



# The Lunar Observer

A publication of the Lunar Section of ALPO

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Recent back issues: [http://moon.scopesandscapes.com/tlo\\_back.html](http://moon.scopesandscapes.com/tlo_back.html)



## March 2020

### In This Issue

Lunar Calendar March 2020	2
An Invitation to Join ALPO	2
Observations Received	3
Submission Through the ALPO Image Achieve	4
When Submitting Observations to the ALPO Lunar Section	5
Call For Observations Focus-On	5
Herodotus, <i>R. H. Hays Jr.</i>	6
Hipparchus C in the Terminator, <i>A. Anunziato</i>	7
Focus-On Tycho & Herodotus, <i>J. Hubbell</i>	8
Some Historical Considerations about the “star in the Moon” in 577, <i>A. Anunziato</i>	17
Thermal Observations of Tycho: a First Look, <i>D. Wilson</i>	20
East of Deslandres, <i>R. Hill</i>	29
Lurking in the Shadows, <i>D. Teske</i>	30
Lunar Central, <i>R. Hill</i>	34
Gardner Megadome, <i>H. Eskildsen</i>	35
The Gardner Megadome and the Lunar Volcanic Shields, <i>R. Lena</i>	41
Recent Topographic Studies	47
Lunar Geologic Change Detection Program, <i>T. Cook</i>	69
Key to Images in this Issue	80

As always, thanks so much for the contributors and readers of *The Lunar Observer*. In the March 2020 issue, we have some rather remarkable articles. Jerry Hubbell concludes is Focus-On section of the ALPO selected regions craters with a discussion of Tycho and Herodotus. Robert H. Hays Jr. brings a timely and very nice article and drawing of Herodotus. Alberto Anunziato gives us two articles. The first is an article and drawing about Hipparchus C. The second is a fascinating historical research about an event on the Moon seen in 577. This was the first LTP ever listed. Darryl Wilson continues his thermal imaging articles with an article about Thermal Imaging of Tycho. His articles of thermal imaging have stirred up much interest lately. The Gardner Megadome is a very interesting area of the Moon to observe. It is the subject of two in-depth articles by Howard Eskildsen and Raffaello Lena. Rik Hill and David Teske continue their wanderings of a remarkable lunar moonscape with images and articles. Sixteen observers contributed articles to the Recent Topographic Studies Program. Tony Cook as always has contributed an interesting article about Lunar Geologic Change. Thanks again to all who contributed. I hope that you can get out and enjoy some wonderful moon observations.

# Lunar Calendar March 2020

Date	Time UT	Event
March 2020 1	0600	Vesta 0.1° north of Moon, occultation Australia to Hawaii
2	1957	First Quarter Moon
4	0900	Moon 1.2° south of M35
5		Moon greatest northern declination +23.4°
5		Lunar west limb most exposed -7.8°
6	2200	Moon 1.1° north of M44
9	1748	Full Moon, largest of the year
10	0600	Moon at perigee, 357,122 km, large tides
11		Lunar south limb most exposed -6.5°
16	0934	Last Quarter Moon
16		Lunar east limb most exposed +7.5°
18	0800	Mars 0.7° north of Moon, occultation South America to Antarctica
18		Moon greatest southern declination -23.4°
19	0000	Saturn 2° north of the Moon
24	0928	New Moon, lunation 1203
24	1500	Moon at apogee, 406,692 km
24		Lunar north limb most exposed +6.5°
26	2100	Uranus 4° north of Moon
28	1100	Venus 7° north of Moon
29	0700	Vesta 0.2° north of Moon, occultation Indian Ocean to Polynesia
30	1600	Moon 0.9° south of M35

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

Comments and suggestions? Please send to David Teske, contact information page 1. Need a hard copy, please contact David Teske.

## 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 nonmember 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.

# Lunar Topographic Studies

Acting Coordinator – David Teske - [david.teske@alpo-astronomy.org](mailto:david.teske@alpo-astronomy.org)  
Assistant Coordinator – William Dembowski - [dembowski@zone-vx.com](mailto:dembowski@zone-vx.com)  
Assistant Coordinator – Jerry Hubbell – [jerry.hubbell@alpo-astronomy.org](mailto:jerry.hubbell@alpo-astronomy.org)  
Assistant Coordinator-Wayne Bailey– [wayne.bailey@alpo-astronomy.org](mailto:wayne.bailey@alpo-astronomy.org)  
Website: <http://moon.scopesandscapes.com/>

## Observations Received

**Alberto Anunziato**, Oro Verde, Argentina. Article *Some historical considerations about the star in the moon in 577*, article and drawing *Hipparchus C in the Terminator* and images of Tycho, Montes Apenninus, Longomontanus and Sinus Iridum.

**Sergio Babino**, Montevideo, Uruguay. Images of a Waxing Gibbous Moon and Tycho.

**Juan Manuel Biagi**, Paraná, Argentina. Images of Gassendi, Byrgius and Schiller.

**Aylen Borgatello**, AEA - Oro Verde, Entre Rios, Argentina . Images of Carlini D and Mons Pico.

**Luis Francisco Alsina Cardinali**, Oro Verde, Argentina. Images of Herodotus (2) and Tycho (2).

**Jairo Chavez**, Popayán, Colombia. Image of the Waning Gibbous Moon.

**Carlos de Luis**, Madrid, Spain. Images of Aristarchus (2).

**Maurice Collins**, Palmerston North, New Zealand. Images of the 5-day old Moon, Atlas and Hercules, Mare Nectaris, Posidonius and Proclus.

**Leonardo Alberto Colombo**, Images of Tycho, the First Quarter Moon, the Waxing Gibbous Moon and Mare Imbrium.

**Walter Ricardo Elias**, AEA - Oro Verde, Entre Rios, Argentina . Images of Mont Blanc, Waxing Crescent Moon (2), Proclus, Torricelli B, Tycho (2), Aristarchus (2), Gassendi and Stevinus.

**Howard Eskildsen**, Ocala, Florida, USA. Article and images *Gardner Megadome*, images of Hortensius/Milichius, the Piccolomini dome, Cauchy, G Bond and Hall 1 Dome.

**Victoria Gomez**, AEA - Oro Verde, Entre Rios, Argentina. Images of Mare Imbrium and Tycho.

**Robert Hays Jr.**, Worth, Illinois, USA. Article and drawing of *Herodotus*.

**Richard Hill**, Tucson Arizona, USA. Article and image *East of Deslandres* and *Lunar Central*.

**Jerry Hubbell**, Wilderness, Virginia, USA. Article and images *Focus-On Tycho and Herodotus*.

**Jaime Izquierdo**, Madrid, Spain. Images of the 12-day old Moon and Aristarchus (2).

**Raffaello Lena**, Italy. Article *The Gardner megadome and the lunar volcanic shields*.

**Raquel R. Mediavilla**, Madrid, Spain. Drawing of Aristarchus.

**Gabriel Re**, AEA - Oro Verde, Entre Rios, Argentina. Images of Copernicus and Promontorium Laplace.

**David Teske**, Louisville, Mississippi, USA. Article and image of *Lurking in the Shadows (Maginus region)*.

**Darryl Wilson**, Marshall, Virginia, USA. Article and images *Thermal Images of Tycho: A First Look*.

**Many thanks for all these observations, images, and drawings.**

## SUBMISSION THROUGH THE ALPO IMAGE ARCHIVE

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

[lunar@alpo-astronomy.org](mailto:lunar@alpo-astronomy.org) (lunar images).

It is helpful if the filenames follow the naming convention :

FEATURE-NAME\_YYYY-MM-DD-HHMM.ext

YYYY {0..9} Year

MM {0..9} Month

DD {0..9} Day

HH {0..9} Hour (UT)

MM {0..9} Minute (UT)

.ext (file type extension)

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

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

Sinus-Iridum\_2018-04-25-0916.jpg

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

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

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

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

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

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

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

**Name and location of observer**

**Name of feature**

**Date and time (UT) of observation (use month name or specify mm-dd-yyyy-hhmm or yyyy-mm-dd-hhmm)**

**Filter (if used)**

Size and type of telescope used Magnification (for sketches)

Medium employed (for photos and electronic images)

Orientation of image: (North/South - East/West)

Seeing: 0 to 10 (0-Worst 10-Best)

Transparency: 1 to 6

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

Digitally submitted images should be sent to:

David Teske – [david.teske@alpo-astronomy.org](mailto:david.teske@alpo-astronomy.org)

Jerry Hubbell – [jerry.hubbell@alpo-astronomy.org](mailto:jerry.hubbell@alpo-astronomy.org)

Wayne Bailey—[wayne.bailey@alpo-astronomy.org](mailto: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: The Lunar 100

**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 **May 2020** edition will be the Lunar 100 as discussed by Charles Wood. 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):

**Jerry Hubbell** – [jerry.hubbell@alpo-astronomy.org](mailto:jerry.hubbell@alpo-astronomy.org)

**David Teske** – [david.teske@alpo-astronomy.org](mailto:david.teske@alpo-astronomy.org)

**Deadline for inclusion in the Lunar 100 article is April. 20, 2020**

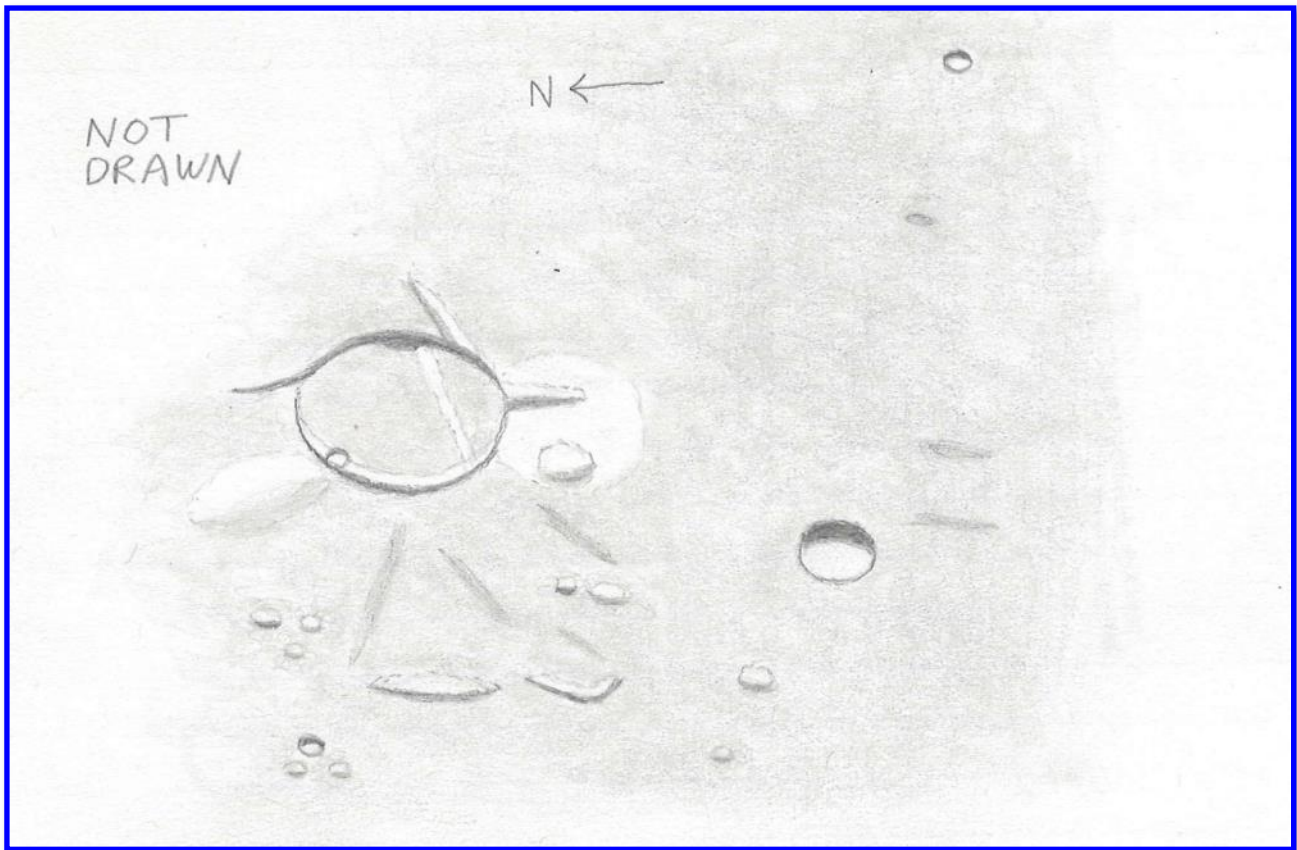
## FUTURE FOCUS ON ARTICLES:

In order to provide more lead time for contributors the following future targets have been selected: The next series of three will concentrate on subjects of the Selected Areas Program.

<u>Subject</u>	<u>TLO Issue</u>	<u>Deadline</u>
Lunar 100 (details forthcoming)	May 2020	April 20, 2020

# Herodotus

Robert H. Hays, Jr.



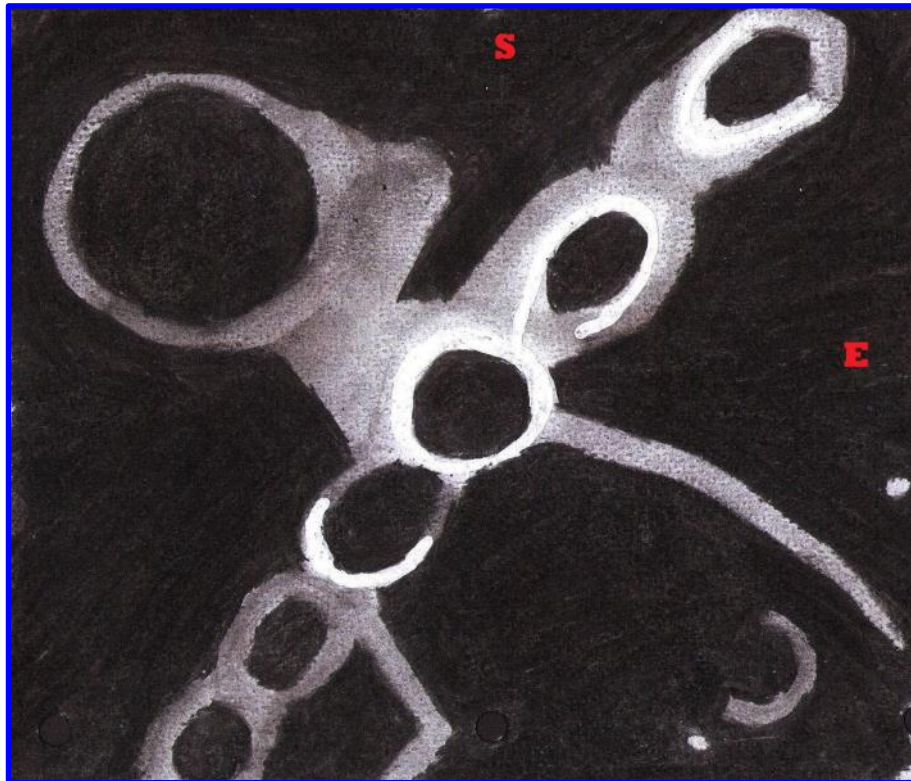
**Herodotus**, Robert H. Hays, Jr., Worth, Illinois, USA. 08/09 January 2020 2349-0015 UT. 15 cm reflector, 170 x. Seeing 7-9/10, transparency 6.

I observed this crater and the area to its south and west on the evening of January 8/9, 2020. Herodotus is a fairly large but shallow crater southwest of Aristarchus (not shown). Its interior is quite level and is the same tint as Oceanus Procellarum to its south. The pit inside its northwest rim is Herodotus N. The only other detail seen on its floor is a bright strip across its southern part. The interior shadow indicated a high point on Herodotus' east rim. This is just north of the bright streak. Three strips of shadow protruded from Herodotus. The ones on the south and southeast rims had sunlit sides, and so are likely ridges. The shadow off the north rim had no sunlit side, but there may be a small gap in the rim there. A low mound is just northwest of Herodotus N. The small crater to the west is Herodotus K. Two tiny peaks are just to its west, and three more peaks are between Herodotus K and the main crater. The northern one of this trio is larger and with darker shadow than its neighbors. This may be Herodotus delta, according to the Lunar Quadrant map. The long ridge west of Herodotus is Herodotus rho, and Herodotus tau is probably the curved ridge to its south. Several peaks and strips of shadow are in this area. A large peak is just south of Herodotus and west of the southern ridge. The map indicates a ghost crater there. An ill-defined bright area envelope this peak and ridge. The conspicuous deep crater south of Herodotus is Herodotus A, and Aristarchus U is the tiny pit well to the east. Two more peaks are west of Herodotus A. The Lunar Quadrant map shows Herodotus omega between the craters, but I saw only some vague bits of shading in the area.

## Hipparchus C in the Terminator

### Alberto Anunziato

When you have a small telescope, delaying over the features on the terminator is the best way to maximize our observation. At 352.7° colongitude, 40% illumination, what looked like three connected bright circles caught my attention. It was an intriguing vision, to which my drawing does not do it justice. It was Hipparchus C, a 17 km. diameter crater, shining brightly. Hind, 30 kilometers in diameter (left) and Hipparchus L (right), 13 kilometers in diameter, escort the brightest circle. Hipparchus L, however, seemed larger than it really is, visible only its east wall, with a slight glow. The circular walls of Hind had an even less intense glow, its bottom as dark as that of Hipparchus C. The outer contour of the circular walls of Hipparchus C



C shone brightly, in contrast to the total darkness of its floor. The most remarkable thing about the observation was what, at first sight, seemed irregular craters, their walls brighter than those of Hind and Hipparchus L, both to the north and to the south. Once again, the old and reliable Atlas of the Lunar Orbiter missions (Lunar Orbiter Photographic Atlas, by David Bowker and J. Kendrick Hughes, NASA, 1971), came to my aid. They are not craters, at least recent craters in terms of lunar geology, but the outline of the elevated terrain in which Hipparchus C formed after the impact that originated it, as can be seen in the cut-out of "Photo N° IV96-H3", corresponding to the "Plate 308". The oblique light of the Sun illuminated the highest areas around Hipparchus C, while the rest of the landscape was still dark.

*Hipparchus C, Alberto Anunziato, Paraná, Argentina . 01 February 2020 0618 UT. Meade ETX 105 telescope, QYH5-LII-M camera.*

*Hipparchus C, Lunar Orbiter*



# Focus On: Tycho & Herodotus

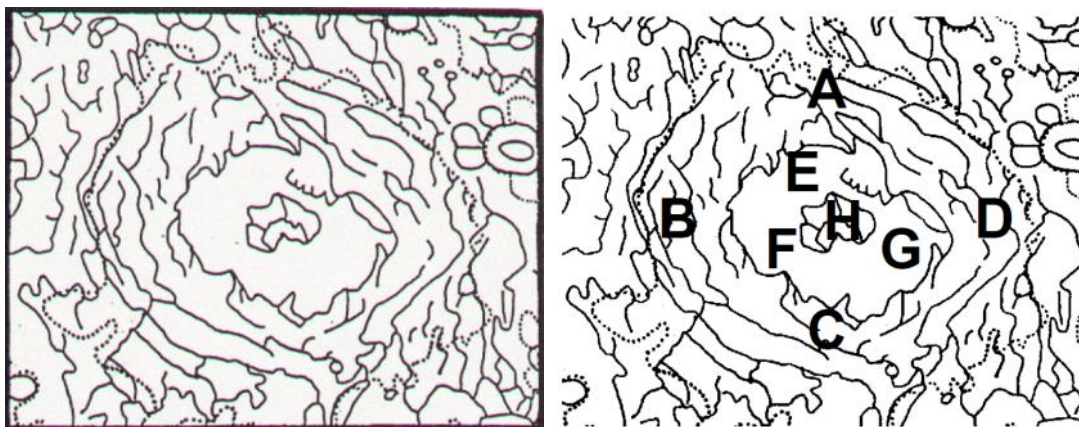
Jerry Hubbell  
Assistant Coordinator, Lunar Topographical Studies

This is the final article of four in our series on the craters in the Lunar Topographical Studies [Selected Areas Program](#) (SAP). This is a visual observing program that most beginners can easily start out using a small refractor or Newtonian reflector. This observing program is designed to focus attention on areas of the moon that have shown unusual albedo changes during the lunation period. The SAP is a great way to get familiar with some of the main features of the Moon and enjoy visually roaming over the landscape to see every tiny detail. You will find all the information needed to start this observing program in the [SAP Handbook](#).

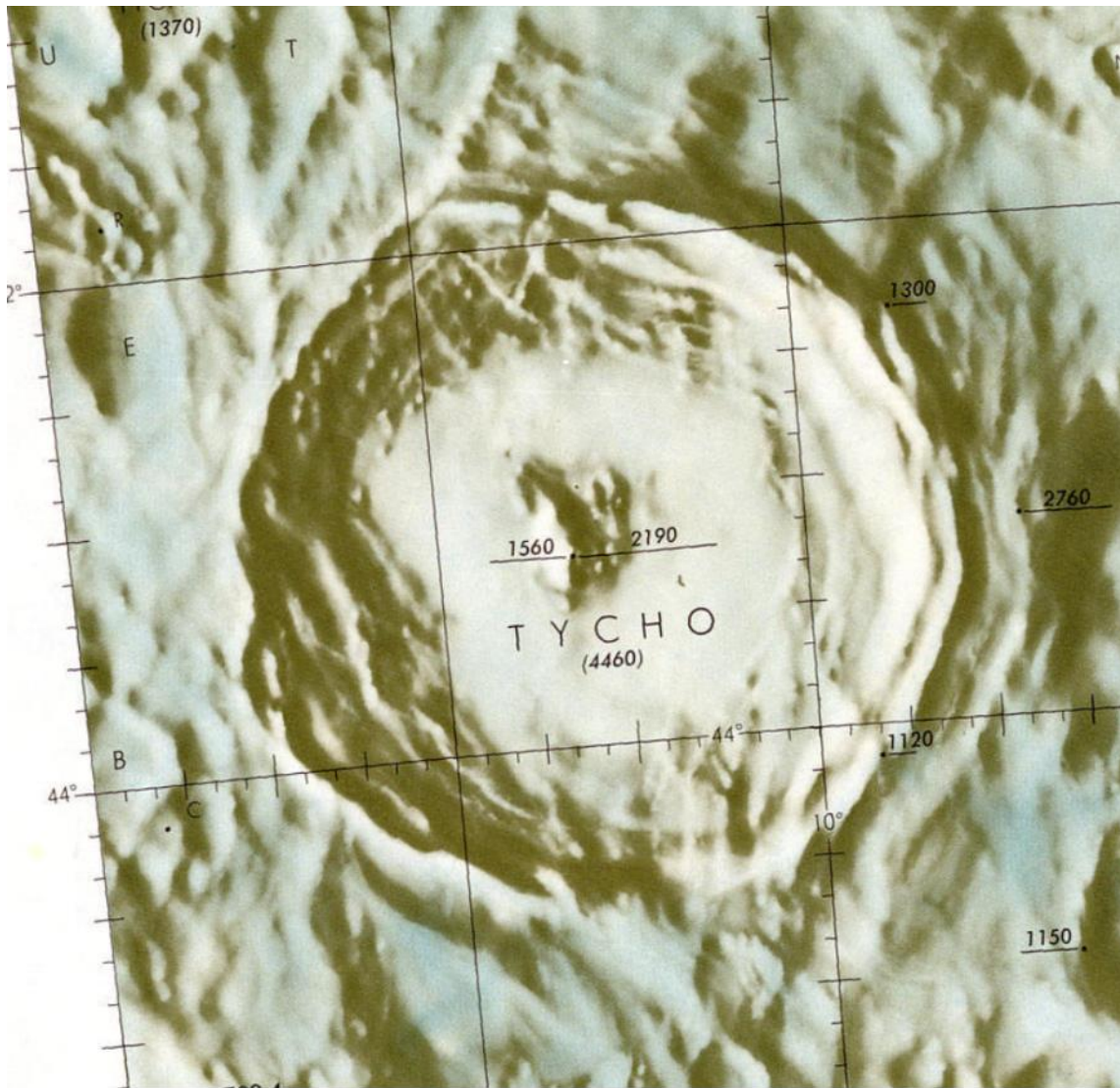
As in the previous articles, we will continue to use the [Lunar Terminator Visualization Tool \(LTVT\)](#) to do various measurements of these craters. The goal is to start using this tool to help monitor and detect the “regular and cyclical long-term variations” that may occur in these areas. To learn more about LTVT please visit the [LTVT Wiki](#). The LTVT allows you to not only measure the size of features, but also systematically measure the size of the various peaks and hills on the moon through shadow measurements. Some of the changes in these areas involve the shifting shadows and by measuring specific locations over the long-term, the apparent shift in the measured heights over time will give us information about the precision of our measurements and detect other shadow anomalies that may occur. Using the [SAP crater drawing templates](#) and the Lunar Aeronautical Charts for each crater, I will be identifying specific shadows to measure. I welcome any suggestions you may have in this regard.

This month I will cover the craters Tycho – 52 miles (86 km) & Herodotus – 21 miles (35 km). Figures 1 and 7 show the crater drawing outlines used in the SAP for Tycho & Herodotus, and Figures 2 and 8 show the Lunar Aeronautical Chart view of these craters. Note that the SAP drawings are depicted rotated 180° (north up, east right) as compared to the [crater drawing outline chart](#) (SAP form) available on the website to more easily compare to the LAC charts.

## TYCHO



**Figure 1.** Outline drawing of Tycho (left) and Albedo Points for Tycho (right) (north-down, east-left).



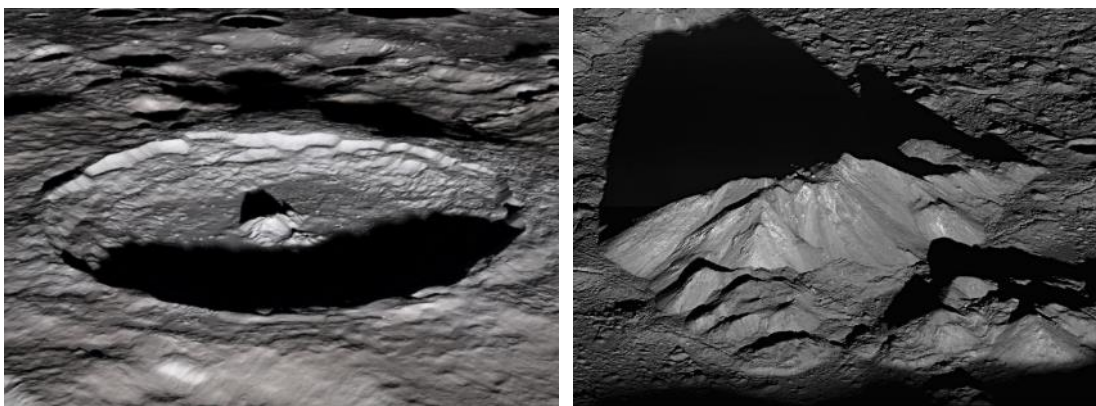
**Figure 2.** LAC112 chart of Tycho. (north-up, east-right)

Tycho 52 miles (86 km), was named after the famous Danish astronomer Tycho Brahe (1546-1601), known for his very accurate and thorough astronomical observations and as a builder of astronomical instruments. He was considered the last of the naked eye astronomers. The crater is located near the center of the Southern Highlands, Selenographic coordinates  $43^{\circ} 18' 36''$  S,  $11^{\circ} 21' 36''$  W, is the most prominent and among the brightest craters seen near and during the full moon. (Figure 3.) Tycho is considered a very young crater at approximately 108 million years, Aristarchus is 450 million years old. There are several other very large craters near Tycho in the Southern Highlands, including Maginus 99 miles (165 km), Clavius 136 miles (225 km), Longomontanus 88 miles (146 km), Deslandres 142 miles (235 km), and Stofler 76 miles (126 km).



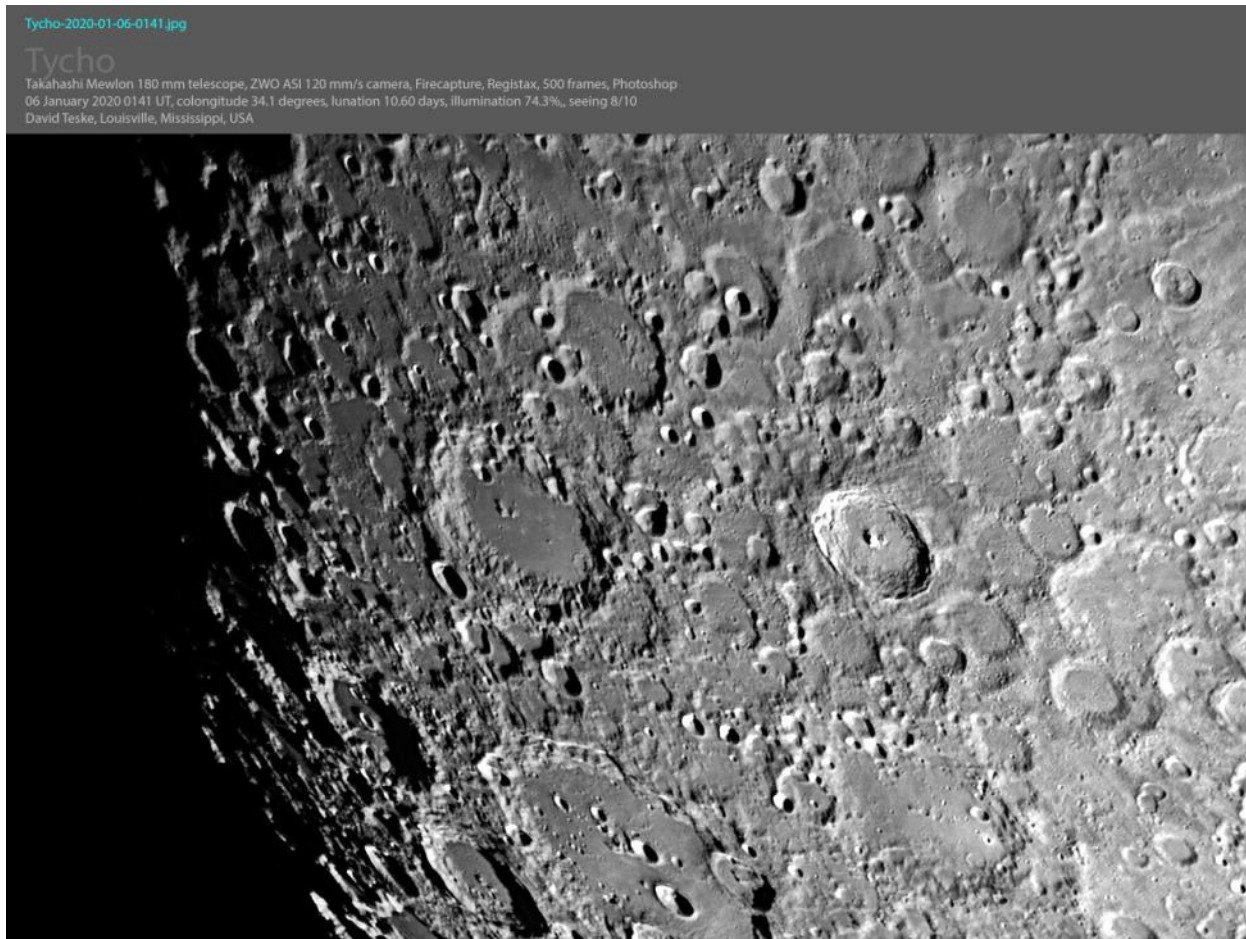
**Figure 3.** 17-day Moon (Tycho), Jerry Hubbell, Mark Slade Remote Observatory (MSRO) Wilderness, Virginia, USA. 02 February 2019 0900 UT, Colongitude 122.2°. 165 mm APO refractor + 0.7x FRFF + Red Filter, QHY 163C camera, 100/150 frames, MaxIm DL, Registax 6, Photoshop. Seeing 6/10, Transparency 5/6. North/Up, East/Right.

When examined at high power when Tycho is near the terminator, this very young crater provides a rim structure that is very sharp and shows virtually no erosion in high resolution ground images and in images from lunar orbit from NASA's Lunar Reconnaissance Orbiter (LRO) (Figures 4a, 4b, and 6). Tycho's central peak is shown to good effect in Figure 4b and gives a stark view of the structure of the mountains that can be compared to ground-based images, and to high magnification views in the telescope.



**Figure 4.** Tycho from Lunar Orbit taken by the LRO. Image a (left) shows the very fresh-looking lunar rim and central peak. Image b (right) shows a very sharp central peak with a boulder placed in the crater at the top. (Images courtesy NASA).

This high-resolution view of crater Tycho (Figure 5) provided by David Teske is an excellent example of what is possible when imaging with a modest size telescope. This requires excellent seeing and great technique when processing the captured data. This image easily shows features down to 2 km. It is a good exercise to compare Figure 5 to the LRO image in Figure 4a.



*Figure 5. Crater Tycho, David Teske, Louisville, Mississippi, USA. 06 January 2020 0141 UT, Colongitude 34.1°. 180 mm Dall-Kirkham reflector telescope, ZWO ASI120mm/s CCD camera, 500 frames, Firecapture, Registax, Photoshop. Seeing 8/10, North/Up, East/Right*



**Figure 6.** LTVT Measurement of Crater Tycho, Jerry Hubbell, Mark Slade Remote Observatory (MSRO) Wilderness, Virginia, USA. 21 January 2013 0122 UT, Colongitude 20.4°. 127 mm APO refractor + 2x Barlow + Red Filter, ATIK 314e camera, 200/1000 frames, Registax 6, Photoshop. Seeing 6/10, Transparency 5/6. North/Up, East/Right

The image in Figure 6 matches the image in Figure 4a in terms of the Colongitude and the way the shadow of the central peak presents itself. The measurement of Tycho's central mountain peak can be done at different Colongitude values to refine the measurement. The LTVT measurement for Figure 6 is (Table 1):

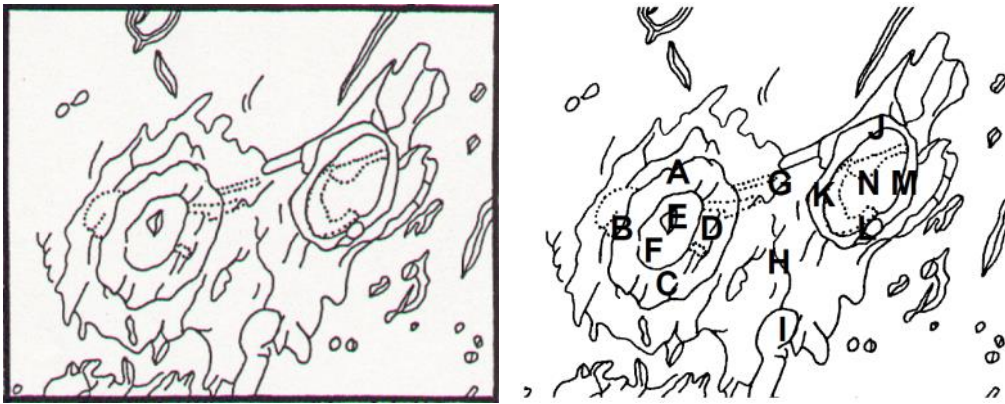
Parameter*	Measured Value	LAC Value	%Difference
Crater Tycho Central Peak	»1527 m (5,009 ft)	»1560 m (5,118 ft)	-2.1%

\*This measurement is at a Colongitude of 20.4°.

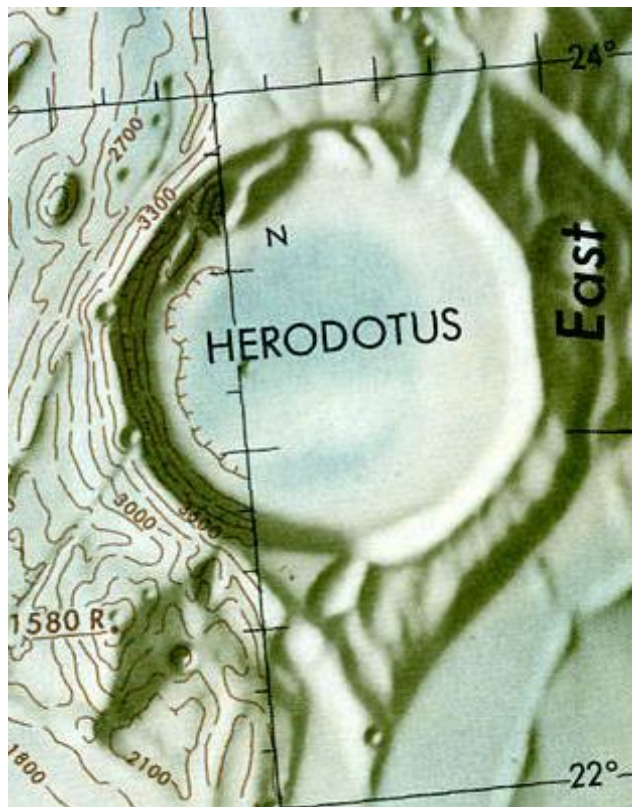
Table 1. Tycho LTVT Measurements

The measurement obtained is surprisingly accurate considering all the factors involved with making it. The main factor in getting this accurate measurement is that the peak of the shadow does not fall on the crater wall and stays on the floor of the crater.

## HERODOTUS



**Figure 7.** Outline drawing of Herodotus (left) and Albedo points for Herodotus (north-down, east-left).



**Figure 8.** LAC38 chart excerpt of crater Herodotus.

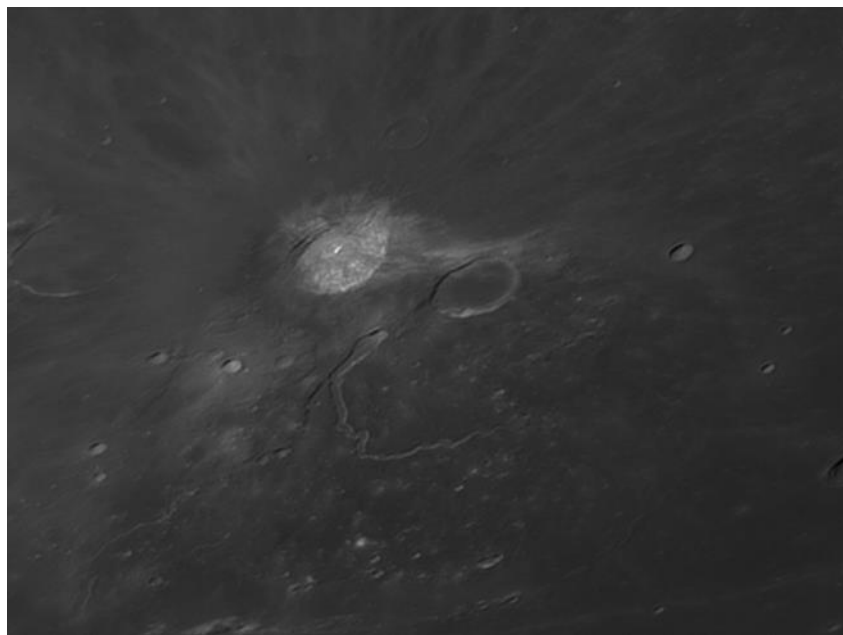
The crater Herodotus 21 miles (35 km), the smallest of all the craters in the [Selected Areas Program](#), (Figure 7) was named after the ancient Greek historian Herodotus (d. 425 B.C.). According to Wikipedia, Herodotus was born in the Persian Empire (modern day Turkey). The crater Herodotus is directly adjacent to the young, bright crater Aristarchus 44 miles (33 km). Aristarchus was discussed in a previous Focus On article published in September 2019. Located at Selenographic coordinates  $23^{\circ} 12' 0''$  N,  $49^{\circ} 42' 0''$  W, Herodotus is a crater that has been overshadowed by its much more interesting neighbor to the east.

Herodotus appears to be a lava-filled crater due to its smooth central plain with no discernable central peak. The central plain lies »1200 meters below the crater rim according to the topographical markings on the Lunar Aeronautical Chart LAC-38 shown in Figure 7. Figure 9 shows an image of Herodotus taken by the LRO.



**Figure 9.** *Herodotus from lunar orbit taken by the LRO. (Image courtesy NASA)*

Here is a fine image of Herodotus (Figure 10) taken by Francisco Alsina Cardinalli, from Oro Verde, Argentina. Immediately adjacent to the very bright crater Aristarchus, it provides a contrasting feature very nearly the same size as its more famous neighbor to the west. Although, not the most interesting crater on the lunar surface, it still provides some interesting opportunities to observe its subtle surface markings within the walls of the crater.



**Figure 10.** *Crater Herodotus Adjacent to Aristarchus, Francisco Alsina Cardinalli, Oro Verde, Argentina, 19 June 2016 0540 UT, Colongitude 108.3°. 250 mm Schmidt-Cassegrain telescope, QHY5 CMOS camera + IR Filter, North/Up, East/Right.*

## CONCLUSION

When repeating the shadow measurements at different Colongitude values, it is important to make sure you are measuring from the same point on the rim of the crater. This will allow you to trend the measured value for that specific point on the rim over time. Several measurements made at the same Colongitude can be averaged and the scatter of the data can be used to estimate the precision of the measurement. You can use the program Virtual Moon Atlas (VMA) to calculate the time and date at your location for a given Colongitude value so that you can image at those times every month to gather your data. Over time, a record of the measurements will show you how your imaging technique has improved the resolution of your images.

In the next few months, I will be establishing the optimum Colongitude for each of the craters in the SAP and the selenographic longitudes and latitudes of the crater rim locations for shadow measurements. That way we all can make repeatable measurements every month and start to understand if we have any odd occurrences going on in these craters with this additional data.

This completes this series of Focus On articles on the ALPO Lunar Section Selected Areas Program. I hope you have enjoyed these articles and have started your own program of observations of these craters. I also encourage everyone to download, install, and start learning about the Lunar Terminator Visualization Tool, it is truly a great resource to better understand the topographical features of the lunar surface.

## COMPUTER PROGRAMS

Virtual Moon Atlas

<https://sourceforge.net/projects/virtualmoon/>

Lunar Terminator Visualization Tool (LTVT) [http://www.alpoastronomy.org/lunarupload/LTVT/ltvt\\_20180429-HTML.zip](http://www.alpoastronomy.org/lunarupload/LTVT/ltvt_20180429-HTML.zip)

## REFERENCES

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# Some Historical Considerations About the “Star on the Moon” in 577

Alberto Anunziato

Reading intermittently and purely for pleasure the "Theatrum Cometicum", the great cometary encyclopedia of 1681 by Stanislaw Lubieniecki, in the same spirit with which the Polish author will have read the old medieval chronicles, as Edgard Allan Poe in "The Raven": "while I pondered ... over many a quaint and curious volume of forgotten lore ", I found an entry corresponding to the year 583 in which it refers that at the death of Samson, son of the King of the Franks Chilperic, "stella in medio Luna fulgens visa est": a star was seen shining in the middle of the moon. After citing mediaeval sources, Lubieniecki says: "I confess ignorant of the nature of this phenomenon. Some very wise and learned person in many studies, including mathematics, resident in this city referred to the possibility that it was an aerial comet subject to the Moon that was located in a straight line between the eyes of the observer and the Moon, transiting through our air, with these words: "A comet on the Moon or was a prodigy or was a fable. The movements of comets and the Moon are not compatible so that a comet can appear on the Moon. It lasted for very few hours and, importantly, it was not visible from all countries, because of its great parallax, as we see with solar eclipses" Of other friends whom I consulted, distinguished mathematicians, I did not get an answer. However, another learned man living in this city, assured me that this phenomenon could be a comet lit between the Moon and the Earth, moving very fast at regular speed. I suspend judgment, but I think I can include this phenomenon as a comet".

The concept "aerial comet subject to the Moon" is explained in the theoretical framework of cometary astronomy of the mid-seventeenth century, when it was thought that comets could be caused, all or a large part of them, by emanations from the planets of the solar system , so for Lubieniecki it would be possible in theory that a comet has emerged from the Moon and had an orbit close to our planet. To the obsessive seeker of cometary antiquities this event seems a rarity that it is possible to include within the cometary phenomena. Now we know that it could not be a moon comet. Is it possible that the Franks of the late sixth century have witnessed a Transient Lunar Phenomenon with the naked eye?

The data to decide on the veracity of the chronicle are few in "Theatrum Cometicum", in which it is located in the year 583, after the death of Samson, although he assures that this fact is difficult to place in time, and therefore, our event is also difficult to place in time. We currently know that Samson, son of Chilperic, died in 577, so that would be the year of the "star on the Moon". Lubieniecki cites two sources: the "Historia Francorum" by Aimoin of Fleury, and the "Historiae Ecclesiasticae Francorum" by Gregory of Tours. The first source is not very helpful: "In that year we saw a star shining in the middle of the moon". The volume that Lubieniecki read had this annotation in the margin "cometa visus", and that is the reason for the inclusion in the "Theatrum". The other source cited is Gregory of Tours and it is more interesting: "After this, on the night of November 10th, while celebrating the vigil of Saint Martin, a great prodigy appeared: for in the middle of the Moon it was seen how a sparkle star was shining; and above and below the Moon other nearby stars appeared. The circle that usually means rain also appeared around it. What this meant, we ignore it. For that year we saw on more than one occasion the Moon turned to darkness ("versam in nigredinem"), and before Christmas there was terrible

thunders. And in addition they appeared around the Sun those shines (splendores) that we already mentioned on the occasion of the defeat of Arvernus, which the uneducated people call "suns" ("soles"). And the waters of the sea went further than usual, and many other signs appeared". Anthony Cook, after reading a first draft of this work, indicated me that the phenomenon reported by Lubieniecki, from medieval sources, was the one that appears as the first Lunar Transient Phenomenon in the "Lunar Transient Phenomenon Catalog" (NASA Space Science Data Center, 1978) by Winifred S. Cameron. The source quoted by Cameron is Cicely Botley, who quoted this event in "TLPs and Solar Activity, and Other Phenomena" (British Astronomical Association Journal 86: 342, 1977). In Botley's article there is a "lapsus calami": "557" instead of "577", as it appears later in the same text. Botley's source is Gregory of Tours. Botley's transcription error (557 instead of 577) had consequences, as it is reproduced in the Cameron catalog and its complements, even in the title of "Analysis of Lunar Transient Phenomena (LTP) Observations from 557-1994 AD". Using the source of Botley (Gregory of Tours), we can review Cameron's analysis in her catalog and determine the influence of the error on the statement of the year in which the event occurred. The same date (November 10th) provided by Gregory is reproduced on page 22 of Cameron's Catalog. Cameron indicates a time ("18.00?") that "has been guessed at by the author from such information as the age of the Moon, the location of the observer and the status of the observer" (page 3). The following information is the description of the phenomenon: "Light on moon (year uncertain accord. to source)". There is really no uncertainty about the year, 577, which is when occurred the historical fact (death of Prince Samson) related to the prodigy ("post haec in nocte"). There is also no uncertainty about the place: it was in present-day France, while Cameron reports "Europe?". Cameron relates the event to solar activity (probable aurorae) based on Botley's research and deduces the age of the moon (3.5 days). Did the error about the year, derived from Botley, influenced that calculation? Using programs such as Virtual Moon Atlas or Cartes du Ciel, we know the age of the Moon at the event's time. On November 10th 577 at 8:00 p.m. (we arbitrarily set the time, since that datum does not appear in Gregory of Tours) in what is present-day territory of France (1932121.512072 on Julian Date) the Moon was illuminated at 99%, in colongitude 81.9°. If the same calculation is made with the date and time indicated by Cameron from Botley's "lapsus calami" (6 pm November 10th 557, 1924816.428333 on Julian Date), the age of the Moon is similar to that stated by Cameron (illuminated at 12% and colongitude 310.5°). From this verification two conclusions arise regarding the appraisal of Cameron's analysis and of the anomalous event itself. First, we can deduce that Cameron's analysis effectively took 557 as the year of the event and that therefore the data derived from the date included in the Catalog should be corrected. Specifically: columns 2 ("date: 11/10/77"), 11 ("age:14.8"), 13 ("colongitude: 81.9°"), 14 ("number of days from Full Moon, nearest full moon: -0.5; 11-11"), 17 ("location: France"). Second, the strangeness of the event increases. For Cameron, taking the colongitude corresponding to November 10th 557, the LTP could have been an increase in brightness that occurred in the illuminated part or in the dark part of the visible face. But the correction of the date (November 10th 577, at 81.9° colongitude) implies that the witnesses would have perceived the brightness of the "stella" on a full moon.

We believe that our knowledge of the 577 event improves with the use of Gregory of Tours' text, which we accessed by the quotation in "Theatrum Cometicum", instead of the more concise information present in Botley. It is a historical LTP of importance, not only for opening the Cameron catalog but because the researcher gave it a 4 grade ("very

experienced, good single observers”). We could not decide whether or not there was a plurality of witnesses, as Cameron seems to assert. Although Gregory uses the plural “apparuit nobis”, it seems more likely that it is a use of the plural of modesty by the author, which in other parts of the text refers to himself in the first person of the plural. It is probable that it was an event of a certain duration, hinted at by the verb used by Gregory: “eluceo”.

The relation of our event of 577 with the event that the monks of Canterbury witnessed in 1178, or much closer to us, the controversial image that Leon Stuart obtained in 1953, is quite evocative, if not rigorous. Perhaps in today's France, in 577, the impact of a meteorite of considerable proportions or a Transient Lunar Phenomenon of a magnitude that we would consider very improbable today could be seen. Appropriately analyzed medieval texts, without underestimating them by the relationship they usually establish between astronomical phenomena and prodigies, has allowed to overcome old prejudices of the Historical Astronomy Scholars and obtain valuable information in various fields (supernovae, comets, meteors) using the philological criticism as an assistant to astronomy. As Antonella Ghignoli and Vito Polcaro have proved: “medieval chroniclers can be extremely accurate in their descriptions” (“Eleventh Century Astronomical Events as Recorded in Contemporary European Sources, in” Mediterranean Archaeology and Archaeometry, Special Issue, Vol.6, N.3, page 61).

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# Thermal Observations of Tycho: A First Look

## Darryl Wilson

### Introduction and Background

This article illustrates thermal emissive behavior of Tycho after lunar sunset. Thermal infrared (TIR) imagery shows that Tycho radiates strongly in the 7 to 14-micron region of the spectrum at least 12 hours after sunset. TIR images of the crater taken in the morning, near midday, and in the afternoon show little anomalous thermal behavior throughout the day.

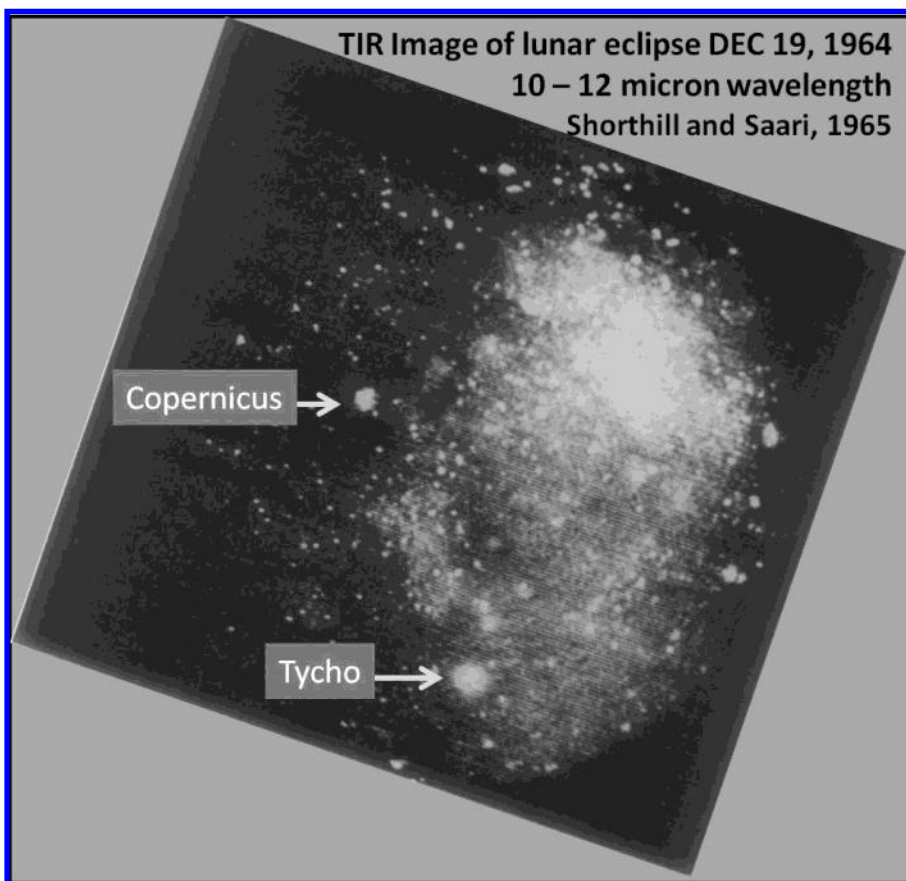
The thermal properties of the lunar surface were studied extensively during the 1960s as the U.S. space program was building towards the Apollo moon landings. As early as 1960, a report by W. M. Sinton titled "Eclipse temperatures of the lunar crater Tycho" was published in Lowell Obs. Bull. 5, 25-26. A TIR image (from R. W. Shorthill and J. M. Saari) of the totally eclipsed moon on December 19, 1964 is reproduced in Figure 1. In 1964, a 74-inch telescope and a liquid neon cooled thermal detector were required to achieve this result. It showed, for the first time, many thermal hotspots on the lunar disk. Most of them correspond to the locations of small craters. With about a half dozen exceptions, large craters are generally unremarkable. Among the exceptions, Tycho seems to be the hottest, with Copernicus, Langrenus, Aristoteles, Aristarchus, and Atlas also anomalously warm.

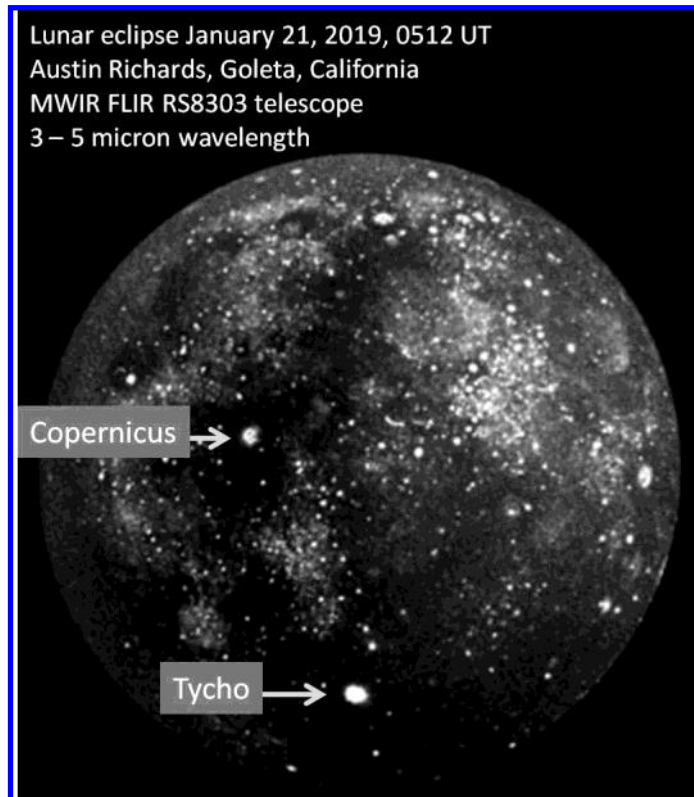
The November 2019 issue of TLO included an article titled "Lunar Nighttime Thermal Analysis". In it, this author noted that many craters in the 5 to 10-mile diameter size range continue to glow visibly in the TIR region of the spectrum for as long as 72 hours after lunar sunset. A diffuse brighter area corresponding to the interior of Atlas was also noted. Unbeknownst to the author at the time, he had rediscovered thermal features noted by Salisbury and Hunt in their 1966 paper.

Tony Cook responded to the November 2019 TLO article by republishing a thermal image that he took during the March 3, 2007 lunar eclipse. It can be seen in the January 2020 issue. Although the spatial and radiometric resolution of his image was limited, it definitely showed that Tycho was an anomalous hotspot on the lunar disk as the surface was cooling during the eclipse.

An online search revealed an image of the moon taken by Austin Richards in Goleta, California with a medium-wave infrared (MWIR, wavelengths from 3 to 5 microns) FLIR RS8303 telescope during the eclipse on January 21, 2019 at 0512 UT. The image is reproduced here in Figure 2. Although his imager was sensitive to a somewhat different temperature range than the TIR imagers used by Shorthill and Saari, and the author, it shows most of the same thermal features.

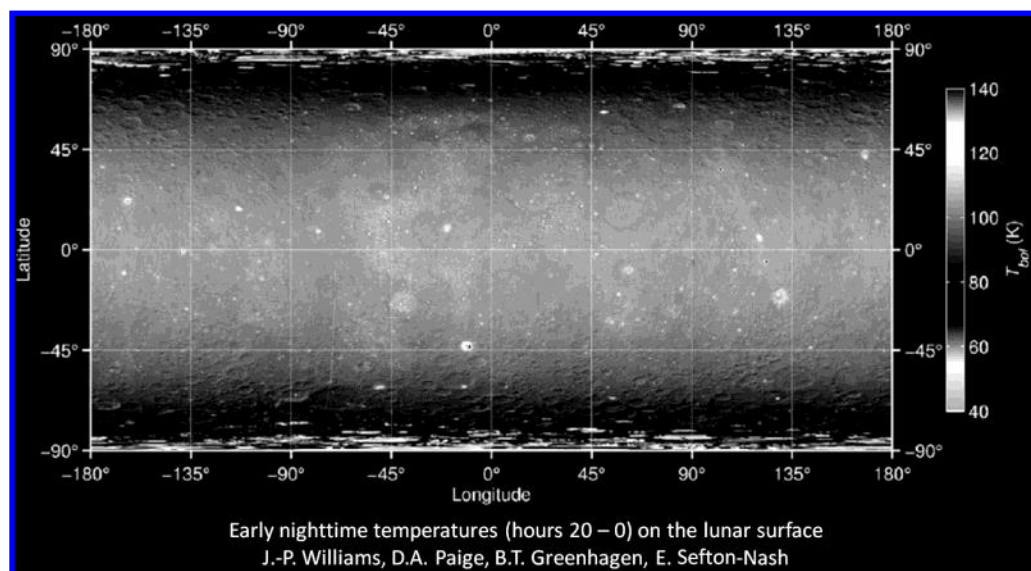
**Figure 1**





*Figure 2*

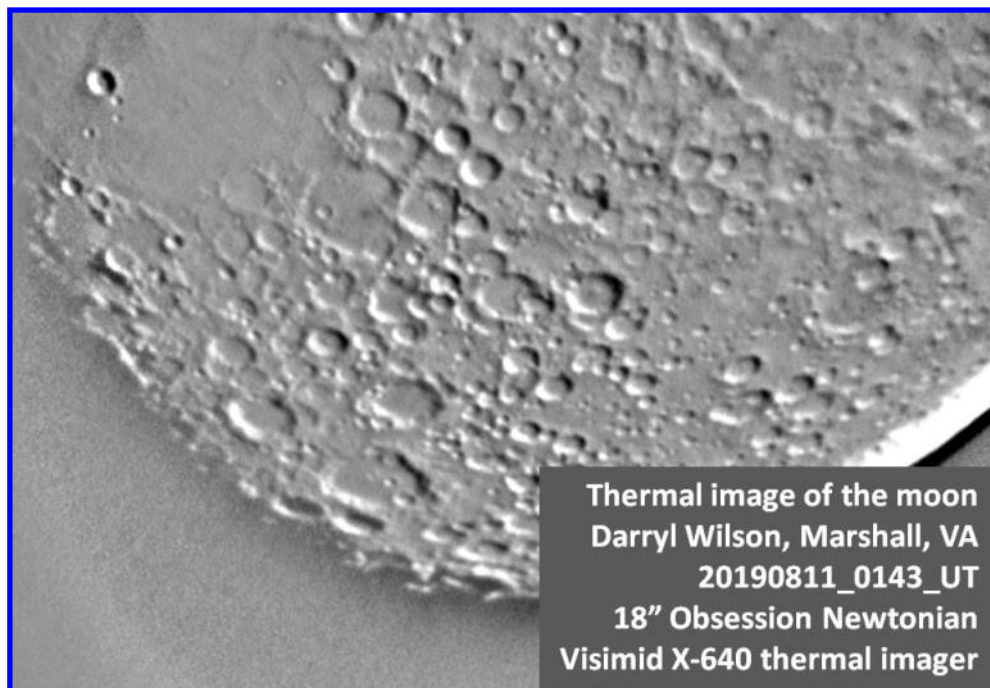
In recent years, research from the Diviner Lunar Radiometer Experiment, part of the Lunar Reconnaissance Orbiter (LRO) program, has shed light on spatial and temporal thermal patterns on the lunar surface. A paper titled “The global surface temperatures of the Moon as measured by the Diviner Lunar Radiometer Experiment” states “Tycho crater represents one of the most significant thermal anomalies in nighttime thermal IR observations”, confirming the validity of our thermal observations. Figure 3 is an early nighttime global temperature map of the surface of the entire moon, generated from LRO data. Tycho is the bright spot at longitude -11 degrees, latitude -43 degrees.



*Figure 3*

## Observations

The thermal image in Figure 4 was taken August 11, 2019, about ten days after new moon, and two days after sunrise on Tycho. Figure 5 is a visible light image taken at about the same time. This is the transition from early to mid morning for the area near Tycho. The general appearance of the crater is similar in both images. The interior of the western wall, and the exterior of the eastern wall are relatively bright, and the central mountain peak is clearly visible. About halfway between the peak and the wall in the NW direction, a light spot is barely discernable in the thermal image. There is a slightly darker area at the same location in the visible image. The visible image shows many bright rays associated with Tycho, but the thermal image only shows one. Prominent in many thermal images taken by the author, the ray that passes through Mare Nectaris is visible as a diagonal dark streak, from the point where it passes just north of Zagut, to the edge of the frame where the southern half of Fracastorius can be seen. No other rays associated with Tycho are visible in this thermal image.



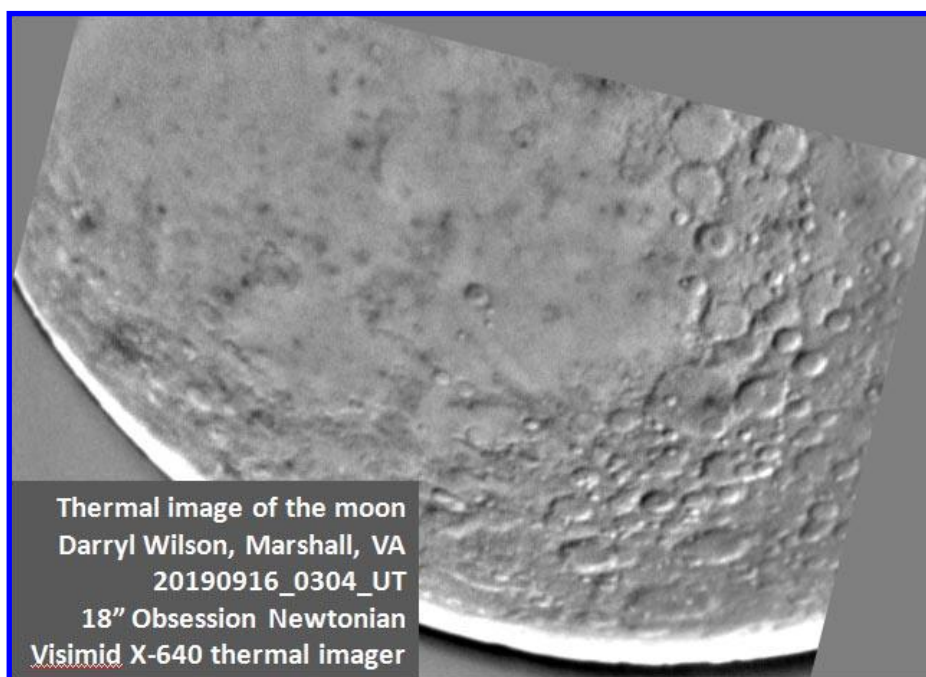
*Figure 4 above, Figure 5 below*



Figure 6 is a thermal image of the Tycho region taken September 16, 2019, about two days after full moon. Figure 7 is a visible light image taken at about the same time. This is near noontime for the Tycho region. As expected near full moon, the visible image has no shadow detail, and albedo variations inside the crater are mostly indistinct. Virtually invisible in the visible image, the central peak is fairly well defined in the thermal image.

The thermal image shows a bright, crescent shaped feature at the SE portion of the inner wall. Extending from about 4 o'clock to about the 6 o'clock position, this is the warmest part of the crater. In the visible image, we see a lower albedo "U" shaped crescent where the floor meets the base of the southern interior wall. It extends from about the 4 o'clock to about the 7 o'clock position, with the darkest part between 6 o'clock and 7 o'clock. It is notable that the lowest albedo area does not correspond to the warmest part of the crescent.

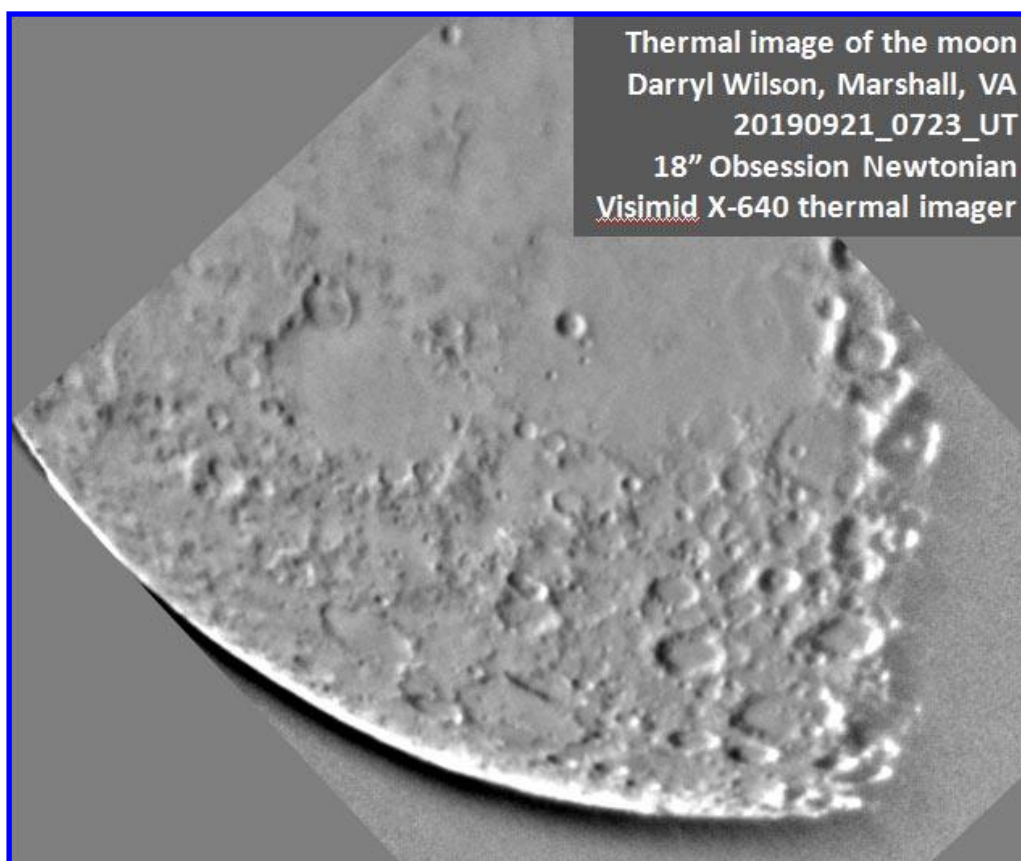
There is a hint of a linear feature in the thermal image, extending in the WSW direction from the central peak to the edge of the interior wall. It is darker on its southern side. The double ray that extends through Mare Nubium towards Kepler is well defined in the thermal image as a pair of dark streaks. Another ray that extends to the southwest, through the eastern edge of Longomontanus, is also faintly visible. None of the other rays associated with Tycho can be detected in this thermal image.



*Figure 6 above, Figure 7 below*



Figure 8 is a thermal image of the same area taken on September 21, 2019. About seven days after full moon, this is late afternoon for Tycho. Figure 9 is a nearly simultaneous visible light reference image. This thermal image is not as sharp as the others, and no detail is visible on the crater floor except the central peak. The double ray through Mare Nubium, still present in the visible image, is no longer visible in the thermal.

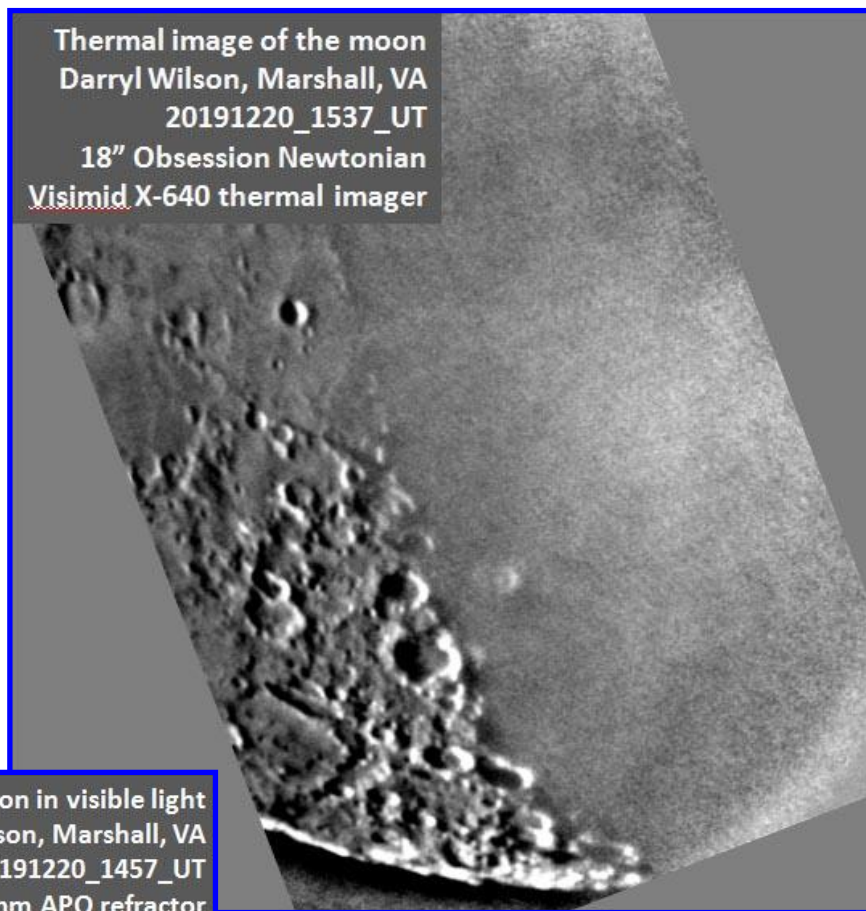


*Figure 8 above, Figure 9 below*

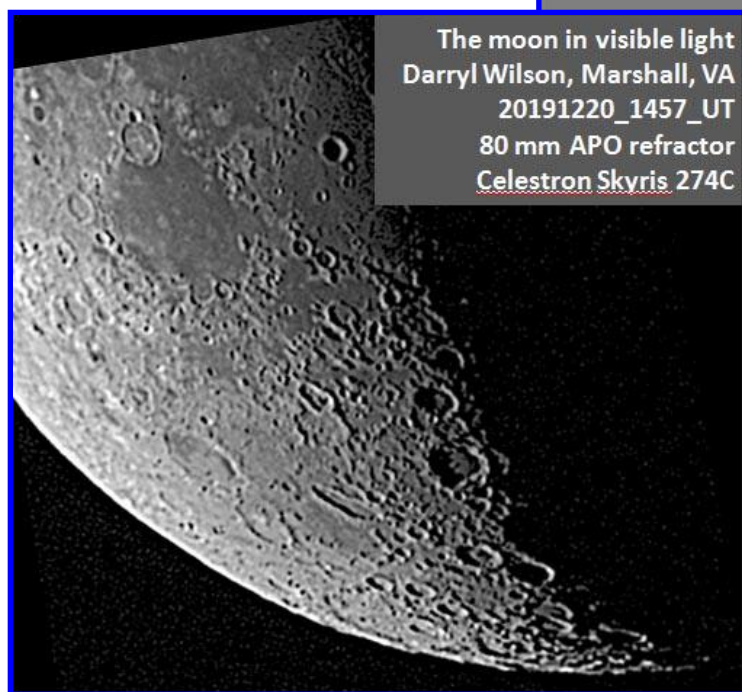


Figure 10 contains a surprise. This thermal image was taken December 20, 2019, about 8 1/2 days after full moon, and about 12 hours after sunset on Tycho. Figure 11 is a visible light image taken at the same time, showing that it was completely in shadow. The thermal image shows Tycho clearly glowing in the lunar night. It is the only crater seen to do this. Furthermore, it glows with considerable spatial detail, not just an amorphous bright blob as it does in Figures 1 and 2. The central peak is definitely visible, as is the oval shape of the outline of the foreshortened rim. The crater wall can be traced almost completely around its circumference. The eastern inner wall radiates more strongly than the western wall. It appears that the glow from the western wall comes from the exterior of the crater because the bright spots seem to be displaced further from the central peak than the bright area corresponding to the eastern wall. Finally, there are also some large, amorphous, brighter features in the image that cover large areas of the lunar surface that are in darkness.

*Figure 10*



*Figure 11*



## Discussion

Throughout the lunar day, Tycho displays nothing unusual in any of the dozens of thermal images that the author has collected over the past six months. Its general appearance is, in most ways, similar to a visible light image taken at a low solar angle, when Tycho's rays are barely visible.

Figures 4 and 5, 6 and 7, and 8 and 9 comprise three pairs of simultaneous visible light and thermal images that were taken soon after lunar sunrise, near solar noon, and just before lunar sunset. In these three cases, Tycho exhibits mostly unremarkable thermal behavior.

The brighter crater walls in Figures 4 and 5 were receiving more direct solar illumination than surrounding areas. This resulted in more reflected radiance in the visible and enhanced warming in the thermal image. The light spot on the crater floor, NW of the central peak, in Figure 4 is somewhat intriguing because a corresponding feature was captured in the visible image as well. Examination of high resolution visible light imagery revealed rough terrain features in that location. Perhaps a preponderance of fresh exposed rock faces in this terrain causes increased thermal emission. Further thermal observations, with higher SNR, may prove enlightening. Crater rays are generally muted in the TIR, and are usually undetectable unless the solar elevation angle is high. This explains why the only visible ray in Figure 4 is the one well to the east, near Mare Nectaris where the sun had risen several days previously.

Thermal images typically show more terrain detail than visible light images when the solar elevation angle is high. This is evidenced here by the well-defined central peak in Figure 6, as compared to the visible image in Figure 7.

The bright crescent shaped area on the southern edge of the crater floor in Figure 6 is mainly the result of more direct solar radiation on the north facing inner wall. Although it is tempting to attribute greater warming to the lower albedo material near the base of the crater wall, noted in the visible image, a careful examination reveals that the darkest area in the visible image is between the 6 o'clock and 7 o'clock locations. This darker segment is distinctly cooler than the adjacent area which forms the brightest part of the crescent. When it comes to warming the lunar surface, at least in this case, the angle of incidence of solar irradiation is a more important factor than albedo.

The dark linear feature extending from the peak in the WSW direction is barely visible, and may be due to noise. It is weak, and there is no clear counterpart to be seen in the visible image. If real, it is likely due to a slope discontinuity on the crater floor. This image pair was taken near local noon at Tycho. Consequently, the rays are at their best presentation. When the solar elevation angle is fairly high, parts of the ray system are visible in thermal images as a faint photographic negative of their visible light counterparts. Even so, most of the many rays associated with the Tycho system are invisible in TIR images taken by the author. Due to the extent of Tycho's ray system, a TIR analysis would require examination of most of the entire lunar disk, at several different times during the lunar day. That larger effort may be the subject of a future article.

The thermal image in Figure 8 shows that, in the lunar afternoon, crater rays tend to disappear. None of Tycho's rays are detectable. This is likely due to a phenomenon known as thermal crossover. A low albedo feature absorbs more solar energy during the day, reaching a higher maximum temperature. Low albedo usually means high emissivity. A highly emissive object radiates more strongly, thereby losing thermal energy more rapidly as solar irradiation decreases. At lower sun angles, insolation becomes less than emission, and the surface begins to cool. By late afternoon, the initially warmer area cools to the same temperature of the cooler one. Thermal contrast is lost and they become indistinguishable to the thermal sensor.

The appearance of Tycho in Figure 10, glowing in the darkness of the lunar night, is ethereal. A detailed understanding of the cause requires consideration of principles of thermal insulation, thermal inertia, emissivity, density, heat capacity, and thermal conductivity, as well as lunar surface erosion processes and crater ages. If that sounds daunting, don't worry. Without much loss of accuracy, it can be explained quickly and simply in two steps.

First, most of the lunar surface is covered by what is called regolith. Regolith is the result of space weathering of the lunar surface. Micrometeoroid bombardment over billions of years has slowly pulverized the surface rock, turning it into tiny bits of fine-grained particles - like a powder. Recall pictures of the footprints of the Apollo astronauts. It is highly insulating, and it prevents most solar heat from penetrating into the lunar surface. Because absorption of thermal energy is minimized during the lunar day, there's not much to radiate away after sunset. That explains why most of the surface cools rapidly to a temperature below the limit of detection from earth.

Second, when a large cratering event occurs (e.g. Tycho), the insulating surface layer is blasted away, and the underlying rock is exposed. Fresh, exposed silicate rock has very different thermal properties than regolith. Its thermal conductivity is greater, so it absorbs more solar energy during the day. After sunset, the lack of an insulating layer allows it to radiate more efficiently than the regolith.

Regolith insulates the moon. Holes in the regolith allow heat to flow in and out. Combine the two ideas and you get a detectable glow from earth from a young (100 MYA) crater.

A look at Figure 11 confirms that Tycho was in complete darkness when the thermal image was taken. Although several features in this image can be correlated with interesting patterns seen in Figure 10, they are not associated with Tycho, so a discussion is beyond the scope of this article. Finally, the amorphous brighter areas that cover parts of the lunar surface that are in darkness are just noise-induced image processing artifacts. This image pair was taken mid-morning, in full daylight, with intermittent thin cloud cover and low elevation angle. Some of the images that were stacked to produce Figure 10 had more cloud content than others. Fortunately, a sufficient number were cloud-free around Tycho to allow for this result.

## Conclusions

Fifty-five years ago, Shorthill and Saari discovered thermal hotspots on the lunar surface using a 74-inch telescope and a liquid neon cooled thermal detector. We can now image these same features with a commercially available TIR camera and a backyard telescope.

After the cancellation of the Apollo program in 1972, it seems that little observational research was conducted in the TIR region of the spectrum until the LRO program efforts began about 11 years ago.

Scientists with the LRO program produced global temperature maps of the lunar surface with unprecedented radiometric and temporal resolution. Among the analysis products were global temperature anomaly maps. They showed numerous locations, usually craters, that remained warmer than their surroundings during the lunar night. Tycho exhibits the greatest thermal anomaly on the nearside.

According to the LRO scientists, the reason seems to be that Tycho is a relatively young crater. The lunar surface is constantly bombarded by micrometeoroids that pulverize the top layer, resulting in a loose mix of fine-grained particles that provide excellent insulation. This process occurs slowly enough that Tycho, about 100 million years old, still exposes a fresh surface. This relatively uninsulated material radiates more strongly than the surroundings.

It is interesting to note that, as of 2015, the LRO analysis was done on data that were binned to a resolution of 0.5 degrees of longitude. That corresponds to about 10 miles at the equator. The resolving limit of a 12" telescope in the TIR region of the spectrum is about 10 miles, which means that amateur astronomers using a TIR camera and a 12" telescope may be able to image the same level of spatial detail as that which is presented in the LRO analysis results. Of course, earthbound observers will not be able to replicate the radiometric fidelity of those results, nor will they be able to record temperatures as low as the orbiter measured. Indeed, it would be impossible to completely reproduce the LRO datasets from earth. Nevertheless, at least some aspects of the program results should be within the capability of amateurs to confirm. The Tycho thermal anomaly is one example.

Finally, the November 2019 TLO article "Lunar Nighttime Thermal Analysis" mentioned surface geometry and the cavity effect as two possible reasons for the visible glow of many small craters as long as 72 hours after sunset. Another possibility must now be added - exposure of fresh, uninsulated silicate rock during the cratering event.

### Suggestions for Future Work

The current explanation for nighttime glow of large craters requires the presence of exposed silicate material at the crater. The glow of small craters may or may not require this. It is still possible that geometric terrain effects on radiative cooling may be the dominant factor. Spectroscopic analysis using M3 data might help resolve the issue. Another possibility involves TIR imaging with narrowband thermal filters centered near 9.5 microns and 8.5 microns. Quartz has a diagnostic feature near 9.5 microns that should allow a silicon material abundance map to be produced by simply ratioing the images collected through each of the two filters. The map would facilitate correlation between craters that have exposed silicates and those that glow after sunset.

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## East of Deslandres

### Rik Hill

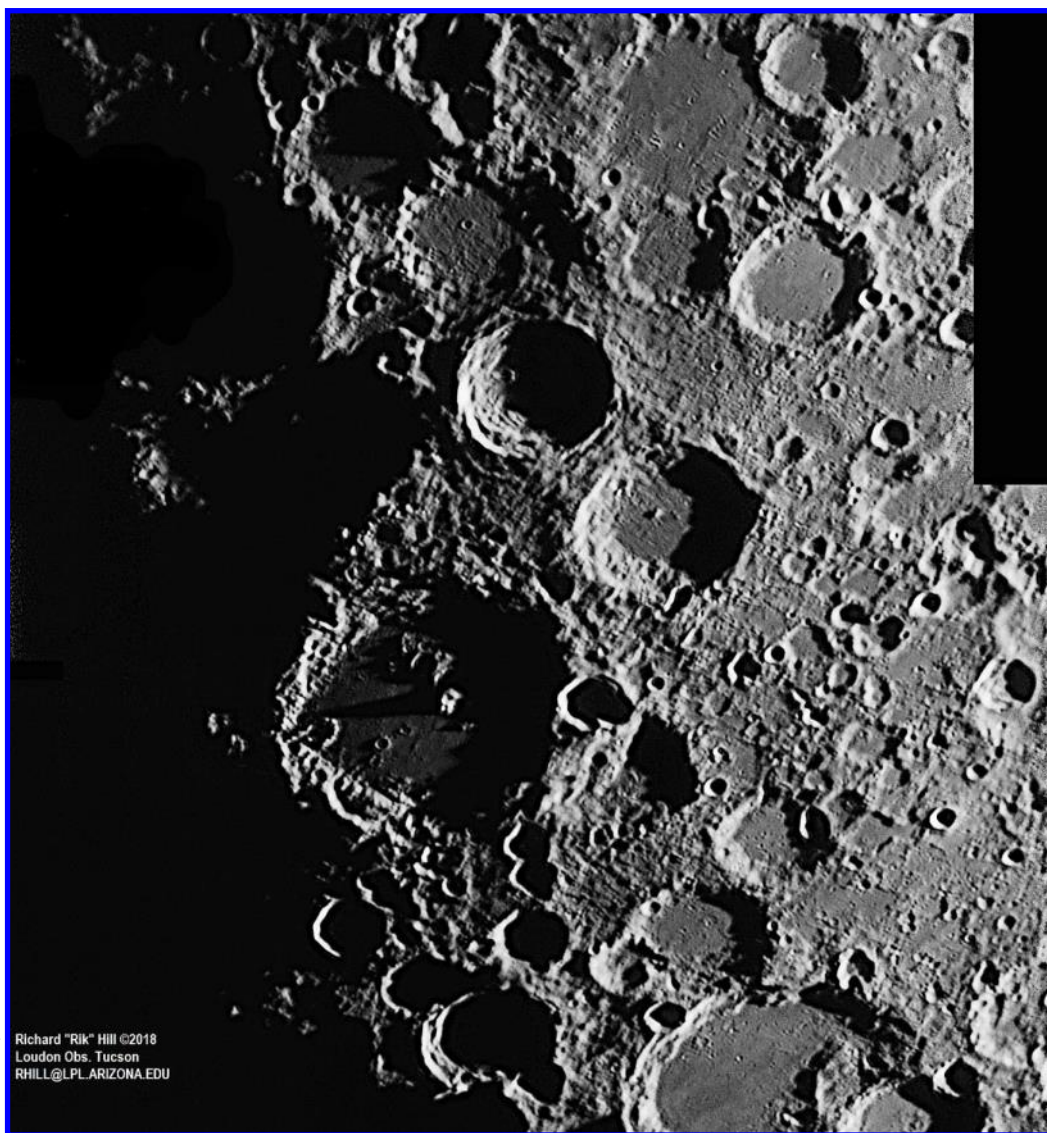
A spectacular view when the Sun first rises on the 145 km diameter Walter just left of center in this image. It's offset central peak is casting a beautiful long shadow all the way to the western wall. Note the crater in the central peak which is heavily sculpted by impacts. East or right of Walter and a little south is a large irregular depression. This is Nonius listed as 71 km in diameter though it is anything but circular! North and east are two similar diameter craters. The southern one is Aliacensis (82 km) and to the north-west of it is Werner (71 km). Notice the beautiful terracing of inner walls of Werner! Above Werner is a raggedy crater Blanchinus (70 km) and further up is the shadow filled La Caille (70 km). The floor of La Caille is fairly flat with lots of small craters so when the Sun rises it *rapidly* becomes illuminated with all the craterlets spattered about. You can see that starting to happen in this image.

*Walter, Richard Hill, Tucson, Arizona, USA. 23 April 2018 0253 UT, colongitude 13.2°. TEC 8" f/20 Mak-Cas, Skyris 445M camera, 610 nm filter. Seeing 9/10.*

Over on the other side of the image in the upper right corner is the crater Playfair (49 km) about 2/3 in the light. One of the twin 3 km craters on the floor can be seen just on the edge of the terminator and then straight across from that, on the west (left) of the

crater floor, is a 1.5 km crater. South of Playfair is Apianus (65 km) and adjacent to it to the west is Krusenstern (49 km) forming an isosceles triangle with Apianus and Aliacensis, partially cut off by the corner of the image montage, is the oddly shaped crater Poisson (82 km) with the strange ridge running through it. This is fascinating to view as are the curious craters just below it shaped like little paw prints in soft soil.

At the bottom of the image is most of the large crater Stöfler (129 km) with the delicately streaked floor. The two craters above it are Fernelius (66 km) and Kaiser (54 km) above it. Between Kaiser and Poisson is a field of craters of all shapes and sizes up to 20 km that make for delightful viewing!



# Lurking in the Shadows

## David Teske

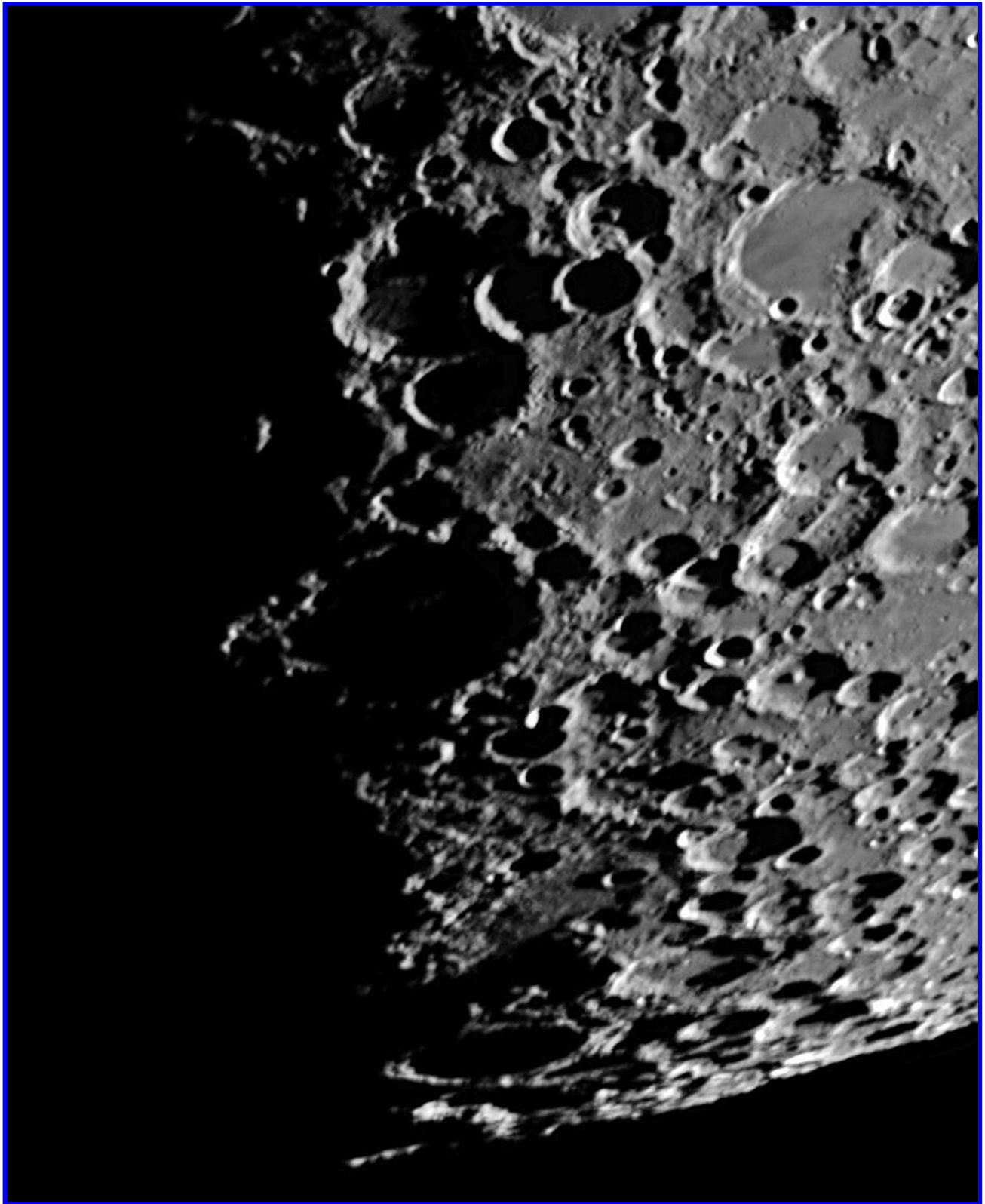
The interplay of light and dark along the lunar terminator is always fascinating, perhaps even more so along the ragged and confusing southern highlands. The whole area around these craters in the southern highlands shows how violently and chaotically the Late Heavy Bombardment around 4 billion years ago restructured this landscape through numerous impacts following one another in time and also the superposition on one another in space.

Maginus is the large crater in shadow at the center of the terminator in this image. Named after Giovanni A. Magini an Italian mathematician, astronomer and astrologer who lived from 1555 to 1617, this ancient crater is 163 km across. Though in shadow, the rim of Maginus can be seen to have been pelted by later impacts, perhaps even basin secondaries from the Imbrium impact 2,600 km to the north. Though ancient, its wall is still well preserved and 4 km tall.

Touching the north wall of Maginus is the polygonal crater Proctor with a diameter of 52 km. This is one of the few craters of the Moon named for a female, in this case Mary Proctor, the daughter of astronomer R. A. Proctor. She as an astronomer herself who lived from 1862 to 1957. North of Proctor is a similar sized crater, Saussure, with a diameter of 54 km. Named after Horace B. de Saussure the Swiss philosopher and natural historian who lived from 1740 to 1799, Saussure looks like a more regular crater shape than Proctor. Saussure is tangential to Orontius, the large, 125 km wide squarish shaped crater on the terminator north on Maginus. Named after Orontius Finaeus the French mathematician and cartographer who lived from 1494 to 1555, Orontius is the oldest crater in the immediate area. The eastern wall of Orontius is overlain by the younger 65 km diameter crater Huggins. The eastern wall of Huggins was destroyed by the younger crater Nasireddin with a diameter of 52 km. Just north of Nasireddin is the crater Miller, at 75 km in diameter and with a conspicuous central peak. The crater walls of Miller and Nasireddin coincide. Perhaps this was a dual-impact event. The ages of both craters is mid-Imbrium, about 3.5 billion-years old. Looking carefully at Miller, there is a large landslide on its southern wall perhaps caused by Nasireddin. In this dramatic area, you can view the ancient history of this landscape around Orontius.

Next, to the east (right) of this area is the large, smooth-floored crater Stöfler. Named after the German mathematician, astronomer and astrologer (talk about having all your bases covered) Johann Stöfler who lived from 1452 to 1534, the crater is large and complex with a diameter of 126 km and a depth of 2.7 km. Stöfler's western wall is largely intact except for three distinct craters all about 15 km in diameter. The western floor of Stöfler is smooth and dusted with rays from Tycho. The eastern portion of the crater's floor is mountainous and gives the impression of being the remnants of a former crater rim. The crater Faraday overlaps Stöfler's eastern wall. Named after Michael Faraday, the English chemist and physicist who lived from 1791 to 1867, this crater is 70 km across. Faraday's 4 km tall walls are breached by craters Faraday A to the northwest and Faraday P and Faraday C on the southwest wall.

South of Stöfler and east of Maginus is an interesting crater complex. First is the 75 km wide crater Licetus with a dimple of a central mound. Named after Fortunio Liceti, the Italian physicist and astronomer who lived from 1577 to 1657, Licetus is the crater just north of the unusual crater Heraclitus. At 90 km in diameter and named for the Greek philosopher of Ephesus back in 480 BC, Heraclitus is a ruined crater with a central mountain range. This range oriented southwest to northeast is about 30 km long. Heraclitus is an ancient crater as its only intact original rim is to the west. The southern floor is indented by Heraclitus D at 49 km in diameter. Along with my image of this area, I am also showing some older images of this area, in particular Stöfler and Heraclitus. These images include (figure 2) Plate 25-d from the Rectified Lunar Atlas, Plate 406 from the Lunar Orbiter (figure 3) and plate C7-d of the Photographic Lunar Atlas. (figure 4)



***Maginus**, David Teske, Louisville, Mississippi, USA, 02 February 2020 at 0142 UT, colongitude  $2.4^\circ$ . Seeing 5/10, 180 mm Takahashi Mewlon, IR blocking filter, ZWOASI120mms, 500 frames, Firecapture, Registax, Photoshop. Seeing 5/10.*

There are many other treats in the area. Lurking in the shadows on the terminator far south of Maginus is the crater Moretus with a diameter of 114 km. Moretus is a starting point for exploring the lunar south polar area. A few more hours of better lighting would help in this exploration. Maybe someday humans might actually put boots on the ground and explore this region, but for now, we can explore from afar.

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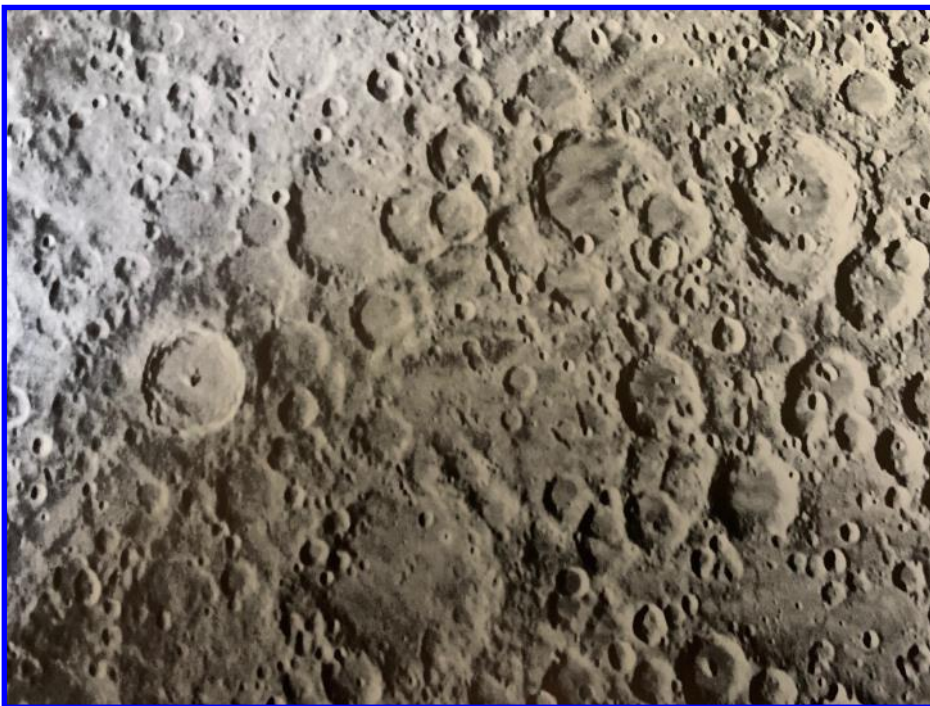
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**Figure 2 Plate 25-d**, Whitaker, E. A., Kuiper, G. P., Hartmann, W. K. and Spradley, L. H. 1963. Rectified Lunar Atlas Supplement Number Two to the USAF Lunar Atlas. United States Air Force, Tucson. Tycho is at the left center, Stöfler is the large flat-floored crater near the upper center and Heraclitus is the crater with the central mountain range below Stöfler. Image taken in 1919!

**Figure 3 Plate 406,** Bowker and Hughes. 1971. Lunar Orbiter Photographic Atlas of the Moon. National Aeronautics and Space Administration. At the upper center is the crater Heraclitus with its central mountain range and crater Heraclitus D in its southwest.



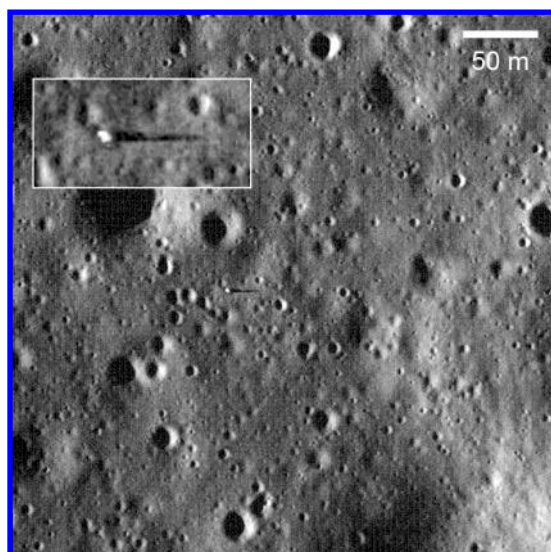
**Figure 4 Plate C7-d,** Kuiper, Gerard P. 1960. Photographic Lunar Atlas. The University of Chicago Press. This image shows the large crater Stöfler in the upper center with a flat floor and rays crossing it from Tycho. In the bottom center of the image is the crater Heraclitus with its central mountain range.

## Lunar Central

### Rik Hill

Imagine working on a spacecraft, putting your whole effort into building, launching and guiding it to its destination (Destination Moon for you old timers) only to lose telemetry 2,5 minutes before the projected touchdown. I've been in a room where that kind of thing happened (on Mars) and everyone looks like a wet dog. Its very depressing. The lunar mission I'm speaking of here is Surveyor 4 which crashed into Sinus Medii very near Hyginus (10 km diameter) and the beautiful squat "V" shaped Rima Hyginus seen in the upper right and Triesnecker (27 km) with its complex of rimae in the center. The mean center of the visible disk of the Moon is seen at the "+" symbol. Above it are two similar sized craters, Bruce (7 km) on the left and Blagg (5 km) on the right. To the left are two numbers "4" and "6". The number 4 indicates the supposed crash site of Surveyor 4 on 17 July 1967. Then just four months later, 10 b1967, Surveyor 6 successfully landed just a few kilometers to the west of Surveyor 4's resting place indicated here by the number 6 on the image. The LROC orbital imaging spacecraft has even taken an image of Surveyor 6 sitting on the surface. I remember as a teenager being disappointed that Surveyor 6 could not see the crashed Surveyor 4 off in the distance but if you think about the curvature of the Moon with its smaller radius than Earth, that simply would not have been possible.

Before leaving this area, I have to point out a couple of my favorite craters just north of the landing sites. The larger one is the ruined crater Murchison (60 km) just above Bruce and Blagg, which is open to the east towards the younger, smaller crater Chladni (14 km). Then to the west (left) of it is Pallas (51 km) with a nice central peak. I always spend some time looking at these when I'm in the area. There's so much to commend this region of the Moon!



*LROC image of Surveyor 6*

*Sinus Medii, Richard Hill, Tucson, Arizona, USA. 20 August 2018 0230 UT, colongitude 14.7°. TEC 8" f/20 Mak-Cas, Skyris 445M camera, 610 nm filter. Seeing 7-8/10.*



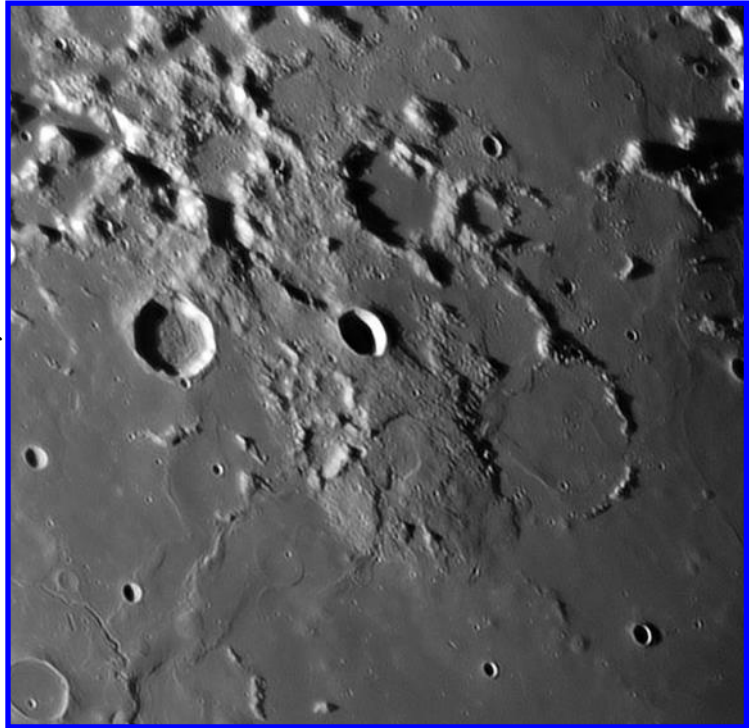
## Gardner Megadome

### Howard Eskildsen

The structure sometimes known as the Gardner Megadome is visible just above the center of the telescopic image (Figure 1). Its namesake crater, Gardner, has a shadowed interior and lies near the northern margin of the proposed megadome. To the right of the megadome is the lava-flooded ring of Maraldi D. Several domes are visible south of the ruined crater as well as on the lower image.

A caldera-like structure lies near the center of the megadome and to the lower left irregular surface features resemble sinuous rilles, or weathered faults. To the southeast of the “caldera” the surface pattern is less heavily cratered and younger than the western surface. Chuck Wood has proposed that this represents more recent lava flow from the caldera (<https://www.lpi.usra.edu/meetings/lpsc2005/pdf/1116.pdf>).

*Figure 1a*

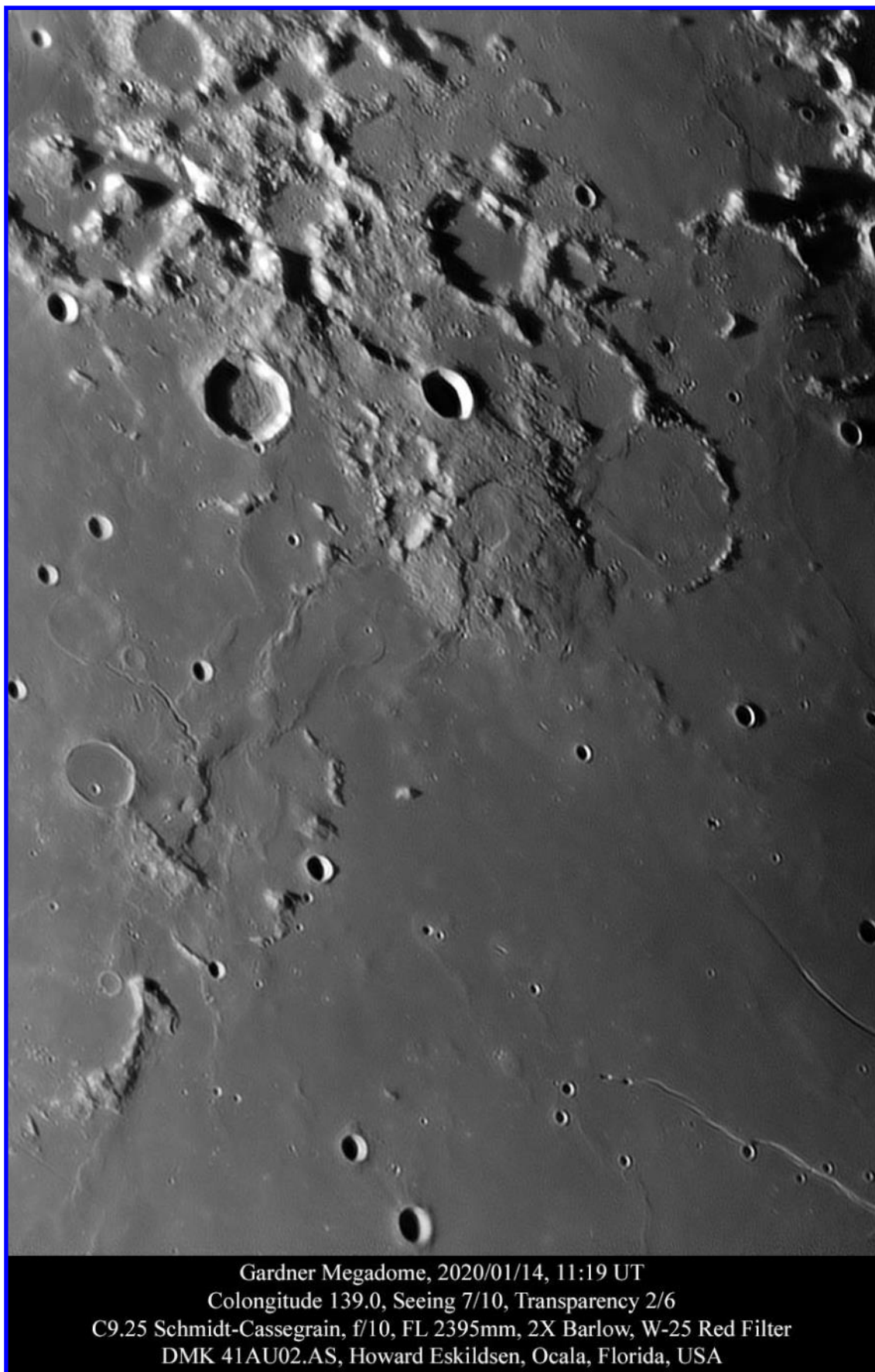


LROC QuickMap was used to generate elevation charts across the megadome from roughly north to south (N-S) and from west to east (W-E). The paths were chosen to intersect within a depression near the middle of the megadome, that might represent a caldera. Figures 2 through 5 show the sampling paths and corresponding elevation profiles. The megadome appears to be approximately 112 km on the N-S sample path and 90 km W-E with a geometric mean diameter of 100 km. Average megadome height above the surrounding surface for the N-S path is 1366 meters and 1206 meters for the E-W path, for a mean height of 1286 meters. This implies an average slope of 1.5°. However, the elevation chart shows steep upslope at the megadome margins with a plateau-like top. The major part of the upslope at the margins measures approximately 3.7° W-E.

The presumed caldera measured 15 km N-S and 12 km W-E over the sampling paths. Its depth relative to mean rim height was 259 meters N-S path, and 137 meters W-E.

LROC QuickMap images show the area under low illumination (Figure 6), the Clementine UVVIS FeO Abundance (Figure 7), and the Clementine Color-Ratio (Figure 8). The letter “C” marks the caldera area on each image. The Clementine UVVIS FeO Abundance shows higher iron southeast of the Caldera than on the southwestern side of the megadome (Figure 7). The Clementine Color-Ratio (Figure 8) shows the megadome in yellow-orange color consistent with basaltic materials of high iron and lower titanium content while the Tranquillitatus mare basalts appear blue, due to higher titanium content. Red areas adjacent to the megadome are consistent with anorthositic highlands materials.

Therefore, it appears that the megadome is composed of basaltic material rather than highland material, but is lower in titanium content than the mare basalts which embay the southern margin of the megadome. Also, the yellow-orange, low-titanium basaltic material extends well beyond margins of the megadome and appears to embay highland material to the east and to the northwest. It appears the megadome and its basaltic material is intermediate age between the older highland anorthosite and the younger, titanium-rich mare basalts to the south.



Gardner Megadome, 2020/01/14, 11:19 UT  
Colongitude 139.0, Seeing 7/10, Transparency 2/6  
C9.25 Schmidt-Cassegrain, f/10, FL 2395mm, 2X Barlow, W-25 Red Filter  
DMK 41AU02.AS, Howard Eskildsen, Ocala, Florida, USA

*Figure 1*

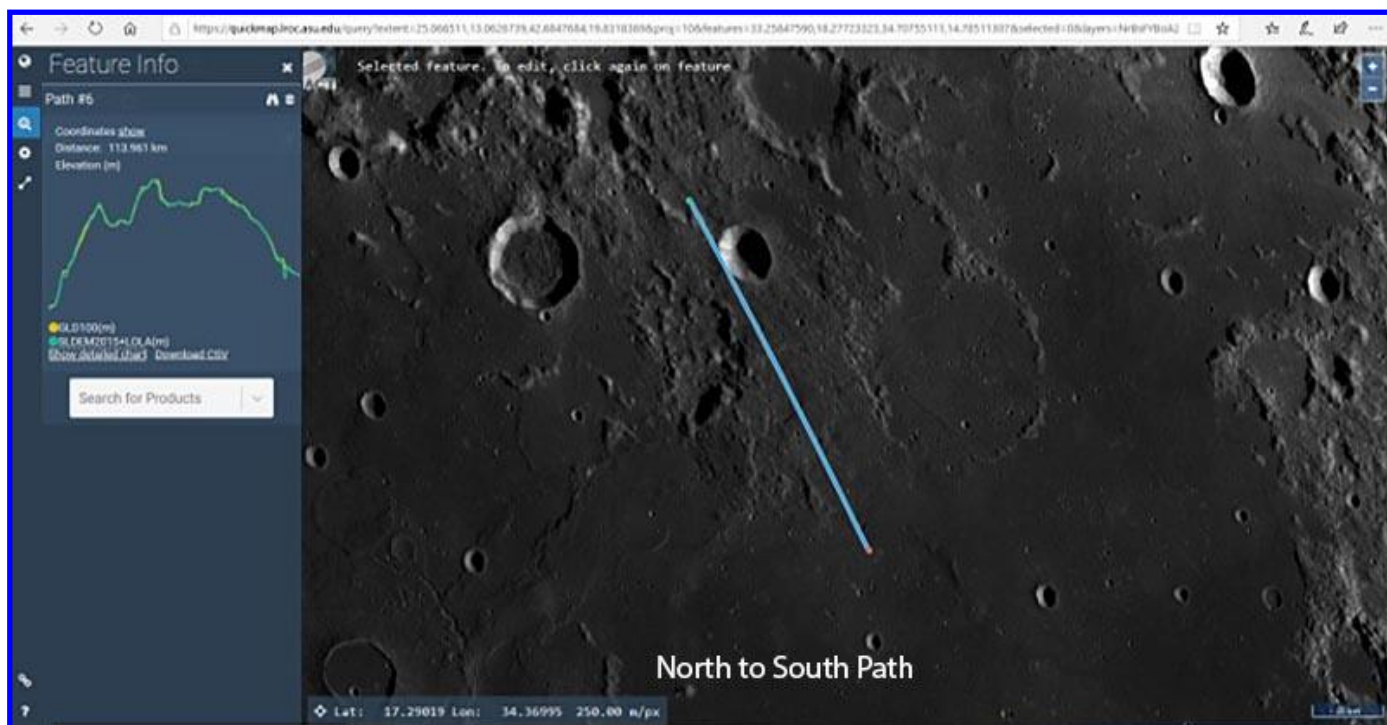


Figure 2

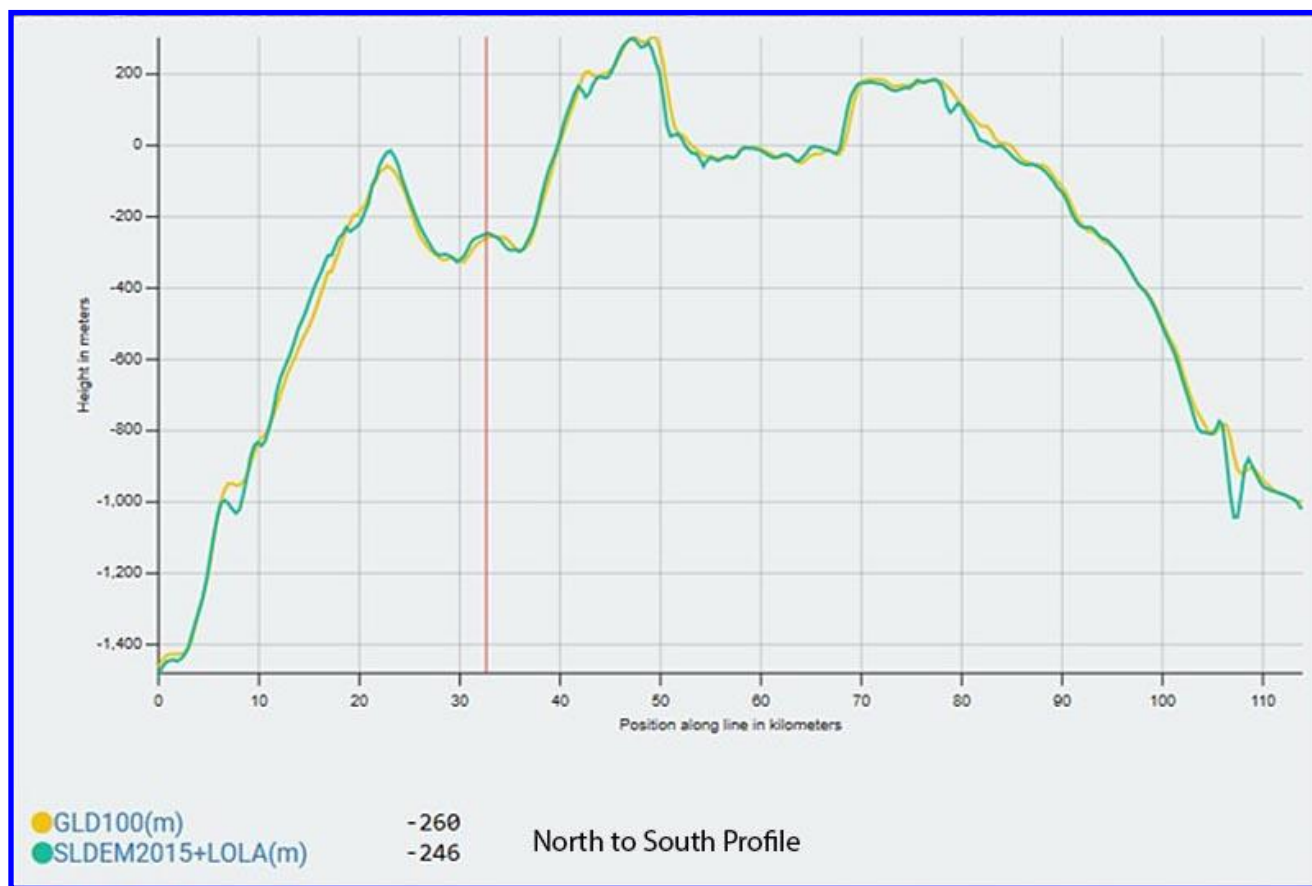


Figure 3



Figure 4

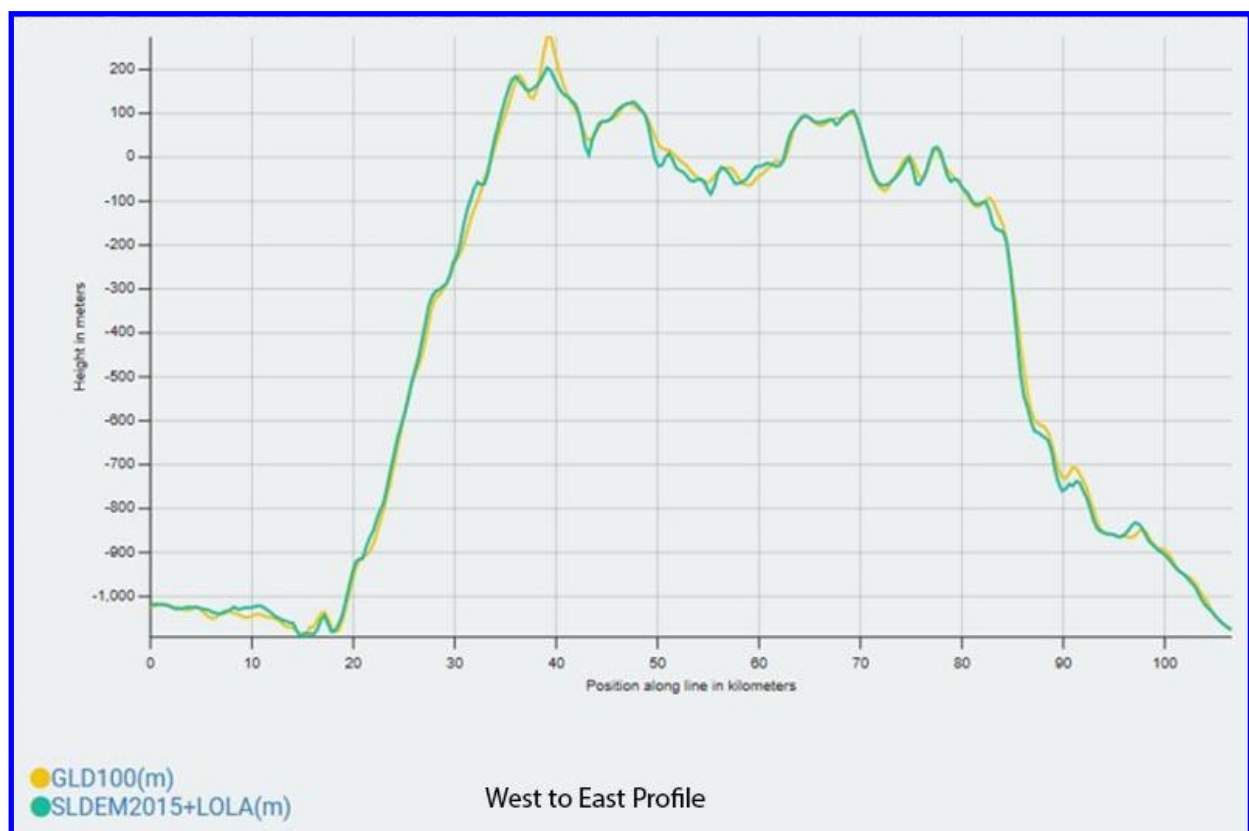


Figure 5

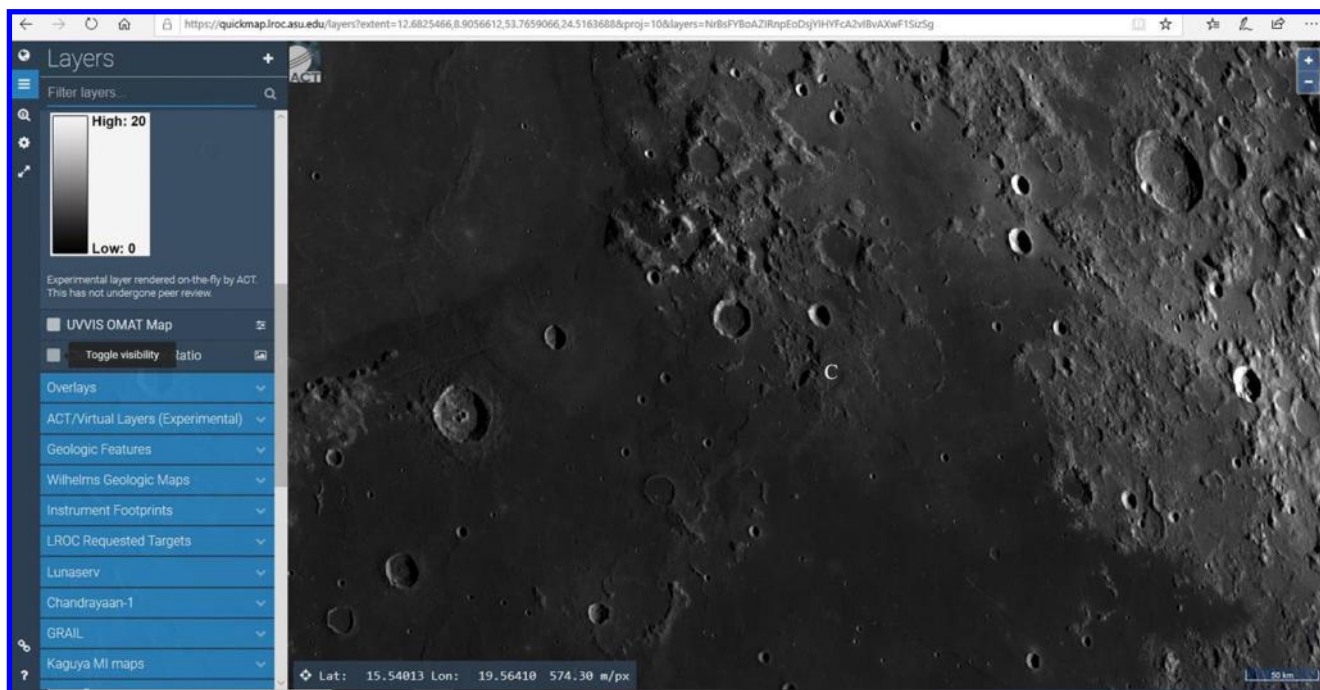


Figure 6

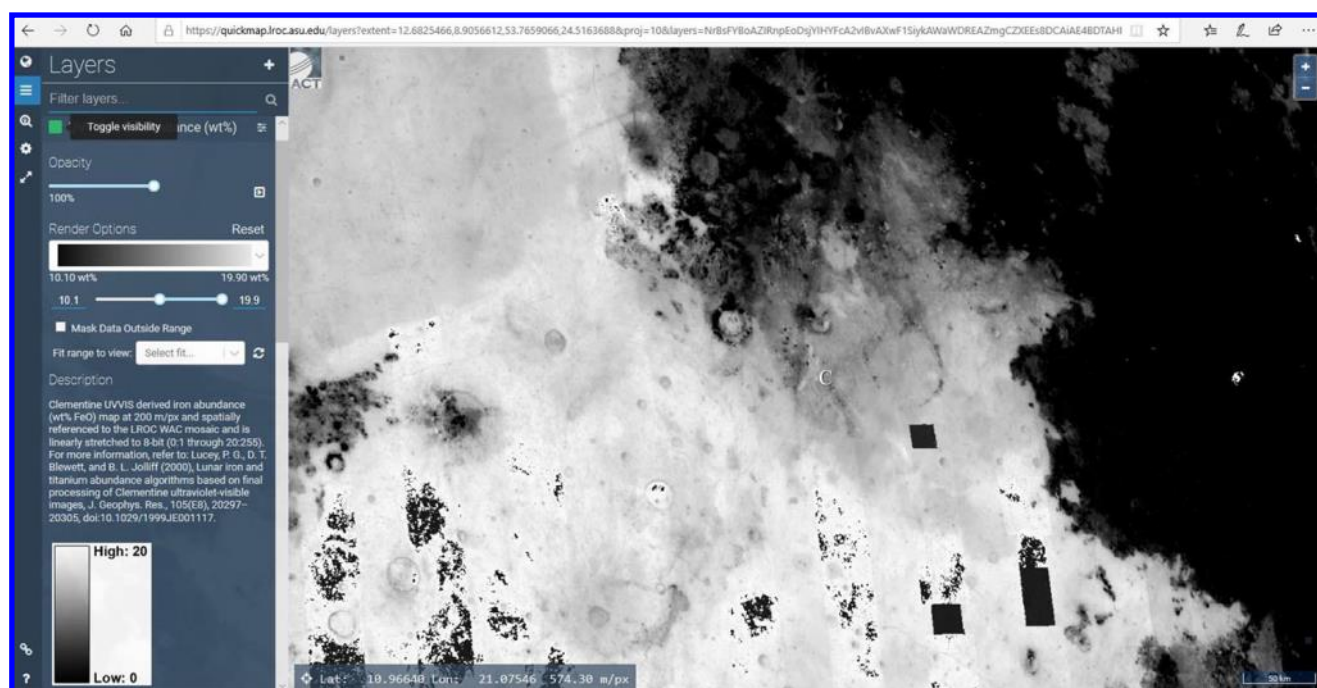
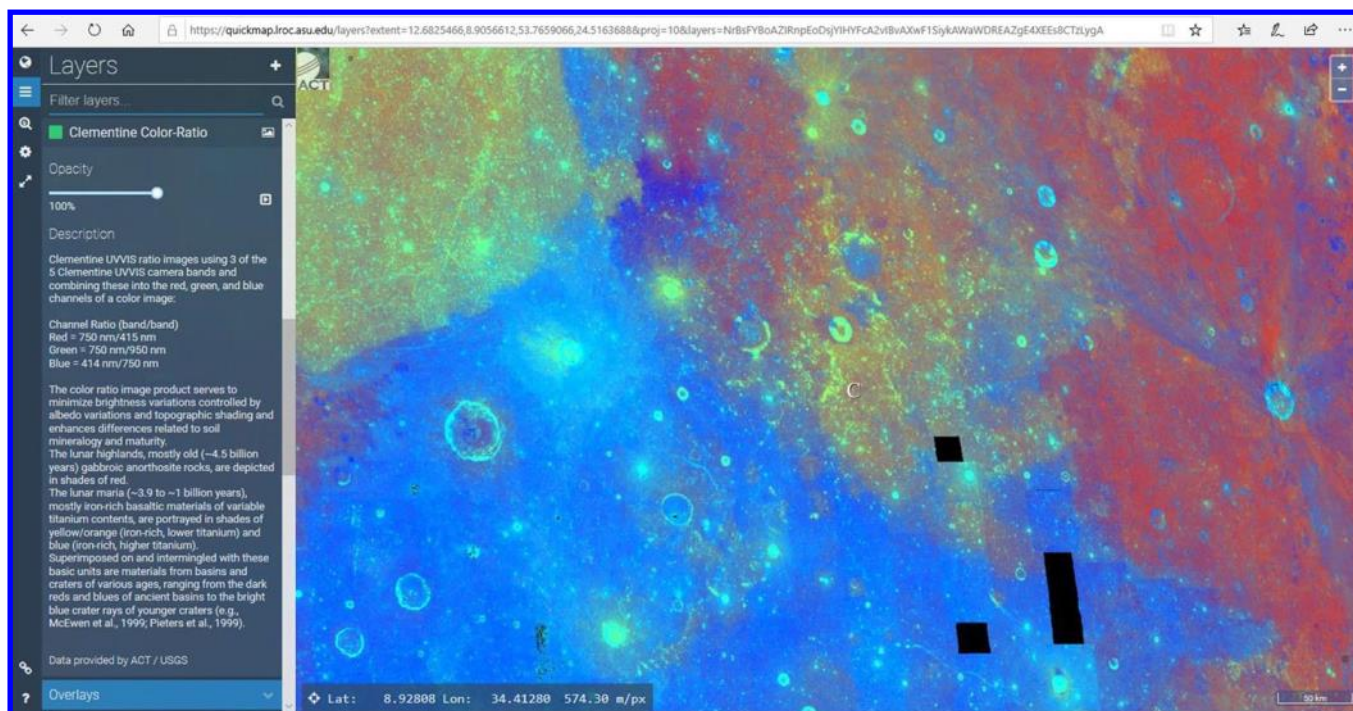


Figure 7



**Figure 8**



**Torricelli B**, Walter Ricardo Elias, AEA - Oro Verde, Entre Rios, Argentina. 30 January 2020 2324 UT. Helios 114 mm x 900 mm telescope. Phillips SPC 900 camera.

# The Gardner Megadome and the Lunar Volcanic Shields

(originally published in BAA LS circular)

Raffaello Lena

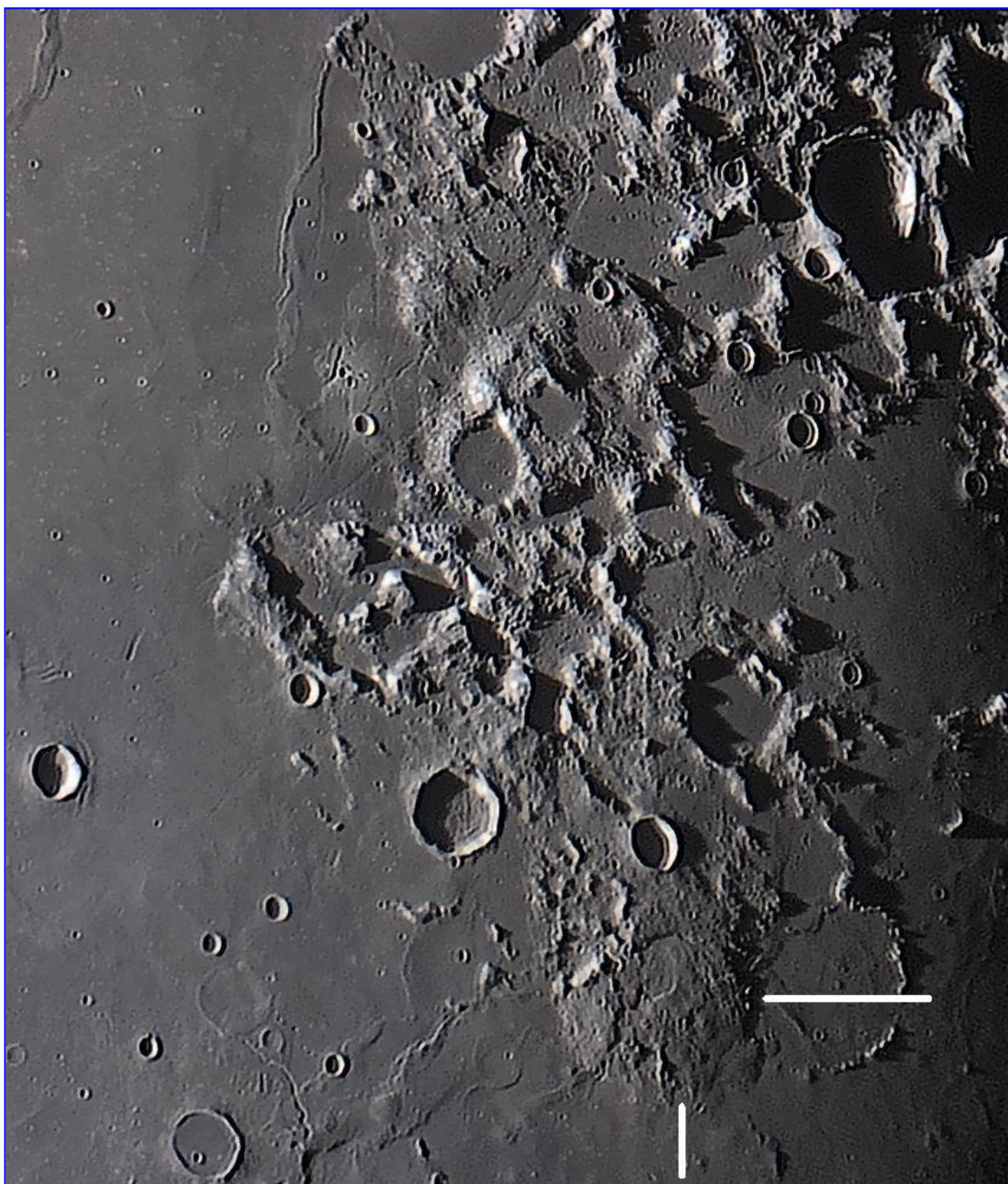
Recently, new global topographic data from the LOLA and LROC instruments on LRO reveal that almost all of the volcanic complexes on the Moon occur on large, regional topographic rises in the lunar *maria*, tens to hundreds of kilometers in extent and between several hundred to several thousand meters high [1]. Spudis et al., correlate large topographic prominences in the lunar *maria* with concentrations of small volcanic features such as domes, pit craters, cones and rilles, interpreting these large, broad topographic features, as shield volcanoes, a previously unrecognized style of lunar volcanic activity [1]. The distribution of these proposed lunar shield volcanoes comprises Marius hills, Prinz, Hortensius, Rümker, Aristarchus, Kepler and Cauchy. The largest of the newly detected volcanic shields is in eastern Mare Tranquillitatis, centered near the crater Cauchy and termed Cauchy shield by Spudis et al. [1]. In this issue I will describe the Gardner mega dome identified by my friend Chuck Wood [2], which occurs on the northern margin of the Cauchy shield. Fig. 1 displays an image of the examined structure. This image was made by Francesco Badalotti on September 24, 2013 at 01:07 UT using a 255mm F20 Maksutov Rumak telescope. Based in part on its alignment with the volcanic area near the crater Jansen, Wood [2] proposed that Gardner is the northern terminus of an elongate quasi-linear volcano-tectonic structure while Spudis et al. [1] suggested that Gardner is a possible parasitic shield of Cauchy located on its periphery. The height of the mega dome (Gardner MD) amounts to  $1000\text{m} \pm 100\text{m}$  and its diameter is of about 70km (E- W). ACT-REACT Quick Map tool was used to access to the GLD100 dataset [3], allowing to obtain the cross-sectional profiles. The corresponding profiles are shown in Fig. 2. The average slope angle  $\xi$  corresponds to  $1.6^\circ$ .

The 3D reconstruction obtained with GLD 100 datasets is shown in Fig. 3.

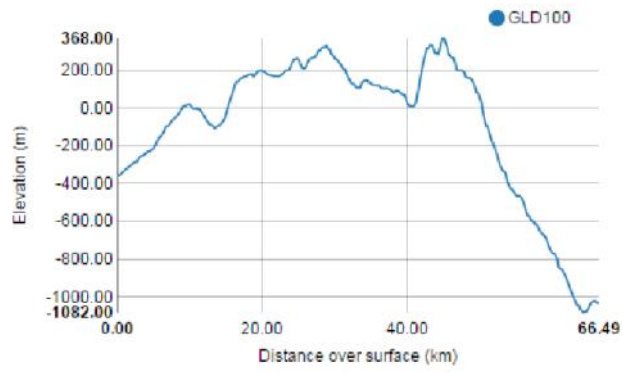
The redness of the examined structure is detectable in the Clementine color ratio imagery shown in Fig. 4. The low  $R_{415}/R_{750}$  ratio of 0.58 suggests a very low  $\text{TiO}_2$  content below 1wt% [4].

Wood proposed the presence of a caldera (the depressed zone at the centre of the examined structure) which was the source of lava flows that covered the eastern portion of the mega dome [2]. With this interpretation, “the break in the southern rim of the caldera appears to be a major drainage area, which carved a channel as lava flowed downhill to the mare”.

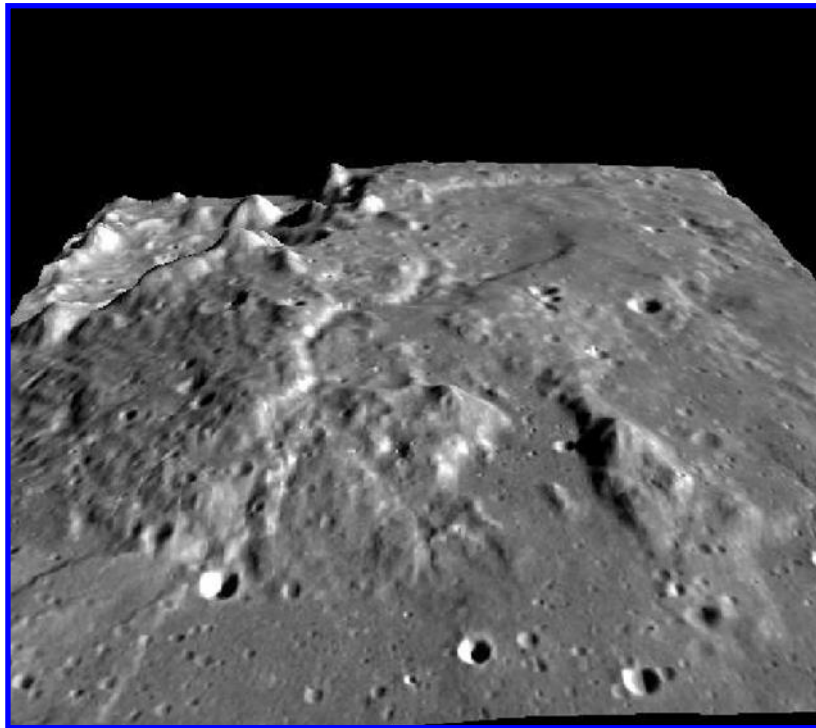
In this scenario, and based on the derived morphometric properties, the Gardner mega dome, for its large diameter and volume ( $1400\text{km}^3$ ) corresponds to a *volcanic shield*, a previously unrecognized style of lunar volcanic activity.



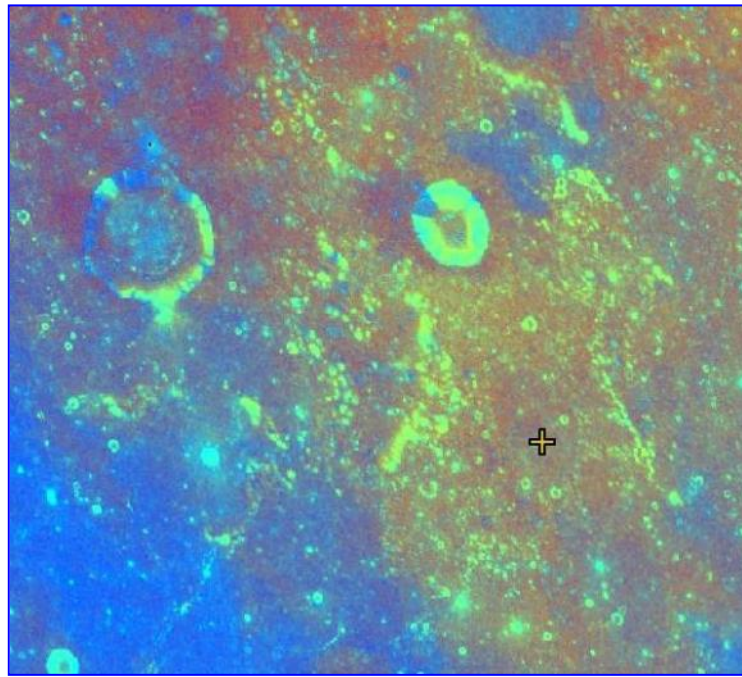
**Figure 1.** Image made by Francesco Badalotti. Marked with white lines the Gardner mega dome (Gardner MD).



**Figure 2:** GLD100 dataset cross sectional profiles of the Gardner mega dome (Gardner MD).

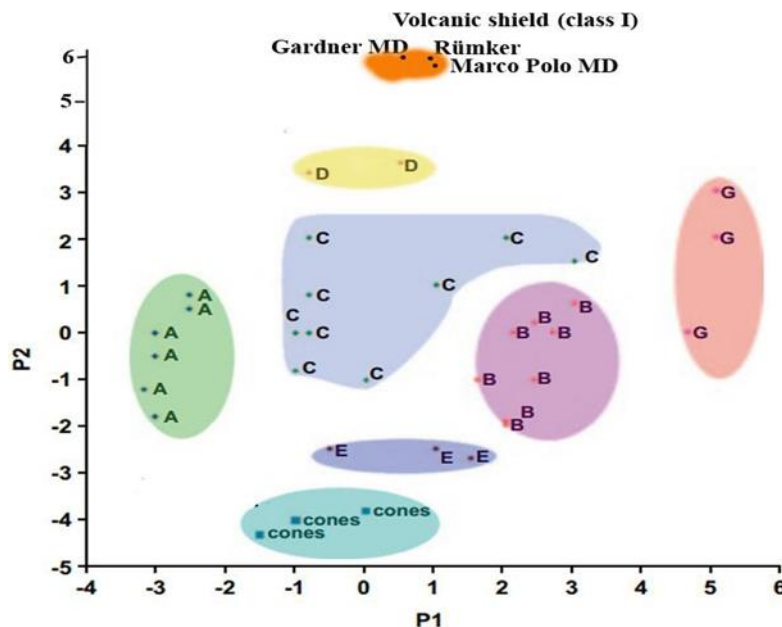


**Figure 3:** The 3D reconstruction obtained using WAC mosaic draped on top of the global WAC-derived elevation model GLD100. The depth of the caldera amounts to 200m.



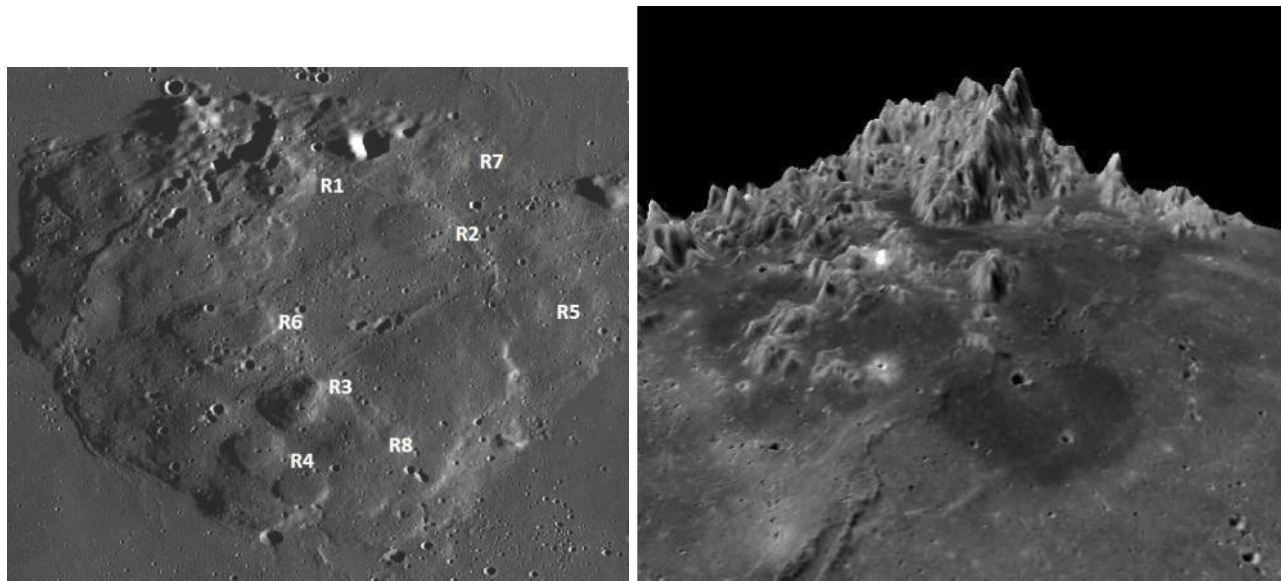
**Figure 4:** Clementine color ratio image of the Gardner mega dome, appearing as a reddish unit.

I have found that also the Marco Polo mega dome (Marco Polo MD), discovered with my friend Barry Fitzgerald, can be considered as another possible lunar volcanic shield, as introduced by Spudis et al. [1]. The Marco Polo mega dome was described in our previous studies [5-6] and is shown in Fig. 6.



**Figure 5.** Classification scheme of effusive lunar mare domes and lunar cones based on a Principal Component Analysis (PCA). Scores P1 and P2 of the features vectors describing the domes on the first two principal components of the data distributions. The dome classes A–E and G (highland domes including Gruithuisen domes) and the lunar cones are indicated. Note that the examined volcanic shields (Gardner MD, Mons Rümker and Marco Polo MD) have their specific class (here termed as new class I).

Another typical exemplar of these features is the volcanic complex Mons Rümker, which is situated in the north-western part of Oceanus Procellarum [7]. With a diameter of about 65km, it is the largest contiguous volcanic edifice on the Moon (Fig. 6). The derived digital elevation model (DEM) of the volcanic complex Mons Rümker shows that the height of the plateau amounts to about 900m in its western and north-western part, 1100m in its southern part, and 650m in its eastern and north-eastern part (yielding an average slope of  $1.7^\circ$ ).



**Figure 6.** Rümker domes and Marco Polo MD (LRO WAC imagey).

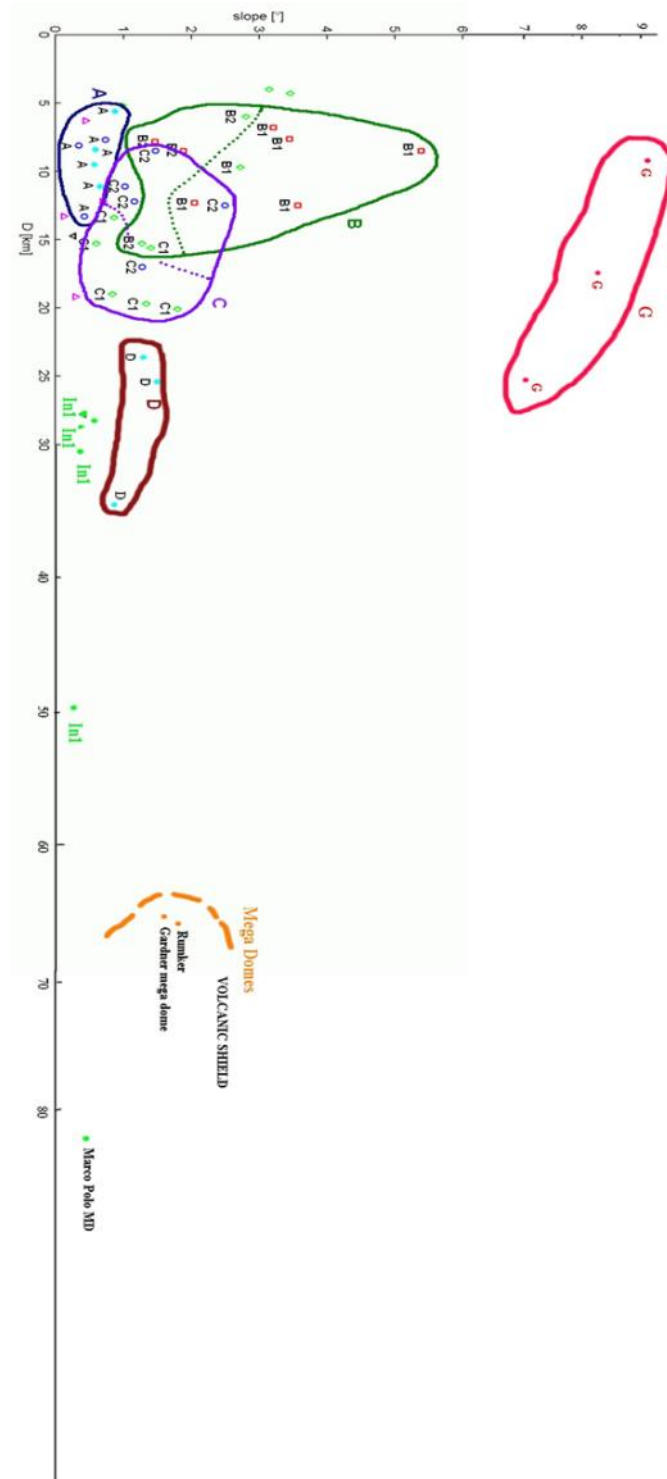
I have found that the examined volcanic shields (Gardner MD, Mons Rümker and Marco Polo MD) form a separate spectral and morphometric group in the lunar domes classification scheme [8], which is shown on a Principal Component Analysis (PCA): thus, I extend the classification scheme and assign the recognized large *volcanic shields* to a new class I (Fig. 5).

For comparison, in the diameter vs. flank slope diagram shown in Fig. 7, the domes are labelled according to their respective classes. Also in this case the volcanic shields display different properties if compared with the classical effusive domes, the non monogenetic domes of class D, the highland domes (class G) and the large putative intrusive domes of class In1 [8].

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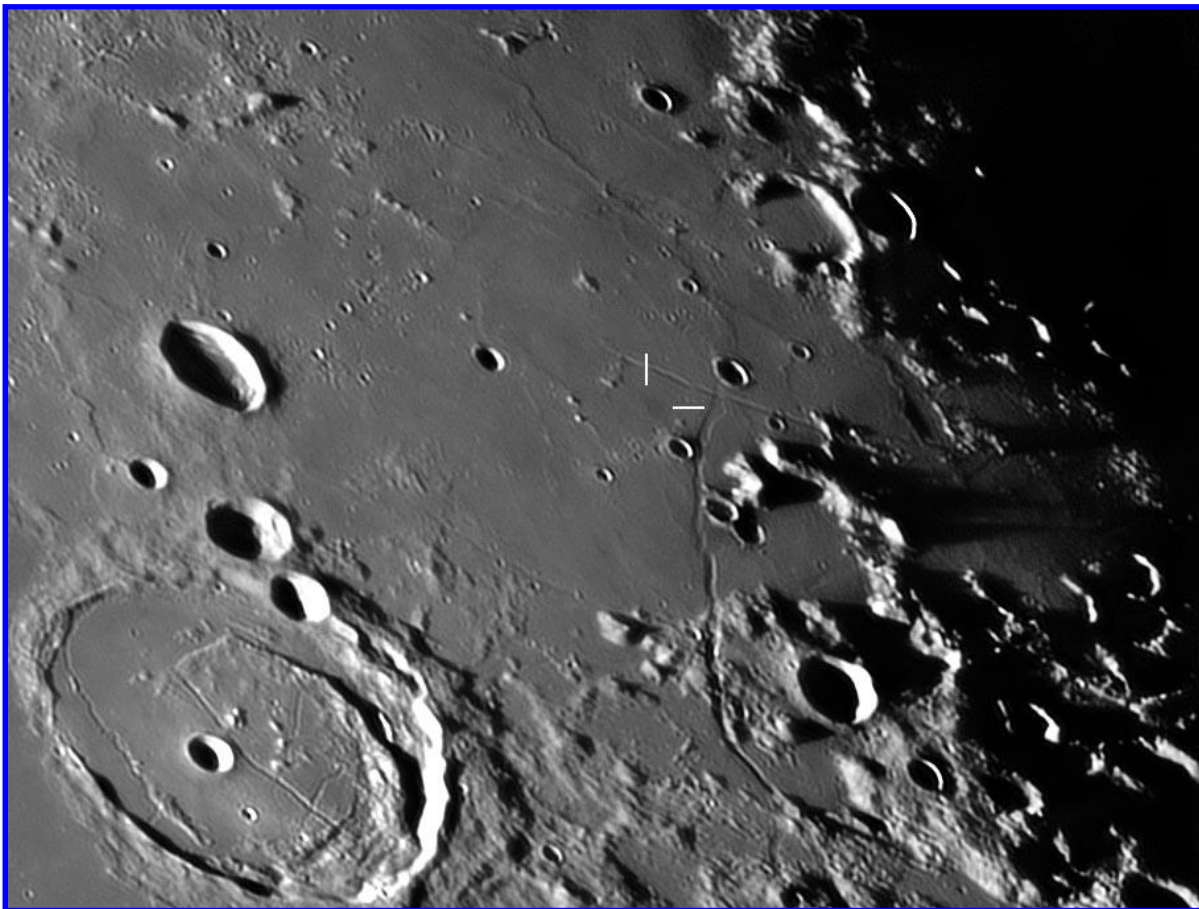
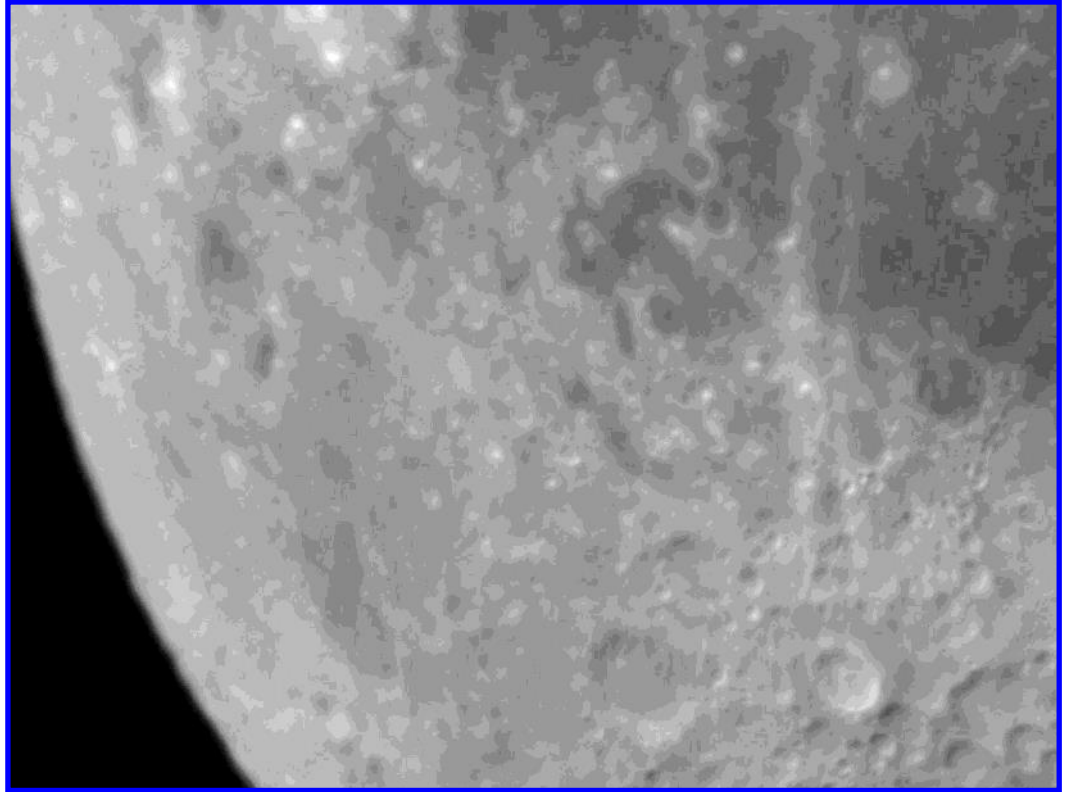
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**Figure 7.** Diameter vs. flank slope diagram described in the text.

## Recent Topographic Studies

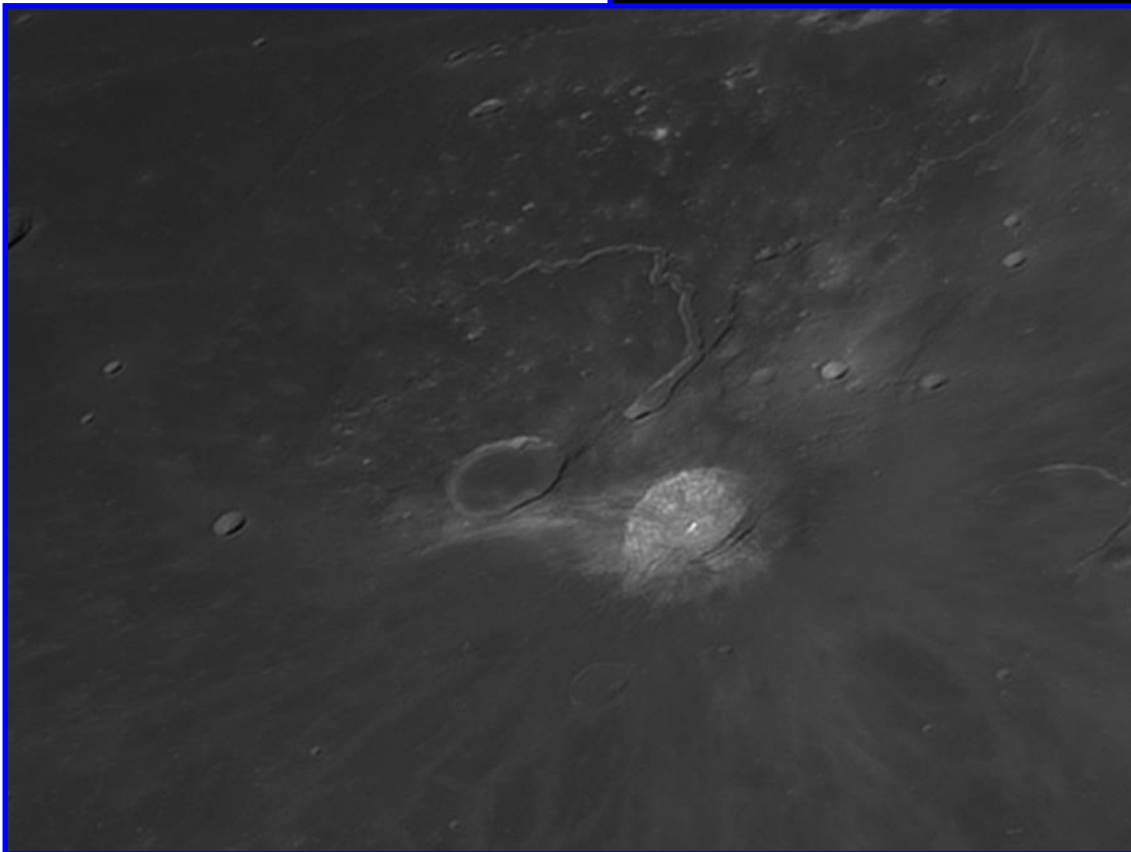
***Tycho,** Alberto Anunziato,  
Paraná, Argentina . 17 No-  
vember 2019 0618 UT.  
Meade ETX 105 telescope,  
QYH5-LII-M camera.*



***Hall 1 Dome,** Howard  
Eskildsen, Oca-  
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USA. 14 Janu-  
ary 2020 1122  
UT, colongit-  
tude 139.0°.  
C9.25 Schmidt-  
Cassegrain tel-  
lescope, f/10, fl  
2395 mm, 2 x  
barlow, W-25  
red filter, DMK  
41AU02.AS  
camera. Seeing  
7/10, transpar-  
ency 2/6.*

## Recent Topographic Studies

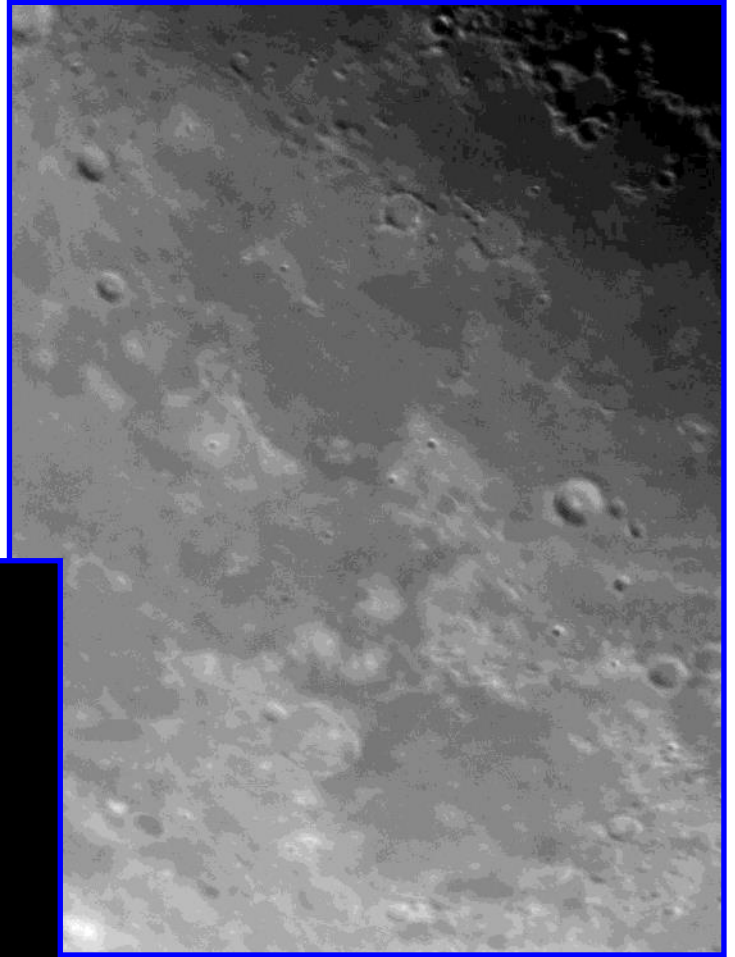
***First Quarter Moon**, Leonard Alberto Colombo,  
Cosquin, Argentina. 12 April 2019 2008 UT. 67  
mm telescope, Samsung SCB 2000 camera.*



***Herodotus**, Francisco Alsina Cardinalli,  
Oro Verde, Argentina. 19 June 2019  
0540 UT. 250 mm  
Meade LX 200  
Schmidt Cassegrain  
telescope, As-  
tronomik ProPlanet  
742 IR-pass filter,  
QHY5-II camera.*

## Recent Topographic Studies

**Gassendi**, Juan Manuel Biagi, Paraná, Argentina. 18 January 2020 0622 UT. Meade ETX 105 telescope, QHY5-LII-M camera.



**5-Day Old Moon**, Maurice Collins, Palmerston North, New Zealand. 30 January 2020, 0839 UT. FLT 110 telescope, ZWO ASI 120 mm camera.

## Recent Topographic Studies

**Aristarchus,**  
Walter Ricardo Elias, AEA - Oro Verde, Entre Rios, Argentina. 07 February 2020 0044 UT. 10 inch Meade LX200 telescope, 2.5 x barlow. ZWO ASI N120 MM/S camera.



**Carlini D,** Aylen Borgatello, AEA - Oro Verde, Entre Rios, Argentina. 04 February 2020 0030 UT. 10 inch Meade LX200 telescope. ZWO ASI 120 MM/S camera.

## Recent Topographic Studies

*Waning Gibbous Moon, Jairo Chavez  
Popayán, Colombia. 10 February 2020  
0124 UT. 114 mm refractor telescope,  
MOTO ES PLAY.*

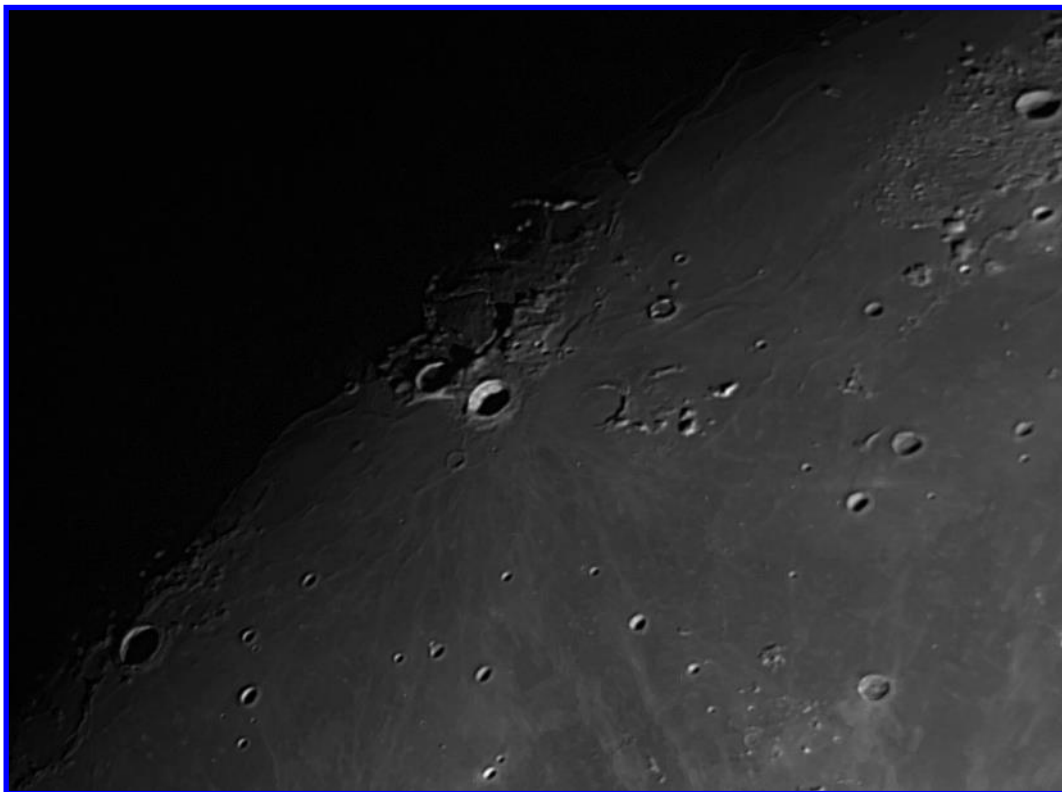
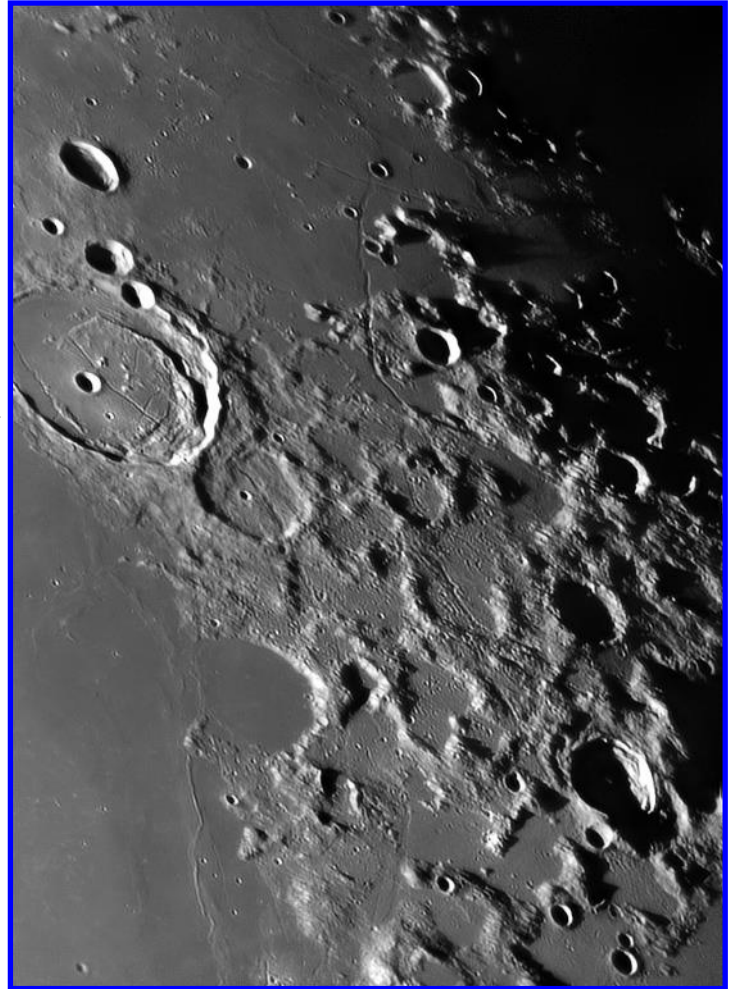


*Atlas and Hercules, Maurice Collins,  
Palmerston North, New Zealand. 30  
January 2020, 0858 UT.  
FLT 110 telescope, f/14,  
ZWO ASI 120 mm camera.*

## Recent Topographic Studies

**Rima G. Bond**, Howard Eskildsen, Ocala, Florida, USA. 14 January 2020 1121 UT, colongitude 139.0°. C9.25 Schmidt-Cassegrain telescope, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 7/10, transparency 2/6.

Rima G Bond is visible on the upper central image and its upper end crosses an unnamed rille near the top of the image. The Rimae Romer cross the lower right image. Its namesake crater, Romer, with its central peak just visible in the interior shadow, appears at the lower right image margin. Other rilles are visible on the floor of Posidonius on the upper left, as well as down the left central image.



**Herodotus**, Francisco Alsina Cardinalli, Oro Verde, Argentina. 12 November 2016 0317 UT. 250 mm Meade LX 200 Schmidt Cassegrain telescope, Astronomik Pro-Planet 742 IR-pass filter, QHY5-II camera.

## Recent Topographic Studies

*Waxing Gibbous Moon,  
Leonard Alberto Colombo,  
Cosquin, Argentina.  
09 January 2020 0237  
UT. 67 mm telescope,  
Samsung SCB 2000  
camera.*



*Aristarchus, Jaime Izquierdo,  
Astronomical Association of Ma-  
drid, Spain, Lunar Observing  
Section. 05 February 2020,  
1920 UT. Takahashi 130 mm  
refractor, focal reducer, QHY5-  
II camera, Registax 6, Pho-  
toshop.*

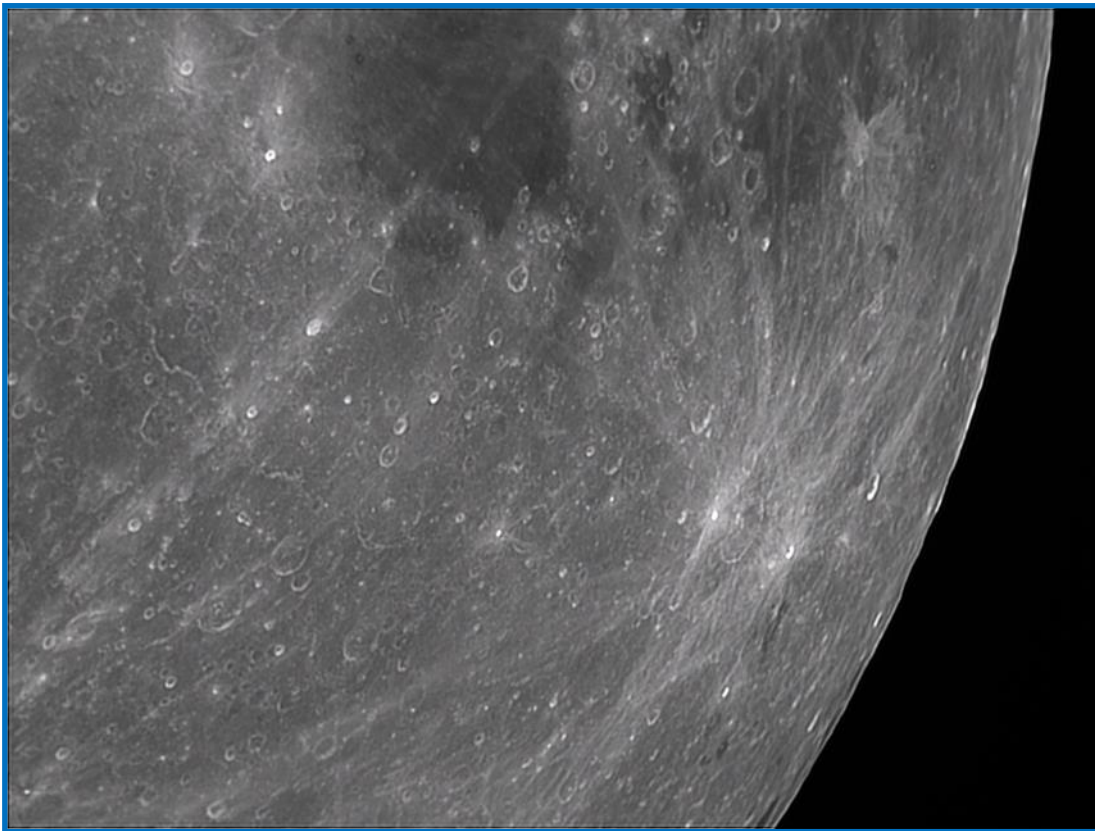
*Jaime Izquierdo Madrid M30*

## Recent Topographic Studies

**Copernicus**, Gabriel Re,  
AEA - Oro Verde, Entre  
Rios, Argentina . 04  
February 2020 0027  
UT. 10 inch Meade  
LX200 telescope, ZWO  
ASI 120 MM/S camera.



**Stevinus**, Walter Ri-  
cardo Elias, AEA -  
Oro Verde, Entre  
Rios, Argentina. 07  
February 2020 0154  
UT. 10 inch Meade  
LX200 telescope,  
ZWO ASI N120 MM/S  
camera.



## Recent Topographic Studies

***Mare Nectaris**, Maurice Collins, Palmerston North, New Zealand. 30 January 2020, 0900 UT. FLT 110 telescope, f/14, ZWO ASI 120 mm camera.*

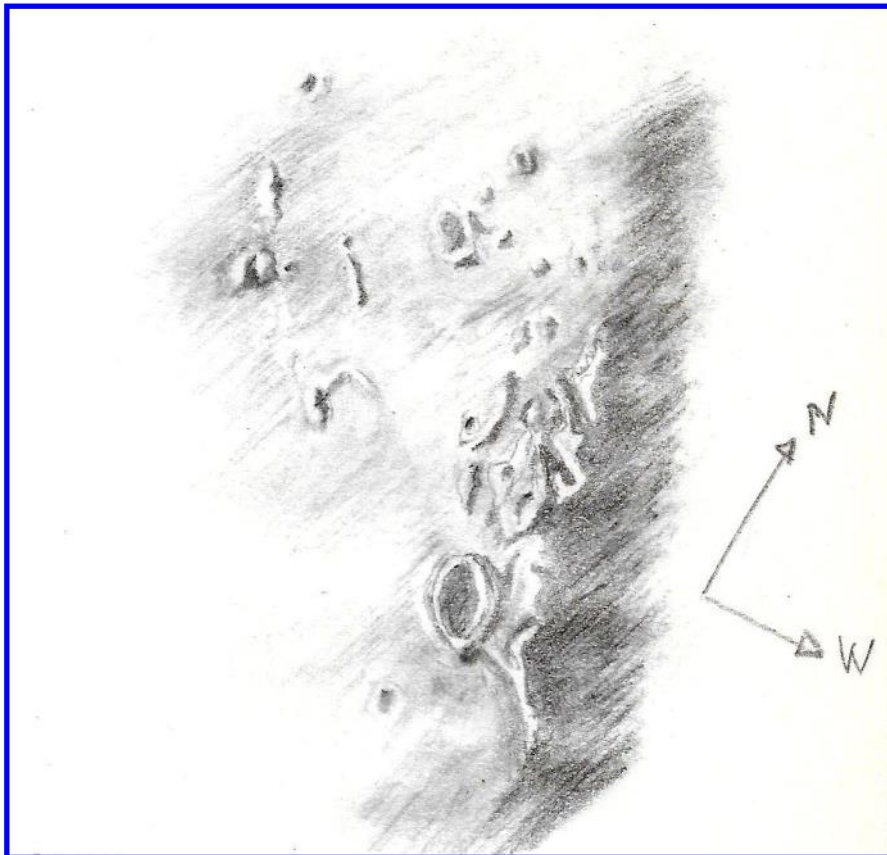


***12-Day Old Moon**, Jaime Izquierdo, Astronomical Association of Madrid, Spain, Lunar Observing Section. 05 February 2020, 1957 UT. Takahashi 130 mm refractor, focal reducer, Pentax K1 camera.*



## Recent Topographic Studies

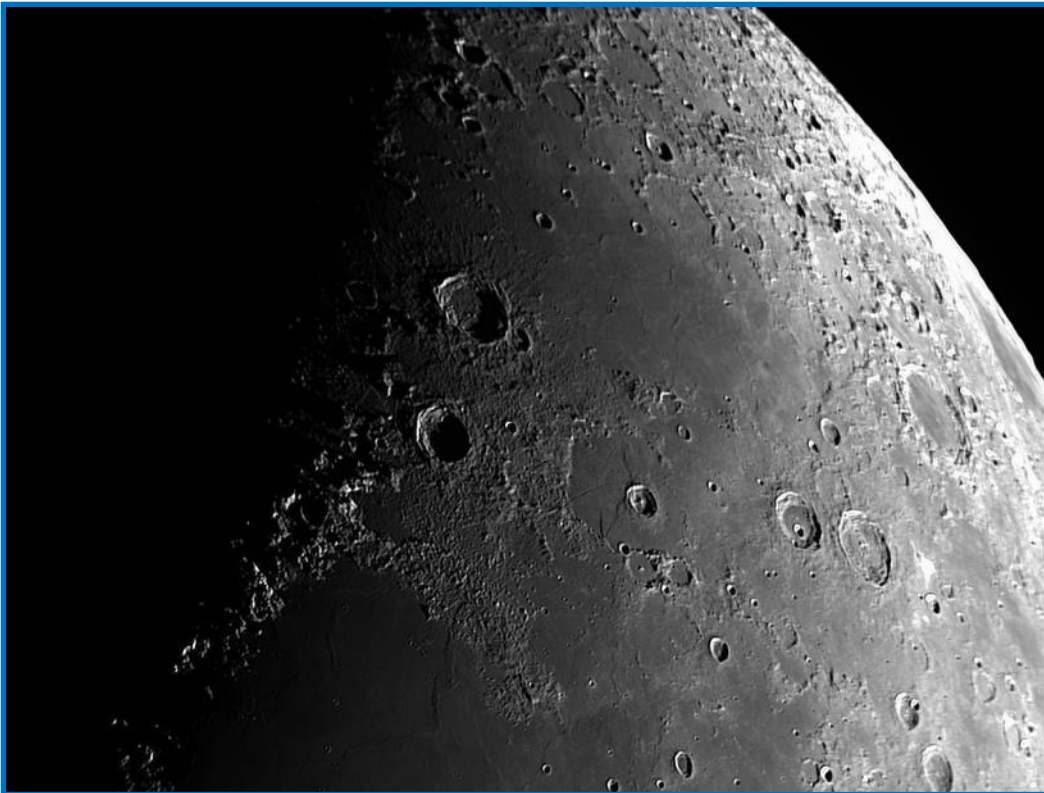
*Montes Apenninus, Alberto Anunziato, Paraná, Argentina . 17 November 2019 0711 UT. Meade ETX 105 telescope, QYH5-LII-M camera.*



*Aristarchus, Raquel R. Mediavilla , the Astronomical Association of Madrid, Spain, Lunar Observing Section. 05 February 2020 1935 UT. 127 mm Maksutov-Cassegrain telescope.*

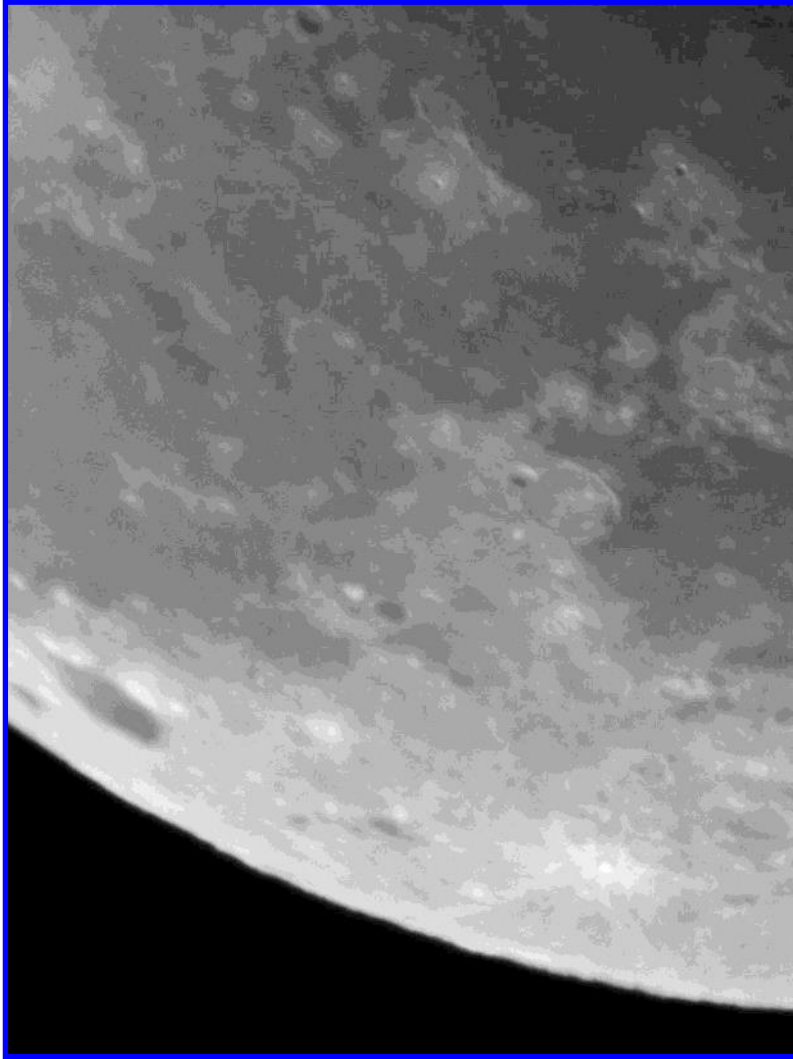
## Recent Topographic Studies

**Mare Imbrium,**  
Victoria Gomez,  
AEA - Oro  
Verde, Entre  
Rios, Argentina.  
04 February  
2020 0034 UT.  
10 inch Meade  
LX 200 tele-  
scope, ZWO ASI  
120 MM/S cam-  
era.



**Mont Blanc,** Walter Ri-  
cardo Elias, AEA - Oro  
Verde, Entre Rios, Argen-  
tina. 31 January 2020  
2329 UT. 10 inch Meade  
LX200 telescope, ZWO  
ASI N120 MM/S camera.

## Recent Topographic Studies



*Byrgius, Juan Manuel Biagi, Paraná, Argentina.  
18 January 2020 0625 UT. Meade ETX 105 tele-  
scope, QHY5-LII-M camera.*

*Tycho Francisco Alsina  
Cardinalli, Oro Verde, Ar-  
gentina. 20 December 2015  
0045 UT. 250 mm Meade  
LX 200 Schmidt Cassegrain  
telescope, Canon EOS Digi-  
tal Rebel XS camera.*

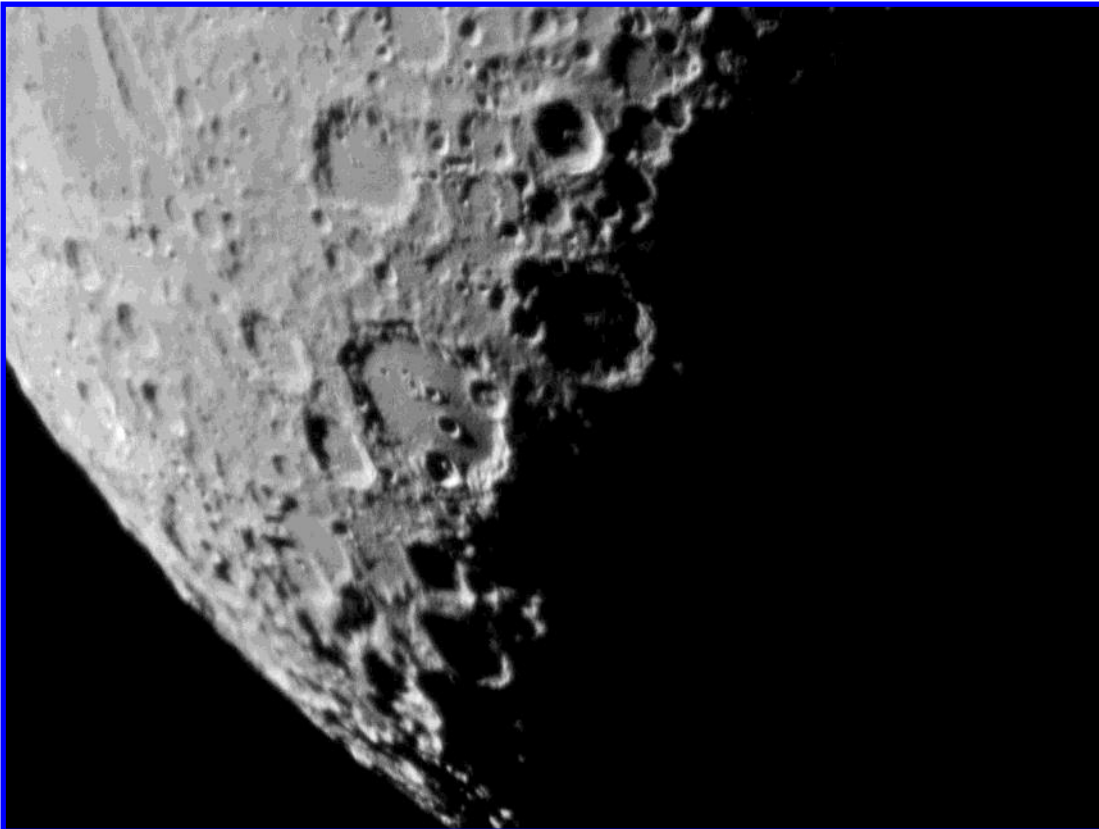


## Recent Topographic Studies

*Waning Gibbous Moon, Sergio Babino, Montevideo, Uruguay. 26 May 2018, 2212 UT. Schmidt Cassegrain 250 mm, ZWO 174 mm camera.*



*Longomontanus, Alberto Anunziato, Paraná, Argentina . 18 January 2020 0631 UT. Meade ETX 105 telescope, QYH5-LII-M camera.*

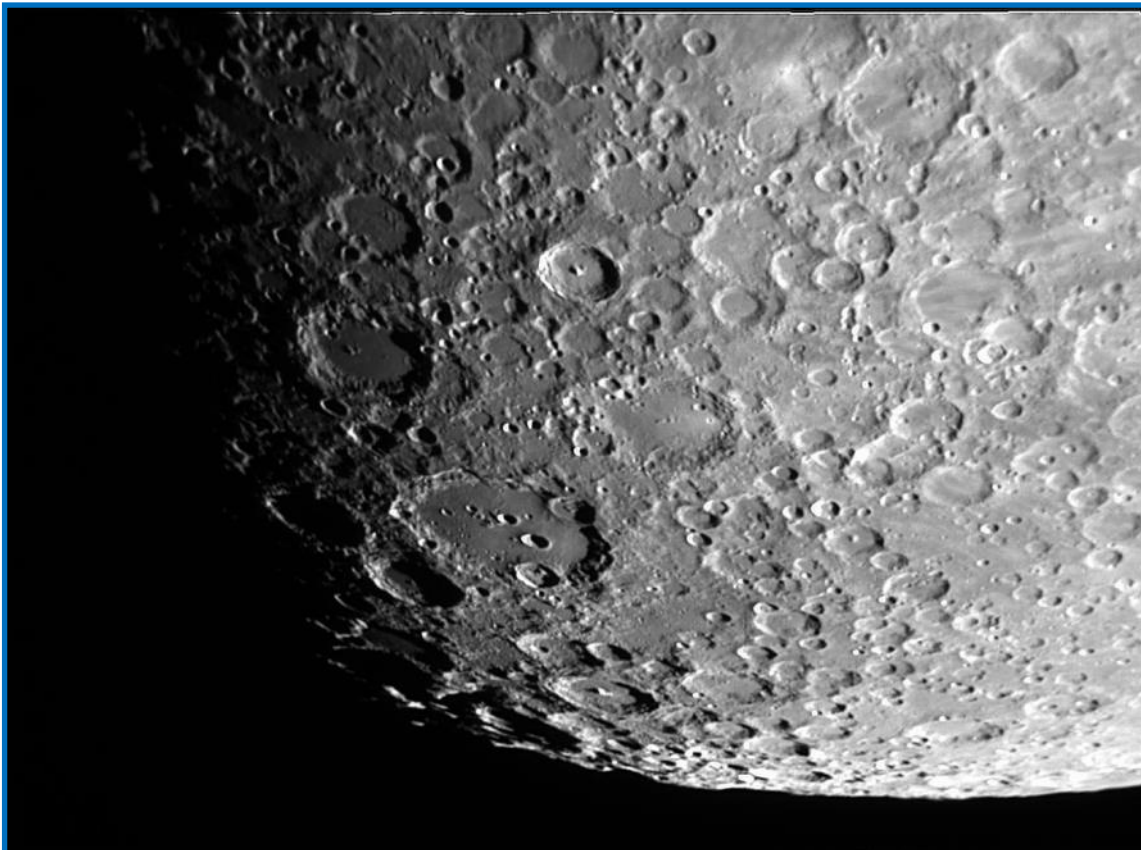


## Recent Topographic Studies

**Mons Pico**, Aylén Bor-  
gatello, AEA - Oro  
Verde, Entre Ríos, Ar-  
gentina. 07 February  
2020 0012 UT. 10 inch  
Meade LX200 tele-  
scope. ZWO ASI 120  
MM/S camera.



**Tycho** Walter  
Ricardo Elias,  
AEA - Oro Verde,  
Entre Ríos, Ar-  
gentina. 04 Feb-  
ruary 2020 0024  
UT. 10 inch  
Meade LX200  
telescope, UH-  
CLPR filter, .  
ZWO ASI N120  
MM/S camera.



## Recent Topographic Studies

***Posidonius***, Maurice Collins, Palmerston North, New Zealand. 30 January 2020, 0856 UT. FLT 110 telescope,  $f/14$ , ZWO ASI 120 mm camera.

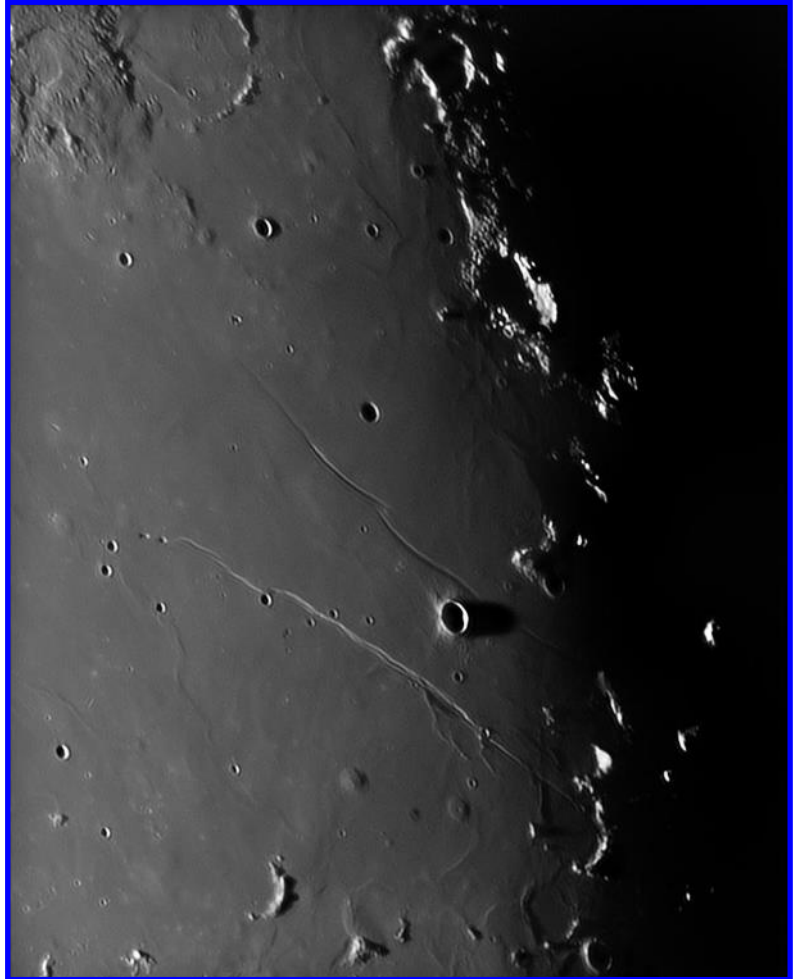


***Aristarchus***, Carlos de Luis, Astronomical Association of Madrid, Spain, Lunar Observing Section. 05 February 2030 UT. 102 mm ED Explore Scientific refractor telescope, 2 x barlow, QHY5-III camera.

## Recent Topographic Studies

**Cauchy Domes**, Howard Eskildsen, Ocala, Florida, USA. 14 January 2020 1117 UT, colongitude 139.0°. C9.25 Schmidt-Cassegrain telescope, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 7/10, transparency 2/6.

Thirteen km Crater Cauchy lies between its namesake rille to the north and its namesake fault to the south. Several domes are visible to the south of the fault, and also beyond its upper left end. More domes are visible on the upper image, while the Gardner megadome is partially visible to the upper left of the image. The pattern of ejecta Cauchy seems to suggest it was caused by an oblique impact from the west.



**Schiller**, Juan Manuel Biagi, Paraná, Argentina. 18 January 2020 0631 UT. Meade ETX 105 telescope, QHY5-LII-M camera.

## Recent Topographic Studies



**Milichius and Hortensius Domes**, Howard Eskildsen, Ocala, Florida, USA. 05 January 2020 2317 UT, colongitude 35.9°. C9.25 Schmidt-Cassegrain telescope, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 7/10, transparency 5/6.

## Recent Topographic Studies

**Tycho,** Victoria Gomez,  
AEA - Oro Verde, Entre  
Rios, Argentina. 07 February 2020 0026  
UT. 10 inch  
Meade LX 200  
telescope,  
ZWO ASI 120  
MM/S camera.

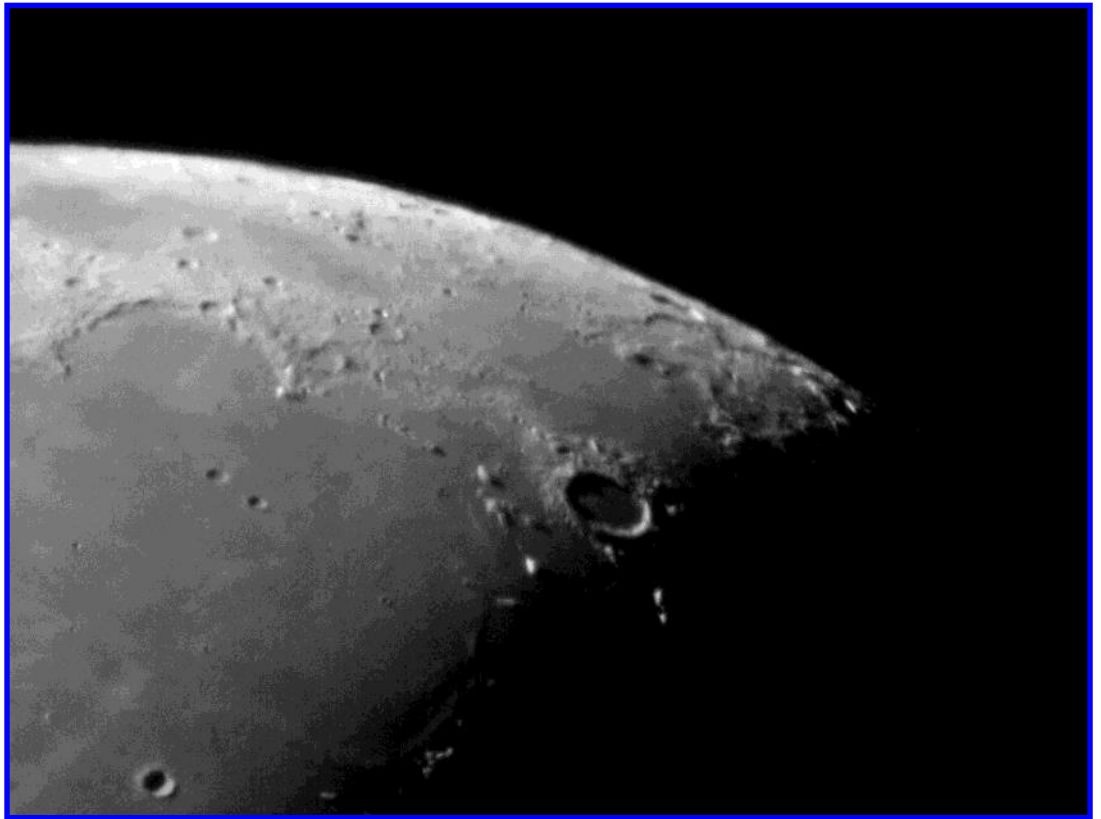


**Gassendi,** Walter  
Ricardo Elias,  
AEA - Oro Verde,  
Entre Rios, Argentina. 04 February  
2020 0011 UT. 10  
inch Meade LX200  
telescope, ZWO  
ASI N120 MM/S  
camera.



## Recent Topographic Studies

***Sinus Iridum,** Alberto Anunziato, Paraná, Argentina . 18 January 2020 0622 UT. Meade ETX 105 telescope, QYH5-LII-M camera.*



***Proclus,** Maurice Collins, Palmerston North, New Zealand. 30 January 2020, 0859 UT. FLT 110 telescope, f/14, ZWO ASI 120 mm camera.*



## Recent Topographic Studies

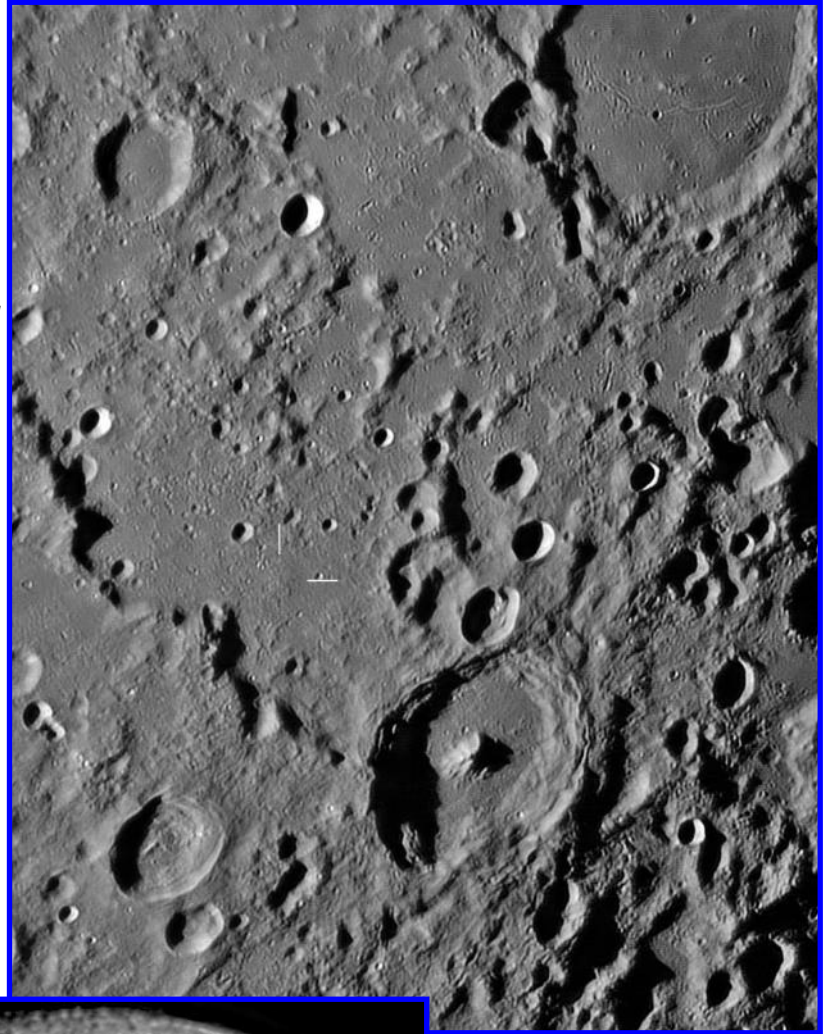
**Tycho**, Francisco Alsina Cardinalli, Oro Verde, Argentina. 21 August 2016 0457 UT. 250 mm Meade LX 200 Schmidt Cassegrain telescope, Astronomik Pro-Planet 742 IR-pass filter, QHY5-II camera.



**Proclus**, Walter Ricardo Elias, AEA - Oro Verde, Entre Rios, Argentina. 30 January 2020 2324 UT. Helios 114 mm x 900 mm telescope. Phillips SPC 900 camera.

## Recent Topographic Studies

**Piccolomini Dome**, Howard Eskildsen, Ocala, Florida, USA. 14 January 2020 1114 UT, colongitude 138.9°. C9.25 Schmidt-Cassegrain telescope, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 7/10, transparency 2/6.



**Mare Imbrium**, Leonard Alberto Colombo, Cosquin, Argentina. 12 December 2019 0159 UT. 67 mm telescope, Samsung SCB 2000 camera.

## Recent Topographic Studies

**Promontorium Laplace,**  
Gabriel Re, AEA - Oro Verde, Entre Rios, Argentina . 07 February 2020  
0121 UT. 10 inch Meade LX200 telescope, ZWO ASI 120 MM/S camera.



**Waxing Crescent Moon,** Walter Ricardo Elias, AEA - Oro Verde, Entre Rios, Argentina. 31 January 2020 2304 UT. Helios 114 mm x 900 mm telescope. Phillips SPC 900 camera.

# Lunar Geologic Change Detection Program

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Assistant Coordinator David O. Darling - [DOD121252@aol.com](mailto:DOD121252@aol.com)

## 2020 March

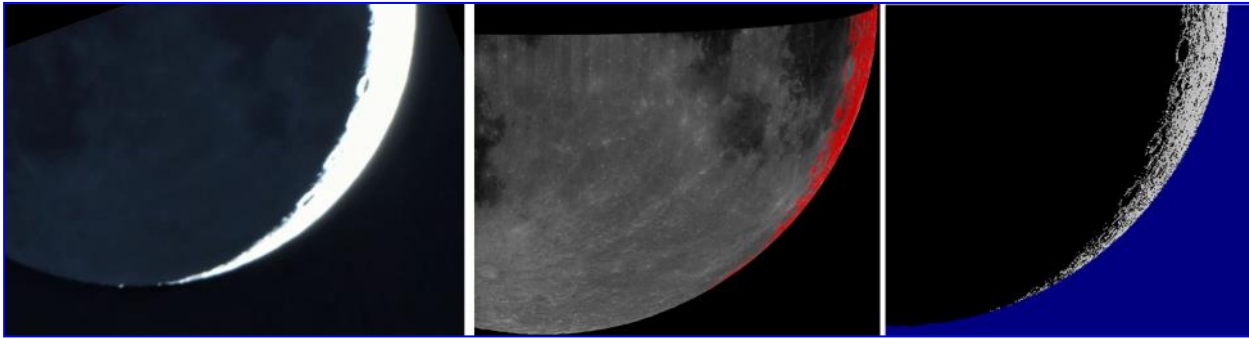
Reports have been received from the following observers for Jan: Jay Albert (Lake Worth, FL, USA - ALPO) observed: Aristarchus, Gassendi, Herodotus, Mare Frigoris, Plato, Proclus and Torricelli B. Alberto Anunziato (Argentina, SLA) sketched Macrobius. Maurice Collins (New Zealand - ALPO/BAA/RASNZ) imaged: Atlas, Mare Nectaris, Posidonius, Proclus, and captured some whole Moon images. Anthony Cook (Newtown, UK, ALPO/BAA) imaged the lunar eclipse with a compact camera telephoto and videoed the Moon at low resolution with a thermal imaging camera. Walter Elias (Argentina, AEA) imaged Aristarchus, Atlas, Gassendi, Romer, Ross, Schmidt and Tycho. Johana Gonzalez (Argentina, AEA) imaged: Aristarchus, Censorinus, Mare Crisium, Mare Tranquillitatis, and Plato. Walter Latrónico (Argentina, AEA) imaged Proclus. Lafra Smit (South Africa) imaged earthshine. Trevor Smith (Codnor, UK, BAA) observed Aristarchus, Gassendi, Hyginus, Plato and Proclus. Aldo Tonon (Italy – UAI) imaged Mutus F and Maurolycus. Alan Trumper (Argentina, AEA) imaged Alphonsus, <sup>oo</sup>Ivan Walton (Amado, AZ, USA, BAA) imaged several features.

**News:** Readers may be interested in the following Lunar and Planetary Science Conference LTP related [abstract](#), for a [conference](#) at League City in Texas on 16-20<sup>th</sup> March - it discusses potential science that a proposed DORN payload could do on upcoming lunar lander missions. I would like to thank Prof Christopher Cokinos for pointing this out to me.

Dietmar Büttner (BAA) has been in contact with me over a 2019 Nov 5 UT 18:29-21:15 observation Tycho of his which matched the repeat illumination window on the Lunar Schedule web site, for searching for the scattered light illumination of the central peak of Tycho. On this occasion, it seems that he was unable to detect any detail inside the crater using a 10 cm refractor. This was at a selenographic colongitude range of: 11.5° to 12.9°. Please take every opportunity to search for the central peak around sunrise/set time as its visibility under presumed internal scattered light off the illuminated rim is difficult to predict.

**LTP reports:** I do not know whether to regard this as a proper LTP or not, but on 2020 Jan 06 UT 22:10 Trevor Smith (BAA) noted, whilst observing Proclus, that Censorinus seemed to have a slight reddish tinge, whereas other nearby craters did not. He was using a 16-inch Newtonian reflector and 9.5mm Plossl at x247. However, I think for now I will put this down as a weight 1 report, just to see if we can get visual confirmation when the illumination reports. Normally Censorinus has a bluish cast, being a relatively young fresh crater.

On 2020 Jan 27 UT 17:58, BAA member Clyde Foster, reported that Lafra Smit (28.2E, 27.2S) had taken an image (Fig 1 – Left) of the earth lit Moon and that it showed a bright point beyond the sunlit south cusp.



**Figure 1** The southern illuminated part of the lunar crescent for 2020 Jan 27 UT 17:58. **(Left)** image by Lafra Smit (South Africa). **(Center)** A visualization produced by Anthony Cook, using ALVIS – red shows the illuminated limb. **(Right)** An LTVT visualization produced by Maurice Collins.

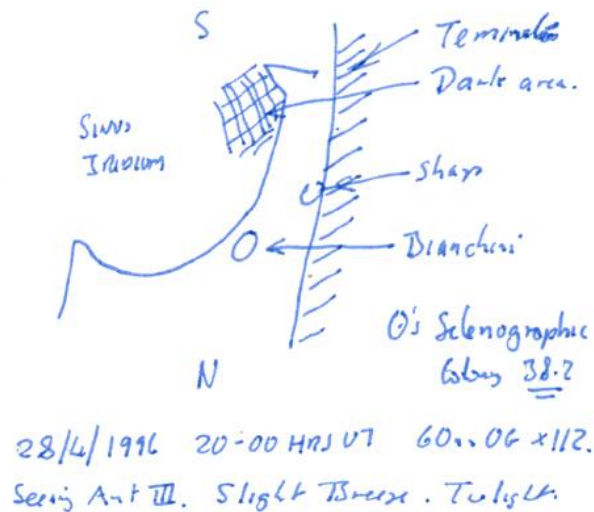
I checked for occultations, using the Occult program, but could not find anything suitably bright. Then I ran my ALVIS simulation software (Fig 1 - Center). Although this produced some small illuminated peaks roughly in the right place, these are not especially bright and do not show up well at all in Fig 1 (Center). Then I asked Maurice Collins to run LTVT and Fig 1 (Right) shows the result from this – again sunlit peaks, but not especially bright. Maurice did however remember that he had seen this offset peak before on previous occasions, so thinks its normal. The reason why the ALVIS and LTVT programs do not portray the polar areas well is maybe that neither of them is good at modelling simultaneously grazing incidence illumination and grazing incidence viewing angles – and do not take into account the width of the Sun's angular diameter well?

In the [November 2019](#) edition of ALPOs The Lunar Observer, p32 Alberto Anunziato, had a sketch showing a bright area on the West rim of Deluc H on 2019 Jun 10 UT 23:40-00:00. I have had a look through similar illumination images in the ALPO/BAA database and cannot find anything resembling this. I shall therefore add it to the [Lunar Schedule](#) web site, to encourage some repeat illumination observations to see if it repeats.

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

**Sinus Iridum:** On 2020 Jan 06 UT 04:06 Alan Trumper (AEA) imaged the NW part of the Moon and captured Sinus Iridum under similar illumination and topocentric libration (to within  $\pm 1.0^\circ$ ) to the following report:

*Sinus Iridum 1996 Apr 28 UT 20:00 Observed by Brook (Plymouth, UK, 60mm re-fractor, x112, seeing III, slight breeze, twilight) "dark shaded area on floor ~1/4 diameter of Sinus Iridum on western interior by rim" BAA Lunar Section Observation. ALPO/BAA weight=1.*



**Figure 2.** Sinus Iridum orientated with north towards the bottom. **(Left)** Color image taken by Alan Trumper (AEA) on 2020 Jan 06 UT 04:06. **(Right)** A sketch made by Clive Brook (BAA) on 1996 Apr 28 UT 20:00.

As you can see from Fig 2, the viewing angle in Alan's image is the same as for Clive Brook's LTP report, and illumination is not too dissimilar too. However, there is no sign of the shading on the SW floor that Clive Brook saw in Alan's image. However, Alan's image does show a light patch on the east side of the floor which is brighter than the mare to the south. I wonder if Clive was comparing the west side to the east side and not considering brightness relative to the mare? It doesn't quite explain the shape of Clive's dark patch, however as you can see comparing Fig 2 Right and Left, Clive's sketch has some cartographic issues as the terminator is further to the west than it is in Alan's image. For now, we shall leave the weight at 1. We have studied this region before in past newsletters: [2016 Oct](#) (p17), [2017 May](#) (p21-22) and [2018 Apr](#) (p22-23).

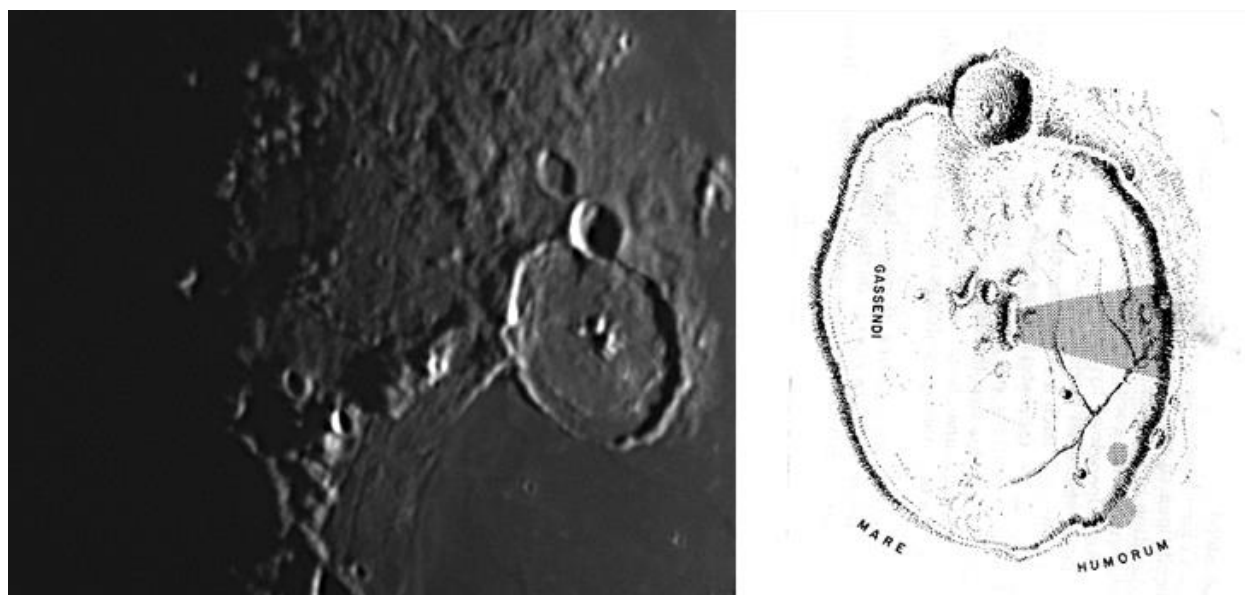
**Gassendi:** On 2020 Jan 06 UT 21:13 and 22:05, Trevor Smith (BAA) observed visually Gassendi under both similar illumination and topocentric libration, to within  $\pm 1.0^\circ$ , to the following report:

On 1977 Apr 29 at UT21:40-23:20 an unknown UK observer reported a LTP in Gassendi crater. The following are reports by observers attempting to confirm activity: J.W. Napper (Didcot, UK, 30cm reflector, x287, Wratten 25 and 44a, conditions clear 5+) received a telephone alert call at 22:00 but the sky was cloudy until 22:30. An initial look revealed nothing unusual, then at 22:54 he observed a color blink just inside the north wall, appearing bright in red and normal in blue or white light. No loss of detail seen and the effect lasted only 2 minutes. A sketch was made. However, the observer stresses that the very bad seeing casts some doubt on this observation. L. Fitton observed using an 8.5" reflector, with Moon blink device at x200, seeing was I-II. All areas negative, including Gassendi from 21:40-21:55 and again 22:00-22:25 and finally 22:50-23:30 negative. Mike Brown (Huntington, York, UK, 30cm reflector, x220 and x350, seeing 3-4/5, and transparency 5/5) - observed from 22:00-23:25UT no color seen, nor obscuration, all filters negative, despite seeing a lot of fine detail inside this crater. ALPO/BAA weight=2.

Trevor, using a 16-inch reflector, noted that everything looked normal with no sign of any clouds or false color seen. At 22h 05m UT Gassendi still looked perfectly normal. We shall therefore leave the weight at 2.

**Gassendi:** On 2020 Jan 06 UT 23:08 & 23:09 Walter Elias (AEA) imaged this crater under similar illumination, to within  $\pm 0.5^\circ$ , to the following report:

*Gassendi 1966 Apr 30 UT 21:30-23:28 Observed by Sartory, Ringsdore (England, 8.5" reflector, S=E), Moore, Moseley (Armagh, Northern Ireland, 10" refractor, S=VG), Corralitos Observatory (Organ Pass, NM, USA, 24" reflector, Moon Blink) "English moon blink system detected red spots with vis. confirm. Ringsdore says no color but saw obscuration. (LRL 60-in photos showed nothing unusual by my casual inspection). Indep. confirm. (even E. wall was in dark). Corralitos did not confirm by MB." N.B. event had finished by the time Corralitos came on-line. NASA catalog weight=5. NASA catalog ID #931. ALPO/BAA weight=4.*



**Figure 3.** Gassendi orientated with north towards the top, **(Left)** as imaged by Walter Elias (AEA) on 2020 Jan 06 UT 23:09 in monochrome and orientated with north towards the top. **(Right)** a sketch map for the events of 1966 Apr 30 / May 01 from p135 from “The Moon and Planets : A Catalog of Astronomical Anomalies” by William R. Corliss (1985), where shaded areas mark color phenomena seen.

Although Walter’s image (Fig 3 – Left) is in monochrome, it can at least address Ringsdore’s comments that an obscuration was seen. Quite clearly there is no sign of any abnormal lack of detail, therefore what Ringsdore reported was abnormal. The 1966 LTP has been covered before – see the newsletters from [2012 Dec](#) (p16) and [2014 Jul](#) (p21-22). We shall therefore leave the weight at 4.

**Proclus:** On 2020 Jan 06 UT 22:10 Trevor Smith (BAA) observed visually and at 23:21 & 23:23 Walter Latrónico (AEA) imaged, this region under similar illumination, to within  $\pm 0.5^\circ$ , to the following report:

*On 1987 Oct 04 at UT 02:20 D. Darling (Sun Prairie, WI, USA, 12.5" reflector, x170, S=8, VG, T=5) obtained the brightest measurement he had ever recorded on the northern rim of Proclus. Brightness 9 and adjacent plain was of brightness 6.5. The Cameron 2006 catalog ID=308 and the weight=3. The ALPO/BAA weight=3.*



**Figure 4.** Proclus and its surrounds as imaged by Walter Latrónico (AEA) on 2020 Jan 06 UT 23:23 and orientated with north towards the top.

Walter's image (Fig 4), although a little saturated on the rim of Proclus, does show that it is very bright, and brighter than Censorinus. A little earlier that evening, Trevor Smith UK had observed visually and found that: *"Proclus looked very bright but not unusually so. That said, it was much brighter than Censorinus"*. I will lower the weight of David Darling's report from 3 to 2 so that we may re-observe and confirm the very bright appearance of Proclus at this colongitude.

**Aristarchus:** On 2020 Jan 08 UT 00:55-01:35 Jay Albert (ALPO) observed under similar illumination ( $\pm 0.5^\circ$ ) to the following 5 reports:

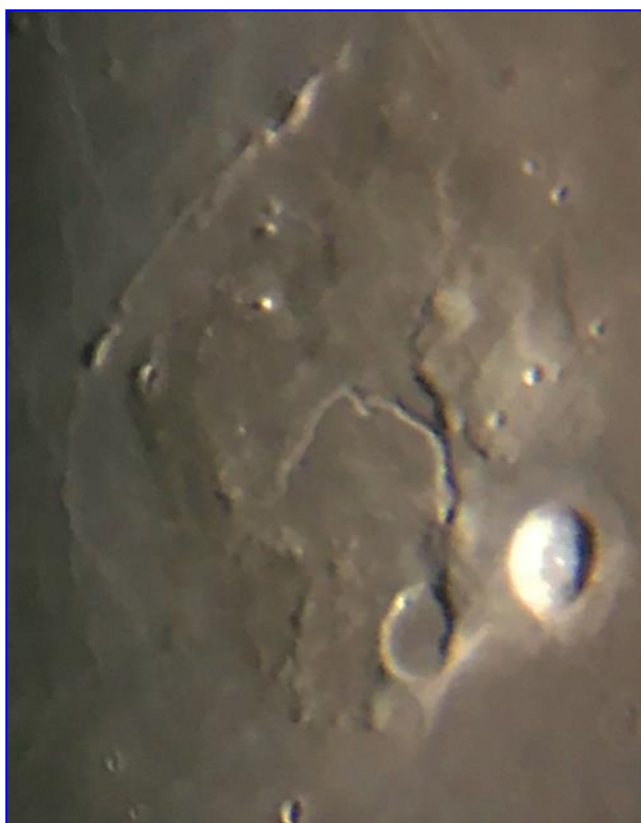
*Cobra Head 1966 May 02 UT 20:05 Observed by Sartory (England, 8.5" reflector x400) "Eng. moon blink detected red spots, seen visually also". NASA catalog weight=4. NASA catalog ID #934. ALPO/BAA weight=3.*

*On 1978 Mar 21 at UT 20:57 an Unknown observer observed a LTP in Aristarchus crater. The details for this report are still being looked up in the archives. In view of the uncertain details this LTP has been given an ALPO/BAA weight of*

*Aristarchus 1982 Jul 03/04 UT 20:55-01:08 Observed by Foley (Kent, UK, Seeing Antoniadi III) "Brightness variance" - CED 3.6-4.1-4.9. When the crater was dark it had a slate-blue-grey interior. Moore found the crater to be exceptionally bright and this was confirmed by J.D. Cook (CED 3.8-4.1). The Cameron 2006 catalog ID=174 and weight=5. The ALPO/BAA weight=3.*

*S. of Aristarchus 1951 Sep 13 UT 14:00? Observed by Osawa (Japan, 6" reflector) "Brownish-red color, blue on NW rim of A." NASA catalog weight=3. NASA catalog ID #546. ALPO/BAA weight=3.*

*On 1965 Jun 12 at UT > 00:00 an unknown observer (Porta?) reported that the area of Herodotus and the Cobra Head expanded and the color went to rose. The next night the floor was normal. In filters, phenomenon accentuated in orange. The Cameron 1978 catalog ID=880 and weight=3. The ALPO/BAA weight=2.*



**Figure 5.** Aristarchus as imaged in color using an iPhone by Jay Albert on 2020 Jan 08 UT 01:31 and orientated with north towards the top.

Jay noted that Aristarchus was the brightest feature on the Moon. However, none of the reported “red spots” were seen visually. The central peak was nevertheless very bright, and plenty of detailed terracing was visible on the interior walls as well as the usual dark, vertical bands. He was unable to see any significant brightness difference when viewing Aristarchus with W25 red and W44A blue filters. Jay observed at 290x from 00:55 to 01:35UT and attempted to image Herodotus and Aristarchus with his iPhone during this time. One respectable image was captured (Fig 5) which confirms much of the visual description that Jay gave. We shall leave the respective weights of these LTP as they are for now.

**Mare Crisium:** On 2020 Jan 10 UT 01:15 Johana Gonzalez (AEA) imaged the Moon under similar illumination to the following report:

*In 1954 Jan 19 at UT 03:00 Porta (Mallorca, Baleares, Spain, 3" refractor, x50) observed the following during a total lunar eclipse: "3 brilliant yellowish-white spots between Picard & Peirce. Phosphor. light distinguished easily against grey-green background of mare. Irreg., intermittent. Did not perceive them all dur. totality. Next day had impression that all of area was less clear & lightly veiled.". The Cameron 1978 catalog ID=561 and weight=3. The ALPO/BAA weight=2.*



**Figure 6.** Mare Crisium as imaged by Johana Gonzalez (AEA) on 2020 Jan 10 UT 01:15 and orientated with north towards the top.

Although Johanna's image is clearly not in an eclipse, and is an equivalent Full Moon image, it does not reveal any sign of brilliant points between Picard and Peirce. The Moon during a total lunar eclipse is essentially what the Full Moon looks like, i.e. an albedo map, but illuminated by the weak refracted light around the Earth's atmosphere. As these points are not visible in Fig 6, they should not have been there back in 1954. We shall therefore leave the weight at 2.

**Penumbral Lunar Eclipse:** On 2020 Jan 10 UT 19:09 Anthony Cook (ALPO/BAA) imaged the Moon during a penumbral lunar eclipse in both visible and thermal infrared light.

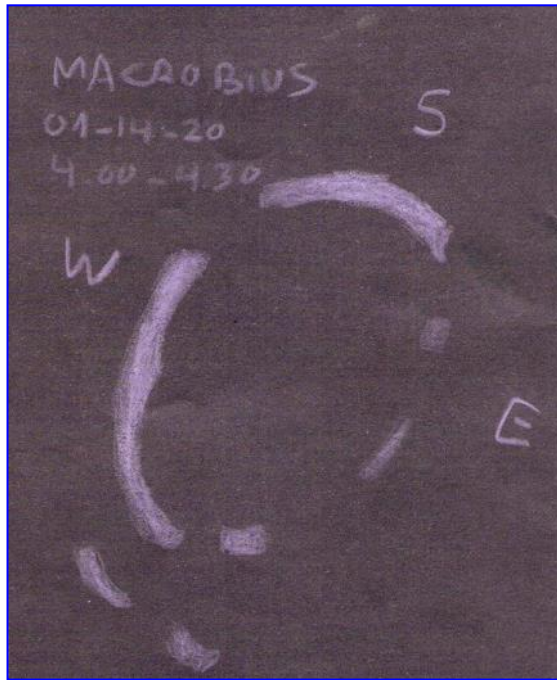


**Figure 7.** A color image of the 2020 Jan 10 penumbral lunar eclipse taken by Anthony Cook with a Lumix DMC-TZ80 compact camera on maximum optical zoom. Color saturation increased to 75%. To bring out the penumbral shadow.

There are numerous past LTP during past lunar eclipses: total, partial and penumbral. I used a thermal imaging camera on my telescope and a tripod mounted Lumix compact camera for optical imaging. Alas the thermal IR camera was being used for the first time (so I was not used to using it) and there were plenty of clouds and haze in the way – therefore this was a bit of a failure and no recognizable lunar features could be seen and no obvious sign of the shadow. The optical images though were a bit more successful and I show one of these in Fig 7, one minute before eclipse maxima. You can just make out the penumbral shadow in the lower part of the Moon.

**Macrobius:** On 2020 Jan 14 UT 04:00-04:30 Alberto Anunziato (SLA) sketched this crater under similar illumination ( $\pm 0.5^\circ$ ) to the following report:

*On 2005 Oct 21 at UT 13:07-14:27 R. Gray (Winnemucca, NV, USA, 15cm F/9 refractor, x228, seeing 4-5, transparency 5-6) observed a possible LTP in Macrobius. His report is as follows: "Blinked Macrobius with Wratten Filters Blue 38A and Red 29. Macrobius became almost invisible through the Blue 38A and essentially the same as in white light through the Red 29. The interior of the crater was completely in shadow. The only part of the east wall that was visible was an apparent high point still in the sun and seen as a bright point of light. This faded into darkness before 13:56UT. No sign of any illumination of the east wall crater interior or the interior of the west wall was seen during the observation period. The outer west wall was a rough looking, complicated mix of deep shadow and illuminated sunlit terrain." The observer concluded that there was not a LTP - although he did get a filter reaction, this may have been due to the different densities of the filters? ALPO/BAA weight=2.*



**Figure 8.** Macrobius as sketched by Alberto Anunziato (LSA) on 2020 Jan 14 UT 04:00-04:30. Orientated with north towards the bottom left.

Alberto's sketch (Fig 8) confirms that the crater is entirely shadow filled at this colongitude, and that the eastern wall has parts of the rim still sunlit, though not a continuous rim. We don't have a sketch from the Robin Gray report, so Alberto's sketch is helpful in our understanding of Robin's description. As Alberto notes no color, we shall leave the weight of Robin's LTP report at 2.

**Copernicus:** On 2020 Jan 18 UT 14:46 Ivan Walton (BAA), remotely logged in via the BEN 6-inch telescope in Amado, AZ, USA (part of the Micro-Observatory Robotic Telescope Network, hosted by the Harvard-Smithsonian Center for Astrophysics or OWN – Observing With NASA) to capture an image of the Moon containing Copernicus, close to the following  $\pm 0.5^\circ$  repeat illumination window for the following report:

*Copernicus 1996 Sep 06 UT 01:45 Observed by C Brook (Plymouth, UK, 60mm re-fractor x28, x112, transparency, not good) "Shadows of central mountains could not be seen although the shadows on the crater ramparts were visible" BAA Lunar Section report. ALPO/BAA weight=2.*



**Figure 9.** The Oceanus Procellarum region, containing Copernicus, orientated with north towards the top. Image by Ivan Walton (BAA).

The great thing about using robotic telescopes is that you can observe from somewhere else in the world even though it might be daylight where you are. It is also a good way of dealing with lunar phases that are best observed during normally anti-social hours. Indeed, we have relatively few images at this particular phase. Although Ivan's image (Fig 9) is only of relatively moderate resolution, it does at least show Copernicus as it would have been seen through Clive Brook's 2" refractor. We shall leave the weight at 2 for now.

**Aristarchus:** On 2020 Jan 20 UT 15:45 Maurice Collins (ALPO/BAA/RASNZ) took a low-resolution Canon 1200D 250mm-fl telephoto shot of the Moon at around the same time that similar illumination occurred for the following LTP:

*On 1987 Oct 17 at UT17:00-18:00 (in daylight) J. Moeller (Kerkville, NY, USA, 6" reflector, x80-x135) observed that Aristarchus had a long trench-like feature going off to the north west limb. On the 18th this feature was more cloud like, "bright white and opaque. (Trench = Schroter's Valley? Similar to 10/13/67)". The Cameron 2006 catalog ID=311 and the weight=1. The ALPO/BAA weight=1.*

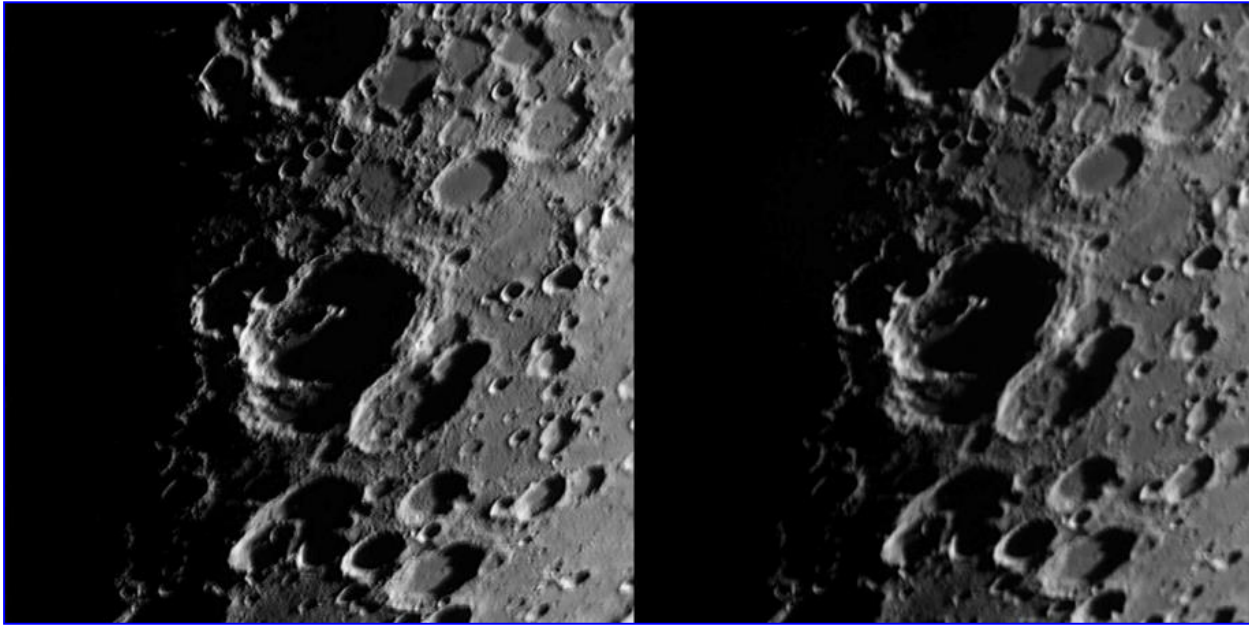


**Figure 10.** The NW area of the Moon taken on 2020 Jan 20 UT 15:45 by Maurice Collins and orientated with north towards the top.

Although Maurice's image (Fig 10) is of low resolution, at this stage in the lunar phase we have very little in the way of observations, so at least it gives us a context view around the crater. There is some wrinkle ridge like features between Aristarchus and the limb. I wonder if any of those could have been mistaken for a "trench-like" feature? Curiously, at this resolution, the pair of features: Reiner Gamma and the crater Reiner look like a light cloud and its dark shadow. They obviously are not cloud and shadow, but it illustrates how resolution can play tricks on one's interpretation of the lunar surface. We shall leave the 1987 report at a weight of 1 for now.

**Maurolycus:** On 2020 Jan 31 UT 18:22-18:32 Aldon Tonon (UAI) imaged this crater for a lunar schedule event for the following past LTP report:

*ALPO Request: On 2012 Feb 28 Raffaello Braga noted that only the tip of the central peak was visible. Most of the crater was in darkness - this was normal at this stage in illumination. When viewed through a red filter, the central peak was visible, but however when viewed through a blue filter it was invisible. Please try to observe this crater visually with red and blue filters, to see if you can replicate this effect? If so, then check for similar effects on other craters on the terminator. Otherwise try to obtain some high-resolution color images. This work is suitable for telescopes of 4" aperture or larger - if you have a choice of a refractor or a reflector, please try the refractor.*



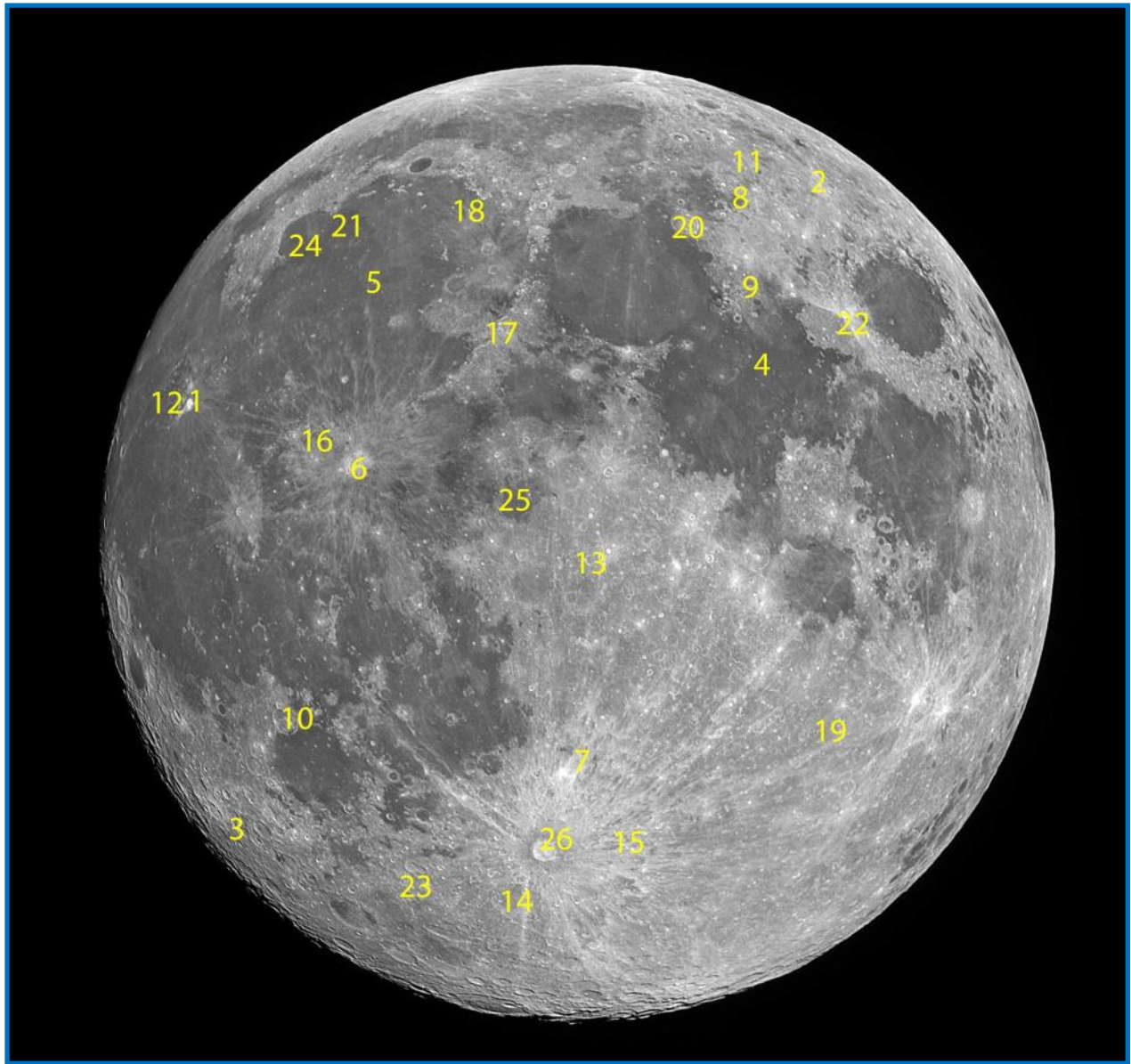
**Figure 11.** Maurolycus orientated with north towards the top, as imaged by Aldo Tonon (UAI), on 2020 Jan 31. **(Left)** 18:23 UT – Red filter. **(Right)** 18:26 UT – Blue filter.

In Fig 11 we see a couple of Aldo's red and blue filter images. Quite obviously the central peaks area of Maurolycus stand out from a mostly shadowed floor as was stated as normal in the description by Raffaello. However, it is clearly visible in both the red and blue filter images in contrast to what Raffaella describes. This was covered in a previous repeat illumination observation discussed in the previously in the [2019 Mar](#) (p22-23) newsletter. We shall keep the Raffaello LTP report at its current weight of 2.

**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](http://users.aber.ac.uk/atc/lunar_schedule.htm) . By re-observing and submitting your observations, only this way can we fully resolve past observational puzzles. To keep yourself busy on cloudy nights, why not try "Spot the Difference" between spacecraft imagery taken on different dates? This can be found on: [http://users.aber.ac.uk/atc/tlp/spot\\_the\\_difference.htm](http://users.aber.ac.uk/atc/tlp/spot_the_difference.htm) . If in the unlikely event you do ever see a LTP, firstly read the LTP checklist on <http://users.aber.ac.uk/atc/alpo/ltp.htm> , and if this does not explain what you are seeing, please give me a call on my cell phone: +44 (0)798 505 5681 and I will alert other observers. Note when telephoning from outside the UK you must not use the (0). When phoning from within the UK please do not use the +44! Twitter LTP alerts can be accessed on <https://twitter.com/lunarnaut> .

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## Key to Images In This Issue



- |                |                          |
|----------------|--------------------------|
| 1. Aristarchus | 14. Longomontanus        |
| 2. Atlas       | 15. Maginus              |
| 3. Byrgius     | 16. Milichius            |
| 4. Cauchy      | 17. Montes Apenninus     |
| 5. Carlini D   | 18. Mons Pico            |
| 6. Copernicus  | 19. Piccolomini          |
| 7. Deslandres  | 20. Posidonius           |
| 8. G. Bond     | 21. Promontorium Laplace |
| 9. Gardner     | 22. Proclus              |
| 10. Gassendi   | 23. Schiller             |
| 11. Hall       | 24. Sinus Iridum         |
| 12. Herodotus  | 25. Sinus Medii          |
| 13. Hipparchus | 26. Tycho                |