In short, none of these hypotheses manages to satisfy scientists. The curious thing is that science had to go back to mythological sources to find an elucidation about the origin of the Moon. Of all the explanations given by different civilizations throughout history, the one that ends up predominating is a slight version of the explanation given by Homer in Hymn XXXI. Indeed, an older myth suggests that Tea and Gaea collided and Selene would have been born from that confrontation [5]. Two scientists from the PSI (Planetary Science Institute), William K. Hartmann and Dr. Donald R. Davis, were the authors of an article published in the journal Icarus in 1975, where it is proposed that 4.5 billion years ago, in its early stages formation, the Earth (Gea) was impacted by a body the size of Mars. A fraction of the debris generated by the crash enters orbit around the Earth, causing the formation of our captivating Moon. This hypothesis (based on the previous work of the Russian astrophysicist Viktor S. Safronov), fits with the fact that the Earth has an iron core, while the Moon does not. According to Hartmann and Davis, the Earth's iron had already drained into the core when the impact occurred, and both the Earth and the impacting planet (Tea) collided their rocky mantles, fusing the impactor's iron core with that of the Earth. Earth, which explains the absence of iron on the Moon [4], and as a consequence, the difference in density, since the Earth has an average density of 5.5 g/cc while the density of the Moon is 3.3 g /cc (this is known from studies on lunar rocks brought back by the Apollo missions). In addition, the authors explain that the composition of oxygen isotopes of the Earth and the Moon is the same, something that differs from other regions of the Solar System, which in turn are different from each other, which is why the Moon was formed with materials from the near-Earth neighborhood.

Half an hour after the giant impact, based on models computer scientists. [3]

Almost ten years later, in 1984, this hypothesis was affirmed as the main one, at a meeting in Kona, Hawaii, on the origin of the Moon, where, in addition, the remaining competing theories were refuted. Later, in the 1990s, Robin Canup continues to study the large-impact hypothesis based on computer models that suggest that the debris generated in the collision created a swarm of moons that formed a ring around Earth. The materials of that ring, over time, combined and came together to form the Moon.

Moon forming from rings. [3]

Lunar Topographic Studies

A recent study published on November 4, 2022 in The Astrophysical Journal Letters, carried out by NASA and the University of Durham, proposes that the Moon could have formed in a matter of hours after the impact between Earth and Tea. In a high-resolution simulation, the collision of a planet the size of Mars with another the size of Earth is modeled, resulting in two bodies. After the collision, the gravity of the larger body propels the smaller one, immediately placing it in an orbit far removed from Earth, beyond the Roche limit. According to the authors of the paper entitled *Immediate origin of the Moon as a post-impact satellite*, even bodies (satellites) that initially transit within the Roche boundary can eventually reliably and predictably avoid decay by being propelled and directed into wider and more stable orbits. Also, scientists propose that the outer layers of these satellites are made up of 60% of their composition by the materials resulting from the impact. This theory would give an answer to the isotopic differences between the Earth and the Moon and would explain the orbital inclination of the Moon. The following illustration that appears in the article shows how a satellite is placed directly and immediately (35 hours), in a wide orbit. In the central graphics, the particles that will form the satellite and the inner remnant are highlighted in purple and green. The black curves show the estimated orbit. In gray color the core is observed and in orange the mantle of the proto-Earth, while, in brown and yellow, the same for Tea (the authors provide a link where a video of this sequence can be seen and, also, NASA does the same).

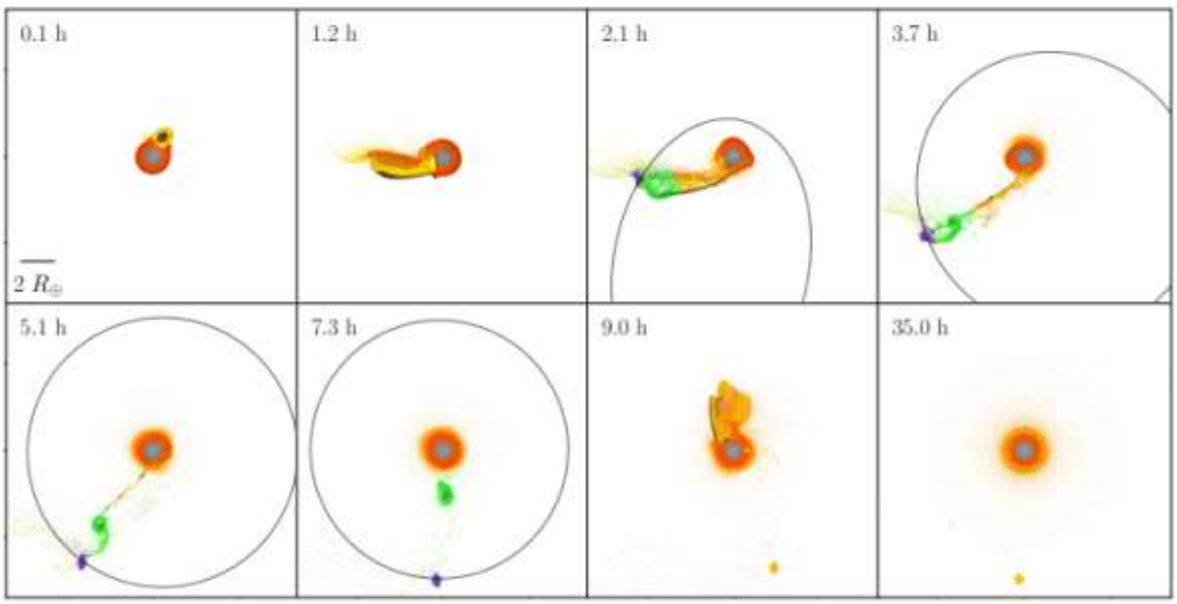


Illustration of the launch into orbit of a satellite formed after the big collision. [6]

Lunar Topographic Studies

A lesser-known explanation.

Although there are other legends and personifications of the Moon and, surely, slight modifications of the scientific theories mentioned before, and which have not been alluded to here, there is a lesser-known version than the previous ones and I will tell you about it below. A few years ago, an elderly man with a nomadic appearance and a gray beard, who found me observing the Moon, asked me the question that gives the title to this article: 'Do you know how the Moon originated?' Feeling in my element, and goaded by the opportunity to elaborate on descriptions of large impacts, mathematical definitions of angular momenta, Roche limits, and satellites propelled into external orbits, I thought I'd start with the explanation. However, the words stopped on my tongue and I understood that the question hid an interesting answer that was worth listening to and, timidly, I replied: 'No. You tell me'. This is what the man told me:

"In a resplendent southern spring, two beautiful birds meet, a swallow and a fiery ember (red pileated finch). The graceful silver swallow, with her rapid flights, fell in love with the ember of fire and together they flew through the spring and summer skies, professing her endearing love. But when autumn arrived, portending the winter cold, the swallow had to leave for the north in search of warmer skies. But her love for the beautiful red-basket soldier (another name for the ember of fire), did not let her go and she decided to stay with her lover. The winter cold weakened her and she died frozen to death one gray rainy afternoon, her fragile silver body riddled with wounds. Her beloved redbasket, the ember of fire, fell into melancholy and sadness and she died of love, following her nemesis to the far wastes where death reigns. But the hard and inflexible heart of Death was moved and she felt sorry for the lovers. She thought for many days looking for a way to perpetuate such intense and faithful love. It was like this, that the fairy of death turned the ember of fire into the Sun, to give warmth to her swallow, and her into the Moon, which leaves and returns in its phases, with its body riddled with scars, always searching to his beloved red-basket soldier".

References:

[1] Foster, Vincent (2016), Modern Mysteries of the Moon, Springer, USA.
[2] Hartmann, W. K. y D. R. Davis (1975), Satellite-Sized Planetesimals and Lunar Origin, Icarus, 24, 505.
[3] Homer (2007). *Homeric hymns. La Batracomiomaquia*, Losada, Buenos Aires, Argentina.
[4] https://www.psi.edu/epo/moon/moon.html
[5] Kébé, Fatoumata (2021), The Book of the Moon. History, myths and legends, Blackie Books, Buenos Aires.
[6] Kegerreis, J.A., Ruiz-Bonilla, S., Eke, V. R., Massey, R. J., Sandnes, T. D., Teodoro, L. F. A., (2022), Immediate Origin of the Moon as a Post-impact Satellite, The Astrophysical Journal Letters, 937:L40 (11pp) (Recovered from https://iopscience.iop.org/article/10.3847/2041-8213/ac8d96/pdf

Lunar Topographic Studies

Total Lunar Eclipse, *Richard Hill, Loudon Observatory, Tucson, Arizona, USA. 2022 November 08 09:12-11:53 UT. Canon Rebel camera, 500 mm f/5.6 Mak-Cass lens.*

Lunar Eclipse, *Darryl Wilson, Marshall, Virginia, USA. 2022 November 08 09:17 UT. 80 mm refractor telescope, SKYRIS 274C camera. Darryl adds "*Attached is an HSV saturation enhanced image of the umbra covering the moon. The weather was again uncooperative - a thin layer of cirrostratus moved in just as the umbra started to cover the disk. Fortunately it wasn't 100% cloud cover like it was last year, so I was able to image through it, but the dynamic range (SNR) of both the visible and the thermal images suffered."

Total Lunar Eclipse November 8, 2022

Total Lunar Eclipse, *Maurice Collins, Palmerston North, New Zealand. 2022 November 08. FLT110 mm refractor telescope, Canon 1200D camera. Above 10:03 UT, below 10:09 UT.*

Total Lunar Eclipse November 8, 2022

Total Lunar Eclipse, *Maurice Collins, Palmerston North, New Zealand. 2022 November 08. FLT110 mm refractor telescope, Canon 1200D camera. Above 10:56 UT, below 10:59 UT.*

Total Lunar Eclipse November 8, 2022

Total Lunar Eclipse, *Maurice Collins, Palmerston North, New Zealand. 2022 November 08. FLT110 mm refractor telescope, Canon 1200D camera. Above 11:26 UT, below 11:44 UT.*

*Maurice adds "*At 10:10 pm (09:10 UT) I setup the FLT-110 refractor on our deck, as the Moon was fairly low in the NE. Attached my Canon 1200D and started taking photos of the eclipse. During the total phase I used a 2 second exposure and 800 to 3200 ISO.

I didn't time any crater passings, I was only watching with binoculars and the telescope had the camera installed. Brightness at mid-eclipse was between 1 and 2 on the Danjon brightness scale. A local astronomer, gave it 1.5, so that seems about right.

During the totality the wind stopped, and afterwards it started up again.

I was able to use binoculars to just faintly pick out M31, but it was very hard to see in 7x50's. Mars started rising at the end of the eclipse. I watched until totality ended and packed away about 12:45am. It was a pleasant evening just watching it and we were lucky to get a nice night in this part of the country, as other up north had rain.

Hope those with the Moon above their horizon got to see at least part of it also."

Total Lunar Eclipse November 8, 2022

Total Lunar Eclipse, 2022 November 08, Crater Timings

David Teske, Louisville, Mississippi, USA
60 mm f/16.7 refractor telescope, 13 mm DeLite, 77x
Clear skies, excellent seeing, dew very heavy.

Robert H. Hays, Jr., Worth, Illinois, USA
6-inch, f/8 reflector telescope, 68 x.
Clear skies, seeing 9-6/10 (early to late), transparency 6/6.
Table: Sky & Telescope's Eclipse-timing predictions for the total lunar eclipse of November 8, 2022

Crater	Predicted Entry UT	Observed Entry UT Teske	Observed Entry UT Hays	Crater	Predicted Exit UT	Observed Exit UT Teske	Observed Exit UT Hays
Grimaldi	9:10	9:09:38	9:10:35	**Harpalus**	11:47	11:46:49	
Billy	9:14	9:13:53		**Aristar-chus**	11:49	11:48:17	11:48:00
Kepler	9:20	9:19:33	9:20:25	**Grimaldi**	11:50	11:50:20	11:49:40
Aristarchus	9:21	9:21:22	9:21:35	**Kepler**	11:55	11:54:50	11:55:15
Campanus	9:24	9:23:58		**Plato**	11:55	11:55:54	
Copernicus	9:29	9:29:04	9:29:00	**Billy**	11:57	11:56:40	
Pytheas	9:31	9:31:01	9:31:40	**Pico**	11:57	11:57:29	
Birt	9:32	9:32:19		**Pytheas**	11:59		11:59:05
Tycho	9:33	9:33:08	9:32:50				
Harpalus	9:37	9:37:11					
Timocharis	9:37	9:36:40	9:36:50				
Pico	9:45	9:44:59					
Manilius	9:46	9:45:57	9:45:40				
Plato	9:47	9:46:50					
Dionysius	9:48	9:48:39					
Menelaus	9:50	9:49:42	9:49:55				
Plinius	9:54	9:53:30	9:53:40				
Eudoxus	9:55	9:55:00					
Censorinus	9:56	9:56:25					
Aristoteles	9:57	9:56:56					
Goclenius	10:00	10:00:14	10:00:20				
Taruntius	10:03	10:03:12					
Proclus	10:05	10:05:02	10:05:15				
Langrenus	10:07	10:06:55					

Total Lunar Eclipse November 8, 2022

Spectral Angle Mapper
A Hyperspectral Algorithm to Generate Surface Material Maps

Darryl Wilson

When I observe the moon, sometimes a specific location or feature grabs my attention and I begin to wonder what it is made of. Is this the only example of this stuff anywhere? Is there perhaps a little bit of it hiding somewhere in the southern highlands, or the mare near the limb? Does the center of Plato have unusual composition or is it like mare material everywhere? Are Tycho's rays like those of Copernicus, or are they different? Is the surface material of the Aristarchus plateau unique to that area? Where else on the moon will I find surface material most like that at the Fra Mauro landing site?

The Spectral Angle Mapper (SAM) is an algorithm that allows us to pick a reference point (a pixel) in an image and ask "where else in the image can I find more of that?". The SAM output image is a brightness (concentration) map of the reference material. This eleventh article in the multiband image processing series presents some results of applying SAM to the six-band image set that was introduced in the August 2022 TLO article "Use of the Principal Component Transformation to Process Six Bands of Imagery". We now combine several of the techniques that were discussed in previous articles and build upon them to create a tool for mineral exploration on the lunar surface. Specifically, this article describes an algorithmic process flow that can be used to select a point (i.e., pixel) on the lunar surface and generate a global concentration map of whatever surface material is present at the selected location.

Although SAM can be used to extract unseen information from any coregistered image set with two or more bands, its value lies mainly its ability to process image stacks that contain four or more bands. Images with more than three bands become difficult to analyze using band-ratio or colorspace transformation (e.g., HSV) techniques. With SAM, they're a breeze.

Figure 1 is a natural color RGB image of the moon taken on April 16, 2022 at 4:16 UT. It is labeled with six (column, row) positions that we'll use in our analysis. We'll work with the six-band image set that we used previously (TLO Aug, 2022). Recall that we made it by collecting roughly 1100 RGB images, and a similar number of ultraviolet (UV), violet (V), and near-infrared (NIR) images. We then stacked (summed) the six bands and stored each as a single floating point image file to form a multi-spectral image set. Image acquisition details can be found in the July and August 2022 issues of "The Lunar Observer". This author wrote a program to coregister the separate bands, but commercially available software could also have been used.

Figure 1, *SAM vector (column, row) locations.*

Let's clarify some jargon for a reader who may cross-reference this article with other image processing writings. The SAM algorithm is often used by the hyperspectral data processing community. They refer to an image stack as a "cube". We avoid that terminology here for two reasons. First, hyperspectral cubes typically have at least several tens, if not hundreds of bands. Ours only has six. Second, hyperspectral bands are usually evenly separated in wavelength space. Our six-band set is sorted from shortest to longest wavelength, but the differences in center wavelengths from band to band is not constant. We'll call our six bands an image stack. This should not be confused with stacking (coadding or averaging) of images during image processing, as discussed in the previous paragraph.

More jargon... In hyperspectral terminology, a set of pixel values at a particular location in an image is called a spectrum because if they are plotted, they are, in fact, a spectrum of whatever material was at that location. Due to the limited number of bands and the uneven wavelength spacing, we do not refer to our six-element set of pixel values as a spectrum. We call it a feature vector. However, we will still refer to the angle θ as a "spectral angle", not a "feature vector angle".

Fortunately, hyperspectral algorithms can usually operate on feature vectors in image stacks as effectively as they can operate on spectra in cubes.

So, what exactly is this Spectral Angle Mapper algorithm? How does it work? Figure 2 illustrates both the concept and the mathematics. The X-axis represents pixel values in band 1 (e.g., blue) and the Y-axis represents pixel values in band 2 (e.g., red). The (blue, red) coordinate pair defines a two-band feature vector that can be compared to the vector associated with every other pixel in the two-band image. The larger the angle between them, the less similar they are. If the calculated angle is tiny, they are almost the same color - and perhaps almost the same material.

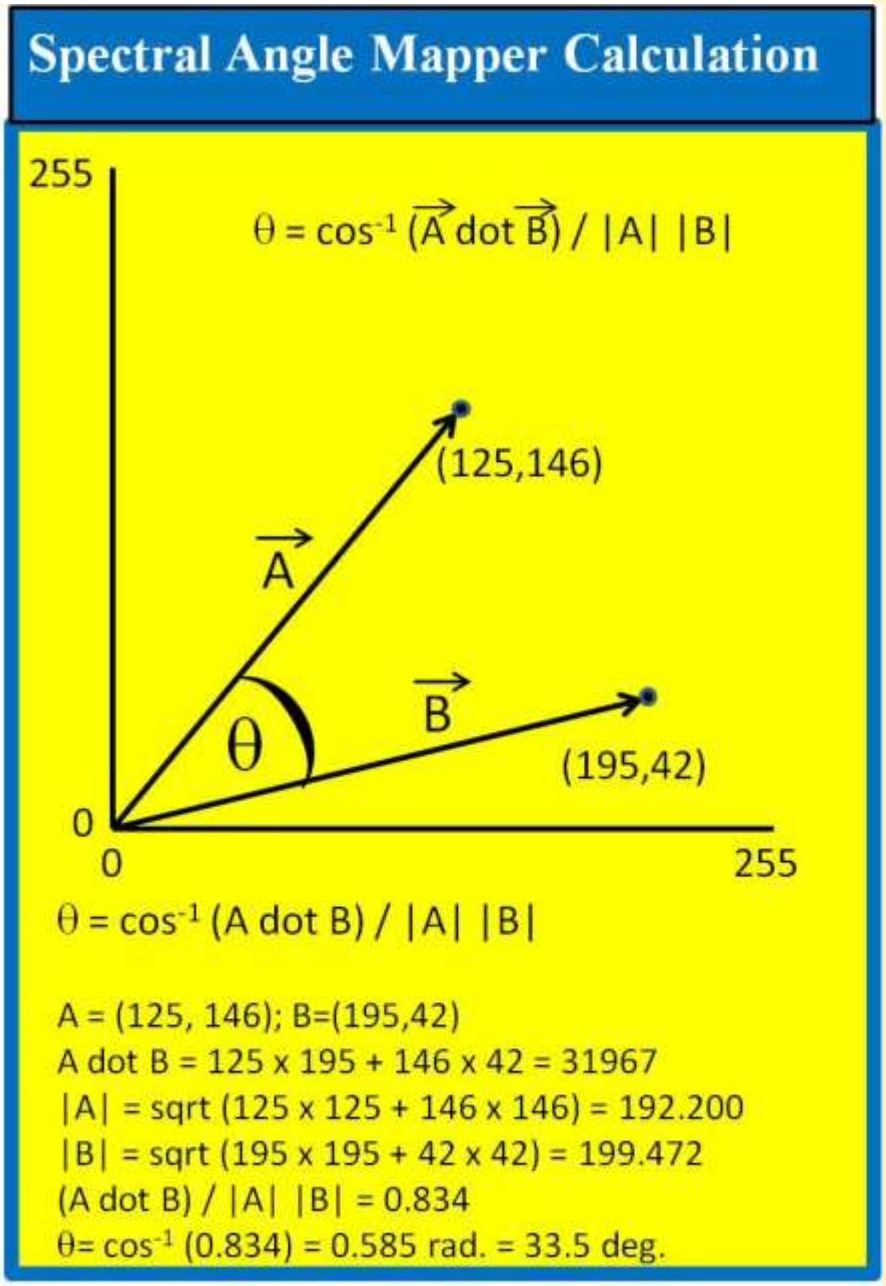


Figure 2 *Spectral Angle Mapper Calculation.*

The SAM calculation is easily extensible to a larger number of bands because this vector angle calculation works for any number of vector elements (a.k.a. dimensions) in the data. There are two main reasons that we would like to use more bands. First, if we add a band that covers a region of the spectrum that we are not already imaging, we add new spectral information to our image stack. Second, adding bands improves our ability to discriminate between surface materials, thereby reducing the number of false positive matches.

Although SAM is widely used by the earth remote sensing (e.g., LANDSAT) community, applying SAM to lunar images is particularly difficult for one reason. Figure 3 is an X-Y scatterplot of the image data from the blue and the red bands. The high correlation of data values between band pairs results in small measured angles between vectors. Two pixels are highlighted, one labeled "*" and one labeled "+". The spectral angle between the two (θ), only a couple of degrees, is calculated from the origin. It should be obvious that the angle between any two points (feature vectors) in the image will be small. This requires the algorithm to be especially sensitive and precise.

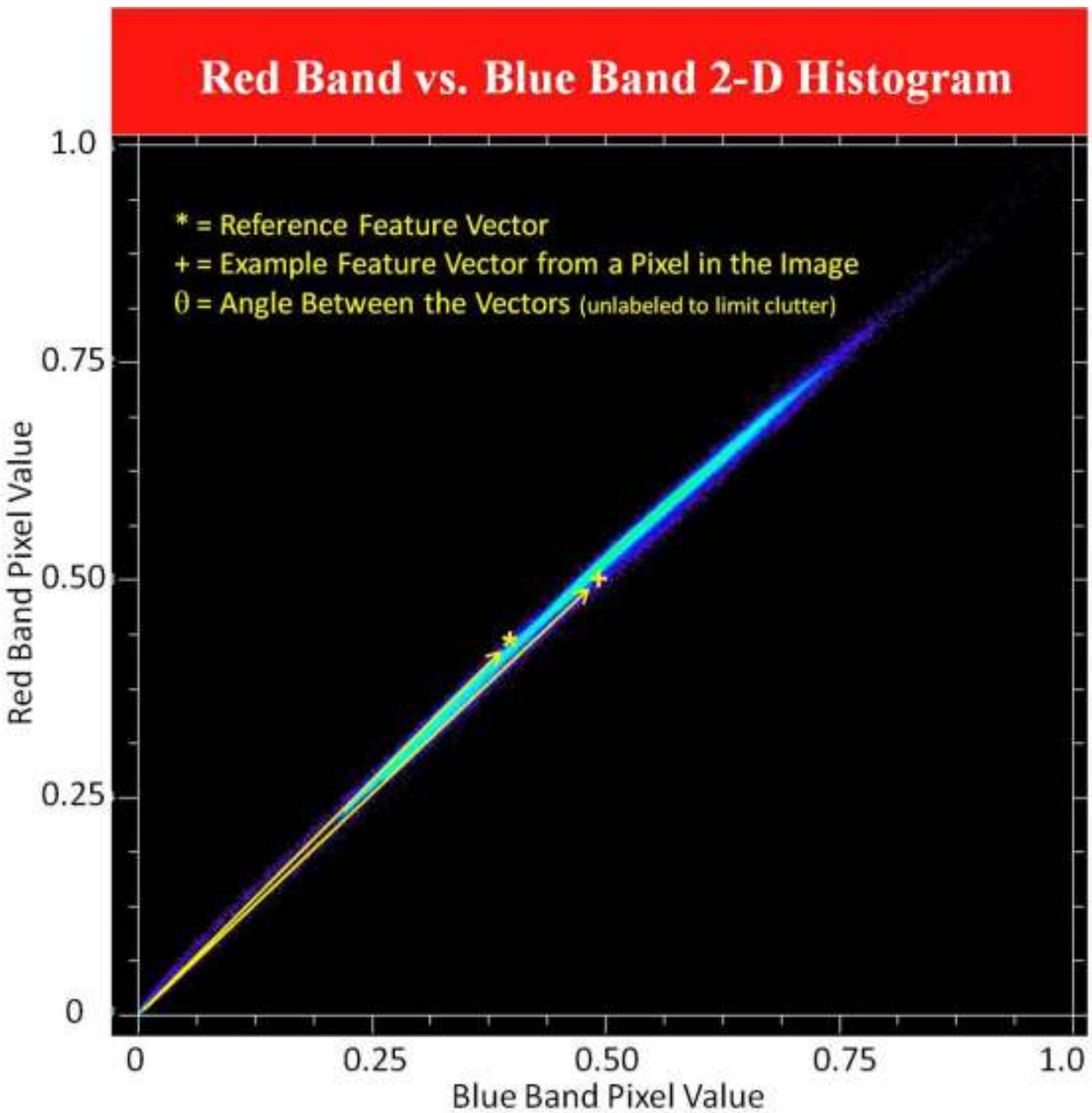


Figure 3, *Red vs. Blue Band Scatterplot.*

SAM can be applied to any multiband (i.e., two or more colors) image, but the results might be disappointing unless the image was created by coadding many individual raw images. When SAM was applied to a single RGB BMP image of the moon, the result was extremely noisy. Coadding hundreds of raw images (stacking) is necessary to increase the SNR so that small angles can be discriminated. Additionally, the output image should be stored in floating point format to preserve precision. If you transform it back to 8-bit per pixel format, you will see quantization error effects in the final output. Figure 4 shows the result of applying SAM to a 3 byte-per-pixel (bpp) BMP image created from the stack of 1100 images. It used the reference vector from (625,306) to search for Mare Tranquillitatus-like material. Figure 5 shows the result of applying SAM to the floating point 1100 image stack. Comparison of the two reveals that Figure 4 is noisier.

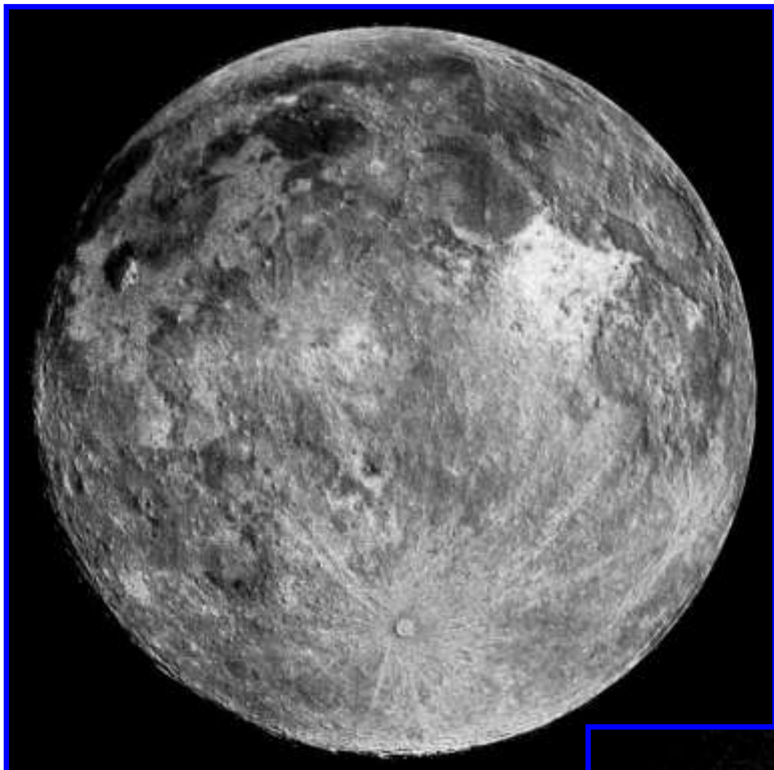


Image 4, *SAM applied to 24-bit RGB image derived from ~1,100 image stack.*

Image 5, *SAM applied to floating point RGB stack of ~1,100 images.*

The second preprocessing step is less important, but is still helpful. Normalization of the input data bands should be done by multiplying the values of each of the individual bands by whatever coefficients are necessary so that the histograms of all of the bands are roughly matched. One way to do this is to equalize the mean values of the data values of the illuminated areas of the moon. Figure 6 diagrams the data flow from image acquisition through stacking, normalization, and application of the SAM algorithm.

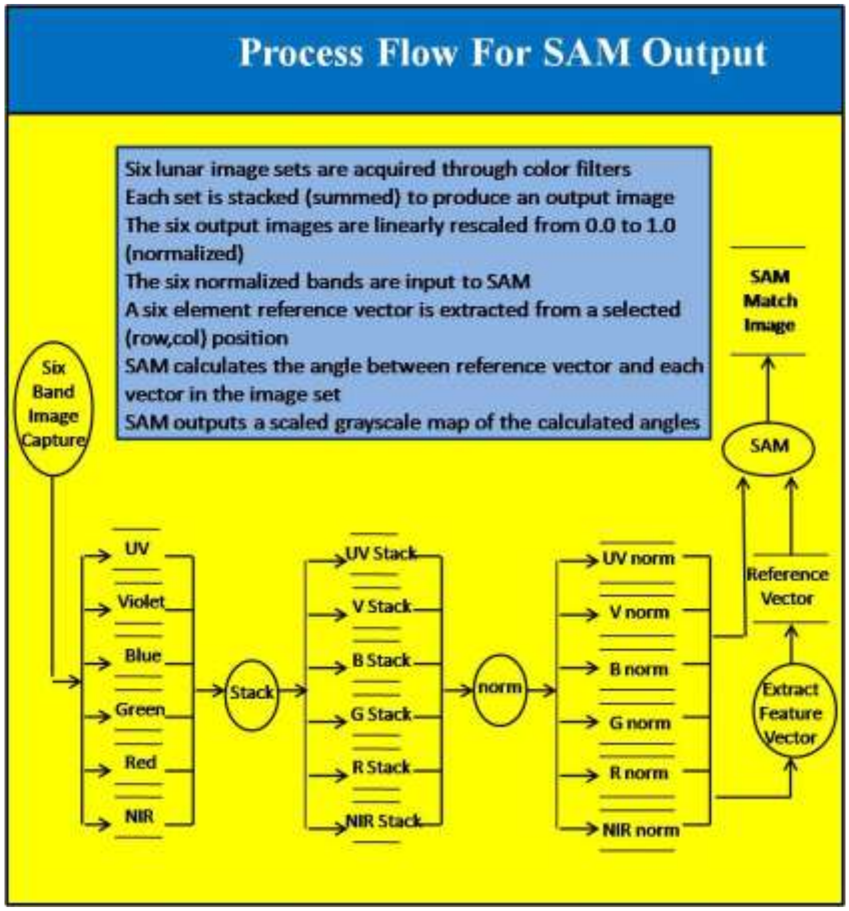


Figure 6, *SAM applied to floating point six band stack of 1,000 images.*

After stacking several hundred images to create each input band and applying multiplicative factors to individual bands, as necessary, to roughly equalize them, you are ready to apply the SAM algorithm. The seventh article in this series presented a band-ratio technique that can be used to generate a titanium abundance map of the lunar surface. Never explicitly stated was the assumption that the reader had one of two things, 1) software that could read two images and divide the numerical values of the pixels in one by the values in the other, or 2) the ability to write a computer program to read the two images, divide one into the other, and save the results to an image file.

This article requires at least that much. Although the SAM algorithm is included in analytic software used by the earth remote sensing and hyperspectral data analysis communities, those software packages are usually expensive. The alternative is to write your own program to perform the calculations. The good news is that if you know how to write small software programs, coding up the SAM algorithm is easy. This author did it in one evening.

The overall process is as follows. Read an RGB image file into memory, copy the RGB values from any pixel you choose into a three-element vector, calculate the angle between that three-element vector and each RGB vector in the image, store those values in a second single-band image, and save that image to disk. The angle calculation is presented in freshman physics texts and Equation 1.

$\theta = \cos^{-1}$ (A dot B) / |A| |B| Equation 1

In words, Equation 1 says that the angle (theta) between the two vectors (i.e., each RGB triplet in the image and the reference RGB triplet you have chosen) is equal to the arccosine of the dot product of the two vectors divided by the product of the magnitudes of the two vectors. Except for a call to the arccosine function, it's just plain arithmetic. An example calculation of the dot product using two image bands is presented in Figure 2.

Qualitatively, what is happening is that we are calculating the angular difference between the color (or spectrum) of our reference pixel every other pixel in the image. When a perfect match is found, the angle will be zero. Larger angles mean whatever surface material is in the image pixel is less like our reference material.

One final point is helpful. The range of the output values is 0.0 to π / 2 (~1.571), with better matches being darker. We would like the best matches to be brighter in the output image. One final calculation makes this happen and simultaneously normalizes the output. Equation 2 shows how.

$$\text{output} = (\pi / 2 - \theta) / (\pi / 2) \qquad \text{Equation 2}$$

The SAM algorithm was run six times - once with each of the feature vectors extracted from the positions labeled in Figure 1. A check was performed after each run to ensure that the output image contained a value of exactly 1.0 in the (column, row) position of the input feature vector, as should occur for an exact match.

The six locations were selected before any processing was done and were not subsequently adjusted to achieve more dramatic outcomes. This methodology is consistent with valid statistical sampling techniques, but caused rejection of some more impressive results. Figure 7 lists the six selected locations, along with the a-priori reasoning for choosing each of them.

Selected Lunar Locations for SAM Application

Feature	Col	Row	Reason
Aristarchus plateau	133	297	Unusual surface composition
Oceanus Procellarum	184	454	Suspected high TiO_2 concentration near Kepler
Edge of Mare Humorum	242	670	Unusual coloration noted TLO Apr2022 p. 9
Northern Mare Imbrium	297	152	Suspected high TiO_2 concentration
Tycho ray material	368	655	Try isolation of ray material
Mare Tranquilitatus	625	306	Suspected high TiO_2 concentration

***Figure** 7, SAM Feature Vector Location List.*

Figure 8 is the SAM output after applying the feature vector from the Aristarchus plateau. The pixel was selected because it appeared to be most typical of the surface material on the plateau, although considerable heterogeneity exists. As expected, most of the plateau appears bright in Figure 8. Additional bright areas are present to the northwest, at the edge of Mare Procellarum. Interestingly, two or three areas in Mare Serenitatis also show brightening, as does northeastern Mare Imbrium, just south of Plato.

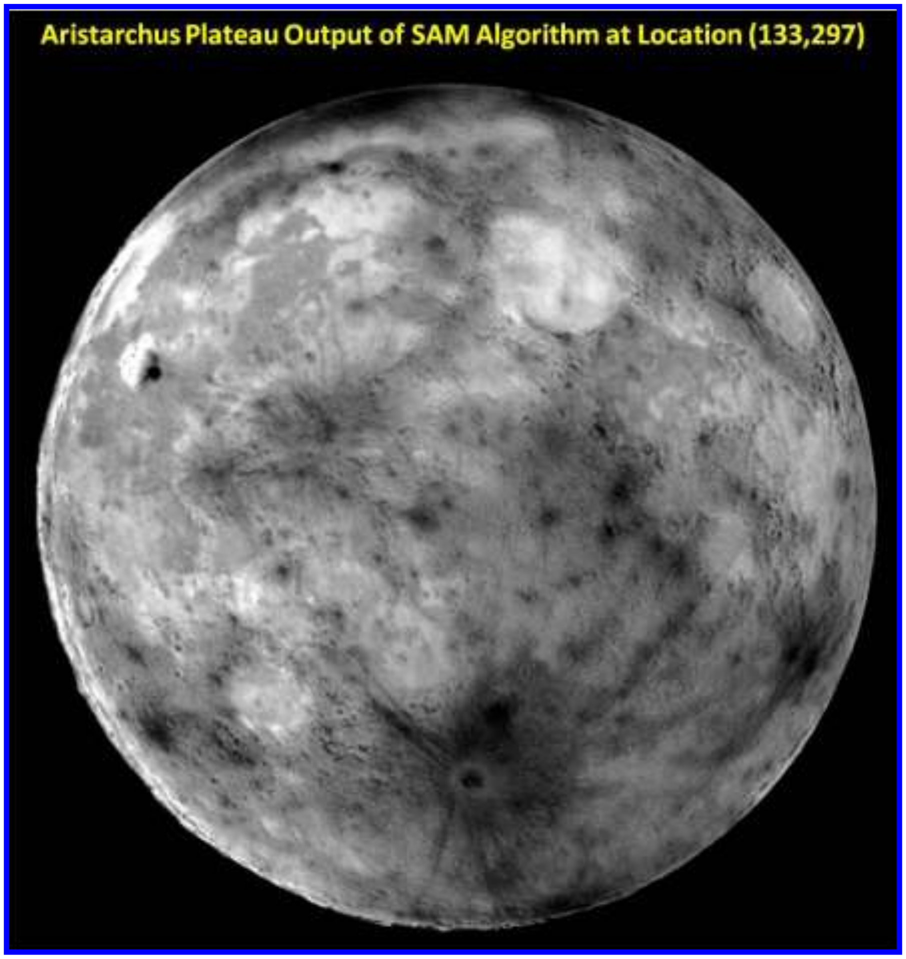


Figure 8, *Aristarchus SAM output..*

SAM output for the Oceanus Procellarum feature vector is shown in Figure 9. The fact that most of Procellarum is not very bright suggests that the point chosen is not well representative of most of the surface material there. A different point could have caused the ocean to brighten dramatically, but the initial choices were not adjusted. Eastern Mare Tranquillitatis seems to have similar material, as does northeast Mare Fecunditatis.

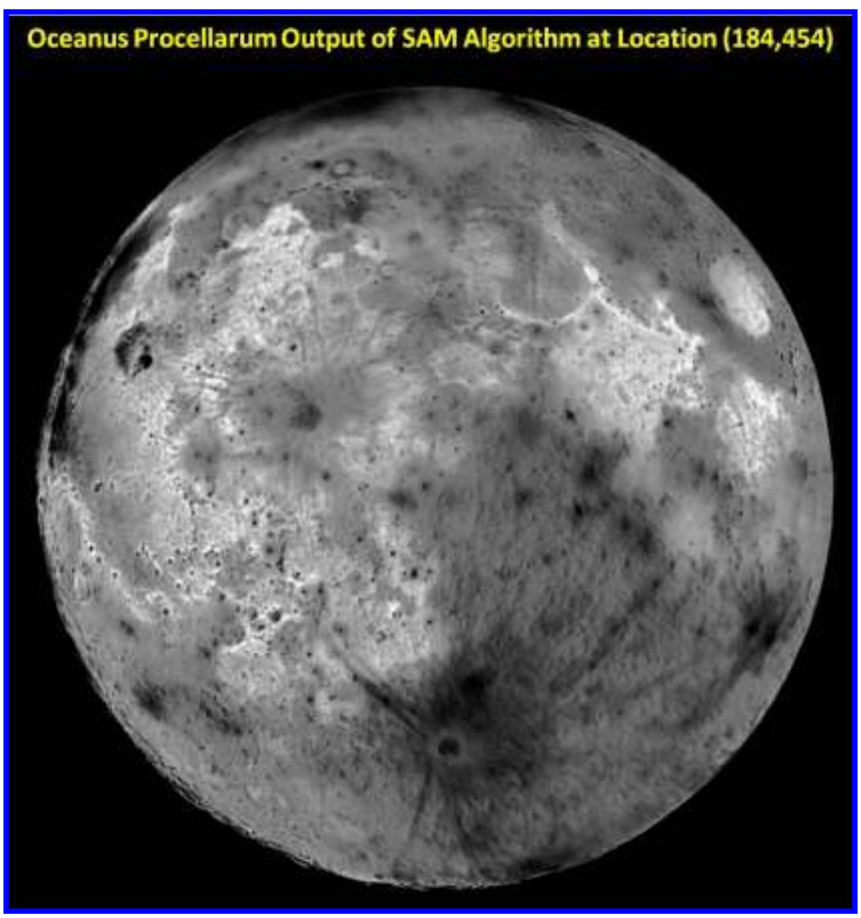
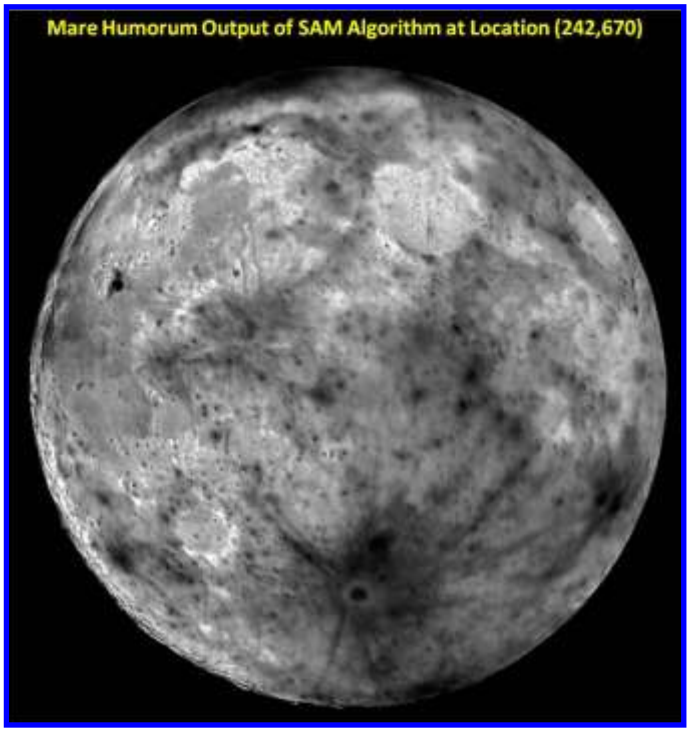


Figure 9, *Oceanus Procellarum SAM output..*



The Mare Humorum SAM output in figure 10 shows brightening in areas that were previously noted for their unusual coloration (TLO April 2022, p. 9). Northwestern Sinus Iridum also lights up for this feature vector. Examination of a previously published color enhanced version of Figure 1 (TLO May 2022, p. 25) shows some red pixels in both locations, but the area of Sinus Iridum shows color noise, which makes the match questionable.

Figure 10, *Mare Humorum SAM output.*

The next image, Figure 11, is an attempt to reproduce a titanium dioxide (TiO_2) abundance map of the lunar surface. The output is quite similar to that of Figure 9, whose feature vector was also selected due to its expected high TiO_2 content. Although the areas in the mare that are known to be rich in TiO_2 are indeed bright, there are some telltale artifacts in this image. Many edges of the maria are extra bright. When image processing algorithms demonstrate obvious edge effects such as these, one suspects some corruption of the data due to mixed pixel effects.

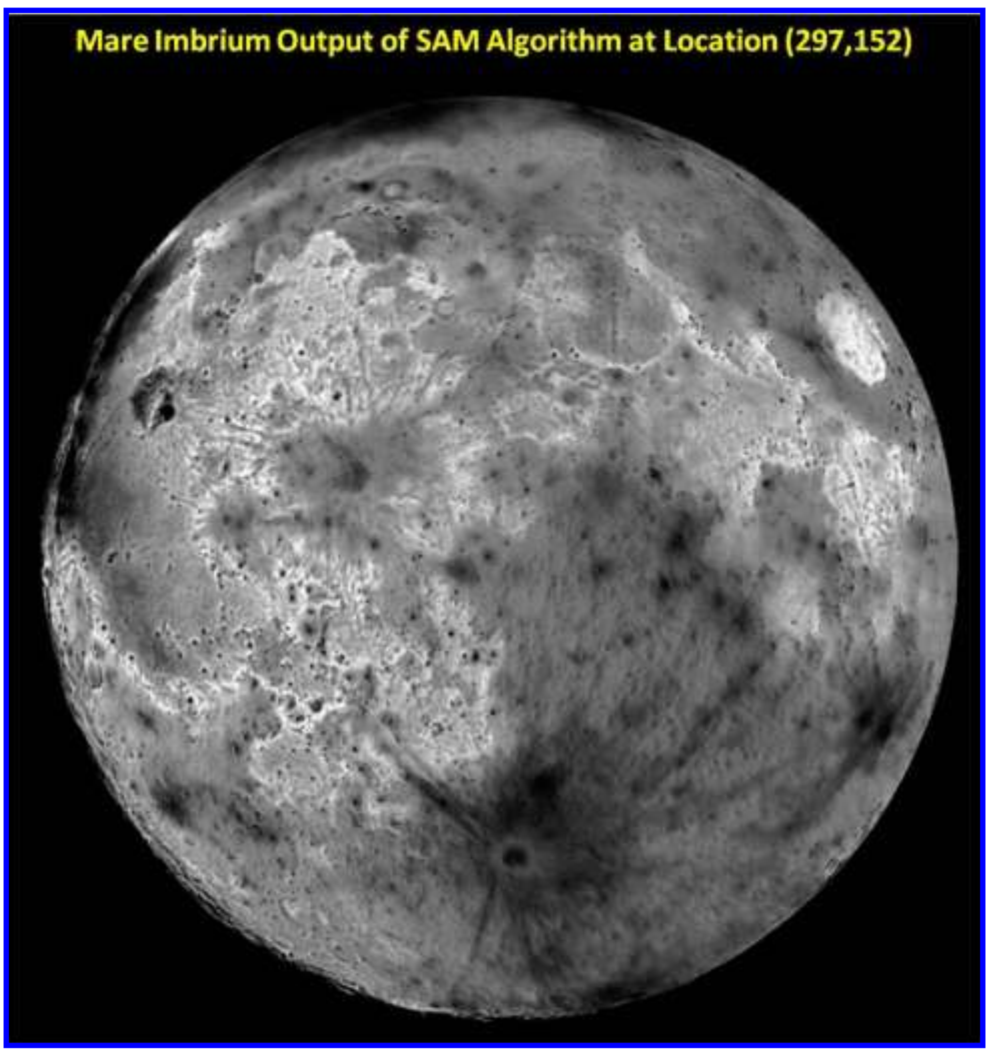


Figure 11, *Mare Imbrium SAM output.*

Figure 12 was an attempt to isolate ray material from other surface features. The output here is disappointing, but other processing efforts (not show here) were considerably more successful. Suffice it to say that a future article may show the usefulness of this particular application. The takeaway here is that SAM can be sensitive to input conditions and practice improves results.

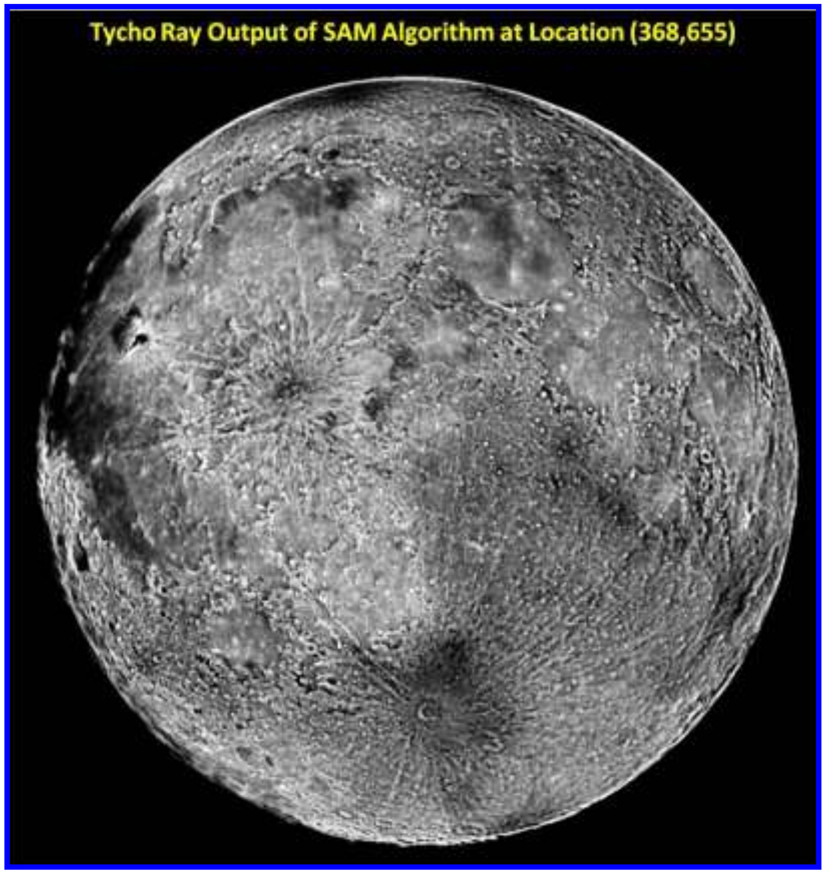


Figure 12, *Tycho Ray SAM output.*

Figure 13 is a map of Sea of Tranquility surface material. As expected, Mare Tranquillitatis lights up nicely. The feature vector extracted from position (625,306) was indeed representative of the surface of the entire mare. An area in northeast Mare Fecunditatis also seems rich in the same surface minerals. This image can be compared with Figures 4 and 5 to show the difference between processing three bands of RGB imagery and stacking six bands that include UV and NIR information. Figures 4 and 5 differ in noise level, but are otherwise similar. Figure 13, calculated with a feature vector from exactly the same position, demonstrates much more discrimination and selectivity. With only three bands, SAM correctly matched much of the similar surface material to the Sea of Tranquility vector, but it was unable to reject the area in and around Tycho as being different. When all six bands were used, the Tycho region was correctly assigned low match values by the algorithm. This essentially highlights the fundamental reason for doing multiband imaging instead of collecting grayscale pics.

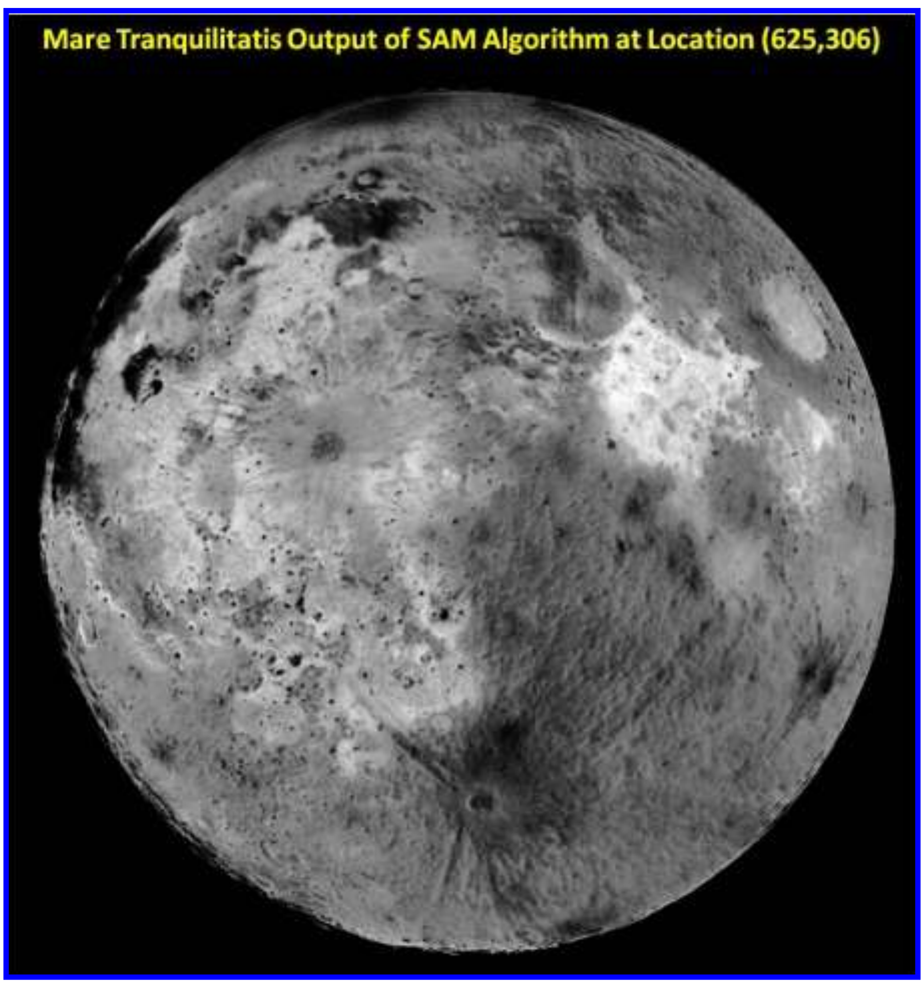


Figure 13, *Mare Tranquillitatis Ray SAM output.*

This article introduced the Spectral Angle Mapper algorithm and demonstrated its use in processing lunar image data. Its ability to handle more than three bands of image data was highlighted as a capability that differentiates it from other multiband algorithms. Presented as a hyperspectral data processing algorithm, two key differences between hyperspectral data and our multiband imagery were noted and language was defined to differentiate the two. The mathematics of spectral angle calculation were demonstrated with an example, and the process flow associated with software development of the algorithm was described and diagrammed. The need for image stacking and floating-point processing was stated and demonstrated by example. Examples of SAM processing of six feature vectors extracted from the lunar surface were presented for examination and each briefly discussed. The final example was also used to illustrate the value of adding image bands that are acquired outside the visible spectrum to the multiband stack.

Rashmi S1, Swapna Addamani1, Venkat1 and Ravikiran S2, "Spectral Angle Mapper Algorithm for Remote Sensing Image Classification", IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 1 Issue 4, June 2014.

Wilson, Darryl G., "Examination of HSV Colorspace Enhanced Imagery of Mare Imbrium, Aristarchus, Copernicus, Kepler, and Selected Lunar Domes", March, 2022, "The Lunar Observer", 6-10.

Wilson, Darryl G., "Examination of HSV Colorspace Enhanced Imagery of Mare Imbrium, Mare Frigoris, Sinus Iridum, and Plato", March, 2022, "The Lunar Observer", 12-14.

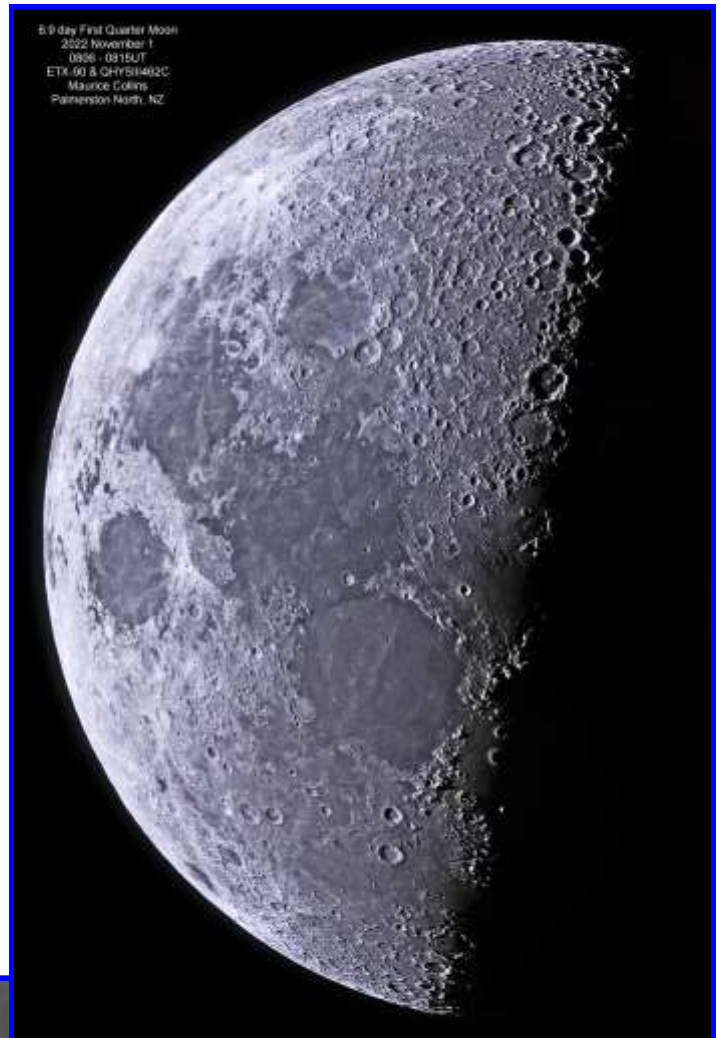
Wilson, Darryl G., "Examination of HSV Colorspace Enhanced Imagery of Oceanus Procellarum, Mare Humorum, and the Western Limb", April, 2022, "The Lunar Observer", 6-9.

Wilson, Darryl G., "Examination of HSV Colorspace Enhanced Imagery of Mare Cognitum, Mare Nubium, the South Polar Highlands, and a Wrap up of the HSV Color Enhancement Process", May, 2022, "The Lunar Observer", 22-27.

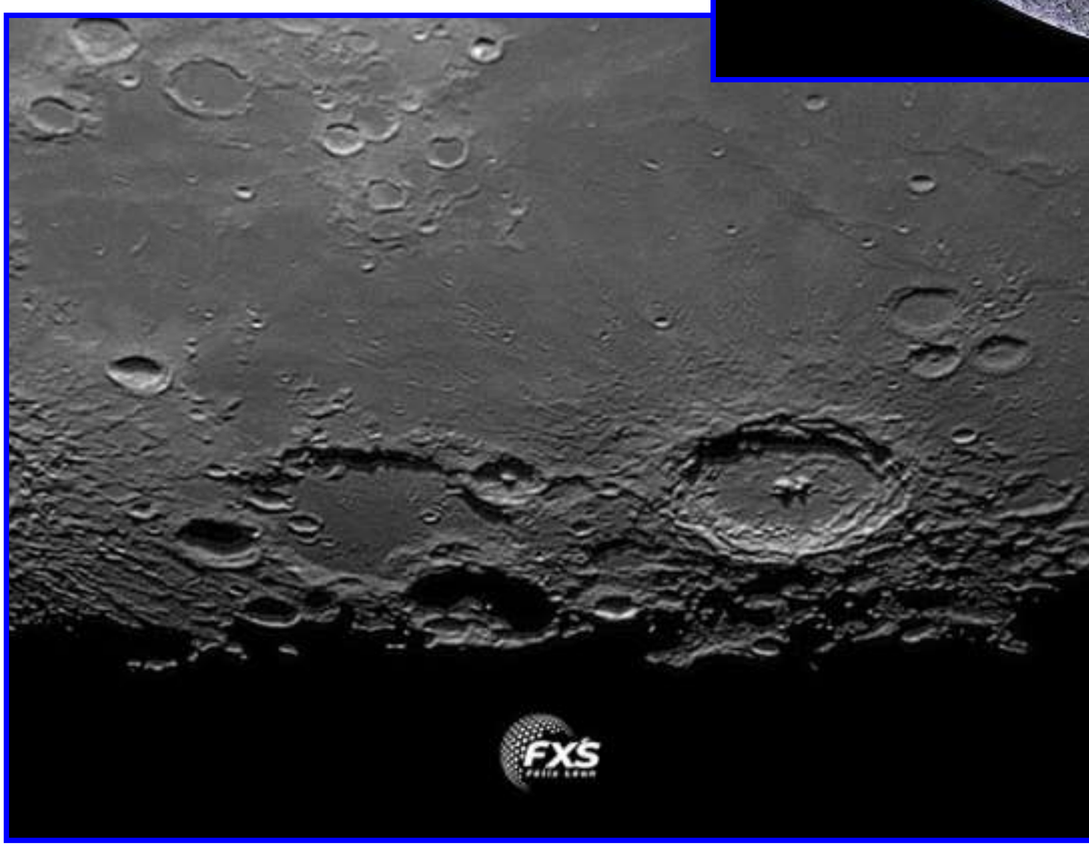
Wilson, Darryl G., "A Simple, Easy-to-Use Algorithm for Qualitative Titanium Mapping of the Lunar Surface", June, 2022, "The Lunar Observer", 24-29.

Wilson, Darryl G., "The Principal Component Transformation Extracts Hidden Information From Multiband Imagery", July, 2022, "The Lunar Observer", 24-29.

Wilson, Darryl G., " Use of the Principal Component Transformation to Process Six Bands of Imagery", August, 2022, "The Lunar Observer", 24-31.



6.9-day old Moon, *Maurice Collins, Palmerston North, New Zealand. 2022 November 01 08:06-08:15 UT. Meade ETX90 Maksutov-Cassegrain telescope, QHY5III462C camera. North is down, west is right.*

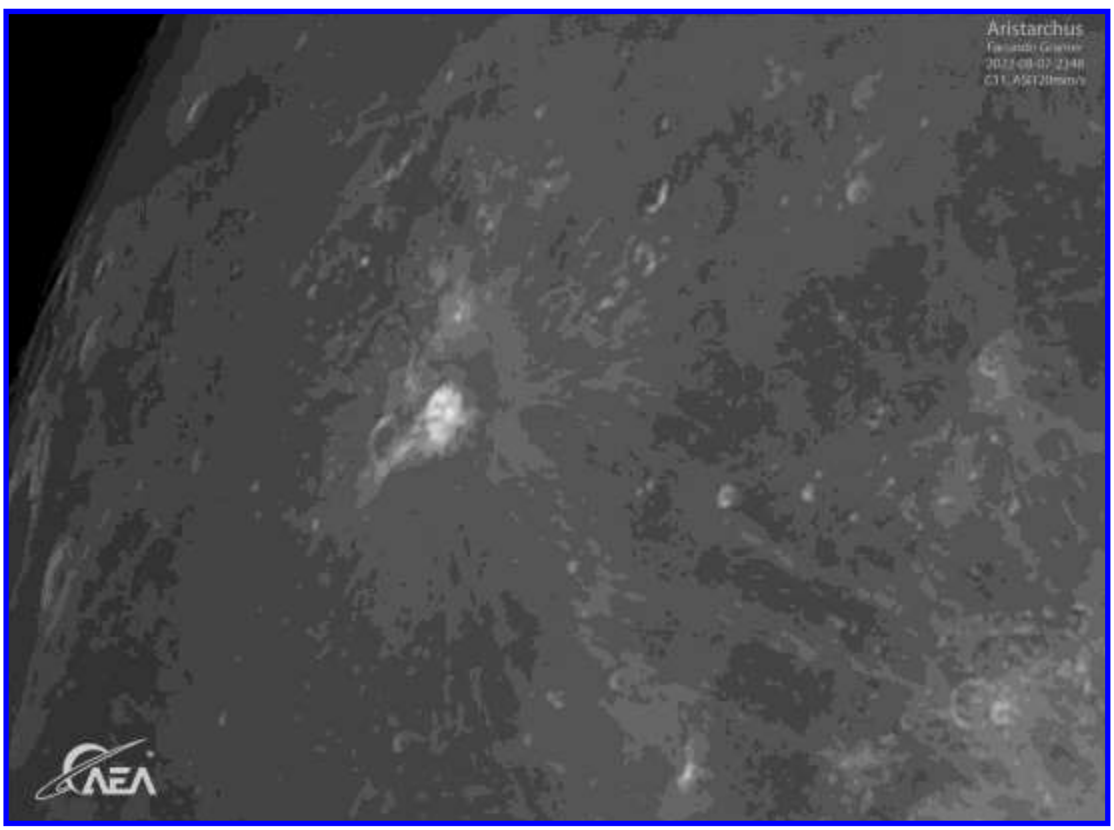


Langrenus, *Felix León, Santo Domingo, República Dominicana. 2022 October 12 05:23 UT. 8 inch Schmidt-Cassegrain telescope, DMK 21 618 AU camera. North is right, west is up.*

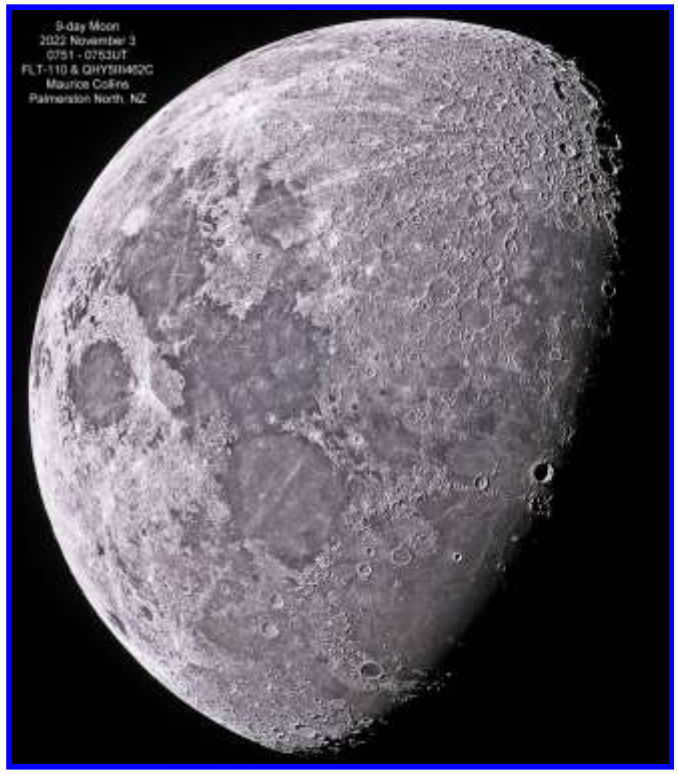
Recent Topographic Studies

Copernicus, *Maurice Collins, Palmerston North, New Zealand. 2022 November 03 08:46 UT. FLT110 mm refractor telescope, 3x barlow, QHY5III462C camera.*

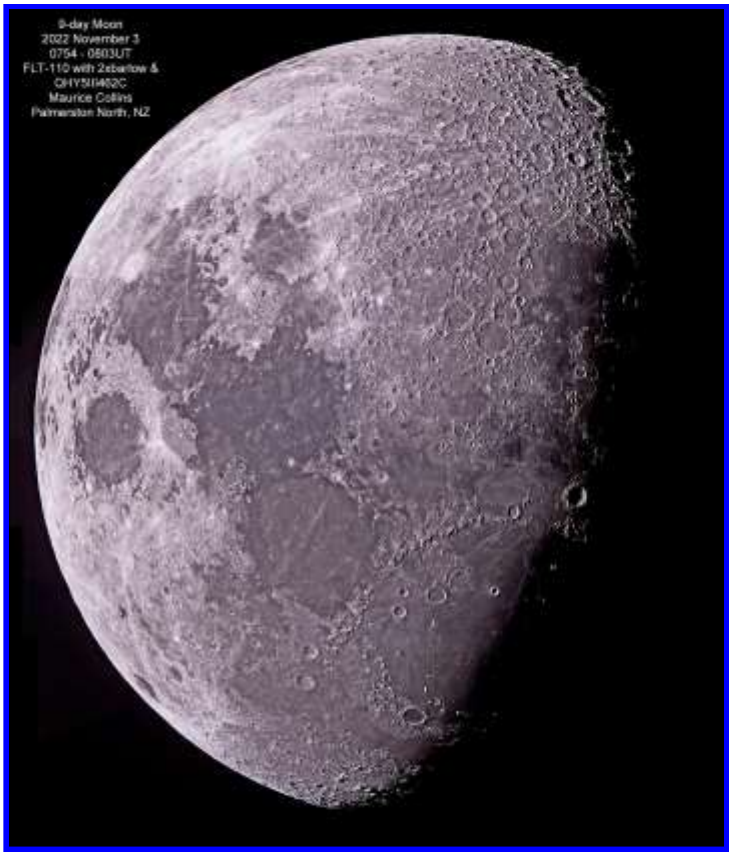
Aristarchus, *Facundo Gramer, AEA, Oro Verde, Argentina. 2022 November 07 23:48 UT. Celestron CPC1100 Schmidt-Cassegrain telescope, ZWO ASI120mm/s camera.*



Recent Topographic Studies



9 Day Old Moon, *Maurice Collins, Palmerston North, New Zealand. 2022 November 03 07:51-07:53 UT. FLT110 mm refractor telescope, QHY5III462C camera. North is down, west is right.*

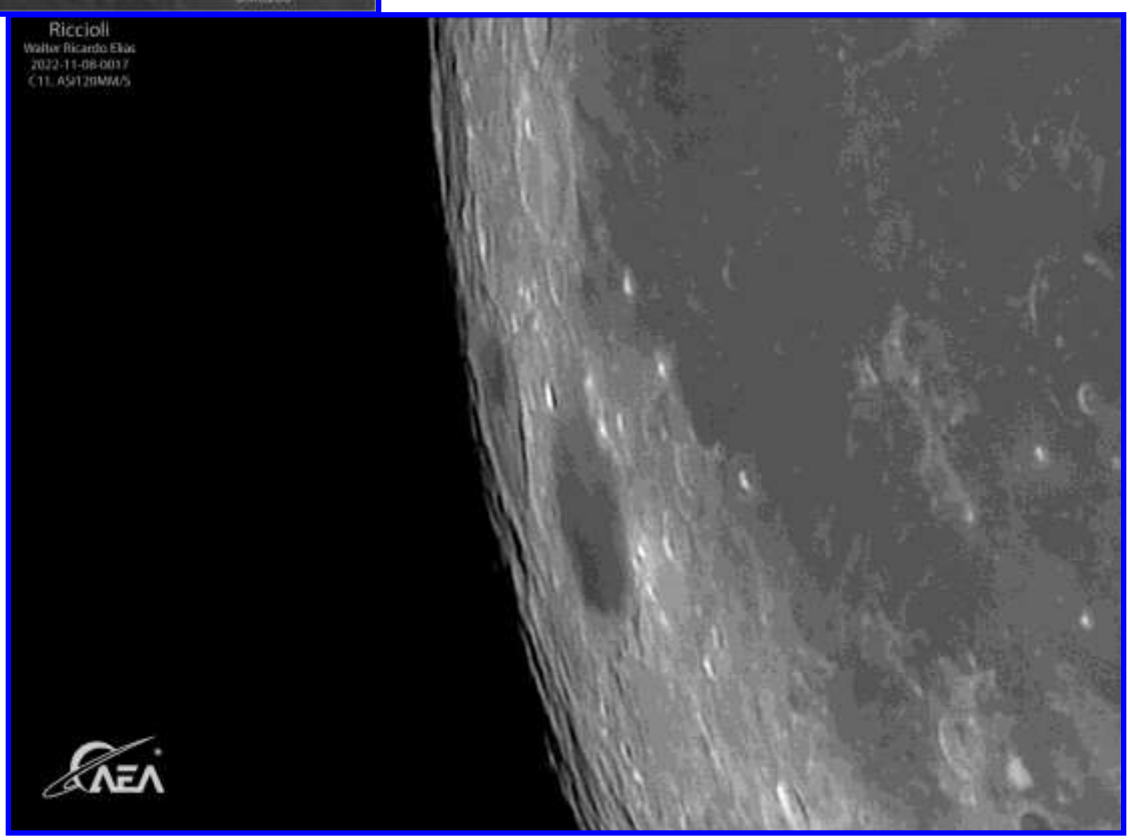


9 Day Old Moon, *Maurice Collins, Palmerston North, New Zealand. 2022 November 03 07:54-08:03 UT. FLT110 mm refractor telescope, 2x barlow, QHY5III462C camera. North is down, west is right.*

9 Day Old Moon, *Maurice Collins, Palmerston North, New Zealand. 2022 November 03 08:46-08:59 UT. FLT110 mm refractor telescope, 3x barlow, QHY5III462C camera. North is down, west is right.*

Recent Topographic Studies

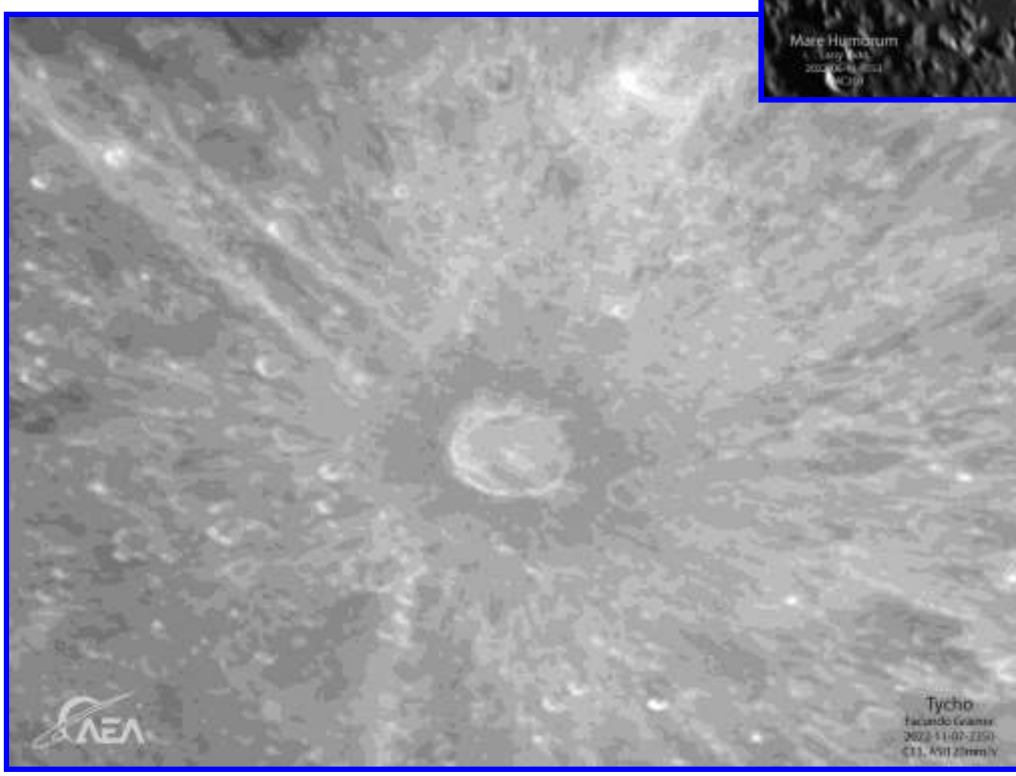
Aristarchus, *Larry Todd, Dunedin New Zealand. 2022 July 11 06:34 UT. 8 inch OMC200 f/20 Maksutov-Cassegrain telescope.*



Riccioli, *Walter Ricardo Elias, AEA, Oro Verde, Argentina. 2022 November 08 00:17 UT. Celestron CPC1100 Schmidt-Cassegrain telescope, ZWO ASI120mm/s camera.*

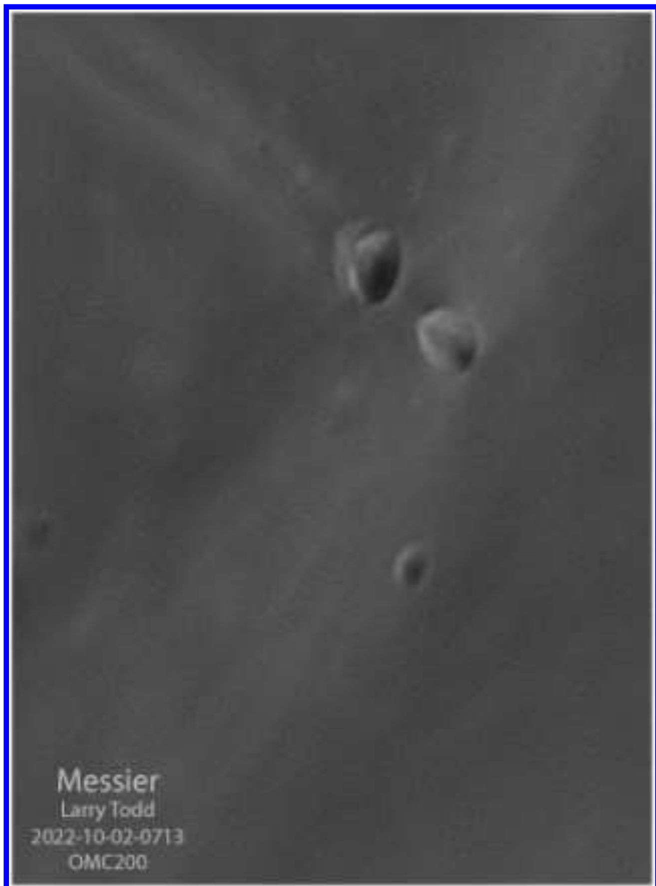
Recent Topographic Studies

Aristarchus, *Larry Todd, Dunedin New Zealand. 2022 June 11 05:53 UT. 8 inch OMC200 f/20 Maksutov-Cassegrain telescope.*



Tycho, *Facundo Gramer, AEA, Oro Verde, Argentina. 2022 November 07 23:50 UT. Celestron CPC1100 Schmidt-Cassegrain telescope, ZWO ASI120mm/s camera.*

Recent Topographic Studies



Messier, *Larry Todd, Dunedin New Zealand. 2022 October 02 07:13 UT. 8 inch OMC200 f/20 Maksutov-Cassegrain telescope.*

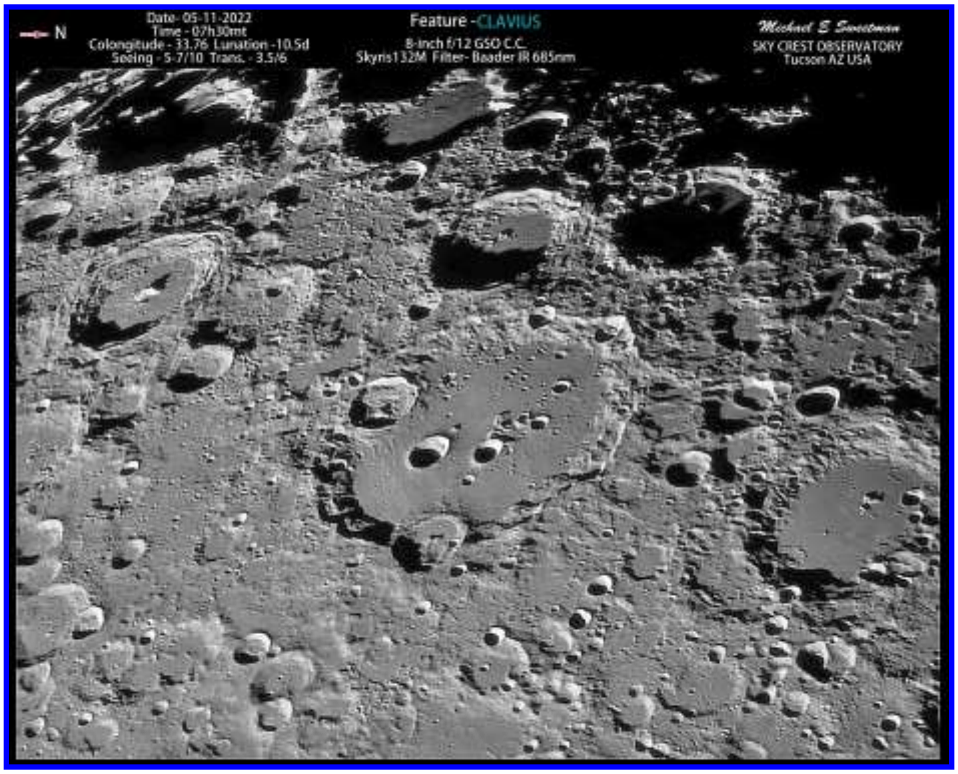
Mount Marilyn and Mare Tranquillitatis, *István Zoltán Földvári, Budapest, Hungary. 2017 September 09, 23:14-23:29 UT, colongitude 139.6°-139.7°. 80 mm refractor telescope, 900 mm focal length, 150 x. Seeing 7/10, transparency 4/6.*

Recent Topographic Studies

Vallis Alpes, *Larry Todd, Dunedin New Zealand. 2022 October 03 09:33 UT. 8 inch OMC200 f/20 Maksutov-Cassegrain telescope.*

Waxing Gibbous Moon, *Marcelo Guarda, Santa Fe, Argentina. 2022 November 02 03:29 UT. 114 mm Newtonian reflector telescope, Xiami Redmi Note 8 Cell phone camera.*

Recent Topographic Studies

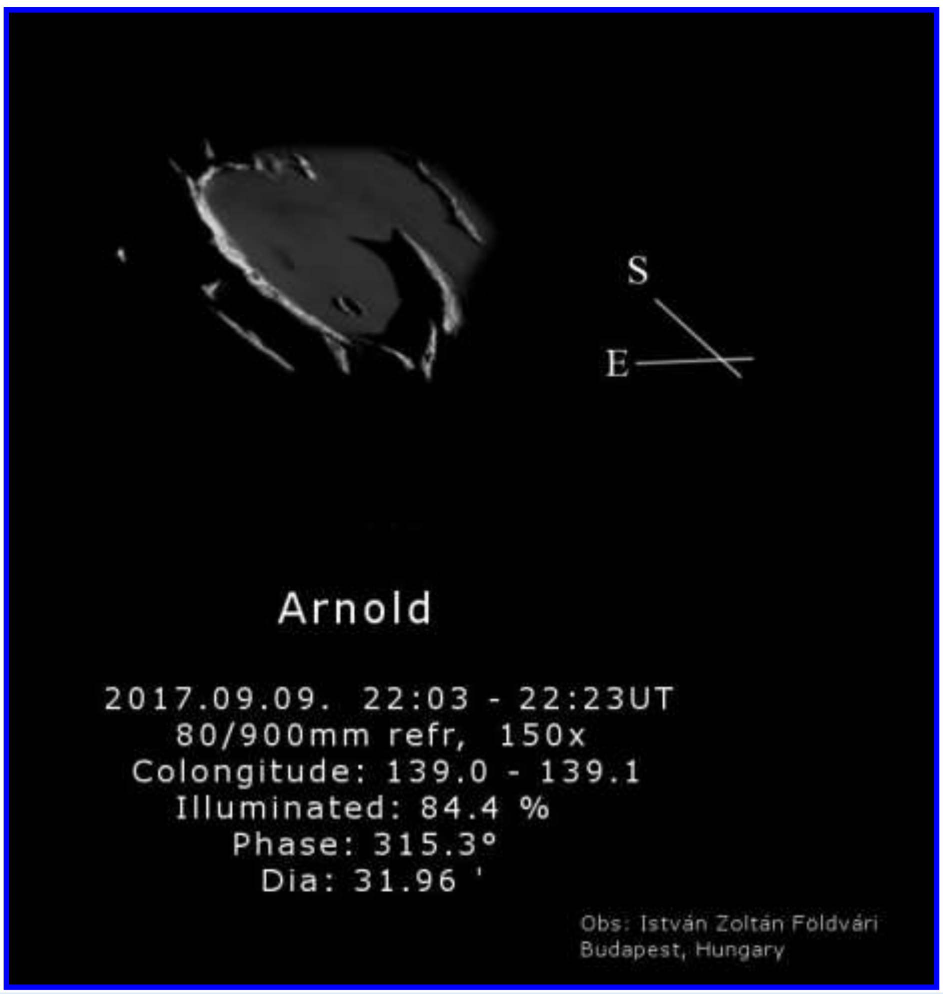


Clavius, *Michael E. Sweetman, Sky Crest Observatory, Tucson, Arizona, USA. 2022 May 11 07:30 UT, colongitude 33.76°. 8 inch f/12 GSO Classical Cassegrain telescope, Baader IR 685 filter, Skyris 132M camera. Seeing 5-7/10 and transparency 3.5/6. North is down, west is right.*

Schiller and Schickard, *Michael Owens, St. Augustine, Florida, USA. 2022 November 06 01:54 UT. Celestron 11 inch Schmidt-Cassegrain telescope, CGEM mount, ZWO ASI678 MC camera.*

Recent Topographic Studies

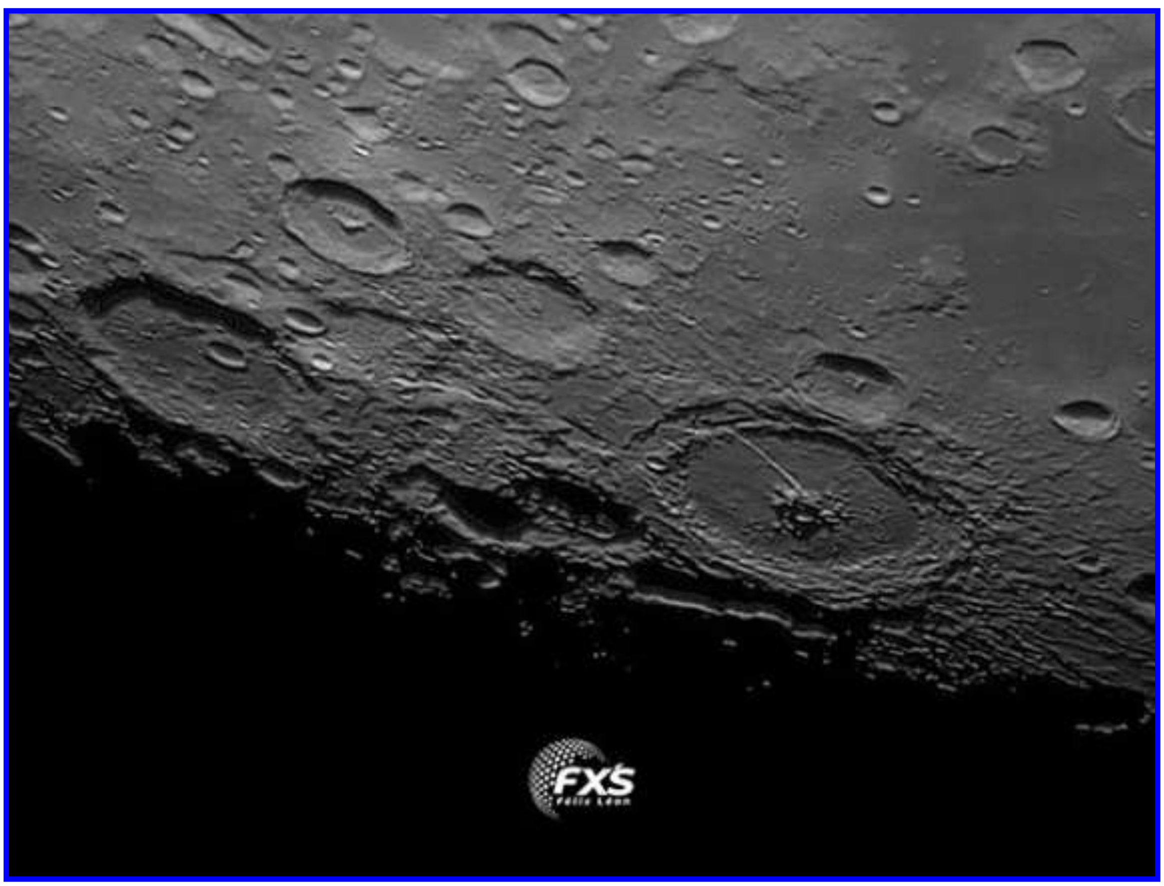
Copernicus, *Michael E. Sweetman, Sky Crest Observatory, Tucson, Arizona, USA. 2022 May 11 07:12 UT, colongitude 33.69°. 8 inch f/12 GSO Classical Cassegrain telescope, Baader IR 685 filter, Skyris 132M camera. Seeing 5-7/10 and transparency 3.5/6. North is down, west is right.*



Arnold, *István Zoltán Földvári, Budapest, Hungary. 2017 September 09, 22:03-22:23 UT, colongitude 139.0°-139.1°. 80 mm refractor telescope, 900 mm focal length, 150 x. Seeing 7-8/10, transparency 4/6.*

Recent Topographic Studies

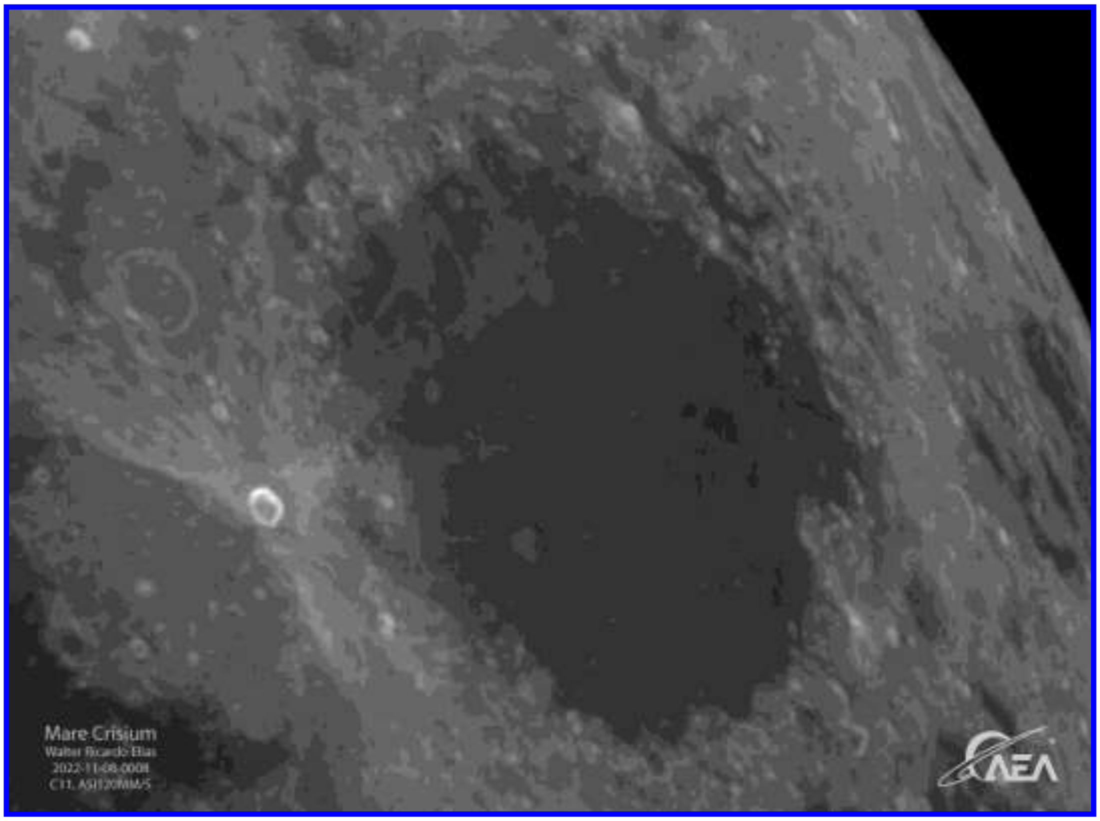
Northern Mare Imbrium, *Michael Owens, St. Augustine, Florida, USA. 2022 November 06 01:54 UT. Celestron 11 inch Schmidt-Cassegrain telescope, CGEM mount, ZWO ASI678 MC camera.*



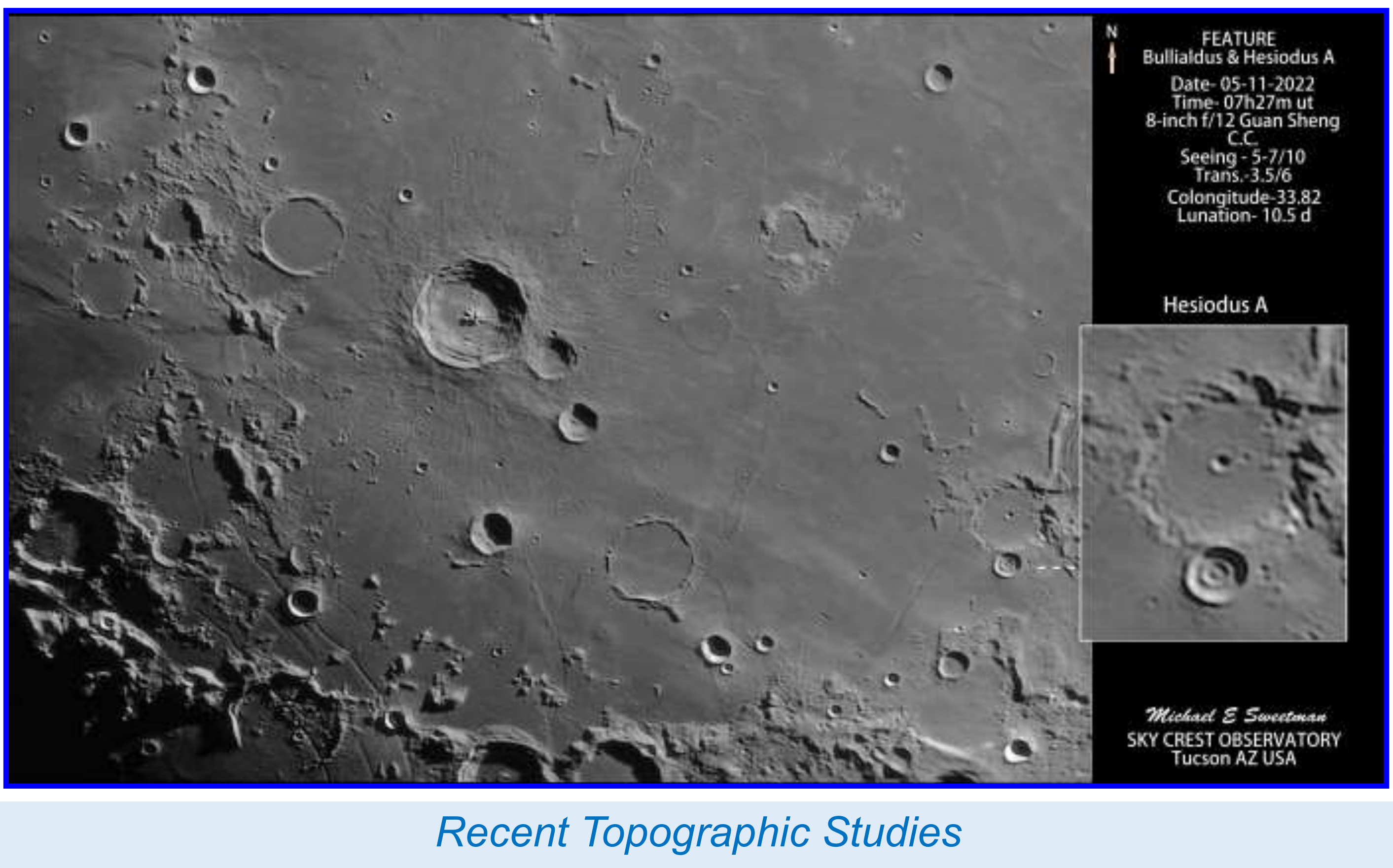
Petavius, *Felix León, Santo Domingo, República Dominicana. 2022 October 12 05:25 UT. 8 inch Schmidt-Cassegrain telescope, DMK 21 618 AU camera. North is right, west is up.*

Recent Topographic Studies

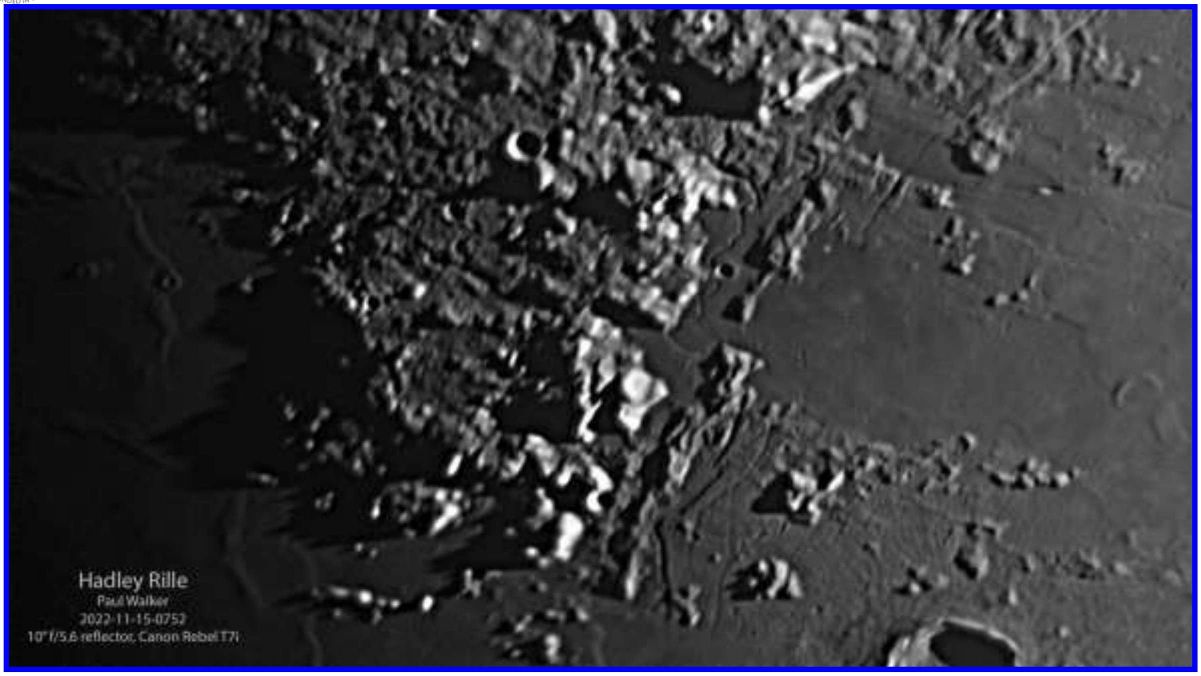
Mare Crisium, *Walter Ricardo Elias, AEA, Oro Verde, Argentina. 2022 November 08 00:08 UT. Celestron CPC1100 Schmidt-Cassegrain telescope, ZWO ASI120mm/s camera.*



Bullialdus, *Michael E. Sweetman, Sky Crest Observatory, Tucson, Arizona, USA. 2022 May 11 07:27 UT, colongitude 33.82º. 8 inch f/12 GSO Classical Cassegrain telescope, Baader IR 685 filter, Skyris 132M camera. Seeing 5-7/10*



Recent Topographic Studies



Hadley Rille, *Paul Walker, Middlebury, Vermont, USA. 2022 November 15 07:52 UT. 10 inch f/5.6 reflector, Canon Rebel T7i camera. North is down, west is right.*

Paul adds ”Hadley Rille and Apollo 15 landing site, 2022-11-15, 2:52 AM EST.

I was out Thursday evening 11/14/2020 and Friday morning 11/15/2022. The seeing started out good and got better. I observed Saturn and Jupiter in the evening, Mars and the Moon in the morning. I also imaged Jupiter, Mars and the Moon. This is the best image of the Hadley Rille/Apollo 15 site that I have gotten so far (see images below or attached). It was also the best view I have gotten. Using my 12.5" f/4.5 and binoviewers at 304X, I could see most of Hadley Rille all the time and could see the northern part over 50% of the time.

Using calculated values for the scale (arc sec/pixels) I measured the size of some of the features (see data below). I found something interesting, though not entirely surprising. On Wikipedia the average width of Hadley Rille is stated as 0.75 miles, however, measuring it's width in a few places on the image I come up with about 1.3 miles or about 1.7 times wider. I attribute this to the fact that the edges of the Rille are blurred and therefore it appears wider that it actually is. Though I did try to take this into account when positioning the cursor for the measurements. I also superimposed a Lunar Reconnaissance Orbiter (LRO) image over mine (image not included here). Measuring Hadley Rille based on the LRO image I come out with measurements in the 0.6-0.8 mile range.

Technical Info:

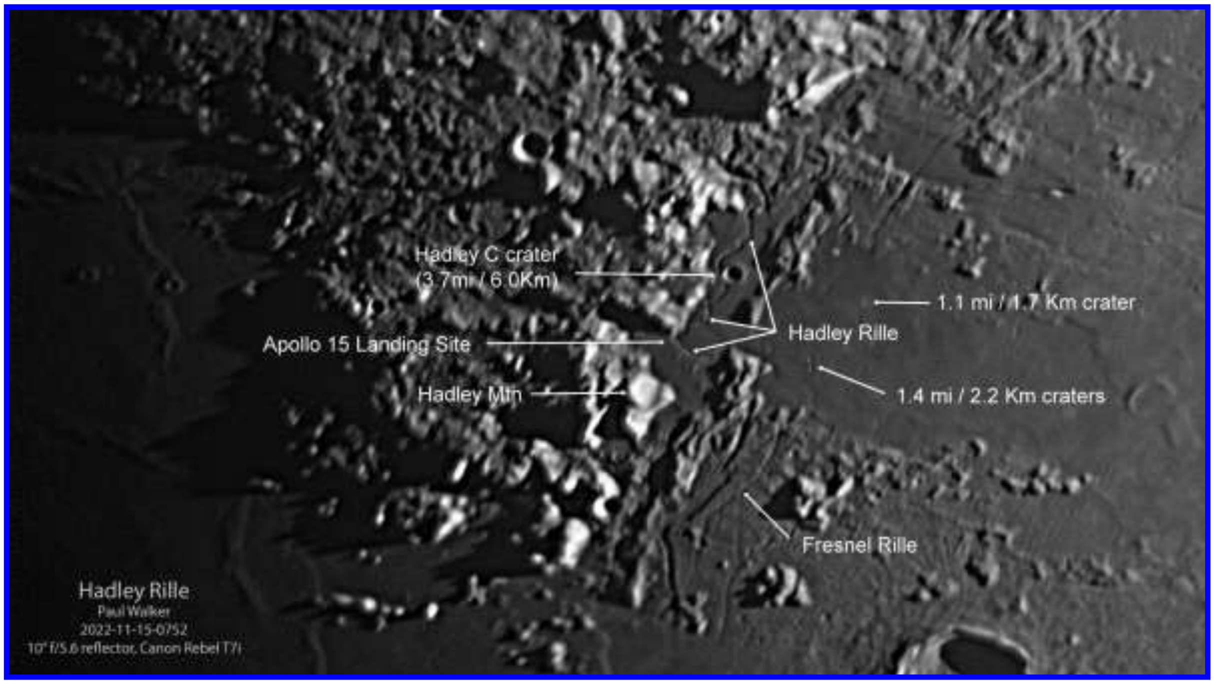
North is down
10 inch f/5.6 (1407mm fl) Newtonian (Homemade with Coulter Optics)
Camera - Modified Canon Rebel T7i (800D) (24 mega pixel) (sensor APS-C, 22.2 x 14.8 mm) (approx 1.6 x form factor)
Exp 1/100, ISO 3200 (video)

Eyepiece Projection with 15mm eyepiece (5.76 x prime) (8110mm efl @ f/32.3) (Field 0.152 x 0.099 deg)
Using **3x digital zoom** in video mode- Eyepiece Proj with 15mm eyepiece (17.3x prime) (24,330mm efl., since the zoom is digital the eff. f/ratio is still f/32) (Field of view is 0.051 x .0.0171 deg. or 184"x104")
Based on some testing it appears that 3x digital zoom gives me the maximum resolution for videos. It essentially does an area of interest of approximately 1/3 of the 6000x3000 sensor.

Recent Topographic Studies

At 3x Digital Zoom-
Field of view - 184"x104" @ 1920x1080 pixels
10.4 px / arc sec (0.096 arc sec / pixel)

Width Measurement of Hadley Rille:



South end 1
10 pixels
1.15 arc sec
1.2 miles
1.9 Km

South end 2
11 pixels
1.27 arc sec
1.3 miles
2.0 Km

Middle 1
12 pixels
1.39 arc sec
1.4 miles
2.2 Km

Middle 2
11 pixels
1.27 arc sec
1.3 miles
2.0 Km

Smallest craters readily recognizable as craters:
12 pixels
1.39 arc sec
1.4 miles
2.2 Km

Video conversion: PIPP
Stacking - Registax 6
Post Processing - Registax 6

Stack of 700 of about 3600 frames (length of video is 2 minutes).
Also see annotated image below this one."

Clavius, *Paul Walker, Middlebury, Vermont, USA. 2022 November 15 07:49 UT. 10 inch f/5.6 reflector, Canon Rebel T7i camera. North is down, west is right. Paul adds:*

Clavius is among my favorite targets on the Moon, both for imaging and viewing.

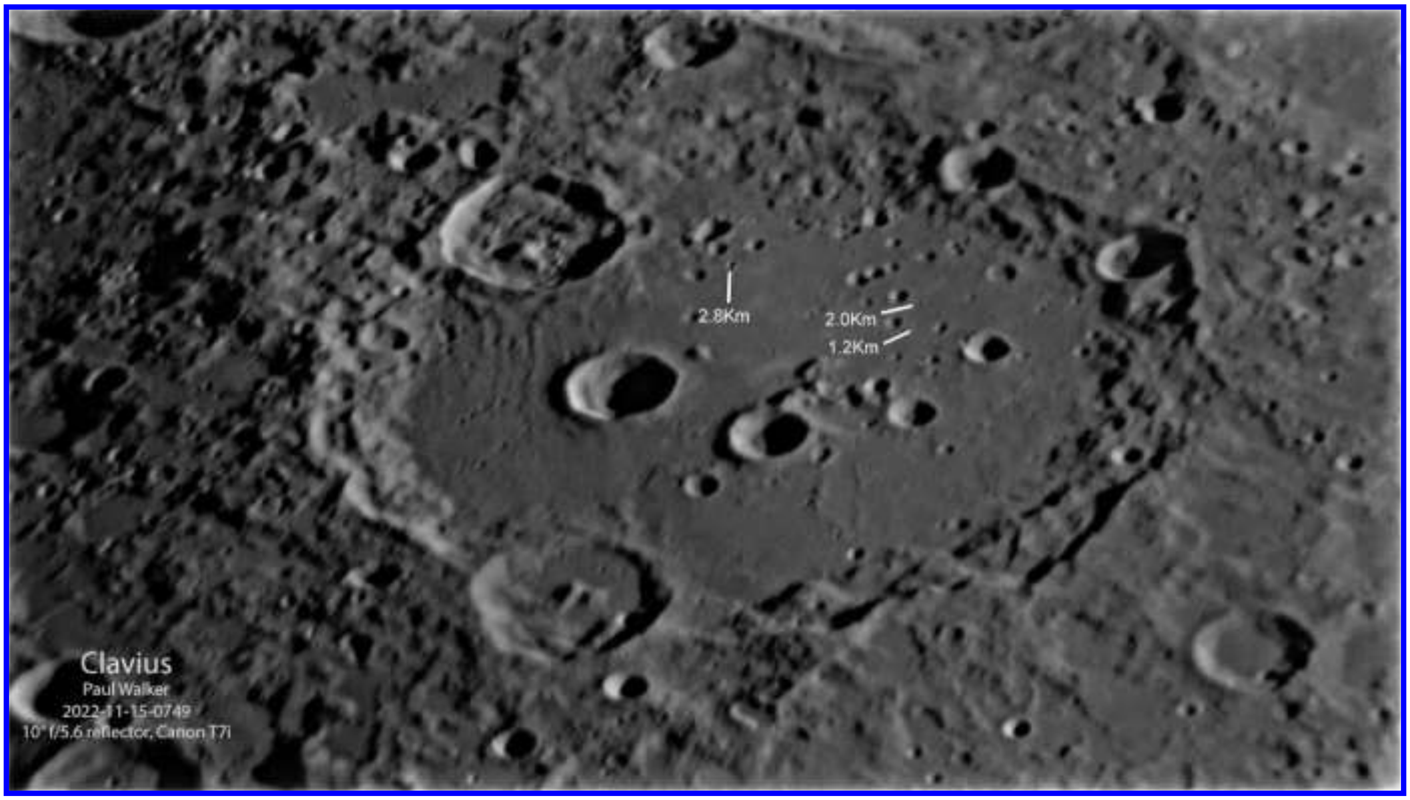
This is from the same night as the Apollo 15 / Hadley Rille image. 11/15/2022 @ 2:49 AM EST (Lunar day 20.86)
The sun angle was ideal for seeing and imaging the small craters.

For the crater sizes on the annotated image I used the Lunar Astronautical Chart (LAC) Series of lunar charts. These are highly details maps from the 1960's that can be downloaded from http://www.lpi.usra.edu/resources/mapcatalog/LAC. I magnified the images on my computer and using a mm ruler and the scale on the chart to measure the size of 3 craters. The sizes as measured on the LAC chart are marked on the annotated image (bottom image).

For the one marked 2.8Km (1.75mi), on the image I measured it on the attached image to be 14px, 1.6mi, 2.6Km across (1.6"). This crater was visible in the 12.5" f/4.5 Dob @ 304 power in the binoviewers and is the smallest crater I saw visually.
For the one marked 2.0Km (1.25mi), on the image I measured it on the attached image to be 10px, 1.2mi, 1.9Km across (1.2").
For the one marked 1.2Km (0.75mi), on the image I measured it on the attached image to be 8px, 0.9mi, 1.5Km across (0.9"). Very low contrast, poorly defined.

10" f/5.6 Newtonian, Canon T7i in video mode, 1/125sec @ ISO 1600, eyepiece projection using a 15mm eyepiece, 8110mm efl @ f/32.3 (5.76 x prime), 3x digital zoom (the 3x zoom gives 24,330mm efl) (17.3x prime) (and a Field of view of 0.051 x .0.0329 deg. for still shots and 0.051 x .0.0287 deg. for the HD video shots). The image field of view (side to side) is same you would see if observing the Moon at about 1200x using an eyepiece with a 60 degree apparent field of view (60 deg / 0.051 deg). It is a stack 700 of 3645 video frames.

Recent Topographic Studies



Clavius, *Paul Walker, Middlebury, Vermont, USA. 2022 November 15 07:49 UT. 10 inch f/5.6 reflector, Canon Rebel T7i camera. North is down, west is right.*

Montes Rook and Lacus Autumni, *István Zoltán Földvári, Budapest, Hungary. 2017 September 09, 22:35-22:50 UT, colongitude 139.2º-139.4º. 80 mm refractor telescope, 900 mm focal length, 150 x. Seeing 7/10, transparency 4/6.*

Recent Topographic Studies

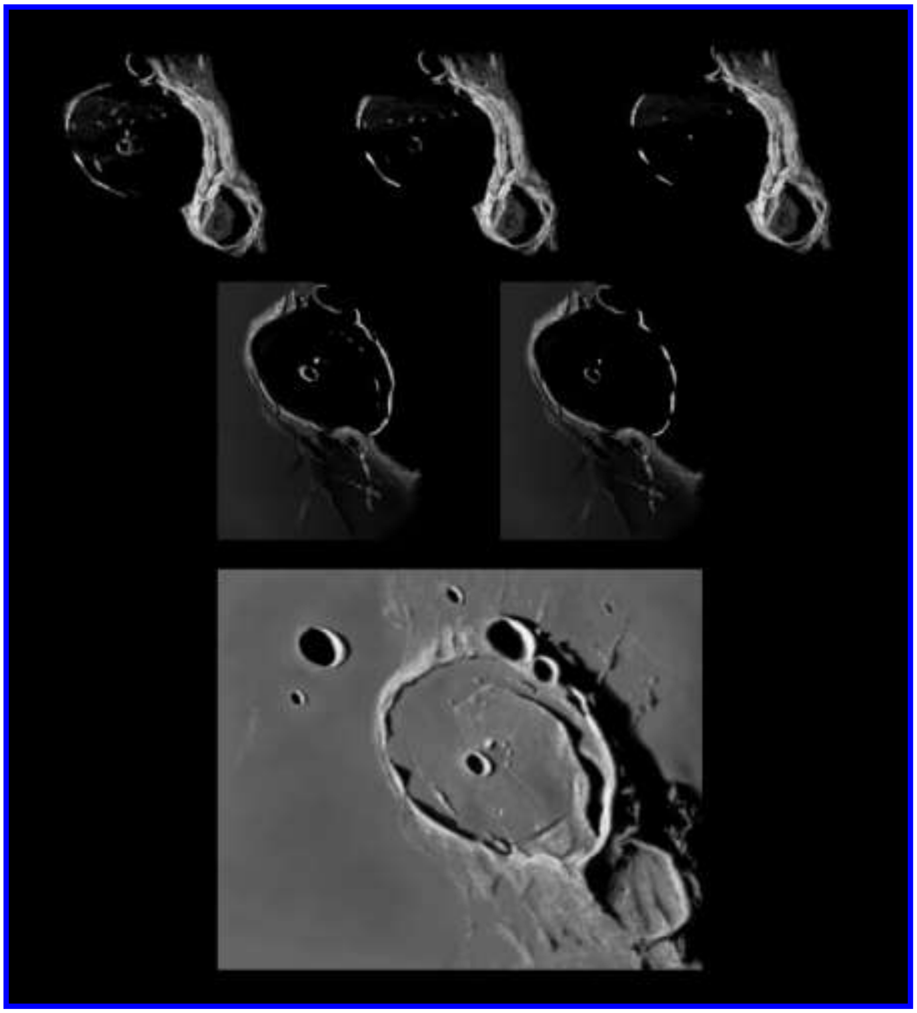
Posidonius, *István Zoltán Földvári, Budapest, Hungary. Mentor: Zoltan Görgei - Leader of Moon group, Hungarian Astronomical Association.*

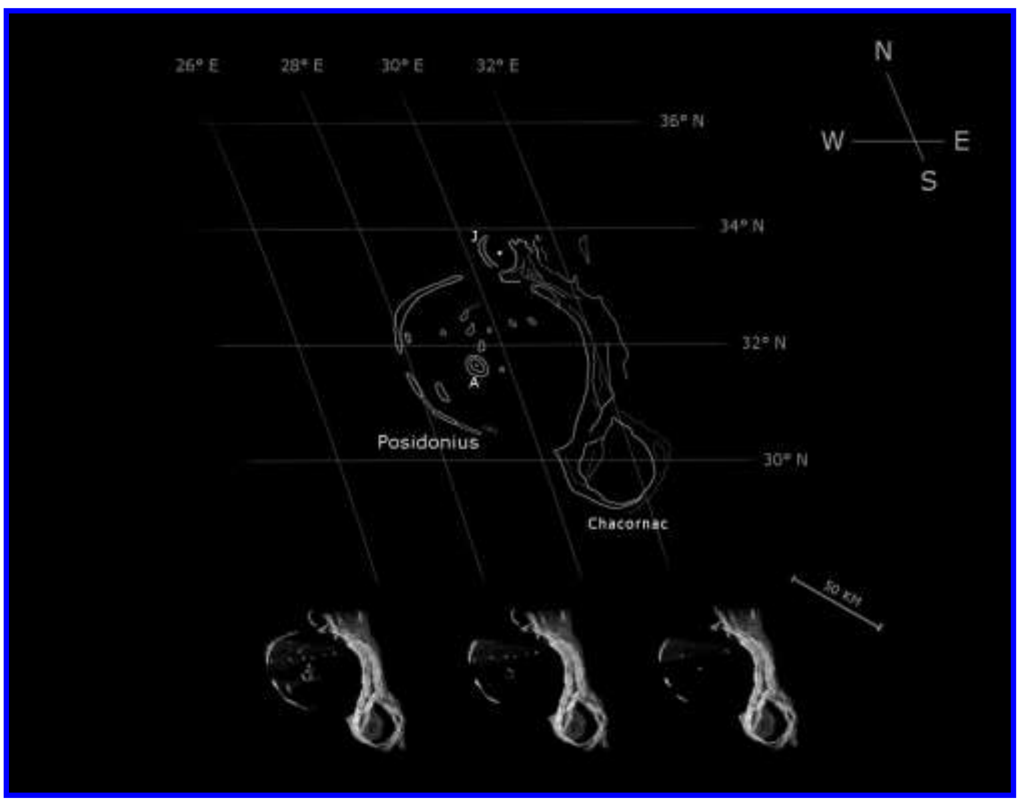
Adds "Mapping the lunar craters

Getting to know the surface of the Moon opened an old but new way for me to analyze what we saw not only in photos, but also on a kind of amateur map. We received help and motivation for this small project from Zoltán Görgei, Leader of Moon group, of the Hungarian Astronomical Association.

The best subject of my small private project was the Posidonius crater, with it continues traditional visual lunar observations in tribute to our great ancestors.

By projecting the sketches onto each other, I created the map, which reached the level I felt completed at the last observation. I finally combined the graphite drawings with a graphics program.

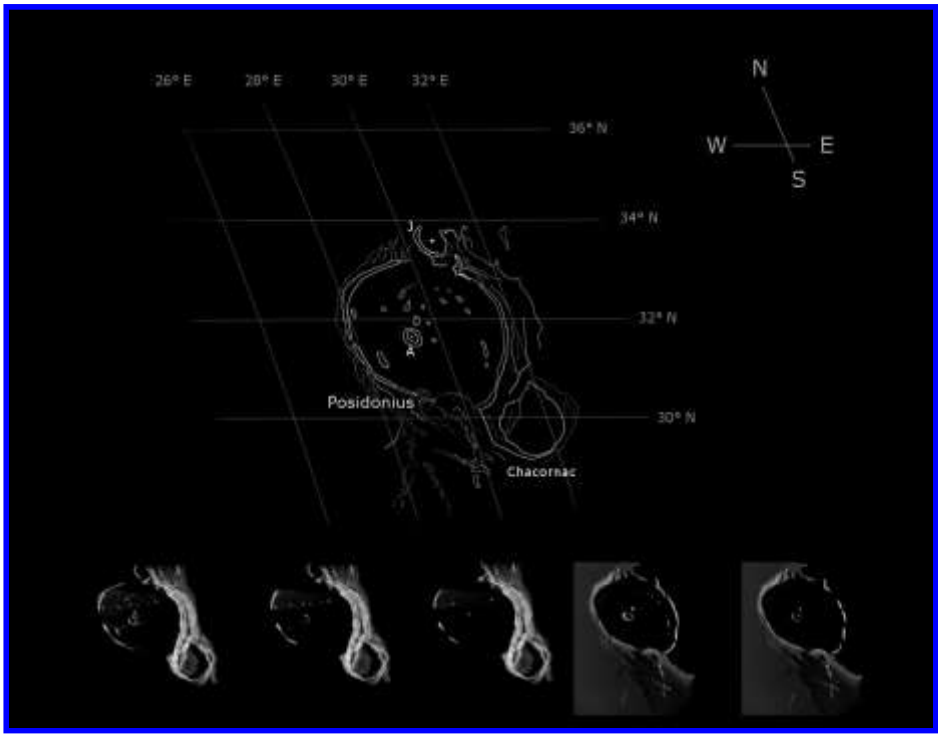




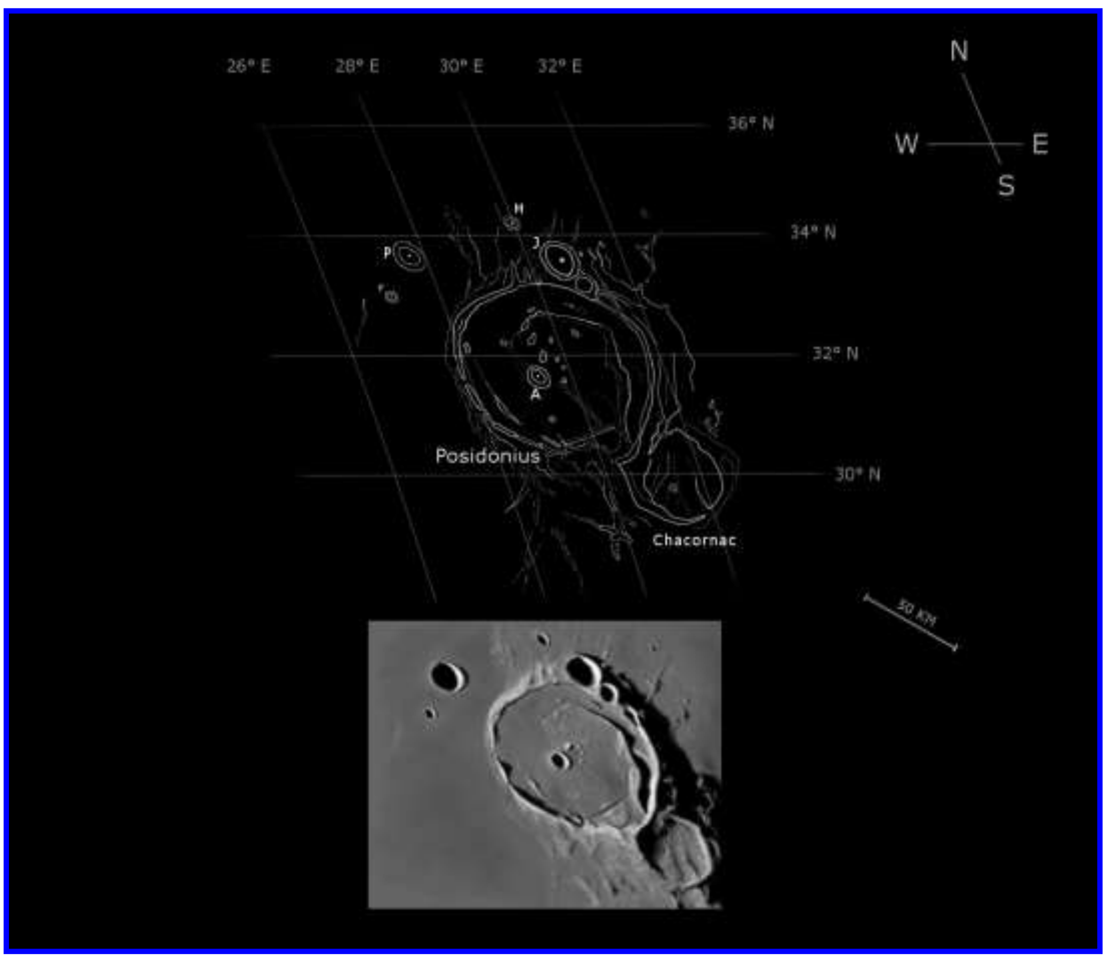
Mapper: Istvan Zoltan Földvari, Budapest Hungary
Date
2018.04.20. Equipment: 70/500mm refr. 100x
2021.08.27. Equipment: 70/500mm refr. 125x
2012.09.26. Equipment: 127/1500mm Maksutov-Cassegrain 225x"

Posidonius, *István Zoltán Földvári, Budapest, Hungary. Mentor: Zoltan Görgei - Leader of Moon group, Hungarian Astronomical Association. 2018 April 20. 70 mm refactor telescope, 500 mm fl, 100x.*

Recent Topographic Studies



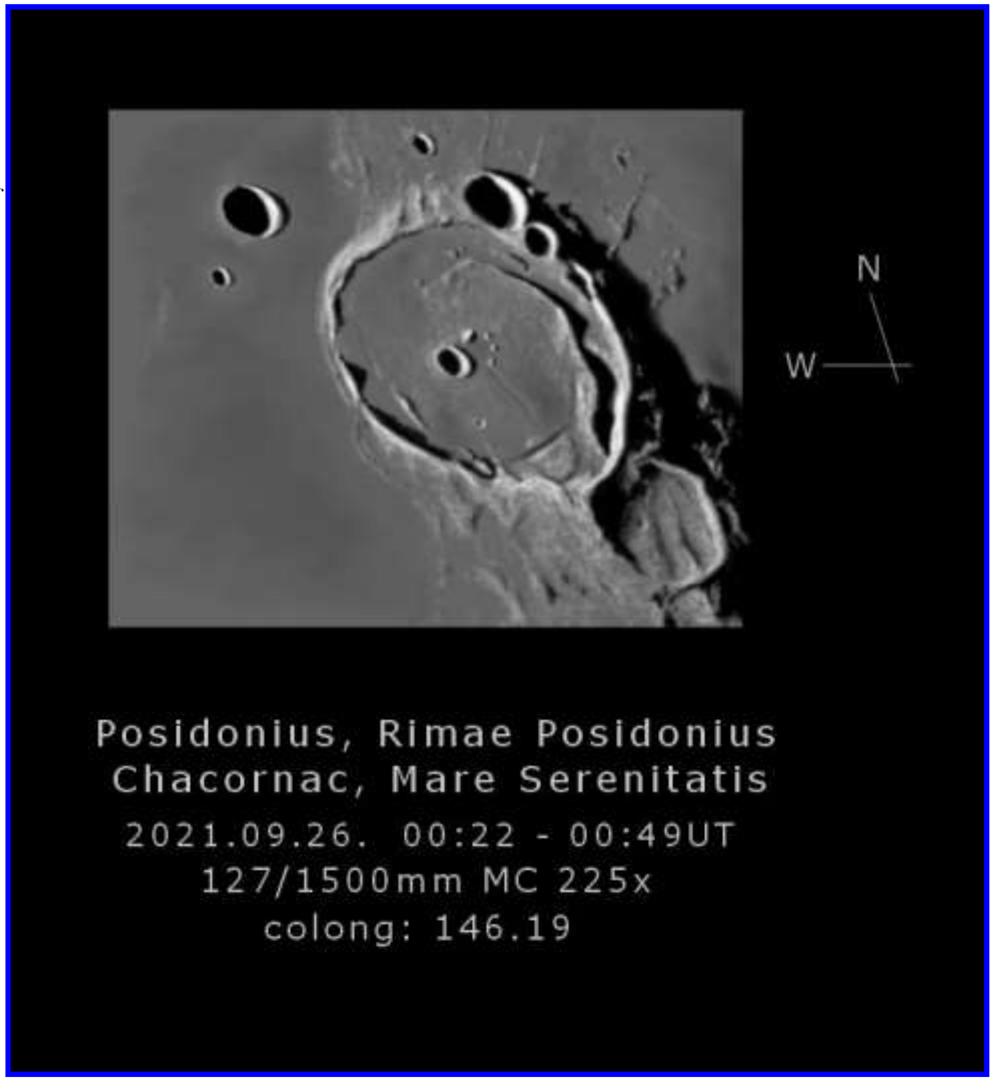
Posidonius, *István Zoltán Földvári, Budapest, Hungary. Mentor: Zoltan Görgei - Leader of Moon group, Hungarian Astronomical Association. 2018 April 20 and 2021 August 27. 70 mm refractor telescope, 500 mm fl, 100x and 125x.*

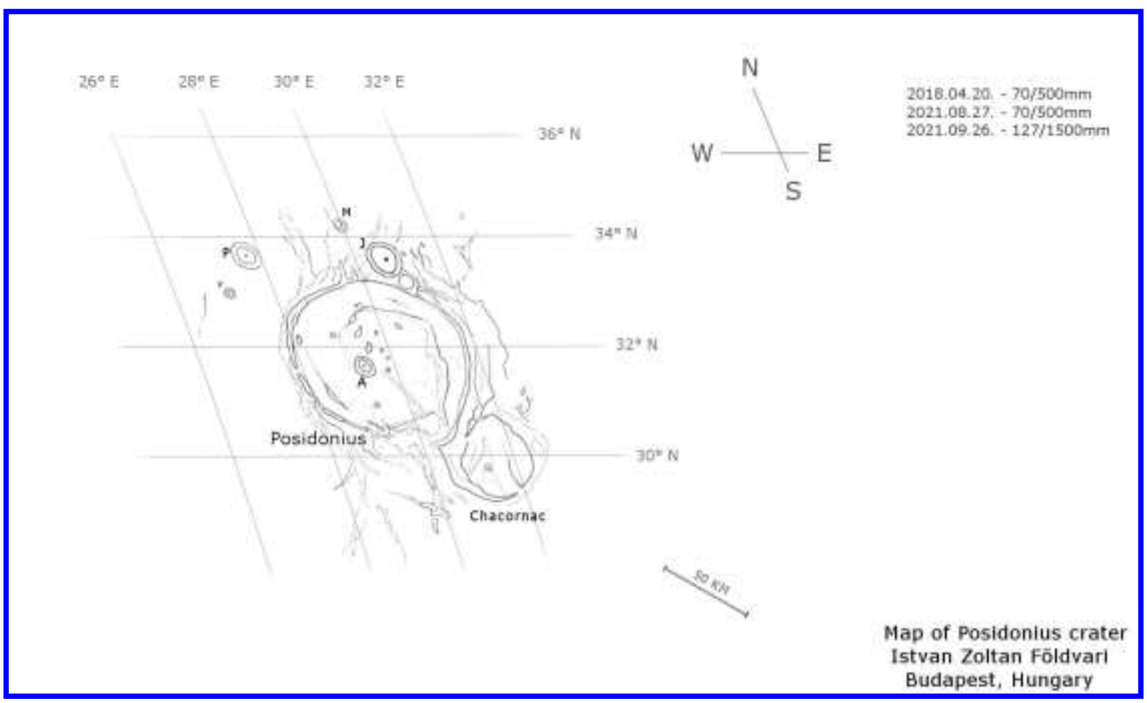


Posidonius, *István Zoltán Földvári, Budapest, Hungary. Mentor: Zoltan Görgei - Leader of Moon group, Hungarian Astronomical Association. 2018 April 20, 2021 August 27 and 2021 September 26. 70 mm refractor telescope, 500 mm fl, 100x, 125x and 127 mm Maksutov-Cassegrain telescope, 1,500 mm fl, 225x.*

Recent Topographic Studies

Posidonius, *István Zoltán Földvári, Budapest, Hungary. Mentor: Zoltan Görgei - Leader of Moon group, Hungarian Astronomical Association. 2021 September 26 00:22-00:49 UT, colongitude 146.19°. 127 mm Maksutov-Cassegrain telescope, 1,500 mm fl, 225x.*





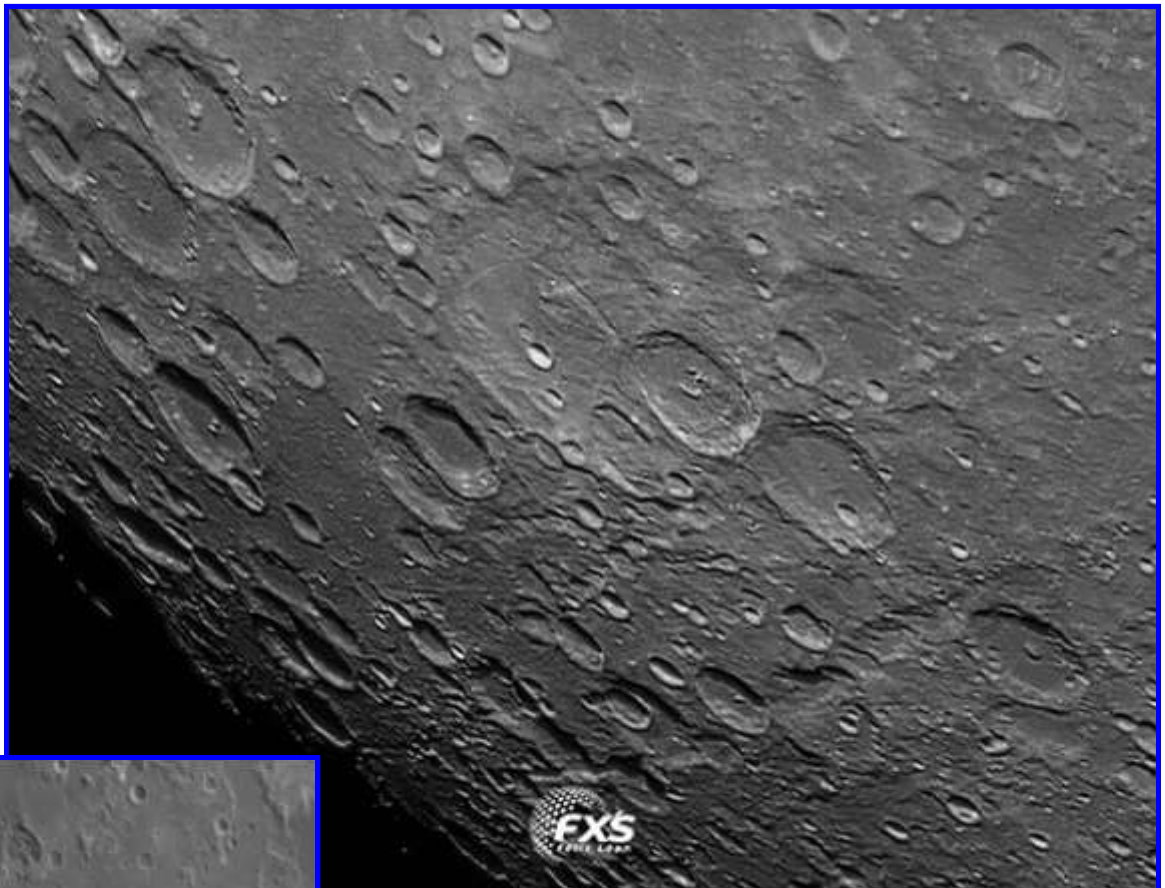
Map of Posidonius, *István Zoltán Földvári, Budapest, Hungary. Mentor: Zoltan Görgei - Leader of Moon group, Hungarian Astronomical Association. 2018 April 20, 2021 August 27 and 2021 September 26. 70 mm refractor telescope, 500 mm fl, 100x, 125x and 127 mm Maksutov-Cassegrain telescope, 1,500 mm fl, 225x.*

Recent Topographic Studies

Waning Gibbous Moon, *Marcelo Guarda, Santa Fe, Argentina. 2022 November 09 04:48 UT. 114 mm Newtonian reflector telescope, Xiami Redmi Note 8 Cell phone camera.*

Theophilus, *Felix León, Santo Domingo, República Dominicana. 2022 October 15 05:12 UT. 8 inch Schmidt-Cassegrain telescope, DMK 21 618 AU camera. North is down, west is left.*

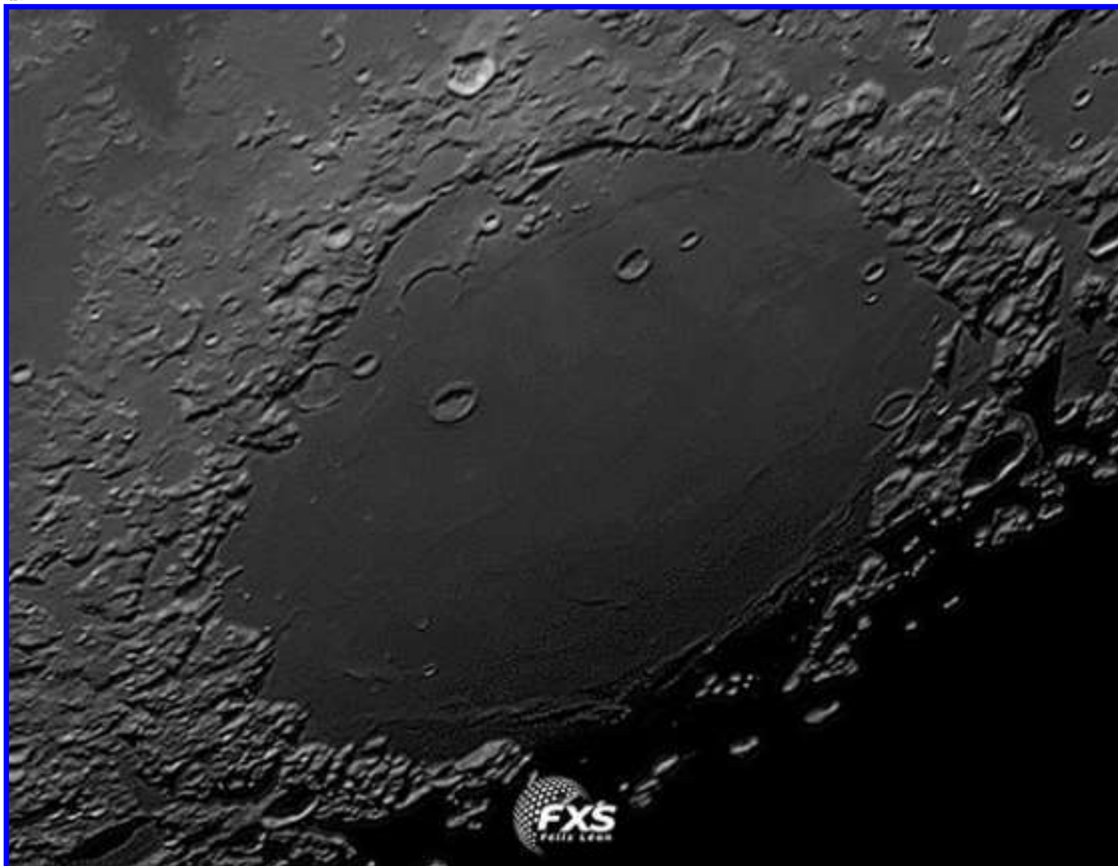
Recent Topographic Studies



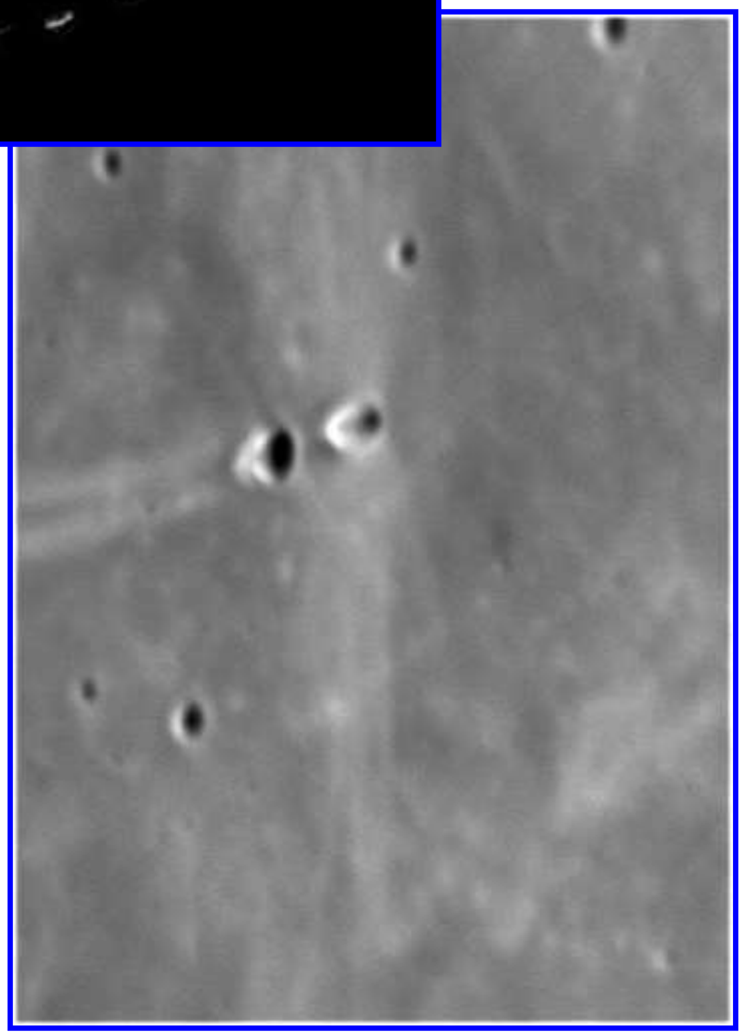
Janssen, *Felix León, Santo Domingo, República Dominicana. 2022 October 12 05:12 UT. 8 inch Schmidt-Cassegrain telescope, DMK 21 618 AU camera. North is right, west is up.*

Theophilus, *Larry Todd, Dunedin New Zealand. 2022 October 02 07:09 UT. 8 inch OMC200 f/20 Maksutov-Cassegrain telescope.*

Recent Topographic Studies



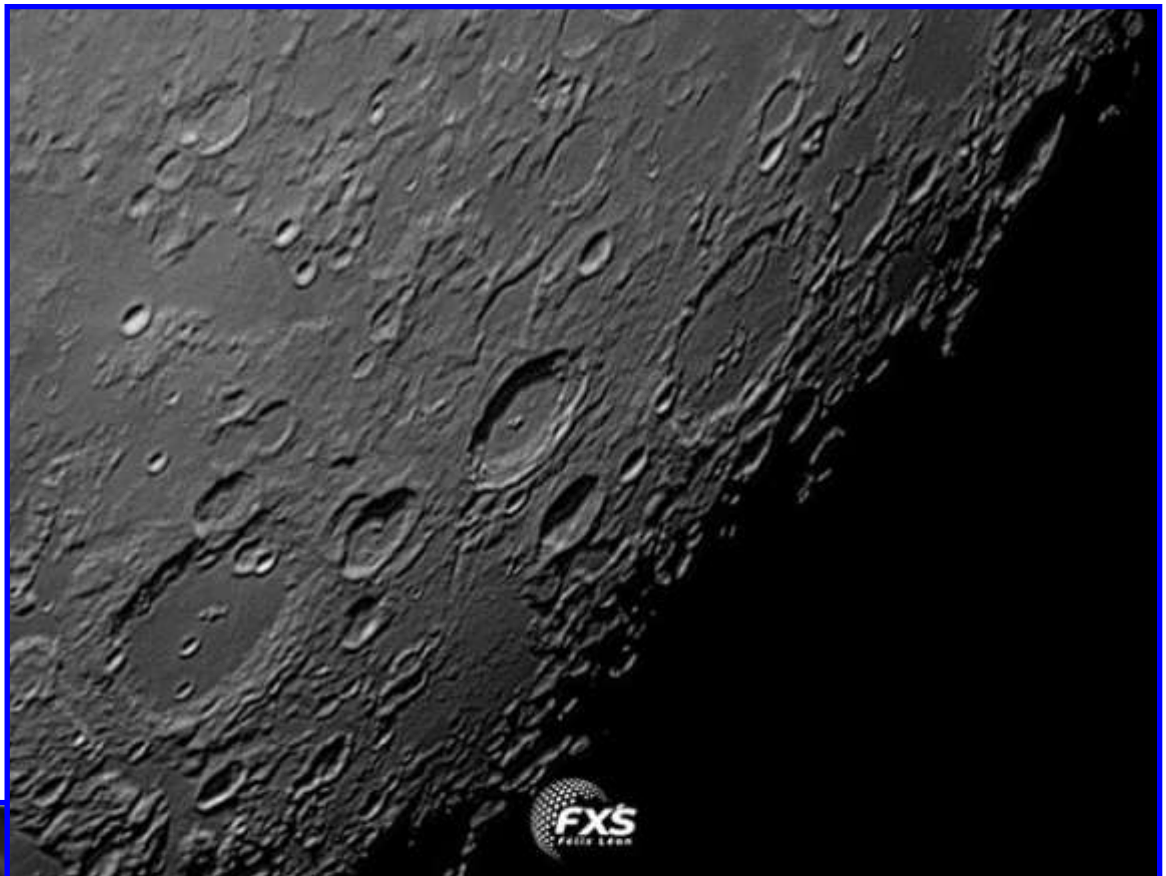
Mare Crisium, *Felix León, Santo Domingo, República Dominicana. 2022 October 12 05:22 UT. 8 inch Schmidt-Cassegrain telescope, DMK 21 618 AU camera. North is to the upper right, west is to the upper left.*



Messier, *Larry Todd, Dunedin New Zealand. 2022 October 31 08:15 UT. 8 inch OMC200 f/20 Maksutov-Cassegrain telescope.*

Recent Topographic Studies

Geminus, *Felix León, Santo Domingo, República Dominicana. 2022 October 12 05:21 UT. 8 inch Schmidt-Cassegrain telescope, DMK 21 618 AU camera. North is right, west is up.*



Arago, *Larry Todd, Dunedin New Zealand. 2022 October 31 08:09 UT. 8 inch OMC200 f/20 Maksutov -Cassegrain telescope.*

Recent Topographic Studies

Cleomedes, *Felix León, Santo Domingo, República Dominicana. 2022 October 12 04:03 UT. 8 inch Schmidt-Cassegrain telescope, DMK 21 618 AU camera. North is left, west is down.*

Kies and Bullialdus, *Larry Todd, Dunedin New Zealand. 2022 June 09 05:57 UT. 8 inch OMC200 f/20 Maksutov-Cassegrain telescope.*

Lunar Geologic Change Detection Program

Coordinator Dr. Anthony Cook- atc@aber.ac.uk
Assistant Coordinator David O. Darling -DOD121252@aol.com

2022 December

LTP reports: No LTP reports have been received for October.

Routine Reports received for October included: Jay Albert (Lake Worth, FL, USA – ALPO) observed: Alphonsus, Bulliadus, Plato, Proclus, and Sinus Iridum. Jonás Alonso (Argentina – SLA) imaged: Rupes Recta. Alberto Anunzatio (Argentina – SLA) observed: Beaumont, Eudoxus, Mons Piton, Ptolemaeus, Stofler and the western limb. Massimo Alessandro Bianchi (Italy – UAI) observed: Aristarchus and imaged the whole lunar disk. Maurice Collins (New Zealand – ALPO/BAA/RASNZ) imaged: Aristarchus, Copernicus, Gassendi, Sinus Iridum and several features. Anthony Cook (Newtown, UK – ALPO/BAA) imaged: several features in the Short-Wave IR (1.5-1.7 microns) and the Long Wave IR (7.5-14 microns). Walter Elias (Argentina – AEA) imaged: Albategnius, Aliacensis, Aristarchus, Aristotles, Beaumont, Mons Pico, Ross D, South and Stofler. Valerio Fontani (Italy – UAI) imaged Aristarchus and Prinz. César Fornari (Argentina – SLA) imaged: Endymion and Proclus. Massimo Giuntoli (Italy – BAA) observed: Cavendish E, the lunar south pole, and several features. Rik Hill (Tucson, AZ, USA - ALPO/BAA) imaged: Vallis Rheita. Erica Reisenauer (Argentina - SLA) imaged: Alphonsus. German Sávor (Argentina – SLA) imaged: Vallis Alpes. Trevor Smith (Codnor, UK – BAA) observed: Proclus. Aldo Tonon (Italy – UAI) imaged: Montes Teneriffe. Fabio Verza (Italy – UAI) imaged: Aristarchus, and Prinz.

Analysis of Reports Received:

Eudoxus: On 2022 Oct 02 UT 23:20-23:30 Alberto Anunziato (SLA) sketched this crater for the following couple of lunar schedule requests:

BAA Request: Eudoxus - please try to image the interior of this crater. We are trying to detect bright spots and linear features within the shadow of the east wall at sunrise. Nigel Longshaw (BAA) suspects that this might explain Trouvelot's observation in 1877 of a luminous rope-like feature. Please send any images to: a t c @ a b e r . a c. u k .

BAA Request: Eudoxus - please try to image or sketch the crater. This is to try to explain a line of light effect seen inside this crater by French astronomer Trouvelot back in Victorian times. The BAAs Nigel Longshaw says that this may be seen between colongitudes of 0.3 to 1.2 degrees. Please send any images or sketches to: a t c @ a b e r . a c. u k .

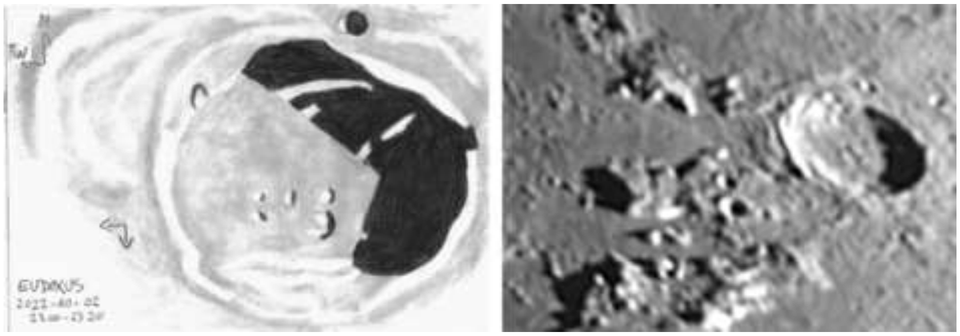


Figure 1. *Eudoxus orientated with north at the top.* ***(Left)*** *A sketch by Albert Anunziato made on 2022 Oct 02 UT 23:20-23:30.* ***(Right)*** *An archive image from Brendan Shaw (BAA) made on 2003 May 08 UT 22:49.*

Alberto's sketch (Fig 1 – Left), backed up by an early archive image from Brendan Shaw (Fig 1 – Right) does indeed show a couple of linear light features in the shadow on the eastern side of the crater. Whether these satisfactory explain the bright spots and linear features in the shadow or "line of light effect" remains debatable, but at least we have some additional observations to backup any theories.

Montes Teneriffe: On 2022 Oct 03 UT 18:57 Aldo Tonon imaged this region following a 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 color camera) we would be very interested to see if you can detect some color 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. Any visual descriptions, sketches or images of Earthshine should be emailed to: a t c @ a b e r . a c . u k

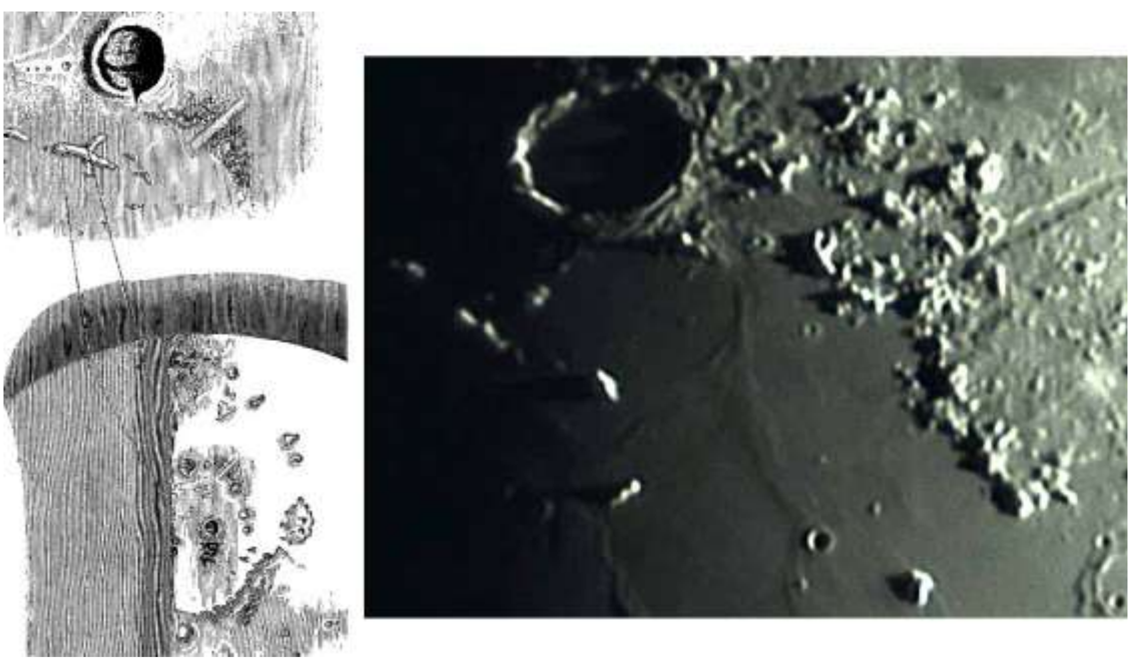


Figure 2. *Montes Teneriffe, Plato and Vallis Alpes with north towards the top.* ***(Left)*** *A couple of sketches from p163 of http://adsabs.harvard.edu/abs/1855MNRAS..15..162H concerning an observation by Hart on 1854 Dec 27 UT 18:00-23:00.* ***(Right)*** *An image by Aldo Tonon from 2022 Oct 03 UT 18:57 – this has been non-linearly contrast stretched to bring out details in the terminator areas.*

We have attempted repeat illumination observations of this area on many occasions now. The bottom diagram from Fig 2 (Left) appears to be a general finder chart illustrating the appearance of the Moon on the night of the LTP report from 1954 Dec 27. The top sketch corresponds to another night and is trying to illustrate parts of Montes Teneriffe that exhibited the colors. I think we will remove this from the Lunar Schedule website, but keep it active on the repeat illumination site, but add a warning that observers should only look when the Moon is very low down, as this seems a reasonable explanation as to the colors seen on these bright mountain peaks. The ALPO/BAA weight is currently set at 2, but will lower it to 1 until we get some low altitude observations which will hopefully confirm those colors?

Alpetragius: On 2022 Oct 04 UT 01:07 Jonás Alonso (SLA) and at 01:33 Erica Reisenauer (SLA) took images that included this crater under similar illumination to the following report:

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

Figure 3. *2022 Oct 04: Alpetragius and Lassell, orientated with north towards the top.* ***(Left)*** *imaged by Jonás Alonso (SLA) on 01:07 UT.* ***(Right)*** *Imaged by Erica Reisenauer (SLA) at 01:33 UT.*

Jonás and Erica were using a 28cm SCT scope equipped with a QHY 5L-II M camera and a 685nm SVBONY IR Pass filter. It is curious that the original report mentions the effect lasting 20 sec. We can see no sign of a shadow anomaly in Fig 3, therefore the weight shall remain at 2 for now.

Yerkes: On 2022 Oct 04 UT 01:25 César Fornari (SLA) imaged this crater under similar illumination to the following report:

Mare Crisium 1969 Jul 23 UT 00:45-00:55, 01:23-01:34 Observed by Jean (Montreal, Canada, 4" refractor) and Chilton and Speck (Hamilton, Canada, 10" reflector) "Bright area, radial rays in Cris. (nr. Yerkes?, if so confirm. fr. Chilton & Speck). Chilton (confirmed by Speck) saw reddening in Yerkes. Phenom. ended at 0134h. It recurred at times thereafter, but never as strong (Apollo 11 watch)." NASA catalog weight=2. NASA catalog ID #1152. ALPO/BAA weight=2.

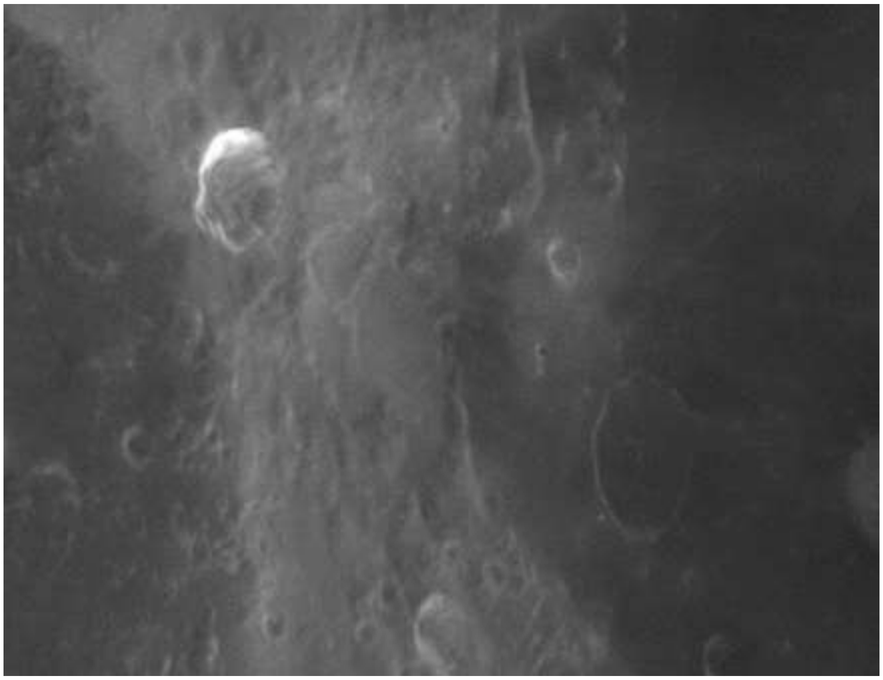


Figure 4. *Yerkes, located to the right of Proclus as imaged* ***by*** *César Fornari (SLA) on 2022 Oct 04 UT 01:25. Image orientated with north towards the top. 28cm SCT scope used equipped with a QHY 5L-II M camera and a 685nm SVBONY IR Pass filter.*

Figure 4 shows the ring wall of Yerkes in the bottom right corner. There are some radial rays, but they are from Proclus. The Jean report makes no mention of what the rays were actually radial to? Alas we do not have Jean's original report, but at least we have some further details on the Cameron LTP card index system. It looks like Jean was seeing plenty of other LTPs that night during the Apollo 11 watch. I am tempted to lower the ALPO/BAA watch from 2 to 1 because of this.

Plato: On 2022 Oct 04 UT 01:34 German Sávor (SLA) image part of Plato just 8 min after the closure of the similar illumination (±˚0.5) window to the following report:

On 1975 Apr 19 UT 21:09 P. Foley (Kent, UK), detected blue in Plato on east. Fiton at UT20:45 found blue along the south wall at the east (IAU?) end, which was very bright white. Blueness extended towards the large landslip at the east of the formation. Immediately north of the landslip, where the bright wall curves first westwards, then again northwards, red could be faintly detected, followed by a very faint blue. All other parts of the formation were normal. Examination with a Moon blink device revealed no color blink. J-H Robinson also found blue, with red on the west wall (exterior?). By 21:30UT Fitton found Plato to be normal and so was Proclus, though he did find Epigenes (bright crescent of east wall only) slightly blue to the N.W and red to the S.E. Mare Crisium was normal. Prominent spurious color seen on Venus, but it was low in the sky, with blue to the north and red to the south. However, J.H. Reading, managed to see the north east floor blurred and slightly blue from 22:45-23:00UT. These reports are BAA observation. The ALPO/BAA weight=2.

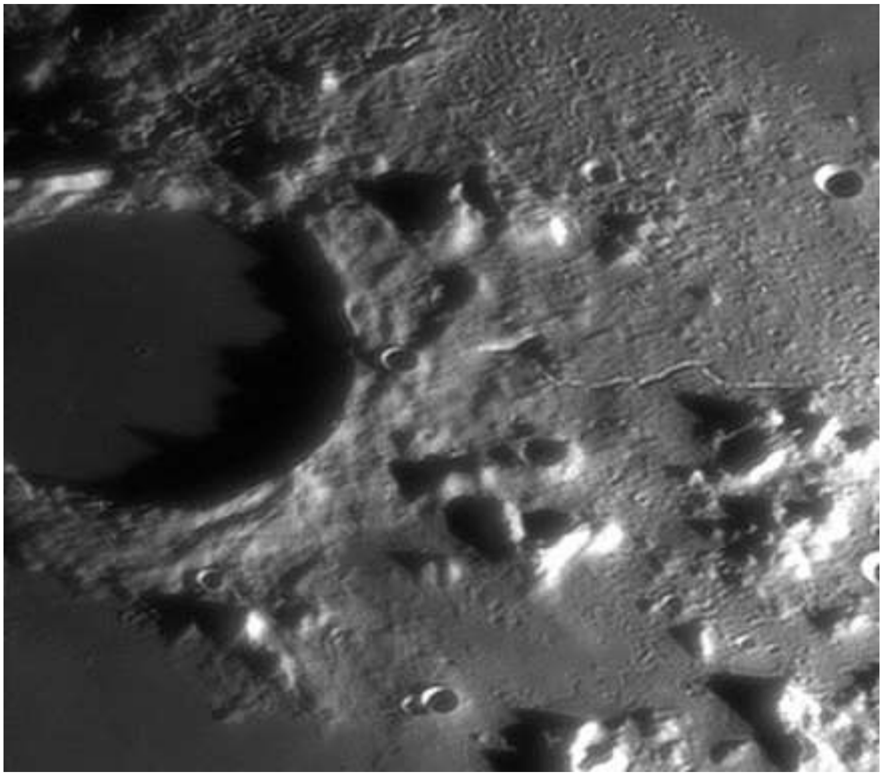


Figure 5. *Plato as imaged by German Sávor (SLA) on 2022 Oct 04 UT 01:34. 28cm SCT scope used equipped with a QHY 5L-II M camera and a 685nm SVBONY IR Pass filter.*

Although German's image (Fig 5) is monochrome, it does at least provide a useful context image of what Plato should have looked like on the night of the 1975 Apr 19. We shall leave the weight at 2 for now.

Sinus Iridum: On 2022 Oct 06 UT 01:10-01:23 Jay Albert observed the crater visually and at 01:37 took an image, at similar illumination to the following report:

Sinus Iridum 2004 May 29 UT 20:44 Observed by Giusi Clementelli (Lido di Ostia, Rome, Italy, 102mm diameter Vixen refractor 80-160x, sky conditions: clear, no wind) "A blue/violet streak, lasting ~10 minutes was seen on the floor of Sinus Iridum between crater Bianchini and Promontorium Heraclides. The suspect LTP maybe an effect of instrumental achromatic aberration, but there is the small possibility that the effect was real." A UAI observational report emailed to David Darling via Albino Carbognani UAI Lunar Section Director. The ALPO/BAA weight=2.

Figure 6. *Sinus Iridum, orientated with north towards the top.* ***(Left)*** *As imaged by Jay Albert on 2022 Oct 06 UT 01:37 using an iPhone placed up to a 9mm eyepiece.* ***(Right)*** *A annotated Virtual Moon Atlas image supplied by the UAI from 2004, showing the location of the blue-violet streak.*

Jay was using a Celestron NexStar Evolution 8" SCT (x226). Transparency was 2nd magnitude to 2nd magnitude and seeing was 5/10. No filters were used. He saw no *"…blue/violet streak…on the floor…between Bianchini and Promontorium Heraclides."* Bianchini was shadow-filled and there were two wrinkle ridges on the floor of Sinus Iridum, but no color. Jay's image (Fig 3 - Left) is interesting in that although again it shows no color on the floor of Sinus Iridum, there are a couple of wrinkle ridges that run in the direction from Bianchini to Promontorium Heraclides, but only part of the way. Looking back at the archives, a Virtual Moon Atlas screen shot was provided by the UAI (Fig 6 – Right) which showed that the purple streak was not in fact linear, but curved around the inner shore of Sinus Iridum, between the two features mentioned in the report. At least the terminator position agrees between Jay's observation and the virtual image, so the date and UT of the 2004 report must be correct. With hind sight, this looks like it could be chromatic aberration as was suggested. Chromatic aberration is strongest off axis in the image, and most notable near bright/dark boundaries. However, no mention is made of color on other light/dark boundaries and it is curious that the effect lasted 10 minutes? For now, we will lower the weight from 2 to 1 as we may have part of an explanation and the telescope aperture used was small.

Aristarchus and Prinz: On 2022 Oct 07 UAI observers: Massimo Alessandro Bianchi, Valerio Fontani and Fabio Verza, provided observations for three repeat illumination and two repeat illuminations + viewing angle LTP events:

Aristarchus: On 2002 Sep 19 at UT 06:31-07:22 R. Gray (Winnemucca, NV, USA) found that the bright areas of the crater floor, and the east facing part of the west rim, were brighter noticeably in red (Wratten 25) or white light, than in blue (Wratten 38A). The observer suspects that the apparent LTP was more to do with the relative densities of the filters and the contrast in Aristarchus than a real event. This was partly confirmed after checks on other craters, though it did not work everywhere. The ALPO/BAA weight=1.

In 1962 Dec 09 at UT 07:42 Wildey and Pohn (Mt Wilson, CA, USA, 60" reflector) observed that Aristarchus was 0.80 magnitudes (x2) fainter than average for this age (photometric measurement) Vmag=3.80, average=3.0. The Cameron 1978 catalog weight=5. The ALPO/BAA weight=2.

Prinz: On 2002 Sep 19 at UT07:36-08:06 R. Gray (Winnemucca, NV, USA) found that Prinz was more difficult to see through a blue Wratten 38A filter than through a red Wratten 25 filter. However, he suspects that it might have something to do with the unequal (to his eyes) transmission density differences between either filter. The ALPO/BAA weight=1.

Aristarchus-Herodotus 1970 Apr 18 UT 20:14 Observed by MacKenzie (UK,2.5" refractor x45, seeing Antoniadi I) "Fairly strong blink in a spot 1/2 way between the 2 craters. Drawing (Apollo 13 watch). NASA catalog weight=2. NASA catalog ID #1257. ALPO/BAA weight=2.

Aristarchus and Cobra Head 1966 Jul 30 UT 06:35-07:29 Observers Ariola and Cross (Whittier, CA, USA). NASA catalog states: "S. part of Cobra Head nr. Herodotus was a red spot; also nr. Aris. & the fork of Schroter's Valley. Variations in phenom. color, 1st on S. rim of Aris., later on N. rim. Drawings". 19" x390 reflector used. NASA catalog weight=5. NASA catalog LTP ID No. #959. ALPO/BAA weight=4.

For the two Robin Gray observations from 2002, Valerio Fontani provides a couple of filtered views (Fig 7) of the region of Aristarchus and Prinz showing what they would have looked like on the night that Robin Gray observed in terms of illumination and topocentric libration, to within ±1.0˚. You can judge for yourself whether the parts of the craters look brighter in red light and less easy to see through the blue filter. Massimo Alessandro Bianchi made a visual observation for Aristarchus (See Fig 8) where he alternated between blue Wratten 38 and red Wratten 25 filters. He found that the lower brightness in the blue was definitely due to the higher density of the filter. He did not notice anything unusual. I think I will lower the weights of both LTPs to 0 and remove them from the ALPO/BAA database of LTP.

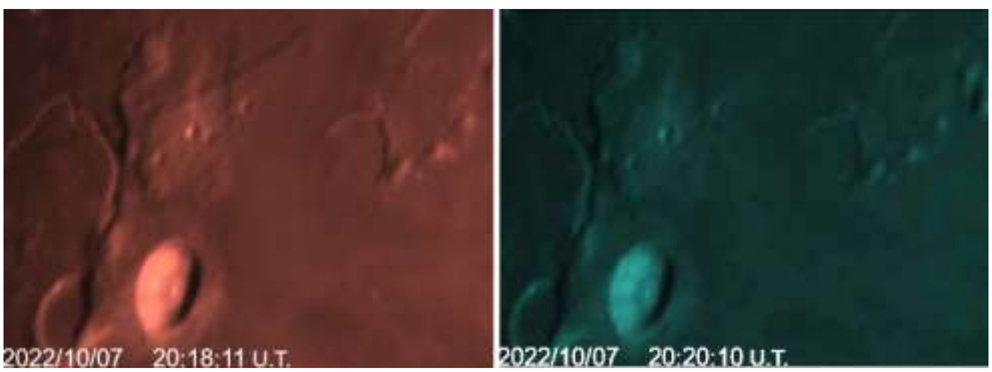
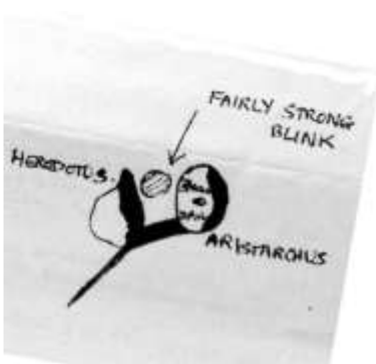


Figure 7. *Aristarchus and Prinz as imaged by Valerio Fontani for the date and UT given and orientated with north towards the top.* ***(Left)*** *taken in red light.* ***(Right)*** *Taken in blue light.*

Figure 8. *Aristarchus as sketched by Massimo Alessandro Bianchi (UAI) on 2022 Oct 07 UT 20:03-20:31 and orientated with north towards the top and slightly to the right. Observation made with a Vixen VMC Mak-Cass 26cm f/11.5 telescope at x500 magnification under Antoniadi III seeing and 3rd magnitude transparency.*

We will ignore the Widley and Pohn LTP from 1962 Dec 29 as the observation was made with a photometer, and anybody who has used a 1-dimensional photometer on the Moon before, will know that it is incredibly difficult to make sure you have the photometer aperture always centered on the right place, even with a 60" telescope. Suffice to say if their measurement was accurate then we should see Aristarchus duller than normal in the images – but that is difficult to quantify unless we have images of the whole Moon and can compare many bright features with each other. So, we will leave the 1962 Dec 29 LTP at a weight of 2.

For the 1970 Apr 18 LTP, Fabrio Verza 's color image (Fig 9 - Left) fails to show any color at the location pointed at in Mackenzie's sketch (Fig 9 – Right), despite some color enhancement. We shall therefore leave the weight at 2 for now.



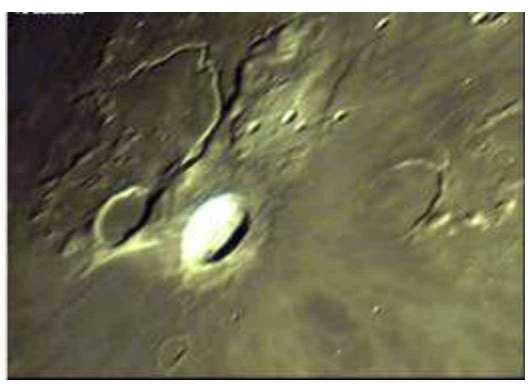


Figure 9 *Aristarchus orientated with north towards the top.* ***(Left)*** *a sketch by R. Mackenzie from 1970 Apr 18 UT21:14.* ***(Right)*** *An image by Fabio Verza from 2022 Oct 7 UT 21:12 – this has been color normalized manually and then had its color saturation increased to 60%.*

For the 1966 Jul 30 Ariola and Cross observation of Aristarchus. Valerio Fontani's images (Fig 10) are exactly what the crater would have looked like in terms of illumination and topocentric libration, to within ±1.0˚. No sign of red spot can be seen on or just south of the Cobra's Head else it would be bright in the red image and darker in the blue in Fig 10. We shall therefore leave the weight at 4 for now.

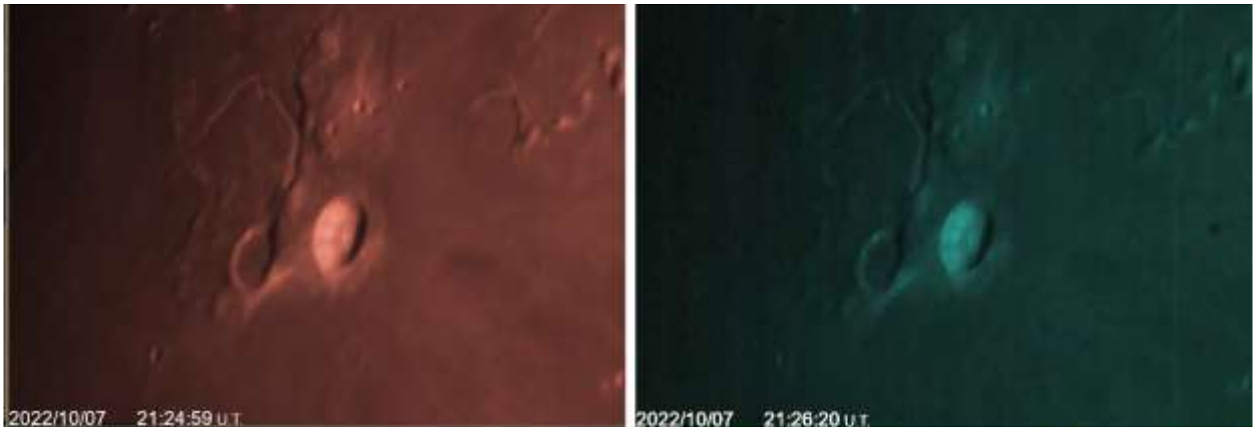


Figure 10. *Aristarchus as imaged by Valerio Fontani for the date and UT given and orientated with north towards the top.* ***(Left)*** *taken in red light.* ***(Right)*** *Taken in blue light.*

South and J. Herschel: On 2022 Oct 07 UT 23:26 Walter Elias (AEA) imaged this crater under similar illumination and topocentric libration to the following report:

40-54W, 54N-60N i.e. nr. South? or J. Herschel 1913 Jun 15 UT 22:00? Observer: Dr W.H. Maw (Surrey, UK, 6" & 8" refractors) "Small distinct reddish spot which became diffused into a patch as term. advanced on the plateau NE of the crater South. When the plateau was on the term. (Goodacre says the crater was J.Herschel for same date -- 2 different spots or misident. for one?" NASA catalog weight=3. NASA catalog ID #345. ALPO/BAA weight=2.

Figure 11. *South and J. Herschel as imaged by Walter Elias (AEA) on 2022 Oct 07 UT 23:26. This has been color normalized and then had color saturation increased to 80%.*

No obvious signs of red can be seen in South or J. Herschel. In Fig 11. But at least now we have what Maw should have seen if there was nothing unusual happening on the date and UT that Cameron gives – note however Cameron has given an estimated UT of 20:00. We shall leave the weight at 2 for now, though we have received other observations for this crater in the 2016 Jan and 2016 Mar newsletters.

Proclus: On 2022 Oct 08 UT 23:55-00:15 Trevor Smith (BAA) sketched this crater under similar illumination to the following report:

Proclus 1973 Jan 17 UT 21:35 Observed by Coates and Neville (both in England, 8" reflector x240) "Walls brilliant, dull white spot seen just S. of center of floor. Not nearly as bright as walls." NASA catalog weight=2. NASA catalog ID #1359. ALP:O/BAA weight=1.

Trevor, using his 16" Newtonian, at x247 under Antoniadi seeing of III, found the Coates description accurate! For example the walls of Proclus were a very bright creamy white, and indeed there was a spot, albeit duller than the walls, just south of the center of the crater. Despite this dullness (compared to the bright crater rime), the spot was star-like in appearance. It was more readily visible in the orange filter (Wratten 21) than the blue (Wratten 38A), but it is possible this is due to Rayleigh scattering in our atmosphere lowering the contrast in blue light – I suggest. Trevor checked some atlases and found the white spot on the Cambridge Photographic Moon atlas (Map 7), but not in the Hatfield Atlas, Rukl's map, or the 21st Century Lunar Atlas. Trevor has a theory that the white spot is a small low-relief hill that catches the overhead sunlight at certain angles and hence why it is not visible in most atlases. Anyway whatever the reason, as it has been re-seen at similar illumination, I think we can lower the ALPO/BAA weight from 1 to 0 and remove it from the LTP database.

Lichtenberg: On 2022 Oct 09 UT 08:22 Maurice Collins imaged the area around Aristarchus under similar illumination to the following report:

On 1988 Apr 01 atUT01:15-03:20 H. Hill (Lancaster, UK, 10" reflector, x286) observed that east of Lichtenberg were extensive rosy areas" around the northern edge of the lava sheet. Hill believes that it may have been the same effect as seen by Madler (Germany), Barcroft (USA) and Baum's (UK) 1951 observation. The color was "unmistakable" and nothing to do with the atmospheric spurious color. Other features were checked. The Cameron 2006 catalog ID=322 and the weight=3. The ALPO/BAA weight=2.

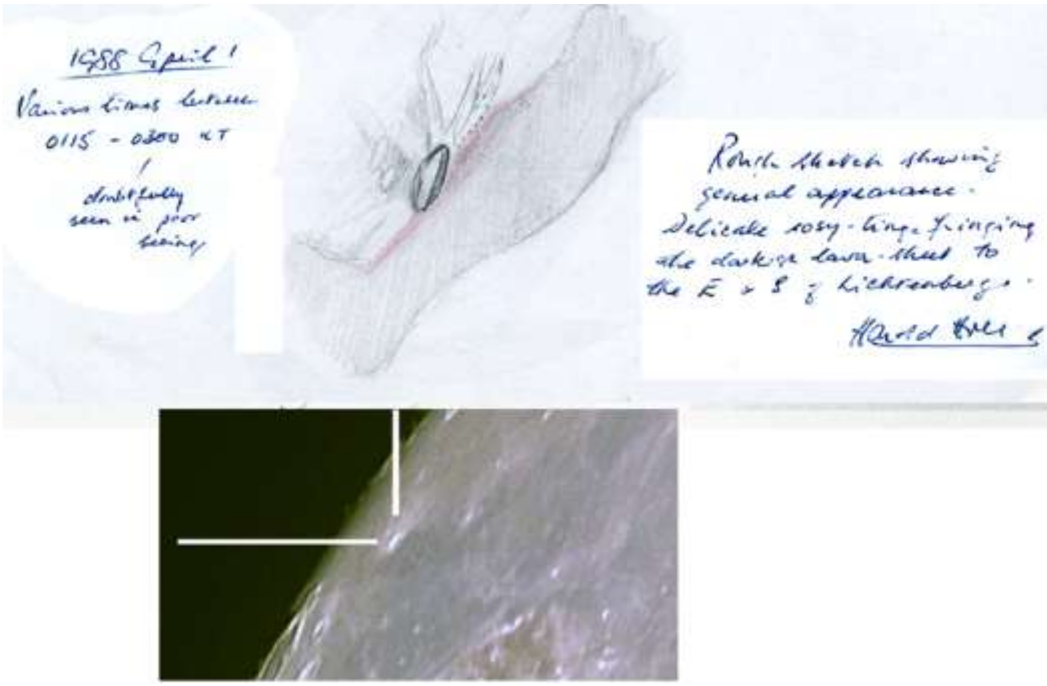


Figure 12. The Lichtenberg, orientated with north towards the top. ***(Top)*** *A color copy of a sketch by Harold Hill (BAA) from 1988 Apr 01 UT 01:15-03:00. The sketch has been rotated to put north at the top and the handwritten notes have been enhanced to make them more readable.* ***(Right)*** *An image by Maurice Collins (ALPO/BAA/RASNZ) that has been color normalized and then had its color saturation increased to 60%. The location of Lichtenburg is indicated by tick marks.*

The rosy area to the eastern shoreline of Lichtenberg has cropped up on several occasions, as Hill mentions in Fig 12 (Top) – though these all seem to be at different colongitudes. I note that the date of Harold Hill's observation is the 1st of April, but doubt if he would make an April Fool's observation as he is generally regarded as a very serious observer. However, looking at the color enhanced view of the image (Fig 22 – bottom) that Maurice sent us, there appears to be no obvious sign of rosy color here. You can quite clearly make out the brown color of the Aristarchus plateau near the bottom of the image though, so if a rose color was near Lichtenberg it should have shown up. We shall keep the weight of the Hill report at 2.

Cavendish E: On 2022 Oct 07 UT 18:30 Massimo Giuntoli (BAA) observed visually this crater to check if it was going to repeat an earlier observation, on 2021 Sep 18 UT 21:15, where they had seen it unusually bright. A 20cm Newtonian was used with a magnification of x250. Seeing was Antoniadi III/IV. Selenographic colongitude was 60.3°, sub-solar latitude was +0.8° and topocentric libration was 3° 40' in longitude and 6° 24' in latitude. Massimo comments that the northern floor of Cavendish E was bright (normal appearance) but not brilliant. I started looking through the archives. Fig 13 shows an example image within ±0.5˚ of the 2021 Sep 18 observation that Massimo made, but it does not look very bright in this image either. I will keep on searching and try to find a better match in topocentric libration.

Figure 13. *Cavendish E located close to the center of this image taken in this archive image by Maurice Collins (ALPO/BAA/RASNZ) on 2015 Dec 23 UT 09:24-09:35. North is towards the top.*

General Information: For repeat illumination (and a few repeat libration) observations for the coming month - these can be found on the following web site: http://users.aber.ac.uk/atc/lunar_schedule.htm . By re-observing and submitting your observations, only this way can we fully resolve past observational puzzles. To keep yourself busy on cloudy nights, why not try "Spot the Difference" between spacecraft imagery taken on different dates? This can be found on: http://users.aber.ac.uk/atc/tlp/spot_the_difference.htm . If in the unlikely event you do ever see a LTP, firstly read the LTP 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 LTP alerts can be accessed on https://twitter.com/lunarnaut .

Dr Anthony Cook, Department of Physics, Aberystwyth University, Penglais, Aberystwyth, Ceredigion, SY23 3BZ, WALES, UNITED KINGDOM. Email: atc @ aber.ac.uk

Basin and Buried Crater Project

Coordinator Dr. Anthony Cook- atc@aber.ac.uk

Figure 1. *Mare Humboldtianum as imaged by Alexander Vandenbohede for the date and UT given in the image caption.*

Only one observation has been received this month. Alexander Vandenbohede's Mare Humboldtianum image (Fig 1). This was taken at an evening selenographic colongitude of 109.1°. Alexander also made a map projection in Fig 2 showing the overhead view, but of course with the over-the-limb portion of the basin missing.

Humboldtianum is a Nectarian era basin, located 82˚E, 57˚N with a main ring of 650 km in diameter (albeit hexagonal in shape), 4.5 km deep and up to 6 rings altogether, though the dark mare area itself is only about 230 km in diameter and Upper Imbrium in age and confined to the inner ring. It is not clear in Fig 2 where the other 4 rings are. Even looking at the grey scale digital elevation model (Fig 3) the other 4 rings remain unclear. For now, we will update the impact basin database with the Alexander's selenographic colongitude, as the best time to see the evening apparition of this basin, though clearly topocentric libration will have a big effect, seeing that part of the basin is on the near side and part on the farside of the Moon.

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.

Alternatively, if you want an observational challenge, try to see if you can image one of more of the basins or buried craters at sunrise/set and establish what colongitude range they are best depicted at.

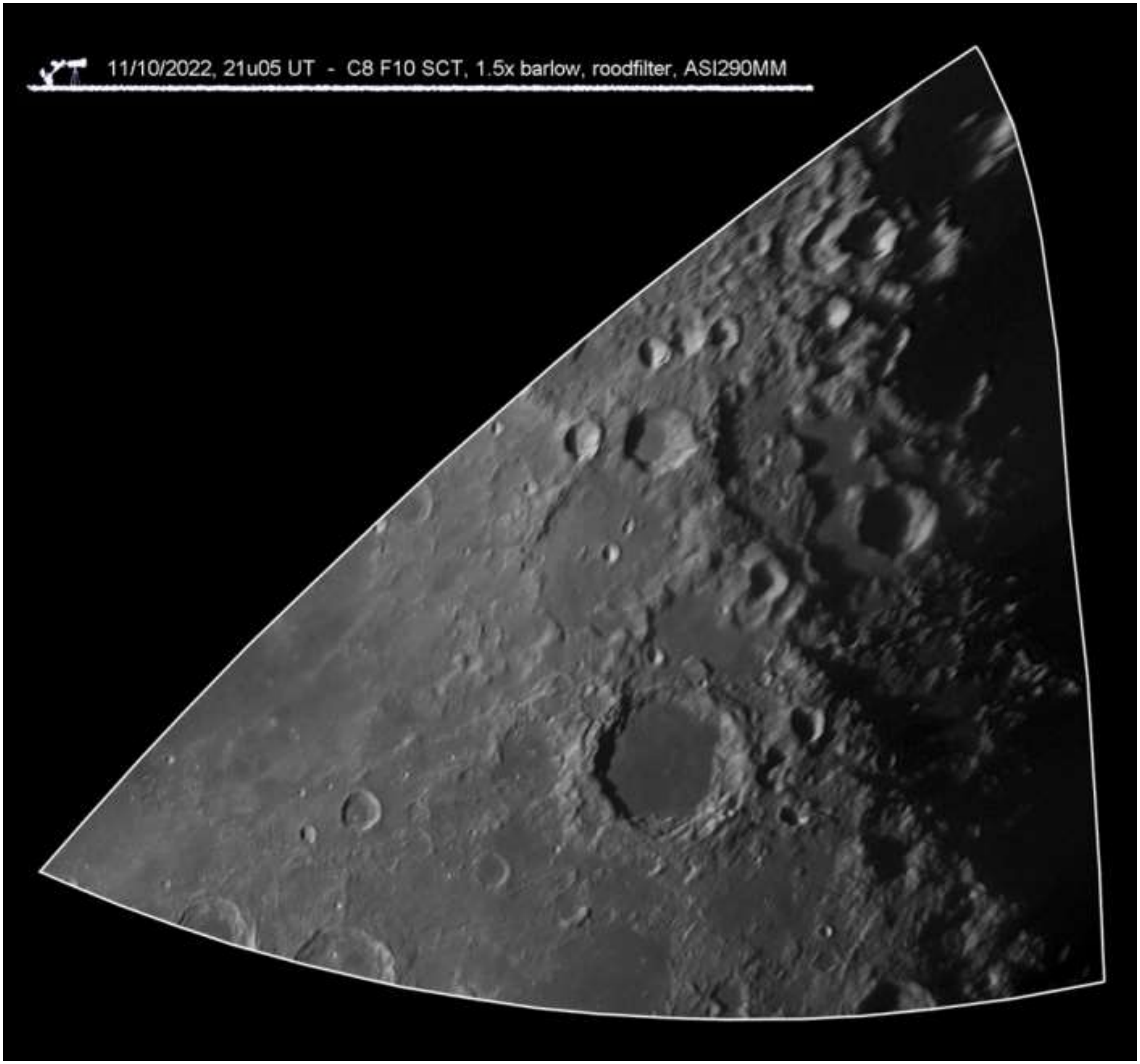


Figure 2. *Map projection of Mare Humboldtianum as imaged by Alexander Vandenbohede for the date and UT given in the image caption.*

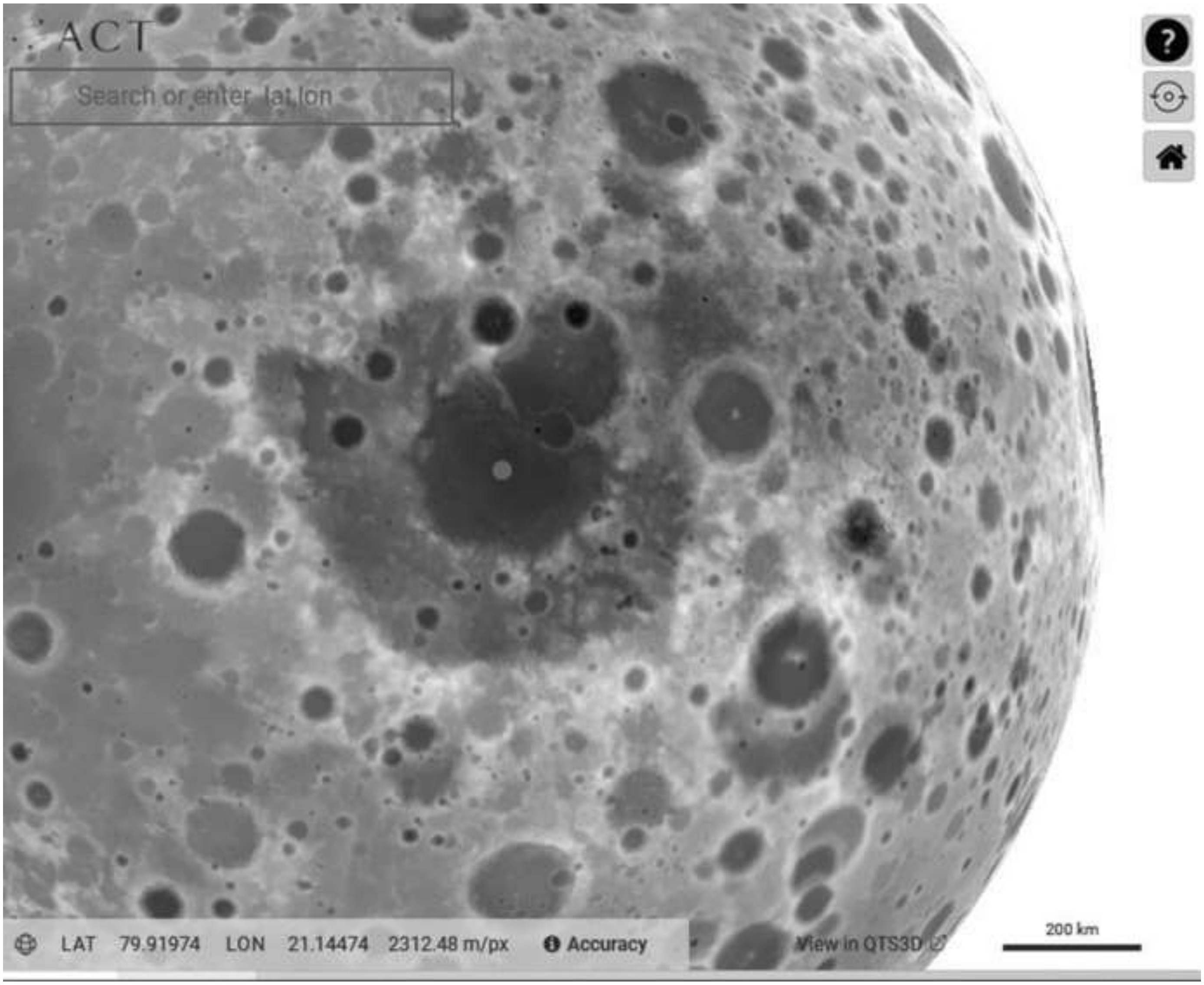


Figure 3. *NASA Quickmap digital elevation model of Mare Humboldtianum (Dark is low and white is high topography).*

Lunar Calendar December 2022

Date	UT	Event
1	0000	Juno 1.2° south of Moon, occultation western USA, Canada
1	1300	Neptune 3° north of Moon
2	0100	Jupiter 3° north of Moon
3		East limb most exposed +6.3°
5	1800	Uranus 0.7° south of Moon, occultation north Africa to Japan
8	0400	Mars 0.5° south of Moon, occultation, northwest Mexico to Europe
8	0408	Full Moon
10		Greatest northern declination, +27.4°
11	0800	Pollux 1.8° north of Moon
12	0000	Moon at apogee 405,888 km
13		South limb most exposed -6.7°
16	0856	Last Quarter Moon
23	1017	New Moon lunation 1237
23	0800	Moon at perigee 358,270 km
23	1100	Venus 3° north of Moon
24		Greatest southern declination, -27.4°
26		North limb most exposed +6.6°
28	2000	Neptune 3° north of Moon
29	1100	Jupiter 2° north of Moon
30	0120	First Quarter Moon
31		East limb most exposed +7.4°

The Lunar Observer welcomes all lunar related images, drawings, articles, reviews of equipment and reviews of books. You do not have to be a member of ALPO to submit material, though membership is highly encouraged. Please see below for membership and near the end of *The Lunar Observer* for submission guidelines.

AN INVITATION TO JOIN THE A.L.P.O.

The Lunar Observer is a publication of the Association of Lunar and Planetary Observers that is available for access and participation by non- members free of charge, but there is more to the A.L.P.O. than a monthly lunar newsletter. If you are a non-member you are invited to join our organization for its many other advantages.

We have sections devoted to the observation of all types of bodies found in our solar system. Section coordinators collect and study members' observations, correspond with observers, encourage beginners, and contribute reports to our Journal at appropriate intervals.

Our quarterly journal, *The Journal of the Association of Lunar and Planetary Observers-The Strolling Astronomer*, contains the results of the many observing programs which we sponsor including the drawings and images produced by individual amateurs. Additional information about the A.L.P.O. and its Journal is on-line at: **http://www.alpo-astronomy.org.** I invite you to spend a few minutes browsing the Section Pages to learn more about the fine work being done by your fellow amateur astronomers.

To learn more about membership in the A.L.P.O. go to: **http://www.alpo- astronomy.org/main/member.html** which now also provides links so that you can enroll and pay your membership dues online.

SUBMISSION THROUGH THE ALPO IMAGE ARCHIVE

ALPO's archives go back many years and preserve the many observations and reports made by amateur astronomers. ALPO's galleries allow you to see on-line the thumbnail images of the submitted pictures/observations, as well as full size versions. It now is as simple as sending an email to include your images in the archives. Simply attach the image to an email addressed to

lunar@alpo-astronomy.org (lunar images).

It is helpful if the filenames follow the naming convention :

FEATURE-NAME_YYYY-MM-DD-HHMM.ext

YYYY {0..9} Year

MM {0..9} Month

DD {0..9} Day

HH {0..9} Hour (UT)

MM {0..9} Minute (UT)

.ext (file type extension)

(NO spaces or special characters other than "_" or "-". Spaces within a feature name should be replaced by "-".)

As an example the following file name would be a valid filename:

Sinus-Iridum_2018-04-25-0916.jpg

(Feature Sinus Iridum, Year 2018, Month April, Day 25, UT Time 09 hr16 min)

Additional information requested for lunar images (next page) should, if possible, be included on the image. Alternatively, include the information in the submittal e-mail, and/or in the file name (in which case, the coordinator will superimpose it on the image before archiving). As always, additional commentary is always welcome and should be included in the submittal email, or attached as a separate file.

If the filename does not conform to the standard, the staff member who uploads the image into the data base will make the changes prior to uploading the image(s). However, use of the recommended format, reduces the effort to post the images significantly. Observers who submit digital versions of drawings should scan their images at a resolution of 72 dpi and save the file as a 8 1/2"x 11" or A4 sized picture.

Finally a word to the type and size of the submitted images. It is recommended that the image type of the file submitted be jpg. Other file types (such as png, bmp or tif) may be submitted, but may be converted to jpg at the discretion of the coordinator. Use the minimum file size that retains image detail (use jpg quality settings. Most single frame images are adequately represented at 200-300 kB). However, images intended for photometric analysis should be submitted as tif or bmp files to avoid lossy compression.

Images may still be submitted directly to the coordinators (as described on the next page). However, since all images submitted through the on-line gallery will be automatically forwarded to the coordinators, it has the advantage of not changing if coordinators change.

When submitting observations to the A.L.P.O. Lunar Section

In addition to information specifically related to the observing program being addressed, the following data should be included:

Name and location of observer
Name of feature
Date and time (UT) of observation (use month name or specify mm-dd-yyyy-hhmm or yyyy-mm-dd-hhmm)
Filter (if used)
Size and type of telescope used Magnification (for sketches)
Medium employed (for photos and electronic images)
Orientation of image: (North/South - East/West)
Seeing: 0 to 10 (0-Worst 10-Best)
Transparency: 1 to 6

Resolution appropriate to the image detail is preferred-it is not necessary to reduce the size of images. *Additional commentary accompanying images is always welcome.* **Items in bold are required. Submissions lacking this basic information will be discarded.**

Digitally submitted images should be sent to:
David Teske – david.teske@alpo-astronomy.org
Alberto Anunziato–albertoanunziato@yahoo.com.ar
Wayne Bailey—wayne.bailey@alpo-astronomy.org

Hard copy submissions should be mailed to David Teske at the address on page one.

CALL FOR OBSERVATIONS: FOCUS ON: Land of Cracks: Petavius

Focus on is a bi-monthly series of articles, which includes observations received for a specific feature or class of features. The subject for the January 2023, will be Eratosthenes. Observations at all phases and of all kinds (electronic or film based images, drawings, etc.) are welcomed and invited. Keep in mind that observations do not have to be recent ones, so search your files and/or add these features to your observing list and send your favorites to (both):

Alberto Anunziato – albertoanziato@yahoo.com-ar
David Teske – david.teske@alpo-astronomy.org

Deadline for inclusion in the Petavius Focus-On article is December 20, 2022

FUTURE FOCUS ON ARTICLES:

In order to provide more lead time for contributors the following future targets have been selected:

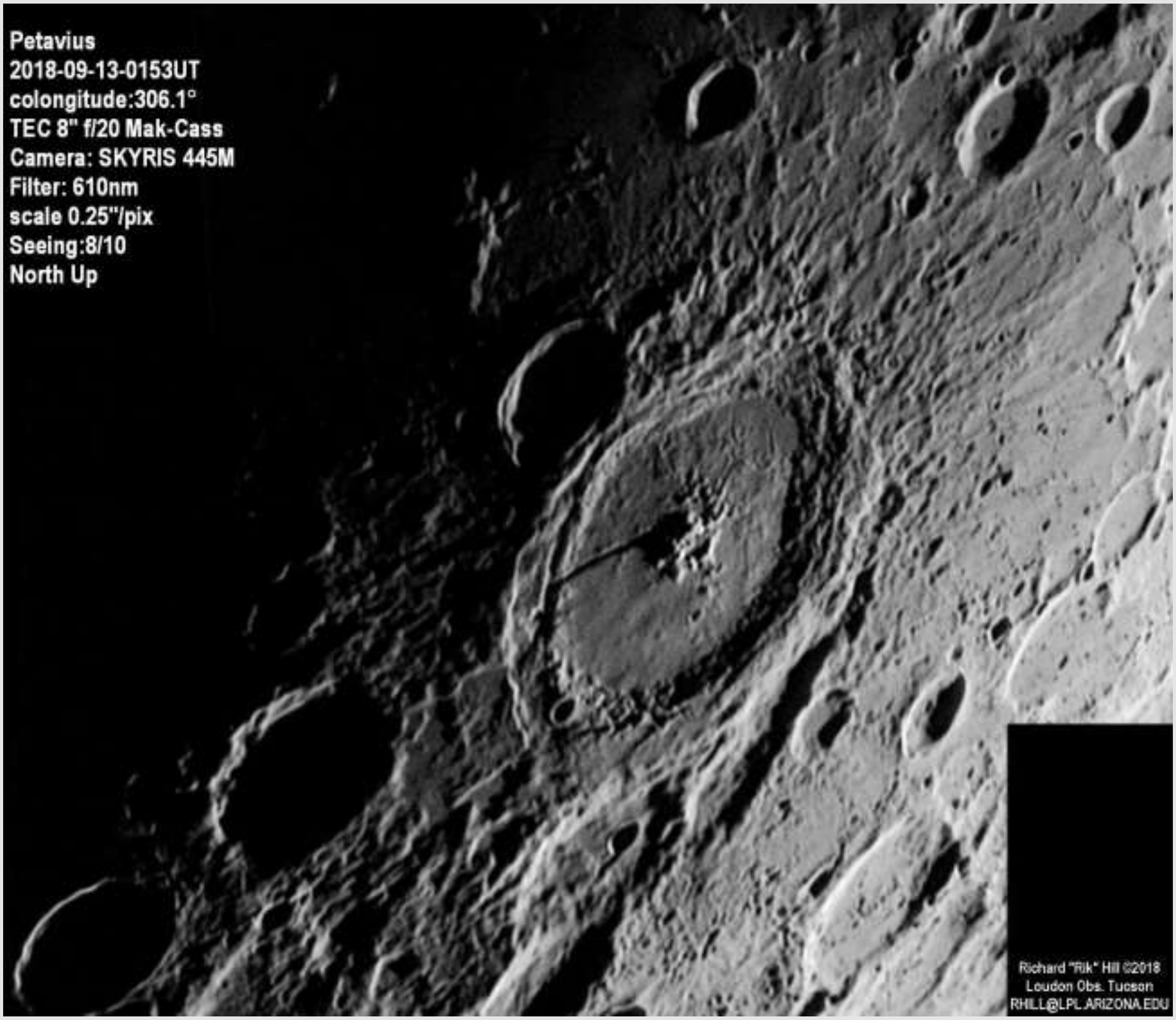
Subject	TLO Issue	Deadline
Petavius	**January 2023**	**December 20, 2022**
Mare Nubium	**March 2023**	**February 20, 2023**
Reiner Gamma	**May 2023**	**April 20, 2023**
Mons Rümker	**July 2023**	**June 20, 2023**

Focus-On Announcement

LAND OF CRACKS: PETAVIUS

Petavius is a venerable antiquity, think how beautiful it must have been, hundreds of millions of years ago, when he would have looked like a super-grown Copernicus. Then it has lived through a whole geological history that has transformed it. Petavius is an opportunity to learn about the remains of its primitive grandeur, its massive, terraced walls, its mighty central peaks, and its ejecta field; and its more recent geological history: its uplifted ground and the rilles that later fractured it, including its best-known and most beautiful feature: Rimae Petavius, "the great cleft," as Elger called it.

JANUARY 2023 ISSUE – Due December 20, 2022: PETAVIUS
MARCH 2023 ISSUE-Due February 20, 2023: MARE NUBIUM
MAY 2023 ISSUE-Due April 20th, 2023: REINER GAMMA
JULY 2023 ISSUE-Due June 20th, 2023: MONS RÜMKER



Rik Hill

Focus-On Announcement

Expedition to Mare Nubium

Mare Nubium is small, not very large, but it has an incredible variety of features: an impact crater beauty, not very fresh but incredibly preserved as Bullialdus, strangely shaped craters like Wolff, giants like Pitatus, almost disappeared craters like Kies or Gould, the most conspicuous concentric crater (Hesiodus A), domes, rilles, wrinkle ridges, the bright rays of distant Tycho, and one of the most beautiful features, Rupes Recta. We will share the lunar images of our observers to dream of an expedition through the sea of clouds.

JANUARY 2023 ISSUE – Due December 20, 2022: PETAVIUS
MARCH 2023 ISSUE-Due February 20, 2023: MARE NUBIUM
MAY 2023 ISSUE-Due April 20th, 2023: REINER GAMMA
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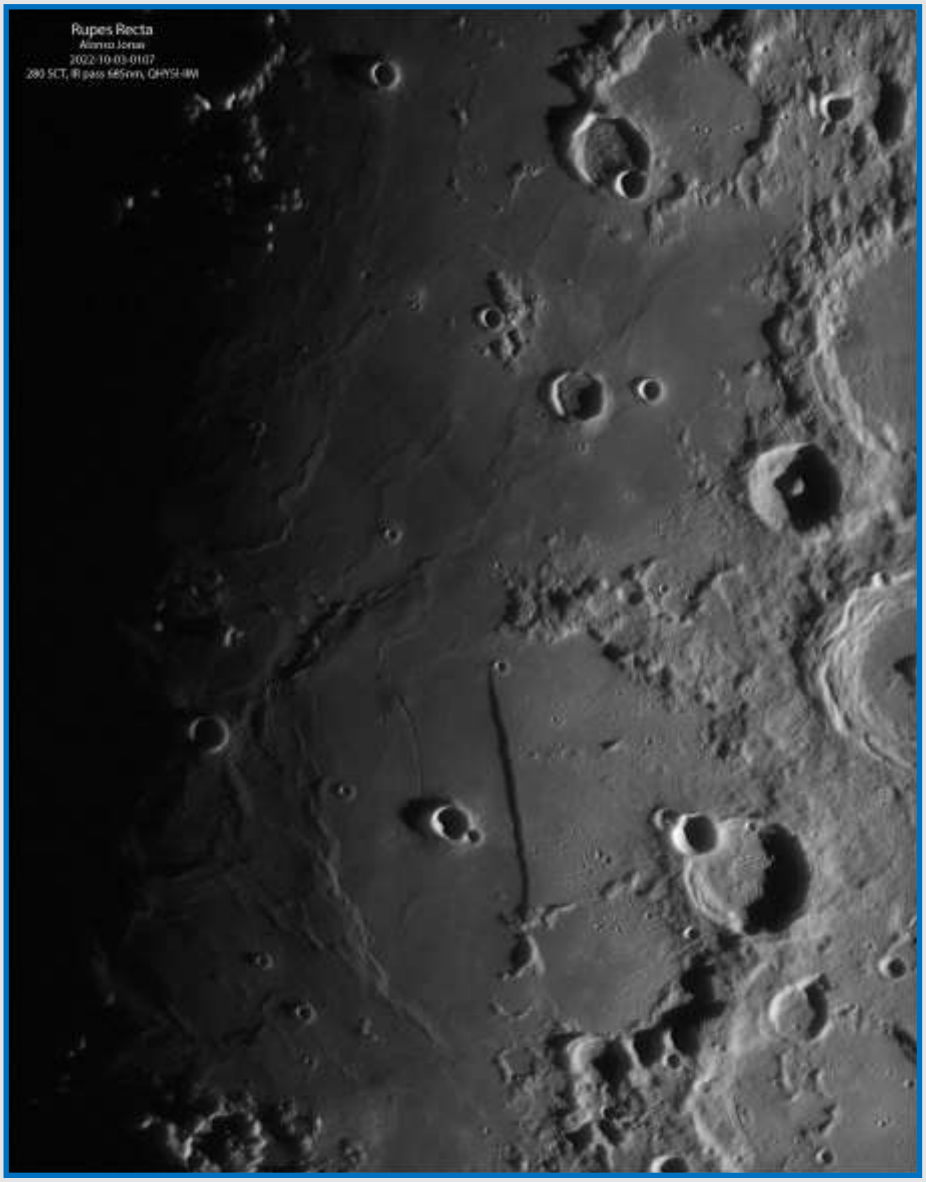
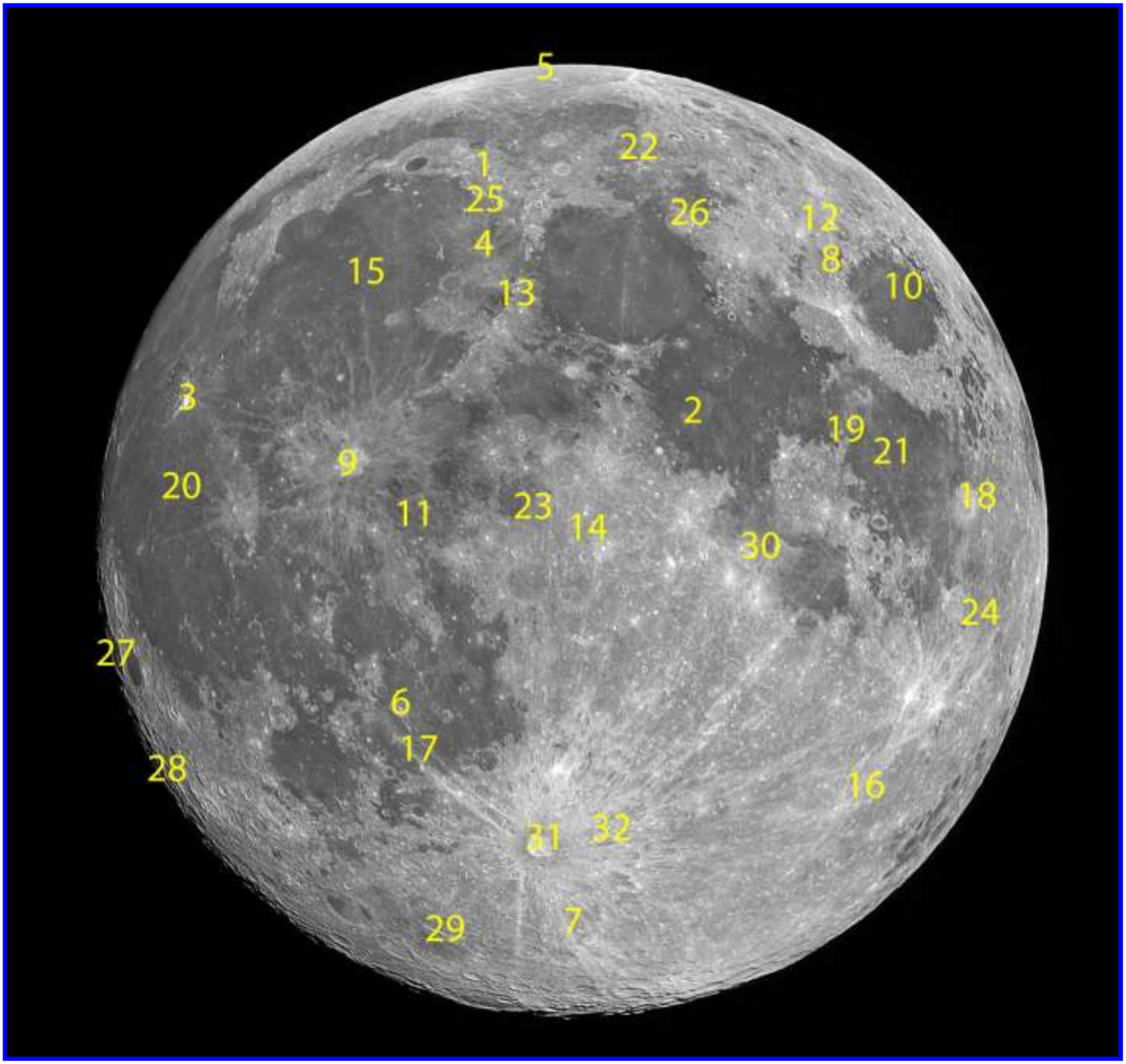


Jonás Alonso

Key to Images In This Issue



1. Alpes, Vallis
2. Arago
3. Aristarchus
4. Aristillus
5. Arnold
6. Bullialdus
7. Clavius
8. Cleomedes
9. Copernicus
10. Crisium, Mare
11. Gambart
12. Geminus
13. Hadley Rille
14. Hipparchus
15. Imbrium, Mare
16. Janssen
17. Kies
18. Langrenus
19. Marilyn, Mount
20. Marius
21. Messier
22. Mortis, Lacus
23. Oppolzer
24. Petavius
25. Piton, Mons
26. Posidonius
27. Riccioli
28. Rook, Montes
29. Schiller
30. Theophilus
31. Tycho
32. Walther