The Lunar Observer

A Publication of the Lunar Section of ALPO
David Teske, editor
Coordinator, Lunar Topographic Studies Section Program

November 2024

In This Issue

Lunar Reflections

A warm greeting to all readers. Hoping that this issue of *The Lunar Observer* finds you doing well. In the issue that you have here you will find lunar topographic articles by Greg Shanos, István Zoltán Földvári, Robert Reeves, and Alberto Anunziato. Darryl Wilson brings an update of his lunar imaging techniques which allows for analysis of the lunar surface materials. Darryl previously wrote several articles here about thermal lunar imaging. Alberto Anunziato leads the Focus On article about the magnificent craters Archimedes, Autolycus and Aristillus with many images of these features from observers throughout the world. In this Focus On, Robert H. Hays, Jr. also contributed a couple of his great lunar drawings and observations. As always, Tony Cook brings us a thorough discussion of Lunar Geologic Change and Buried Basins and Craters. Many thanks to the 31 contributors of articles, drawings and lunar images that you see in this issue of *The Lunar Observer.*

Please remember to follow the future Focus-On topics and gather observations of these features. Next up is the very interesting Anaxagoras. Observations are due to Alberto and myself by December 20, 2024.

Clear skies,
-David Teske

Guidelines Reminder

CHOOSE ONLY YOUR BEST IMAGES and limit the number to no more than eight (8) per each issue of the TLO. (obviously, if there is an article you are writing or contributing to this does not apply).

The image filename should be submitted with the object name spelled correctly, then the year-month-day-hour-minutes-Your Name or initials So, my image of Copernicus should have a file name of:
Copernicus_2023-08-31-2134-DTe
means
Copernicus, 2023 August 31, 21:34 UT by David Teske

Please keep images to 400 kB or less
Please see end of issue for more details.
Email to drteske@yahoo.com or lunar@alpo-astronomy.org

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Online readers, click on images for hyperlinks

Lunar Topographic Studies

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Observations Received

Name	Location and Organization	Image/Article
Alberto Anunziato	Paraná, Argentina	Image of Archimedes, Articles and drawings *Wrinkle Ridges Around Laplace F* and *Focus On: Archimedes, Autolycus and Aristillus: The Magnificent Three.*
Sergio Babino	Montevideo, Uruguay	Images of Aristillus and Archimedes.
Jean Bourgeois	Pic du Mid Observatory, France	Images of Aristoteles (4).
James Brunkella	Thousand Oaks, California, USA	Images of Archimedes (3).
Ariel Cappelletti	Córdoba, Argentina, SLA	Image of Aristillus.
Francisco Alsina Cardinalli	Oro Verde, Argentina	Images of Archimedes (2).
Jairo Chavez	Popayán, Colombia	Images of Hadley, 14% Waxing Crescent Moon, 31% Waxing Crescent Moon, 87% Waxing Gibbous Moon, 94% Waxing Gibbous Moon, 78% Waxing Gibbous Moon, Waning Gibbous Moon and 98% Waning Gibbous Moon.
Maurice Collins	Palmerston North, New Zealand	Images of 7.5 day-old Moon, 8.5 day-old Moon and 13.6 day-old Moon.
Michel Deconinck	Aquarellia Observatory, France	Drawing of Archimedes.
Massimo Dionisi	Sassari, Italy	Image of Abulfedo.
Jef De Wit	Hove, Belgium	Drawing of Archimedes.
Walter Ricardo Elias	Oro Verde, Argentina, AEA	Images of Copernicus (3), Montes Apenninus, Clavius, Alphonsus, Montes Spitzbergen, Parry, Proclus, Plato, Scoresby, Tycho, Aristarchus (2), Gassendi and Rupes Recta.
István Zoltán Földvári	Budapest, Hungary	Drawings of Beketov, Lade, Anděl, article and drawing *Descartes Highlands*.
Aurore Guillerand	Margny-Les-Compiègne, Oise, Hauts-de-France, France	Drawings of Archimedes, the Alpes, Plato, Gassendi and the Waning Gibbous Moon.
Marcelo Mojica Gundlach	Cochabamba, Bolivia	Images of Archimedes (2), Cassini and Aristillus (2).
Robert H. Hays, Jr.	Worth, Illinois, USA	Articles and drawings *Autolycus* and *Montes Spitzbergen.*
Rik Hill	Loudon Observatory, Tucson, Arizona,	Images of Archimedes (5).

Lunar Topographic Studies

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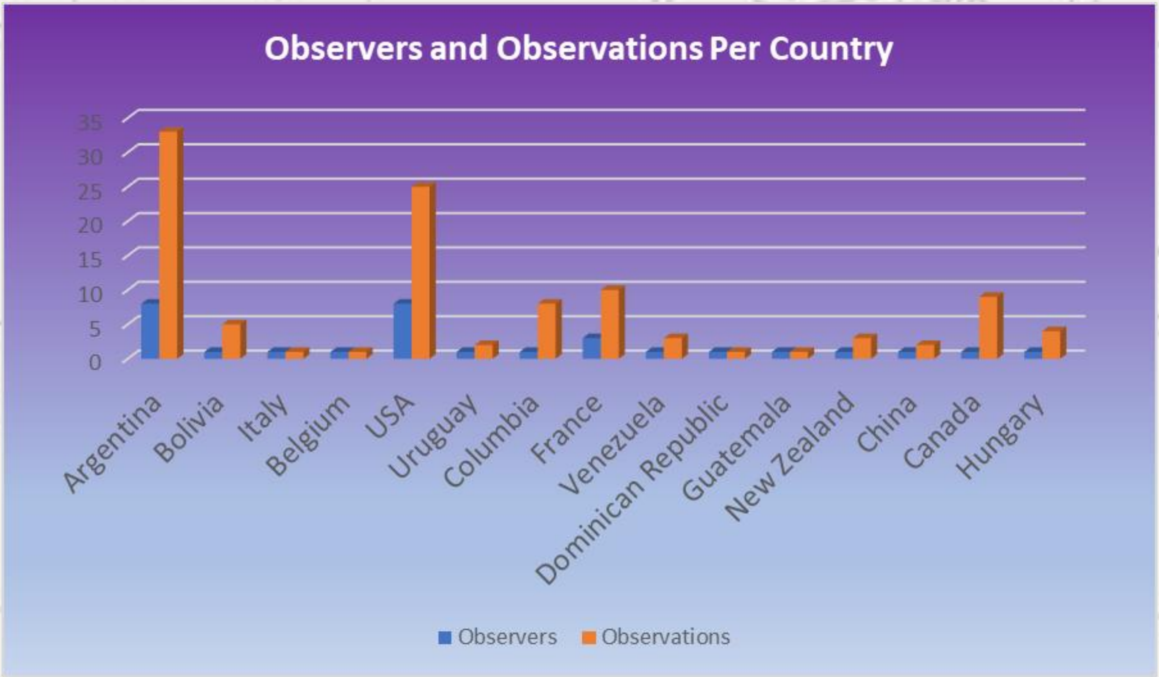
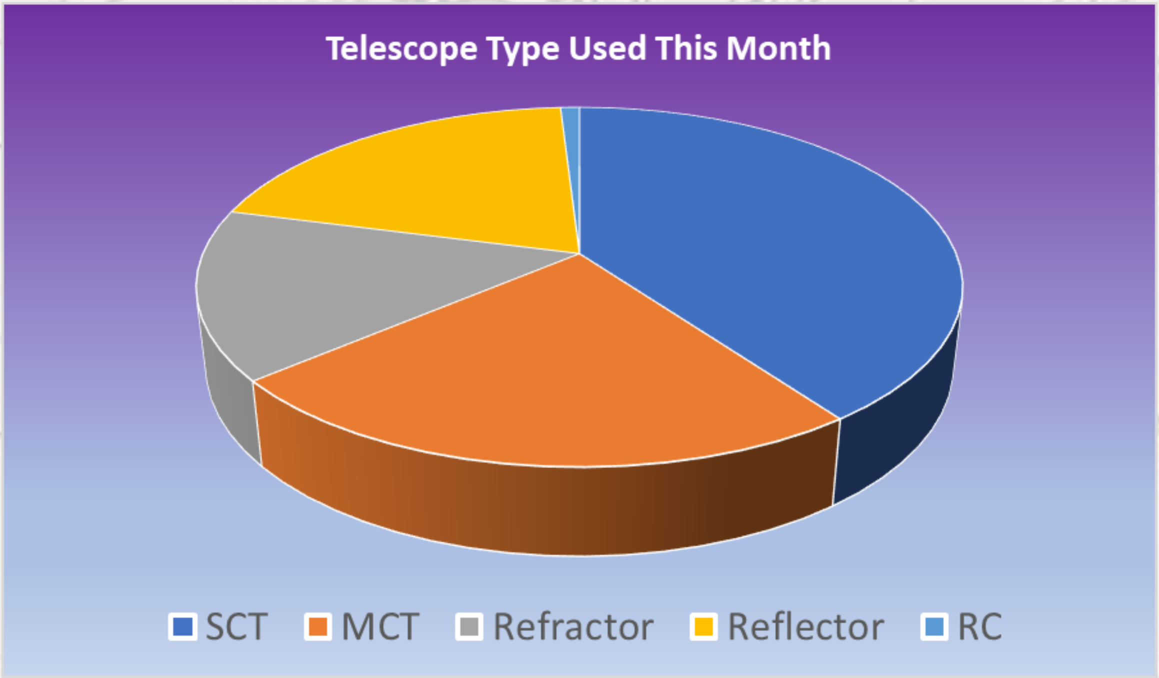
Observations Received

Name	Location and Organization	Image/Article
Felix León	Santo Domingo, República Dominicana	Image of Aristillus.
Rafael Lara Muñoz	Guatemala, Guatemala, SLA	Image of Montes Apenninus.
KC Pau	Hong Kong, China	Images of Aristillus and Aristarchus.
Jesús Piñeiro	San Antonio de los Altos, Venezuela	Images of Archimedes (3).
Raúl Roberto Podestá	Formosa, Argentina	Images of Aristillus, Aristarchus, Copernicus, Tycho and Kepler.
Robert Reeves	San Antonio, Texas, USA	Article and 11 images *A Look At 10 Non-Traditional Lunar Basins*.
Pedro Romano	San Juan, Argentina	Image of Archimedes.
Greg Shanos	Sarasota, Florida, USA	Article and image *The Hunter's Supermoon*.
Fernando Sura	San Nicolás de los Arroyos, Argentina	Images of Copernicus, Tycho, Licetus, Ptolemaeus and Clavius.
David Teske	Louisville, Mississippi, USA	Image of Palus Putredinis.
Jim Tomney	Towson, Maryland, USA	Image of Taruntius.
Ken Vaughan	Cattle Point, Victoria, British Colombia, Canada	Images of Aristoteles, Atlas, Deslandres, East of Copernicus, Hadley Rille, Maurolycus, southwestern Mare Tranquillitatis, Archimedes and Tycho.
Román García Verdier	Román García Verdier	Images of Bessel and Archimedes.
Darryl Wilson	Marshall, Virginia, USA	Article and images *A Review of Multiband Image Processing Techniques For Lunar Surface Material Analysis.*

November 2024 *The Lunar Observer*
By the Numbers

This month there were 108 observations by 31 contributors in 15 countries.





Lunar X Predictions for 2024

40°N-75°W, Eastern Time Zone

Date, 2024	358° Colongitude	Altitude/Azimuth	Cloudy Nights
January 18	5:15 am	–37° / 345°	4:05 am
February 16	7:40 pm	+66° / 236°	6:49 pm
March 17	10:22 am	–11° / 38°	10:10 am
April 15	11:08 pm	+43° / 268°	11:41 pm
May 15	11:01 am	–16° / 53°	12:13 pm
June 13	10:15 pm	+34° / 244°	11:49 pm
July 13	9:11 am	–43° / 58°	10:48 am
August 11	8:15 pm	+24° / 212°	9:31 pm
September 10	7:49 am	–65° / 65°	8:29 am
October 9	8:12 pm	+16° / 206°	8:09 pm
November 8	8:33 am	–49° / 79°	7:49 am
December 7	10:43 pm	+4° / 253°	9:36 pm

Note: The Lunar X is not an instantaneous phenomenon; rather, it appears and evolves over several hours, so the times above are fundamentally approximate and serve only as a guide. The ardent observer should look a little early to catch the initial visible illumination. A less-dramatic Lunar X against a fully illuminated background can still be seen at least several days later. Because of the Moon's nominal 29.5-day synodic period (phase-to-phase), favorable dates for a given location tend to occur on alternate months (unfavorable dates for 40°N-75°W are shaded gray in this table). The 358° colongitude value for the terminator reaching the Lunar X and making it visible (see this RASC paper) and the corresponding lunar altitude/azimuth for 40°N-75°W were determined with WinJUPOS, which is freeware linked from the WinJUPOS download page.

The Cloudy Nights comparative data, derived by a different method, was presented in this post.

Daylight Saving Time for 2024 begins on March 10 and ends on November 3. The listed times are EST/EDT as appropriate for the date.

Submitted by Greg Shanos.

Lunar X Predictions for 2024-2028

5 Year Lunar "X" and "V" Schedule * **					
	2024	2025	2026	2027	2028
Jan	18: 0830	6: 1645	25: 1630	15: 0015	4: 0830
Feb	16: 2345	5: 0800	24: 0730	13: 1530	3: 0015
Mar	17: 1400	6: 2300	25: 2145	15: 0600	3: 1500
Apr	16: 0300	5: 1300	24: 1100	13: 1930	2: 0430
					1: 1700
May	15: 1600	5: 0130	23: 2245	13: 0730	31: 0400
Jun	14: 0400	3: 1330	22: 0945	11: 1830	29: 1430
Jul	13: 1430	3: 0015	21: 2000	11: 0500	29: 0030
		1: 1100			
Aug	12: 0130	30: 2130	20: 0630	9: 1530	27: 1100
Sep	10: 1230	29: 0900	18: 1730	8: 0200	25: 2245
Oct	10: 0015	28: 2115	18: 0530	7: 1400	25: 1130
Nov	8: 1245	27: 1045	16: 1900	6: 0300	24: 0145
Dec	8: 0230	27: 0115	16: 0930	5: 1730	23: 1645

* All times are listed as the day of the month and then the hour in **UT**

** All times are approximations based on LTVT calculations. They are accurate to ± 1 hour.

Submitted by Greg Shanos.

Photographic Atlas of the Moon: A Comprehensive Guide for the Amateur Astronomer, Robert Reeves, Hardcover – September 1, 2024

Written by a dedicated selenophile (a person who loves the Moon), this guide to Earth's celestial companion is a non-technical narrative that quickly elevates the lunar novice to lunar authority.

Photographic Atlas of the Moon explains how the Earth and the Moon are locked together in a co-dependent embrace, each affecting the other in ways that impact our lives. The reader will learn in comprehensible, jargon-free language about the Moon we see, its orbit, its creation and the differing geologic details of the Moon, some of which can be seen with the naked eye. All the photographs in this lavishly illustrated book were taken by the author, an internationally recognized authority on celestial photography. Reeves has perfected image processing techniques that allow the amateur astronomer, using modest equipment, to exceed the quality of Earth-based professional lunar photographs taken during the Apollo era.

Although Reeves is an accomplished deep-sky photographer, his current passion is re-popularizing the Moon within the amateur astronomy community. Momentum is building for a manned return to the Moon to continue the exploration started over half a century ago. Photographic Atlas of the Moon will provide even the most novice reader with an understanding of the Moon and its allure so they can appreciate the upcoming explorations by NASA's Artemis lunar program.

https://www.amazon.com/Photographic-Atlas-Moon-Comprehensive-Astronomer/dp/022810498X/ref=rvi_d_sccl_1/136-6077595-9611424?pd_rd_w=NTjEa&content-id=amzn1.sym.f5690a4d-f2bb-45d9-9d1b-736fee412437&pf_rd_p=f5690a4d-f2bb-45d9-9d1b-736fee412437&pf_rd_r=7XZ4992GTVJKS0K7P4F5&pd_rd_wg=WEmPb&pd_rd_r=310acd54-2b8b-4d1c-a84a-abe0a3d2034f&pd_rd_i=022810498X&psc=1

Descartes Highlands

István Zoltán Földvári

"I arrived at the perfect time. The Descartes Plateau is the place where the Apollo 16 mission reached the surface of the Moon in April 1972. During my observation, the landscape was incredibly captivating. It can be identified as a very difficult-to-draw, triangular-shaped, sponge-like area, with its western side perfectly showing the two mountains between which the Orion lunar module descended. I probably didn't draw it flawlessly, but the atmosphere of the landscape might come through. The northern mountain is "Smoky," and the lighter, southern one is "Stone Mountain." These two elevations seem to enclose the plateau from the west, where there is a lower-lying, very dark area. My observation was slightly hindered by moonlight-scattering but translucent clouds, which reduced the contrast somewhat, but fortunately, the calmness was very good throughout."

Lunar Topographic Studies
Descartes Highlands

A Look at Ten Non-Traditional Lunar Basins

Robert Reeves

It is time for some of us lunar old timers to update how we think about basins on the Moon. When I started studying the Moon over 60 years ago, the nature and structure of features on the Moon rarely covered more than a page in an astronomy book. Today, after six decades of space age study, we know enough about the Moon that I have written two 300-page books about Luna and still have more to say about our natural satellite. One feature that has gone from obscurity to acceptance is lunar basins, but now the definition of a lunar basin is in flux.

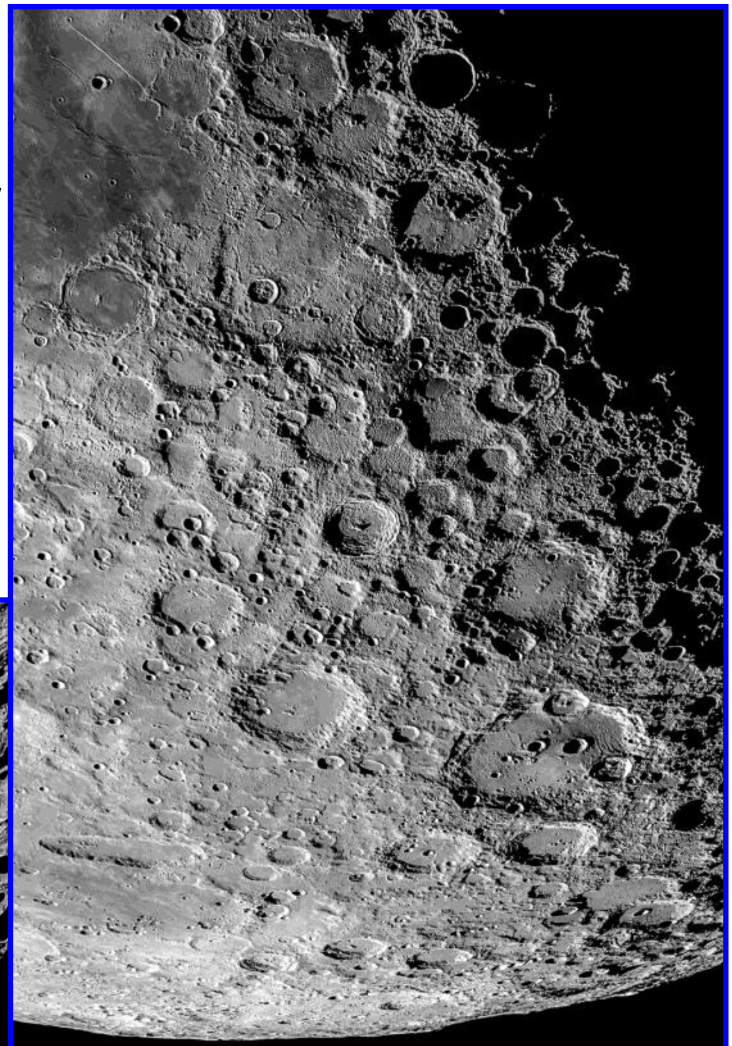
Basins on the Moon were rarely openly discussed before the space age. A lunar basin is nothing more than a huge crater. Today, it is common to think of a lunar basin as the gigantic depression cradling one of the lunar maria. The thought that asteroid impacts created the gigantic circular features, some of which were later filled by lava flows to create the maria, was promoted by a minority of lunar specialists in the early 20th century. Even up to the time of the Apollo manned landings on the Moon, scientific opinion about the origin of many features was split between those who promoted an impact origin and those who clung to the belief that lunar craters and pits were of volcanic origin. Only after NASA's Lunar Orbiter missions to the Moon from 1966 to 1968 mapped 99% of the Moon's surface from a vertical perspective was it realized that impact basins play a major role in the evolution of the Moon's face. Analysis of the Lunar Orbiter satellite's irregular orbit around the Moon also revealed many of the maria had increased gravitational pull due to mascons, or denser concentrations of rock under the basins cradling the maria.

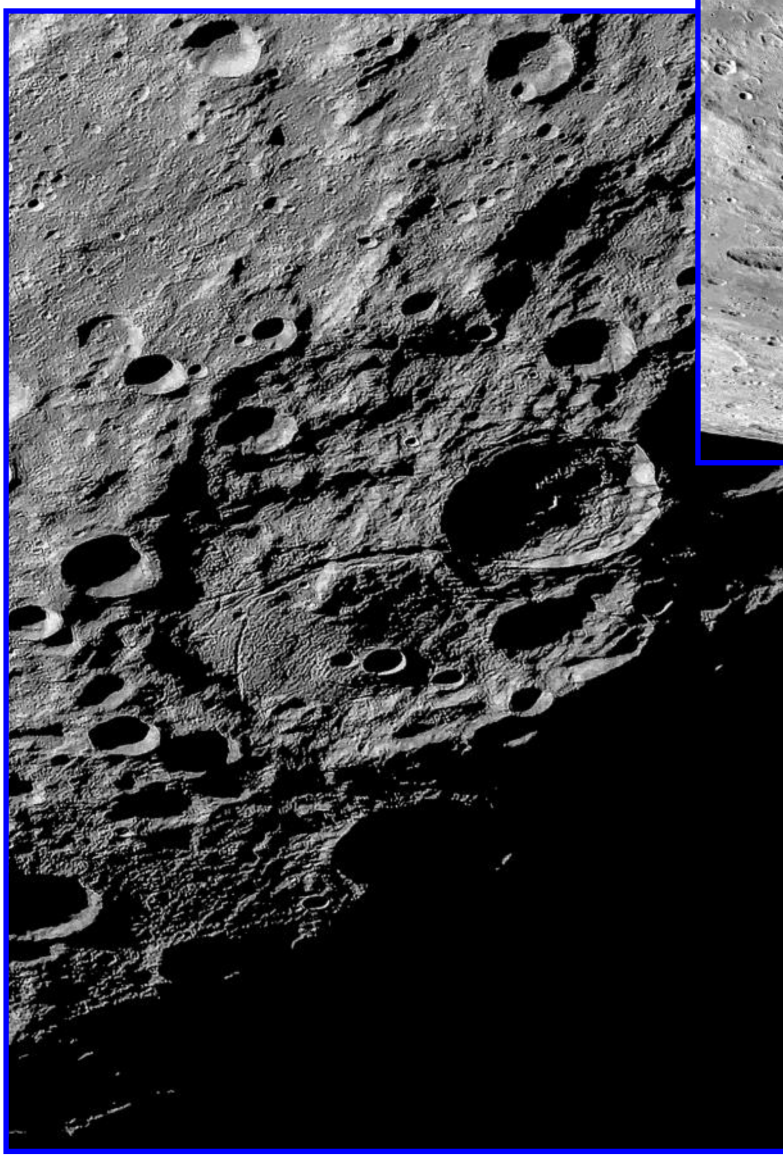
As the existence of impact-created basins on the Moon became an accepted fact in the 1970s, a basin was defined as a crater larger than 300 kilometers in diameter. Many of the far side impact features exceeded the 300-kilometer definition and were thus designated as basins after they were recognized in Lunar Orbiter imagery. On the near side, Bailly crater, named by Schröter in 1802, exceeds the 300-kilometer definition by three kilometers, and now bears both the legacy designation of Bailly crater as well as modern recognition as Bailly Basin.

Lunar gravity studies in the 21st century further investigated the gravity anomalies found by the Lunar Orbiter satellites. Particularly revealing were studies by the twin GRAIL satellites in 2011 that gravitationally revealed hidden basin structures as well as showing some near side craters smaller than 300 kilometers should also be geologically classed as basins. Two other near side features easily seen in a modest telescope are now also considered to be basins.

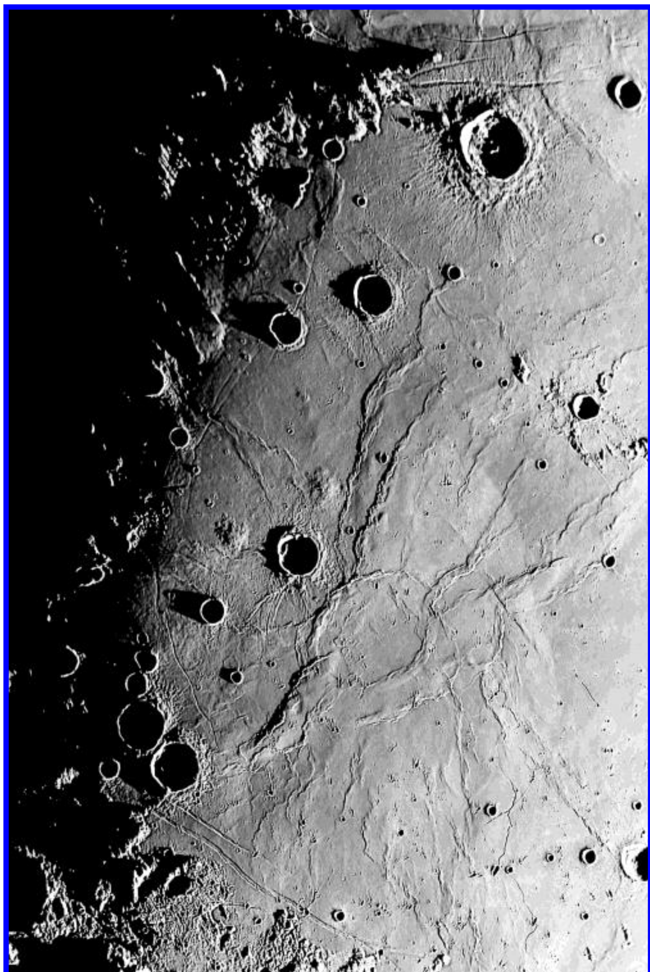
As our understanding of the Moon continues to evolve, it is now recognized that lunar basins can be smaller than the arbitrarily assigned 300-kilometer minimum diameter. The existence of gravity anomalies, and sometimes visible impact rings around some legacy craters under 300 kilometers in width, has elevated their geological status from crater to basin. The result is basins can no longer be defined by their size alone. The accompanying images show ten familiar near side features, some previously considered to be craters, that are now regarded as lunar basins.

A look at the classic southern terminator during the third quarter Moon reveals five lunar basins that laid in plain sight before being designated as a basin. The Rupes Recta Basin lies at the top left with the Deslandres Basin to its lower right. Familiar Clavius crater at lower right joins Bailly along the southern limb as basins. The Shiller-Zucchius Basin lies below elongated Schiller crater.



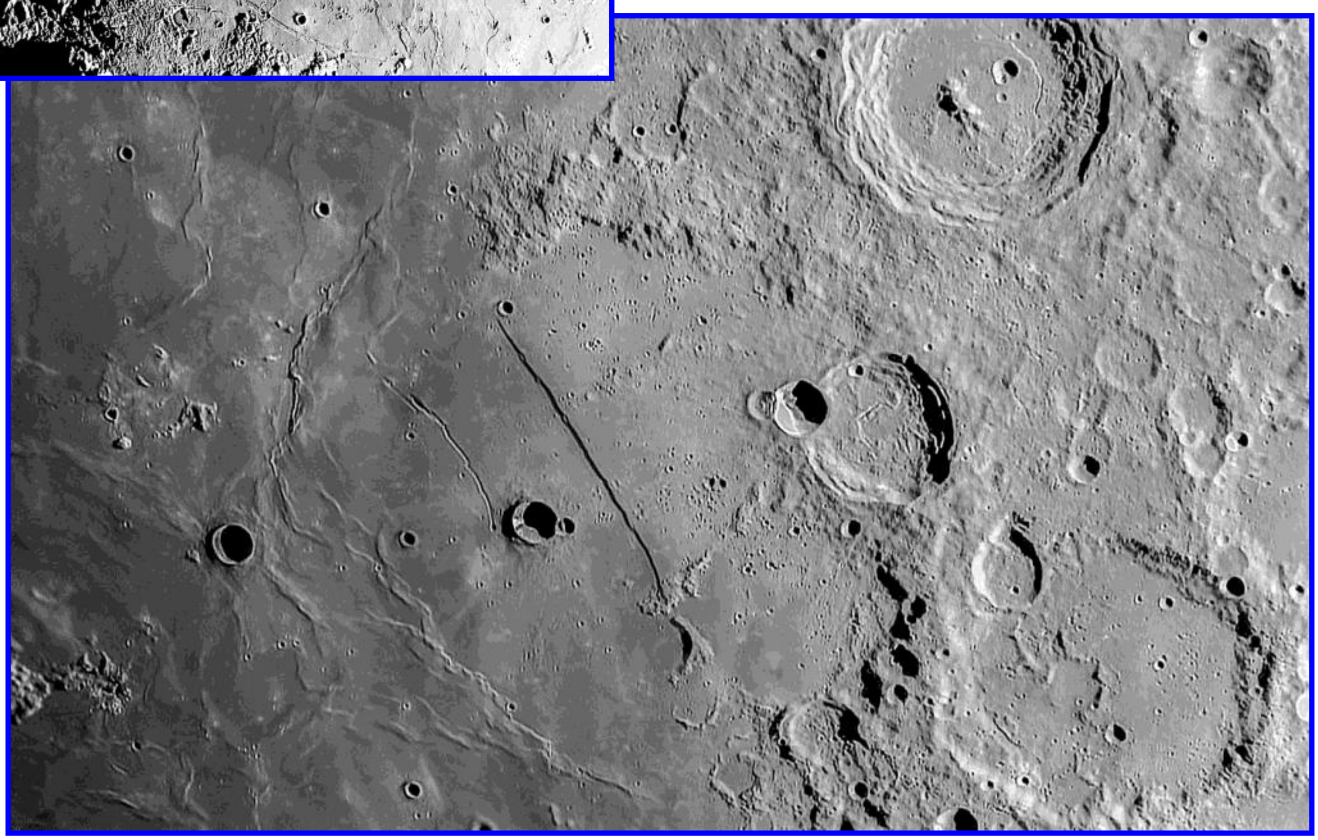


Shallow Janssen spans 191 kilometers but is only two kilometers deep. The lack of vertical relief makes Janssen hard to spot under high sun illumination, but sunrise shadows reveal its ancient and tortured interior. A faint hint of an outer impact ring suggests Janssen is a small impact basin.

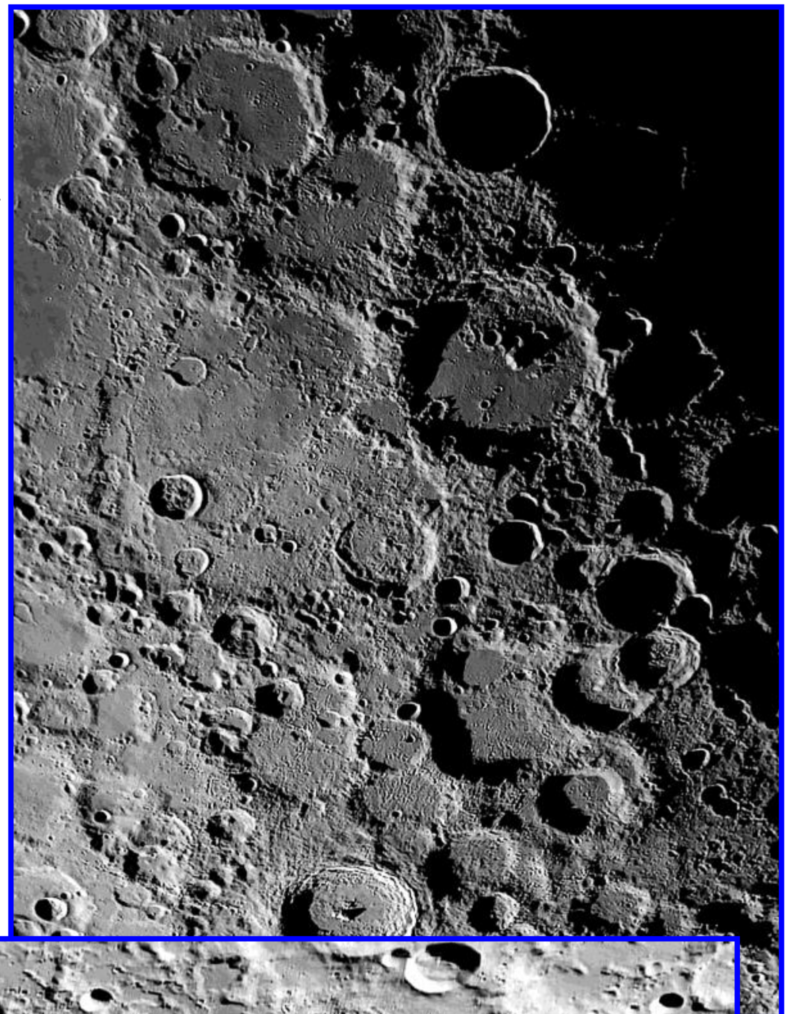


The ghost crater Lamont on western Mare Tranquillitatis is traditionally listed as 75 kilometers in diameter. Modern interpretation of Lamont's buried structure regards the outer southeastern ring arc as evidence of an outer impact ring, promoting Lamont to the status of a ghost basin. All photos by Robert Reeves

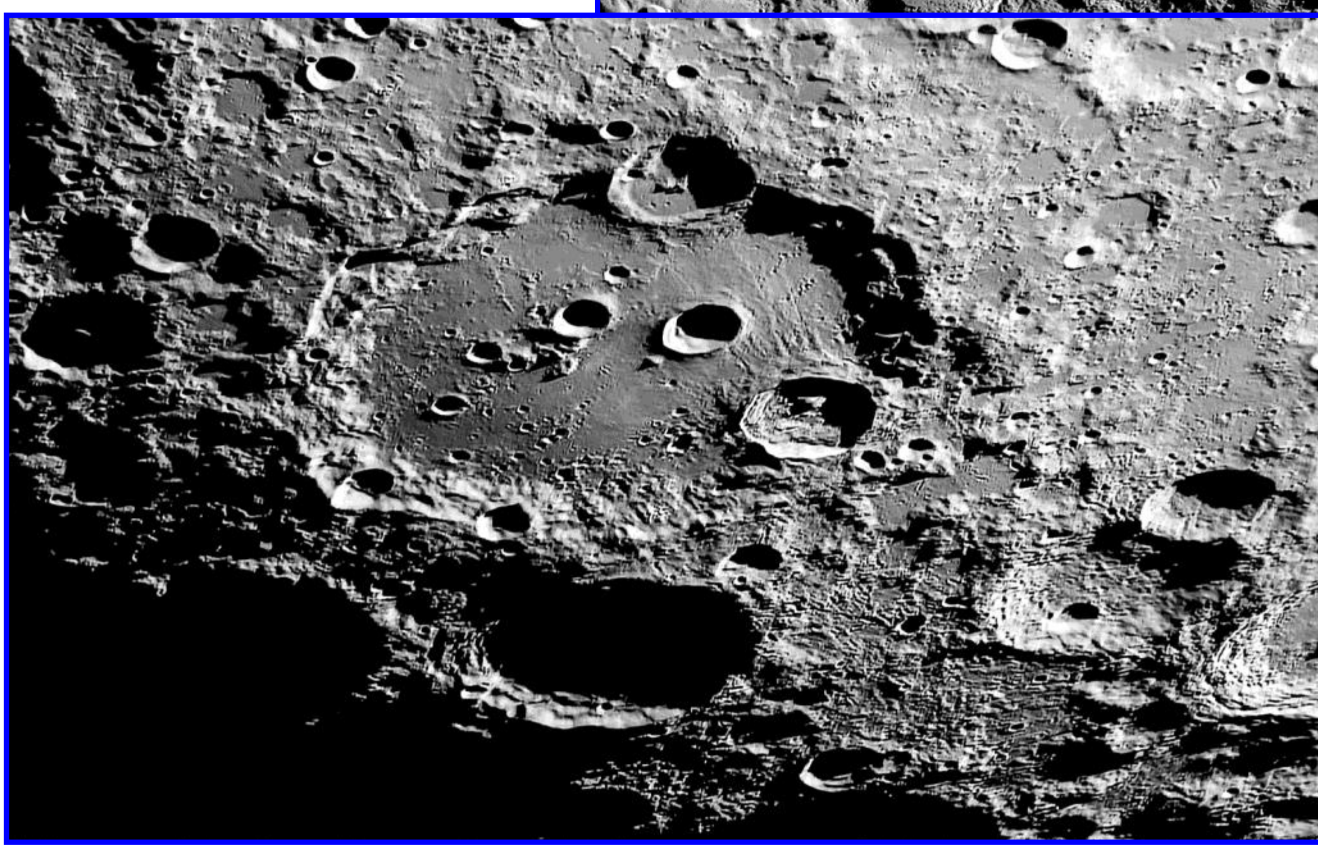
The arresting appearance of Rupes Recta on eastern Mare Nubium diverts our attention from the fact that Straight Wall lies within an unnamed 200-kilometer-wide crater. The eastern rim of the crater forms a horseshoe bay on the Nubium shoreline while wrinkle ridges on Mare Nubium complete the arc of the crater rim buried under Nubium basalt. Unofficially named "Ancient Thebit" by Chuck Wood, this feature is now regarded as a small basin.



Located 200 kilometers south of Rupes Recta, Deslandres crater spans 235 kilometers and was only recognized as a crater and officially named in the mid-20th century. Formerly unofficially known as Hell Plain for the 33-kilometer crater Hell within its ruined rim, Deslandres is now regarded as a basin.



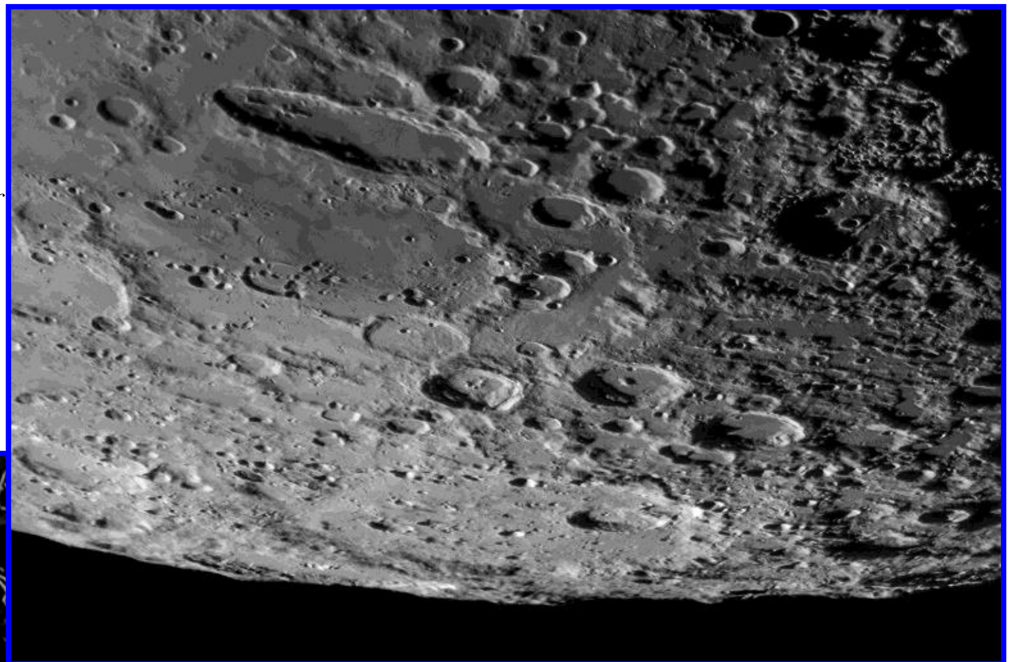
In the mid-20th century, 225-kilometer-wide Clavius was thought to be the largest crater on the near side. Now outsized by Deslandres, Clavius regains status by holding the dual designation as the legacy Clavius crater and Clavius Basin.

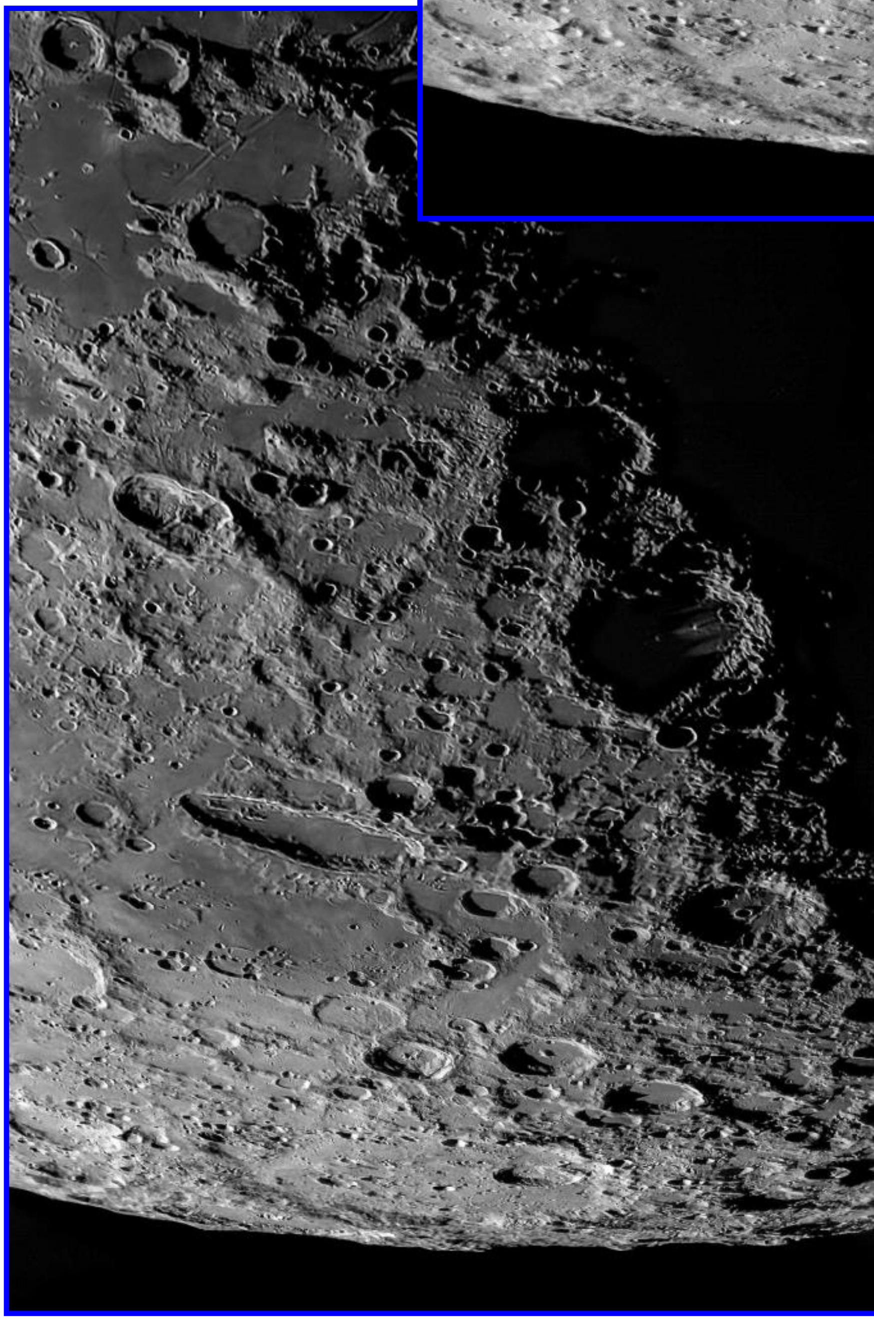


Lunar Topographic Studies

A Look At 10 Non-Traditional Lunar Basins

The 303-kilometer expanse of Bailly crater hugs the southwestern limb and plays hide and seek, depending on the current libration angle. Bailly gained basin status after the proclamation that any crater larger than 300 kilometers is a basin.

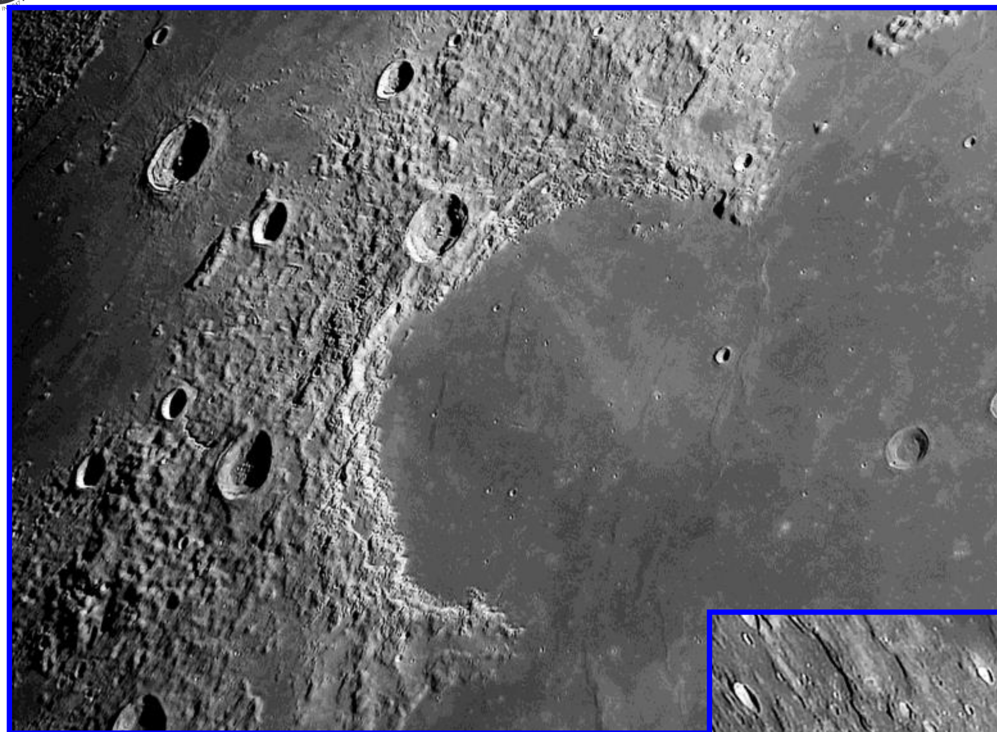




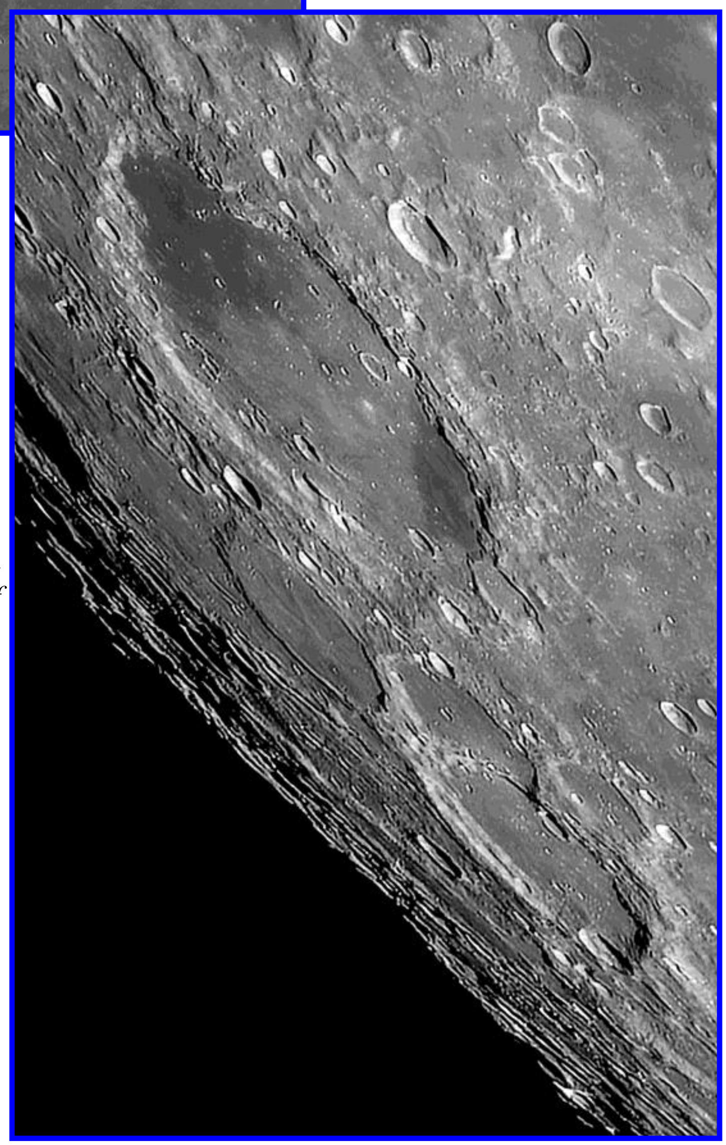
Visually recognized as a basin from its multiple impact rings, the Schiller-Zucchius Basin lies between cigar-shaped Schiller crater on the basin's northern rim and sharply defined Zucchius crater on the southern rim.

Lunar Topographic Studies

A Look At 10 Non-Traditional Lunar Basins



The horseshoe bay of Sinus Iridum dominates the northwestern shore of Mare Imbrium. Spanning 250 kilometers, the feature is now regarded as a basin.

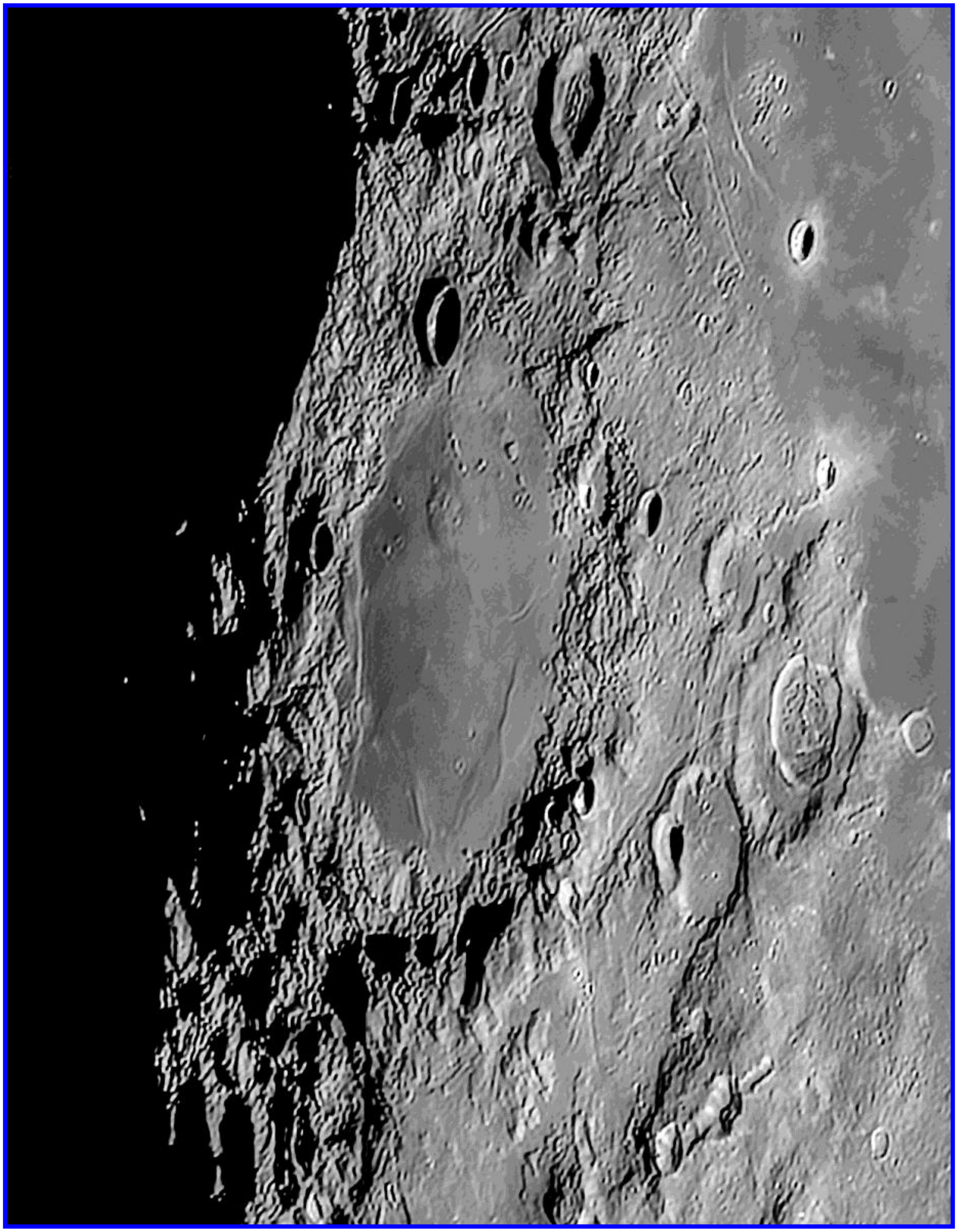


Shickard crater, with its mysterious two-toned basalt interior, spans 227 kilometers and joins the growing legion of large craters now recognized as basins.

Lunar Topographic Studies

A Look At 10 Non-Traditional Lunar Basins

Basalt filled Grimaldi crater displays an outer impact ring beyond its traditional 225-kilometer width, leading to its redesignation as a basin. If named today, but retaining the name Grimaldi, the features would likely be called Mare Grimaldi.



Lunar Topographic Studies

A Look At 10 Non-Traditional Lunar Basins

The Hunter’s Supermoon

Gregory T. Shanos

The Hunters Supermoon occurred at 7:26 am EDT (11h 26m UT) on Thursday, October 17, 2024, when the moon was 100% fully illuminated. However, it was daytime from my location and the moon was setting. This was the largest supermoon of the year. This moon was 14% larger at 33.5 arc sec in diameter. This image was taken on October 17, 2024 at 10:33pm local time or October 18, 2024 at 2h 33m UT when the moon was full at 99.4% phase and only 41°above the horizon. The seeing was rather good and the transparency was excellent under perfectly clear skies. However, it was rather windy. This was the orientation of the moon as it was rising. A Meade 60mm 260mm f/4 refractor was tracking the moon on an inexpensive Orion EQ equatorially mounted tripod. A ZWO ASI 178MM monochrome camera with an Optolong UV-IR cut filter and Firecapture v2.7.14 to acquire the video using an MSI GF 65 gaming computer. The SER video file was processed using Autostakkert 3.14 and Registax 6.1.08. Further sharpening and processing in Photoshop CS4. Image by Gregory T. Shanos, Longboat Key, Sarasota, Florida.

A Review of Multiband Image Processing Techniques For Lunar Surface Material Analysis

Darryl Wilson

Introduction:

The Lunar Observer (TLO) published a series of articles by this author from December 2021 to December 2022 that described several different multiband image processing techniques that can be used to map the material composition of the lunar surface. The articles covered mapping the concentration of titanium dioxide on the lunar surface, the color-enhanced mapping of surface minerals, the detection of unusual minerals on the surface, and the automated search over the entire lunar disk for a surface material selected from one particular location. Results from using each of the four techniques to process a five-band image set of the moon are presented here. The purpose of each is to extract and display information contained in the multiband image set that cannot be collected in a single grayscale image. Since detailed algorithm descriptions, including process flow diagrams, were included in prior TLO publications, interested readers can investigate the reference sections of those publications for further information, including source research papers for the algorithms.

Multiband imaging is the process by which two or more images are collected, processed, and analyzed in order to extract useful information. People most often focus on the use of three bands because three-band RGB cameras are ubiquitous. Two-band techniques are seldom used, and amateur astronomers do not typically think about four-band, or five-band, or many-band cameras. These articles were intended to illustrate that anyone with a telescope and a filter set that they are, in fact, the owner of a multi-band camera. All you need to do is process the data from multiple bands in a way that extracts the hidden information so that it can be displayed. Figure 1 is a list of the algorithms described in this paper.

Multiband Algorithm Synopsis

Algorithm	Purpose	# Bands	Answers What Question
1) Color Enhancement	Visual enhancement	3	What color is the lunar surface?
2) Two-Band Ratio	Titanium dioxide mapping	2	Where is material X?
3) Principal Component Transformation	Anomaly detection	2 or more	Where is the unusual stuff?
4) Spectral Angle Mapper	Surface material locator	2 or more	Where can I find more of this?

Figure 1
List of algorithms discussed with selected characteristics.

Equipment Used

All images were taken with a 3.2” f/5 refractor, a Celestron 274M CCD imager, and a ZWO motorized filter wheel. The plate (a.k.a. image) scale was 2.25 arcseconds/detector. The color filters used and exposure settings are detailed in Figure 2

Color Filter Wavelengths and Exposure Settings

Band	Filter	Wavelength	Exp.	Gain (dB)
1 UV	Astrodon UVenus UV filter	<400 nm SP	1/10	0.0
2 Blue	Orion #38A Blue	434 nm CWL	1/200	0.0
3 Green	Orion #58 Green	524 nm CWL	1/250	0.0
4 Red	Orion #25 Red	596 nm LP	1/624	0.0
5 NIR	Astronomic ProPlanet 807 IR	807 nm LP	1/200	0.0

Wavelength Throughput; SP=shortpass, CWL=center wavelength, LP=longpass

Figure 2
Five-band image acquisition and filter information.

It may be useful to note that there is nothing magic about this particular filter set. You will get interesting results with almost any filter set you own. In general, the more filters you use, the more materials you can discriminate in your image – as long as the filter bandpasses do not overlap too much. Although these techniques can all be used with 3-band RGB imagery, your results will improve if you include UV and/or NIR bands. Invisible information exists outside the visible spectrum and these algorithms will show it if you provide it. All images were taken with a 3.2” f/5 refractor, a Celestron 274M CCD imager, and a ZWO motorized filter wheel. The plate (a.k.a. image) scale was 2.25 arcseconds/detector. The color filters used and exposure settings are detailed in Figure 2. All images were taken from Marshall, VA – Lat. 39 N, Long. 77 W).

The Areas of Interest:

Figure 3 is a true-color RGB image of the moon. It was sharpened with Registax, but was not color enhanced. This is the natural color of the moon as perceived by the human eye. Close inspection reveals slight coloration in the Aristarchus plateau, as is the case when observing visually with a telescope.

Figure 3 has been labeled to highlight the three areas of examination. The following six red spots are included in the three areas:

1) Mons Gruithuisen Domes (γ δ gamma and delta)
2) Mons Hansteen (Earlier Hansteen-α)
3) Helmet
4) Southern Montes Riphaeus
5) Darney (χ τ chi and tau)
6) Lassel Massif

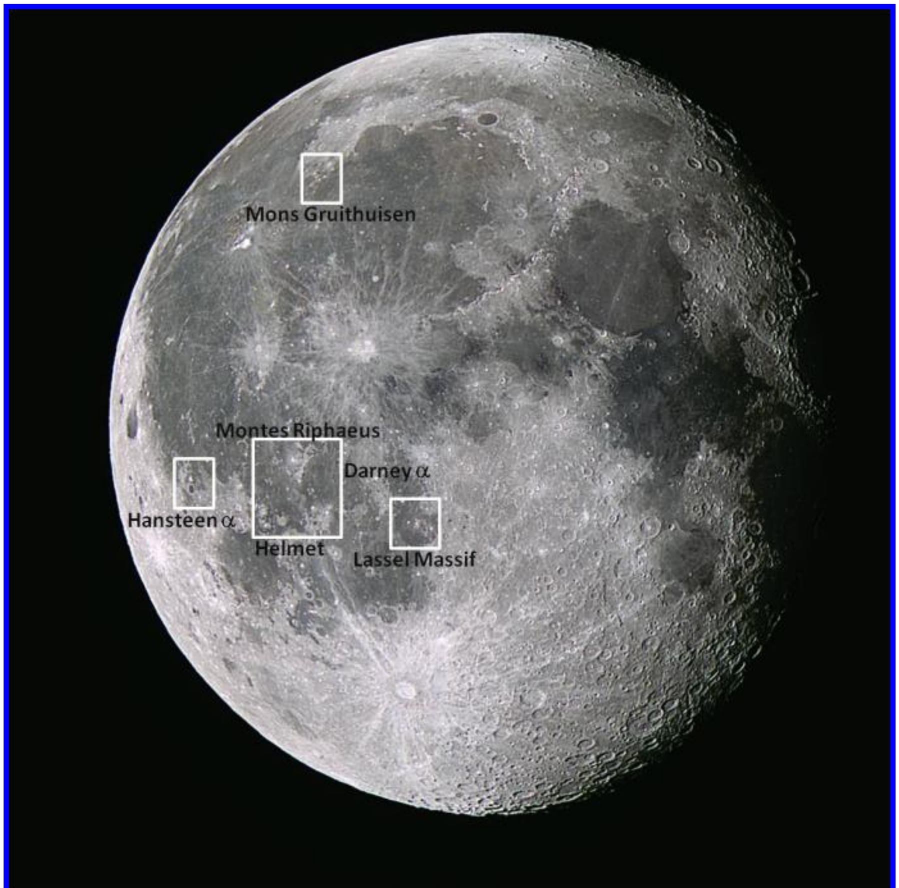


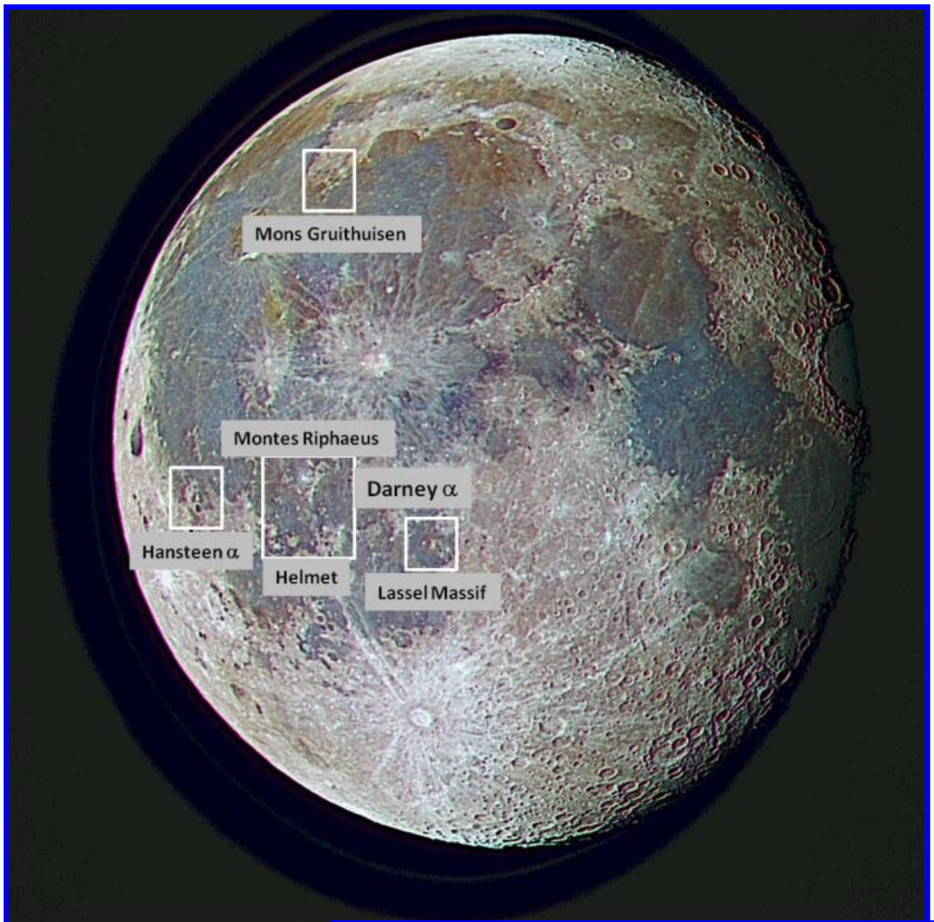
Figure 3
Locations of red spot areas examined in this paper. RGB composite taken 2024AUG22 from 0350 UT to 0352 UT. 3X3 sharpening filter applied.

The Algorithms:

A three-band HSV-based **Color Enhancement (**CE) technique was presented and explored in several issues of TLO, beginning in December 2021. The most obvious selenophysical relevance of the algorithm is that it enables the viewer to visually estimate the lunar surface content of titanium (Ti) and iron (Fe) oxides. Surface mining techniques to extract oxygen from these minerals were proposed long ago, so this surface material is a candidate for oxygen supply to a lunar base. In this issue, we revisit the usefulness and beauty of this method of processing and displaying lunar imagery.

Figure 4 is a typical color enhanced image of the moon. As was described in several issues of TLO [Refs. 4 - 9], blue color is indicative of Ti oxides. Brown colors are associated with low Ti oxide concentration.

Figure 4
Saturation stretched color enhanced (CE) image. RGB composite taken 2024AUG22 from 0350 UT to 0352 UT. HSV Saturation stretch applied. Registax dyadic default sharpening.



This algorithm was designed to be used with three band RGB color imagery. Since it doesn't use UV imagery, it does a poor job of displaying lunar red spots. One valuable use of this technique is to provide an information-enriched, color-consistent background for displaying other relevant information such as named lunar features. This is done in Figure 5. Later in this article we shall see a better example of this use.

Figure 5
Saturation stretched CE image with red spot areas located. RGB composite taken 2024AUG22 from 0350 UT to 0352 UT. HSV Saturation stretch applied. Registax dyadic default sharpening.

This algorithm is flexible in several ways. Some were explored in the TLO articles, but one was not included. Figure 6 shows that the degree of saturation can easily be adjusted to give anything from a subtle visual effect of coloration, to a strongly colored image that makes every nuance easily visible. The range extends well beyond that of Figure 5(e), but for aesthetic reasons we end with that one.

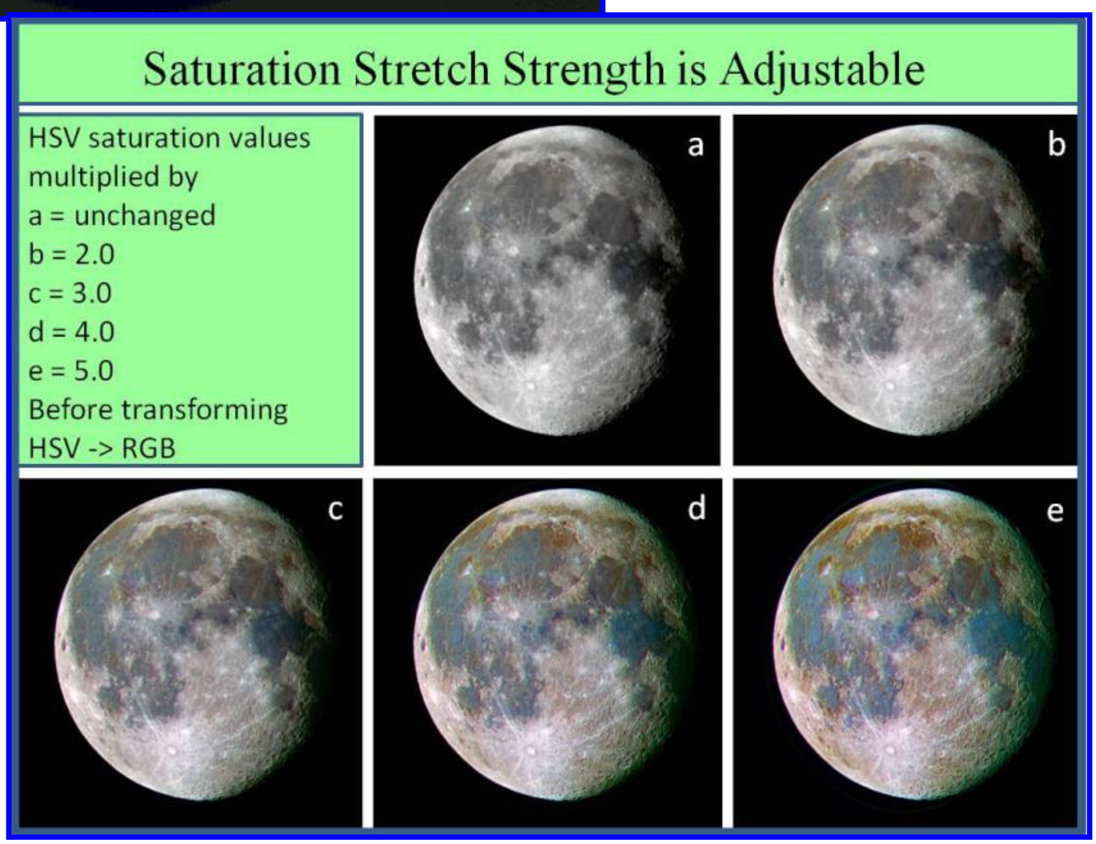


Figure 6
Range of saturation stretches from histogram mapping slope=1.0 (unchanged) to histogram mapping slope=5.0 (saturation band values multiplied by 5.0 before HSV -> RGB backtransformation). RGB composite taken 2024AUG22 from 0350 UT to 0352 UT. HSV Saturation stretch applied. Registax dyadic default sharpening

The **Two-Band Ratio** (TBR) algorithm **c**an be used for a variety of purposes including mineral mapping and quantification. The May 2022 issue of TLO presented a previously published two-band algorithm that was used to quantitatively map the titanium and iron content of the lunar surface. In that publication, a somewhat mismatched set of spectral bands was applied to generate a qualitative map of iron on the surface of the moon, with considerable success. In this paper, we use the two-band ratio approach to locate and map lunar dome material.

This algorithm takes advantage of the wavelength-dependent differences in the absorption of light by different materials. It is the simplest of a class of two-band algorithms that employ band-algebra to generate a gray-scale output image that highlights a particular surface material of interest.

Figure 7 displays half of the possible band ratios for the 5-band data set. The lower half of the triangular matrix (not displayed) is simply the reciprocal of the upper half. Below, we examine one of the band ratios in some detail. Perhaps the most important fact to note about Figure 7 is the variety of brightness patterns that have been generated by this simple operation. Each of these ratio images highlights potential surface features of interest.

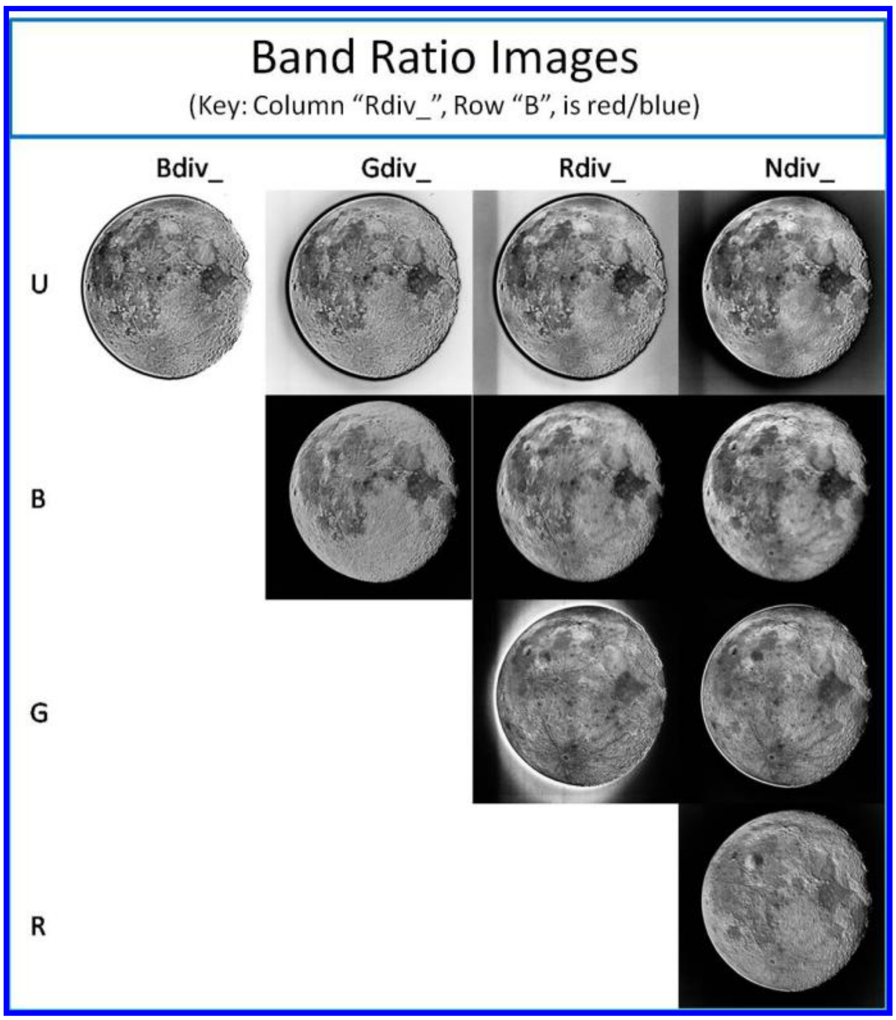


Figure 7
Band-ratio thumbnails. Upper triangular matrix of band-ratio images for the five-band image set. Column is the numerator; row is the denominator. Naming convention is <Numerator>_div_<Denominator>. UV band imaged on 2024AUG22 0349 UT. Blue band imaged on 2024AUG22 0350 UT. Green band imaged on 2024AUG22 0351 UT. Red band imaged on 2024AUG22 0352 UT. NIR band imaged on 2024AUG22 0354 UT

We will examine the green / ultraviolet (G/U) ratio, displayed in Figure 8, to locate lunar red spots.

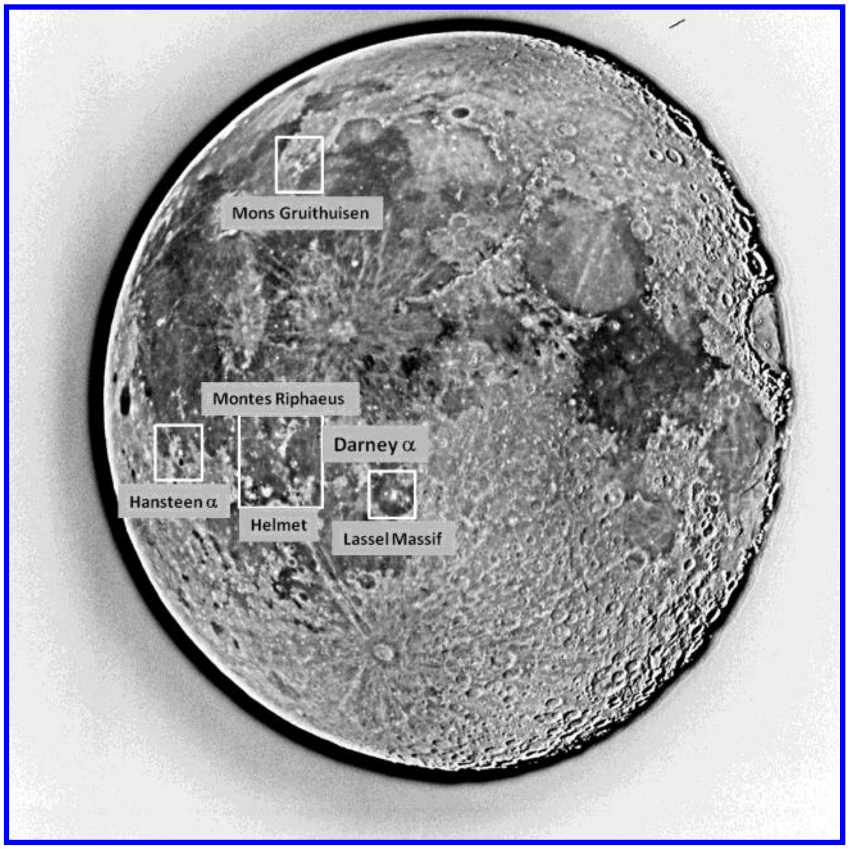
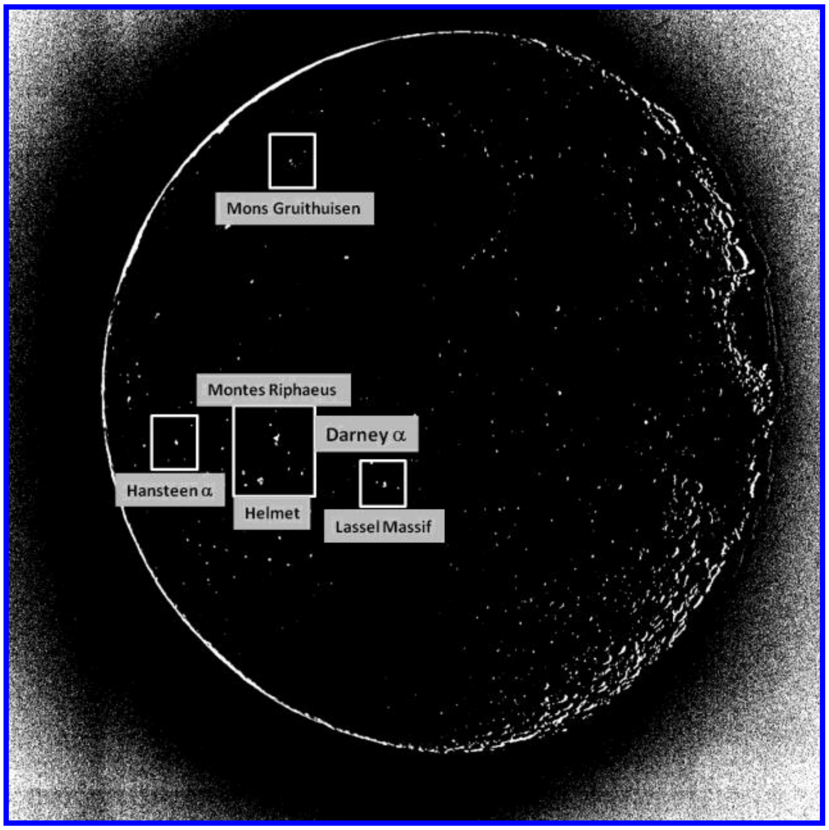


Figure 8
G / U
Band ratio (BR) of the green and the ultraviolet bands.

"Red spot" is actually a misnomer: even in color-enhanced RGB imagery the areas are not noticeably red to the human eye. The distinguishing radiometric characteristic of lunar red spots is that they are strong UV absorbers. They only appear red if ultraviolet image data is fed to the green and blue display channels. This suggests that we might obtain color display results similar to those of the LRO team [Ref. 1, 3] by forming either a G:B:U or a G:U:U color composite. More importantly, a G/U band ratio image might be a good locator of "red spots". It is.



The histogram of Figure 8 can be adjusted to highlight red spots. Figure 9 is an attempt to highlight all six of the red spots while minimizing the number of false alarms (e.g. the arc at the western limb and the crater walls near the terminator). The results are quite good for a two-band algorithm.

Figure 9
BR image histogram stretch adjusted to approximate Figure 13 brightness range.

The **Principal Component Transformation** (PCT) can be used to automatically locate spectrally anomalous materials in a scene. The June and July 2022 issues of TLO covered this algorithm in some detail. In this paper, we examine the results after applying it to our 5-band image set. Figure 10 shows the output for all five of the bands (Note: bands 1 and 2 have been displayed as negatives of their output values in order to facilitate easy comparison of scene content). Each of the PC output bands contains unique, potentially valuable information, and it is always worthwhile to examine them closely – especially the higher numbered bands.

As noted in the TLO articles, the PCT is a statistics-based, not a physics-based algorithm. It is driven entirely by the content of the image, so its output depends on what is in the field-of-view. Depending on the mix of materials in your image, it may or may not help you locate exactly what you want to find.

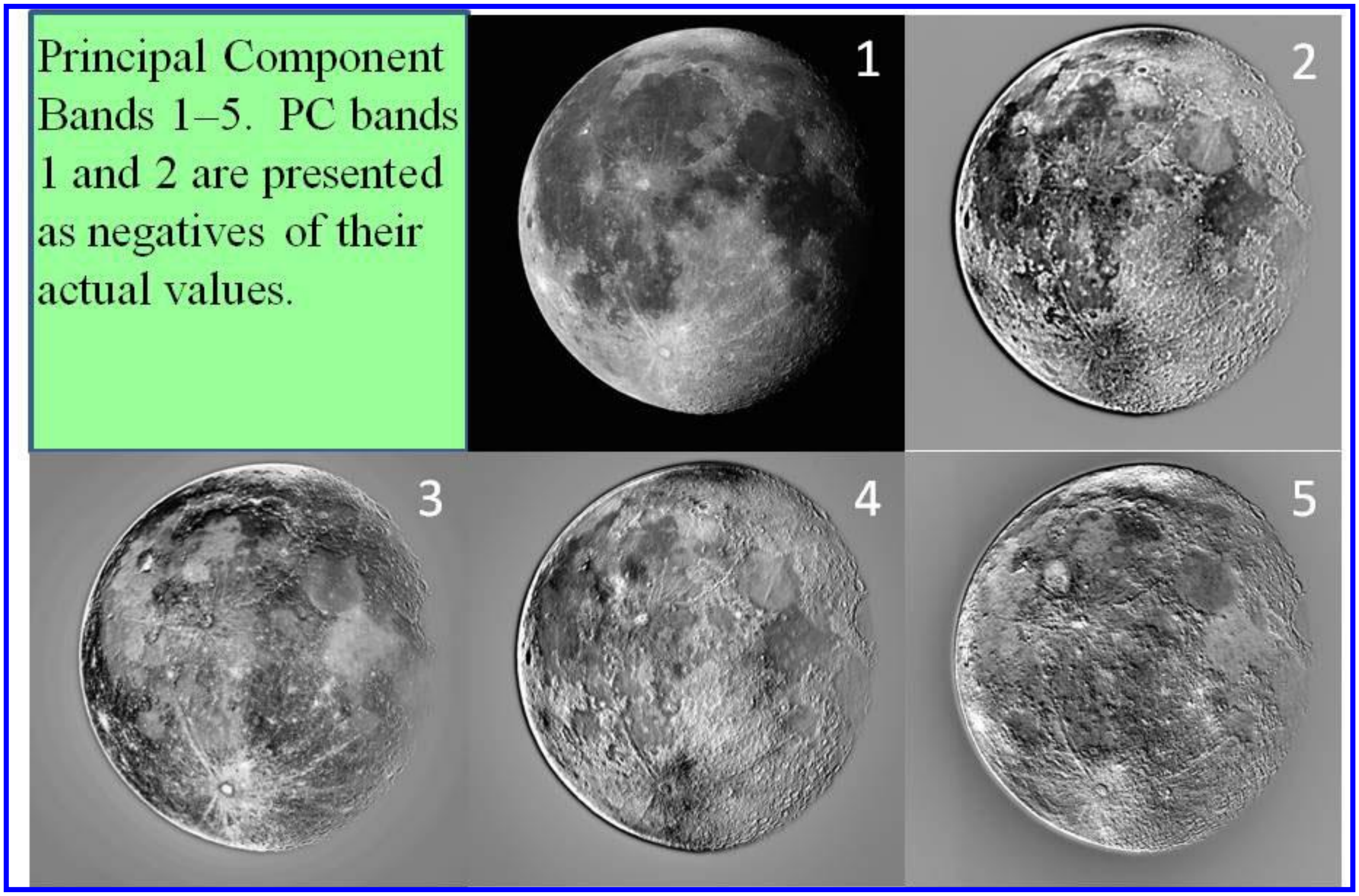


Figure 10
Principal component transformation (PCT) of all five bands. Bands 1 and 2 negated for easy visual comparison.

Fortunately for us, in this case, PC band 2 did a fairly good job of highlighting a number of lunar red spots. Figure 11 shows the results for the entire lunar disk, and Figure 12 highlights the histogram-thresholded red spot areas. The results are visually comparable to the G/U band-ratio algorithm.

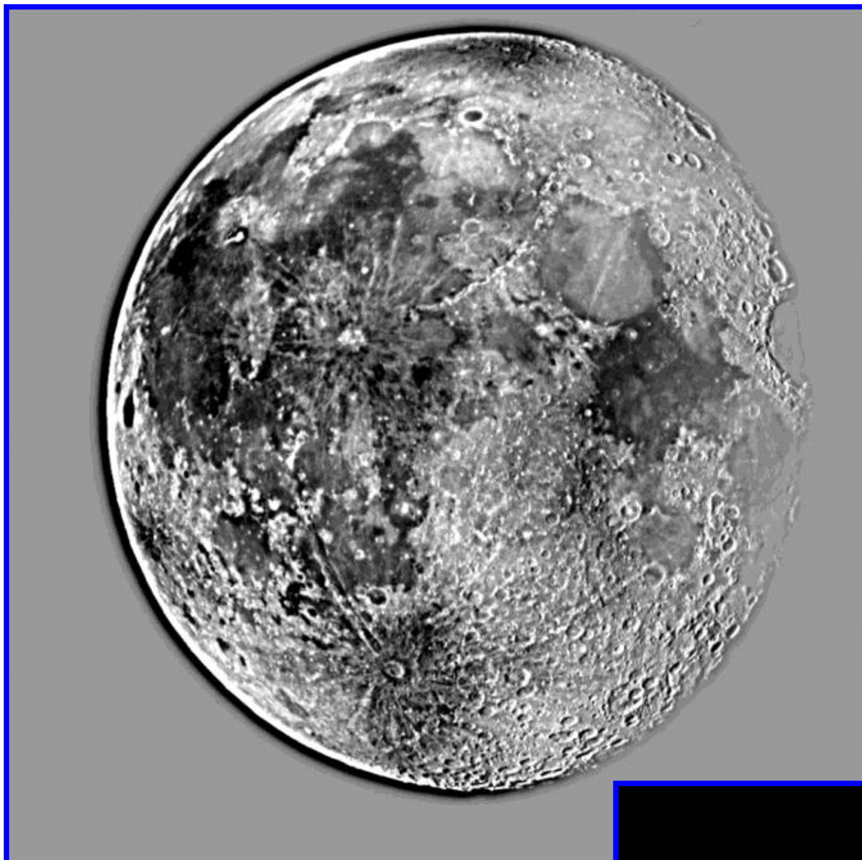


Figure 11
The negative of PC band 2.

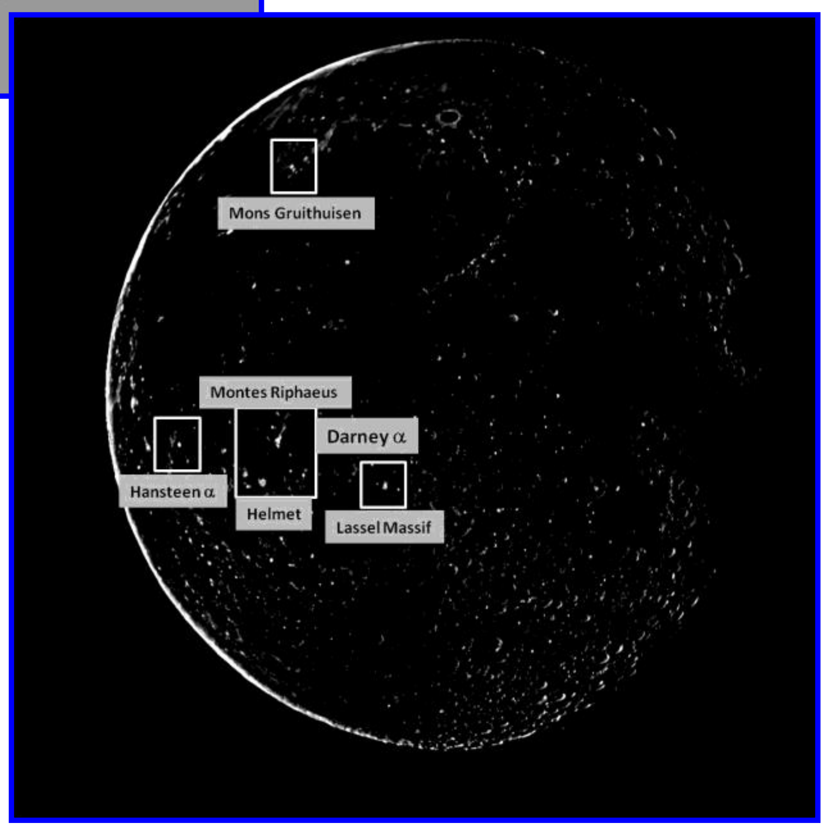


Figure 12
The negative of PC band 2 histogram stretch adjusted to approximate Figure 13 brightness range.

The somewhat cryptic sounding **Spectral Angle Mapper** (SAM) gives us the ability to select a pixel in our image and automatically locate other pixels that are similar. When used with multiband data that covers regions outside the visible spectrum, it makes correlations that are completely invisible to the human eye, and eliminates most matches that otherwise look exactly the same to us (a.k.a. false alarms). In TLO December 2022, several examples were given of its use in locating selected lunar features. Here, as with the previous algorithms, we focus on locating lunar dome material.

A single feature vector was extracted from (col 312, row 577) of the 5-band image stack. SAM was used to search the entire image, scoring every location according to the goodness of match with the selected vector. Figure 13 shows the full disk result, and Figure 14 shows the histogram-stretched result. As with the other algorithms, the results are quite good. Qualitatively, this result appeared to be the best of the three (BR, PCT, and SAM).

Figure 13
Spectral angle mapper (SAM) values relative to one pixel (col 312, row 577) from Helmet. Spectral angle values calculated using all 5 raw image bands.

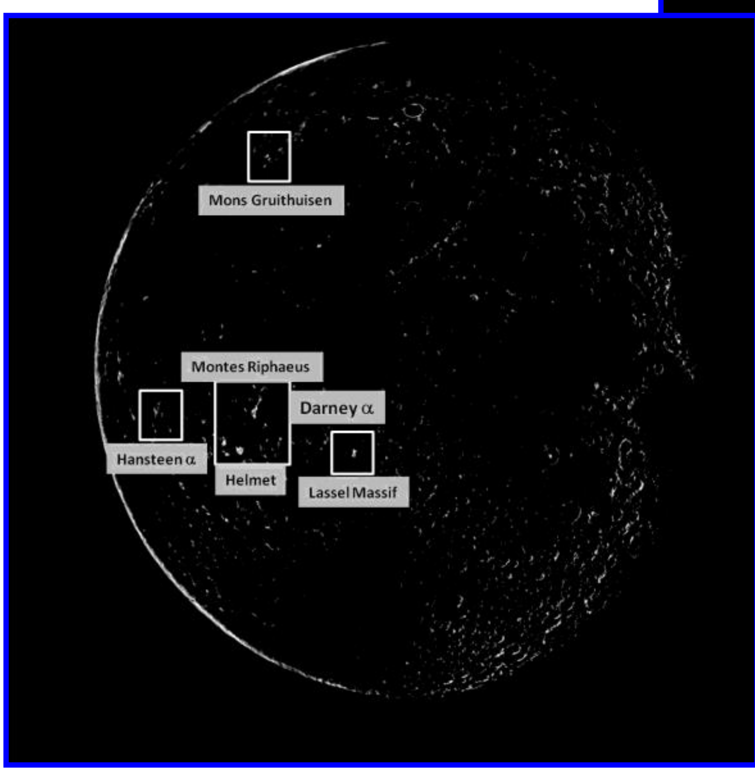


Figure 14
SAM image from Figure 13. Histogram stretch adjusted to display lunar red spots while minimizing false alarms.

Hyperspectral image processing experts may notice that we applied SAM to the raw image stack, not the PC output stack. Application of SAM to the PC image stack is beyond the scope of this article, but the author tried it and the results were clearly superior to any of the three algorithms presented here. If you know how to do it, that is certainly the way to go.

Finally, a CE image may be used as a backdrop for presentation of other information. A CE image provides more contextual information that often enhances the presentation of study results. Figure 15 shows how the SAM band-thresholded results might be combined with a CE image. This is not a scientific point; it is a matter of style. You be the judge.

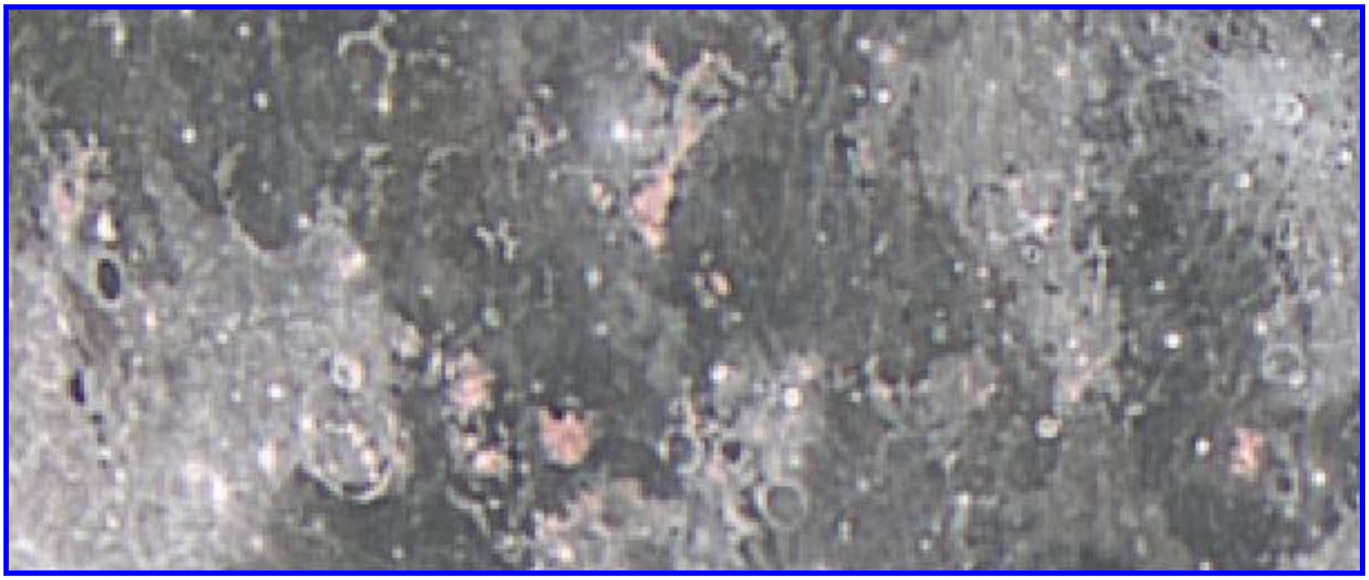


Figure 15
Hansteen-a, Helmet, Montes Riphaeus, Darney, and Lassel Massif areas. CE image combined with SAM threshold image for illustrative purposes.

Discussion:

The TBR, PCT, and SAM algorithms all achieved some success at finding lunar red spots. TBR was expected to work because we divided by a band (UV) that contained a red spot absorption feature. PCT worked by chance. If we had used a long focal length scope with a small field of view, there would have been no assurance that any of the output bands would have highlighted red spots. Since we selected a feature vector from a known red spot as input to SAM, we expected good results and the algorithm indeed performed well.

With the exception of CE, all of the algorithms found Mons Gruithuisen, Mons Hansteen, Helmet, Mons Riphaeus, Darney, and Lassel Massif.

What about false alarms? There were some differences in false alarm performance of the three algorithms. All three generated false alarms at the lunar limb and at the rims of craters near the terminator. This is not unusual. Slight band-to-band misregistration often causes algorithms to false alarm on edges in the scene. These false alarms are often easy to visually ignore. It is fair to say that these algorithms all have the potential to assist a selenologist in significantly narrowing the scope of the area to be searched when looking for same material of interest on the moon. They point directly to small areas that deserve further investigation.

While discussing false alarms, we should note that some of the bright pixels in the thresholded images that are not in our named study areas are, in fact, other red spots. They are valid detections that we have simply not discussed because the purpose of this article is to review some image processing techniques, not to make a comprehensive inventory of lunar red spots. So the results of all three algorithms are really a little better than they might appear.

Summary:

This article reviewed four multiband image processing algorithms that were covered in technical detail in previous issues of TLO. We examined the results of applying each of the algorithms to locate red spot areas on the moon. The equipment used to collect the images was listed. We noted that this filter set is not special; almost any set will give useful results. We defined the study areas to include six distinct red spot areas. Each of the algorithms was briefly described, and processing results from each of the four was presented as both a full disk output image, and a histogram thresholded image that highlighted the red spots that were detected. The results were good for the TBR, PCT, and SAM algorithms. We explained that RGB CE was ineffective because red spots, by definition, have their primary absorption band in the UV and CE only works with visible light image bands. We briefly discussed false alarms that were present in all three histogram thresholded images, noting that they were not particularly troublesome. Some of the unlabeled bright pixels in the threshold images were actual red spots that we didn't use – not false alarms. As an afterthought we mentioned that it is known in the hyperspectral community that use of the PCT image stack with the SAM algorithm will give much superior results; this was verified but not illustrated in this paper. Finally, the reference section contains a complete list of TLO articles on the topic of multiband image processing to which the interested reader may refer for detailed algorithm descriptions and other technical information.

References:

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2) Rukl, Antonin, Atlas of the Moon, Kalmbach Publishing Co., 1992.

3) Y. Shkuratov, et. al., "Comparison of lunar red spots including the crater Copernicus", ICARUS, p. 125 – 139, 3 March 2016.

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5) Wilson, Darryl G., "A Basic Color Enhancement Technique for Lunar Surface Material Discrimination, RGB->HSV; enhance S; HSV->RGB", December, 2021, "The Lunar Observer", p. 5-7.

6) Wilson, Darryl G., "A Sharpening Technique in HSV Colorspace for Lunar Surface Material Discrimination, RGB->HSV; enhance S; replace V; HSV->RGB", January, 2022, "The Lunar Observer", p. 7-10.

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

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

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

10) 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", p. 22-27.

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

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

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

14) Wilson, Darryl G., " Insertion of Principal Component Bands Into the HSV Color Enhancement Process Flow", September, 2022, "The Lunar Observer", p. 29-32.

15) Wilson, Darryl G., "Saturation Enhanced Image of the November 2022 Lunar Eclipse", December, 2022, "The Lunar Observer", p. 27.

16) Wilson, Darryl G., "Spectral Angle Mapper - A Hyperspectral Algorithm to Generate Surface Material Maps", December, 2022, "The Lunar Observer", p. 32-41.

Wrinkle Ridges Around Laplace F

Alberto Anunziato

It is amazing how the surface of the Moon changes with changes in illumination. I know, I am stating an obvious truth that you already know. But it is still an amazing fact, how the perspective changes and how we perceive the maria areas as a dark mirror of lava and the next night we see a fleeting mountainous landscape. The case of Sinus Iridum is paradigmatic, both the bay and its surroundings look like a dark ocean and yet it is full of small elevations, like those we tried to report in IMAGE 1, where you can see the surroundings of Laplace F (6 kms in diameter), east of Sinus Iridum and south of Montes Recti. These are two ridges that seem to embrace Laplace F. One is lower, located to the east of the crater, and has a higher area (the crest), which seems to run through the center of the arc (the inferior, lower and wider component of the wrinkle ridges), while the one running from west to east (to the north) is perceived as higher, with a rather pronounced crest running along the northern slope. This crest looked high at the time of observation, not only because of its brightness, but because the shadow of the arch to the north widened in the part of said crest (as if the shadows of the arch and crest were added together). Further east, in the area where both wrinkle ridges seem to touch, there is a crest, also quite pronounced, which projects a small shadow inside the arch (a feature not very common to observe with my small telescope).

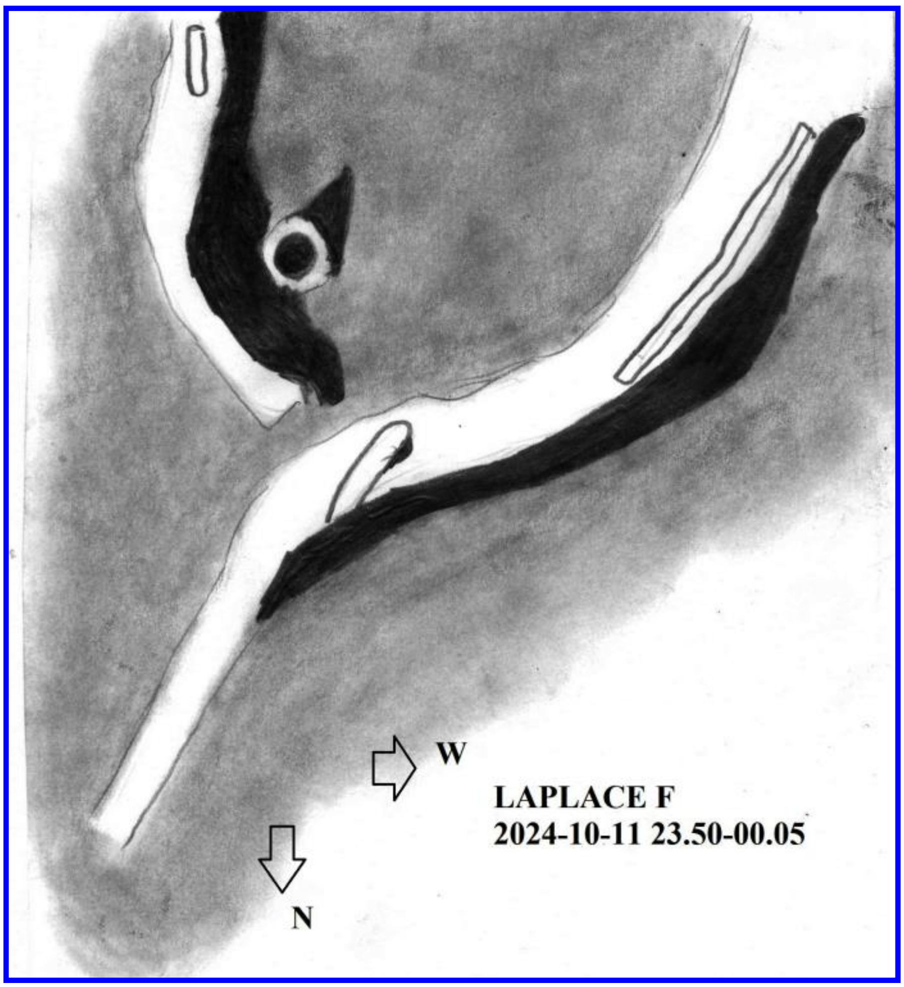

Image 1, Dorsa Laplace, Alberto Anunziato, Paraná, Argentina. 2024 October 11 23:50-00:05 UT. Meade EX105 Maksutov-Cassegrain telescope, 154x.

As usual, I went to test the precision of my observation with the Photographic Lunar Atlas for Moon Observers, by Kwok Pau. I could not find both ridges complete, but I did find an image on page 263 of Volume 2, a cutout of which is IMAGE 2. In IMAGE 2, we do not see the southern part of the wrinkle ridge east of Laplace F. The comparison is interesting to test the visual observation. Both wrinkle ridges appear much more curved visually, which I already knew from previous observations. The ridge east of Laplace in IMAGE 2 has a not very high crest that I was not able to observe. In IMAGE 1, the ridge to the north appears with a simplified structure, as a wide bright arch in which two crests' segments stand out, while in IMAGE 2 it is shown as it really is, with a more complex structure with several quite high crests. I marked with the numbers 1 and 2 in IMAGE 2 what would be the crests that appear in IMAGE 1, the brightest ones in principle (since they are visually distinguishable). The number 1 is the most prominent in IMAGE 2 and corresponds to the crest that we drew on the northern slope in IMAGE 1. The 2 would be, due to its internal orientation in the arch, the one that appears further east in IMAGE 1. One last consideration. In an excellent image like the one of the Kwok Pau Atlas, it can be seen that both ridges have quite different topography. The one that runs from north to south is more sinuous, with gentler slopes and not so steep crests, the one that runs from east to west presents a narrow arch and a plurality of very prominent crests, like a mountain range. Could these differences be due to geological causes?

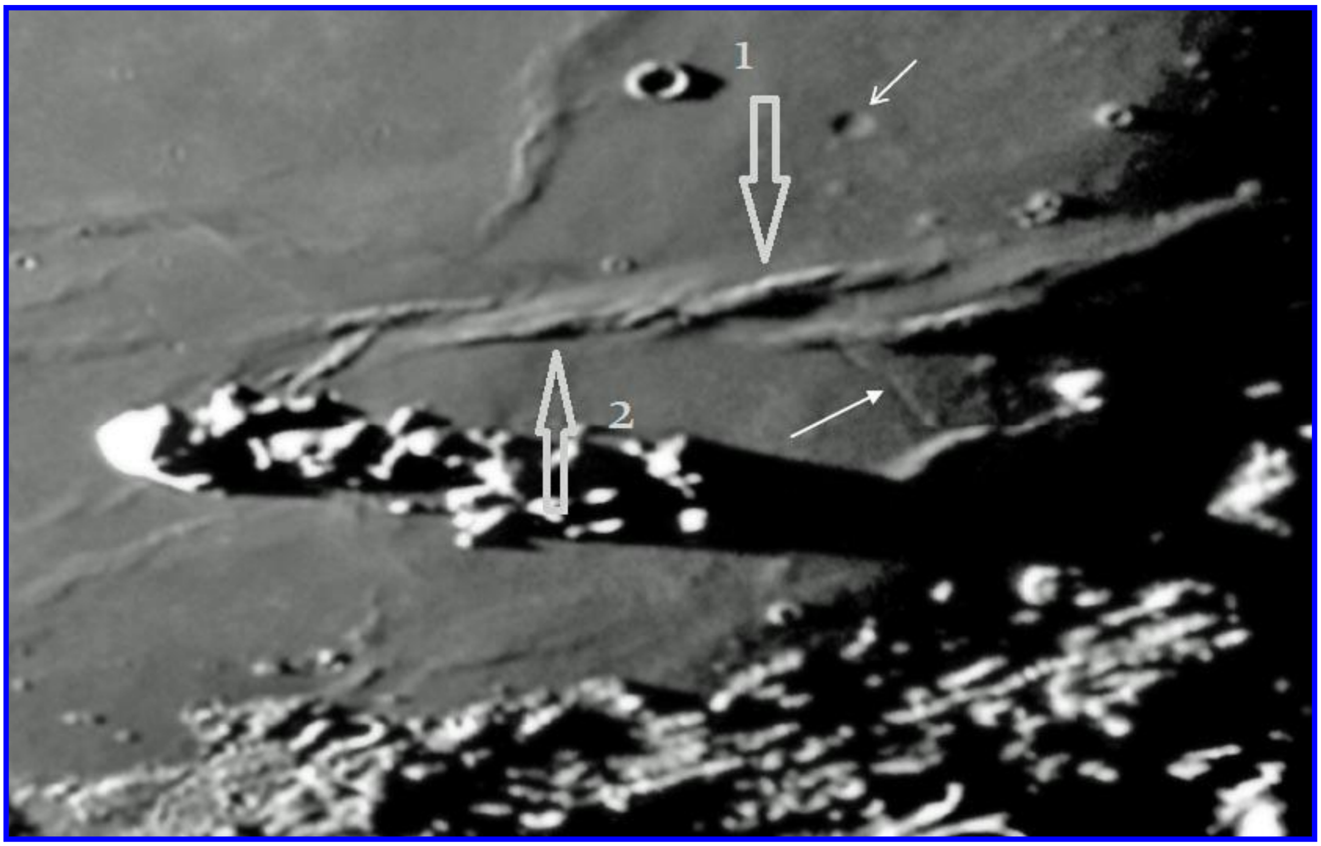

Image 2, *"Photographic Lunar Atlas for Moon Observers" by Kwok Pau, Volume 2, page 263. North is down, west is right.*

Focus On:
Archimedes, Autolycus and Aristillus: The Magnificent Three

Alberto Anunziato

1.-TIMELINE.

This is one of the most interesting areas of the Moon's near side, without a doubt. In the average field of view of the images we present in this edition of the Focus On Section, the topographic and geological variety of what we see is incredible. That is why we will concentrate on 3 magnificent specimens of craters, Archimedes, Autolycus and Aristillus, although we will briefly refer to the selenographic features that surround them.

Archimedes is, evidently, the largest crater of the trio (83 km in diameter) and also the largest crater in the entire Mare Imbrium. To the east of Archimedes we find two craters of similar size: Aristillus (55 km in diameter) to the north and Autolycus (39 km in diameter) to the south. Which is the most recent? Because of the delicacy of its features, characteristic of Copernican craters, one could say that it is Aristillus... and it really is. Charles Wood beautifully summarizes the stratigraphy of the área: "With the data collector, a detailed chronology of events can be inferred for this area of the Moon. Approximately 3.84 billion years ago the Imbrium basin formed, creating the Apennine Mountains. A half billion years later, Imbrium basalts flooded the area. Therefore, at some point between these two events, the Archimedes impact occurred. Thanks to the Apollo 15 samples, we can assume that more than a billion years later-2.1 billion years ago-a projectile excavated Autolycus out of the Apennine Bench, and that nearly another billion years later Aristillus was formed".

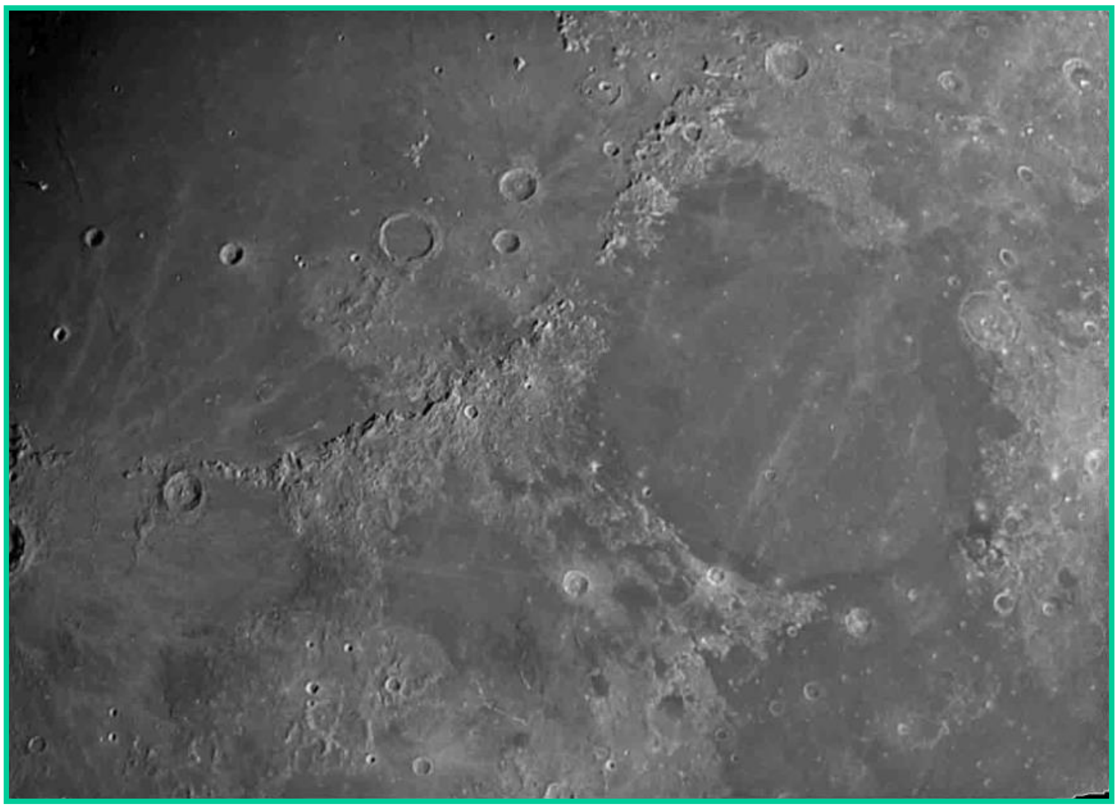

Image 1, Bessel, *Román García Verdier, Paraná, Argentina. 2020 September 26 23:57 UT. 180 mm Newtonian reflector telescope, QHY5-II camera.*

Focus On: Lunar Topographic Studies

Archimedes, Autolycus and Aristillus: The Magnificent Three

2.- ARCHIMEDES, THE RARITY

The area we are dealing with is different from the rest of Mare Imbrium: "Mare Imbrium's eastern reaches are of a lighter tone than the rest of the sea. Through binoculars it will be seen that much of the brightness is made up of ray material ejected from the impact craters Aristillus and Autolycus along with rays from Copernicus in the southwest and the uplands of Montes Archimedes to the southeast" (Grego).

Archimedes, "the finest object in the Mare Imbrium" (Elger) is "a superb crater. With is flat, lava-flooded floor and its extensive, well-structured walls, it dominates the plains of southeastern Mare Imbrium" (Grego). The walls are thick on the outside and with a complicated system of interior terraces that is interrupted by a much higher than normal floor, as if flooded... "It was recognized early in that Archimedes (like Plato to the north) must be partially flooded with mare lavas. Measurements of the length of the shadow cast by its rim onto the surrounding mare surface demonstrate that Archimedes's floor is at about the same level as the surrounding Mare Imbrium. There are no breaches in the crater's walls, so Archimedes must have been flooded by lava that rose up through fractures in the basin and crater floor. If Archimedes were a typical Copernicus-like complex crater, it would be 4 km deep and have a 2-km-high central peal. But the crater is only about 1.6 km deep, so it must be filled by 2.4 km of lava (4-1.6=2.4), wich means that its 2-km-high central peaks are completely buried!" (Wood). Both the intricate, partially visible walls and its lava-covered floor are seen in quite some detail in **IMAGE 2**. Garfinkle describes its walls like this: "The crater has thick terraces around most of the interior walls, but there are two noticeable breaks in the terraces. In the north the walls are smoothed with ejecta materials and in the south, mounds of materials appear to be spilling out of the crater to form Montes Archimedes".

An interesting question I show smooth is the floor of Archimedes, which at first glance is seen as dark carpet of lava. According to Grego: "apart from three very tiny craters near its inner wall, Archimedes' floor appears flat and topographically featureless even at very low angles of illumination, using a 150mm telescope with a high magnification". In **IMAGE 2**, 6 craters are clearly visible on the western part of the floor, which agrees with what Garfinkle says: "there are only about six observable small impact craters on the Archimedes' floor" although there are several more small, less obvious craters, as we see in IMAGE 3. These small craters "are all surrounded by narrow, rayless, high-albedo ejecta blankets. Look for one pair in the northwest area, another pair in the southwestern part of the floor, and the other two are near the eastern wall, with one crater of this last pair almost up against the base of the wall" (Garfinkle). Is there a crater chain in the center of Archimedes' floor? It seems to be visible in **IMAGE 3** and especially if we zoom in on the area in **IMAGE 4**. The fact is that the uniformity of Archimedes' floor seems to be deceptive and can be a fascinating subject of research, at least it was for Mr. Stanley Williams, who devoted almost a lifetime to its recounting, as Elger recounts: "The most noteworthy features in connection with this formation are the crater-cones, craterlets, pits, white spots, and light streaks which figure on the otherwise smooth interior. Mr. T. P. Gray, F.K.A.S., of Bedford, who, with praiseworthy assiduity, has devoted more than ten years to the close scrutiny of these features, Mr. Stanley Williams, and others, have detected four crater-cones on the E. half of the floor, and about fifty minute craters and white spots, also probably volcanic vents, and a very curious and interesting series of light streaks, mostly traversing the formation from E. to W. A little E. of the center is a dusky oval area about 6 miles across, and S.W. of this is another, much smaller. Under some conditions of illumination the two principal light markings may be traced over the W. wall, and for some distance on the plain beyond". Undoubtedly, an interesting subject for a comparative investigation between ancient visual observations and our modern photographic images.

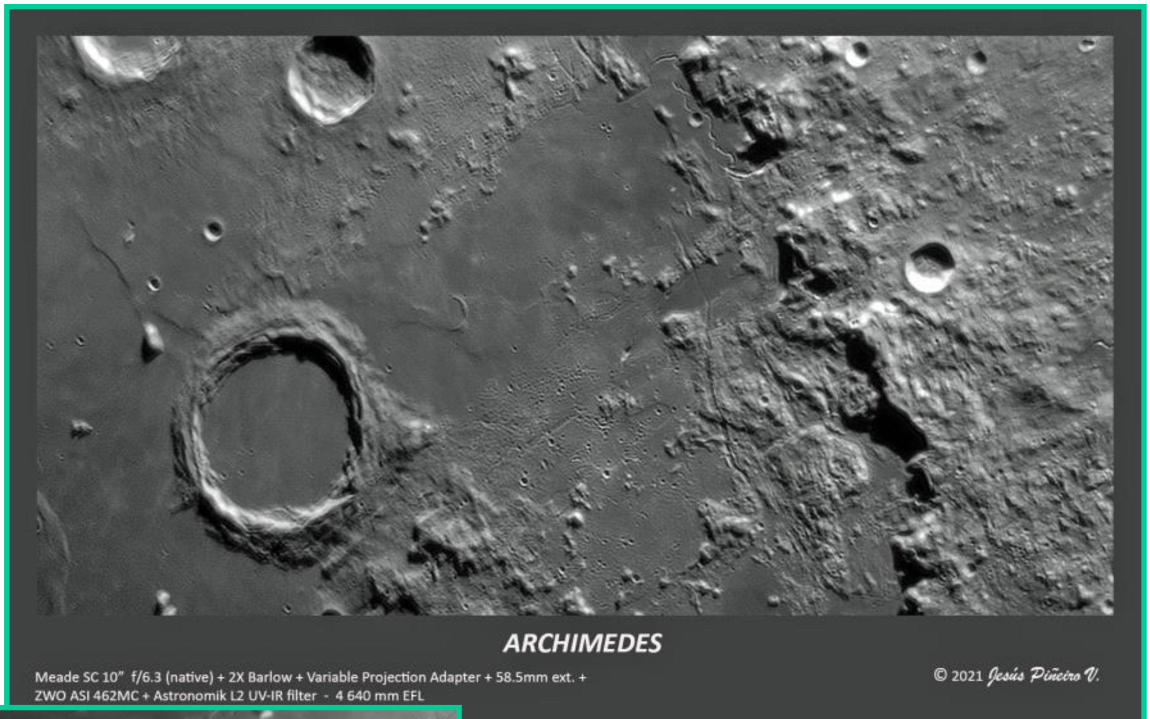

Image 2, Archimedes, *Jesús Piñeiro, San Antonio de los Altos, Venezuela. 2021 December 12 23:54 UT. 254 mm Schmidt-Cassegrain telescope, Astronomik L2 UV/IR 2" filter, ZWO ASI462MC camera. North is left, west is down.*

Image 3, Archimedes, *Francisco Alsina Cardinalli, Oro Verde, Argentina. 2018 February 25 01:52 UT. 200 mm refractor telescope, QHY5-II camera.*

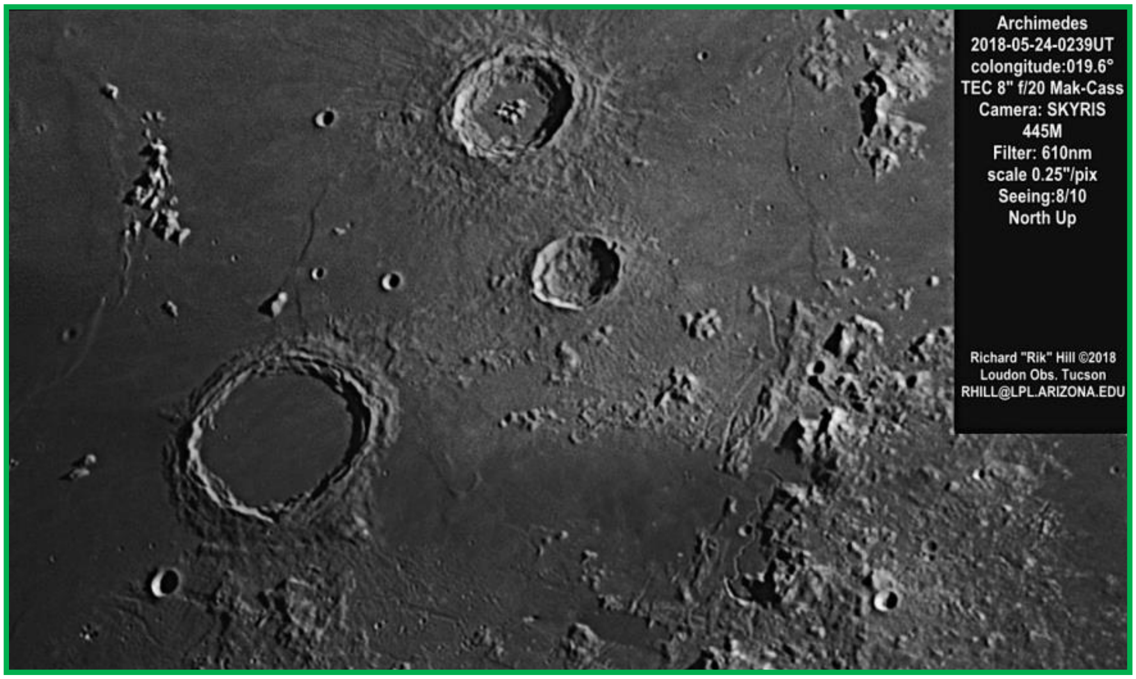

***Image 4, Archimedes**, Richard Hill, Loudon Observatory, Tucson, Arizona, USA. 2018 May 24 02:39 UT, colongitude 19.6˚. TEC 8 inch f/20 Maksutov-Cassegrain telescope, 610 nm filter, SKYRIS 445M camera. Seeing 8/10.*

Another interesting feature of Archimedes floor is the strange appearance of its tones. (**IMAGES 5 and 6**): "The crater floor is flat with dark patchy low-albedo areas and light areas of Aristillus and Autolycus ray materials. These overlying ray materials indicate that lava flooding of Archimedes is previous to the impacts that formed those two craters" (Garfinkle). Clearly the vast majority of the bright rays come out from Aristillus (**IMAGES 7 and 8**).

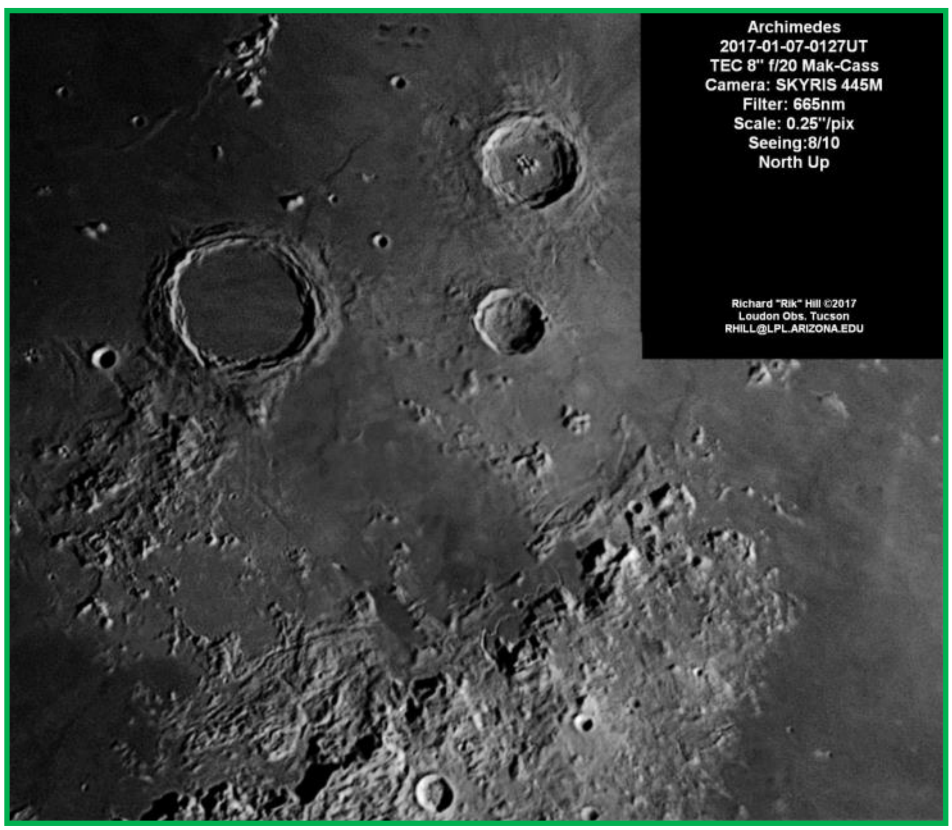

***Image 5, Archimedes**, Richard Hill, Loudon Observatory, Tucson, Arizona, USA. 2017 January 07 01:27 UT. TEC 8 inch f/20 Maksutov-Cassegrain telescope, 665 nm filter, SKYRIS 445M camera. Seeing 8/10.*

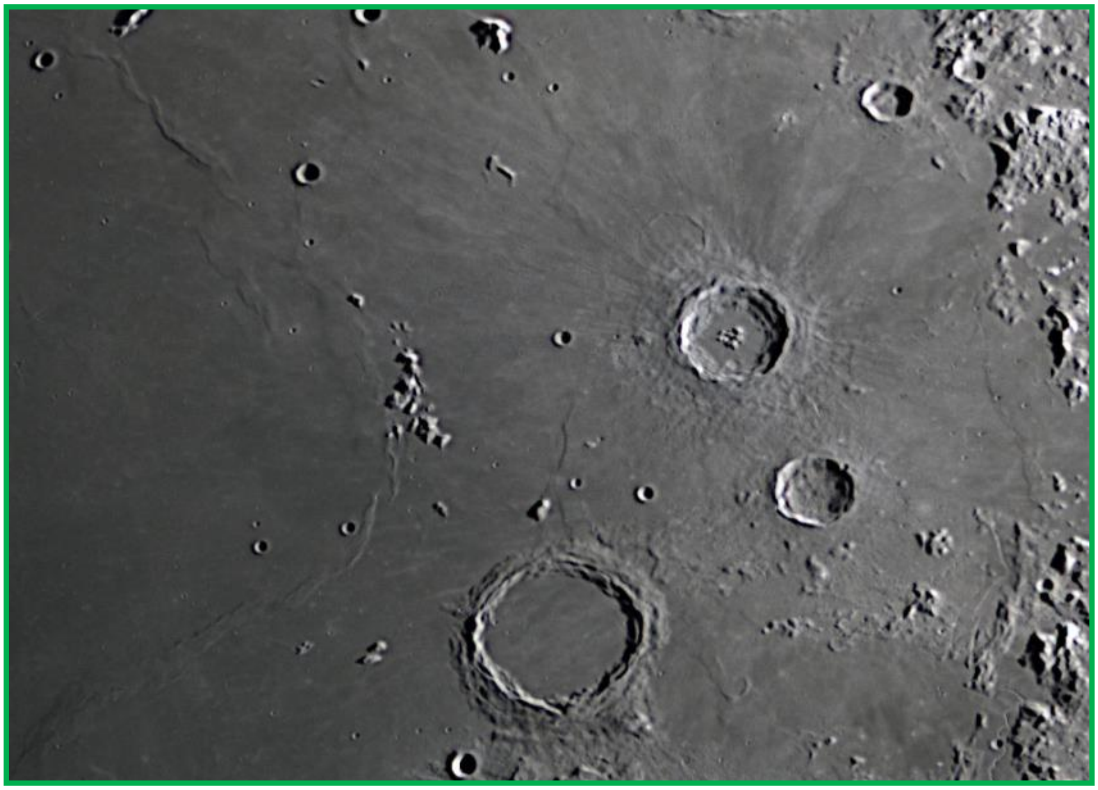

Image 6, Archimedes, *Walter Ricardo Elias, Oro Verde, Argentina, AEA. 2024 October 11 23:38 UT. Celestron 11 inch Schmidt-Cassegrain telescope, QHY5-II-C camera.*

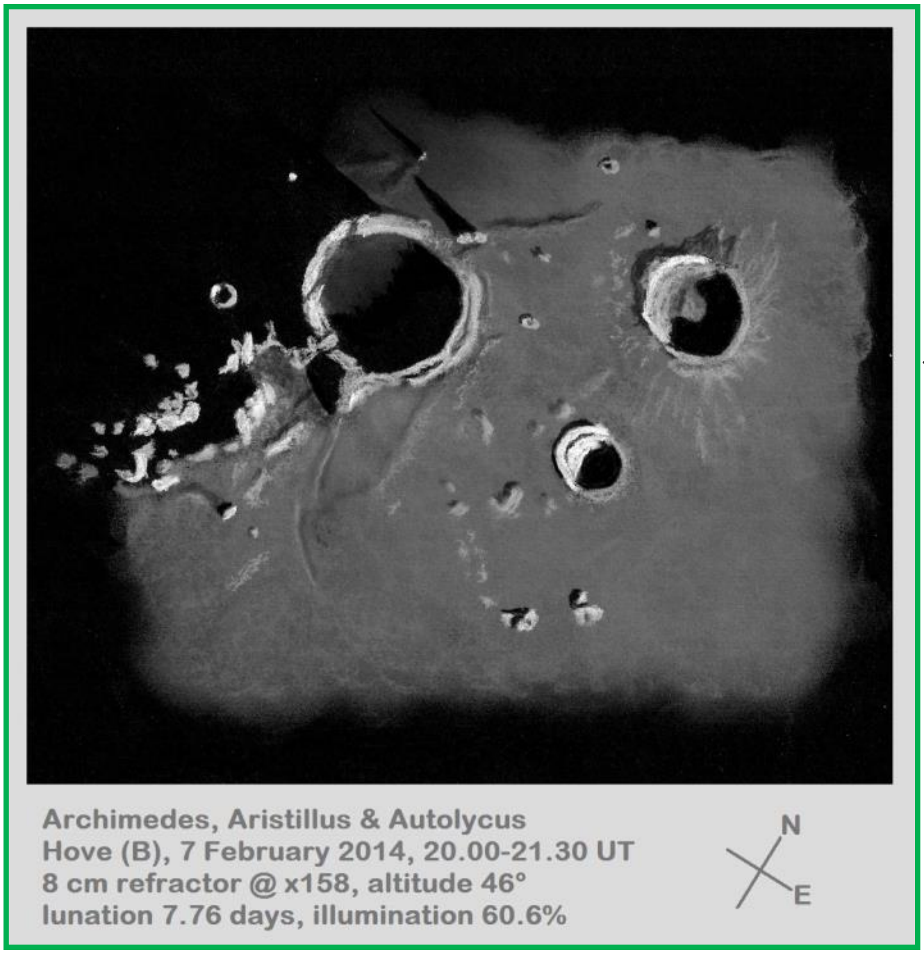

Image 7, Archimedes, Aristillus and Autolycus*, Jef De Wit, Hove, Belgium. 2014 February 7 20:00-21:30 UT. 8 cm refractor telescope, 158 x.*

Image 8, Archimedes, *Marcelo Mojica Gundlach, Cochabamba, Bolivia. 2018 July 22 23:36 UT. 150 mm refractor telescope, Orion V-minus filter, SWO CMOS camera.*

Outer and inner walls so complicated create complicated expressionist shadows: "The shadows cast by Archimedes' rim onto its floor when the crater is near the terminator are fascinating to observe. In the early morning, at least seven individual spikes of shadow can be discerned, projecting westward from the broad black shadow cast by the eastern wall. Archimedes' interior walls are terraced, and outside its sharp rim there are well-rounded flanks indented with a prominent concentric groove" (Grego), as we see in **IMAGES 9 and 10**. In the shadows of **IMAGE 9 and 11**, shine the isolated oblong twin peaks of Archimedes ζ, west of Archimedes. In **IMAGE 11** we see emerge from the shadows the mass of Montes Archimedes: "Much of its original external impact structure has been obliterated by Mare Imbrium, although it can be traced in the highlands of Montes Archimedes to the south, including a narrow radial crater chain some 50 km long, a section of which can be resolved through a 100 mm telescope. Montes Archimedes sprawl across an area of around 45,000 sq km, and its highest peaks rise to more than 3,000 m" (Grego).

Image 9, Aristillus, *Sergio Babino, Montevideo, Uruguay. 2019 December 05 00:56 UT 250 mm catadrioptic telescope, ZWO ASI174 MM camera.*

Image 10, Archimedes, Richard Hill, Loudon Observatory, Tucson, Arizona, USA. 2014 April 08 02:47 UT, colongitude 18.7°. TEC 8 inch f/20 Maksutov-Cassegrain telescope, 610 nm filter, SKYRIS 445M camera. Seeing 8/10.

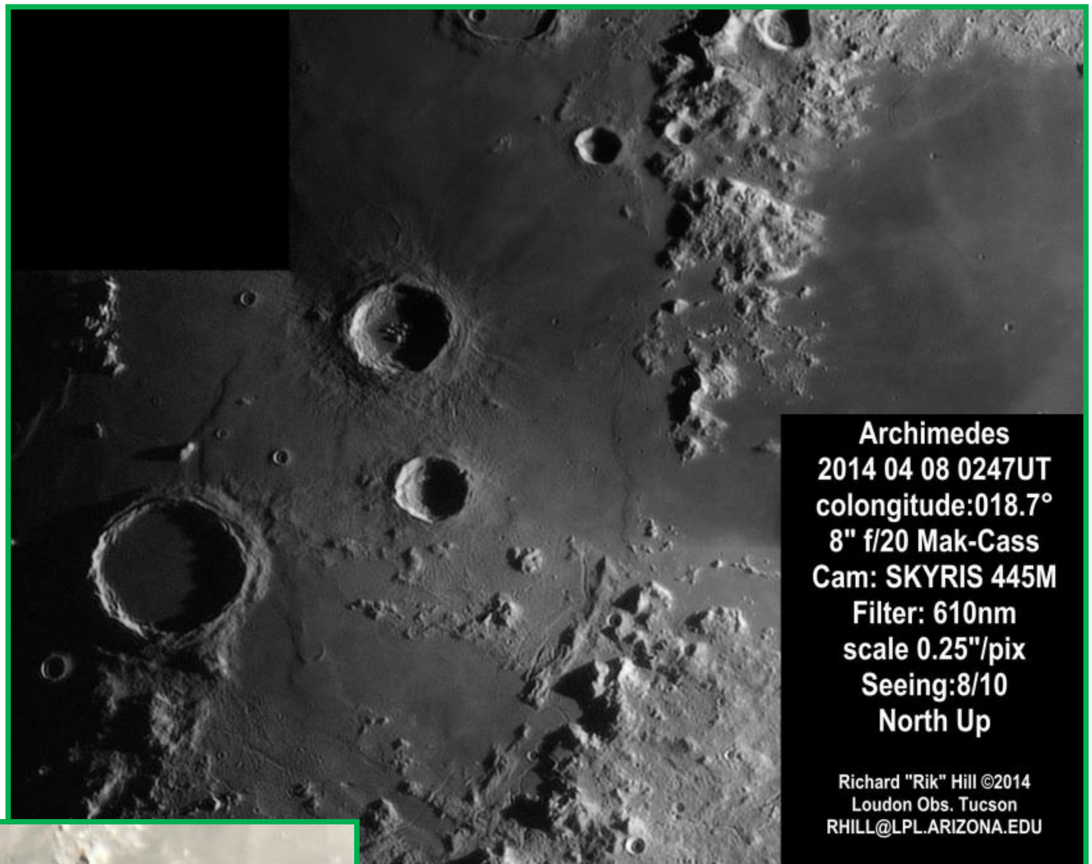

Image 11, Archimedes, James Brunkella, Thousand Oaks, California, USA. 2023 October 23 04:15 UT. 9 inch Intes f/13 Maksutov-Cassegrain telescope, 12 mm eyepiece, iPhone 12 camera.

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3.- MONTES ARCHIMEDES

"On the southern side of Archimedes is a very rugged mountain region, extending for more than 100 miles towards the south: on the W. of this originates a remarkable rill- system, best seen under evening illumination. The two principal clefts follow a nearly parallel course up to the face of the Apennines near Mount Bradley, crossing in their way, almost at right angles, other clefts which run at no great distance from the E. foot of this range and ramify among the outlying hills" (Elger). This strange landscape is beautifully portrayed in **IMAGES 11 to 13**. Especially in **IMAGE 13** it is clearly seen that "The mountains have several deep valleys, sinuous rilles, and catenas that are radial to Archimedes. To the west of the mountains is Mare Imbrium and to the east is Palus Putredinis. The mountains appear to be a massive amount of ejecta from the formation of the crater Archimedes with a block of the material overlaying the southern rim of Archimedes. With the crater count vastly lower on Mare Imbrium than in the lower, smoother elevations of Montes Archimedes, it appears that the formation of the mountains pre-date the final lava flows that filled the "Imbrium Basin". (Garfinkle).

Image 12, Archimedes, *James Brunkella, Thousand Oaks, California, USA. 2024 October 11 02:28 UT. 9 inch Intes f/13 Maksutov-Cassegrain telescope, ZWO ASI678MM camera.*

Image 13, Archimedes, *James Brunkella, Thousand Oaks, California, USA. 2023 April 17 03:20 UT. 9 inch Intes f/13 Maksutov-Cassegrain telescope, 12 mm eyepiece, iPhone 12 camera.*

4.-AUTOLYCUS, THE LITTLE ONE

Autolycus is an extremely interesting crater, but its proximity to the flooded and majestic Archimedes and the spectacular example of a Copernican crater, Aristillus, overshadows its prominence. In **IMAGE 15,** with the right illumination conditions, it can be seen that Autolycus is located "among its heavily pockmarked ejecta blanket and what could be large blocks of ejecta that now appear as isolated massifs" (Garfinkle). In **IMAGE 16** we can see the other features that Garfinkle points out: the rim crests are sharp, which can be deduced from the intense brightness of the area near the terminator. In **IMAGE 17** we can see that the interior walls are terraced and drop down to the lumpy floor. In **IMAGE 18**, still looking at Autolycus, we see how it is "surrounded by a heavily pockmarked, bright-rayed ejecta blanket. To the north, the blanket mixes with that of Aristillus. To the west of Autolycus is a wide plateau of materials that extends to the rumpled ejecta field on the eastern side of the crater Archimedes" (Garfinkle). **IMAGE 19** is interesting, since inside Autolycus a luminous point can be perceived that would allow us to identify what Elger noted in "The Moon": "Its floor, which contains an inconspicuous central mountain", mountain that is difficult to identify in the other images of the chaotic floor of this crater, such as **IMAGE 20**. Likewise, **IMAGE 21** illustrates another claim by Elger about this crater: "Dr. Sheldon of Macclesfield has seen two shallow crateriform depressions in the interior, one nearly central, and the other about midway between it and the N. wall". The rays of Autolycus are almost imperceptible, probably because they have been obscured by the ray system of the neighboring Aristillus (**IMAGE 22**). A magnificent description of Autolycus accompanies the drawing by Robert Hays Jr. that appears in this issue of TLO.

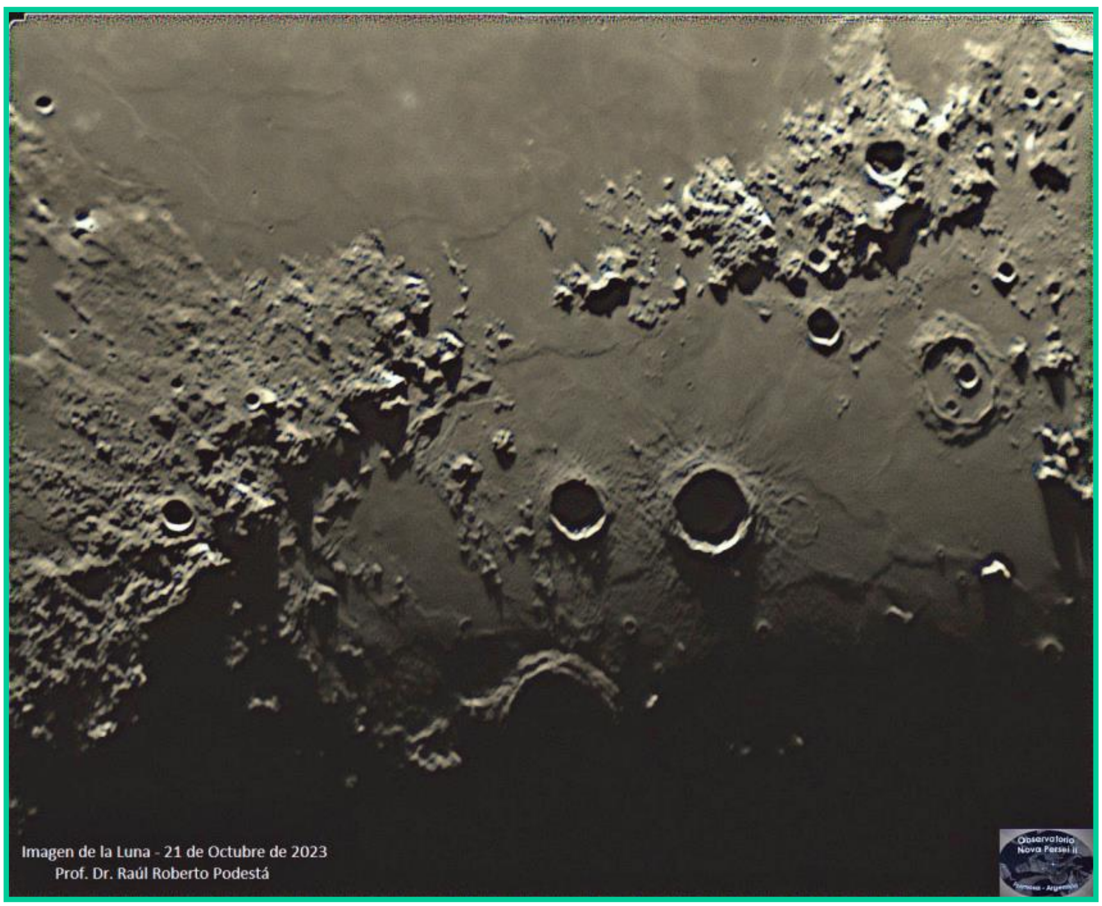


Image 15, Aristillus, *Raúl Roberto Podestá , Formosa, Argentina. 2023 October 22 00:21 UT. 127 mm Maksutov-Cassegrain telecope, UV/IR cut and Blue #80 filters, ZWO ASI178MC camera. North is to the right, west is down.*

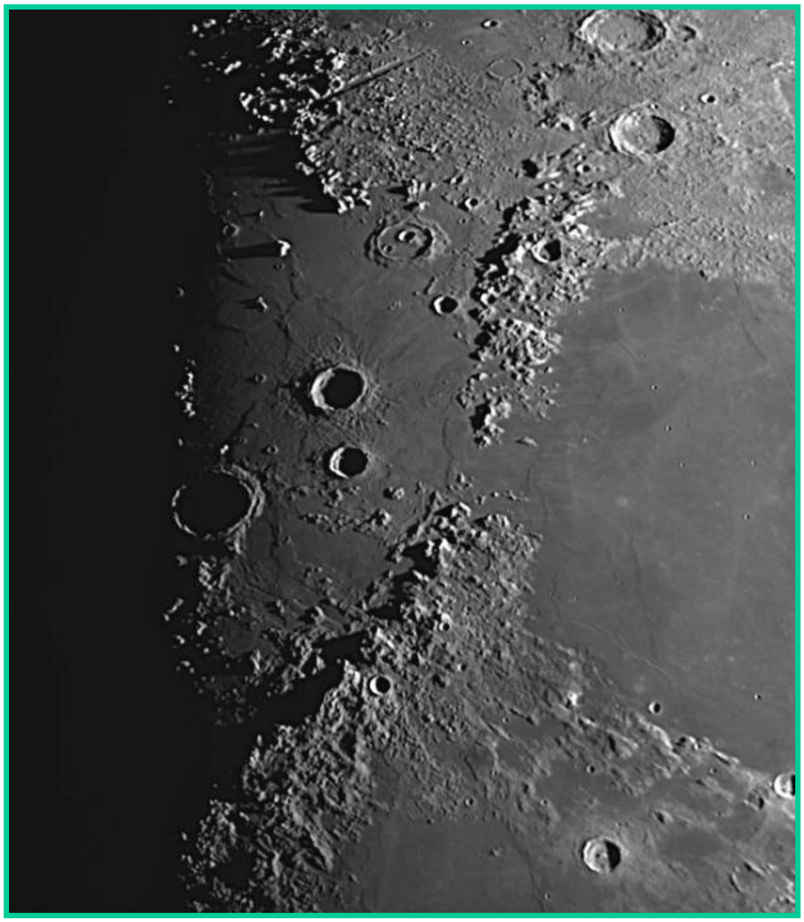
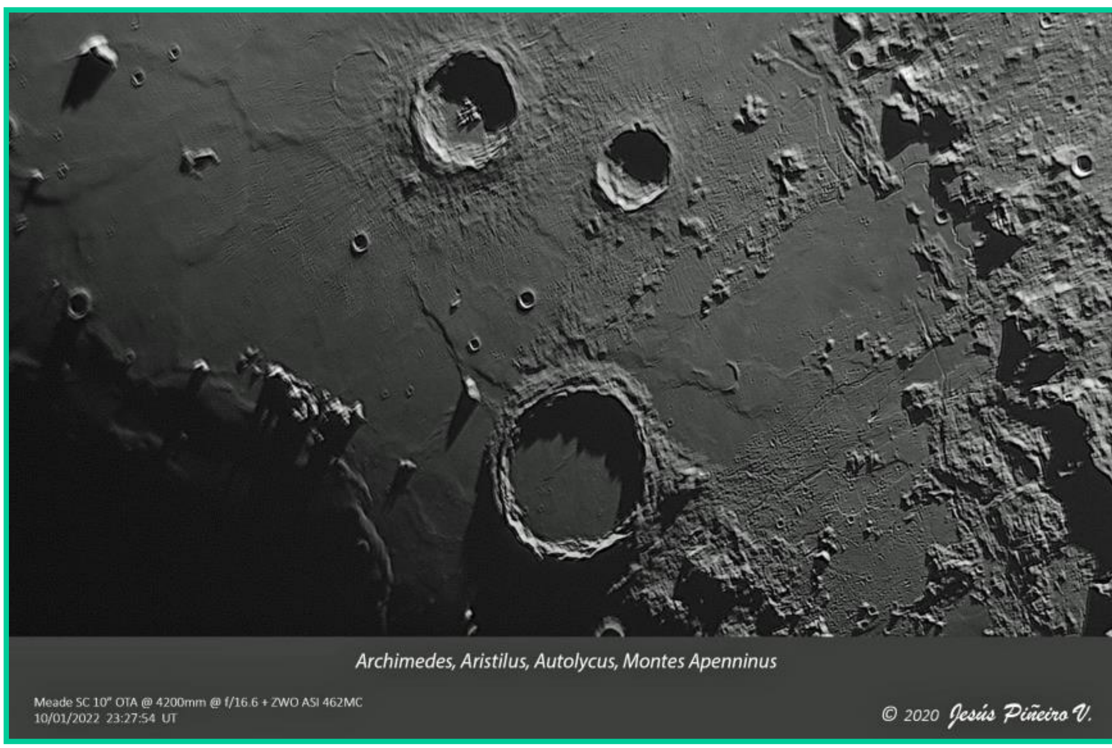


Image 16, Archimedes, *Francisco Alsina Cardinalli, Oro Verde, Argentina. 2017 July 02 00:03 UT. 200 mm refractor telescope, 742 nm IR pass filter, QHY5-II camera.*

Image 17, Archimedes, *Jesús Piñeiro, San Antonio de los Altos, Venezuela. 2022 January 10 23:57 UT. 254 mm Schmidt-Cassegrain telescope, Astronomik L2 UV/IR 2" filter, ZWO ASI462MC camera. North is left, west is down,*



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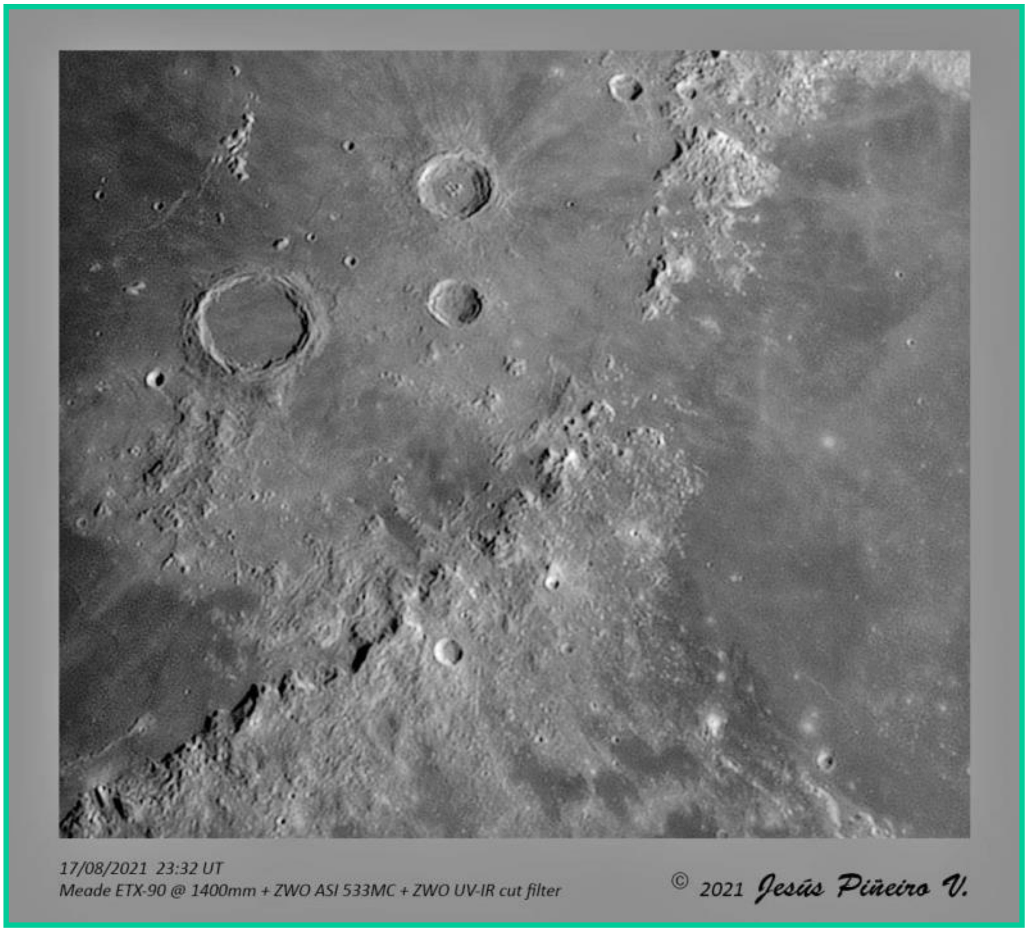

Image 18, Archimedes, *Jesús Piñeiro, San Antonio de los Altos, Venezuela. 2021 August 17 23:22 UT. 90 mm Maksutov-Cassegrain telescope, Astronomik L2 UV/IR 2" filter, ZWO ASI533MC camera*

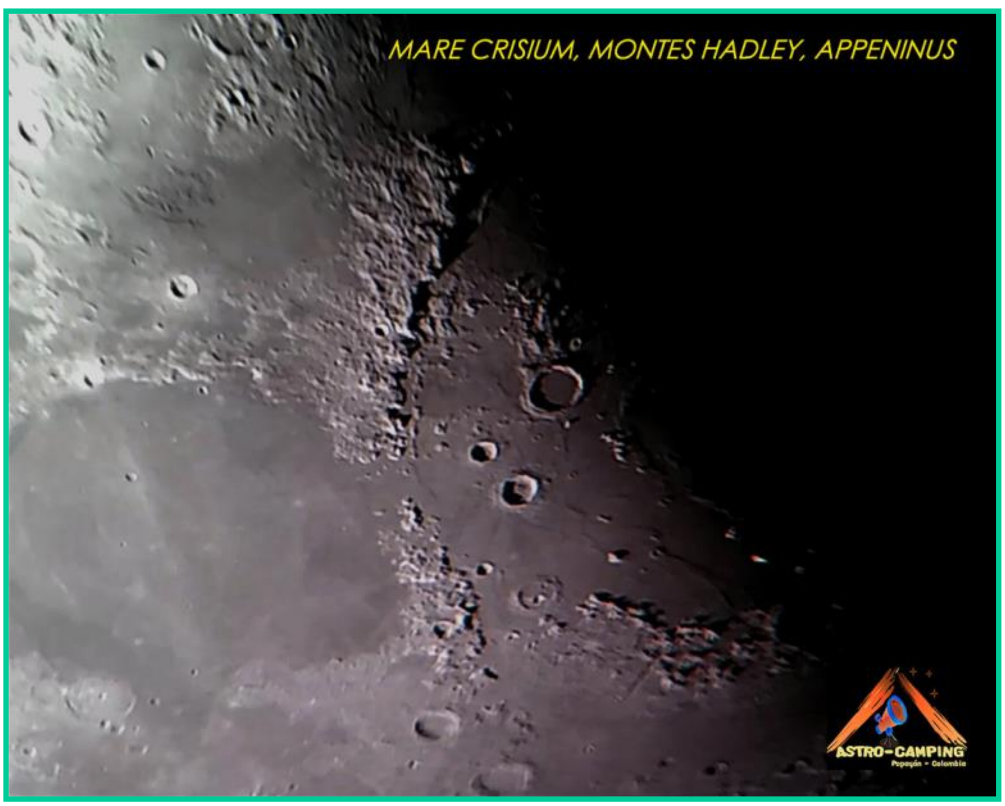

Image 19, Hadley, *Jairo Chavez, Popayán, Colombia. 2022 July 07 02:42 UT. 311 mm truss tube Dobsonian reflector telescope, MOTO E5 PLAY camera. North is down, west is right.*

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Image 20, Archimedes, *Michel Deconinck, Aquarellia Observatory, France. 2017 April 17 04:10 UT. 6 inch refractor telescope, 5 mm Nagler eyepiece, 240 x.*

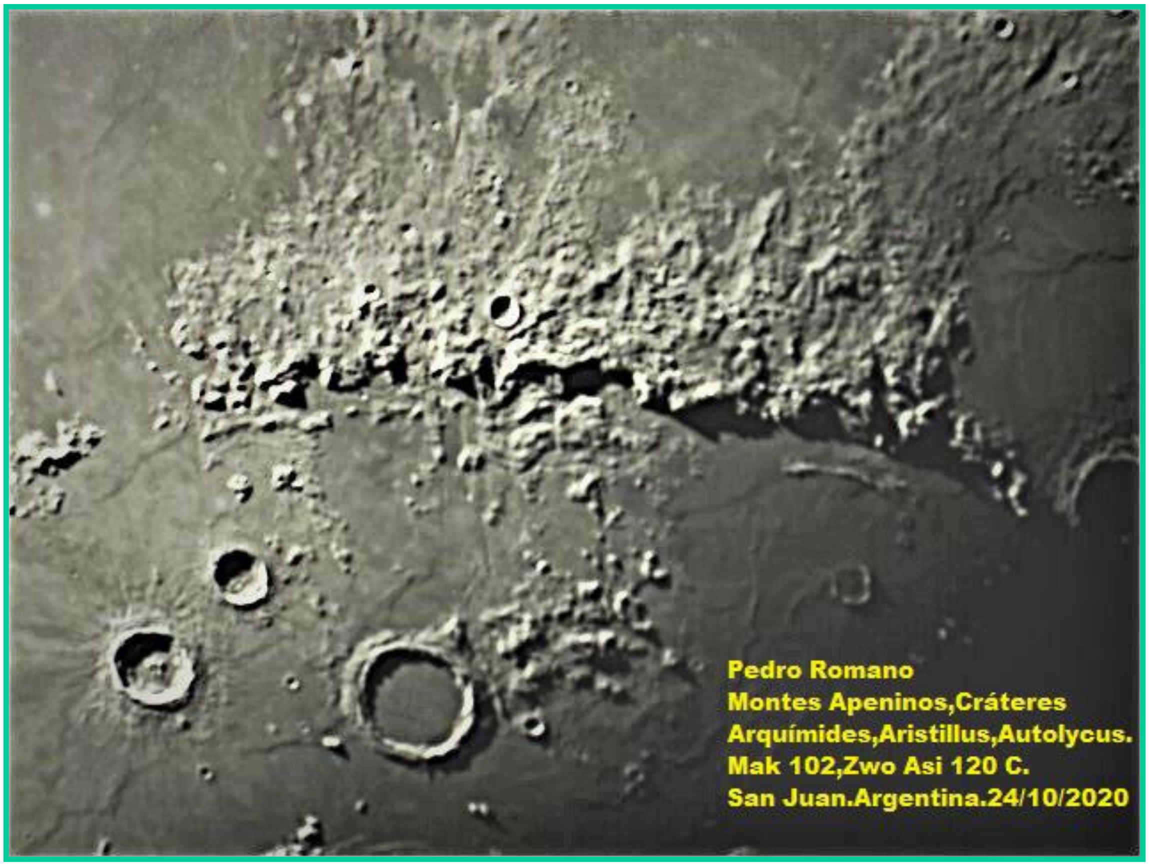
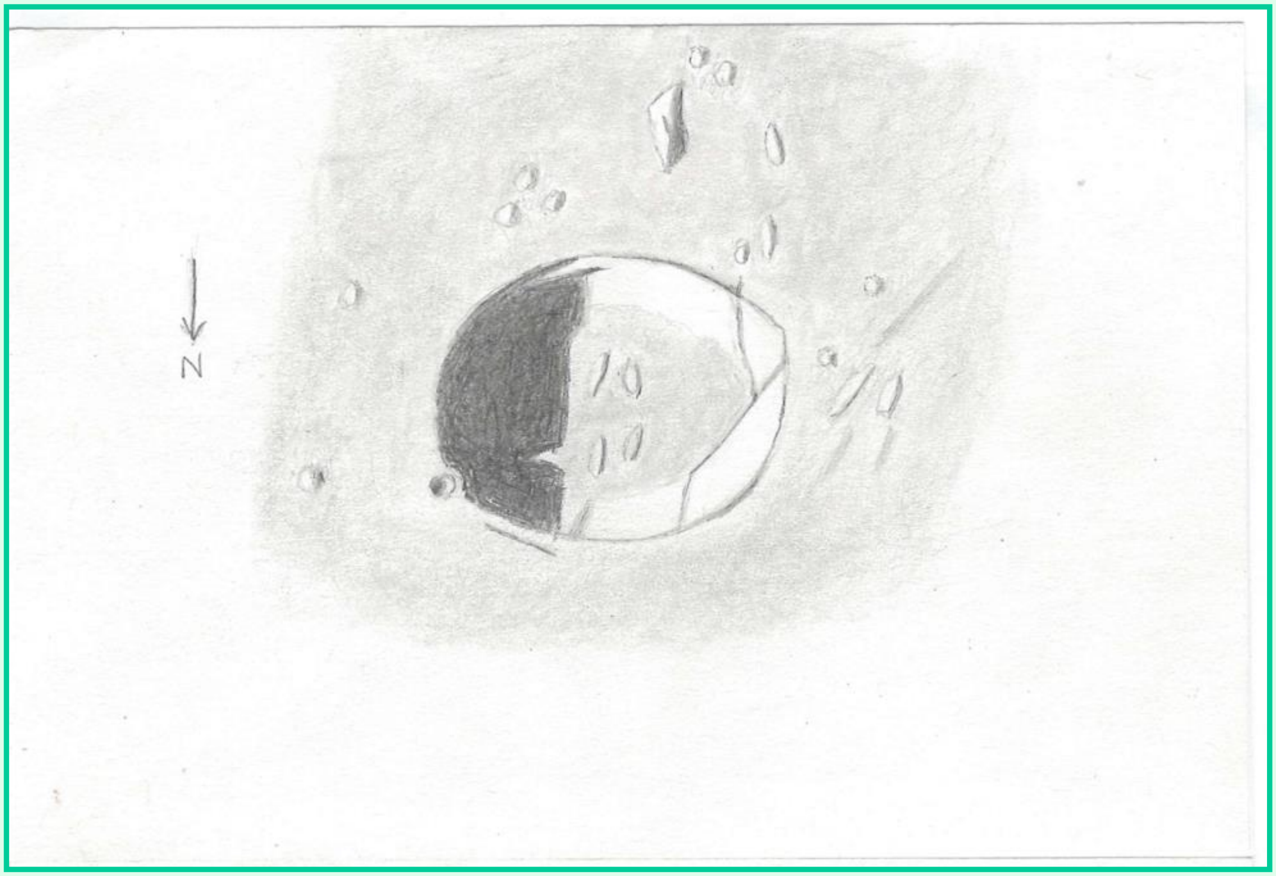


Image 21, Archimedes, *Pedro Romano, San Juan, Argentina. 2020 October 24 01:24 UT. 102 mm Maksutov-Cassegrain telescope, ZWO ASI camera. North is to the lower left, west is to the lower right.*

Image 22, Aristillus, *Marcelo Mojica Gundlach, Cochabamba, Bolivia. 2019 May 14 04:42 UT. 150 mm refractor telescope, ZWO ASI120 camera.*

Autolycus

Robert H. Hays, Jr.



Autolycus, *Robert H. Hays, Jr., Worth, Illinois, USA. 2004 January 1 00:38-01:08 UT. 15 cm reflector telescope, 170 x. Seeing 7-8/10, transparency 6/6.*

I sketched this crater on the evening of December 31, 2003, UT date January 1, 2004. This crater is in extreme Mare Imbrium near Archimedes and Aristillus. It looks reasonably oval at first glance, but the west rim has a substantial point, and the northeast rim appears slightly dented, possibly from the pit Autolycus A. This crater does not really have a central peak, but there are four low elongated mounds on the floor. The interior shadow appeared straight except on the inside south wall, and a notch near the interior mounds. The inside west wall showed strips of shadow that made Autolycus look like a cracked bowl. This crater appears to be fairly deep, but there is little evidence of a raised rim. There are many hills nearby, the largest being Autolycus alpha to the south. The Lunar Quadrant map shows a spot labeled Autolycus B east of alpha, but I saw three small hills there. Autolycus eta is plotted just west of Autolycus, but a loose group of four peaks is in that area. That designation may refer to the largest hill in the group. There were more small peaks near Autolycus alpha, and two more east of Autolycus. A small strip of shadow was seen just north of Autolycus.

5.-ARISTILLUS, THE COPERNICAN BEAUTY

Aristillus is a true beauty as a model crater of the most recent lunar geological era. In **IMAGE 23** we see the terraced walls, the extensive and complicated ejecta blanket and the motley set of central peaks ("Its massive central mountain, surmounted by many peaks, occupies a considerable area on the floor, and exhibits a digitated outline at the base", Elger). In **IMAGE 24** we can see with more detail its ejecta blanket and "the radiating ridges and tiny secondary craters and tiny secondary craters that are part of the crater's ejecta system" (Wood). It is interesting that "Because Aristillus lies on a generally smooth and level lava plain, it possesses one of the clearest observable systems of impact structures on the Moon for any crater of its size" (Grego). The bright ray system of Aristillus is quite impressive, appearing even under oblique illumination (**IMAGE 25** and **26**), but especially under frontal illumination, as in **IMAGE 27** and the wider panorama in **IMAGE 28**. In **IMAGE 29** we see the strange formation reported by Garfinkle: "A streak-like chain of disconnected small craters cuts across the ejecta field from the southeastern side of the crater and runs southeastward to the vicinity of the isolated Fra Mauro formation hills designated Autolycus γ". In **IMAGE 30** we see what Garfinkle considers "the most interesting fact about the pronounced crater Aristillus is the unnamed ghost-crater immediately north of it, interesting because it is a very easy telescopic target during local sunrise or sunset circumstances! Nobody of the I.A.U. (International Astronomical Union) seems to have thought of it to give that easy-to-observe ghost crater an official name or letter designation. Well, I call it the *Ghost of Aristillus*, or rather the *Unsung Ghost of Aristillus*. - DannyCaes Feb 19, 2017"

We can take **IMAGE 30** to observe the panorama around Aristillus. To the south, beyond Autolycus, east of Archimedes we find Palus Putredinis, which "is generally rectangular in shape extending as a wide band of dark lava for about 180.45 km from the crater Archimedes to Montes Apenninus" (Garfinkle). Can you see "the flooded ghost crater Spurr forms a horseshoe arc of mountains southeast of the crater Archimedes?" East of Aristillus are the Apenninus Mountains, which are nothing more than part of the outer ring of the basin that formed Mare Imbrium. In **IMAGES 31-34** we see the asymmetrical arrangement of these three giants on the eastern shore of Mare Imbrium, which is almost empty on the rest of its surface by comparison. West of Aristillus is the Spitzbergen Mountains: "an arc of Imbrian-age mountain peaks located on Mare Imbrium. The peaks probably mark the location for the eastern rim of a ghost crater. The mountains are overlain and smoothed with bright ejecta materials from the crater Aristillus to the east" (Garfinkle). This area is seen in **IMAGE 35** and is covered in detail along with the excellent drawing by Robert Hays Jr. published in this same issue.

As Charles Wood points out (https://www2.lpod.org/wiki/April_25,_2006) "Aristillus is a crater that looks pretty typical but it has its own peculiarities. Its clump of central peaks differs from the more typical one or two peaks, looking like a cluster of triangles whose apices point inward. (…). A remarkable dark streamer extends from the floor up the east wall and over the rim". No doubt, this dark ribbon is the most peculiar feature of Aristillus and perhaps of the entire area: "The northeastern inner wall is marked by a prominent dark band that extends from the crater's floor to its rim. This feature, one of the most noteworthy dark albedo bands to be found in any lunar crater, does not appear to be associated with any topographic formation" (Grego). It is certainly a rarity, and many people have probably wondered what I wondered the first time I saw this dark area: Is it a transient darkening or an artifact in the image? The area is clearly visible in IMAGE 36 and under different illumination in **IMAGE 37**. Garfinkle gives a little more detail about this rarity in Aristillus: "This dark ribbon divides into two and continues about to the bottom of the outer rim. It looks like a piece of dark ejecta that was excavated and draped across the crater; a high Sun view demonstrates that it is quite dark material - either mare basalts or pyroclastics. It seems like the dark ribbon starts at the top of the lowest terrace with some dark material perhaps falling towards the floor. If it does originate at the terrace it is very strange - seeming less like a streamer of ejecta. Unfortunately the source region occurs right at a boundary of two Clemetine swaths one of which is not sharp. This is a feature that needs high resolution imaging with higher lighting to learn more what it might be".

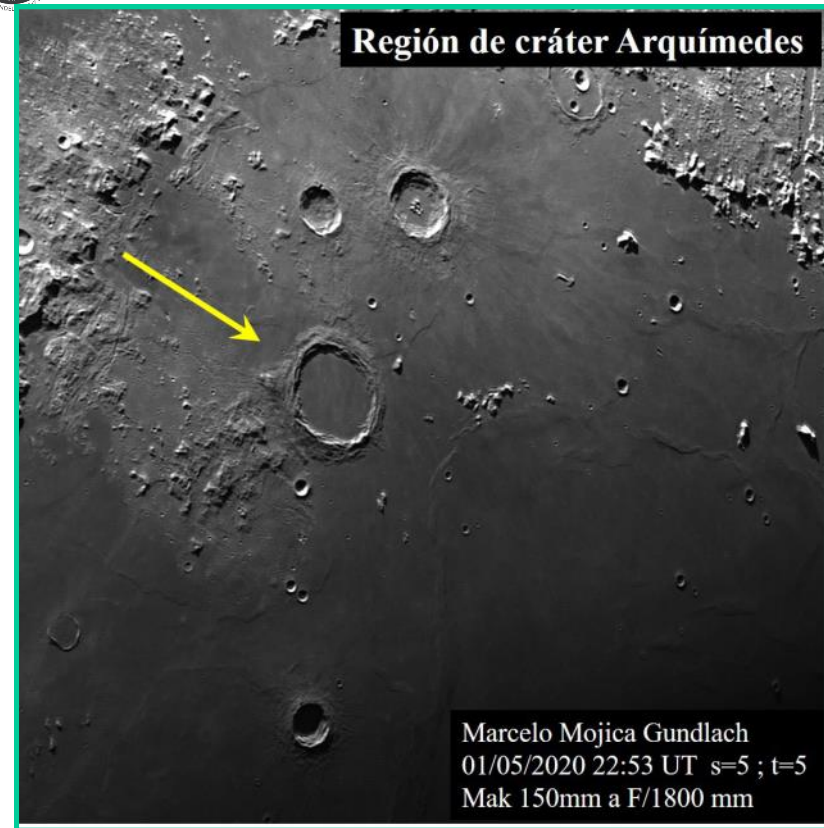


Image 23, Archimedes, *Marcelo Mojica Gundlach, Cochabamba, Bolivia. 2020 May 01 22:53 UT. 150 mm Maksutov-Cassegrain telescope, ZWO ASI120 camera. North is to the right and west is down.*

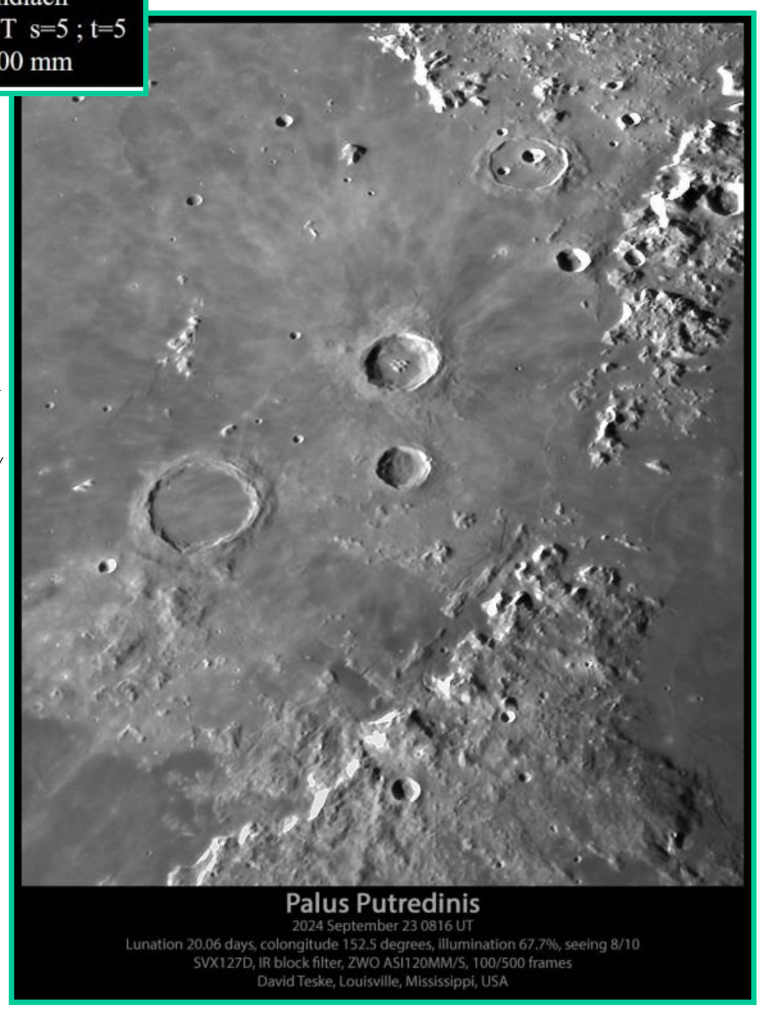


Image 24, Palus Putredinis, *David Teske, Louisville, Mississippi, USA. 2024 September 23 08:56 UT, colongitude 152.5˚. SVX127D refractor telescope, 2.5x barlow, IR cut filter, ZWO ASI120MM/S camera.*

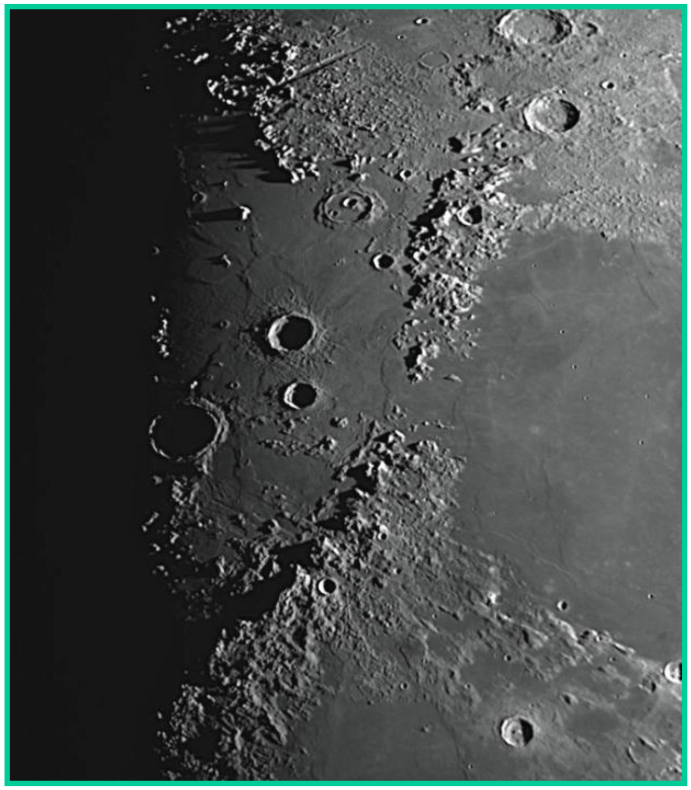
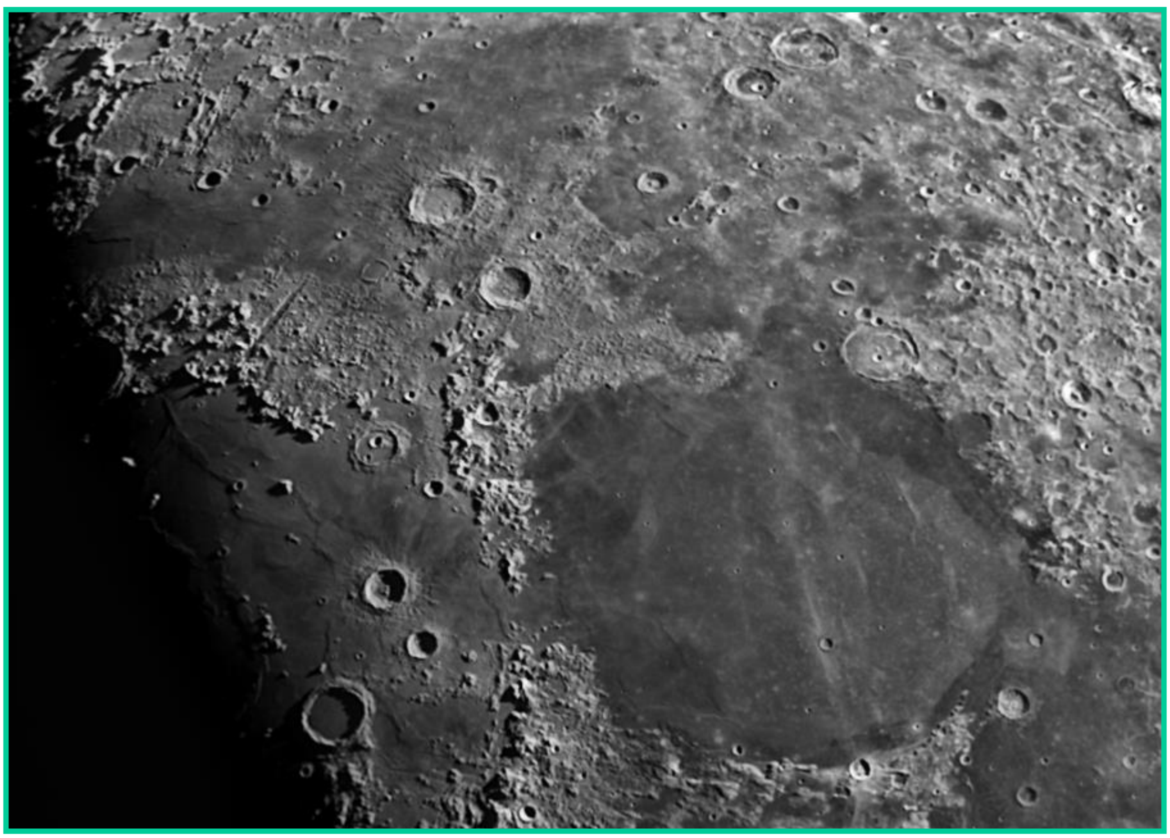


Image 25, Archimedes, *Francisco Alsina Cardinalli, Oro Verde, Argentina. 2017 July 02 00:03 UT. 200 mm refractor telescope, 742 nm IR pass filter, QHY5-II camera.*

Image 26, Aristoteles, *Sergio Babino, Montevideo, Uruguay. 2019 December 05 00:56 UT 250 mm catadrioptic telescope, ZWO ASI174 MM camera.*



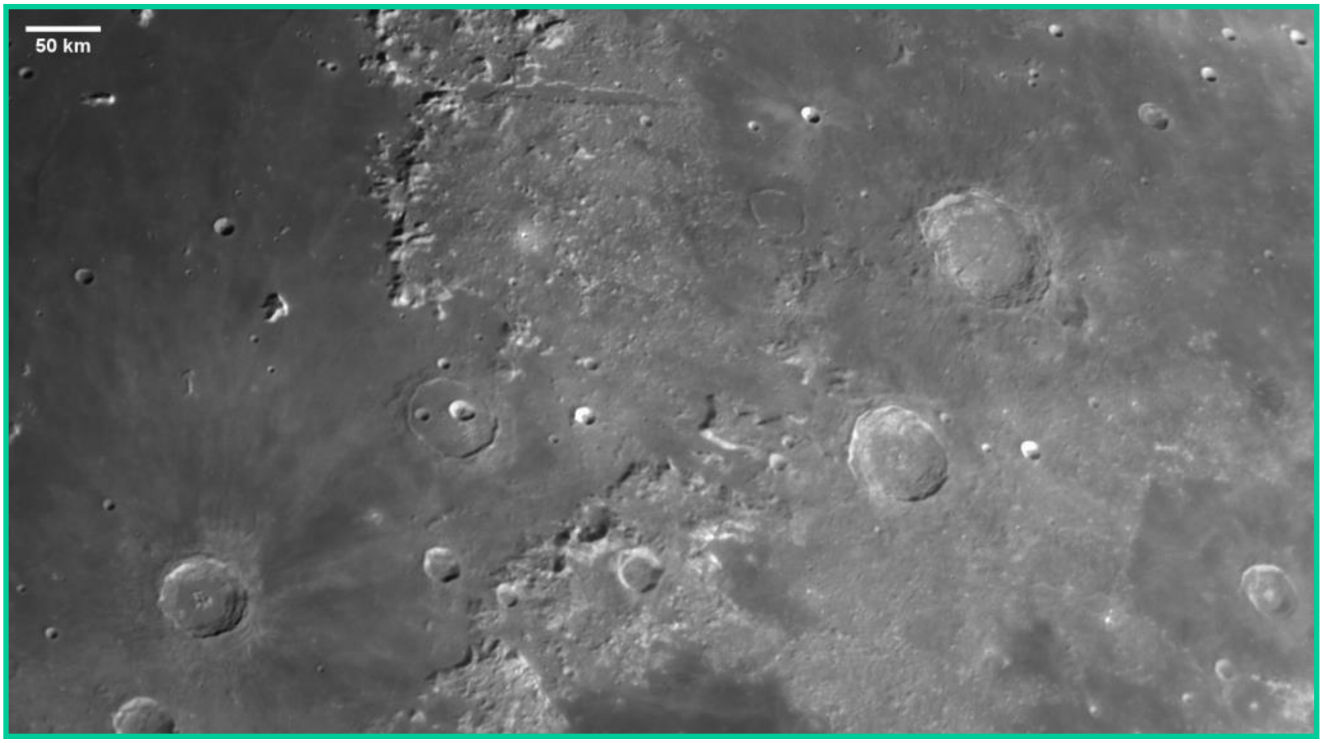


Image 27, Aristillus, *Ariel Cappelletti, Córdoba, Argentina, SLA. 2020 October 26 23:40 UT. 254 mm Newtonian reflector telescope, QHY5III 462c camera.*

Image 28, Aristillus*, Felix León, Santo Domingo, República Dominicana. 2021 January 23 23:00 UT. 127 mm Maksutov-Cassegrain telescope, DMK21618AU camera. North is to the right, west is down.*

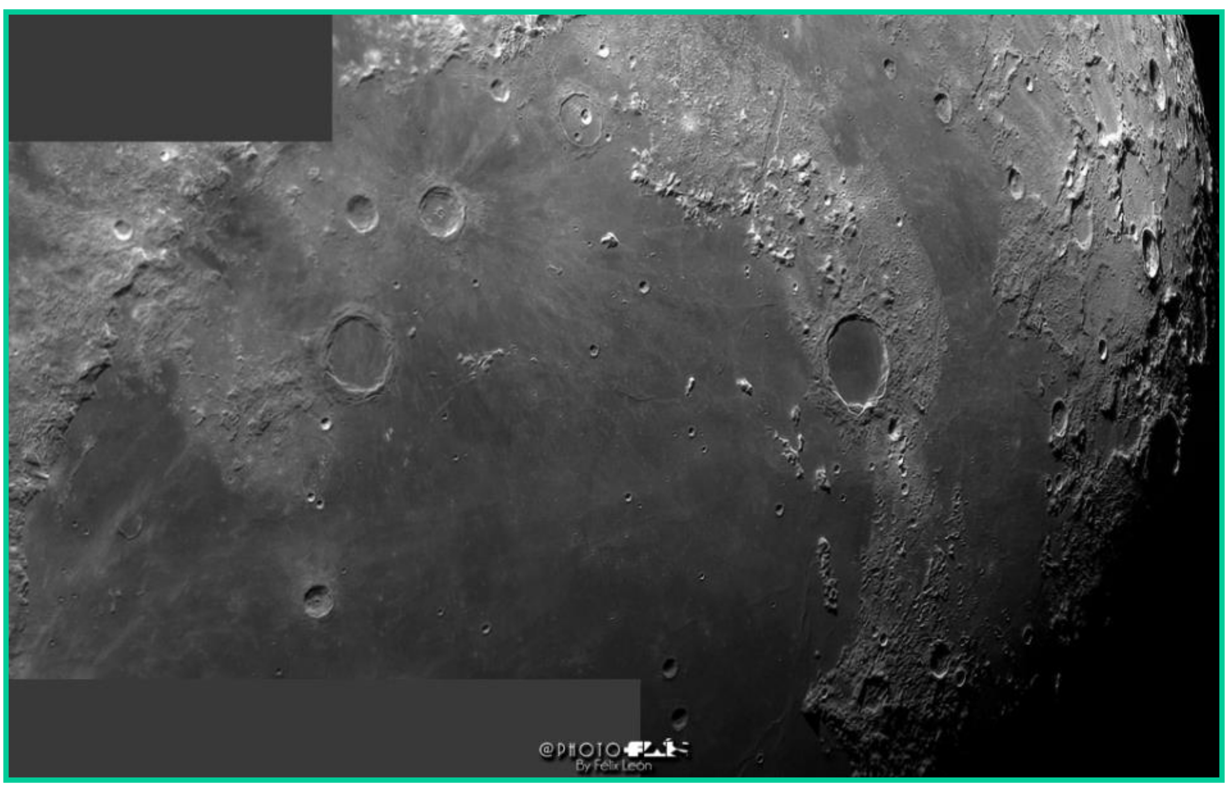
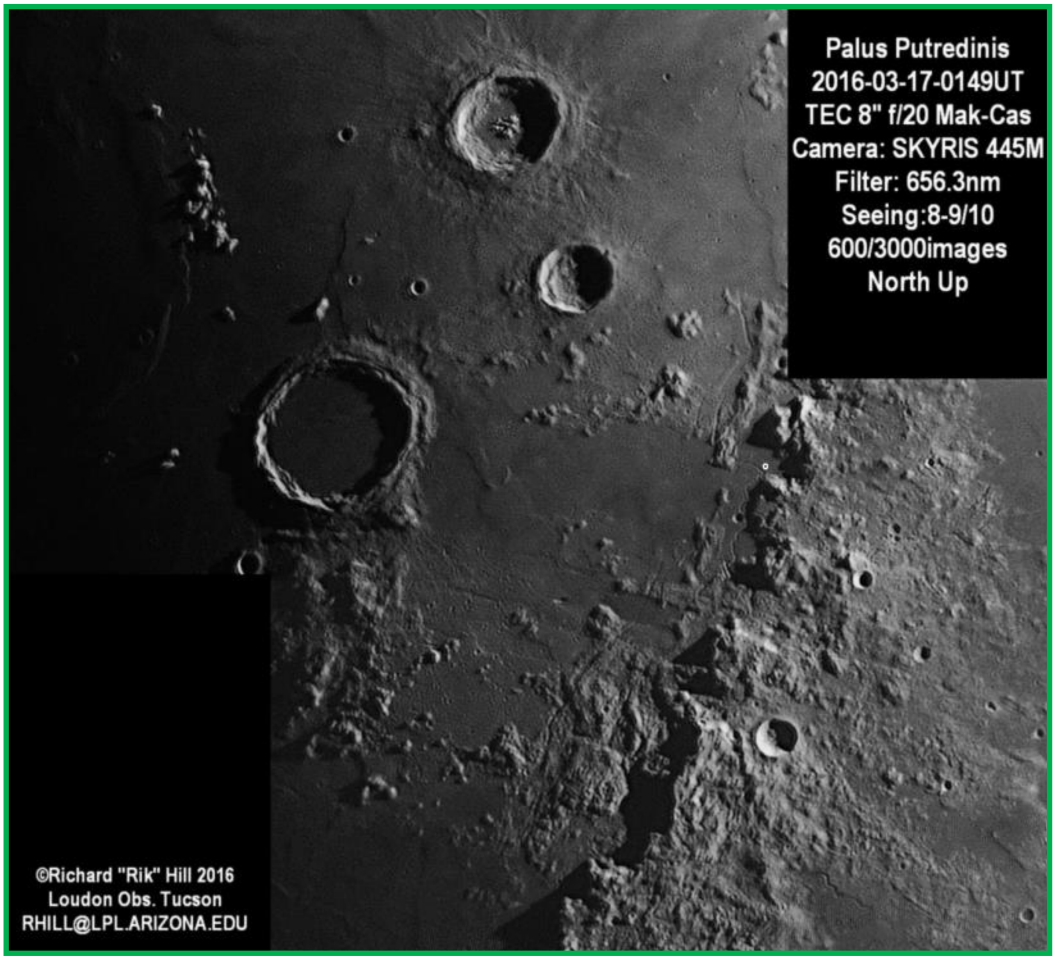


Image 29, Palus Putredinis, *Richard Hill, Loudon Observatory, Tucson, Arizona, USA. 2016 March 17 01:49 UT. TEC 8 inch f/20 Maksutov-Cassegrain telescope, 656.3° nm filter, SKYRIS 445M camera. Seeing 8-9/10.*



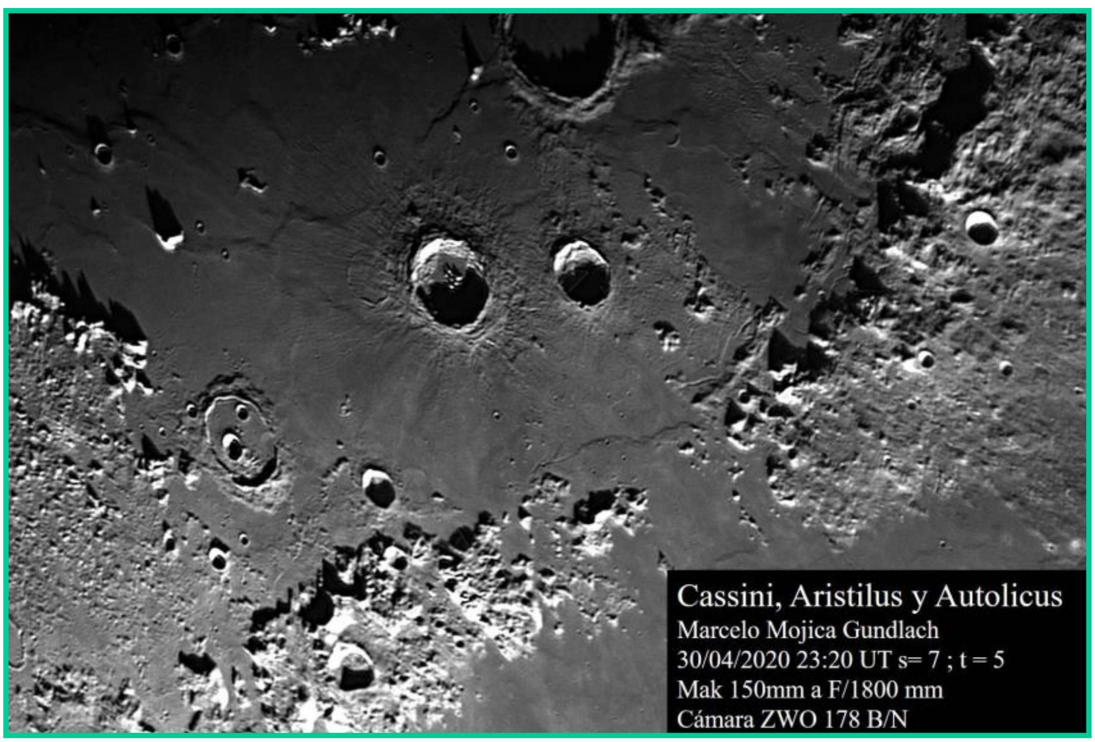


Image 30, Archimedes, *Marcelo Mojica Gundlach, Cochabamba, Bolivia. 2020 April 20 23:20 UT. 150 mm Maksutov-Cassegrain telescope, f/ 1800 mm, ZWO ASI178 B/ N camera. Seeing 7/10, transparency 5/6. North is to the left, west is up.*

Image 31, Aristoteles to Archimedes, *Aurore Guillerand, Margny-Les-Compiègne, Oise, Hauts-de-France, France. 2024 October 11 18:30 UT. Takahashi DF 100 mm refractor telescope, 740 mm focal length, 2.5x barlow, 8 mm eyepiece, 230 x.*

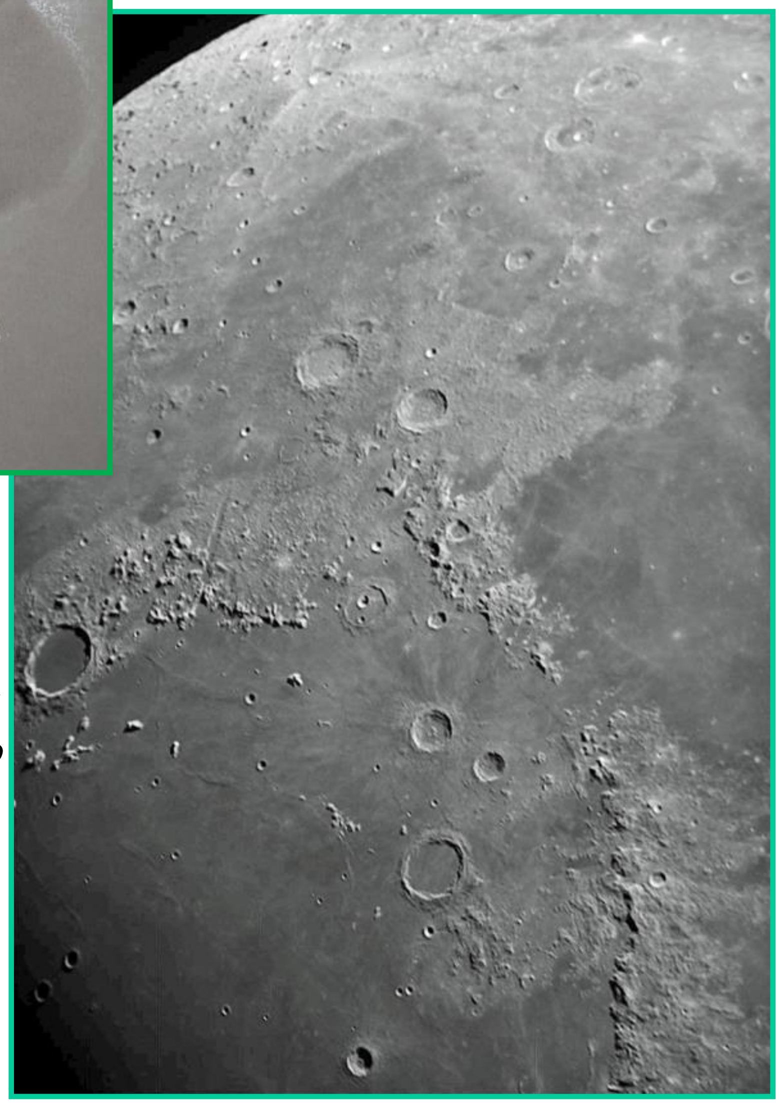


Image 32, Aristillus, *Marcelo Mojica Gundlach, Cochabamba, Bolivia. 2023 April 30 02:00 UT. 90 mm Maksutov-Cassegrain telescope, IR filter, ZWO ASI120 camera.*

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Image 33, Montes Apenninus, *Rafael Lara Muñoz, Guatemala, Guatemala, SLA. 2020 April 30 19:32 UT. 114 mm reflector telescope, Samsung Note 9 cell phone camera.*

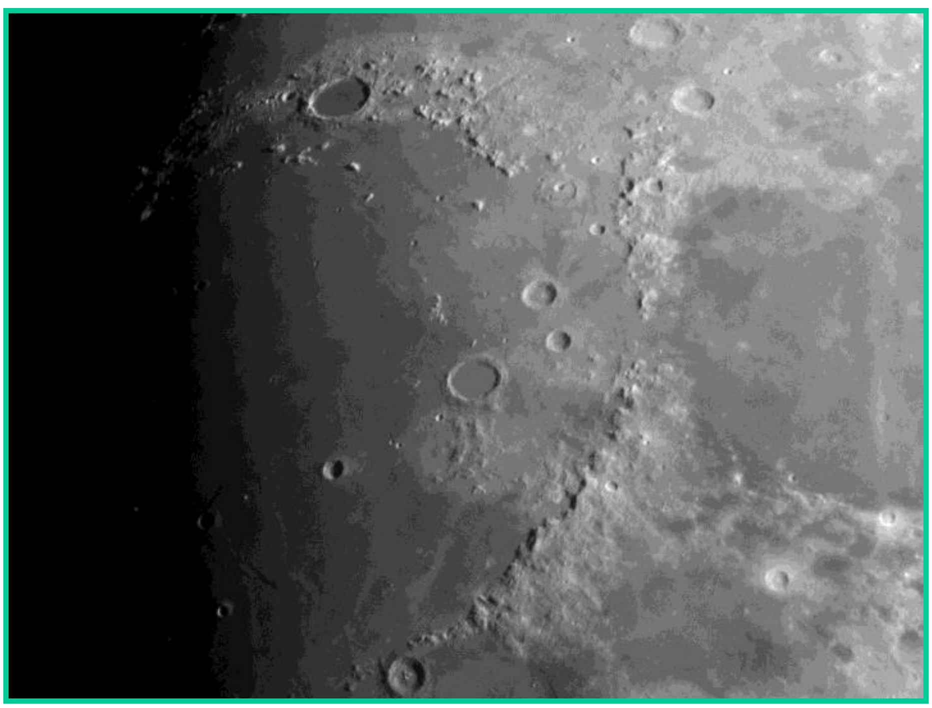

Image 34, Archimedes, *Román García Verdier, Paraná, Argentina. 2021 July 18 22:47 UT. 180 mm Newtonian reflector telescope, ZWO ASI120MC camera.*

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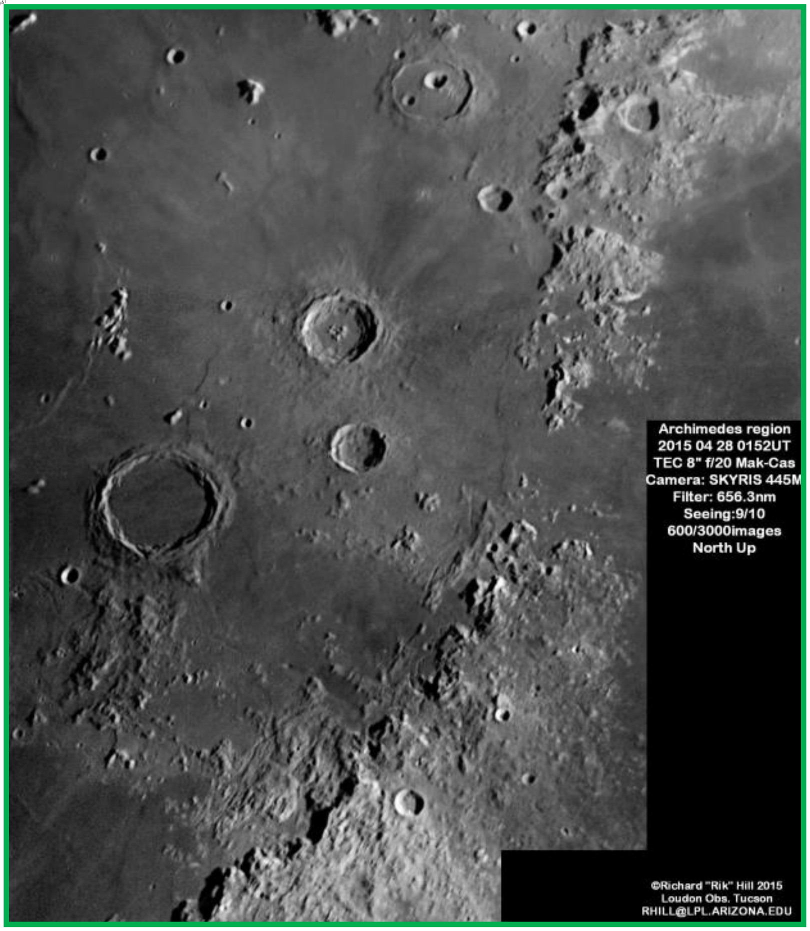

Image 35, Archimedes*, Richard Hill, Loudon Observatory, Tucson, Arizona, USA. 2015 April 28 01:52 UT. TEC 8 inch f/20 Maksutov-Cassegrain telescope, 656.3 nm filter, SKYRIS 445M camera. Seeing 9/10.*

Aristillus and its bright rays

Taken on 14 October 2024 at 13h40m UT with 250mm f/6 newtonian reflector + 2.5X barlow + QHYCCD 290M camera
Taken by KC Pau, Hong Kong

Image 36, Aristillus, *KC Pau, Hong Kong, China. 2024 October 14 13:40 UT. 250 mm f/6 Newtonian reflector telescope, 2.5x barlow, QHYCCD290M camera.*

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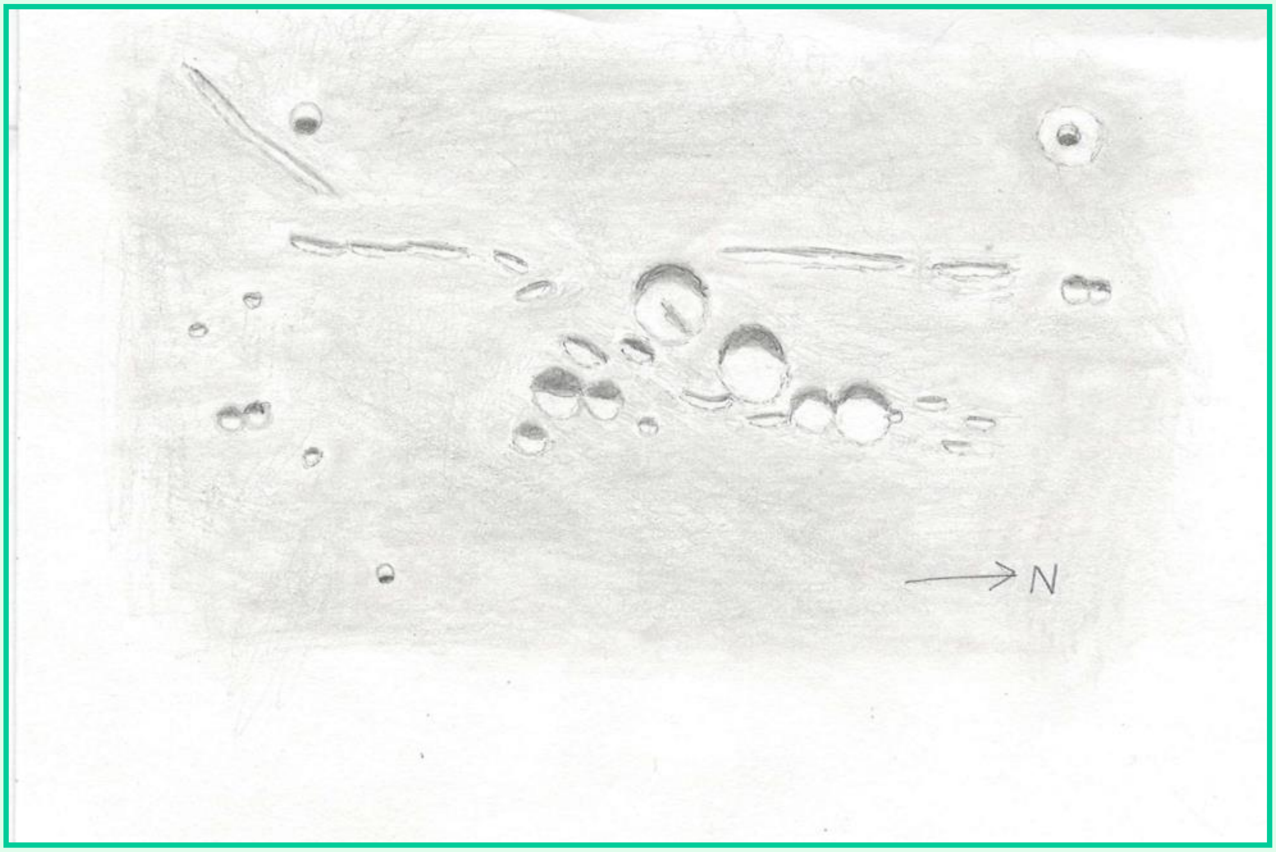
Montes Spitzbergen

Robert H. Hays, Jr.



Montes Spitzbergen, *Robert H. Hays, Jr., Worth, Illinois, USA. 2005 November 10 23:25-23:39; 23:46-23:58 UT. 15 cm reflector telescope, 170 x. Seeing 7-8/10, transparency 6/6.*

I drew this area on the evening of November 10, 2005. This clump of peaks is in eastern Mare Imbrium north of Archimedes. It is one of several isolated mountain groups in Mare Imbrium. Some of the conspicuous peaks are in pairs. Montes Spitzbergen (M.S.) mu is a small pair of peaks north of the main group. The tiny pit west of M.S. mu is Kirch E, according to the Lunar Quadrant Map. This crater has a modest halo. The large pair at the north end of the main group appears to be M.S. epsilon, and M.S. beta is at the west end. The latter feature had a strip of shadow within it, and also appeared less bright than nearby peaks. There is a large peak between epsilon and beta which is shown, but not labeled on the Lunar Quadrant map. The large double peak at the south end of the main group is M. S. gamma, and M.S. alpha is just to its southeast. M.S. delta may be one of several peaks west of gamma and south of beta. The moderate-sized crater to the southwest is Montes Spitzbergen A, and the small pit to the southeast is Archimedes V. Neither of these craters has a halo. The double peak between these craters is Archimedes xi. This pair is as far south of the main group as M.S. mu is to the north. This area has a varied assortment of small peaks and ridges which I have tried to draw as well as possible.

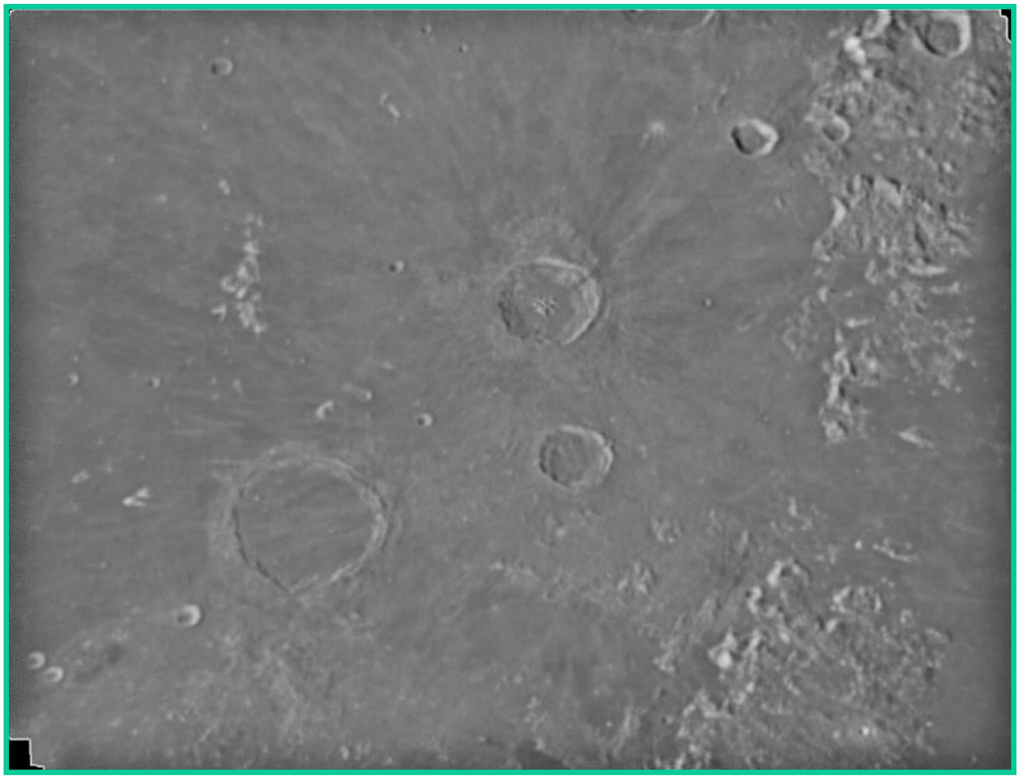


***Image 37, Archimedes,** Alberto Anunziato, Oro Verde, Argentina. 2016 August 21 05:28 UT. Meade LX200 10 inch Schmidt-Cassegrain telescope, Astronomik Pro-Planet 742 nm IR pass filter, QHY5-II camera.*

6.-THE CANALS OF ARISTILLUS

In the fascinating booklet by Walter Haas (published by ALPO) "Does Anything Ever Happened on the Moon?", 1942, reference is made to the 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 behaviour 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". Haas mentions several authors who devoted years of observation to the changes in appearance of these 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 evidente and beautiful… At colongitude 63º the internal canal become les visible, and the duplication seems to disappear… till 80º of colongitude the canal remains invisible… the configuration just described is mantained 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).

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 Schiapparelli 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 excedes 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 uusual 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 (approx 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 localised, 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 the ray by a slightly elevated topography in its path, giving rise to a shadow effect downrange”.

The observations of the astronomers at the beginning of the last century could be the subject of an interesting study, now that we have photographic material such as that presented in this dossier.

7.- WE'VE BEEN THERE

Indirectly, humans have been to this region, which belongs in its own right to the history of humanity. The interplanetary adventure began with a Soviet probe crashing in free fall on the Moon. On September 13, 1959, the Luna 2 probe (also known as Lunik 2) crashed northeast of Archimedes, southwest of Aristillus, in an area covered by the bright rays of this crater. In honor of the first human artifact to have reached another celestial body, this area was named Sinus Lunicus (Lunik Bay or Bay of Luna). In fact, geologically it is part of Mare Imbrium, the delimitation is artificial and responds to the desire to pay tribute to the accomplished adventure, in the same way that the area where the pioneering images of the Ranger 7 probe were taken was named Mare Cognitum.

We also have, on Earth, two fragments of Aristillus and Autolycus, brought by the astronauts of the Apollo 15 mission. The best-known fragment is sample 15405: “Establishing the chronology of the Copernican Period is hindered by the small number of well-dated stratigraphic units of regional extent. At 1.29 aeons old (Bernatowicz and others, 1978), sample 15405 from the Apollo 15 landing site is the youngest rock-size lunar sample and the oldest that could be Copernican (fig. 13.9; table 13.2). This sample contains KREEP-rich "granitic" and "monzodioritic" material (Ryder and others, 1975a; Ryder, 1976) that is exotic to the landing site. A source in the Copernican craters Aristillus or Autolycus, centered 250 and 150 km north of the landing site, respectively, is considered possible by most investigators. Autolycus is marginally favored for several reasons: (1) It formed at least partly on the required target, KREEP-rich plains (Metzger and others, 19791, whereas mare basalt probably constitutes the uppermost target material of Aristillus; (2) it is closer than Aristillus to the collection site, easing somewhat the objection that the 1-m boulder from which sample 15405 was taken should have disintegrated in a long flight; and (3) it is older than Aristillus, making it the more likely source of 1.29-aeon-old material if Aristillus is younger than Copernicus" (Wilhelms).

It is true that the Apollo 15 astronauts did not set foot in the area, but the story, as told by Wood, is an interesting example of the enormous role that astronauts played in scientific progress through acts as simple as collecting samples. Acts that, in reality, are anything but simple, because the selection of samples in the field was a skill they developed after intense geological training, which evidently bore fruit: "an observant lunar scientist noted that some unique Apollo 15 KREEP-rich samples were collected from a ray by either Aristillus or Autolycus. This material was dated at 2.1 billion years (…) and is shocked material excavated from the Apennine Bench by Autolycus. Another impact-heated Apollo sample, dated at 1.29 billion years, is proposed to date to the time of the Aristillus impact event. Since there are two events identified in the Apollo samples and two nearby young craters. It is reasonable to link the older sample with the morphologically older crater and the younger-looking crater".

And to close our tour of this fascinating area, we continue with Wood and return to the privileged aspect, from the stratographic point of view, of this area: "a detailed chronology of events can be inferred for this area of the Moon. Approximately 3.84 billion years ago the Imbrium basin formed creating the Apennine Mountains. A half billion years later. Imbrium basalts flooded the area. Therefore, at some point between the two events, the Archimedes impact occurred. Thanks to the Apollo 15 samples, we can assume that more than a billion years later-2.1 billion years ago-a projectile excavated Autolycus out of the Apennine Bench, and that nearly another billion later Aristillus was formed (…) There are few places on the Moon where sequences of events are known in such detail"

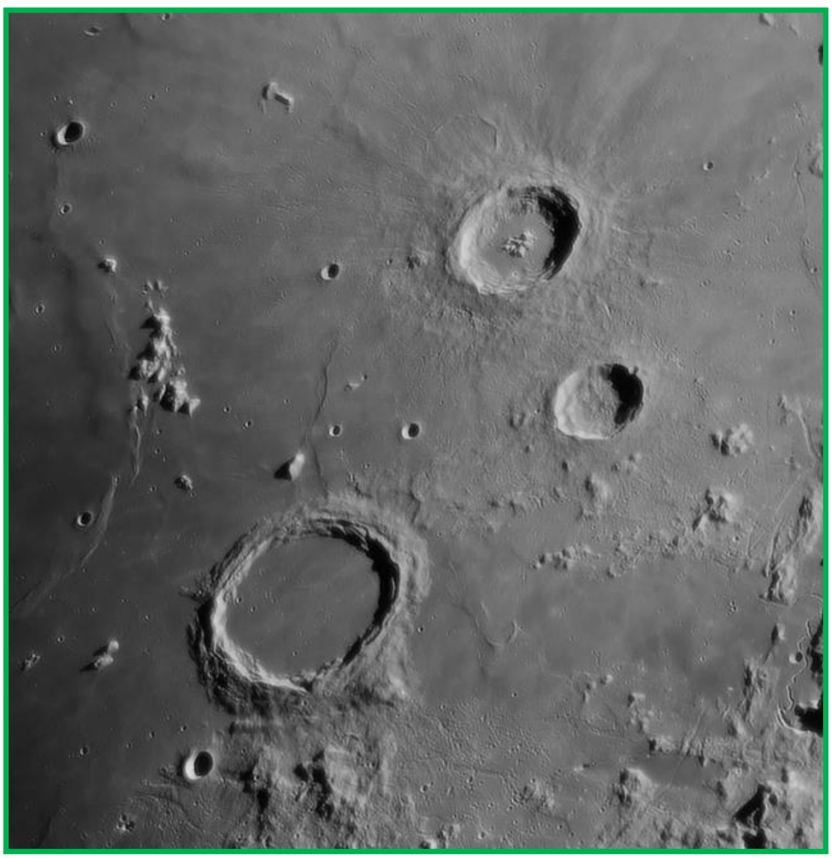


Image 38, The Three A's, *Ken Vaughan, Cattle Point, Victoria, British Colombia, Canada. 2024 March 19 03:55 UT. Meade 12 inch LX200 GPS Schmidt-Cassegrain telescope, Astronomik 642 nm R-IR filter, ZWO ASI178MM camera.*

Thanks to the area we visited, we know much more about the Moon, and it is also a key place in the history of human exploration.

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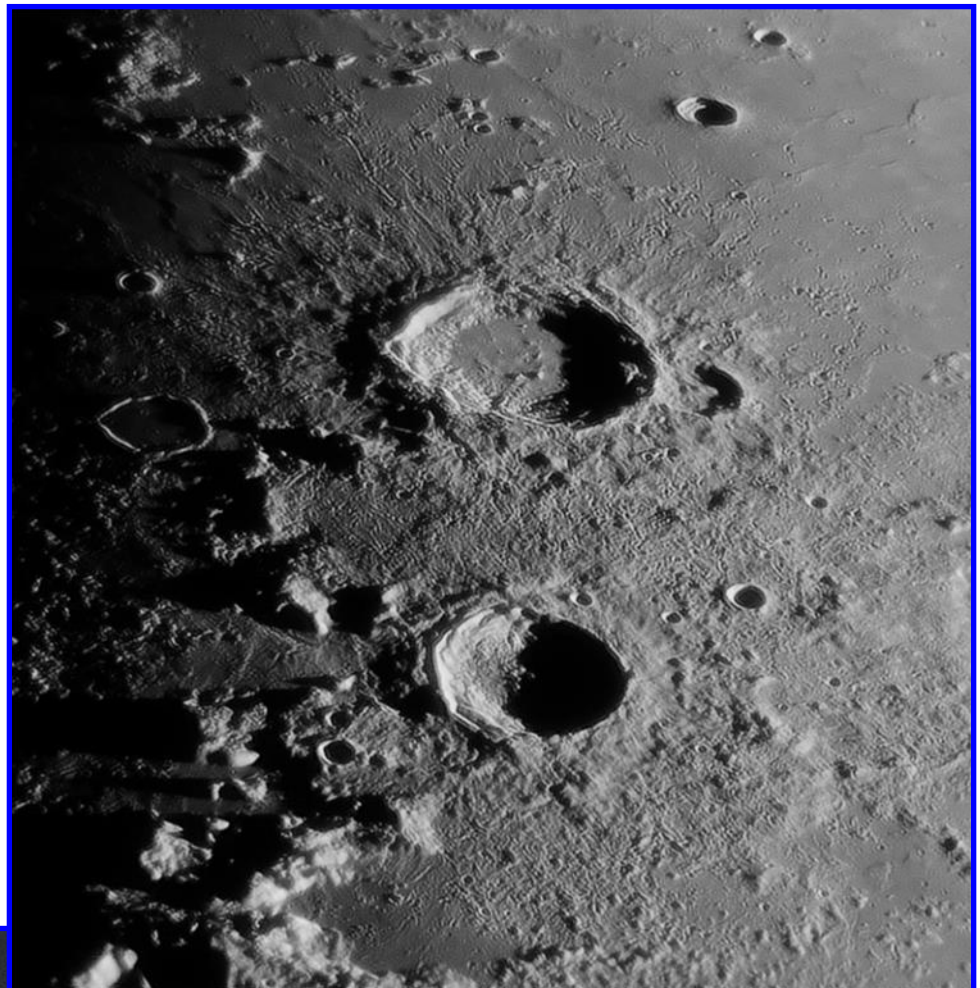
Beketov and Jansen R, *István Zoltán Földvári, Budapest, Hungary. 2024 September 23 01:56-02:20 UT, colongitude 150.4°. 70 mm refractor telescope, 500 mm focal length, 4 mm Vixen LV Lanthanum eyepiece, 125x. Seeing 6-7/10, transparency 5/6.*

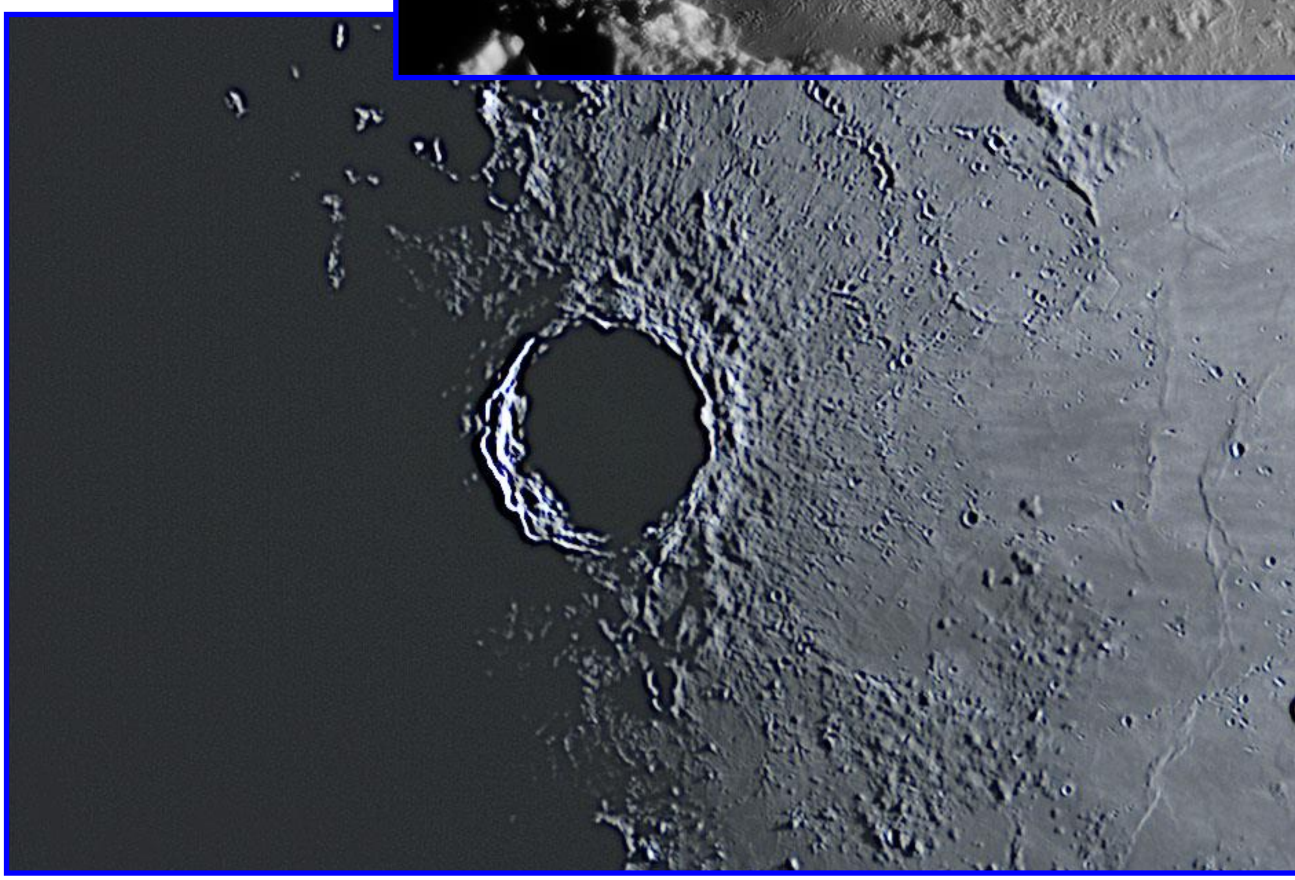
Aristoteles, *Jean Bourgeois, Pic du Midi Observatory, France. 1985 April 30. 1 m reflector telescope. Image submitted by Michel Deconinck.*

Recent Topographic Studies

__Aristoteles and Eudoxus,__ Ken Vaughan, Cattle Point, Victoria, British Colombia, Canada. 2024 March 17 03:42 UT. Meade 12 inch LX200 GPS Schmidt-Cassegrain telescope, Astronomik 642 nm R-IR filter, ZWO ASI178MM camera.



__Copernicus,__ Walter Ricardo Elias, Oro Verde, Argentina, AEA. 2024 October 11 23:14 UT. Celestron 11 inch Schmidt-Cassegrain telescope, QHY5-II-C camera.



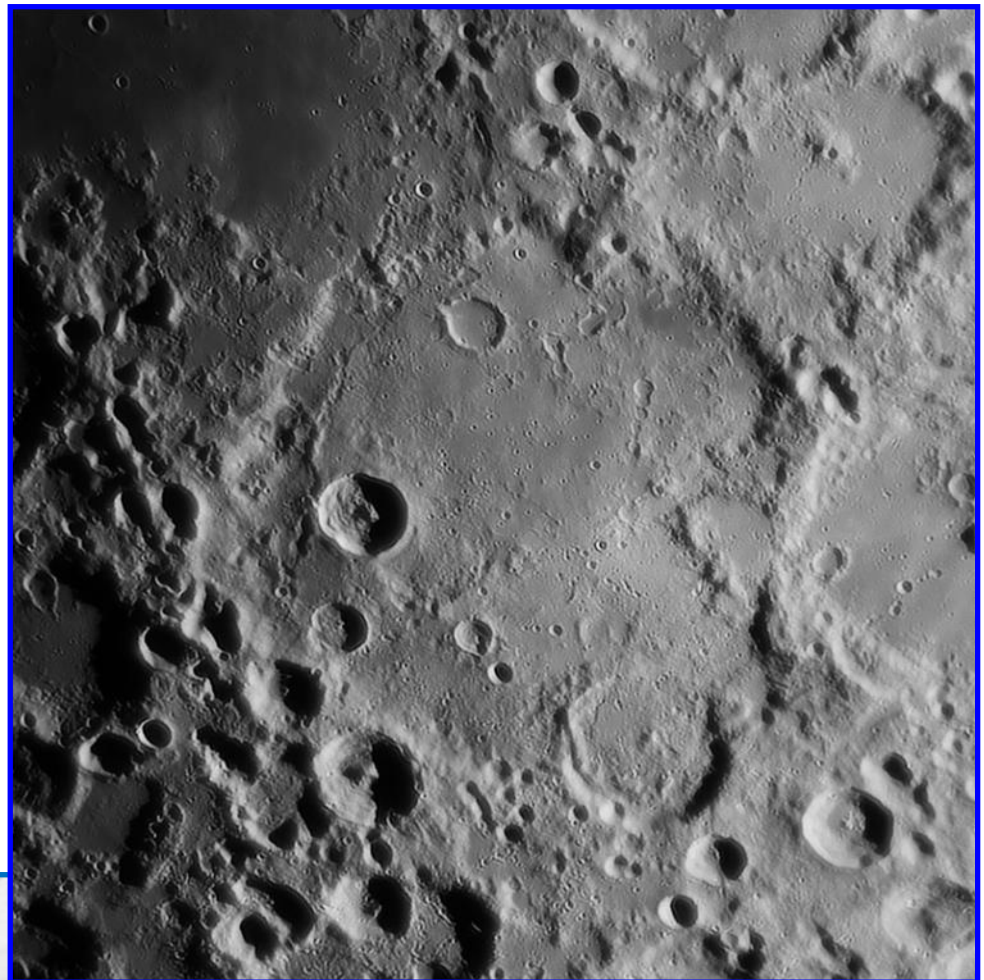
Recent Topographic Studies

Atlas and Hercules, *Ken Vaughan, Cattle Point, Victoria, British Colombia, Canada. 2024 March 17 03:38 UT. Meade 12 inch LX200 GPS Schmidt-Cassegrain telescope, Astronomik 642 nm R-IR filter, ZWO ASI178MM camera.*

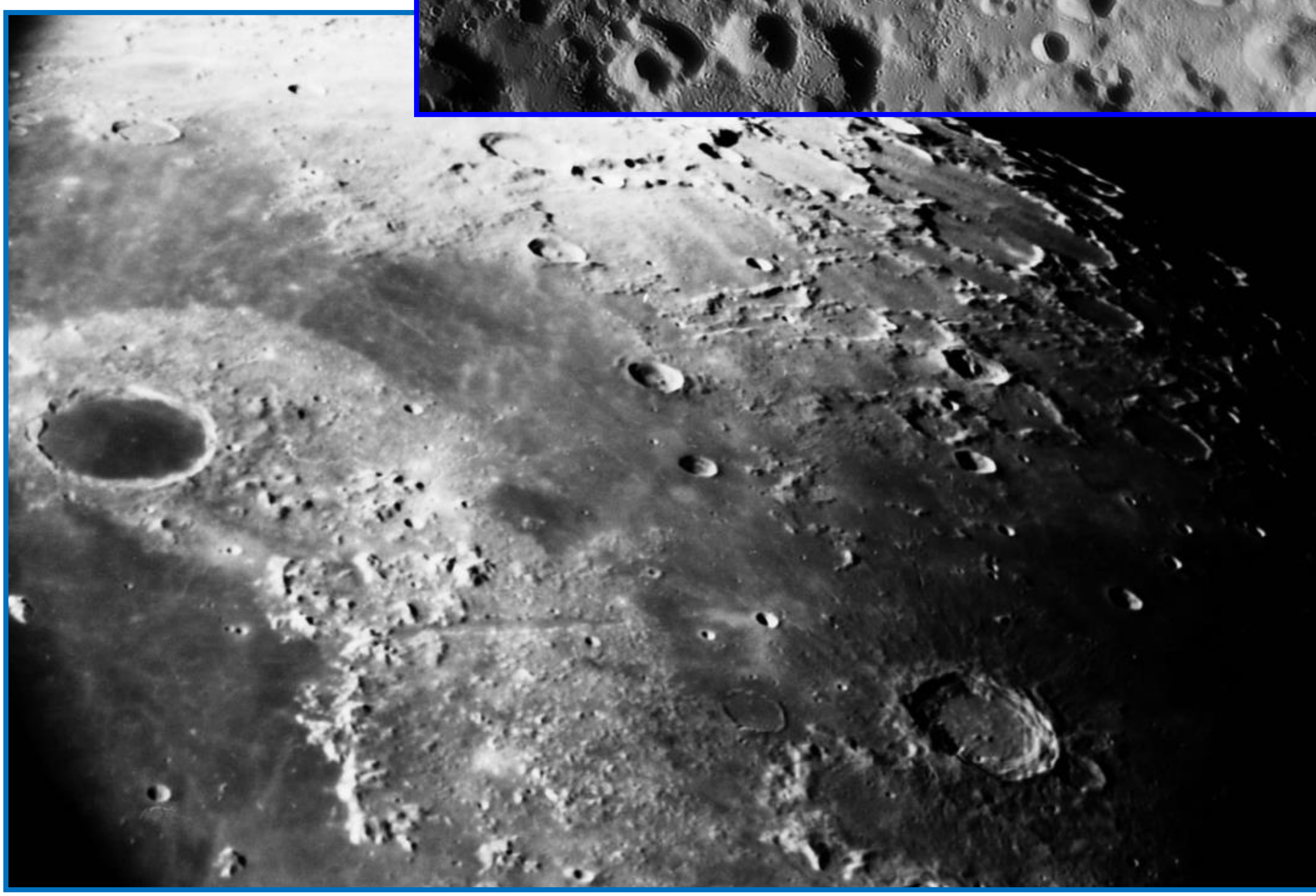
Aristoteles, *Jean Bourgeois, Pic du Midi Observatory, France. 1987 September 12. 1 m reflector telescope. Image submitted by Michel Deconinck.*

Recent Topographic Studies

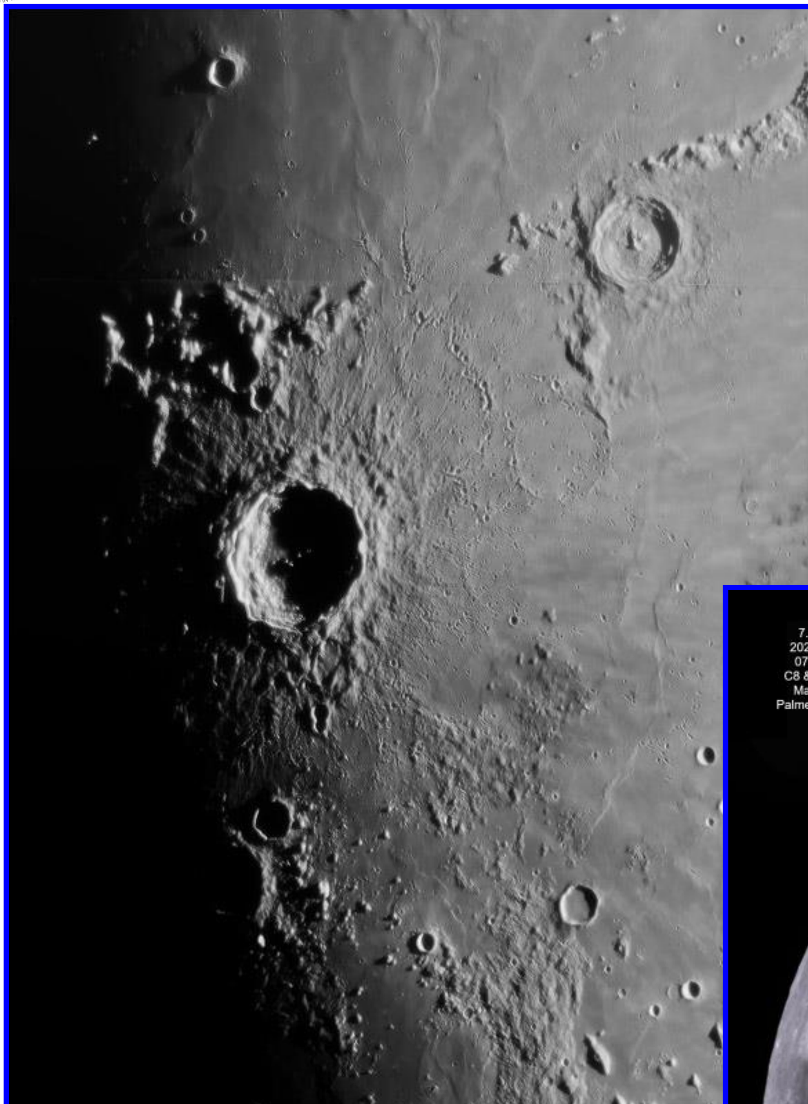
Deslandres, *Ken Vaughan, Cattle Point, Victoria, British Colombia, Canada. 2024 March 19 05:48 UT. Meade 12 inch LX200 GPS Schmidt-Cassegrain telescope, Astronomik 642 nm R-IR filter, ZWO ASI178MM camera.*



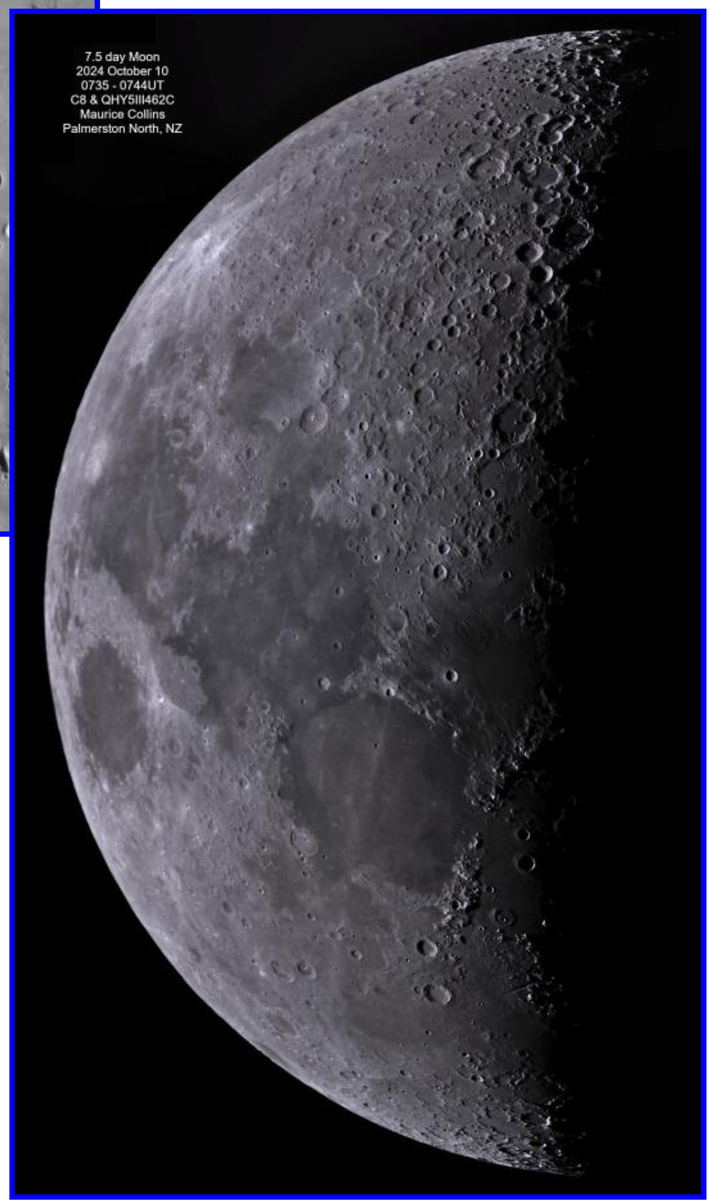
Aristoteles to Plato, *Jean Bourgeois, Pic du Midi Observatory, France. 1987 September 12. 1 m reflector telescope. Image submitted by Michel Deconinck.*



Recent Topographic Studies



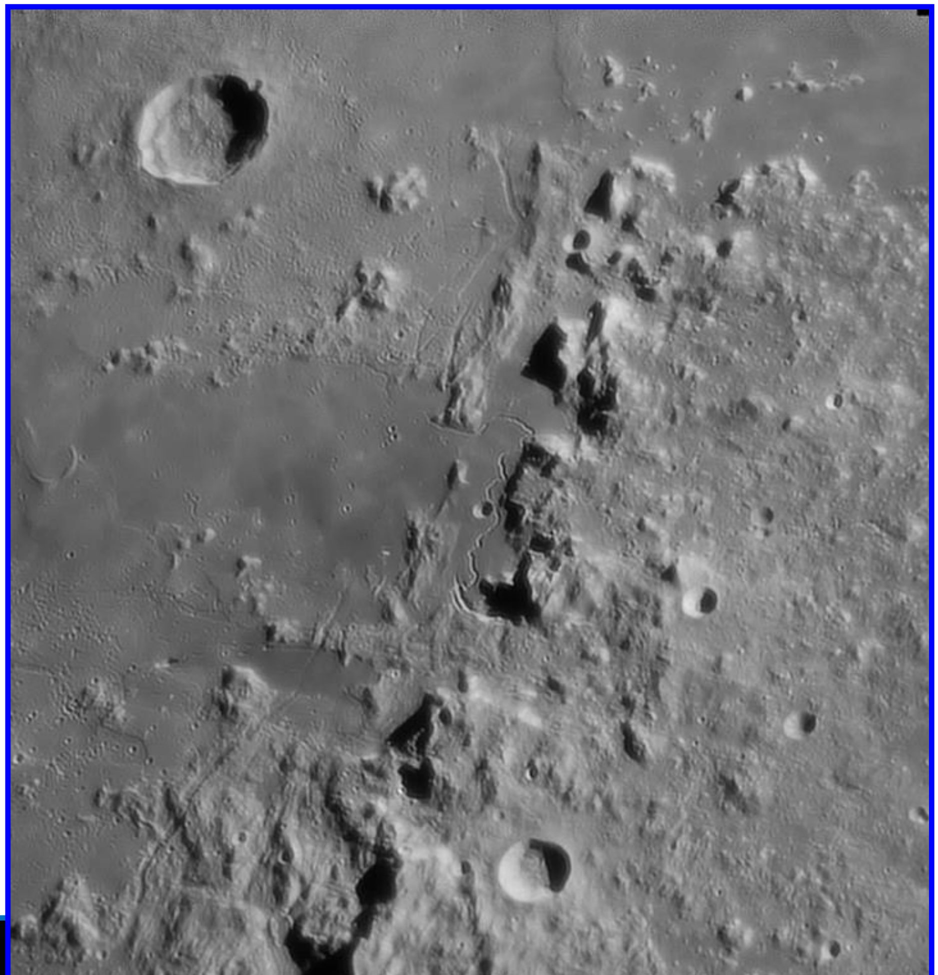
East of Copernicus, *Ken Vaughan, Cattle Point, Victoria, British Colombia, Canada. 2024 April 18 04:25 UT. Meade 12 inch LX200 GPS Schmidt-Cassegrain telescope, Astronomik 642 nm R-IR filter, ZWO ASI178MM camera*



7.5 day-old Moon, *Maurice Collins, Palmerston North, New Zealand. 2024 October 10 07:35-07:44 UT. Celestron 8 inch Schmidt-Cassegrain telescope, QHYIII462C camera. North is down, west is to the right.*

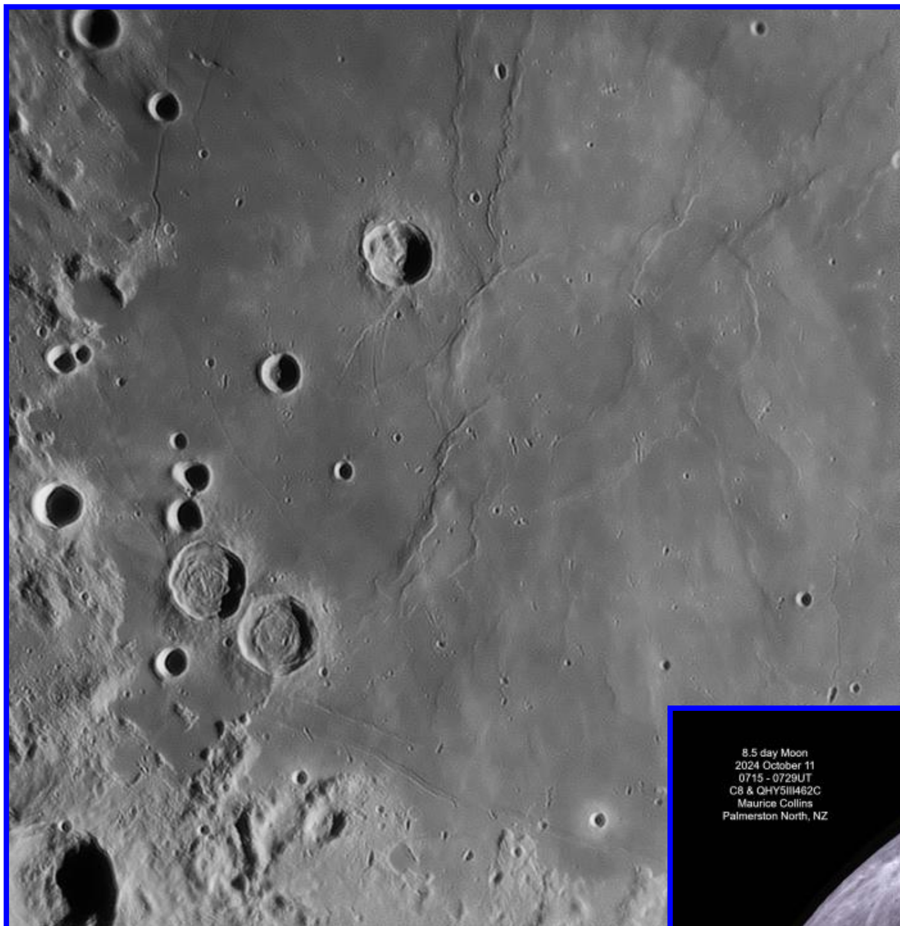
Recent Topographic Studies

Hadley Rille, *Ken Vaughan, Cattle Point, Victoria, British Colombia, Canada. 2024 March 19 03:57 UT. Meade 12 inch LX200 GPS Schmidt-Cassegrain telescope, Astronomik 642 nm R-IR filter, ZWO ASI178MM camera.*



Aristoteles to Scoresby, *Jean Bourgeois, Pic du Midi Observatory, France. 1988 December 27. 1 m reflector telescope. Image submitted by Michel Deconinck.*

Recent Topographic Studies

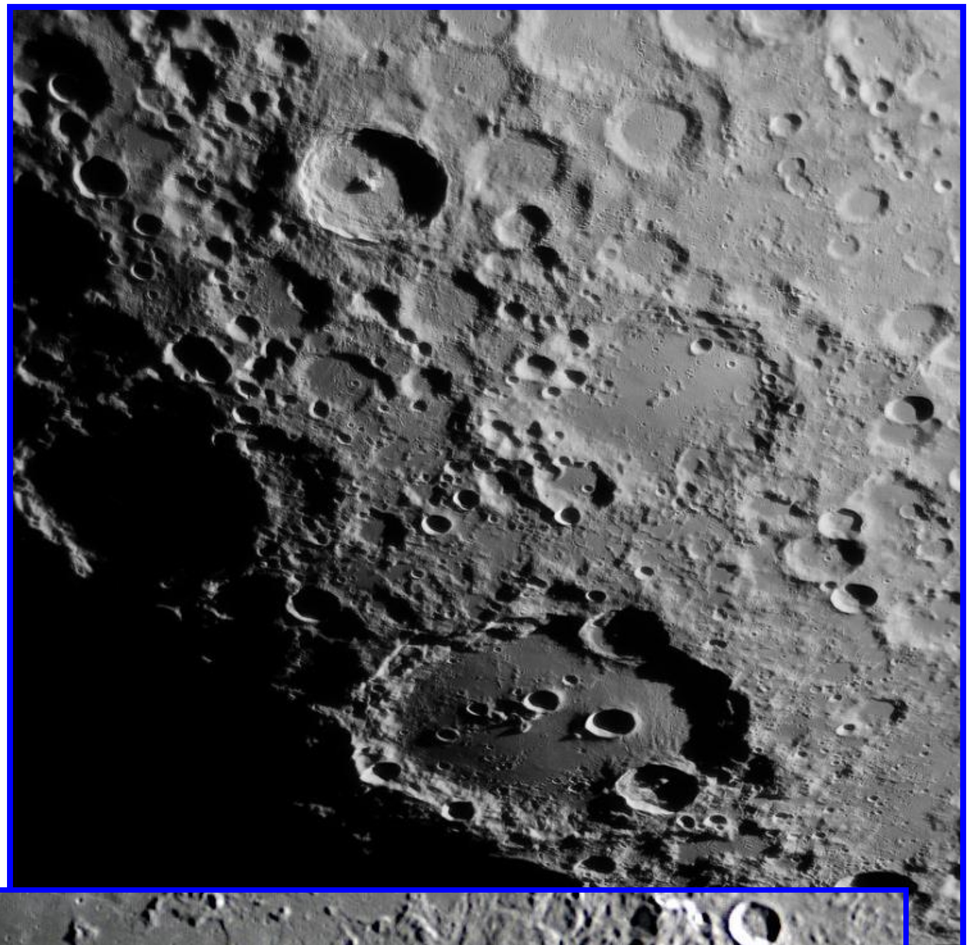


Southwestern Mare Tranquillitatis, *Ken Vaughan, Cattle Point, Victoria, British Colombia, Canada. 2024 March 17 03:49 UT. Meade 12 inch LX200 GPS Schmidt-Cassegrain telescope, Astronomik 642 nm R-IR filter, ZWO ASI178MM camera*

8.5 day-old Moon, *Maurice Collins, Palmerston North, New Zealand. 2024 October 11 07:15-07:29 UT. Celestron 8 inch Schmidt-Cassegrain telescope, QHYIII462C camera. North is down, west is to the right.*

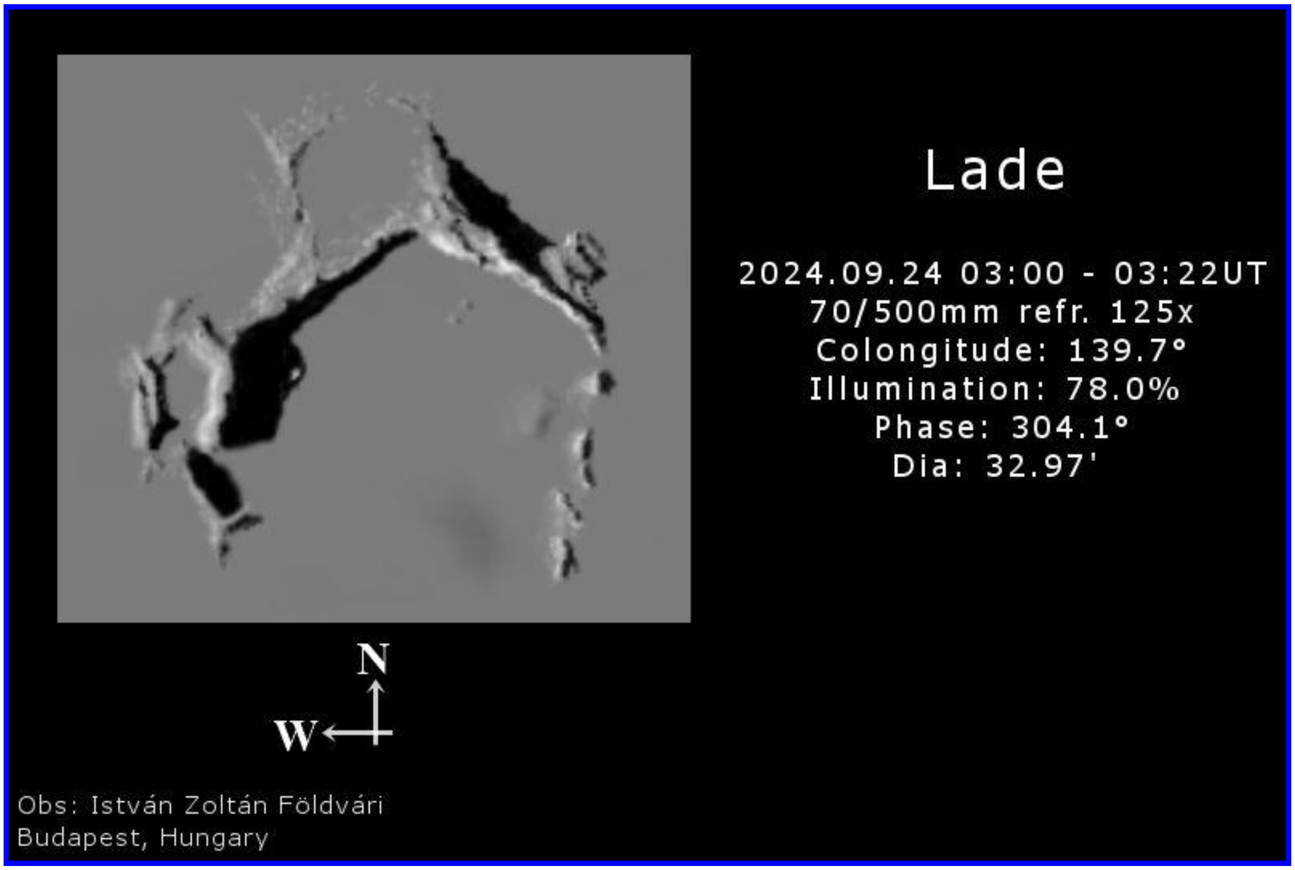
Recent Topographic Studies

Tycho and Clavius, *Ken Vaughan, Cattle Point, Victoria, British Colombia, Canada. 2024 April 18 04:47 UT. Meade 12 inch LX200 GPS Schmidt-Cassegrain telescope, Astronomik 642 nm R-IR filter, ZWO ASI178MM camera.*

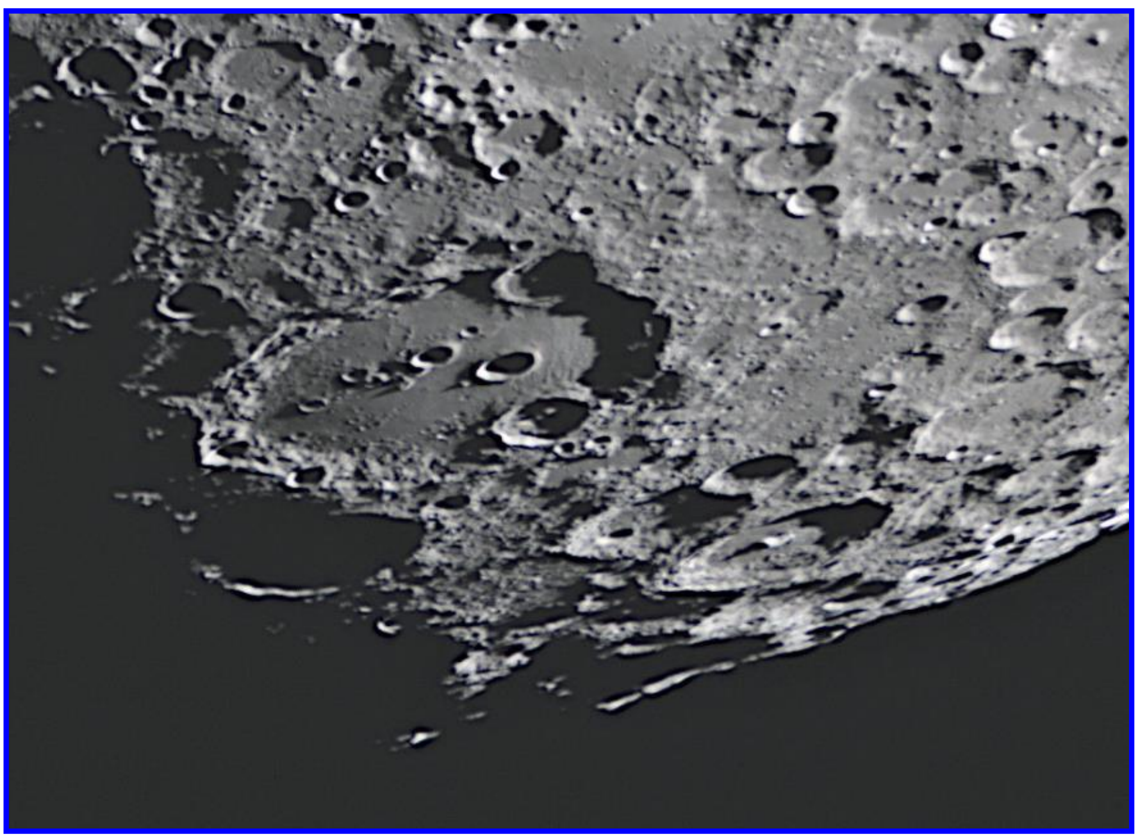


Montes Apenninus, *Walter Ricardo Elias, Oro Verde, Argentina, AEA. 2024 October 11 23:22 UT. Celestron 11 inch Schmidt-Cassegrain telescope, QHY5-II-C camera.*

Recent Topographic Studies



Lade, *István Zoltán Földvári, Budapest, Hungary. 2024 September 24 03:30-03:22 UT, colongitude 139.7º. 70 mm refractor telescope, 500 mm focal length, 4 mm Vixen LV Lanthanum eyepiece, 125x. Seeing 7/10, transparency 5/6.*



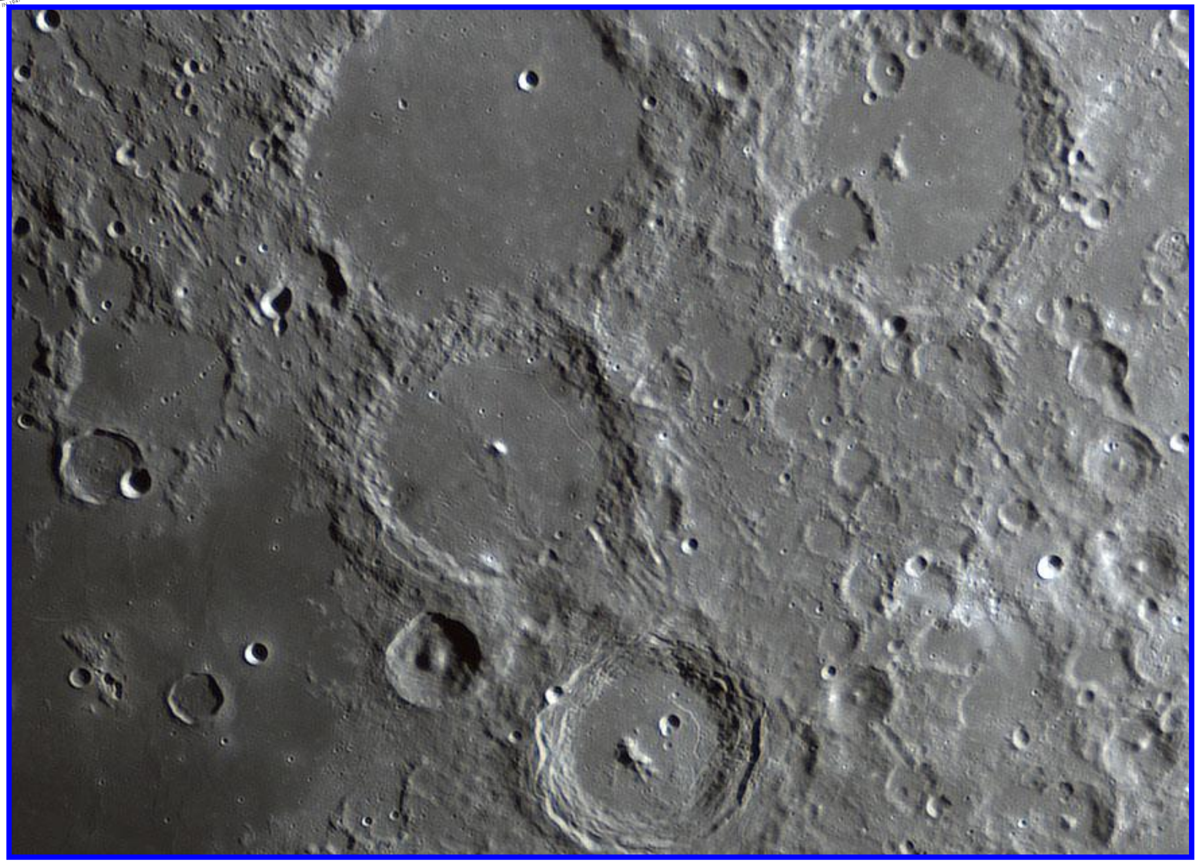
Clavius, *Walter Ricardo Elias, Oro Verde, Argentina, AEA. 2024 October 11 23:53 UT. Celestron 11 inch Schmidt-Cassegrain telescope, QHY5-II-C camera.*

Recent Topographic Studies

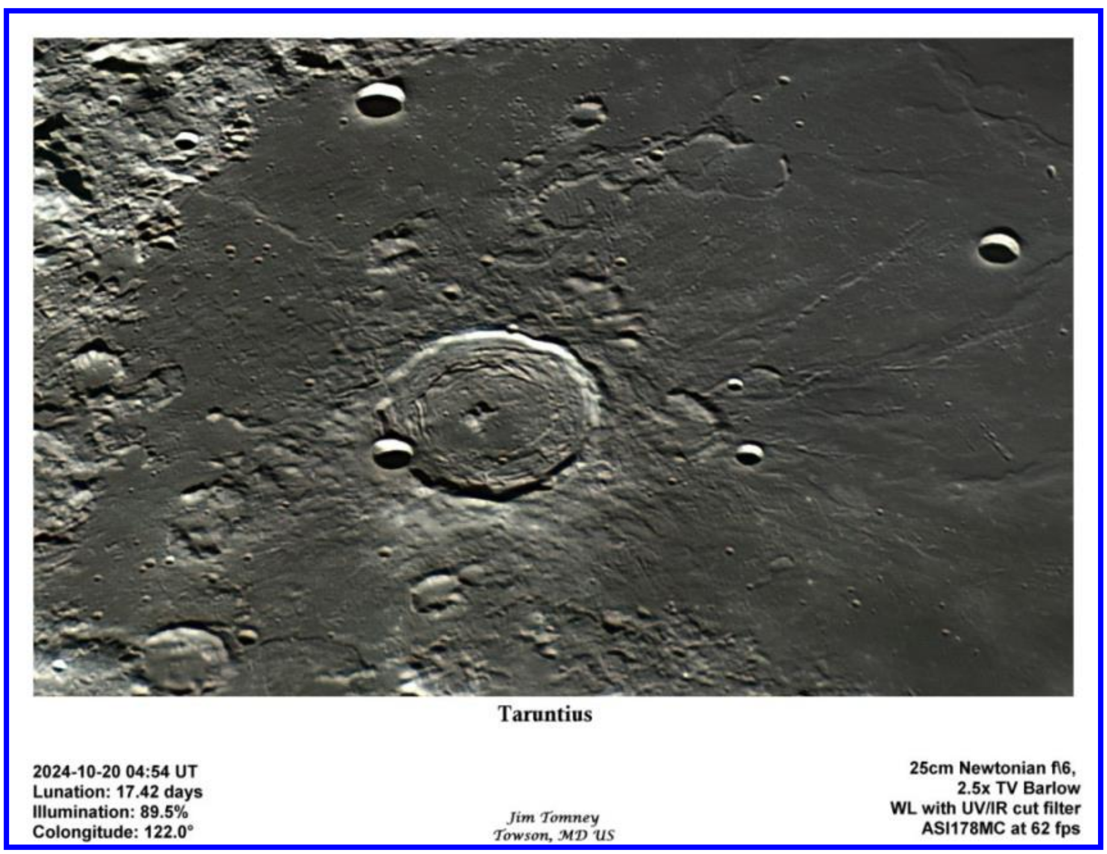
Copernicus, *Walter Ricardo Elias, Oro Verde, Argentina, AEA. 2024 October 11 23:25 UT. Celestron 11 inch Schmidt-Cassegrain telescope, QHY5-II-C camera.*

13.6 day-old Moon, *Maurice Collins, Palmerston North, New Zealand. 2024 October 16 08:43-08:51 UT. 80 mm ED refractor telescope, 3x barlow, QHYIII462C camera. North is down, west is to the right.*

Recent Topographic Studies

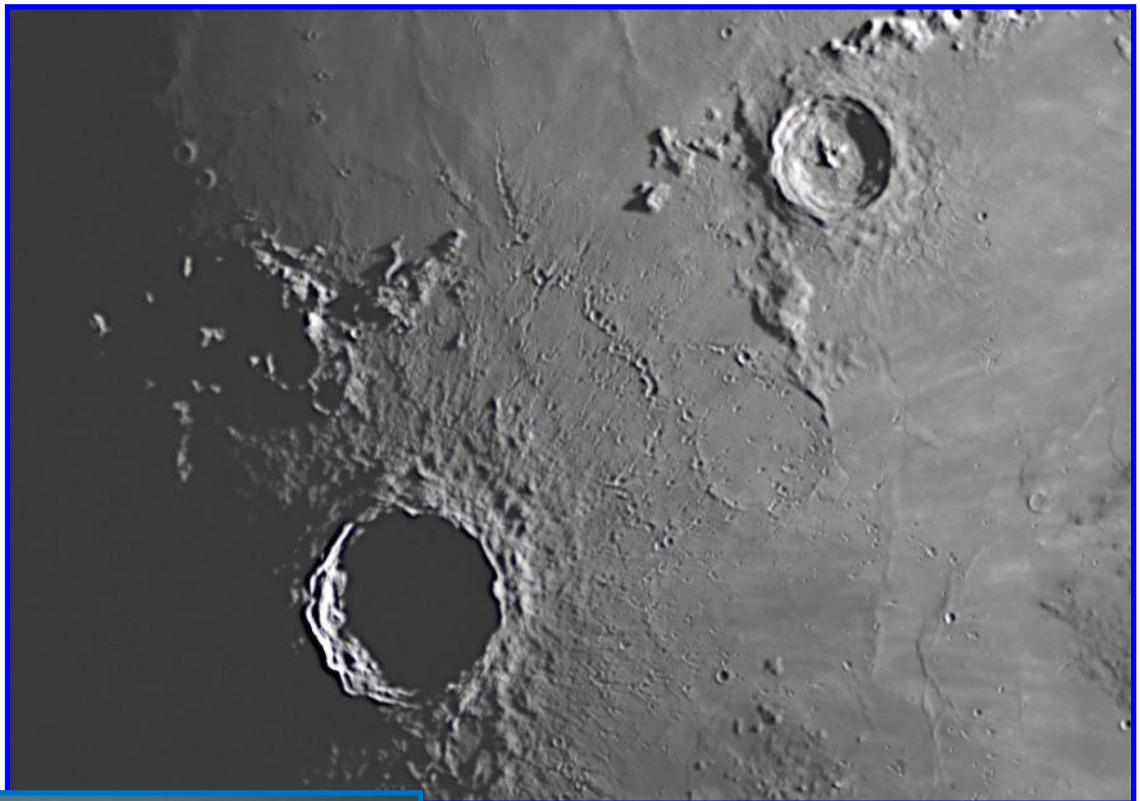


Alphonsus, *Walter Ricardo Elias, Oro Verde, Argentina, AEA. 2024 October 11 23:16 UT. Celestron 11 inch Schmidt-Cassegrain telescope, QHY5-II-C camera.*



Taruntius, *Jim Tomney, Towson, Maryland, USA. 22024 October 20 04:54 UT, colongitude 122.0˚. 25 cm Newtonian reflector telescope, 2.5x Tele Vue barlow, UV/IR cut filter, ASI178 MC camera.*

Recent Topographic Studies



Copernicus, *Walter Ricardo Elias, Oro Verde, Argentina, AEA. 2024 October 11 23:26 UT. Celestron 11 inch Schmidt-Cassegrain telescope, QHY5-II-C camera.*

Waning Gibbous Moon, *Aurore Guillerand, Margny-Les-Compiègne, Oise, Hauts-de-France, France. 2024 June 27 03:35 UT. 60 mm Takahashi refractor telescope, fl 355 mm, 2.5x barlow, 12 mm eyepiece.*

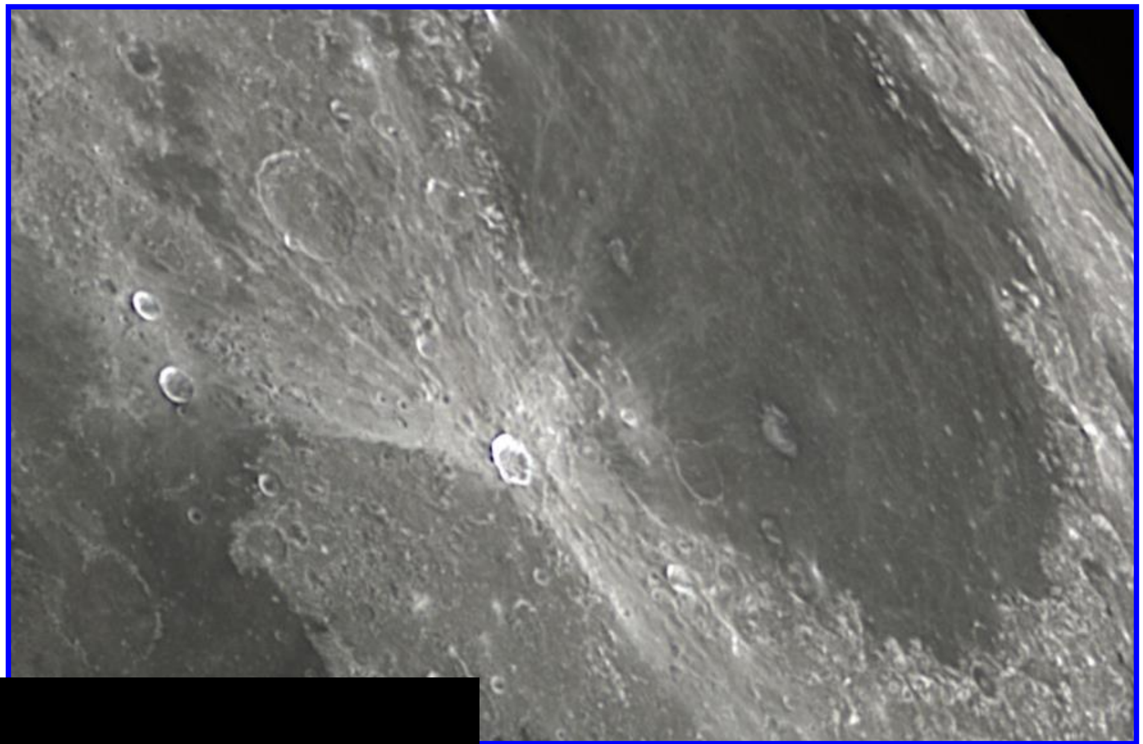
Recent Topographic Studies

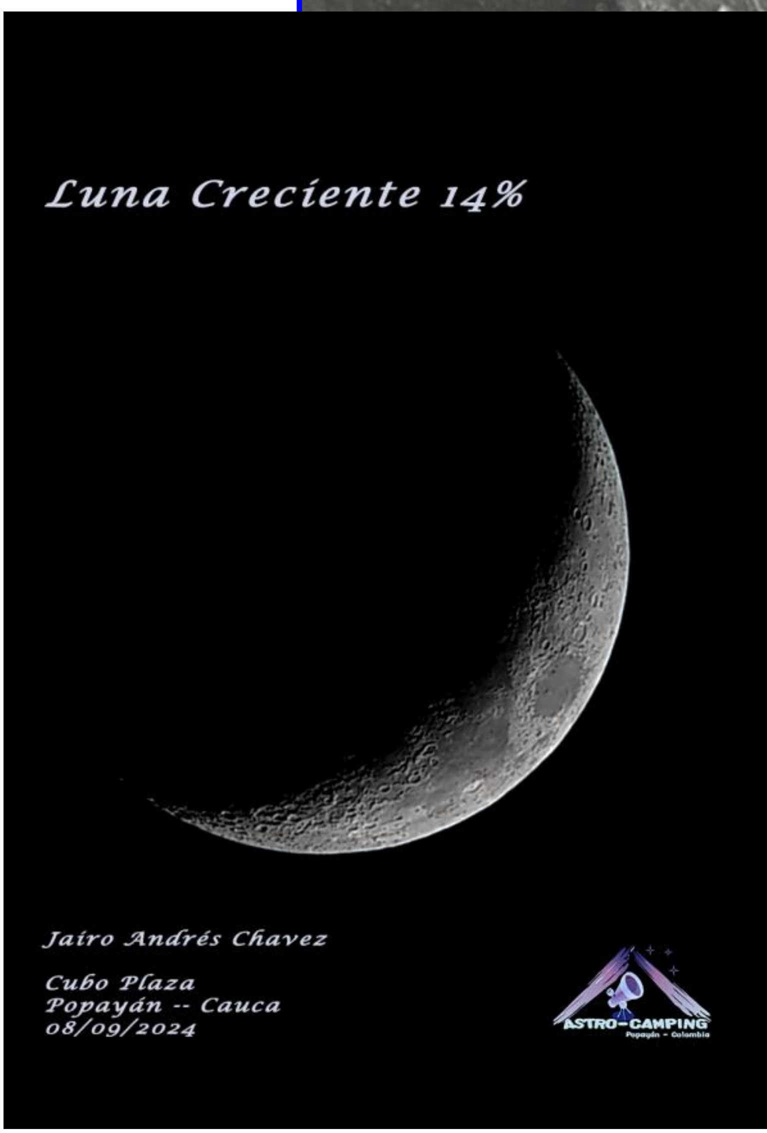
Parry, *Walter Ricardo Elias, Oro Verde, Argentina, AEA. 2024 October 11 23:35 UT. Celestron 11 inch Schmidt-Cassegrain telescope, QHY5-II-C camera.*

Copernicus, *Fernando Sura, San Nicolás de los Arroyos, Argentina. 2024 September 13 01:00 UT. 127 mm Maksutov-Cassegrain telescope, NEXIMAGE 5 camera.*

Recent Topographic Studies

Proclus, *Walter Ricardo Elias, Oro Verde, Argentina, AEA. 2024 October 11 23:18 UT. Celestron 11 inch Schmidt-Cassegrain telescope, QHY5-II-C camera.*





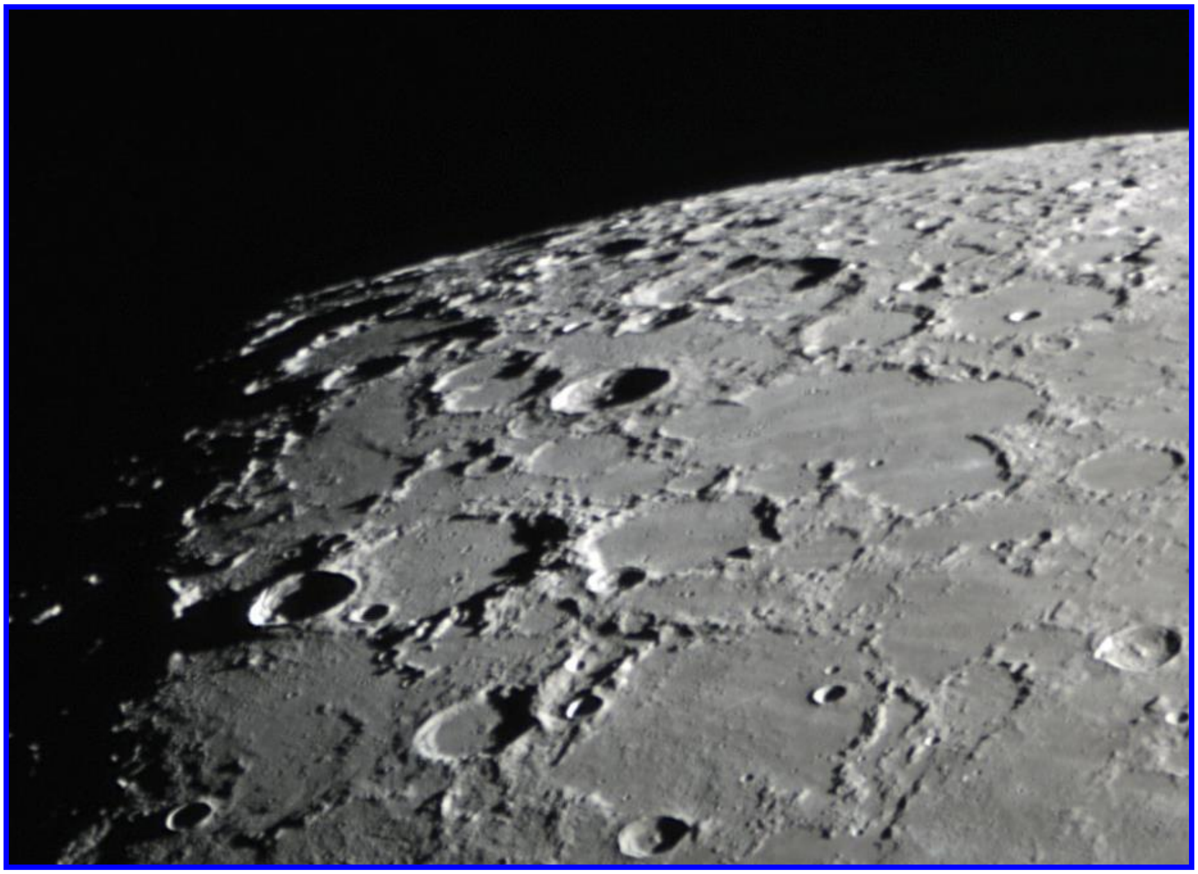
Waxing Crescent Moon, 14%, *Jairo Chavez, Popayán, Colombia. 2022 September 07 23:26 UT. 311 mm truss tube Dobsonian reflector telescope, MOTO E5 PLAY camera.*

Recent Topographic Studies

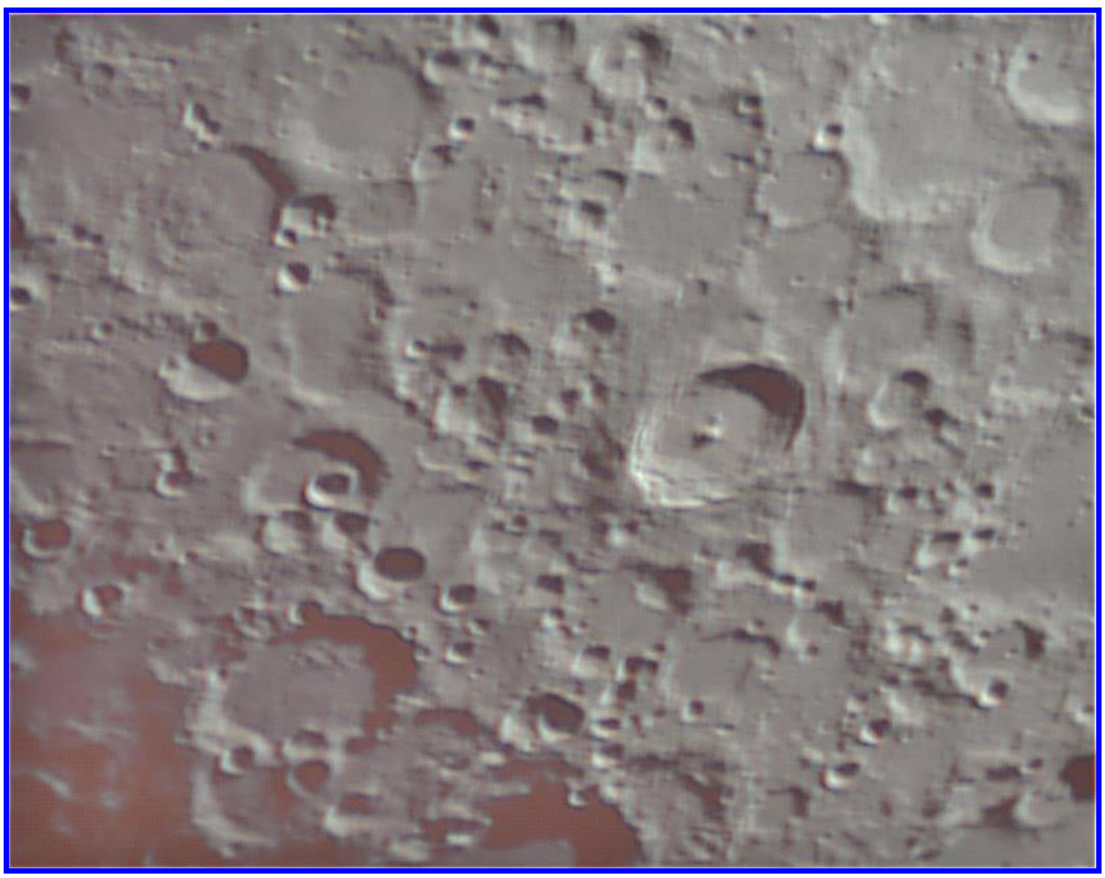
Plato, *Walter Ricardo Elias, Oro Verde, Argentina, AEA. 2024 October 11 23:10 UT. Celestron 11 inch Schmidt-Cassegrain telescope, QHY5-II-C camera.*

Waxing Crescent Moon, 31%, *Jairo Chavez, Popayán, Colombia. 2022 September 10 00:15 UT. 311 mm truss tube Dobsonian reflector telescope, MOTO E5 PLAY camera.*

Recent Topographic Studies



Scoresby, *Walter Ricardo Elias, Oro Verde, Argentina, AEA. 2024 October 11 23:41 UT. Celestron 11 inch Schmidt-Cassegrain telescope, QHY5-II-C camera.*



Tycho, *Fernando Sura, San Nicolás de los Arroyos, Argentina. 2024 September 13 01:00 UT. 127 mm Maksutov-Cassegrain telescope, NEXIMAGE 5 camera*

Recent Topographic Studies

Tycho, *Walter Ricardo Elias, Oro Verde, Argentina, AEA. 2024 October 11 23:31 UT. Celestron 11 inch Schmidt-Cassegrain telescope, QHY5-II-C camera.*

Waxing Gibbous Moon, 78%, *Jairo Chavez, Popayán, Colombia. 2022 October 13 23:06 UT. 311 mm truss tube Dobsonian reflector telescope, MOTO E5 PLAY camera. North is to the lower right, west is to the upper right.*

Recent Topographic Studies

Rupes Recta, *Walter Ricardo Elias, Oro Verde, Argentina, AEA. 2024 October 11 23:29 UT. Celestron 11 inch Schmidt-Cassegrain telescope, QHY5-II-C camera.*

Waxing Gibbous Moon, 87%, *Jairo Chavez, Popayán, Colombia. 2022 September 15 03:17 UT. 311 mm truss tube Dobsonian reflector telescope, MOTO E5 PLAY camera. North is to the lower left, west is to the lower right.*

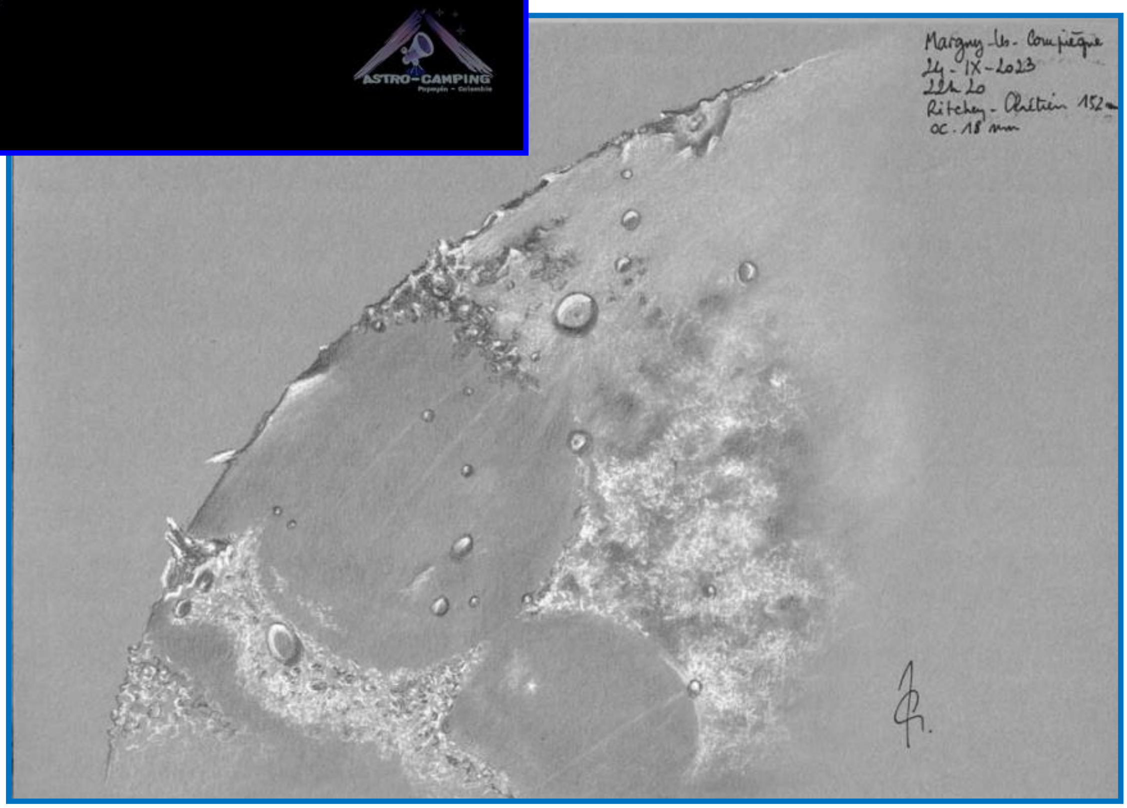
Recent Topographic Studies

Aristarchus, *KC Pau, Hong Kong, China. 2024 October 14 13:21 UT. 250 mm f/6 Newtonian reflector telescope, 2.5x barlow, QHYCCD290M camera.*

Aristarchus Plateau
Taken on 14 October 2024,13h21m UT
with 250mm f/6 newtonian reflector + 2.5X barlow + QHYCCD 290M camera, mosaic of 2 images
Taken by KC Pau, Hong Kong

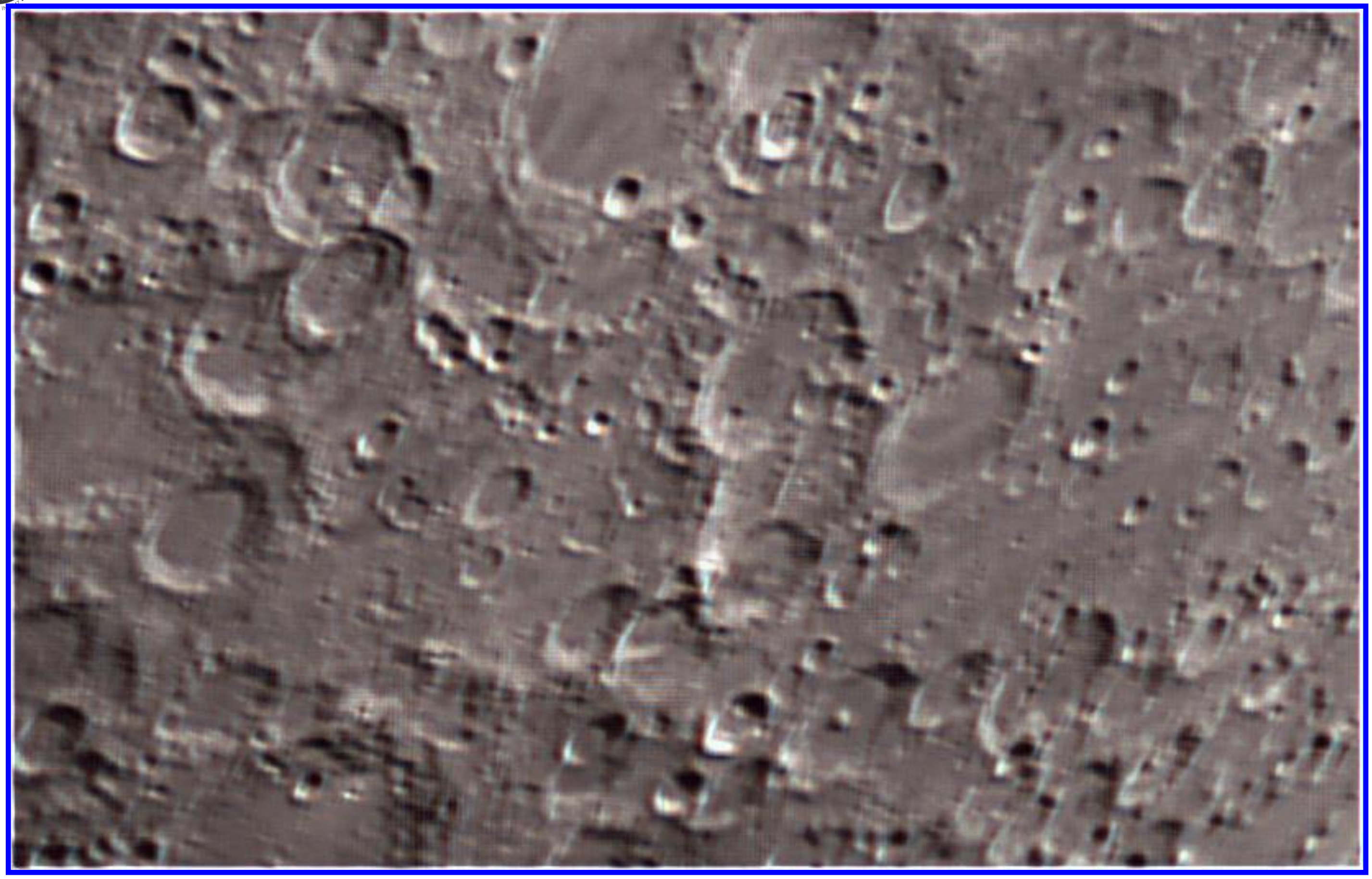
Recent Topographic Studies

Waxing Gibbous Moon, 94%, *Jairo Chavez, Popayán, Colombia. 2022 September 15 23:17 UT. 311 mm truss tube Dobsonian reflector telescope, MOTO E5 PLAY camera. North is to the lower right, west is to the upper right.*



Alpes to Montes Apenninus, *Aurore Guillerand, Margny-Les-Compiègne, Oise, Hauts-de-France, France. 2023 September 24 20:20 UT. 152 mm Ritchey Chretien telescope, 8 mm eyepiece. North is to the lower left, west is to the upper left.*

Recent Topographic Studies

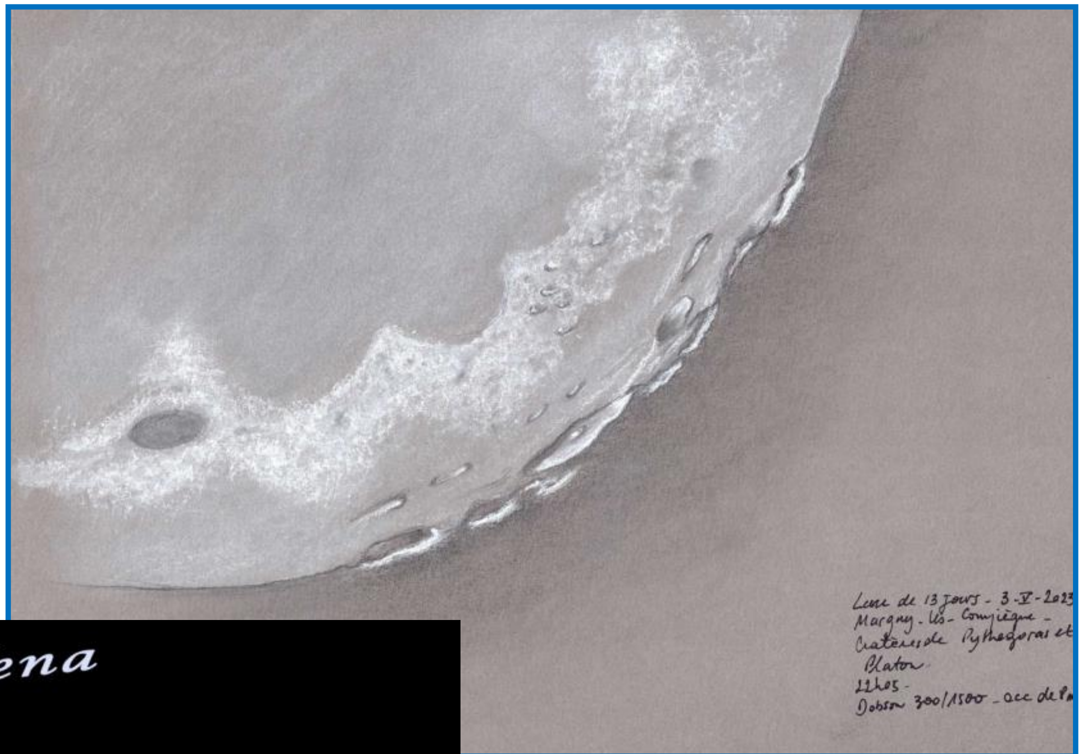


Licetus, *Fernando Sura, San Nicolás de los Arroyos, Argentina. 2024 September 13 01:00 UT. 127 mm Maksutov-Cassegrain telescope, NEXIMAGE 5 camera*

Aristarchus, *Raúl Roberto Podestá , Formosa, Argentina. 2024 September 15 22:33 UT. 127 mm Maksutov-Cassegrain telecope, UV/IR cut filter, ZWO ASI178MC camera. North is to the lower left, west is up.*

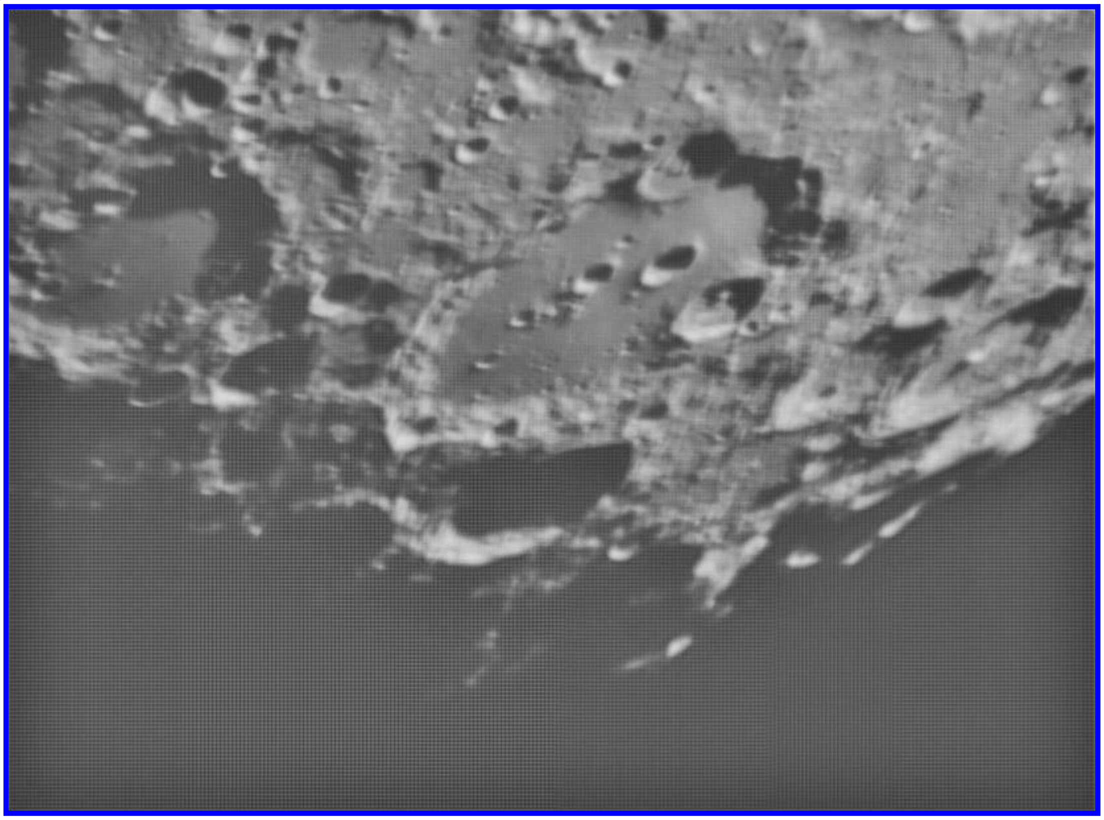
Recent Topographic Studies

Plato to Pythagoras, *Aurore Guillerand, Margny-Les-Compiègne, Oise, Hauts-de-France, France. 2023 May 03 20:05 UT. 300 mm Dobsonian reflector telescope, focal length 1500 mm, 8 mm eyepiece. North is to the lower right, west is up.*



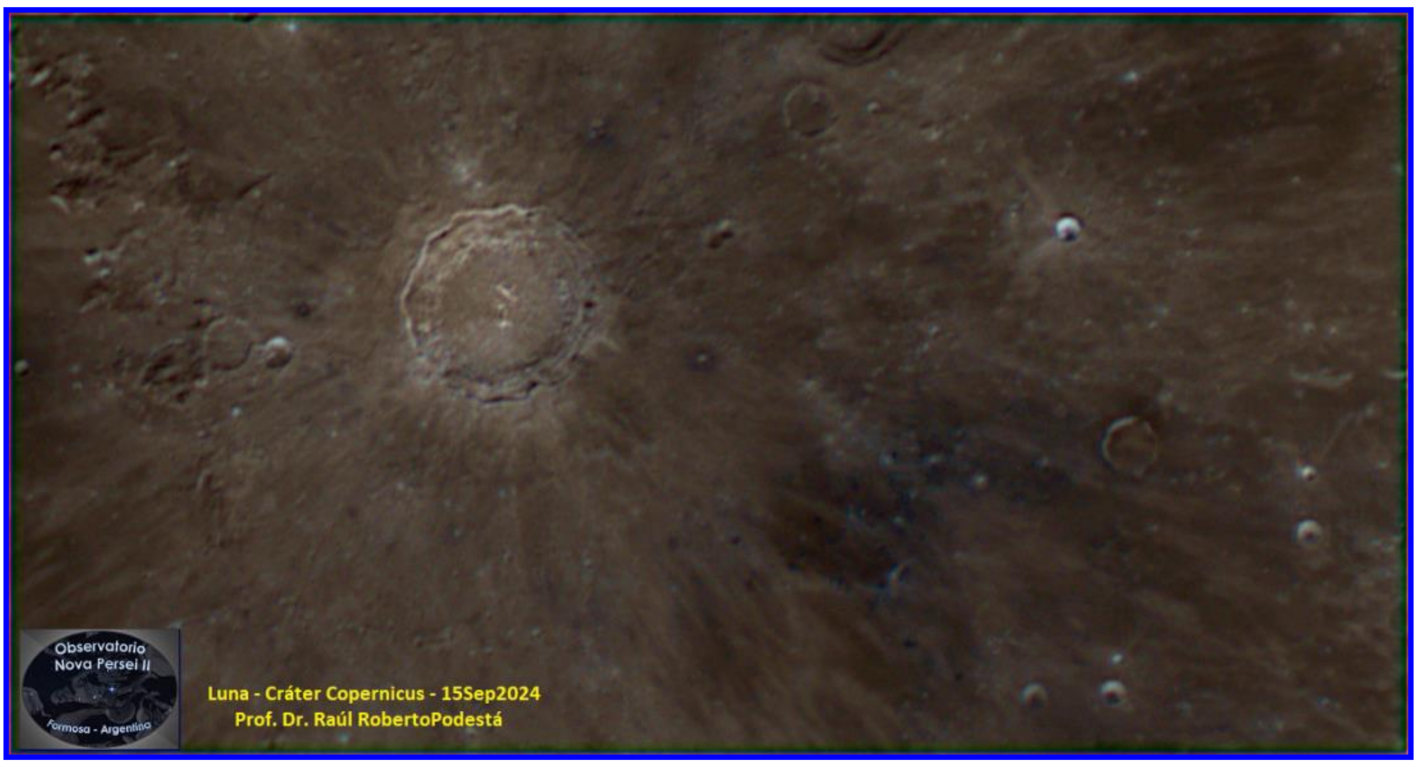
Waning Gibbous Moon, *Jairo Chavez, Popayán, Colombia. 2022 October 18 02:17 UT. 311 mm truss tube Dobsonian reflector telescope, MOTO E5 PLAY camera. North is to the lower right, west is to the upper right.*

Recent Topographic Studies



Clavius, *Fernando Sura, San Nicolás de los Arroyos, Argentina. 2024 September 13 01:00 UT. 127 mm Maksutov-Cassegrain telescope, NEXIMAGE 5 camera*

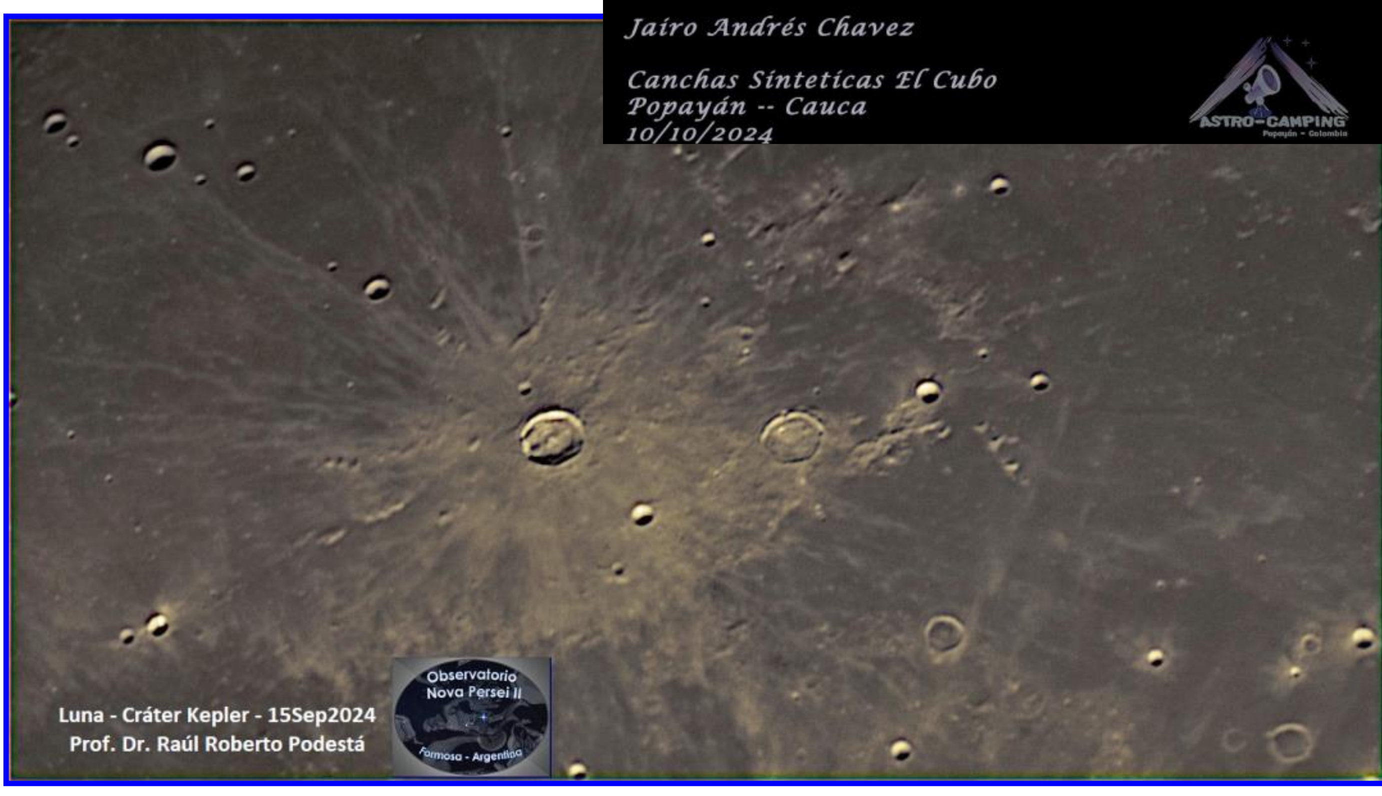
Copernicus, *Raúl Roberto Podestá , Formosa, Argentina. 2024 September 15 22:35 UT. 127 mm Maksutov-Cassegrain telecope, UV/IR cut filter, ZWO ASI178MC camera. North is to the left, west is up.*



Recent Topographic Studies

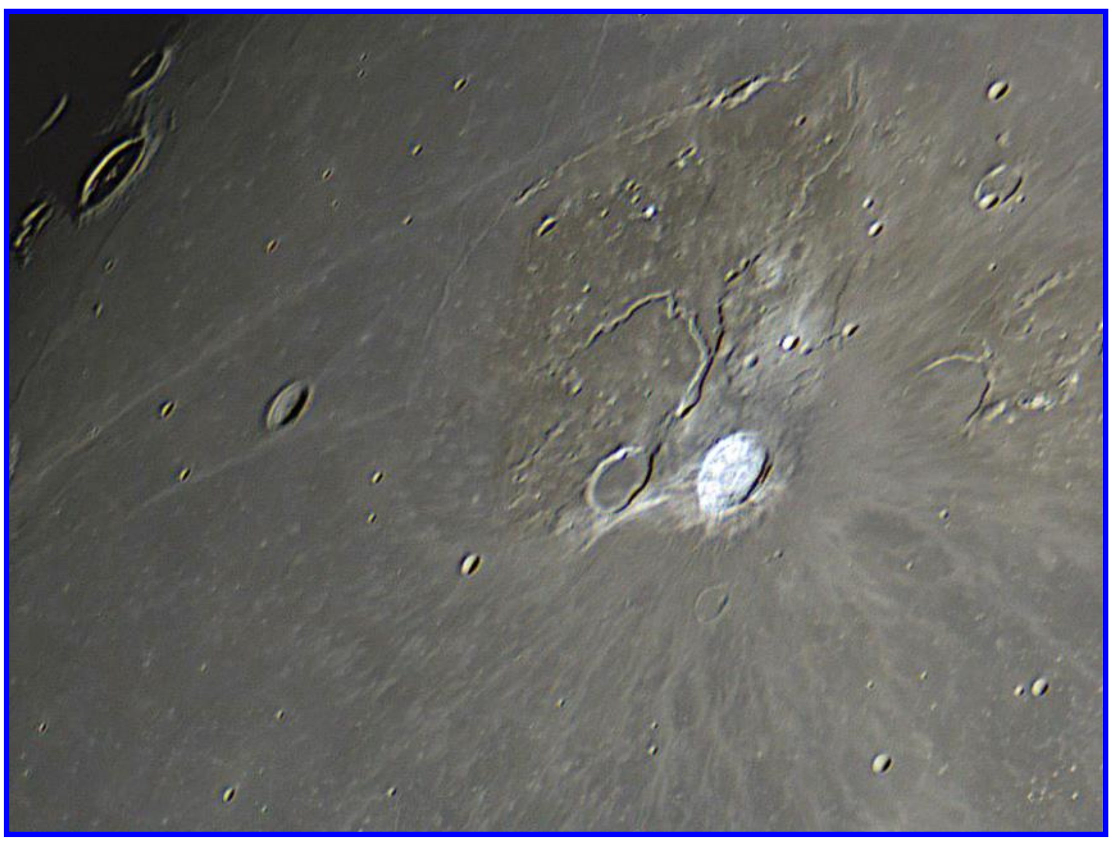
Waning Gibbous Moon, 98%, *Jairo Chavez, Popayán, Colombia. 2022 October 18 01:31 UT. 311 mm truss tube Dobsonian reflector telescope, MOTO E5 PLAY camera. North is to the lower right, west is to the upper right.*

Kepler, *Raúl Roberto Podestá , Formosa, Argentina. 2024 September 15 22:32 UT. 127 mm Maksutov-Cassegrain telecope, UV/IR cut filter, ZWO ASI178MC camera. North is to the left, west is up.*



Recent Topographic Studies

Tycho, *Raúl Roberto Podestá , Formosa, Argentina. 2024 September 15 22:46 UT. 127 mm Maksutov-Cassegrain telecope, UV/IR cut filter, ZWO ASI178MC camera. North is to the left, west is up.*

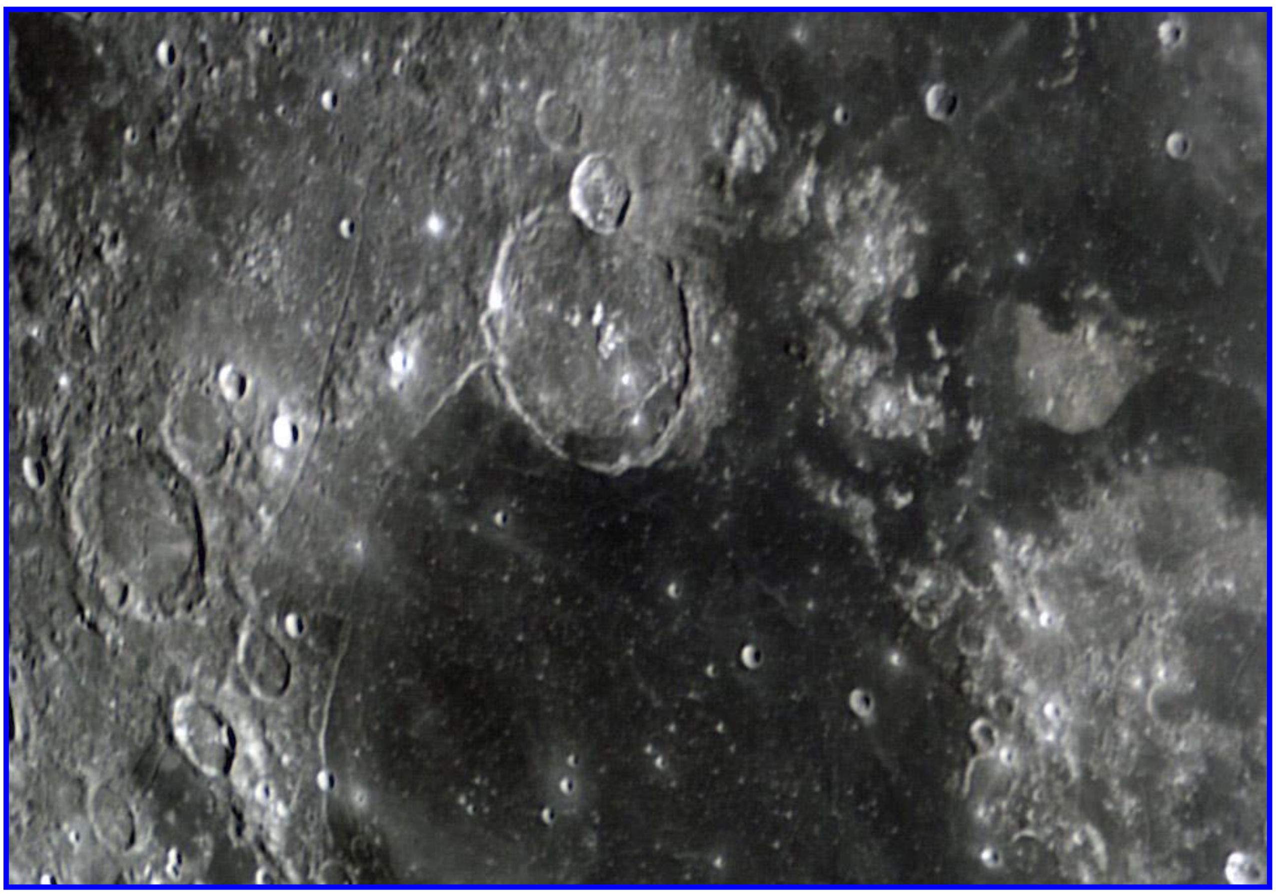


Aristarchus, *Walter Ricardo Elias, Oro Verde, Argentina, AEA. 2024 October 16 1:32 UT. Celestron 11 inch Schmidt-Cassegrain telescope, QHY5C-II camera.*

Recent Topographic Studies

Ptolemaeus, Alphonsus and Arzachel, *Fernando Sura, San Nicolás de los Arroyos, Argentina. 2024 September 13 01:00 UT. 127 mm Maksutov-Cassegrain telescope, NE-XIMAGE 5 camera.*

Gassendi, *Walter Ricardo Elias, Oro Verde, Argentina, AEA. 2024 October 16 1:33 UT. Celestron 11 inch Schmidt-Cassegrain telescope, QHY5C-II camera.*

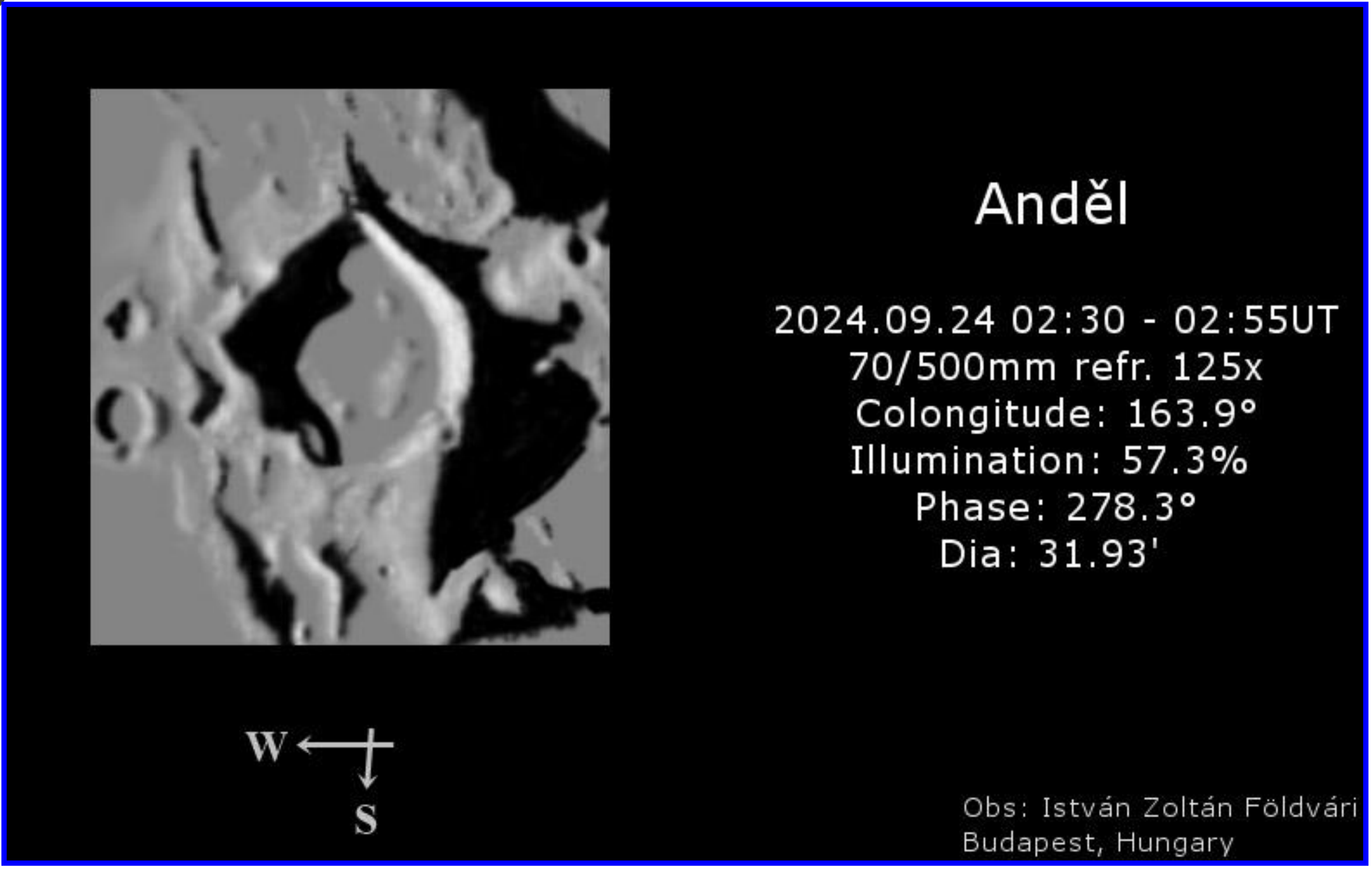


Recent Topographic Studies

Gassendi, *Aurore Guillerand, Margny-Les-Compiègne, Oise, Hauts-de-France, France. 2023 May 01 19:45 UT. 300 mm Dobsonian reflector telescope, focal length 1500 mm, 8 mm eyepiece. North is down, west is to the left.*

Aristarchus, *Walter Ricardo Elias, Oro Verde, Argentina, AEA. 2024 October 15 23:16 UT. Celestron 11 inch Schmidt-Cassegrain telescope,40 mm ocular, Moto Edge 40 cellphone camera.*

Recent Topographic Studies



Anděl, *István Zoltán Földvári, Budapest, Hungary. 2024 September 24 02:30-02:55 UT, colongitude 163.9°. 70 mm refractor telescope, 500 mm focal length, 4 mm Vixen LV Lanthanum eyepiece, 125x. Seeing 7/10, transparency 4/6.*

Abulfeda, *Massimo Dionisi, Sassari, Italy. 2024 July 27 01:52 UT. 250 mm SkyWatcher f/4.8 Newtonian reflector telescope, 3x barlow, 3600 mm focal length, IR pass filter 685 nm, Neptune M camera.*

Recent Topographic Studies

Lunar Geologic Change Detection Program

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

2024 November

LTP Reports Received
No new LTPs have been reported.

Routine reports received for September included: Alberto Anunziato (Argentina – SLA) observed: Bianchini G, Gassendi, Mare Crisium and Walther. John Axtell (Woking, UK – BAA) imaged: the lunar eclipse and several features. Tony Cook (Mundesley, UK - BAA) imaged: the lunar eclipse. Les Fry (West Wales, UK – NAS) imaged: several features. Rik Hill (Tucson, AZ, USA -ALPO/BAA) imaged: several features. Lars Lindhard (Denmark – BAA) imaged: Mare Crisium. Chris Longthorn (Rugby, UK – BAA) imaged: several features. Trevor Smith (Codnor, UK – BAA) observed: Aristarchus, Gassendi and Plato. Alan Tough (Lossiemouth, UK – BAA) imaged: the lunar eclipse. Alexander Vandenbohede (Belgium - BAA) imaged: Cleomedes, Endymion, Gauss, the lunar eclipse, Mare Anguis, Mare Humboldtianum, Messier, Moretus, Palus Somni, Petavius, Posidonius, Rheita, and Thales. Alex Vincent (Worthing, UK – BAA) imaged: the lunar eclipse. Ivan Walton (SLOOH Canary Islands H-alpha remotely operated telescope – BAA) images several features.

Note that we I have included some BAA pooled observations in with this report.

Analysis of Routine Reports Received (September)

Bianchini G: On 2024 Sep 14 UT 02:46-02:56 Alberto Anunziato (SLA) observed this crater under similar illumination to the following report:

On 1987 Sep 04 at UT 03:00 J. Caruso (Middletown, CT, USA, 3" refractor, x155, S=6/10 and T=8/10) found that Bianchini G was not visible, however Heraclides E, Helicon G, and indeed many other smaller craters could be seen. There were two small mountains in the general area of Bianchini G. and a mare ridge - all these were clearly seen. Caruso states that Bianchini G should normally be much more clearly seen than the other features mentioned and is the same size as Heraclides E. The Cameron 2006 catalog ID=305 and the weight=3. The ALPO/BAA weight=1.

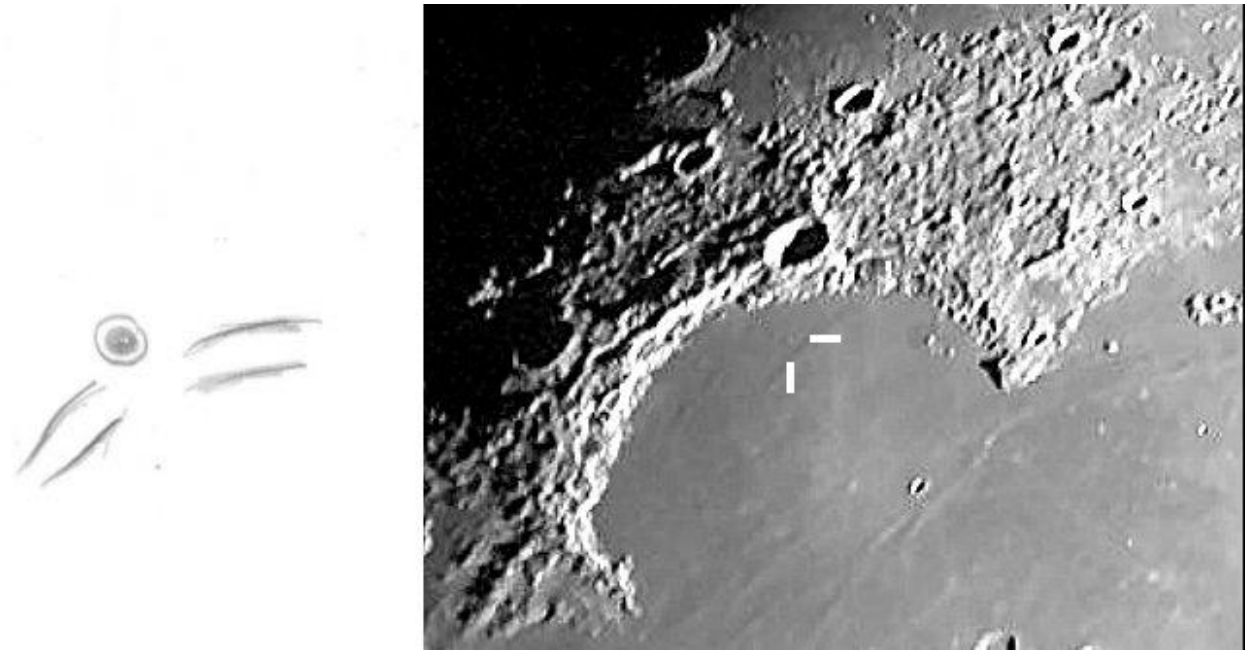


Figure 1. *Bianchini G with north towards the top* ***(Left)*** *As sketched by Alberto Anunziato (SLA) on 2024 Sep 14 UT 02:46-02:56.* ***(Right)*** *An image by Ed Crandall (ALPO) taken on 2004 Feb 25 UT 01:49 – the ticks mark the location of Bianchini G. This image has undergone some sharpening and contrast stretching.*

Alberto comments: Bianchini G was barely visible, behind two mountains? Two segments of one wrinkle ridge? Heraclides E (very faint) and Helicon G (better visibility) were seen. In a previous observation for this same event, (2016 Feb 19 UT 03:30-04:00) he could not observe this crater with the same telescope and eye-piece. Alberto sent in a sketch (Fig 1 - Left). Looking back through the archives I came across an image by Ed Crandall (ALPO) made under similar illumination. As you can see in Fig 1 (Right) the crater is barely visible, even with some sharpening and contrast stretching, also Heraclides E is not very visible either. I think we shall leave the weight at 1 for now because back in 1987 the comment was that Heraclides E and Helicon G could be seen (did he mean Helicon C?) but Bianchini G was barely seen. However, I suspect it might all be explained by seeing and transparency perhaps?

Aristarchus: On 2024 Sep 14 UT 20:37, 20:40 and 20:48 Aldo Tonon (UAI – thanks to Antonio Mercatali for forwarding this) imaged this crater under similar illumination to the following report:
Aristarchus 1880 Jan 23 UT 20:00? Observed by Trouvelot (Meudon, France) "Luminous light like a luminous cable or shining wall". NASA catalog weight=3. NASA catalog ID #217. ALPO/BAA weight=3.

Figure 2. *Aristarchus as imaged by Aldo Tonon (UAI) for the dates and UTs given in the image. North is towards the top.*

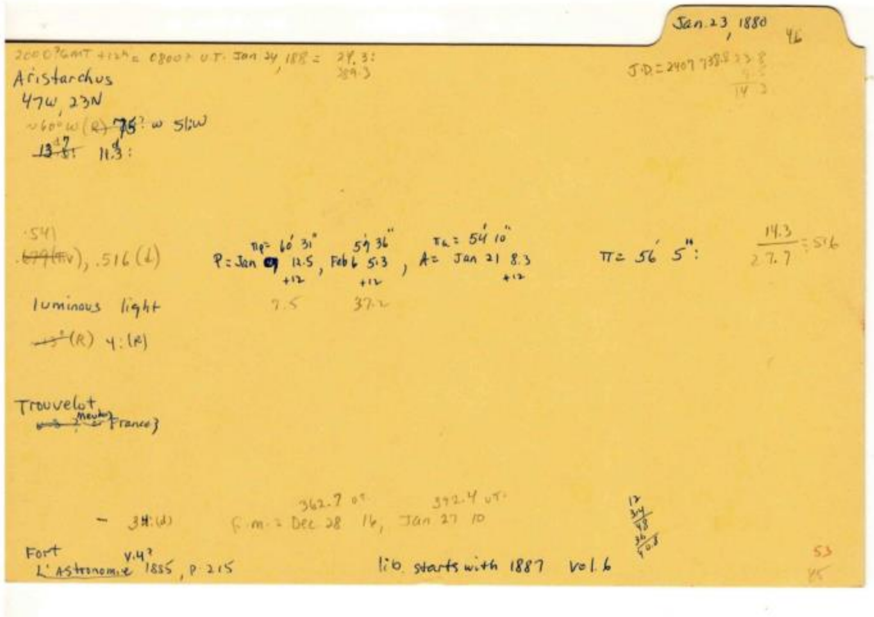


Figure 3. The Cameron LTP catalog card for the 1880 Jan 23 observation by Trouvelot.

As you can see from the images taken by Aldo (Fig 2), one can see a "rope-like" feature between Aristarchus and Herodotus, however this is really quite normal at this stage in the illumination. It would probably be unlikely that Trouvelot, an experienced observer, would be fooled by this feature, so maybe the original report refers to something inside the rim of Aristarchus itself? In the past I have also been in discussions with the BAA's Nigel Longshore, over whether the times given refer to Meudon France or to Cambridge MA, USA. Trouvelot observed from both sites. However, the Moon would have been quite low from the USA site, so Meudon seems more likely. The Cameron time of 20:00UT is estimated (Fig 3) – Nigel Longshaw reckons it was more likely to be around 21:35UT. Either way the Lunar Schedule web site has these range of colongitudes built in. I am tempted to lower the weight from 3 to 2 as that feature between Aristarchus and Herodotus does appear a bit rope like though we cannot be sure that was what Trouvelot was definitely referring to?.

Gassendi: On 2024 Sep 16 UT 21:01-21:15 Trevor Smith (BAA) observed this crater visually with a 16" Newtonian under Antoniadi III seeing conditions for the following repeat illumination event:

Gassendi 1961 Aug 25 UT 01:00-02:00 Observed by Cameron (Adelphi, MD, USA, 3.5" reflector x160) "Crater had a capital gamma-shaped string of star-like pts. (only abnormal thing noted)." NASA catalog weight=1. NASA catalog ID #745. ALPO/BAA weight=1.

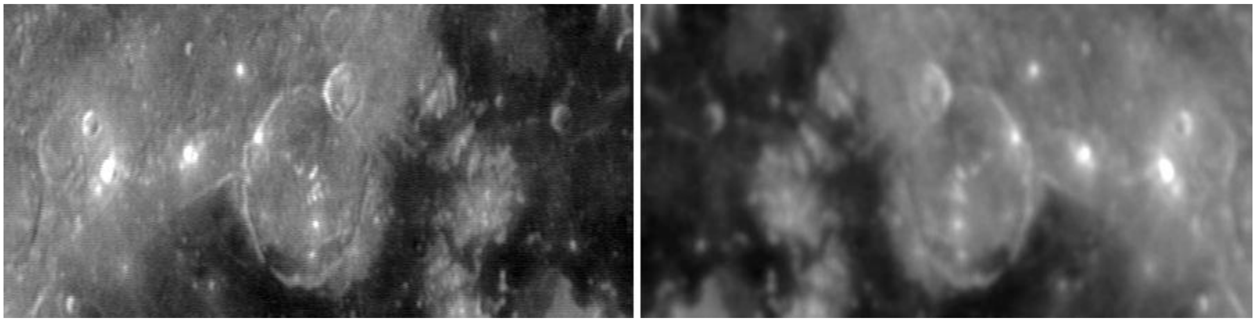


Figure 4**. Gassendi as imaged by Brendan Shaw (BAA) on 2003 Nov 08 UT 00:56 with north towards the top.* ***(Left) *The original image.* ***(Right)*** *A simulated Questar telescope mirror image version, with some artificial seeing blur added.*

Trevor comments: "The central peaks do form a Γ Gamma shape but in a Newtonian telescope they appear upside down and back to front. Was Cameron using a Maksutov I wonder with a star diagonal (Possibly a Questar)? The small aperture would cause the central peaks to look small and star-like I think! Strangely, I noticed something didn't appear to look quite right. The central peaks were easily seen to be extended objects and not star-like points but the stem of the gamma shape seemed too long. It continued across the southern floor of Gassendi to almost the inner crater rim. I had not seen this before so I made a very quick sketch (not shown here/not included). Later I looked at my Cambridge Photographic Moon Atlas and I noticed that two small craterlets lie to the south of Gassendi. One is the 3 km diameter craterlet designated Gassendi M and is some 15 km or so from the center of Gassendi. The other is a further 15 km away to the south and is around 2 km in dia. These two (craterlets) when illuminated by a high sun angle appear bright and are of a similar size as the central peaks. Tonight, the lighting conditions, i.e. a high Sun over Gassendi, the Moon being some 93% illuminated and slightly hazy skies meant I could not resolve the two craterlets and I could not tell with any certainty whether they were craterlets or peaks! Note, objects of similar size but on the terminator could be resolved with ease! It shows just how crucial the angle of lighting can be when making observations of small details. So, in conclusion I believe a small telescope and a high lunar Sun caused the appearance of the central peaks and the two craterlets to resemble the Γ shape."

I quite agree with Trevor's reasoning and upon examining the original Cameron card catalog I can definitely confirm that she was using a Questar telescope, and hence a star diagonal. A similar illumination image was captured by Brendan Shaw (BAA) in 2003 and is shown in Fig 4 along with a simulation of a Questar view where you can quite clearly see the "Γ" feature. A nice piece of detective work! We have covered this report before in the 2015 Nov and 2016 Jan newsletters. We shall therefore lower the weight of this LTP report to 0 and remove it from the ALPO/BAA database.

Schickard: On 2024 Sep 17 UT 20:44 Ivan Walton imaged the whole Moon using a SLOOH robotic telescope in the Canary Islands, in the Hydrogen Alpha waveband at 656 nm. This was at similar illumination to the following report:

Schickard 1934 Feb 28 UT 22:00? Observed by Woolridge (Bromsgrove, England, 6.5" reflector) "Well-known crater form obj. presented anomalous, misty appearance of white spots. Confirmed by Moore in 1939, 1941. NASA catalog ID #411. NASA catalog weight=3. ALPO/BAA weight=2.

Figure 5. *Schickard orientated with north towards the top.* ***(Top Right)*** *Section taken from a larger image of the whole Moon captured on 2024Sep17 UT 20:44 by Ivan Walton (BAA) in a waveband of 656nm.* ***(Main Image)*** *Natural color image of the whole Moon, with an enlargement around Schickard, taken by Maurice Collins (ALPO/BAA/RASNZ) on 2011 Jan 19 UT 09:50-10:53.*

Several LTP reports involve misty appearances on the floor of Schickard. But we see nothing of this in Ivan's image (Fig 5 – Top Right), nor in a similar illumination image by Maurice Collins from 2011 (Fig 5). Though Woolridge details a misty appearance of white spots are probably below the resolution of the telescopes used in Fig 5. We shall leave the weight at 2 for now.

Atlas: On 2024 Sep 18 UT BAA observers: John Axtell, Anthony Cook, Alan Tough, Alexander Vandenbohede and Alex Vincent imaged the partial lunar eclipse. We may use some of these images in future to subtract from Full Moon images to reveal the density of the umbral shadow. Because the predictions are to within ±0.5˚ of sub-solar longitude and latitude, and shadow extent varies between eclipses, there was only one past LTP report that we can possibly check out with a past LTP report, and that was one that was similar in both illumination and topocentric libration to within ±1˚ to the 2024 Sep eclipse:

In 1950 Apr 02 at UT 20:00 Chernov (Russia) observed two dark spots in Atlas during a penumbral phase of a lunar eclipse to quickly darken and become sharp in detail. The Cameron 1978 catalog ID=524 and weight=1. The ALPO/BAA weight=1.

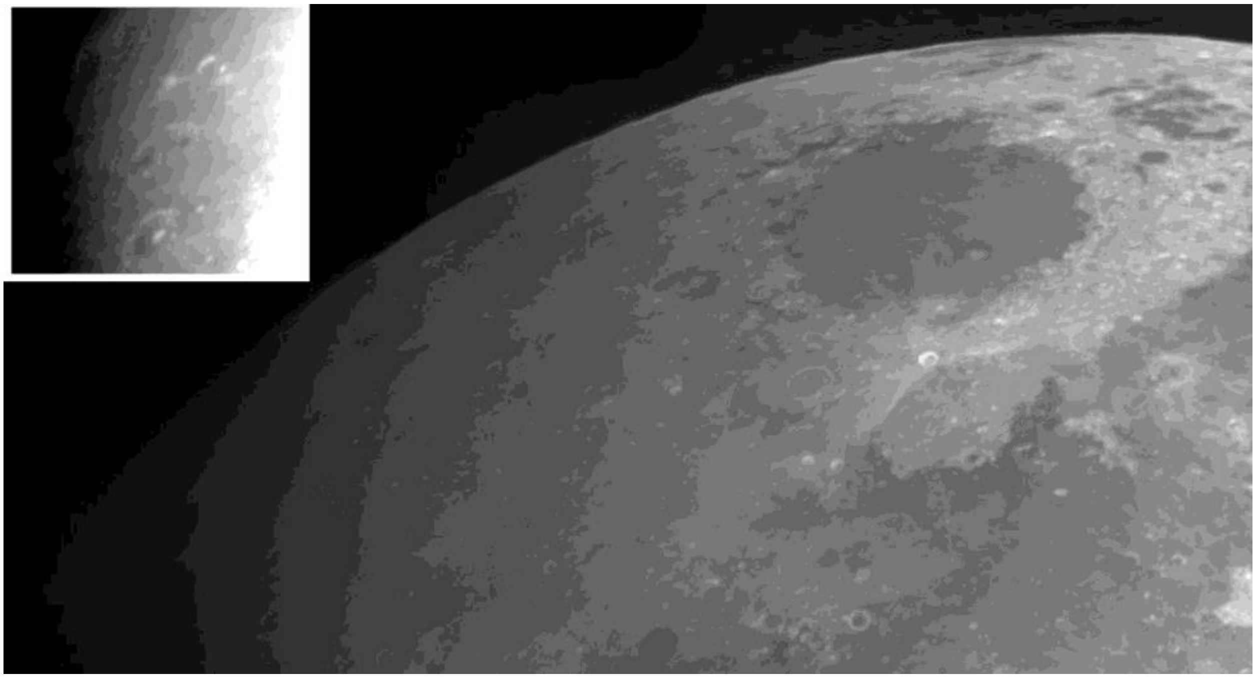


Figure 6. *The lunar eclipse on 2024 Sep 18 UT 02:56 as imaged by Alexander Vandenbohede . North is to the right and the inset shows a close up of Atlas and Hercules outside the umbral shadow Taken using a C8 F10 SCT with an ASI 290MM through a red filter.*

Although technically speaking the Markov observation was made during the penumbral stage of the 1950 eclipse and Alexander's image (Fig 6) of the area was when there was umbra on the Moon, but not actually on Hercules, we can at least see the two dark spots on the floor of Atlas crater. As to whether these "quickly darken and become sharp in detail" we cannot say from just one image. I suspect Markov may have just noticed a contrast change if the umbral edge was not far away. It is not uncommon for past LTP reports during eclipses to mention a change of visibility, size or sharpness of features on the Moon – though I have some doubts about physical reasons why these should take place. Alas I don't have much in the way of additional details of the 1950 report and the 20:00UT given by Cameron for Markov's observing time looks to be estimated. For now, we shall leave the ALPO/BAA weight at 1.

General Information: For repeat illumination (and a few repeat libration) observations for the coming month - these can be found on the following web site: http://users.aber.ac.uk/atc/lunar_schedule.htm . By re-observing and submitting your observations, only this way can we fully resolve past observational puzzles. If in the unlikely event you do ever see a 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**

by Skylar Rees

There are many features on the lunar surface that exhibit morphology intermediate between complex craters and peak-ring basins, such as *Antoniadi* or *Compton*, which are unofficially known as "protobasins". Baker et al (2011) define protobasins by a "nested melt model", in which upon the impact melting of ~75% of the initial (transient) crater's depth, a protobasin forms. Multiring basins form at ≥100%, when the impact melt sheet burns to a greater depth than the transient crater. Peak ring forms in between by impeding uplift. Based on *Lunar Orbital Laser Altimetry (LOLA)* data alone (i.e. purely topography), this method may be insufficient for detecting ancient, heavily degraded or buried formations. Fortunately, other layers in the NASA *QuickMap* suite can help.

So, this month, we take a closer look at *Oppenheimer* – cited by Neumann *et al* (2015) to be a ~208 km diameter feature on the lunar far-side, at approximately Lon = 166˚W, Lat = 35˚S. Curiously although cited as a peak-ring basin in their study, it was also described as a protobasin by Liu et al (2022) – thus there is no clear consensus. By giving a brief overview here we will let the reader decide themselves whether it looks more like a peak-ring or protobasin to you?

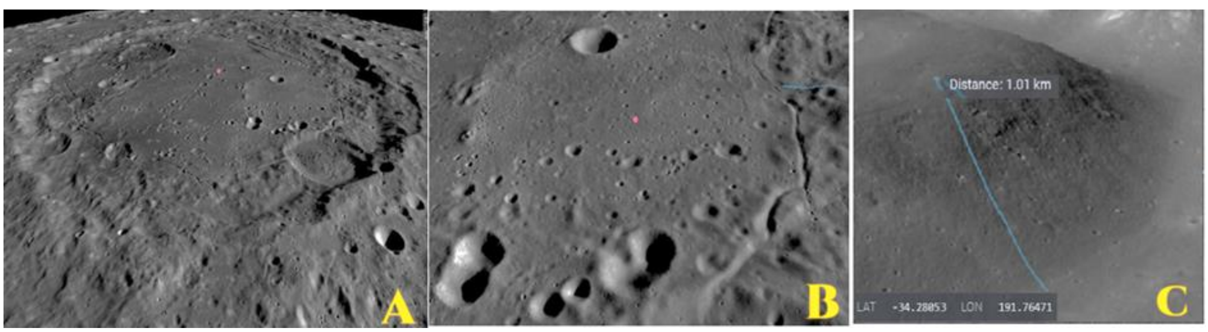


Fig.1 (a) QuickMap Lunar Globe mosaic view. (b) A hidden crater? (c) Oppenheimer U fault depth with FPV.

The new *Lunar Globe/First Person View (FPV)* projection feature in QuickMap gives a simulated perspective projection view, and morphometric depth to any target of interest. Using FPV, we can see that the shadowy eastern edge of *Oppenheimer* is more raised (a difference of around ~4km compared to floor depth) than the higher-albedo western edge (only ~2km difference); the rim of *Oppenheimer* is therefore quite uneven. It's not immediately clear if this is a result of erosion from secondary impacts (e.g. perhaps *Oppenheimer U* to the northwest), or the feature is naturally asymmetric. Interestingly, there are partly hidden craters present such as this ~50km depression around Lon = 164.2˚W , Lat = 35.4˚S – these will be added to the Buried Crater List. Subsequent erosion of interior features in *Oppenheimer* cannot be ruled out either

Baker, D.M et al. (2011). "The transition from complex crater to peak-ring basin on the Moon: New observations from the Lunar Orbiter Laser Altimeter (LOLA) instrument". *Icarus, 214(2):377-393.* DOI: https://doi.org/10.1016/j.icarus.2011.05.030.
Neumann, G.A. et al. (2015). "Lunar impact basins revealed by Gravity Recovery and Interior Laboratory measurements." *Sci. Adv.1,e1500852*. DOI: https://doi.org/10.1126/sciadv.1500852.
Liu, J. et al. (2022). "Characterization and interpretation of the global lunar impact basins based on remote sensing". *Icarus, 378:114952.* DOI: https://doi.org/10.1016/j.icarus.2022.114952.

with the concentric fault lines and floor-fractured cratering; *FPV* inside one of *Oppenheimer U*'s fractures reveals a depth of at least 1km.

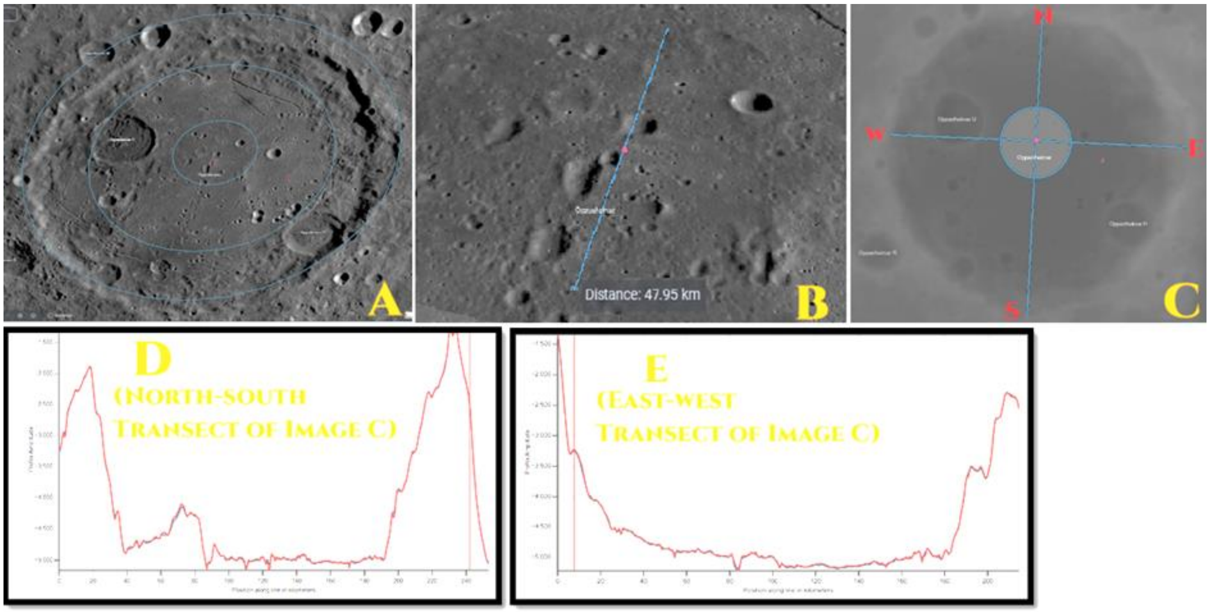


Fig.2 (a) Proposed ring structure for Oppenheimer. (b) Estimating transient crater extent. (c) Crosshairs of Terrain-Height plot. (d) Longitudinal and (e) Lateral profiles, 1.5-5km scale.

Moving on to the *QuickMap* layers, or filter suite, let us address the transient crater and rings. The transient crater at the centre of *Oppenheimer* is highly eroded and difficult to determine; what appears to be the rim spans a diameter of around 48km. TerrainHeight records the central depth to be 5312m, while the peak lateral depth is ~2100m at the 'outer ring' and 4700m at the 'inner ring' – these are absolute heights relative to the Lunar Datum (radius of 1737.4km). The longitudinal plot in (d) is affected by *Oppenheimer U* but displays relatively similar values (1660m, 4800m).

75% of the transient crater is around 3800m here, where 100% is about 5300m. The inner ring's depth is in between these two, which in Baker *et al*'s model would indicate a peak ring basin, while the outer ring in both cases is between about 30-40% of the transient crater depth. That said, it must be noted that a peak depth of over 5km (as measured from rim to floor) is deeper than many confirmed basins such as *Grimaldi (3.2km)* and *Schrödinger (4.8km)*; it lays in the outer limb of the *South Pole Aitken* and it is perhaps possible that the crust or subsurface was "pre-weakened". Even measured in relative depth, i.e. the difference between highest and lowest elevations, this would still yield 3700m depth – deeper than *Grimaldi*.

TerrainSlope and TerrainAzimuth (Fig.3a,3b below) both agree on >15˚sloping walls at the outer ring, and of azimuthal slope granular texture. Evidence for the inner ring is comparatively lacking on both, though both Bouguer Gradient (3f)'s red (high-gradient) sections do hint at its presence through arcuate fragments – distinct from the outer rim, which itself is a deep blue (low-gradient, "flat"). GRAIL Thickness corroborates *Oppenheimer*'s depth and reaffirms this as a deep impact – although USGS Geological Mapping (3c) suggests volcanic infilling (Imbrian Plains) may have resurfaced the region this would be closer to the mantle. Bouguer Gravity (3e) seems to support a peak ring – the centre is more neutral (around -50mGal) than the immediate encirclement (around -100mGal), which is interpreted as less mass 'missing' than expected; another thin ring of neutral anomaly is seen in comparable areas to their high-gradient map equivalents, ending in a heavily positive (>50-100mGal) outer ring interpretable as the outer rim.

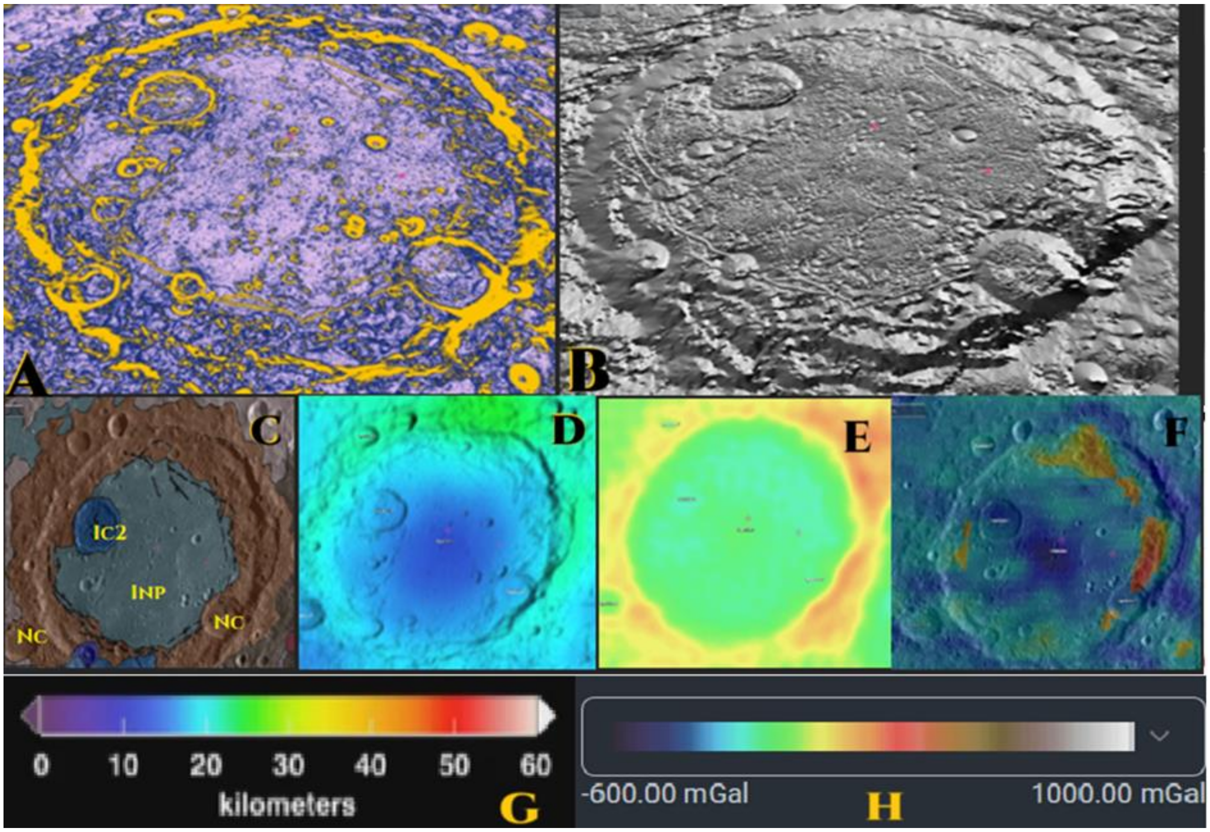


Fig.3 Various structural filters. (a) TerrainSlope. (b) TerrainAzimuth. (c) USGS Geologic Labels. (d) GRAIL Thickness. (e) Free Air + Bouguer Gravity. (f) Bouguer Gradient. (g) Scale bar for GRAIL Thickness. (h) Scale bar for Bouguer Gravity and Gradient.

So, is *Oppenheimer* a peak-ring basin, just a large complex crater, or a protobasin? Based on Baker *et al*'s 'nested melt' model, it would appear to be a peak-ring basin as it does not exceed the central depression's depth. Utilising the wider set of filters, Bouguer Gradient does also suggest (albeit in fragmented form) two separate rings, and TerrainSlope has a very weak inner circle of raised slope. The distribution in Bouguer Gravity also suggests a centrally neutral anomaly with "less missing mass" than its surroundings, which could be interpreted as a peak. Conversely, neither TerrainHeight profile nor TerrainAzimuth detects the inner ring; there is the possibility, given the USGS' classification of widespread Imbrian Plains, that volcanic and/or tectonic resurfacing may have eroded any signs, giving an explanation for the fragments in Bouguer Gradient.
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. Or you can even do this "virtually" with LTVT software. As you can see from the tables on the web sites there are lot of blank cells to fill in on the sunrise and sunset colongitude columns – so a good opportunity for you to get busy!

Lunar Calendar November 2024

Date	UT	Event
1	1247	New Moon (lunation 1260)
3	0800	Mercury 2˚ north of Moon
4	0100	Antares 0.08˚ north of Moon, occultation Indonesia
5	0000	Venus 3˚ north of Moon
6		Greatest southern declination -28.5˚
6		North limb most exposed +6.7˚
8		West limb most exposed -6.4˚
9	0555	First Quarter Moon
11	0200	Saturn 0.09˚ south of Moon, occultation Polynesia to Azores
12	0200	Neptune 0.6˚ south of Moon, Polynesia to Iceland
12	1559	Moon at ascending node
14	1100	Moon at perigee 360,109 km
15	2129	Full Moon
16	0100	Uranus 4˚ south of the Moon
16	0800	Moon in Pleiades
17	1500	Jupiter 6˚ south of Moon
18		Greatest northern declination +28.4˚
19		South limb most exposed -6.6˚
20		East limb most exposed +7.3˚
20	0300	Pollux 1.9˚ north of Moon
20	2100	Mars 2˚ south of Moon
23	0128	Last Quarter Moon
25	2131	Moon at descending node
26	1200	Moon at apogee 405,314 km
27	1200	Spica 0.4˚ south of Moon occultation Canada, USA, West Africa

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.

CONTRIBUTION GUIDELINES

While it is a great honor to put together The Lunar Observer, we are now overwhelmed by our success with some issues in excess of 200 pages.

The increased time it requires for me to perform this job (as a volunteer) pulls me away from my own family and other obligations. Thus, the following rules are being implemented to improve content flow on my end and provide you with the criteria needed to make the "TLO" even more professional in appearance and subject matter.

1. **Review your image(s) at your location before submitting it/them, then brighten or darken it/them as needed and if required, using whatever tools you have at hand. Images deemed unsuitable (including blurry, out-of-focus or "clouded-out" images) will either be returned for your attention or simply not used.**
2. **Images in jpeg format are preferred but others are also acceptable.**
3. **Crop your images to avoid jagged edges.**
4. **Orient the image so it makes the most sense. North at the top (with Mare Crisium at the upper right) is preferred but not required. To our many wonderful southern hemisphere contributors, please orient as you wish (probably south at top).**
5. **Be very limited on end-of-the-month submissions.**
6. **CHOOSE ONLY YOUR BEST IMAGES and limit the number to no more than eight (8) per each issue of the TLO. (obviously, if there is an article you are writing or contributing to this does not apply).**
7. **The image filename should be submitted with the object name spelled correctly, then the year-month-day-hour-minutes-Your Name or initials So, my image of Copernicus should have a file name of:**

Copernicus_2023-08-31-2134-DTe
means
Copernicus, 2023 August 31, 21:34 UT by David Teske

If we all do this going forward, it should make putting this all together faster and easier. Many of you already do this. Thank you for your contributions and your help. We have a premier lunar resource for the planet.

Please send images/drawings/text to drteske@yahoo.com or lunar@alpo-astronomy.org

Below are two sample captions. Both at least attempt to follow the above-stated guidelines

Meton Region as imaged by Massimo Dionisi of Sassari, Italy (10°43'26" N, 8° 33'9" E), on 2024 January 30, at 00:03 UT. Equipment details: Sky Watcher 250 mm, f/4.8 reflector telescope, Tecnosky ADC, Celestron X-cel LX 3x Barlow lens, effective focal length = 4,750 mm, 685 nm IR pass filter, Neptune-M camera, Skywatcher EQ6-R Pro mount. Seeing conditions = III-to-IV (Antoniadi scale). Software details: SharpCap 4.0 acquisition (mono), AutoStakkert! 3.1.4 ELAB, Registax Wavelets.

Lunar craters Hausen and Bailly D as imaged by István Zoltán Földvári of Budapest, Hungary on 2020 April 07, at 21:03-21:17 UT. Colongitude 86.5°. Equipment details: 70 mm refractor telescope, f/l = 500 mm, Vixen Lanthanum LV 4mm eyepiece, 125x, Baader Contrast Booster Filter. Sky seeing = 7 out of 10, sky transparency = 6 out of 6.

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: Anaxagoras region

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 2025, will be Anaxagoras. 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 Anaxagoras Focus-On article is December 20, 2024

FUTURE FOCUS ON ARTICLES:

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

Subject	TLO Issue	Deadline
Anaxagoras	**January 2025**	**December 20, 2024**
Clavius	**March 2025**	**February 2025**
Volcanic Features	**May 2025**	**April 20, 2025**

Focus-On Announcement
Anaxagoras, the "Tycho" of the North

Anaxagoras, with a diameter of 50 km, is a relatively small and relatively recent crater (it belongs to the Copernican period) and that is why we can appreciate the deadly magnificence of the ejected materials, which cover surfaces that reach more than 600 kilometers from the crater and with the Sun's rays striking frontally near the full moon it has an undeniable similarity to Tycho. With a more oblique illumination it is a real challenge to locate it, since it is quite close to the northern limb, a location that has taken away its prominence among those who observe and photograph the Moon. It is an interesting crater, with features such as a central peak of anorthosite and bright rays that cross its walls.

FOCUS ON NOVEMBER 2024: Due: October 20, 2024: ARCHIMEDES, AUTOLYCUS AND ARISTILLUS

FOCUS ON JANUARY 2025: Due December 20, 2024: ANAXAGORAS

FOCUS ON MARCH 2025: Due February 20, 2025: CLAVIUS

FOCUS ON: MAY 2025: Due April 20, 2025: VOLCANIC FEATURES

Image Alberto Anunziato

Focus On Announcement:
Lunar Base Clavius

Clavius has literary and cinematic reminiscences, at least for those of us who dream of 2001: A Space Odyssey, in which a gigantic underground base was located in this crater. Due to its size and peculiar structure, it is a very recognizable place among the somewhat monotonous southern lands. In this Focus On we will have the opportunity to study a giant from the most remote times of the Moon, the Nectarian period. In addition, Clavius may be a place of importance in the future of lunar exploration, since in 2020 the presence of water (or rather the trace of hydrated minerals) was detected in this crater. Will the literary Clavius Base become a reality?

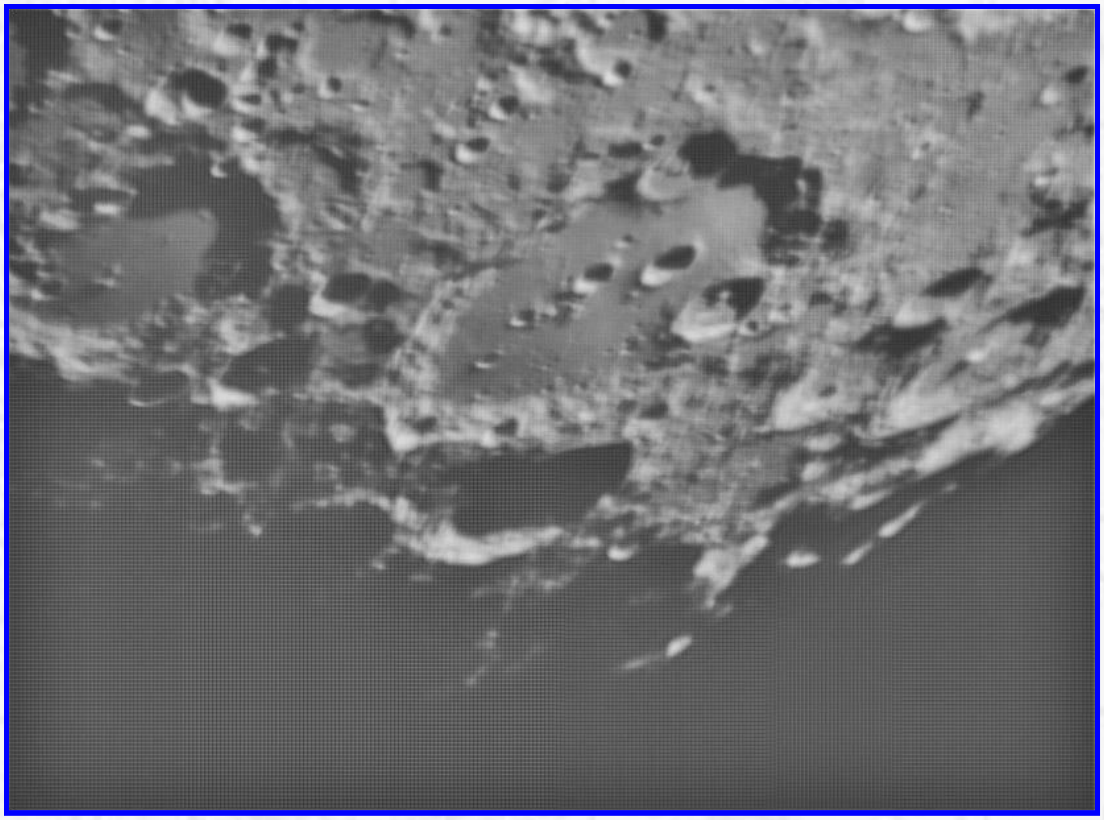
JANUARY 2025 ISSUE-Due December 20 2024: ANAXAGORAS

MARCH 2025 ISSUE-Due February 20 2025: CLAVIUS

MAY 2025 ISSUE-Due April 20 2025: VOLCANIC FEATURES

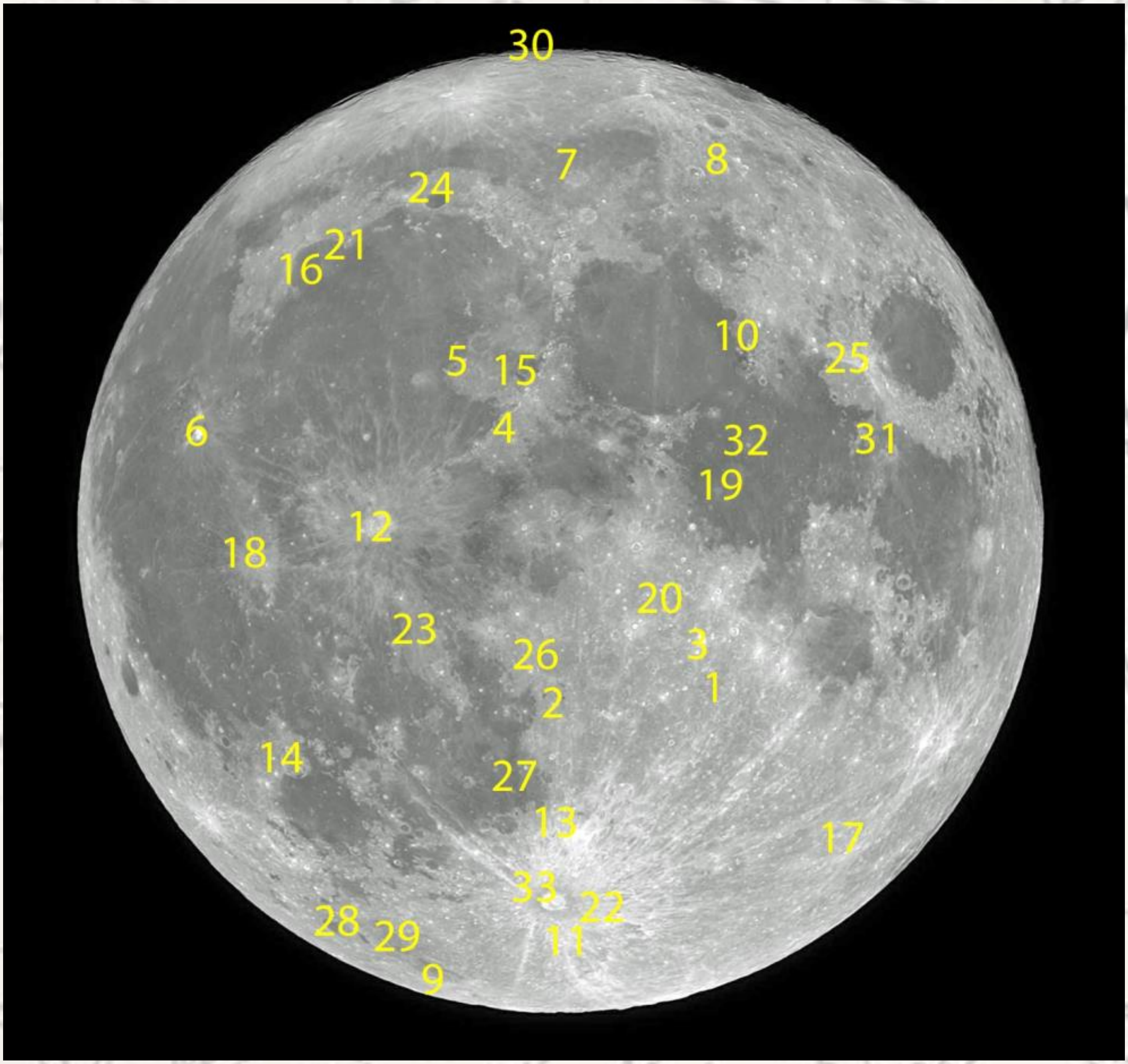
JULY 2025 ISSUE-Due June 20, 2025: RUPES RECTA

September 2025 ISSUE-Due August 20, 2025: MARE HUMORUM



Fernando *Sura*

Key to Lunar Images In This Issue



Gregory Shanos

1. Abulfeda
2. Alphonsus
3. Anděl
4. Apenninus, Montes
5. Archimedes
6. Aristarchus
7. Aristoteles
8. Atlas
9. Bailey
10. Beketov
11. Clavius
12. Copernicus
13. Deslandres
14. Gassendi
15. Hadley
16. Iridum, Sinus
17. Janssen
18. Kepler
19. Lamont
20. Lade
21. Laplace
22. Licetus
23. Parry
24. Plato
25. Proclus
26. Ptolemaeus
27. Recta, Rupes
28. Schickard
29. Schiller
30. Scoresby
31. Taruntius
32. Tranquillitatis, Mare
33. Tycho