The Lunar Observer

A publication of the Lunar Section of ALPO

Edited by David Teske: david.teske@alpo-astronomy.org
2162 Enon Road, Louisville, Mississippi, USA
Recent back issues: http://moon.scopesandscapes.com/tlo_back.html

November 2019

In This Issue

25-Day Old Moon, *David Teske, Louisville, Mississippi, USA. 24 October 2019 1039-1112 UT, colongitude 219.1°-219.4°. Mewlon 180 mm telescope, ASI 120mms camera, Firecapture, Registax, Photoshop. Panorama of 15 images. Seeing 7/10.*

Lunar Calendar November 2019

2019	U.T.	EVENT
November 02	0700	Saturn 0.6° north of Moon, occultation visible in Kerguelen Is, Prince Edward Island, East Antarctica, South Tasmania, New Zealand, South Polynesia.
02	1800	Pluto 0.4° north of the Moon, occultation visible from southern South America, South Georgia, Southern Africa, Madagascar
02		Greatest southern declination, -23.0°.
04	1023	First Quarter Moon
07	0900	Moon at apogee, 405, 058 km
12	1334	Full Moon
15	2000	Moon 1.5° south of M35
17		Greatest north declination, +23.0°.
18	1100	Moon 0.9° north of M44
19	2111	Last Quarter Moon
23	0800	Moon at perigee 366, 716 km
25	0300	Mercury 1.9° south of Moon
26	1506	New Moon, lunation 1199
28	1100	Jupiter 0.7° south of Moon, occultation visible from north Africa, most of Europe, Middle East, western Asia.
28	1900	Venus 1.9° south of the Moon
29	2100	Saturn 0.9° north of the Moon, occultation visible from southern New Zealand, Antarctica, South Georgia.
29		Greatest southern declination, -23.1°.
30	0400	Pluto 0.5° north of the Moon, occultation visible from Australasia, Kerguelen Is, parts of Antarctica, southeast Polynesia.

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 TOPOGRAPHICAL STUDIES

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

OBSERVATIONS RECEIVED

Alberto Anunziato, Oro Verde, Argentina. Article, images and drawings *A Show of a Few Minutes on the Western Wall of Deluc H, Atlas and a Bright Spot on the Full Moon, Three Views of Copernicus*, images of Copernicus, Hahn, Petavius and Anaxagoras.

Francisco Alsina Cardinali, Oro Verde, Argentina. Article and images *Three Views of Copernicus*.

Jairo Chavez, Popayán, Columbia. Images of the Waxing Gibbous Moon, Aristarchus, Bianchini and Plato.

Howard Eskildsen, Ocala, Florida, USA. Articles and images *Cauchy and Northern Tranquillitatis Domes, What Its Cracked Up To Be, Lacus Mortis et al, Mons Hansteen, Huxley Domes*, images of Marius Domes (3), Menelaus Dome, Fracastorius Dome, Meton Dome, Piccolomini Dome (2), Vitruvius and Cauchy Domes, Hansteen and Gassendi Domes, Mons Gruithuisen Gamma and Delta, Gambart Domes, Grimaldi Dome, Birt Domes, Lavoisier Region, Mons Rumker (2) and Hortensius and Milichius Domes.

Richard Hill, Tucson Arizona, USA. Articles and images *Sunset Drama* and *Brahe's Crater*.

Jerry Hubbell, Wilderness, Virginia, USA. Article: Focus on Atlas and Copernicus

Lena, Raffaello and Jim Phillips, Article and images *Searching Domes in the Sinus Iridum Region.*

Roberto Podestá, Formosa, Argentina . Images of Plato, Copernicus, Tycho and Proclus.

Sweetman, Michael E., Tucson, Arizona, USA. Images of Copernicus (2), Mons Rumker and Arago Domes: Alpha and Beta.

David Teske, Louisville, Mississippi, USA. Article and image *The Bay of Rainbows*, images of the 4-Day old Moon, 25-Day old Moon, Copernicus and Atlas

Román García Verdier, Paraná, Argentina. Images of Aristarchus, Proclus and Plato.

Darryl Wilson, Marshall, Virginia, USA. Articles and images (10) *Mosaic Analysis* and *Lunar Thermal Nighttime Analysis.*

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

Focus On: Atlas & Copernicus

Jerry Hubbell

Assistant Coordinator, Lunar Topographical Studies

This is the second article 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.

We will continue to use the Lunar Terminator Visualization Tool (LTVT) to do various measurements of these craters and perhaps provide more insight into 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 might give us additional data. 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 we cover the craters Atlas – 53 miles (88 km) & Copernicus – 56 miles (93 km). **Figures 1** and **3** show the crater drawing outlines used in the SAP for Atlas & Copernicus, and **Figures 2** and **4** 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.

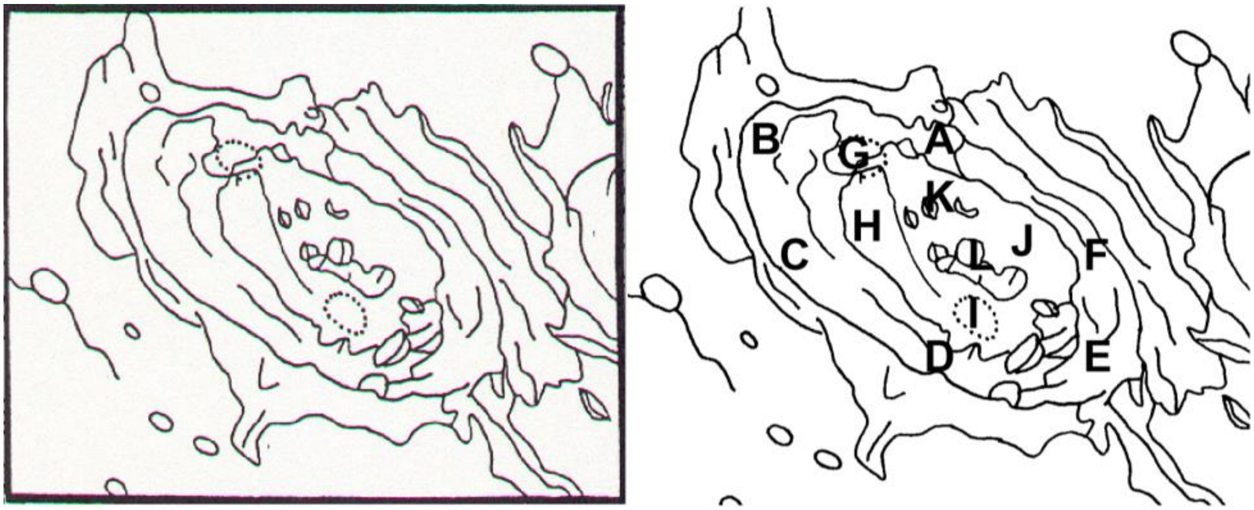


Figure 1. *Outline drawing of Atlas (left) and Albedo Points for Atlas (right) (north-down, east-left)*

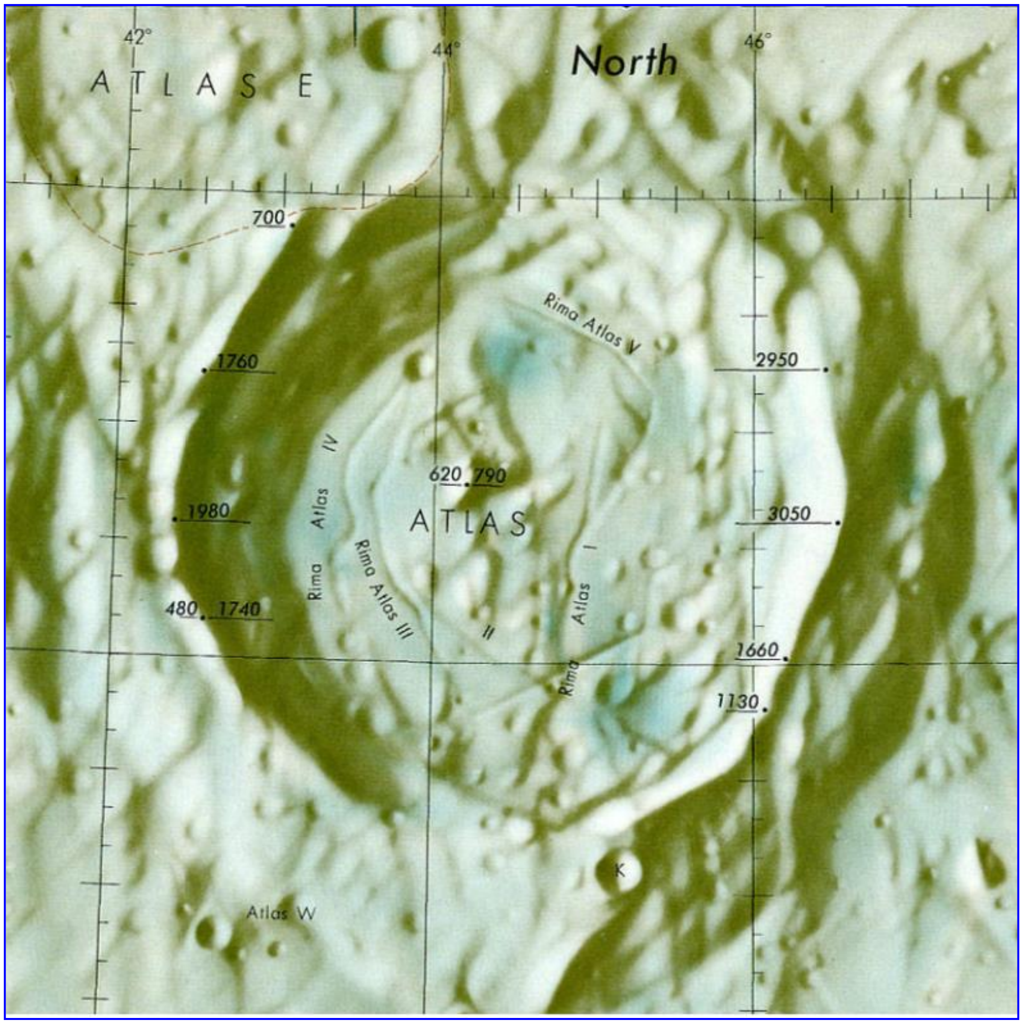


***Figure 2**. LAC27 chart of Atlas. (north-up, east-right)*

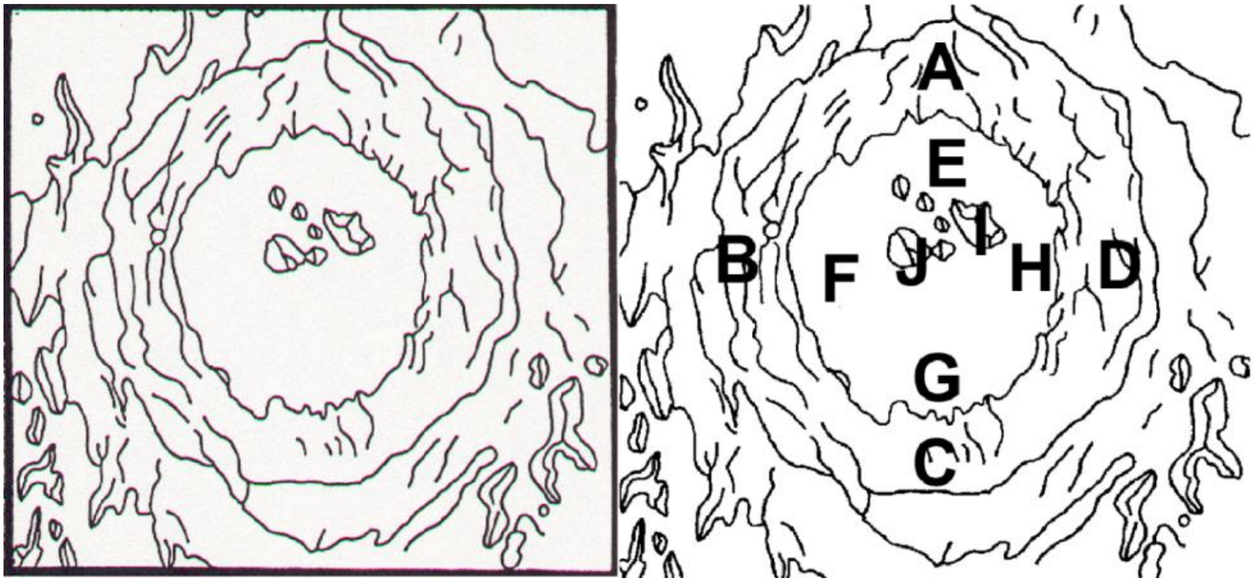


***Figure 3**. Outline drawing of Copernicus (left) and Albedo points for Copernicus (north-down, east-left).*

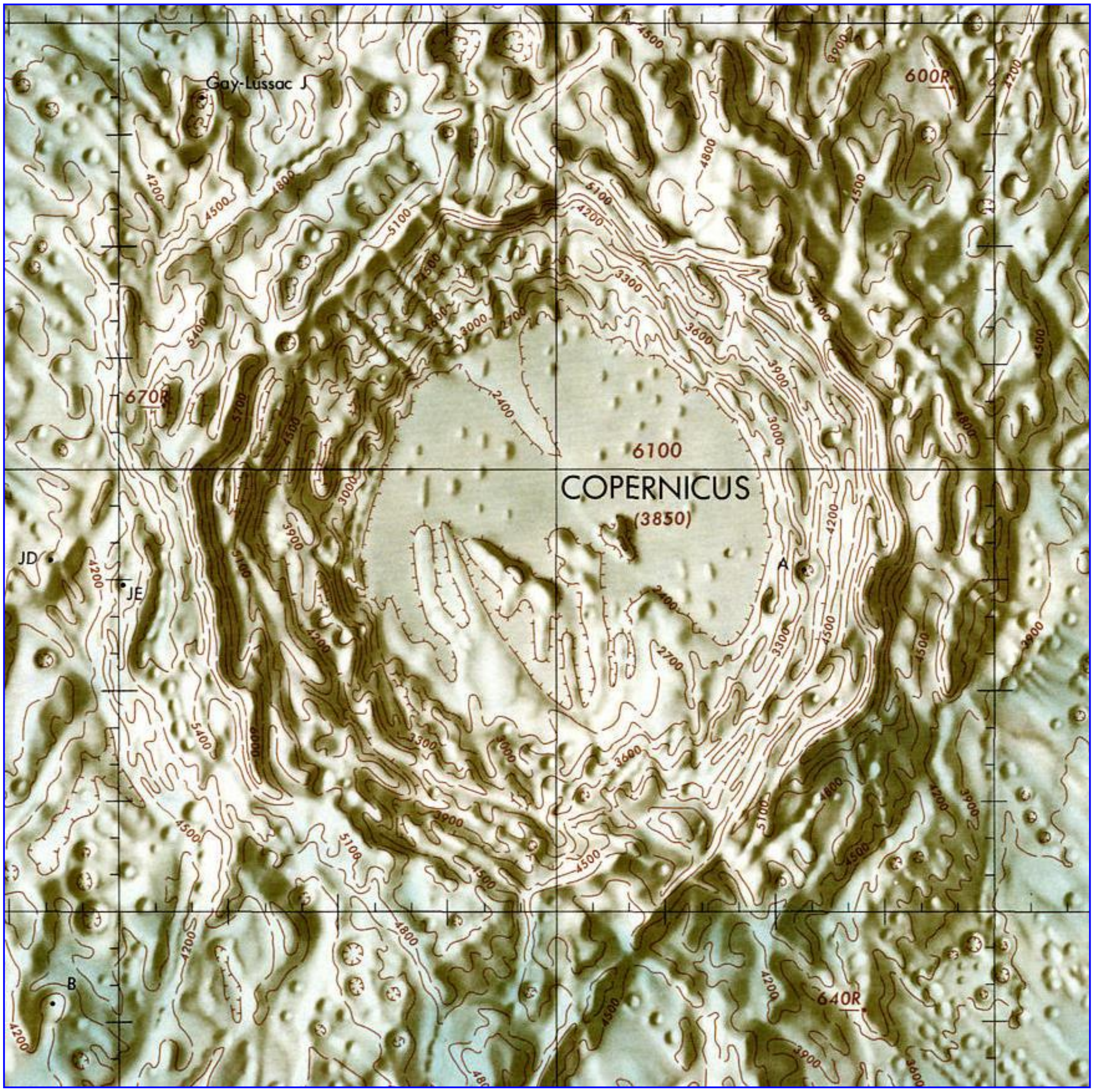


Figure 4. *LAC58 chart excerpt of crater Copernicus.*

ATLAS

David Teske has provided an excellent image of craters Atlas and Hercules that can be measured using LTVT.

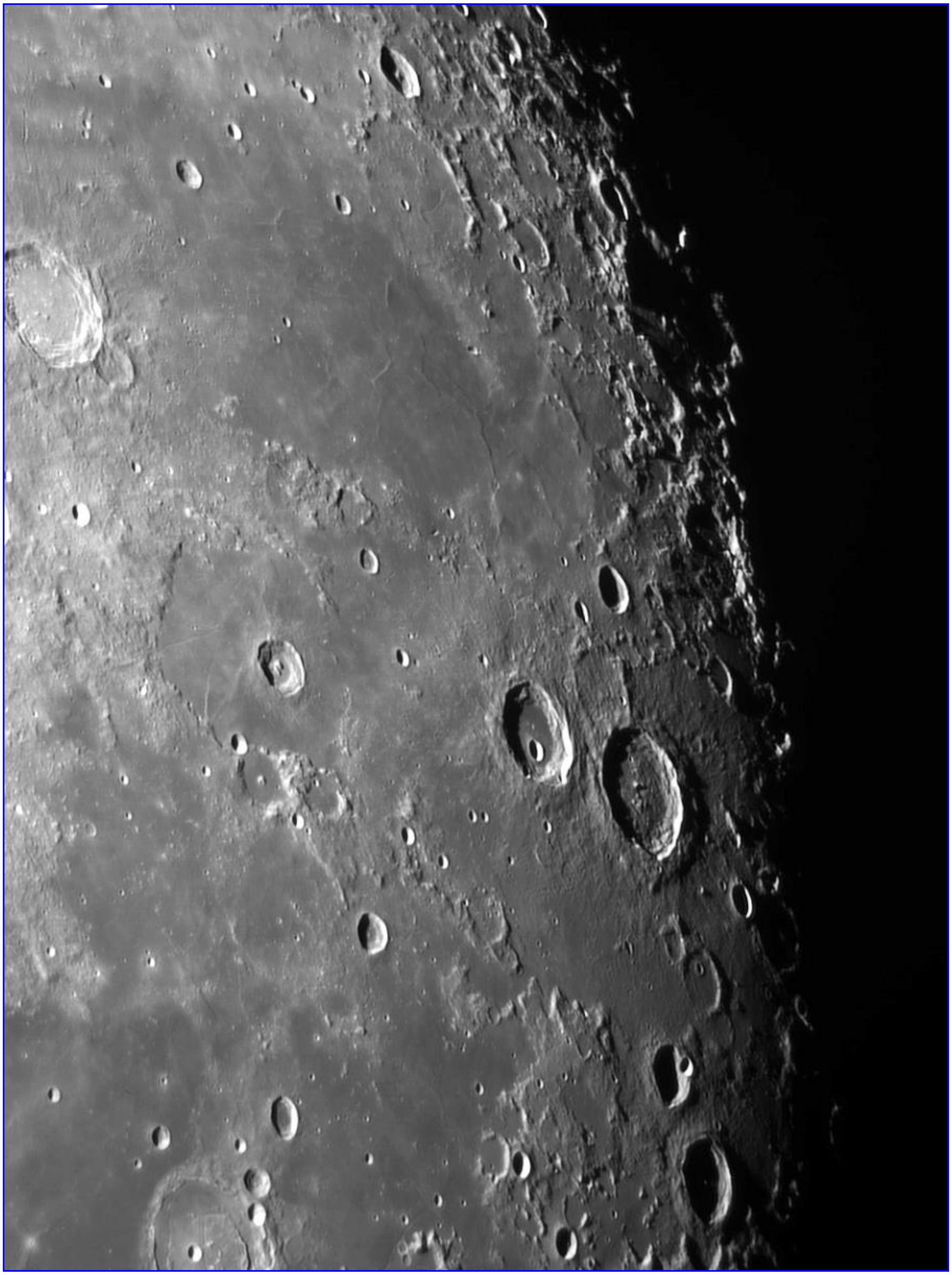


***Figure 5**. Craters Atlas and Hercules, David Teske, Louisville, Mississippi, USA. 17 September 2019 0912 UT, Colongitude 127.2°. 180 mm Takahashi Mewlon telescope, ZWO ASI 120 mms camera, 500 frames, Firecapture, Registax, Photoshop. Seeing 7/10.*

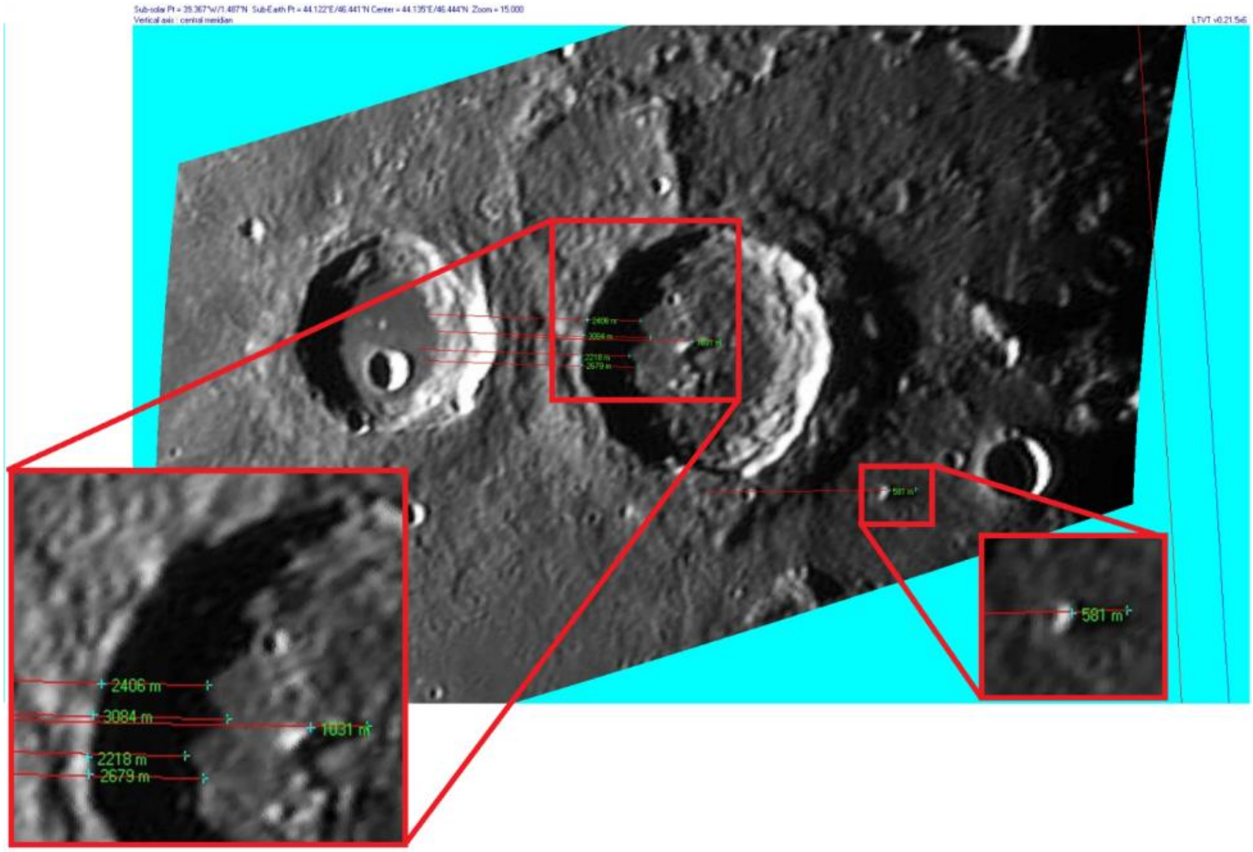


Figure 6*. Closeup Aerial view of Craters Atlas and Hercules processed in LTVT, David Teske, Louisville, Mississippi, USA. 17 September 2019 0912 UT, Colongitude 127.2°. 180 mm Takahashi Mewlon telescope, ZWO ASI 120 mms camera, 500 frames, Firecapture, Registax, Photoshop. Seeing 7/10. (Processed by Jerry Hubbell)*

Parameter*	**Measured Value**
Crater Rim Shadow Point 1	2406 m (7,894 ft)
Crater Rim Shadow Point 2	3084 m (10,118 ft)
Crater Rim Shadow Point 3	2679 m (8,789 ft)
Crater Rim Shadow Point 4	963 m (3,159 ft)
Central Peak Shadow Point 1	1031 m (3,382 ft)
Isolated Peak Shadow Point 1	581 m (1,906 ft)

*As shown from North to South on Figure 6 insets. These measurements are at a Colongitude of 127.2°.

Table 1. Atlas LTVT Measurements.

COPERNICUS

I think it is safe to say that Copernicus is one of the most observed and photographed craters on the moon. There are several reasons for this including its central location near the center of the face of the Moon, it's size that shows a wealth of detail including features such as the terraced crater walls central peaks, and ejecta field, and finally, it's changing character over the lunar cycle.

Alberto submitted this excellent image of Copernicus (**Figure 7**). Here is his description of this image:

> *A dramatic view of the shaded interior of Copernicus. As always, Peter Grego describes a brief moment of the lunation in all its splendor: "A spectacular lighting effect is caused during the early morning and late evening, when Copernicus is partly filled with shadow and some of the higher ridges within the terracing are illuminated by the Sun, amid the shadows. Even a cursory telescopic view will convince the observer that Copernicus's floor is considerably depressed beneath the mean level of the surrounding landscape. Measured from the highest points on the crater's rim to the mean level of the floor, Copernicus is 3,760 m. deep".*
>
> – Alberto Anunziato

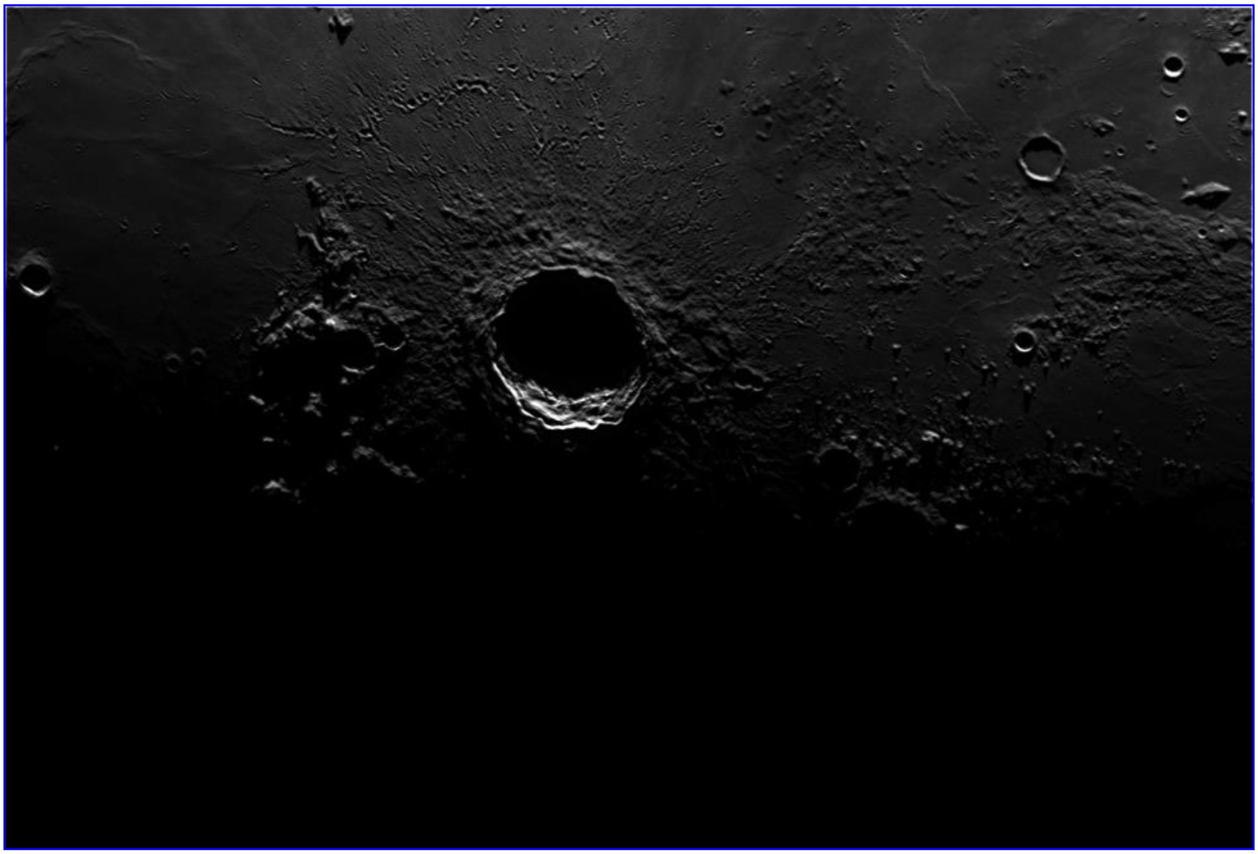


***Figure** 7. Crater Copernicus, Alberto Anunziato, Oro Verde, Argentina. 21 August 2016 0534 UT, Colongitude 28.2°. 250 mm Meade SCT, Astronomik IR-pass Filter, QHY5-II CCD Camera, east/up, north/left.*

Michael Sweetman and David Teske also provided great images of the crater Copernicus. (**Figures 8** and **9**).

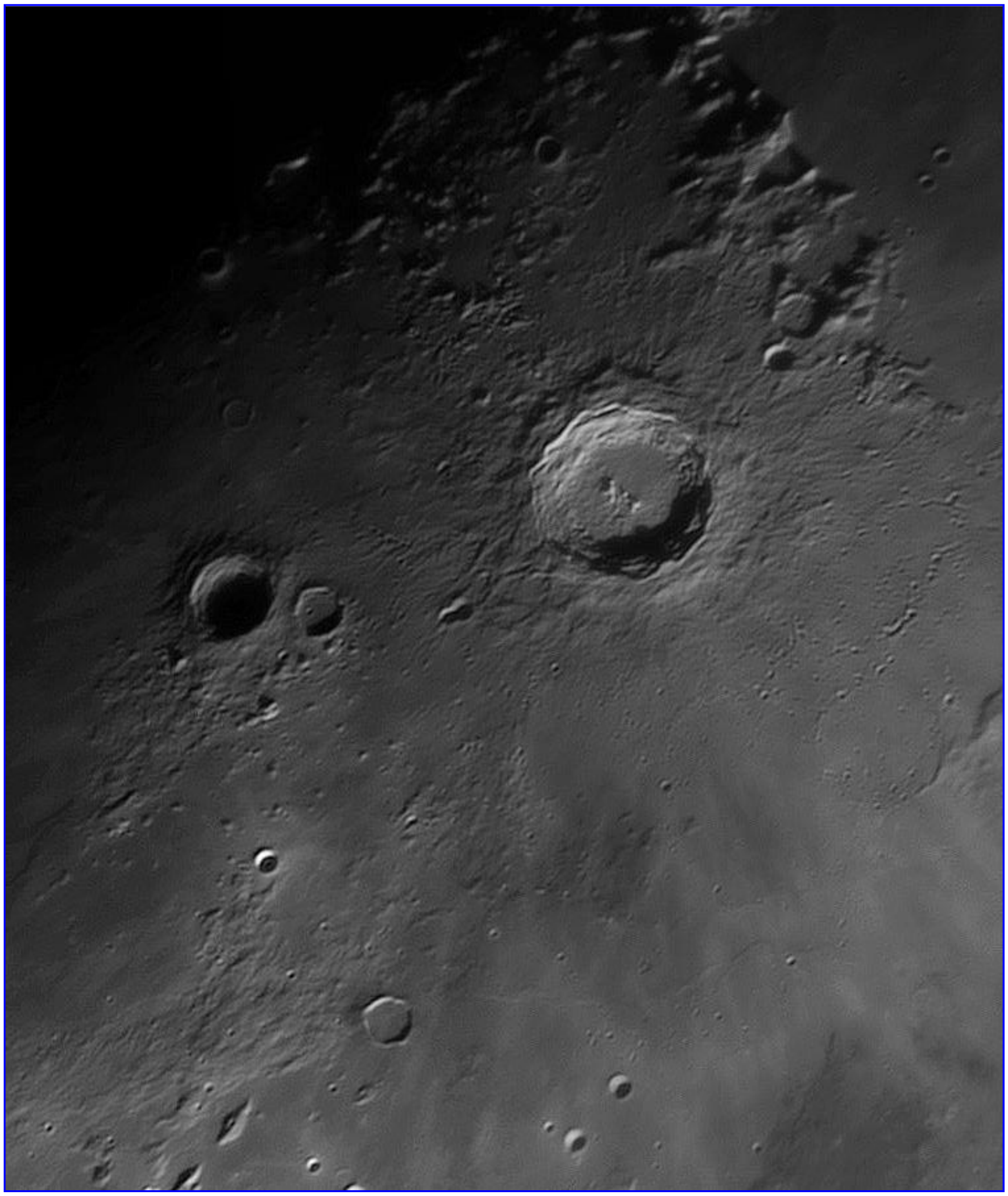


Figure 8. *Crater Copernicus. Michael Sweetman, Sky Crest Observatory, Tucson, Arizona, USA, 25 February 2018, 0654 UT. Colongitude, 33.9°, Celestron 4-inch AR f/20, CCD Camera. Seeing, 4/10, Transparency 3/6.*

Figure 9. Crater Copernicus, David Teske, Louisville, Mississippi, USA. 22 September 2019 at 0951 UT, Colongitude 188.3°, 180 mm Takahashi Mewlon telescope, 2.5 x Tele Vue Power Mate, ZWO ASI 120 mms camera, 500 frames, Firecapture, Registax, Photoshop. Seeing 6/10.

David Teske's image of Copernicus is a great candidate for analysis using LTVT. (**Figure 10**.)

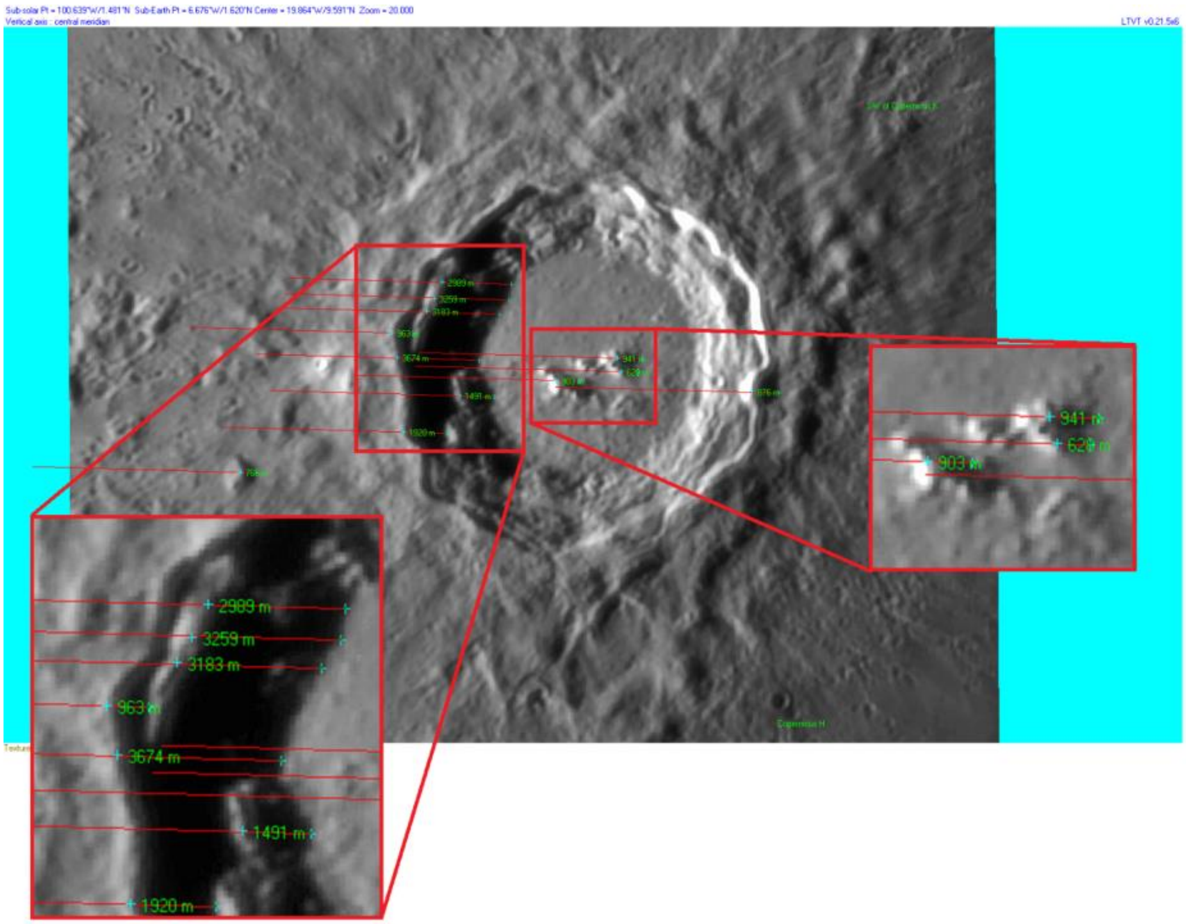


***Figure 10**. LTVT Processed Image of Crater Copernicus, David Teske, Louisville, Mississippi, USA. 22 September 2019 at 0951 UT, Colongitude 188.3°, 180 mm Takahashi Mewlon telescope, 2.5 x Tele Vue Power Mate, ZWO ASI 120 mms camera, 500 frames, Firecapture, Registax, Photoshop. Seeing 6/10. (Processed by Jerry Hubbell).*

Parameter*	**Measured Value**
Crater Rim Shadow Point 1	2989 m (9,806 ft)
Crater Rim Shadow Point 2	3259 m (10,692 ft)
Crater Rim Shadow Point 3	3183 m (10,443 ft)
Crater Rim Shadow Point 4	963 m (3,159 ft)
Crater Rim Shadow Point 5	3674 m (12,053 ft)
Crater Rim Shadow Point 6	1491 m (4,891 ft)
Crater Rim Shadow Point 7	1920 m (6,299 ft)
Central Peak Shadow Point 1	940 m (3,084 ft)
Central Peak Shadow Point 2	620 m (2,034 ft)
Central Peak Shadow Point 3	903 m (2,963 ft)

*As shown from North to South on Figure 10 insets. These measurements are at a Colongitude of 188.3°.

Table 2. Copernicus LTVT Measurements

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.

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

REFERENCES

Lunar Reconnaissance Office ACT-REACT Quick Map, http://target.lroc.asu.edu/q3/ (retrieved October 31, 2017)

Patrick Chevalley, Christian Legrand, *Virtual Moon Atlas*, http://ap-i.net/avl/en/start (retrieved June 30, 2018)

Aeronautical Chart Information Center (ACIC), United States Air Force, *Lunar Chart Series (LAC) LAC-27 Geminus (July 1967), LAC-58 Copernicus (April 1964)*, hosted by the Lunar and Planetary Institute, https://www.lpi.usra.edu/resources/mapcatalog/LAC/ (retrieved September 1, 2019)

Aeronautical Chart Information Center (ACIC), United States Air Force, *LAC Series Chart Reference*, hosted by the Lunar and Planetary Institute, https://www.lpi.usra.edu/resources/mapcatalog/LAC/lac_reference.pdf (retrieved September 1, 2019)

Lunar and Planetary Institute, *Digital Lunar Orbiter Photographic Atlas of the Moon*, http://www.lpi.usra.edu/resources/lunar_orbiter/ (retrieved September 1, 2017).

ADDITIONAL READING

Bussey, Ben & Paul Spudis. 2004. The Clementine Atlas of the Moon. Cambridge University Press, New York.

Byrne, Charles. 2005. Lunar Orbiter Photographic Atlas of the Near Side of the Moon. Springer-Verlag, London.

Chong, S.M., Albert C.H. Lim, & P.S. Ang. 2002. Photographic Atlas of the Moon. Cambridge University Press, New York.

Chu, Alan, Wolfgang Paech, Mario Wigand & Storm Dunlop. 2012. The Cambridge Photographic Moon Atlas. Cambridge University Press, New York.

Cocks, E.E. & J.C. Cocks. 1995. Who's Who on the Moon: A biographical Dictionary of Lunar Nomenclature. Tudor Publishers, Greensboro

Gillis, Jeffrey J. ed. 2004. Digital Lunar Orbiter Photographic Atlas of the Moon. Lunar & Planetary Institute, Houston. Contribution #1205 (DVD). (http://www.lpi.usra.edu/resources/lunar_orbiter/).

Grego, Peter. 2005. The Moon and How to Observe It. Springer-Verlag, London.

IAU/USGS/NASA. Gazetteer of Planetary Nomenclature. (http://planetarynames.wr.usgs.gov/Page/MOON/target).

North, Gerald. 2000. Observing the Moon, Cambridge University Press, Cambridge.

Rukl, Antonin. 2004. Atlas of the Moon, revised updated edition, ed. Gary Seronik, Sky Publishing Corp., Cambridge.

Schultz, Peter. 1972. Moon Morphology. University of Texas Press, Austin. The-Moon Wiki. http://the-moon.wikispaces.com/Introduction

Wlasuk, Peter. 2000. Observing the Moon. Springer-Verlag, London.

Wood, Charles. 2003. The Moon: A Personal View. Sky Publishing Corp. Cambridge.

Wood, Charles & Maurice Collins. 2012. 21st Century Atlas of the Moon. Lunar Publishing, UIAI Inc., Wheeling.

Searching Lunar Domes in Sinus Iridum Region: A Dome in Promontorium Laplace

Raffaello Lena and Jim Phillips

Detailed study of lunar domes is based on lunar images obtained under oblique illumination conditions for their measurements and for maximum detail. Lunar mare domes formed during the later stages of volcanic episode on the Moon, characterized by a decreasing rate of lava extrusion and comparably low eruption temperatures, resulted in the formation of effusive domes [1-3].

Maximilian Teodorescu, from Romania, has reported a possible dome, with a vent on the summit, located near Promontorium Laplace (**Fig. 1**). We term provisionally this volcanic construct as L1, to be consistent with previous classification regarding Sinus Iridum region. It lies at coordinates of 48.57°N and 26.37° W.

In Fig. 1 the dome displays a curved edge with the shadow bending around it, showing that the center of the structure is higher than the edges.Teodorescu has imaged this region with higher solar illumination angle as shown in **Figs. 2** and **3**. Another image of this region, made by Phillips, is shown in **Fig. 4**.

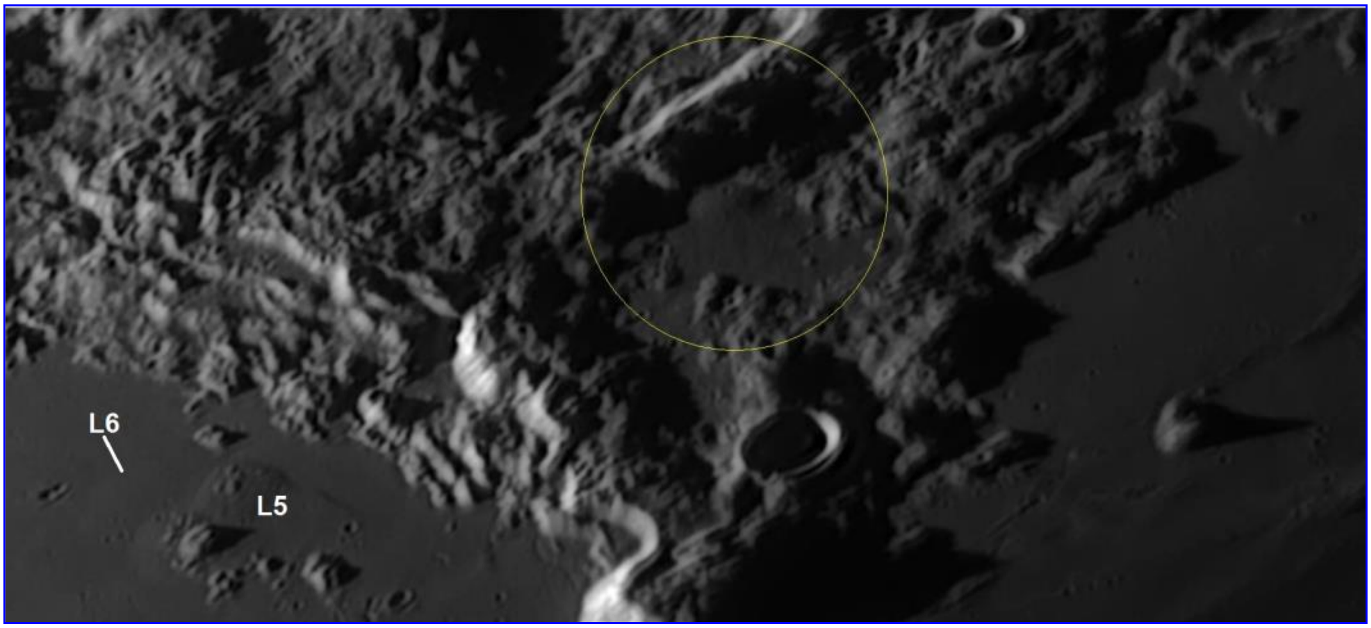


Figure 1. *Image by Teodorescu taken on September 23, 2019 at 02:30 UT using a 355mm Newtonian telescope and ASI 174MM CCD camera. The examined lunar dome-termed L1- is marked with a circle. Two domes, termed L5 and L6, have been previously described by Lena et al. [3].*

As shown in Figs. 1-4, slightly different solar elevation angles may result in strong differences and appearance of the dome. A possible vent of about 1 km diameter is present on the summit. According to the LOLA DEM the vent has a depth of 90 ± 10 m. The dome has a diameter of 7.6 ± 0.2 km and a height of 100 ± 10 m determined in E-W direction, resulting in an average flank slope of 1.5° ± 0.1°. Note that the most elevated part of the surface section covered by the DEM (in N-S direction) has a height of 230 ± 20 m, resulting in a slope of 3.4° ± 0.3°. The 3D reconstruction of the examined dome, obtained using WAC mosaic draped on top of the global WAC-derived elevation model GLD100, is shown in **Fig. 5**.

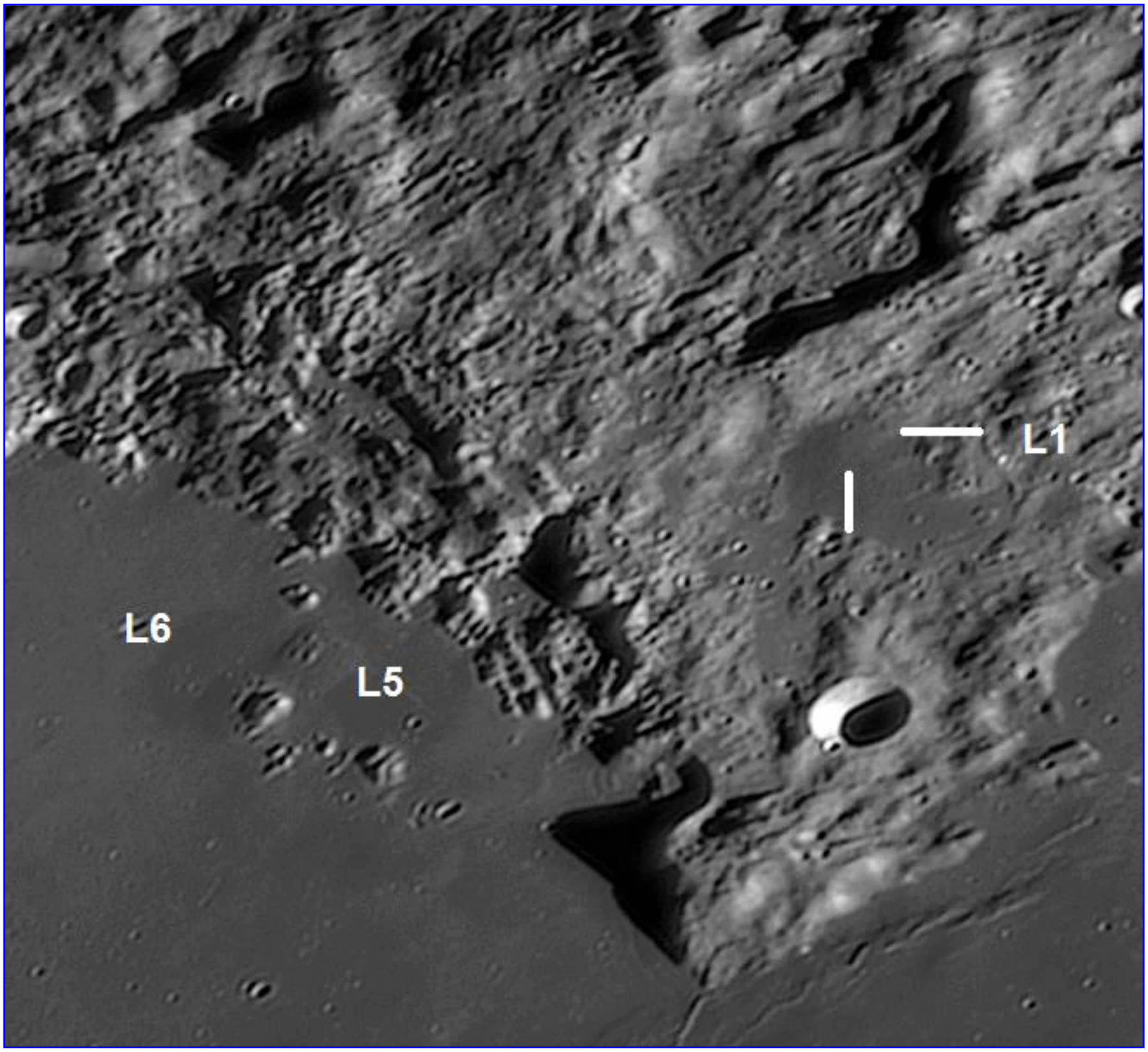


Figure 2. *Another Image made by Teodorescu from Romania showing the dome L1. Two domes, termed L5 and L6, have been previously described by Lena et al. [3].*

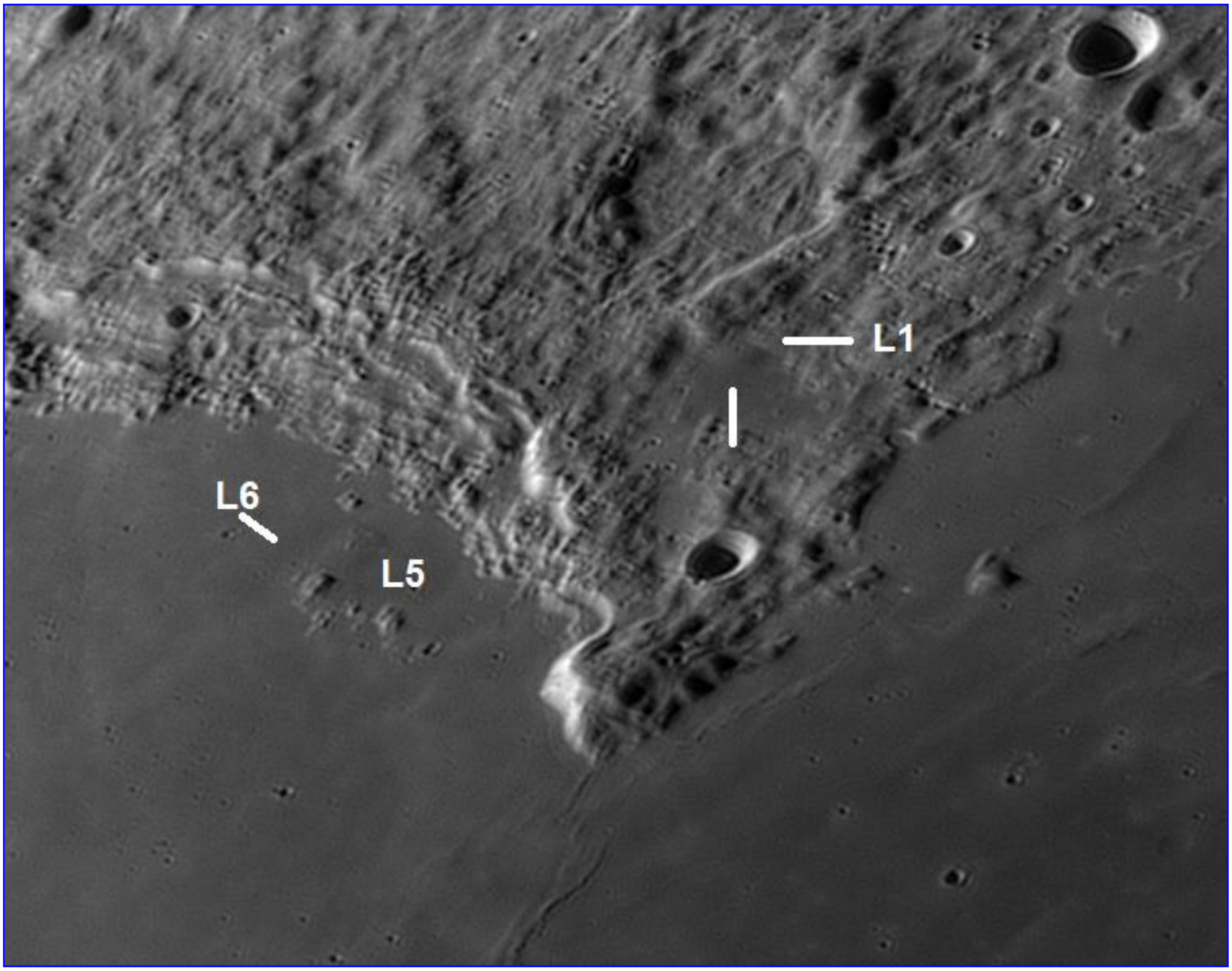


Figure 3. *Another Image made by Teodorescu from Romania showing the dome L1. Two domes, termed L5 and L6, have been previously described by Lena et al. [3].*

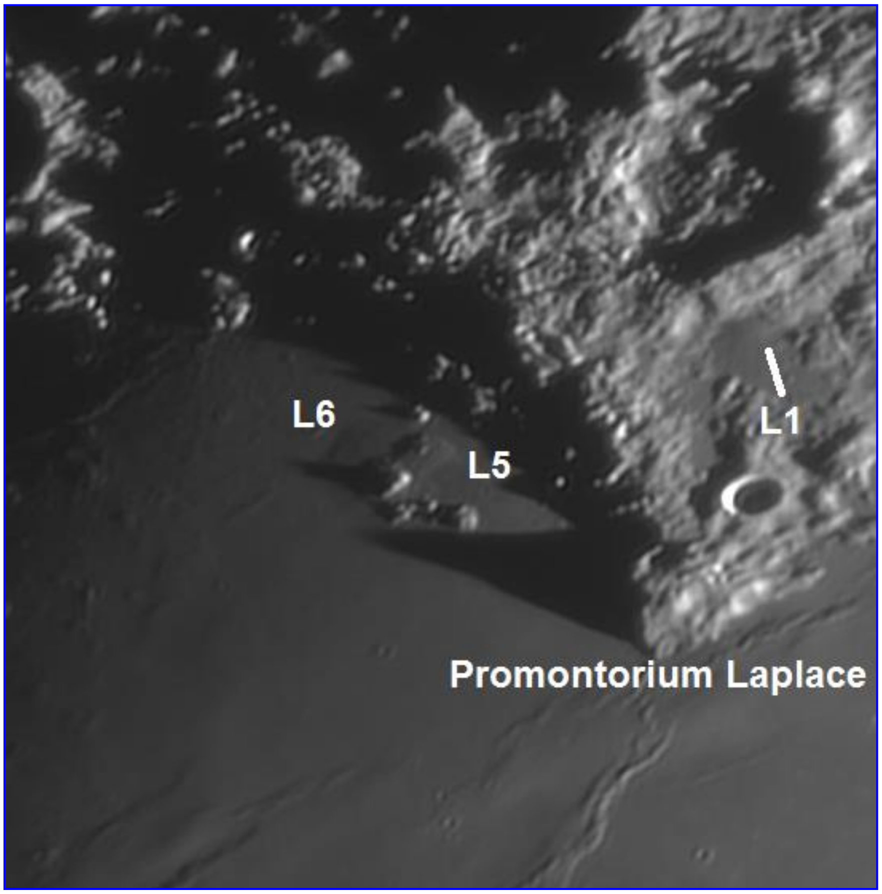


Figure 4. *Image by Phillips taken on November 17, 2018 with a 254 mm Maksutov telescope.*

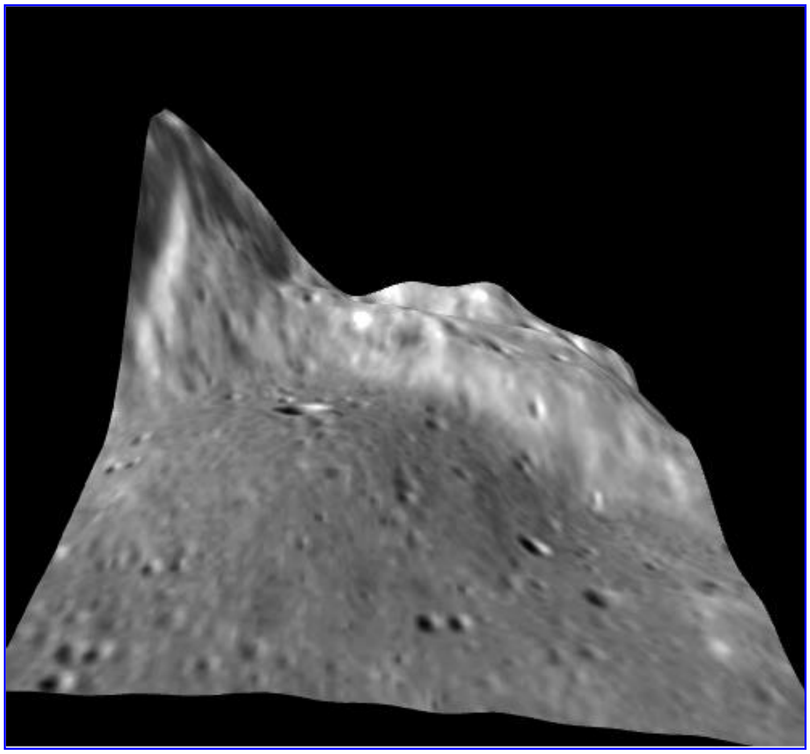


Figure 5. *WAC mosaic draped on top of the global LRO WAC-derived elevation model (GLD100). The vertical axis is 7 times exaggerated.*

Previous domes reported in Sinus Iridum, near Promontorium Laplace, are termed Laplace 5 and 6 (Figs. 1-4).

Laplace 5 (L5) has a diameter of 9.0 ± 0.5 km, height of 125 ± 15 m with an average slope of 1.60° ± 0.10°. The edifice volume is determined to 3.7 km^3. Laplace 5 belongs to class B_2. Rheologic modelling indicates that it was built by lava of moderate viscosity of 2.4×10^5 Pa s, erupting at a high effusion rate of 110 $m^3 s^{-1}$ over a period of time of 1.2 years. The second elongated dome, named Laplace 6 (L6), with a low average slope of 0.7° ± 0.10° is considered a putative intrusive dome, and modelling results indicate that it belongs to class In2 [3]. A map of this region is published in our lunar domes atlas (http://sinusiridumdomes.blogspot.com/).

Spectral data have been obtained using Chandrayaan-1 Moon Mineralogy Mapper (M^3) an imaging reflectance spectrometer that can detect 85 channels between 460 to 3000 nm. The spectrum of the dome (**Fig. 6**) displays a narrow trough around 1000 nm with a minimum wavelength at 980 nm and an absorption band at 2000 nm, corresponding to a typical high-Ca pyroxene signature (Besse et al., 2014), indicating a basaltic composition. The highland to the north of the dome displays a spectrum of more feldspar composition, which lacks any observable mafic absorption feature in the range between 1000 and 2300 nm. Thus, the dome consists of mare material, which contradicts the possible interpretation that this feature is merely an elevated deposit of hummocky material.

The spectral properties of major lunar minerals exhibit absorption bands that differ by their shape and position along the spectral domain. Pyroxenes (orthopyroxenes and clinopyroxenes) have two absorption bands, one centered near 1000 nm and another near 2000 nm. Olivine has a complex absorption centered over 1000nm, with no absorption at 2000 nm. Therefore, olivine-rich lunar deposits are characterized by a broad 1000nm absorption band which is enhanced relative to the weak or absent 2000 nm band (**Fig. 7**).

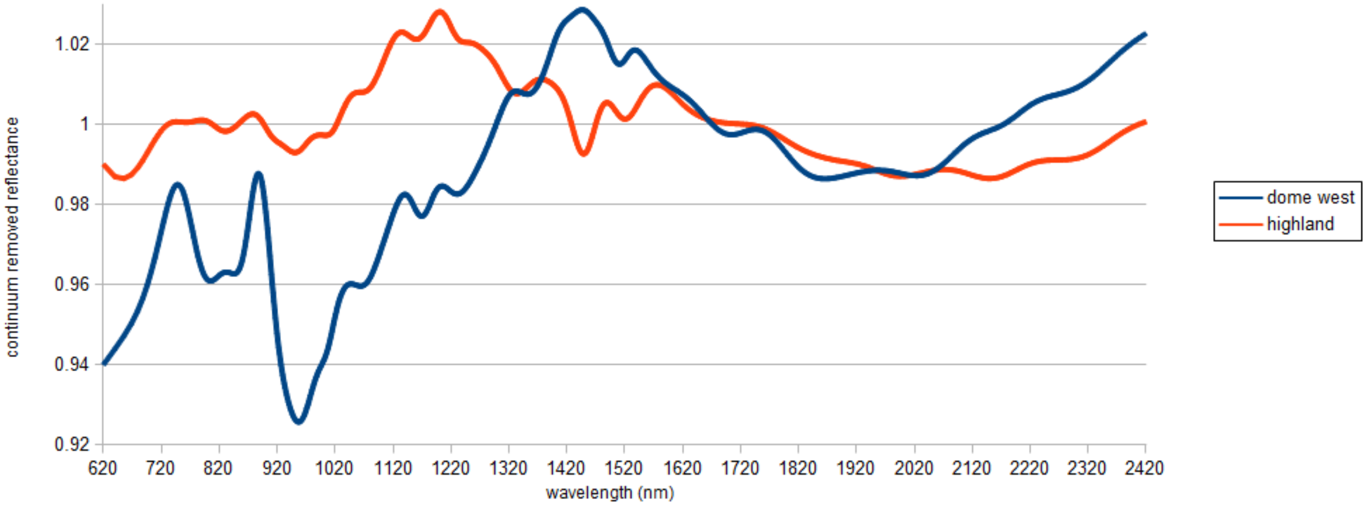


Figure 6. *Moon Mineralogy Mapper (M^3) spectra of the examined dome identified by Teodorescu and the highlands north of the dome.*

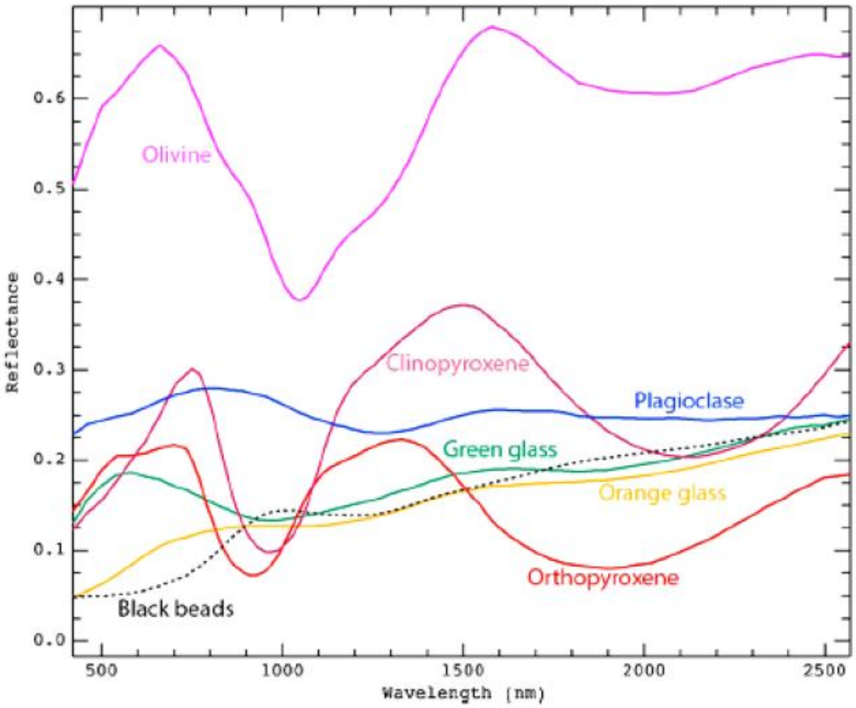


Figure 7. *Spectral properties of major lunar minerals, including volcanic glasses.*

We encourage more high-resolution imagery of this dome, which has been not characterized in the morphometric and spectral properties yet. Further analyses are in progress. Please check also your past imagery and send them to us for the ongoing study (lunar-domes@alpo-astronomy.org).

References

[1] Basaltic Volcanism Study Project, 1981. Basaltic Volcanism on the Terrestrial Planets. New York: Pergamon Press.
[2] Lena, R., Lunar domes, chapter in Encyclopedia of Lunar Science Editor: Brian Cudnik, 2015, Springer ISBN: 978-3-319-05546-6.
[3] Lena, R., Wöhler, C., Phillips, J., Chiocchetta, M.T., 2013. Lunar domes: Properties and Formation Processes, Springer Praxis Books.
[4] Besse, S., J. M. Sunshine, and L. R. Gaddis (2014), Volcanic glass signatures in spectroscopic survey of newly proposed lunar pyroclastic deposits, J. Geophys. Res. Planets, 119, doi:10.1002/2013JE004537.

Mosaic Analysis

Darryl Wilson

Initial Observations

The sun is nearly directly above Copernicus in this thermal image mosaic, **figure 1**, taken about 3:00 UT, September 16, 2019. A visible light image, **figure 2**, taken at the same time is dominated by bright rays and bright clutter from small, highly reflective craters and other high albedo features in the highlands.

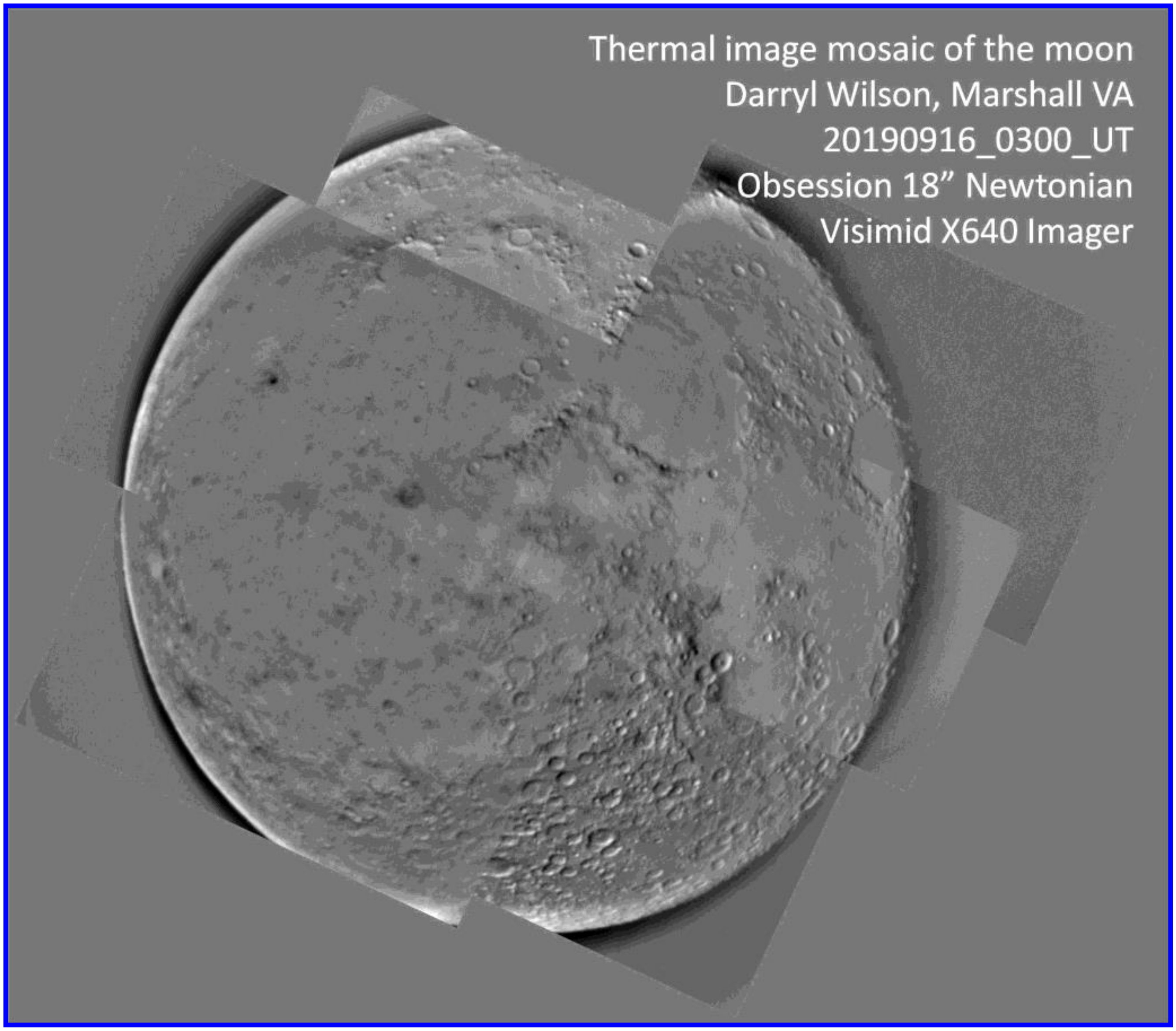


Figure 1

The thermal image is quite different. Most of the brightest rays are visible, but only as muted, somewhat darker, low contrast features. The clearest examples in this image are those of Copernicus and Kepler, although some of those in the Tycho system are also visible.

Figure 2

One of the most obvious differences is that almost all craters are clearly delineated. It's as if the terminator was simultaneously everywhere. The common knowledge that the full moon is a bad time to observe crater detail is clearly not valid in the thermal infrared wavelength range.

Careful examination of the image mosaic reveals an interesting pattern. As one moves away from the subsolar point (Copernicus), crater shadows are formed as though the illumination source was directly above Copernicus. Craters in the north polar region (e.g. Aristoteles and Eudoxus) appear to be illuminated from the south and craters in the south polar region seem to be illuminated from the north. Neither of these patterns are ever obvious when we observe the moon in visible light. Craters near the eastern limb have the familiar look that we expect during a waning gibbous moon. To the west of Copernicus however, the crater shadow pattern reappears. It is more difficult to see due to the comparative lack of medium and larger sized craters in Oceanus Procellarum, but if one carefully examines Marius and Reiner a brighter far wall and dimmer nearside are both definitely visible.

Mare Vaporum and Sinus Medii appear warmer than their surroundings, as does the area within 100 miles just north of Aristarchus, and Grimaldi. The extremely bright areas near the limb, mainly at the polar regions, are image processing artifacts due to imperfect flat fielding and should be ignored.

Aristarchus is the coolest area in the image. Copernicus and Byrgius are also notably cooler than their surrounding regions. No other craters show similar strong temperature differences. The area surrounding Delambre, just SSW of the Apollo 11 landing site appears to be cooler than most of the rest of the surface, and the cooler area extends WNW to the region between Mare Vaporum and Sinus Medii. Thermal striations can be seen on the eastern side of Mare Vaporum, and they correspond to lower albedo striations that can be seen in visible images.

Discussion

Surface areas with high albedo reflect more solar irradiation than those that appear darker in the visible. This causes them to warm more slowly, and to reach a lower maximum temperature during the lunar day. So, the cooler temperatures evident at Copernicus, Aristarchus, Byrgius, and other regions is expected.

The visually bright ray systems of Copernicus, Kepler, and Tycho appear as somewhat blurred features, slightly darker (cooler) than the background mare. This is also expected due to their higher albedo as compared with the mare.

Albedo induced cooling also explains why the myriad of small, highly reflective craters appear as dark spots in the thermal image. Correspondingly, the floor of Plato appears warmer than most of the mare, presumably because its albedo is lower, causing it to absorb more thermal energy after sunrise.

The unexpected and interesting observation is that not all areas that are apparently equally bright in the visible show the effects of albedo induced cooling. For example, Copernicus appears notably cooler than Arzachel, a similarly sized crater that also has terraced walls and a central peak. The walls of Copernicus are one of the coolest features on the entire disk. Arzachel's interior walls show the effects of thermal shadowing as a result of the crater's location far from the subsolar point, but overall, they appear much warmer than those of Copernicus. The central peak of Arzachel appears to be cooler than the floor, but Copernicus' central peaks seem to be even cooler. Overall, the crater appears to be significantly warmer than Copernicus. Perhaps Copernicus' albedo is higher than is visually apparent from figure 2.

The enhanced visibility of many craters far from the terminator is interesting. Apparently, something close to a thermal equilibrium is established between insolation, which is proportional to the solar elevation angle, and radiative cooling. The temperatures of the side of the wall facing the sun, and the opposite wall, which receives sunlight at a more oblique angle, adjust to significant heat differences. As the sun drifts across the lunar sky, this energy balance is constantly changing at every location on the crater walls, and it changes rapidly enough to cause shadow detail to always appear to be oriented radially outward from the subsolar point on the disk.

Mare Vaporum and Sinus Medii are two of the lowest albedo features on the disk of the full moon. They are also near the equator; thus, they receive solar radiation of maximum intensity. These two factors easily explain why they appear warmer than their surroundings. The area just north of Aristarchus also has significant surface area of relatively low albedo, although it is more heterogenous than Mare Vaporum. Radiometrically calibrated imagery would be helpful in explaining the increased temperature on the surface here.

The apparent warmness of Grimaldi is somewhat puzzling. In the visible light image, Grimaldi appears to have about the same albedo as the adjacent area of Oceanus Procellarum. This implies that they should have absorbed about the same amount of solar energy, and be at about the same temperature. One of three possible explanations is likely. First, since Grimaldi is near the limb, the electromagnetic radiation that reaches us left the surface at a shallow angle. At very shallow angles, bidirectional reflection distribution function (BRDF) effects sometimes become prominent. BRDF effects are deviations from lambertian (isotropic) reflection behavior. Perhaps the observation angle for Grimaldi has become shallow enough for it to exhibit this effect even though the adjacent mare does not yet show it in our image. Second, perhaps Grimaldi, or at least part of it, actually has lower albedo than the mare, even though it is not obvious in the visible light image. Third, it might be an image processing artifact due to the imperfect flat fielding technique employed. Although this image is largely free of these artifacts, it is not completely so, and these artifacts are most pronounced near the limb.

Aristarchus is the brightest area on the lunar disk, so it should be expected to exhibit the greatest amount of albedo induced cooling, and it does. It is by far the darkest feature in the thermal image.

A large thermal feature in figure 1 extends from the area surrounding Delambre to the region between Mare Vaporum and Sinus Medii. This cooler region is particularly interesting because it is predominately near the equator, where one would expect temperatures to be warmer. There is apparently something different about the lunar surface on this area. The visible light image shows numerous small, bright craters in the region which collectively cause a somewhat higher albedo than much of the rest of the highlands. So perhaps it is just albedo induced cooling averaged over the area. The difficulty with this hypothesis arises when we examine the area surrounding Tycho. It appears at least as bright, but it does not appear cooler than its surroundings. The only obvious difference that author can see between the two regions is that from the area near Delambre to Mare Vaporum there are a number of linear features that all extend approximately from the NW to the SE, exactly along the long axis of the cooler area. These features are not visible in figure 2, but they are easily seen on Sky & Telescope's 2012 Moon Map. No such linear features are visible in the highlands area near Tycho. Only circular craters are seen there. Currently, the author can offer no causal explanation of this phenomenon.

The thermal striations on the eastern side of Mare Vaporum are another interesting example of lower albedo features warming more that brighter ones.

As always, the lack of radiometric calibration leads to large uncertainties when interpreting the imagery. Without calibrated images, it is often impossible to know if location X, which is brighter than location Y, is really warmer. If the locations are not too far apart, then we can usually be reasonably sure that brighter really does mean warmer. But there are sometimes exceptions. And even if brighter does mean warmer, it is certainly true in these images that equal steps in brightness do not represent equal steps in temperature. The next version of control software for the camera should provide brightness, contrast, and gain controls that will alleviate this problem. At that time, many of the above questions and issues may be quickly resolved.

Lunar Nighttime Thermal Analysis
Darryl Wilson

Initial Observations

Four pairs of images are included in this article. Each is composed of a thermal image of the moon and a visible light image of the same region of the lunar surface taken at about the same spatial resolution. There is a significant time difference between the images in each pair. This is intentionally done so that the visible light reference image can show the area on the moon that correspond to the glowing areas in the thermal images. Some of the thermal features are visible more than two days after lunar sunset, so the lunar phase corresponding to the visible light images had to be two to three days earlier than that of the thermal ones. The thermal images were taken on two dates, September 20 and October 19, 2019.

Numerous bright spots can be seen in the thermal images. Almost all correspond to the locations of small craters. The following ten locations are circled and labeled:

A – Bessel
B – Dawes
C – Ross
D – Area immediately SW of Julius Caesar
E – Broken crater wall
F – Burg
G – Grove
H – Hercules
I – Proclus
J – Messier/Pickering

For selenographic reference, a white "X" marks the location of the Apollo 11 landing site in the Sea of Tranquility. About 250 miles to the SW, another "X" marks the Apollo 16 landing site. All of the above craters are responsible for hotspots in the thermal images. There are many other hotspots for which the author does not have crater names or designations, so they remain unlabeled here. Most of the spots are associated with craters from about 5 to 10 miles in diameter. Craters larger than about 10 miles in diameter do not seem to produce glowing bright areas in the lunar night. Craters smaller than about 5 miles in diameter are also not visible.

The thermal image in **figure 1** was taken on September 20, 2019. Sunset on the Sea of Tranquility occurred September 19, one earth day earlier. The visible light image in **figure 2** was taken on September 18, 2019, two days prior to the thermal image. The Apollo 11 landing site had been in darkness almost 24 hours at the time the thermal image was taken, and the Apollo 16 landing site had experienced sunset just an hour or so earlier. Bessel (A), Dawes (B), and Ross (C), are clearly visible as warm spots, as are numerous other small craters.

Within a few hours of sunset, immediately adjacent to the terminator, features other than small craters are still sometimes visible. Immediately SSE of Julius Caesar a somewhat amorphous warmer area (D) doesn't correspond to any apparent crater at this resolution. Also, about 15 miles east of the Apollo 16 landing site, two closely spaced bright spots (E) seem to correspond to parts of a crater wall.

Figure 1

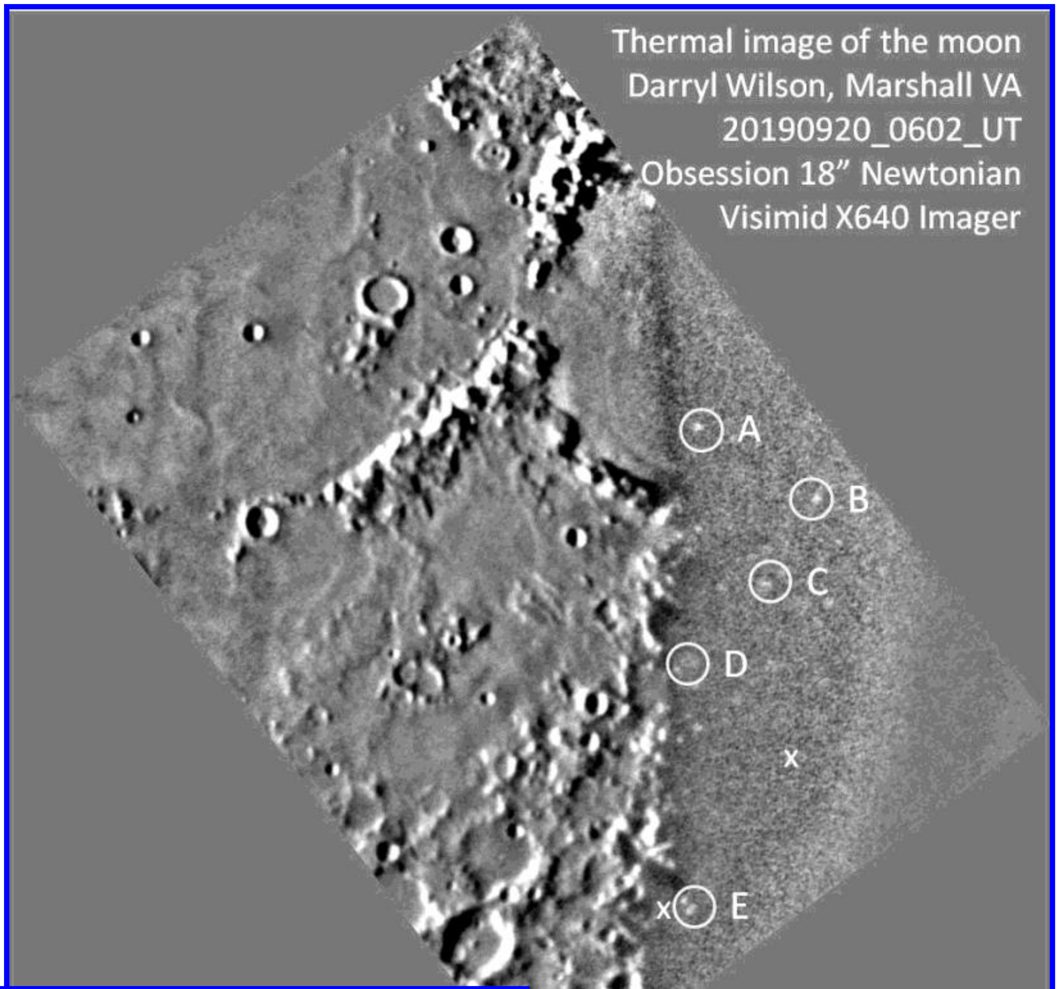


Figure 2

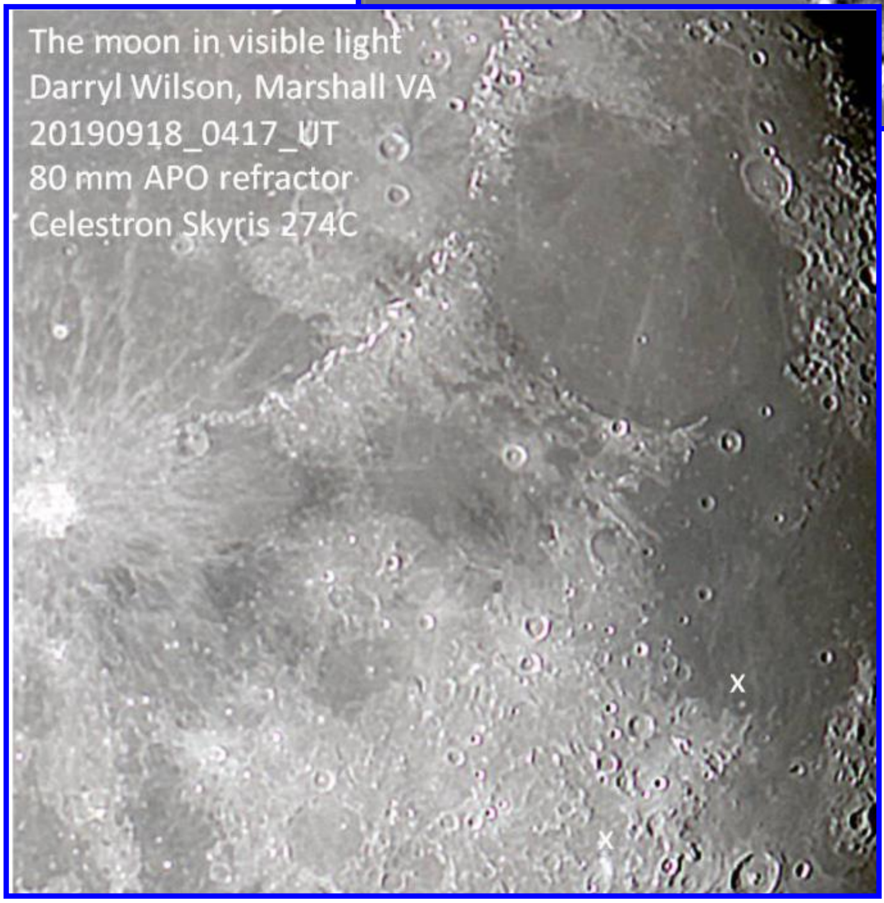


Figure 3 shows the same region of the moon, imaged about 16 minutes before Figure 1. It apparently has lower SNR (signal to noise ratio) than figure 1, since only the brightest spots are visible. Bessel (A) and Dawes (B) are labeled.

Figure 3

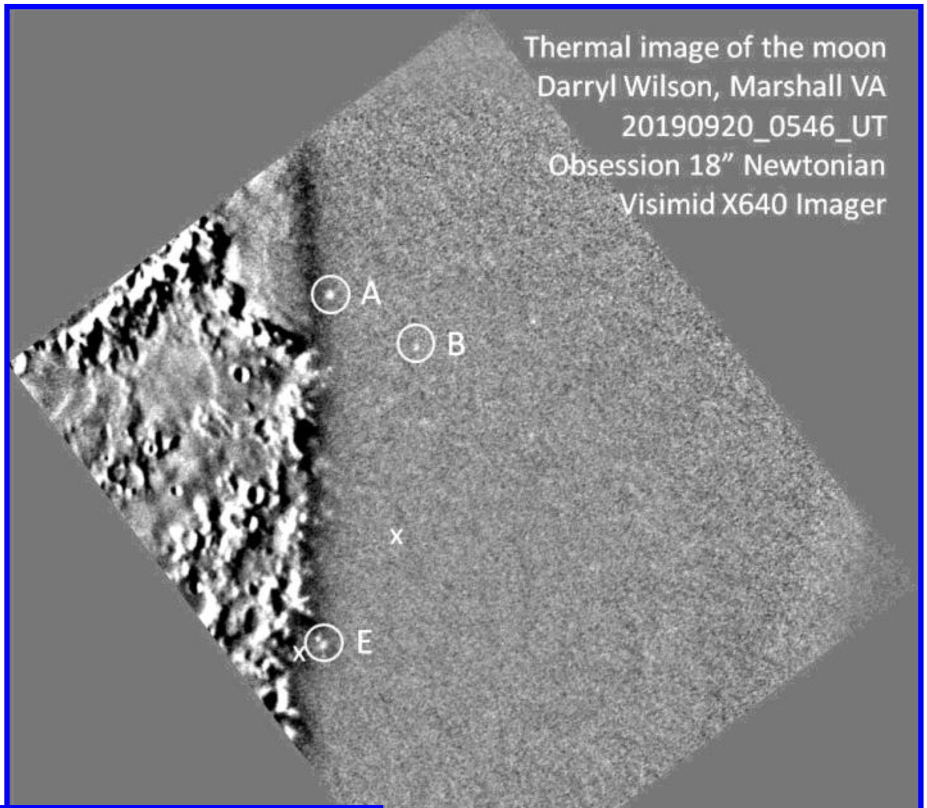


Figure 4

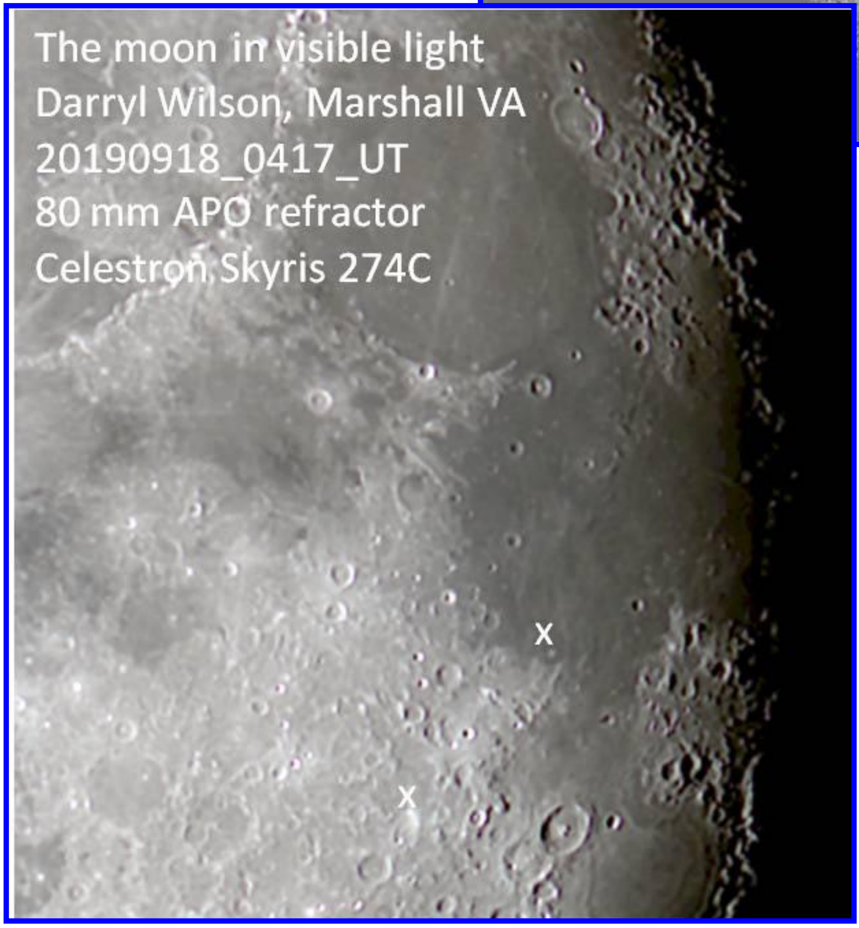


Figure 5 shows bright spots corresponding to Burg (F), Grove (G), and a location inside Hercules (H), as well as a number of other small craters. Immediately to the right of Hercules is a diffuse bright area that seems to correspond to the interior of Atlas. This area was not circled and labeled in order to limit clutter in the annotated image.

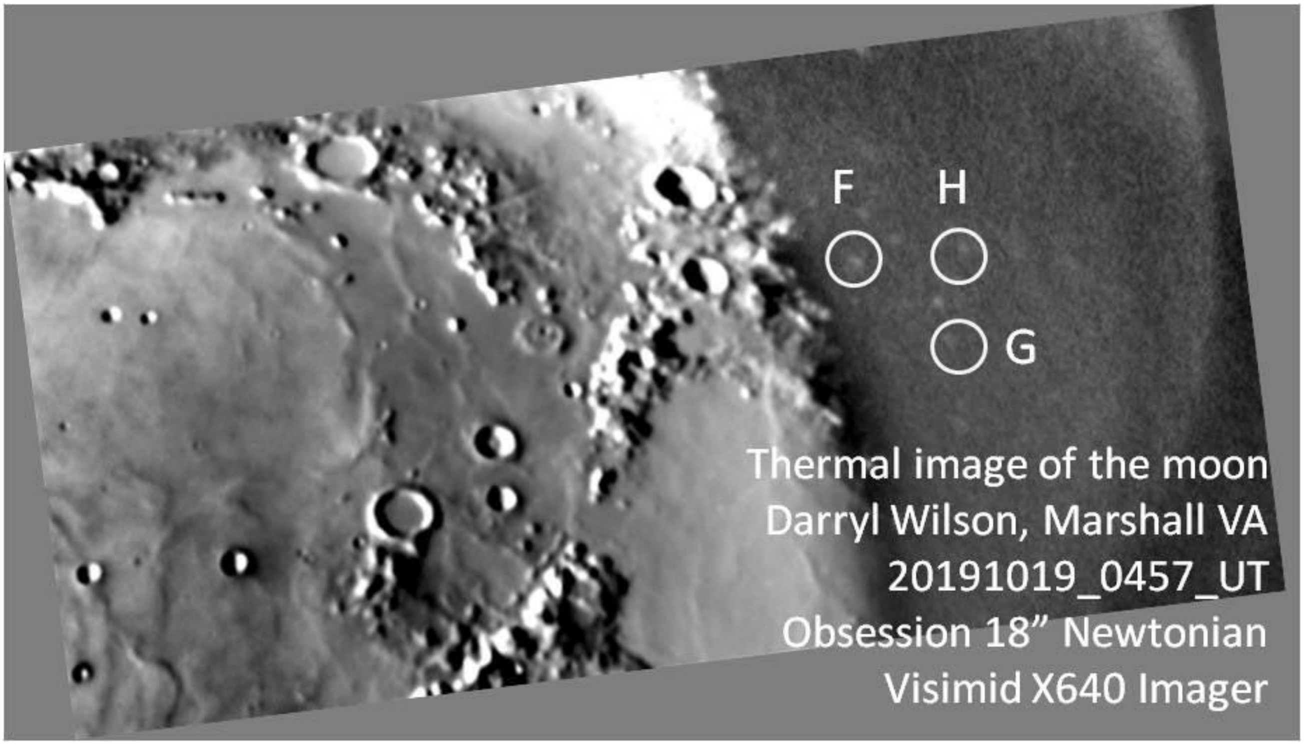


Figure 5

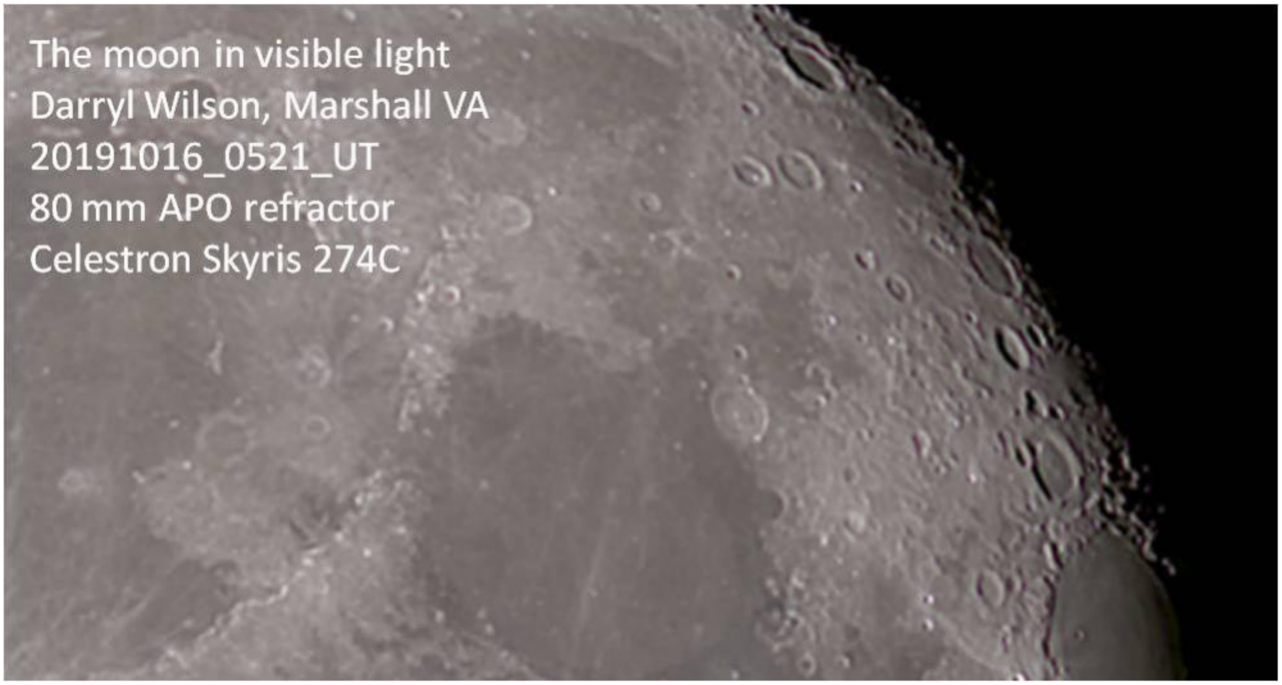
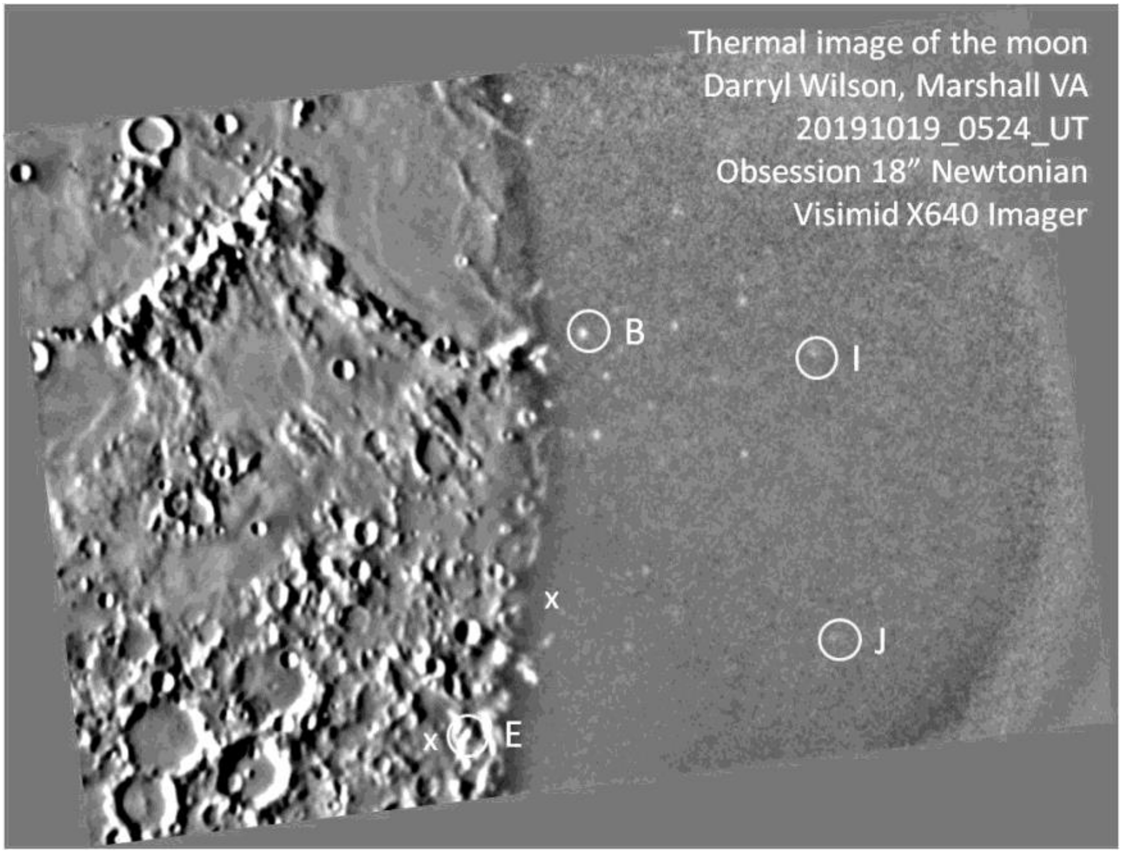


Figure 6

Figure 7 shows bright spots caused by Dawes (B), Proclus (I), the Messier/Pickering pair (J), as well as many others. For reference, the broken crater wall next to the Apollo 16 site (E) is also noted.

Figure 7



Thermal image of the moon
Darryl Wilson, Marshall VA
20191019_0524_UT
Obsession 18" Newtonian
Visimid X640 Imager

The moon in visible light
Darryl Wilson, Marshall VA
20191016_0521_UT
80 mm APO refractor
Celestron Skyris 274C

Figure 8

Although craters in the 5 to 10 mile size range tend to remain visible for many hours - even days – after sunset, other types of surface features, including the sun facing side of crater walls, mountain peaks, and basalt lava plains apparently cool rapidly and are not visible in the images more than a few hours after lunar sunset. Additionally, the lunar limb was not apparent in any of the images processed so far.

Lunar Nighttime Thermal Analysis - Discussion

The appearance of small craters glowing in the lunar night is likely due, at least in part, to something known as the cavity effect. It is known that concave areas in thermal images appear to have higher emissivity than flat areas of the same material at the same temperature. The deeper the concavity, the greater the effect. Most of the craters listed above are relatively smooth, deep concavities.

The cavity effect may not be the entire story though. Geometric calculations can show that the center point in a crater that is six miles in diameter and one mile deep is only exposed to about 2/3 (68.4%) the area of the sky that a point on a flat surface (e.g. mare) would be. Radiative cooling is the only mechanism available to the surface after sunset. Therefore, a point on the mare surface will experience cooling at a 50% greater rate than a point near the center of the crater.

These geometric effects at least partly explain why mountain peaks, flat plains, and isolated walls apparently cool more rapidly to a point below the limit of detectability, and do not continue to visibly glow after sunset. The resolution of these thermal images is about 6 or 7 miles at the lunar surface, which should explain why craters smaller than about 5 miles in diameter are not seen to glow in the night. The sudden cutoff in visibility for craters larger than about 10 miles in diameter is a little puzzling, though. In general, the larger the crater, the less deep the concavity. This partly explains the observation, but other factors may also be involved. Further analysis is needed.

The somewhat amorphous warmer area immediately SSE of Julius Caesar is currently unexplained. At this resolution, the visible image does not show any obvious cause. Likewise, the comparatively warm area in the vicinity of Atlas does not follow the pattern of almost all of the other nighttime thermal features. Perhaps examination of higher resolution imagery will prove enlightening.

The two bright spots just east of the Apollo 16 landing site are probably easy to explain. There is a somewhat broken crater wall in that vicinity. It would have received solar illumination at a steeper angle than the adjacent surface until the time of sunset, and it would have continued to be illuminated for an hour or so after sunset on the adjacent area. Since sunset just occurred, it had not had time to cool.

Individual frames from the thermal imager are visibly noisy, and stacking multiple images results in a final image with higher SNR. The September 20 images here show the result of stacking about 41 individual frames. Further processing with larger image stacks will extend the limit of detectability, and reveal more details of the surface after sunset.

Both images are the result of stacking about 41 individual, raw frames. So, they might be expected to have comparable SNR. Figure 5 is the result of a 360-frame stack, while figure 7 is a 160-image stack. It is unsurprising that improving the SNR increases the number of features that can be detected after lunar sunset. As reported in the September TLO article, the current version of software available with the Visimid X640 has limited functionality. It does not provide for exposure, gain, or gamma control. The camera's electronic auto-gain feature results in a constantly changing sensitivity that affects image brightness, contrast, SNR, and vignetting. The next version of control software from Visimid should greatly improve the situation, and may allow thermal imaging of the nighttime surface in a manner analogous to visible light imaging of earthshine.

This report shows that thermal imaging in the 8 to 14-micron region of the spectrum can be used to capture details on the lunar surface for more than 48 hours after sunset. With improved software control, the capability can be extended. It is hoped that the entire surface can be imaged into the lunar night so that the manner in which the moon radiates the thermal energy that it absorbed during the day may be observed and studied. The radiative behavior during and after a lunar eclipse should prove interesting. Thermal video would be an ideal observation method for such an event. If the next version of the software provides enough capability, it may even be feasible to collect thermal video and post-process to detect transient events such as meteoroid strikes.

Lunar Thermal Imaging – Thermal Imaging Hardware Availability

The imager used to collect all of the images in this article is a Visimid X640. It can be purchased through the company's website and is available in the U.S., and can be exported to numerous other countries. I would recommend that anyone who is interested contact the company directly and explain the intended use of the camera, since astronomy is not their primary focus. They should be able to ensure that you get the best version of the software, and they can eliminate the lens thread grease that provides protection against accidental submersion in water. This will make it easier for you to remove the camera lens – necessary to use your telescope as the primary optic. They are currently in the process of developing a new version of their application software, and the author has provided several user-interface suggestions that would be useful to amateur astronomers. Since purchasing a camera from Visimid, the author has had a pleasant rapport with the staff, and hopes to continue a productive relationship well into the future. They can be contacted at www.visimid.com, (469) 906-2660.

The author's experience with thermal imaging of the moon and planets began several years ago, with another brand of imager. i3System is a South Korean company that sells thermal imagers comparable in performance to the X640. Although no rigorous testing has been performed, a qualitative assessment is that the i3System imaging hardware may be slightly better than the Visimid camera. Unfortunately, the author was unable to successfully install and run the full-featured software that accompanied the i3System imager on a Windows 7 computer system. Apparently, i3System has focused their development efforts on Windows 10 and later. Their control software was much more advanced than Visimid's. Unfortunately, it didn't connect to the camera using Windows 7, and upgrading to Windows 10 was not an option. If you have a Windows 10 system, you might want to consider this option since you might immediately have a full-featured thermal imaging system and an excellent camera. Contact Terry Clausing, Drysdale & Associates, Ph (513) 831-9625, terry@drysdaleenergy.com. They can also supply anywhere in the U.S. and export to several other countries.

Although purchasing a thermal imaging camera is one of the necessary first steps toward producing thermal images of the moon and planets, there are a number of potential pitfalls that must be successfully navigated in order to produce good quality thermal images of the moon. The author hopes to provide helpful guidelines, dos and don'ts, and must-haves in a future article.

A Show of a Few Minutes on the West Rim of Deluc H

Alberto Anunziato

This is an observation experience and not an exact selenographic survey. On October 6th, a couple of observers from the Sociedad Lunar Argentina were observing a series of craters whose observation was required by the Lunar Geological Change Detection Program. Later, at 23.40 UT, we started a walk through the terminator and there we found a surprising bright spot with an indeterminate shape (**Figure 1**) near Maginus. Although it seemed the product of sunlight falling upon obliquely on the surface as the lunar day progressed, the bright spot due to its irregular shape and its size invited the imagination, so we decided to register it (just in case). When consulting the Virtual Moon Atlas, it turned out that it encompassed part of Deluc crater and part of Deluc H. In the minutes that passed between the consultation of the atlas and the very elementary drawing of the craters to register the bright area, the bright spot had varied and was limited to Deluc H and part of the northern rim of Deluc (**Figure 2** at 00.12 UT on October 7th). Now it clearly encompassed the western third of Deluc H and part of the northern edge of Deluc. We went to dinner and took out the telescope later to see how the bright area had changed, at 4.15 UT the shadows inside Deluc H were still receding (**Figure 3**). We were interested in reporting a bright phenomenon that lasted a few minutes, we could not observe its beginning but we did observe how it disappeared quickly. A unique moment in the lunation (colongitude 8.2º) that we intend to observe again. There are not many images of the Deluc-Deluc H pair. The best belongs to the old reliable Lunar Orbiter mission. In “Photo Nº IV.118-H3”, which corresponds to Plate 478 of the “Lunar Orbiter Photographic Atlas of the Moon” (David Bowker and J. Kendrick Hughes, NASA, 1971), we can observe what motivated the intense brightening: the first rays of the Sun hits the highest area of the pair of craters: the north slope of Deluc on which the meteorite that generated Deluc H impacted and exposed internal and "fresh" material that reflects more strongly sunlight.

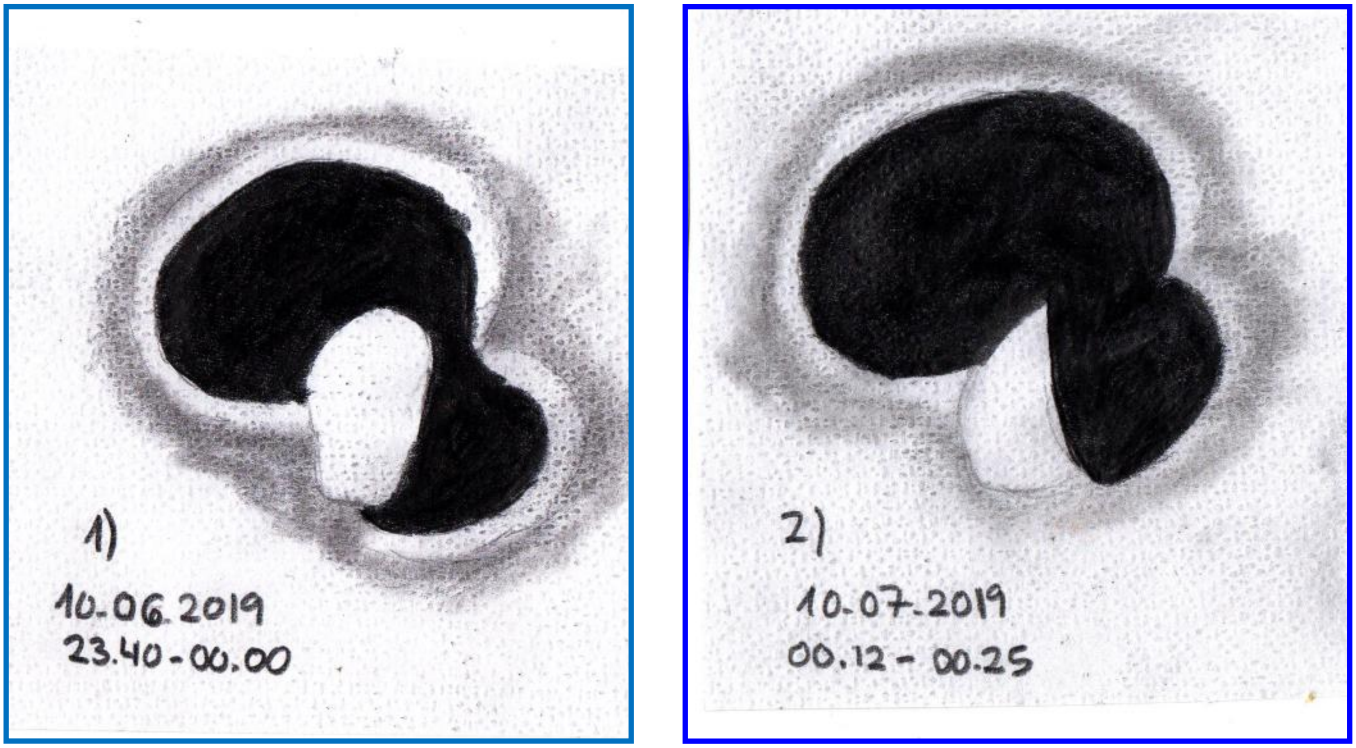


Figure 1 (left) and Figure 2 (right). Deluc and Deluc H*, Alberto Anunziato, Paraná, Argentina . 06-07 October 2019 2340-0025 UT. Meade ETX 105 Mak-Cass, 154 x.*

***Figure 3. Deluc and Deluc H**, Alberto Anunziato, Paraná, Argentina . 07 October 2019 0425 UT. Meade ETX 105 Mak-Cass, 154 x.*

***Figure 4.** Photo Nº IV.118-H3, Plate 478 of the "Lunar Orbiter Photographic Atlas of the Moon" (David Bowker and J. Kendrick Hughes, NASA, 1971).*

The Bay of Rainbows
David Teske

Sinus Iridum, the Bay of Rainbows, is the most splendid of all the lunar bays. Captured near sunset in the image below, I am amazed at the ripples of lava that flow into the bay, much like gentle water waves at the edge of the sea. Sinus Iridum is the striking landmark on the northwest shores of Mare Imbrium. Sinus Iridum has a diameter of about 260 km with a surface area of 237,000 km^2, about the size of the state of Kentucky. As such, it may actually be one of the smaller impact basins. It is the remains of a giant impact crater bordered on the northwest by the Jura Mountains, which are a portion of the original crater wall. Named after the Jura Mountains of Earth by Giovanni Riccioli in 1651, the Jura mountains are composed of several lines of parallel, concentric mountains 30 km wide with peaks up to 4,000 m high. These mountains terminate in the southwest with Promontorium Heraclides with a height of 1.7 km. This was named the 'Moon Maiden' by Cassini back in 1692 as it has the shape of a lady's head near lunar sunrise, around 10.5 day past New Moon. The Jura mountains abruptly stop in the southeast at Promontorium Laplace which tower 2.6 km high. The lava plains of Sinus Iridum has several small craterlets and crater pits. Under low sun angles such as the sunset image, a series of wrinkle ridges are visible within Sinus Iridum that are parallel to each other and the Jura mountains. The wrinkle ridge that crossed Sinus Iridum to southeast may be related to the inner wall of the Imbrium Basin.

So, what formed this remarkable and beautiful lunar bay? Sinus Iridum was likely formed after the Imbrium impact, but before the various lava flows which flooded the Imbrium Basin. That means that an asteroid some 15 km across slammed into this area 3.2 to 3.8 billion years ago. Perhaps the asteroid slammed into Mare Imbrium at such an angle that the southeast was of Sinus Iridum was totally buried by the basin. Since the southeast wall of Sinus Iridum is missing, the most likely explanation is that the Sinus Iridum projectile impacted on the sloping floor of the Imbrium basin and that the southern rim is buried under mare lavas. Promontorium Heraclides tapers down in height, suggesting this tilting, but Promontorium Laplace ends abruptly, giving evidence for faulting that down-dropped Iridum's missing rim. If this is the case, could there be a large, Apennine scarp-like feature buried under Imbrium lavas that was the rim of Sinus Iridum? Upon researching this subject, I find another theory that Sinus Iridum was formed before Mare Imbrium and much later filled with lavas from the basin. This theory is supported as the northern edge of the bay lies 600 m below 'sea level', as if the lava was unable to fill the bay completely.

As you ponder the origin of the Bay of Rainbows and marvel at its majestic beauty, you are looking at the site of two lunar landings and rovers. The Soviet probe Luna 17 landed 30 km from Promontorium Heraclides on November 17, 1970, which released Lunakhod 1, an eight wheeled rover remotely controlled from Earth. It journeyed around 12 km in the next 11 months. More recently, the first Chinese lunar lander Chang'e 3 landed on December 14, 2013 just southeast of Promontorium Laplace and released the small rover Yutu. The Yutu rover survived and sent back data for 31 months, well beyond the expected three-month lifespan.

References

Chu, Alan, Wolfgang Paech, Mario Wigand & Storm Dunlop. 2012. The Cambridge Photographic Moon Atlas. Cambridge University Press, New York.

Lacroux, Jean and Legrand, Christian. 2003. Discover the Moon. Cambridge University Press.

Legault, Thierry and Brunier, Serge. 2006. New Atlas of the Moon, Firefly Books.

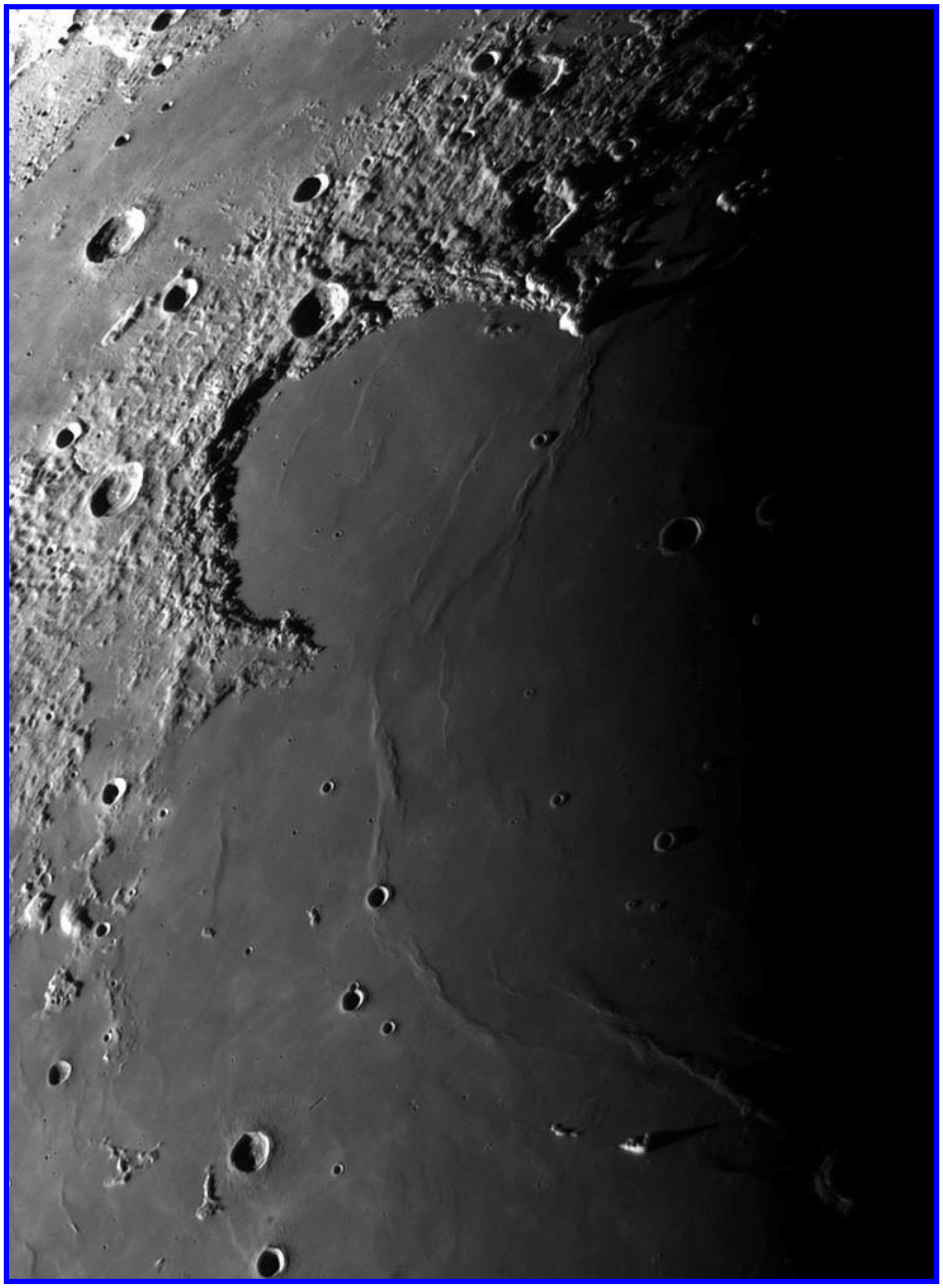
Moore, Patrick. 2001. On the Moon, Cassell & Co.

Shirao, Motomaro and Charles Wood. 2011. The Kaguya Lunar Atlas: The Moon in High Resolution. Springer, New York.

Wood, Charles. 2003. The Modern Moon: A Personal View. Sky Publishing Corp. Cambridge.

Wood, Charles & Maurice Collins. 2012. 21st Century Atlas of the Moon. Lunar Publishing, UIAI Inc., Wheeling.

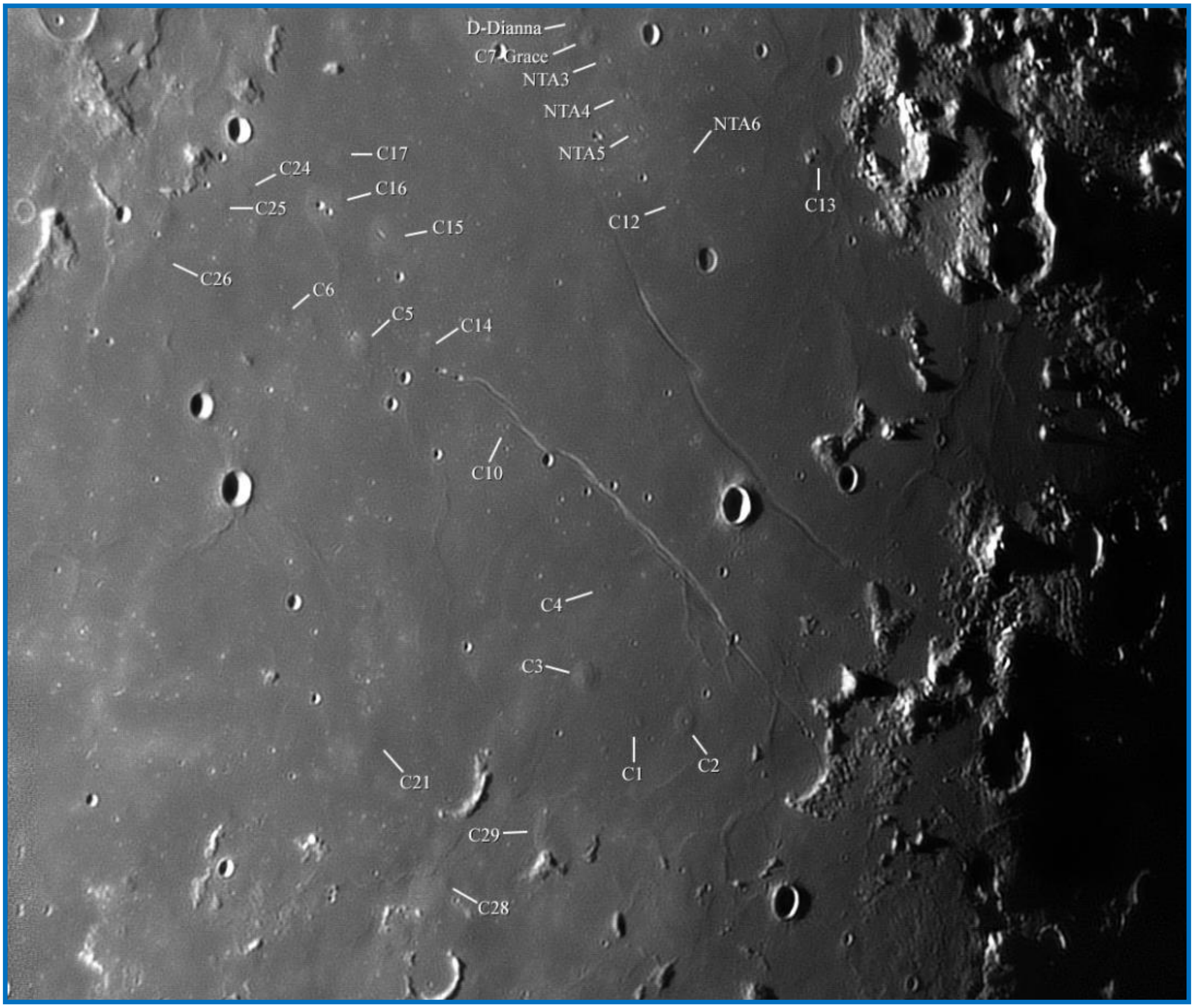
Sinus Iridum, *David Teske, Louisville, Mississippi, USA, 23 September 2019 at 1012 UT. Colongitude 200.8°, Seeing 7/10, 180 mm Takahashi Mewlon, ZWOASI120mms, 500 frames, Firecapture, Registax, Photoshop.*



Cauchy and Northern Tranquillitatis Domes

Howard Eskildsen

There are several more domes here that were not marked and are not visible on this image under this illumination. The domes marked with "C" followed by a number are related to the Cauchy group and the "NTA" relates to "northern Tranquillitatis domes. Prominent domes "C2" and "C3" are also known as Cauchy Omega and Cauchy Tau, respectively. Note the interesting, nearly linear, string of domes at the top of the image. Their alignment is roughly radial to the Imbrium basin. Dome labels were based on the Lunar Domes Atlas GLR group, Vitruvius Cauchy Plate, (see http://vitruviuscauchy.blogspot.com/). The website also has a very interesting discussion of this region as well as a list of the domes' coordinates, measurements, and classifications. Perhaps this area should become known as Domeland II.



Cauchy Domes, *Howard Eskildsen, Ocala, Florida, USA. 17 October 2019 0929 UT, colongitude 135.3°. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 7/10, transparency 4/6.*

Sunset Drama

Rik Hill

I don't usually get to see sunset terminators because of the mountains and trees to my east so this night was a treat because the moon was at such a high declination that it was overhead. A number of my favorites were in one field of view here. The large crater at the top is Aristoteles (90 km) with Mitchell (31 km) taking a bite out of its southeast (lower right) wall. Due south of this pair is Eudoxus (70 km) and east of that, deep in shadow, is Burg (41 km) in the center of the hexagonal Lacus Mortis. All three of these large craters are recent by lunar standards. The latter two are Copernican age of 1.1 billion years or less while Aristoteles is a older, Eratosthenian age between 1.1-3.2 billion years. But if you want something really old, Lacus Mortis, is Pre-Nectarian age may be as much as 4.5 billion years old, that's 18 rotations of our galaxy ago!!

Aristoteles*, Richard Hill, Tucson, Arizona, USA. 18 October 2019 0735 UT, colongitude 149.8*^{o}*. 8" f/20 Mak-Cass, Skyris 445 m camera, 610 nm filter. Seeing 7/10. North is up.*

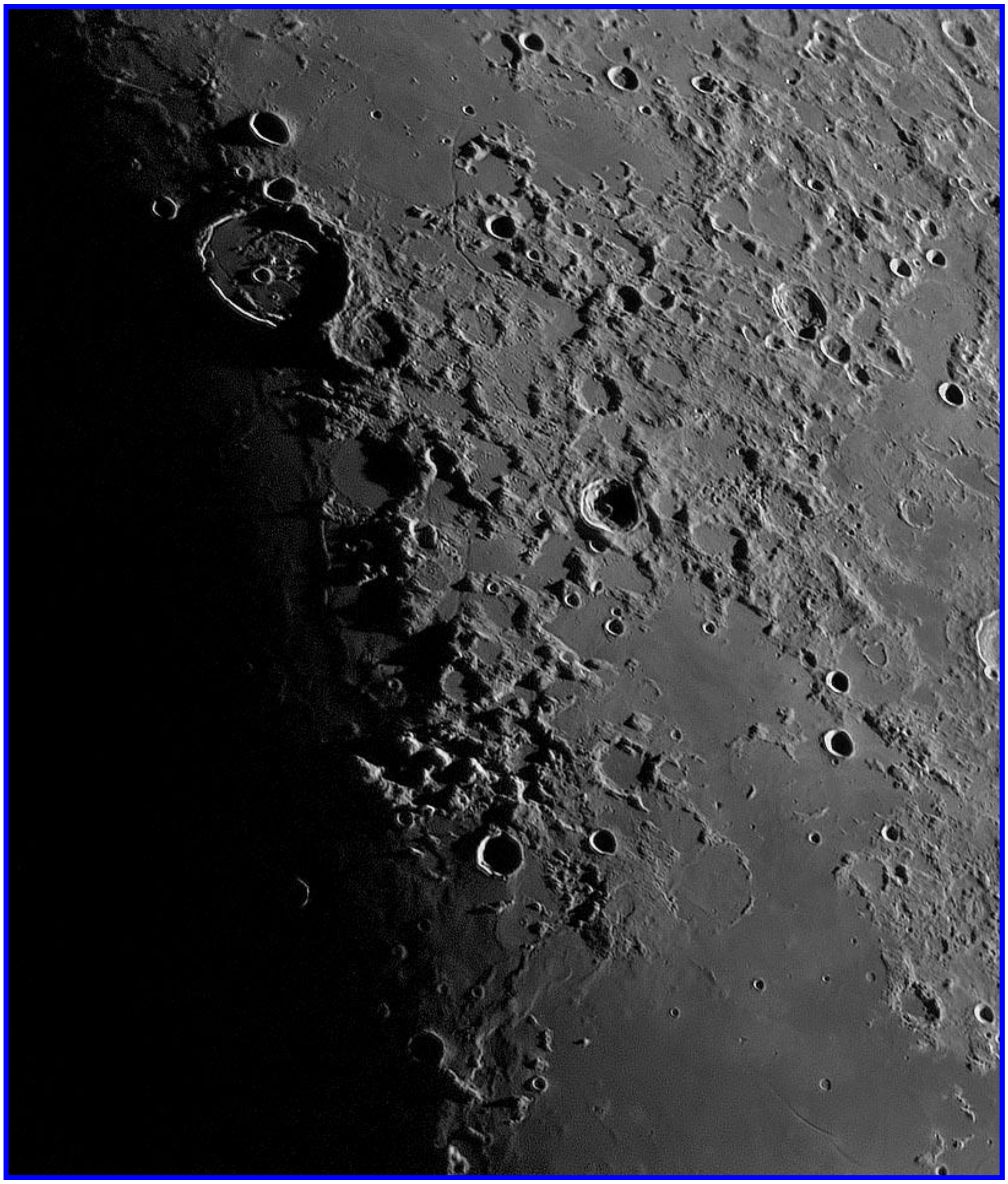
What It's Cracked Up to Be
Howard Eskildsen

On the upper image, Lacus Somniorum is marked by a vertical rill snaking downward towards its namesake crater G. Bond. The upper portion of the Rima G. Bond extends downwards from an unnamed rill which runs roughly west to east across the lacus. Another unnamed rille runs from above Posidonius towards the crater G. Bond, nearly parallel to the more northern unnamed rille.

Farther south, Rimae Romer runs northward across the Montes Taurus from crater Romer, the medium-sized crater to the right of center with a prominent central peak. Sections of the rimae angle upward, through a ruined crater east of Posidonius, and it appears to contact Rima G. Bond.

Good old Posidonius has multiple rilles and faults on its fractured floor. Adjacent to it, Rimae Chacornac crosses its namesake crater and angles downward nearly to le Monnier. Farther south the Rimae Littrow angles towards the northwest margin of crater Littrow. Finally, on the right lower image, Rima Cauchy angles in disjointed curves to the image margin.

__Posidonius to Proclus__, Howard Eskildsen, Ocala, Florida, USA. 03 October 2019 2354 UT, colongitude 332.2°. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, W-25 red filter, DMK 41AU02.AS camera. Seeing 5/10, transparency 5/6.

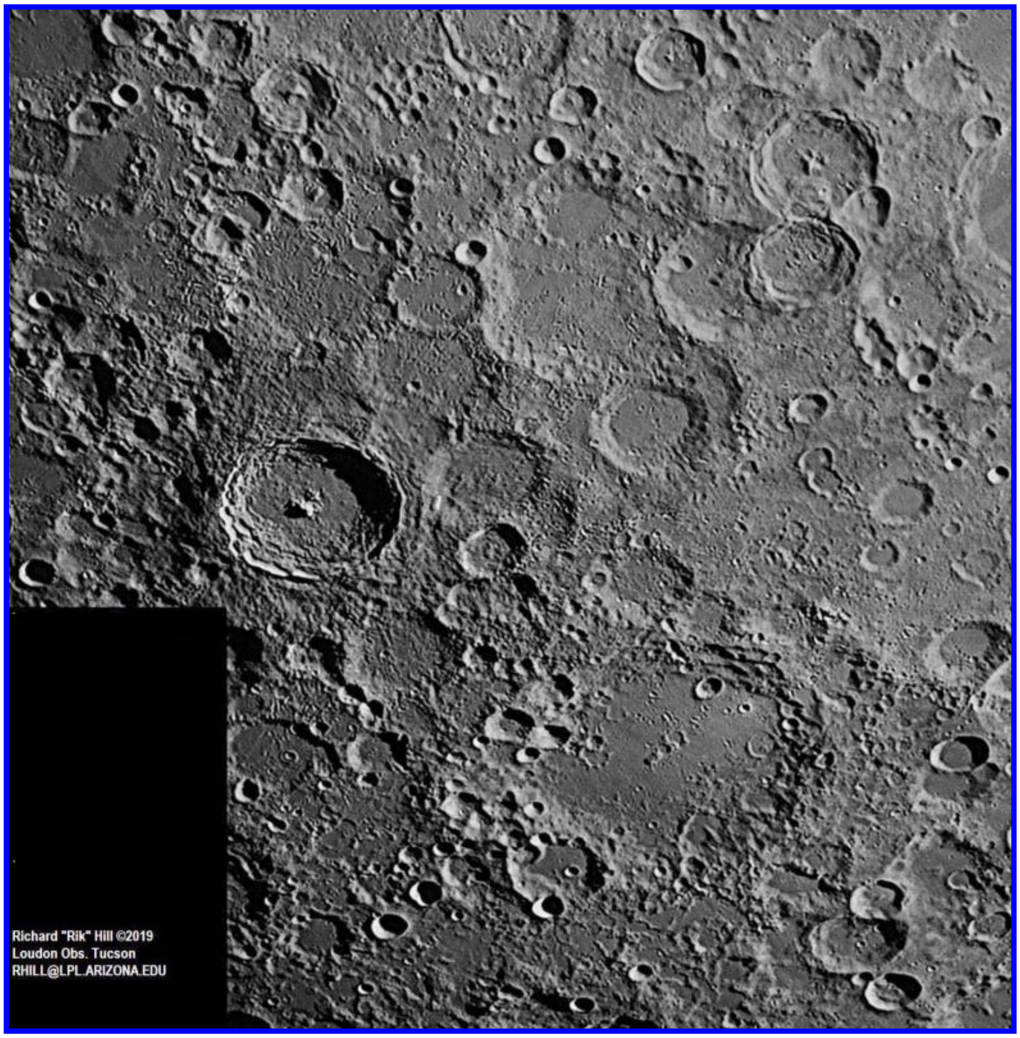


Brahe's Crater

Rik Hill

The area around Tycho is so busy that you have to study it in pieces. Here we start with Tycho (88 km) on the left of center and look to the east (right). One of the first things we run into is below and east of Tycho and the largest named crater in the image, Maginus (168 km) an oft overlooked crater lying between the spectacular Tycho and magnificent Clavius (just off the southern edge of this image). Between Tycho and Maginus is the crater Street (60 km). Then below and to the right of Maginus is a sideways Mickey Mouse formed by three craters. The larger crater of the trio is Deluc (49 km). From Tycho going east we see (65 km) almost adjacent and further is Saussure (56 km) with an interesting flat bottom. Above this Pictet last crater is another large one, Orontius (126 km) with a triplet of craters just east of it in order, Huggins (66 km), Nasireddin (54 km) and above it Miller (77 km). Notice the central peak in this last crater and the material flooded into the southern floor up to that peak. Nasireddin has some nice terraced walls to enjoy and a curious merge of three craters just outside the southeastern wall. But by far the most interesting terraced walls are in the crater due north of Tycho near the top of the image. This is Ball (43 km) on the southern edge of Deslandres just outside tis north edge of this image.

Notice over this whole image there is a splattering of secondary craters from 5 km diameter on down beyond the resolution limit of this image (about 1.5 km). Many of these were created in the Tycho impact around 100 million years ago while most the rest of the large craters in this image range from 3.8 to 4.5 billion years in age. Many of the secondary craters form alignments or streams pointing back at Tycho like the horizontal one in the middle of the image and the one radiating away from Tycho at about 10 o'clock. The more you look, the more you see.

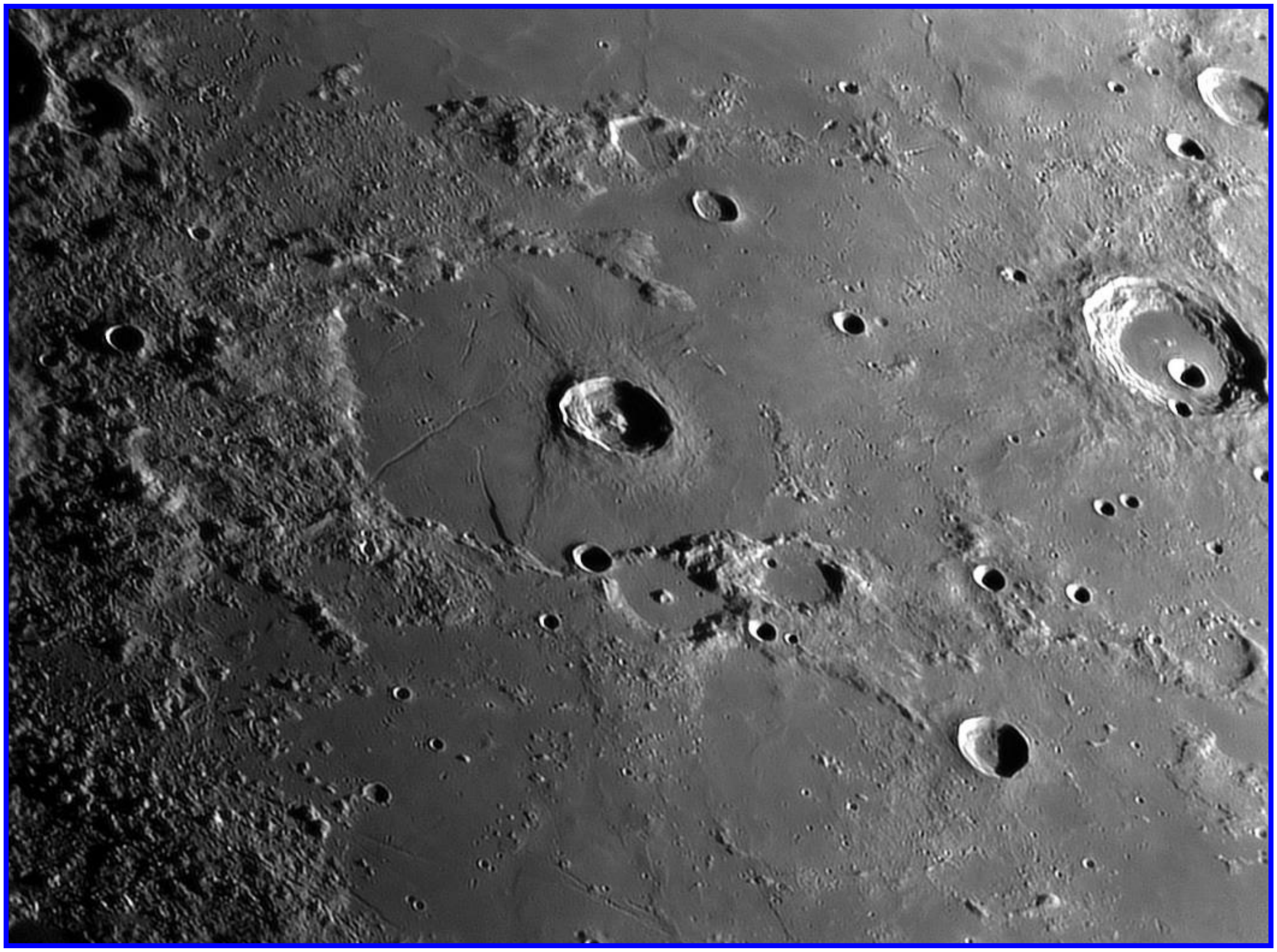


***Tycho East**, Richard Hill, Tucson, Arizona, USA. 14 May 2019 0219 UT, colongitude 27.0^o. 8" f/20 Mak-Cass, Skyris 445 m camera, 610 nm filter. Seeing 8-9/10. North is up.*

Lacus Mortis et al
Howard Eskildsen

Lacus Mortis dominates the image, just to left of center. Burg splashes its ejecta asymmetrically across the floor of Lacus Mortis, and wrinkle ridges angle from the upper and lower lacus rims towards the western rim of Burg. Rimae Burg marks the western floor of Mortis, and on the southern margin one of the rilles transitions into a fault, while another rill crosses into the surrounding Imbrium ejecta at the southwest margin of the lacus.

Two old, tired craters lie south of Lacus Mortis; partially-filled Plana with the obvious central peak, and Mason, which is nearly filled with to its rim. The Clementine color-ratio of the material inside the craters is consistent with mare basalt . Farther south across the ejecta and plains, several branches of Rimae Daniel are visible.

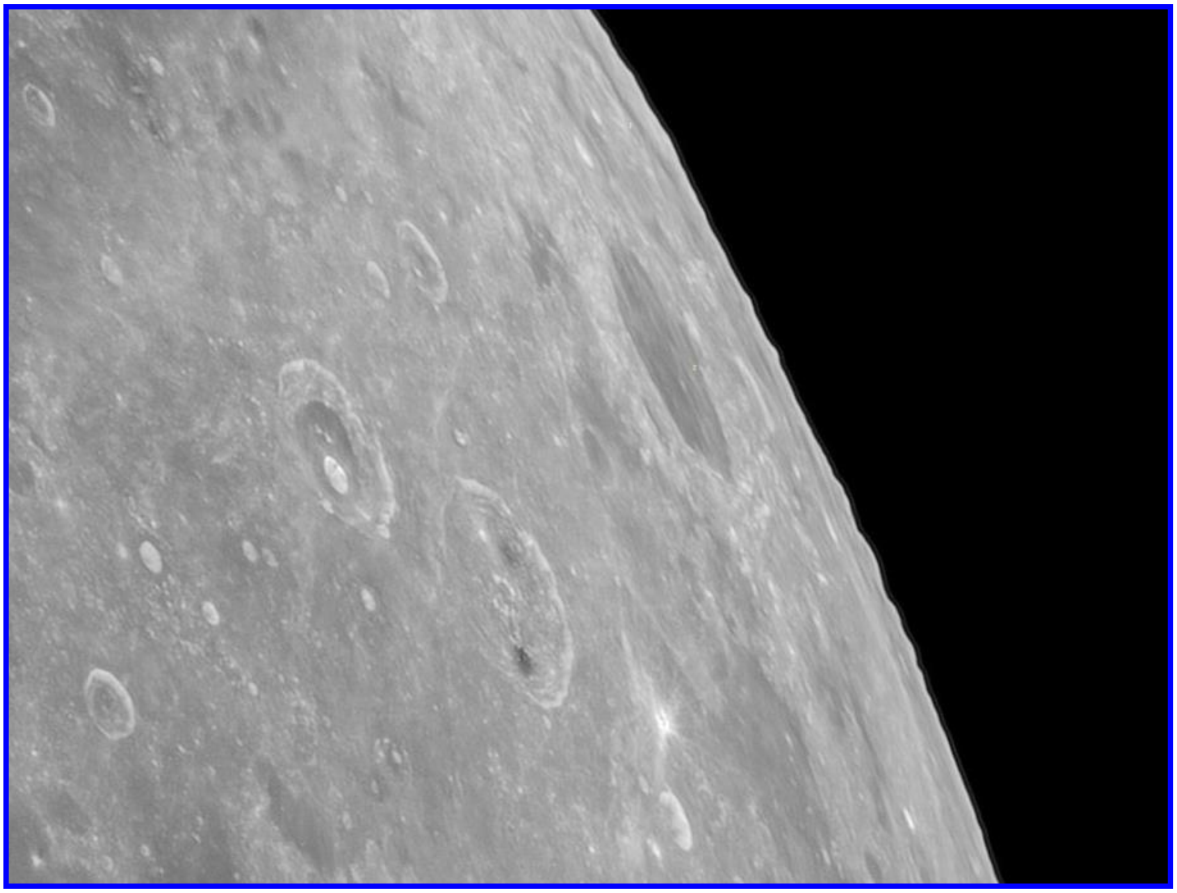


***Lacus Mortis**, Howard Eskildsen, Ocala, Florida, USA. 04 October 2019 2347 UT, colongitude 344.3^o. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 7/10, transparency 4/6.*

Atlas and a Bright Spot on the Full Moon
Alberto Anunziato

Atlas and his eternal companion Hercules are one of the most interesting pairs of craters on the lunar surface. The attractions of Atlas are many: its terraced walls, the cracks and numerous low hills of its rugged floor, its central peak. What attracted us to this image, taken by a member of the Sociedad Lunar Argentina, is an attraction that can only be observed when sunlight strikes the surface vertically. In the words of the remembered Peter Grego (The Moon and How to Observe It, page 147), they are *"two very prominent, well-defined dark, circular spots, each about 10 km in diameter, can be seen within. One lies on the northern floor, the other in the south amid the terracing of the inner wall, and they have no obvious topographical associations other than that they each appear to lie at points where two sinuous rilles begin to branch out across the crater floor".*

There are other wonders to observe at colongitude 106.9º: the dark ground of volcanic lava with low albedo of Endymion, the dark patch of the north of Hercules, the bands of Hercules G and a strange and attractive bright spot between Atlas and Atlas A. Visually observing few years ago I was surprised by that of imprecise shape that I did not find in the atlases and that was the third brightest feature on the lunar surface at 106.9º colongitude. Later I met his unofficial name: "Atlas Companion", with which it appears on the list of bright rays craters of the ALPO's Lunar Section. What causes its high albedo? If you enlarge the image it can be seen that the rays expand towards the 4 cardinal points from a brighter interior area in the shape of an elongated horseshoe. In an image of the Lunar Reconnaissance Orbiter we see the detail of this crater so bright even though its diameter is only 3 kms. It is found at http://lroc.sese.asu.edu/posts/541 and its high albedo is thus explained: "the ejecta of a young impact crater will often produce an irregular veneer of light material intermingled with the lower reflectance materials of the older target layer beneath. The resulting dark and light patterns can be very beautiful". We will look for other Atlas images to know a little more about the moment in which this bright spot becomes visible and when it disappears.



***Atlas,** Alberto Anunziato, Paraná, Argentina. 16 June 2016, 0258 UT. 250 mm Meade LX200, 742 nm filter, QHY5-11 camera.*

Mons Hansteen
Howard Eskildsen

Mons Hansteen is the arrowhead-shaped mountain complex at the center of the image, which is a volcanic dome composed of high-viscosity lavas. Crater Hansteen is the floor-fractured crater above and to the left of the mons. The crater Billy lies just below the mons and has a dark, basalt-covered floor. The namesake, Christopher Hansteen, was a Norwegian astronomer and geophysicist born in the 18th century, who discovered variations in the Earth's magnetic field. Crater Billy was named by Riccioli for the 17th century French mathematician and astronomer/astrologer, Jacques Billy. who also believed in mysterious cometary influence.
(Information from *Virtual Moon Atlas*.)

***Mons Hansteen**, Howard Eskildsen, Ocala, Florida, USA. 11 October 2019 0106 UT, colongitude 58.1^o. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 6/10, transparency 3/6.*

Three Views of Copernicus

Francisco Alsina Cardinali and Alberto Anunziato

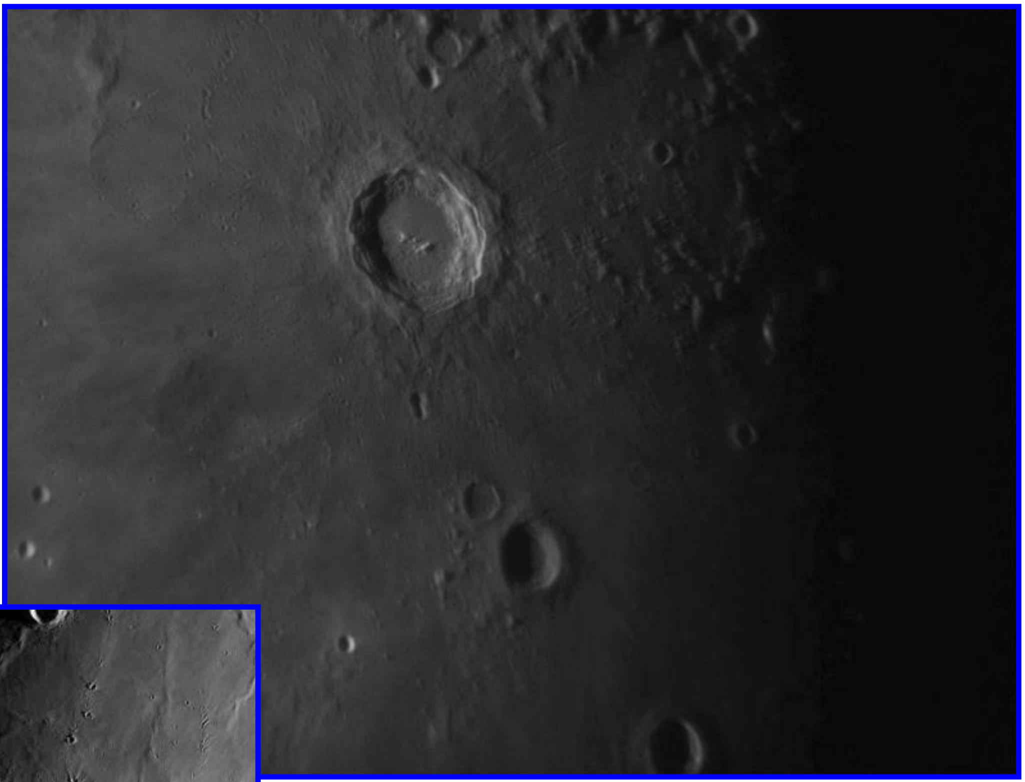
Focus-On Copernicus implies deciding among the many features that make it worthy of the title of the most spectacular crater of the Moon. Among the images that lunar observers of the Sociedad Lunar Argentina treasure, we select the following three to illustrate what we like most about Copernicus:

In **figure 1**, panoramic view of its ray system, which extends over a radial distance of more than 800 kilometers. The relative youth of Copernicus allows us to observe the details that space weathering has erased from older ray systems. In this image we can compare the Copernicus ray system with that of Kepler: its shapes are very different.

***Copernicus, Figure 1**, Francisco Alsina Cardinali, Paraná, Argentina . 17 February 2019 0317 UT. 200 mm refractor, 742 nm filter, QH5Y-II camera.*

In **figure 2**, we see the outline of Copernicus is especially complex, because there are recent (in geological terms) landslides in weak areas that are evident close to the terminator as brighter areas (in which sunlight hits the highest points) and darker areas (sinkings). You can also see the set of central peaks, which reach 1,200 meters high.

Copernicus, Figure 2*, Francisco Alsina Cardinali, Paraná, Argentina . 24 February 2018 2317 UT. 200 mm refractor, QH5Y-II camera.*



Copernicus, Figure 3*, Alberto Anunziato, Oro Verde, Argentina. 21 August 2016 0534 UT. 250 mm Meade LX200, 742 nm filter, QH5Y-II camera.*

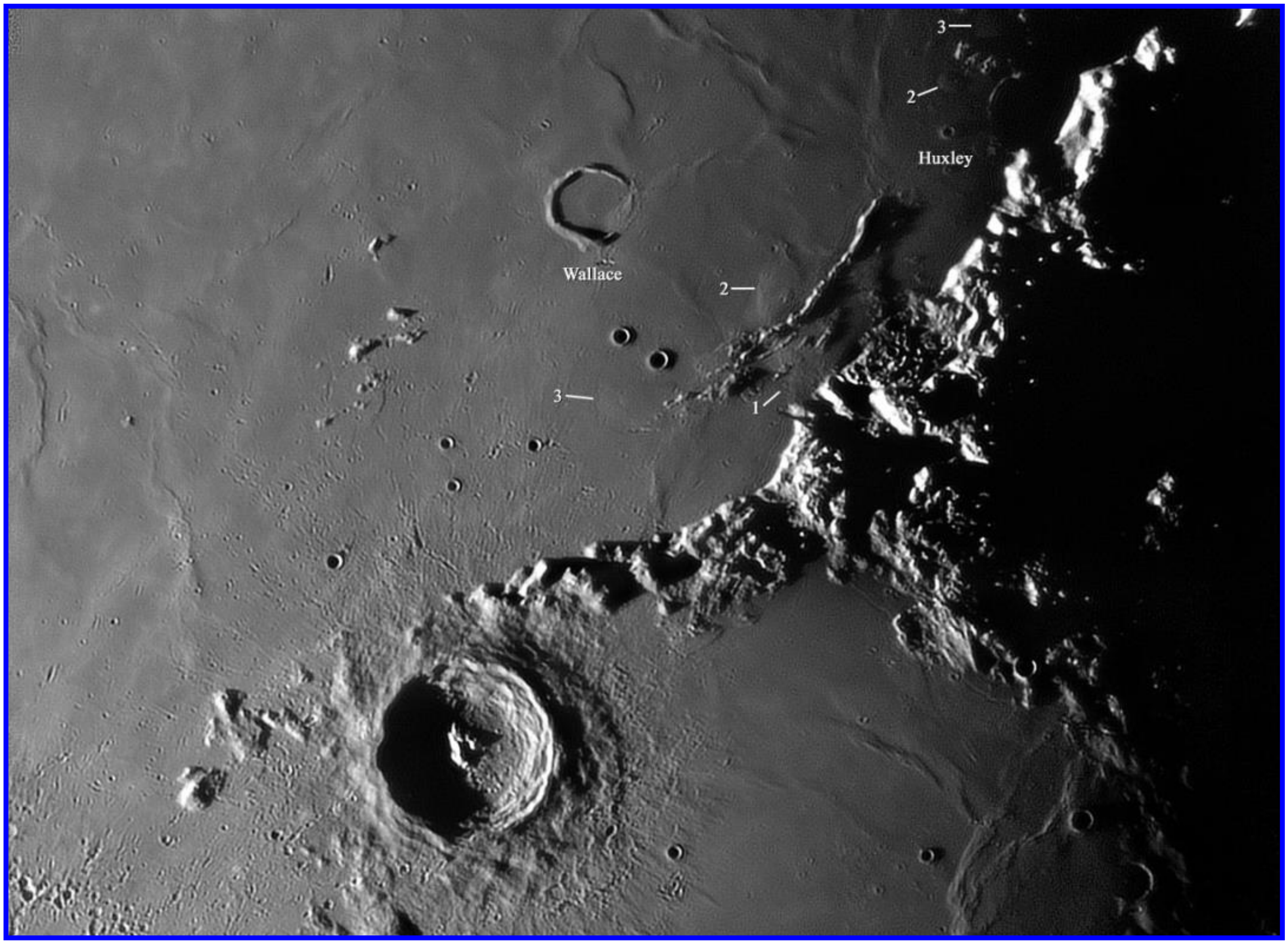
A dramatic view of the shaded interior of Copernicus. As always, Peter Grego describes a brief moment of the lunation in all its splendor: *"A spectacular lighting effect is caused during the early morning and late evening, when Copernicus is partly filled with shadow and some of the higher ridges within the terracing are illuminated by the Sun, amid the shadows. Even a cursory telescopic view will convince the observer that Copernicus's floor is considerably depressed beneath the mean level of the surrounding landscape. Measured from the highest points on the crater's rim to the mean level of the floor, Copernicus is 3,760 m. deep".*

Huxley Domes

Howard Eskildsen

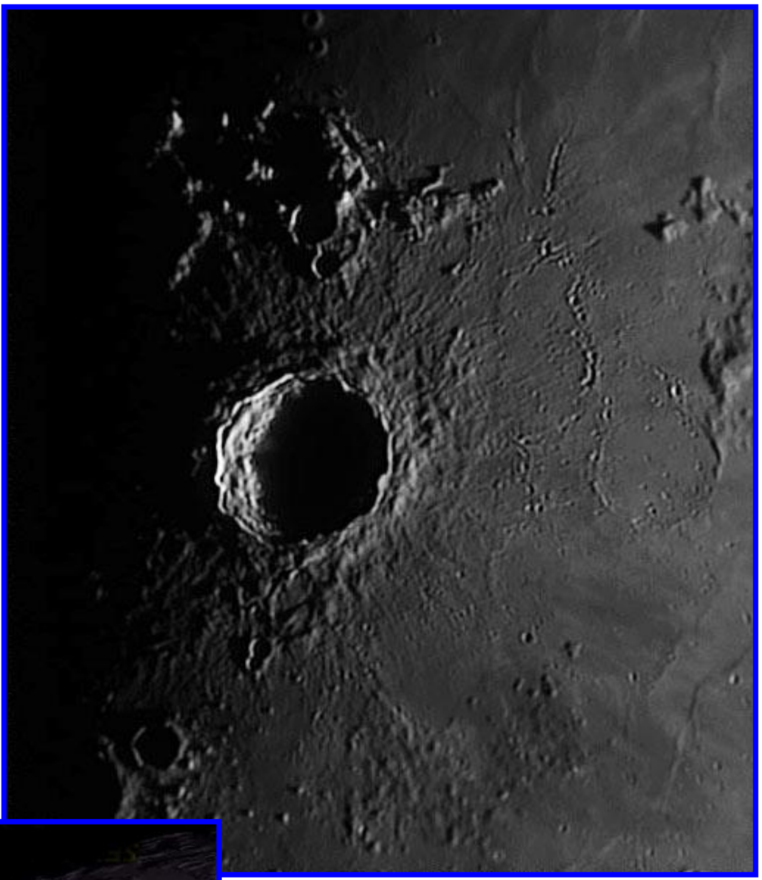
Several domes are visible on the upper portion of this image north of Eratosthenes and the Montes Apenninus. The Huxley domes have been described in the article: Lunar domes in the Apennine region near crater Huxley: Morphometry and mode of formation. M. Wirths and R. Lena - Geologic Lunar Research (GLR) Group. 1km 67 Camino Observatorio, Baja California, Mexico; mwirths@starband.net; 2 Via Cartesio 144, sc. D, 00137 Rome, Italy; r.lena@sanita.it. The article is available through the Lunar and Planetary Institute website at https://www.lpi.usra.edu/meetings/lpsc2013/pdf/1006.pdf.

Other possible domes are indicated on this image based on in information from http://www.chamaeleon-observatory-onjala.de/mondatlas-en/bilder-vulkanismus/s08/s8b/8-5-tage/huxley-wallace-23-06-07_18-37+18-37+18-41.png. The domes lie to the lower right of crater Wallace and are along the margins of an unnamed ridge near the Apennine front.



Wallace and Huxley Domes, *Howard Eskildsen, Ocala, Florida, USA. 21 October 2019 0956 UT, colongitude 184.2°. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 9/10, transparency 4/6.*

Recent Topographic Studies



Copernicus, *Michael E. Sweetman, Sky Crest Observatory, Tucson, Arizona, USA. 14 April 2019 0655 UT. Jaegers 4 inch achromatic refractor, f/8.6 @ f/26. Seeing 4-5/10, transparency 3/6.*

Plato*, Jairo Chavez, Popayán, Colombia . 11 September 2019 0136 UT. 10 inch Dobsonian truss tube, Sony DSC-WX 50.*

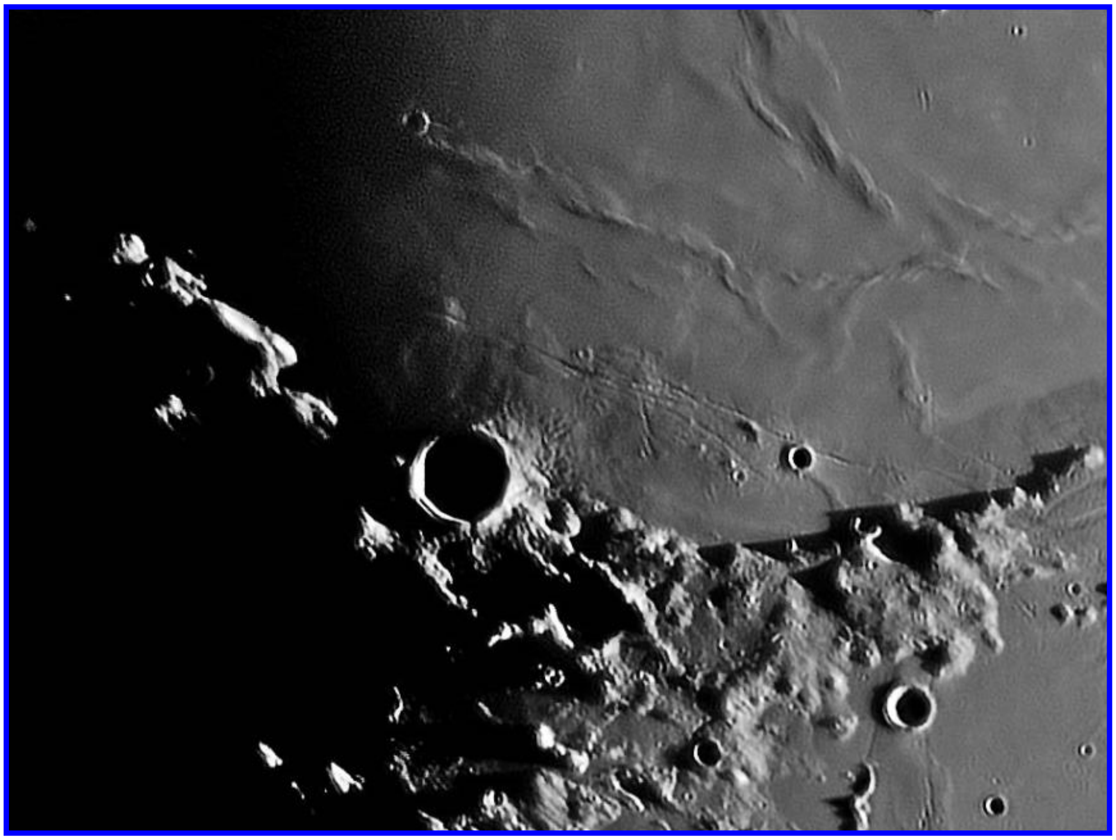
Recent Topographic Studies

***Marius Domes**, Howard Eskildsen, Ocala, Florida, USA. 24 October 2019 1010 UT, colongitude 220.9°. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 5/10, transparency 5/6.*

***Waxing Gibbous Moon** Jairo Chavez, Popayán, Colombia . 11 September 2019 0117 UT. 10 inch Dobsonian truss tube, Sony DSC-WX 50.*

Recent Topographic Studies

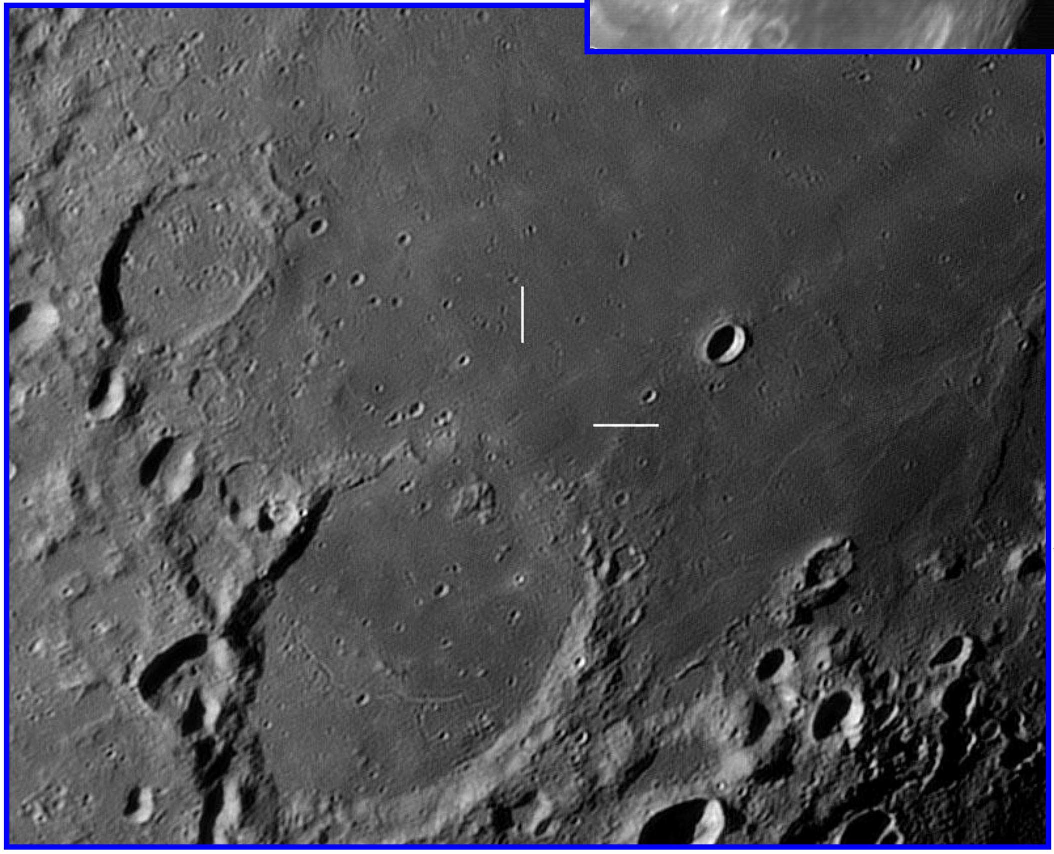
***Aristarchus**, Román García Verdier, Paraná, Argentina. 15 September 2019 0328 UT. 180 mm Newtonian, QH5Y-II camera.*



***Menelaus Dome**, Howard Eskildsen, Ocala, Florida, USA. 04 October 2019 2342 UT, colongitude 344.3^o. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 7/10, transparency 4/6.*

Recent Topographic Studies

***Hahn**, Alberto Anunziato, Paraná, Argentina. 15 September 2019 0251 UT. 180 mm Newtonian, QH5Y-II camera.*



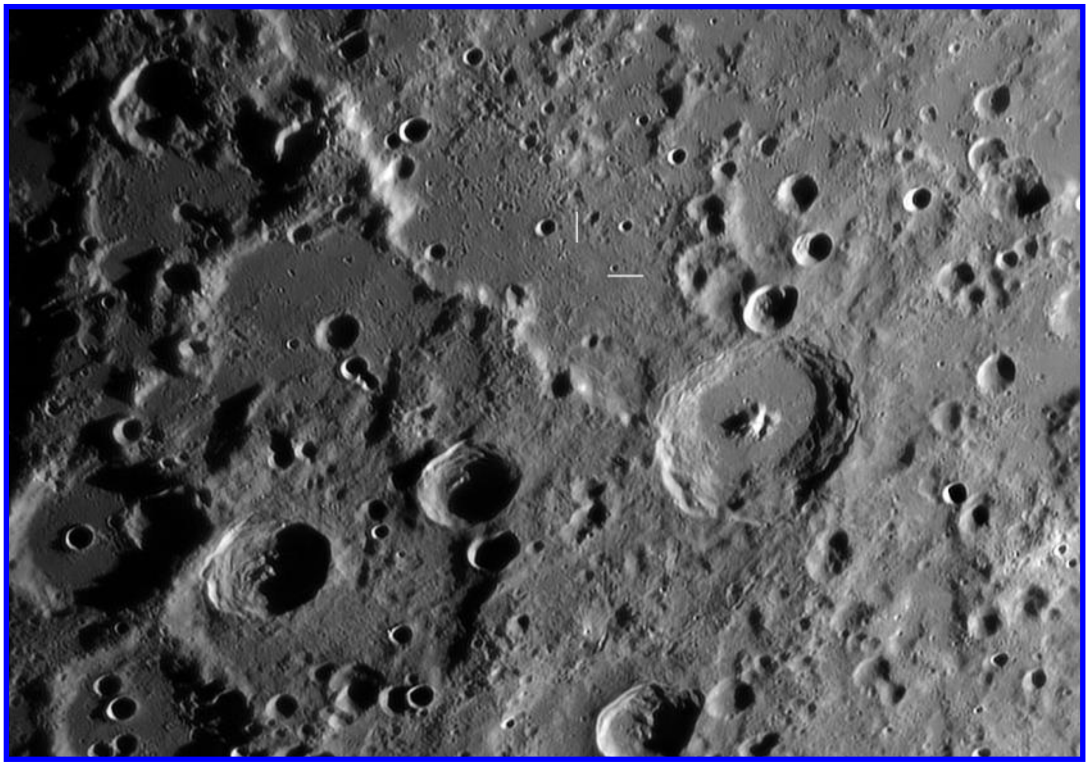
***Fracastorius Dome**, Howard Eskildsen, Ocala, Florida, USA. 17 October 2019 0924 UT, colongitude 135.2°. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 7/10, transparency 4/6.*

Recent Topographic Studies

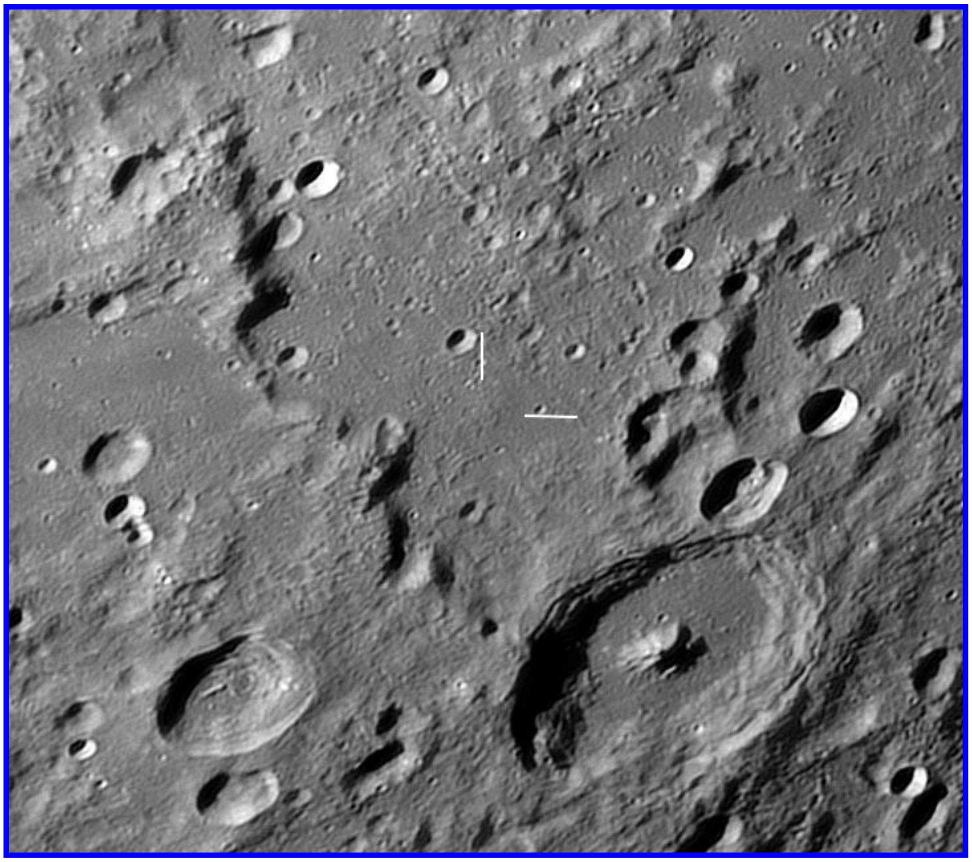
Meton Dome, *Howard Eskildsen, Ocala, Florida, USA. 04 October 2019 2343 UT, colongitude 344.3°. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 7/10, transparency 4/6.*

Plato, *Roberto Podestá, Formosa, Argentina . 13 October 2019 0014 UT. 127 mm Maksutov-Cassegrain, fl 1500 mm, CCD camera.*

Recent Topographic Studies



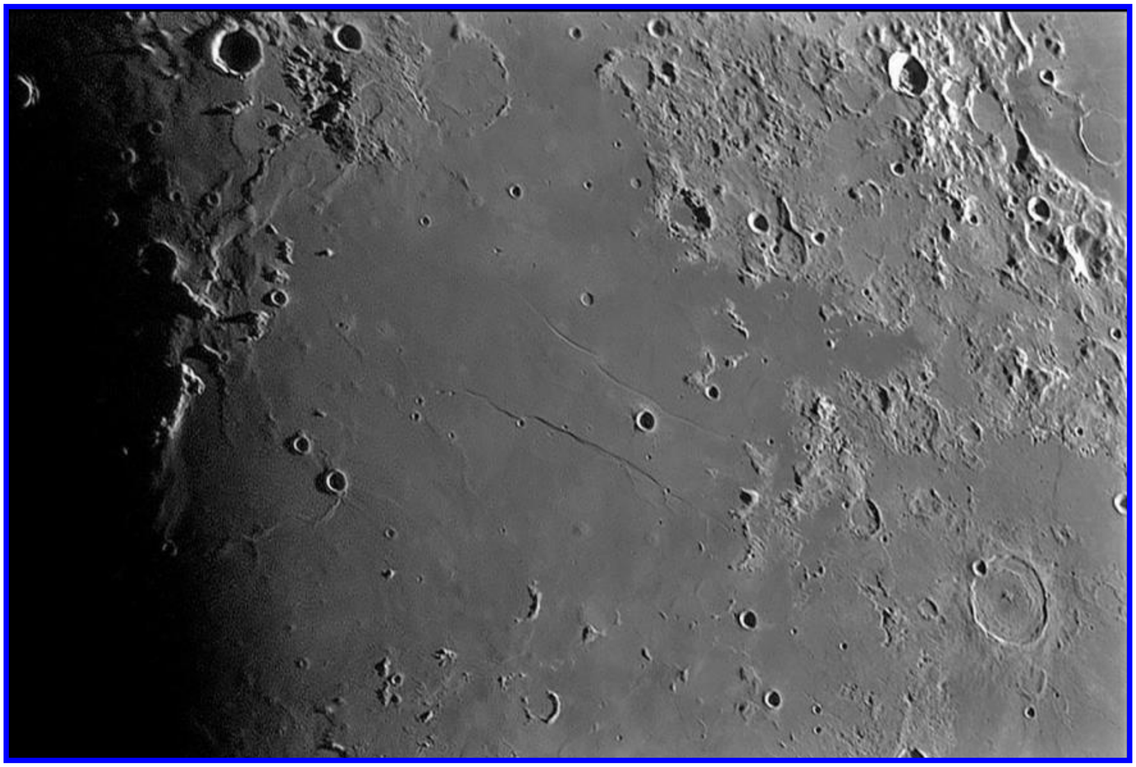
***Piccolomini Dome**, Howard Eskildsen, Ocala, Florida, USA. 04 October 2019 2345 UT, colongitude 344.3^o. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 7/10, transparency 4/6.*



***Piccolomini Dome**, Howard Eskildsen, Ocala, Florida, USA. 17 October 2019 0922 UT, colongitude 135.2^o. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 7/10, transparency 4/6.*

Recent Topographic Studies

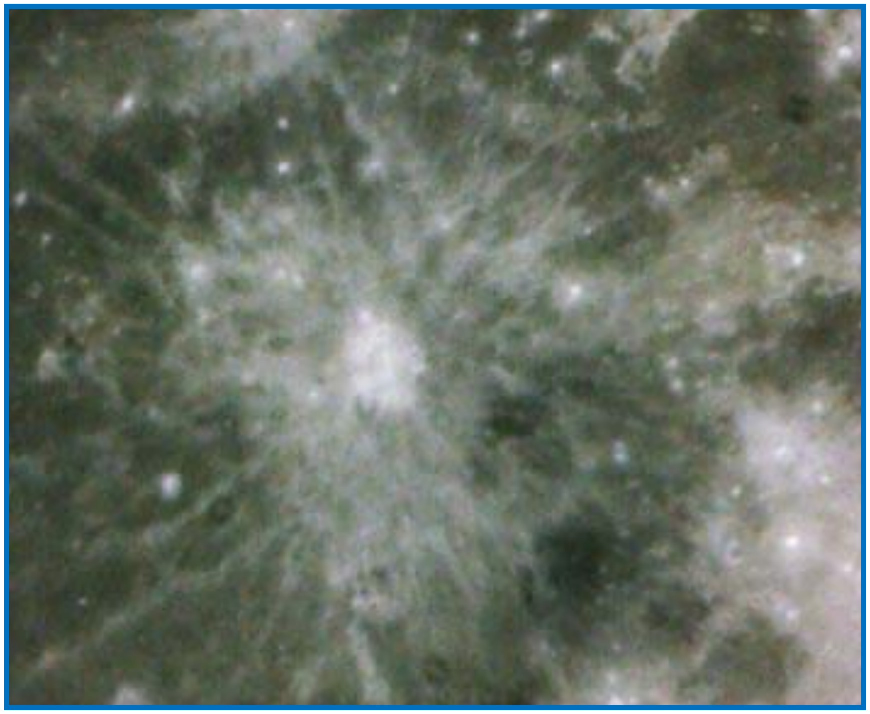
__Vitruvius and Cauchy Domes__, Howard Eskildsen, Ocala, Florida, USA. 03 October 2019 2356 UT, colongitude 332.2°. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, W-25 red filter, DMK 41AU02.AS camera. Seeing 5/10, transparency 5/6.



__Petavius__, Alberto Anunziato, Paraná, Argentina. 15 September 2019 0402 UT. 180 mm Newtonian, QH5Y-II camera.

Recent Topographic Studies

***Copernicus**, Roberto Podestá, Formosa, Argentina . 13 October 2019 0014 UT. 127 mm Maksutov-Cassegrain, fl 1500 mm, CCD camera.*



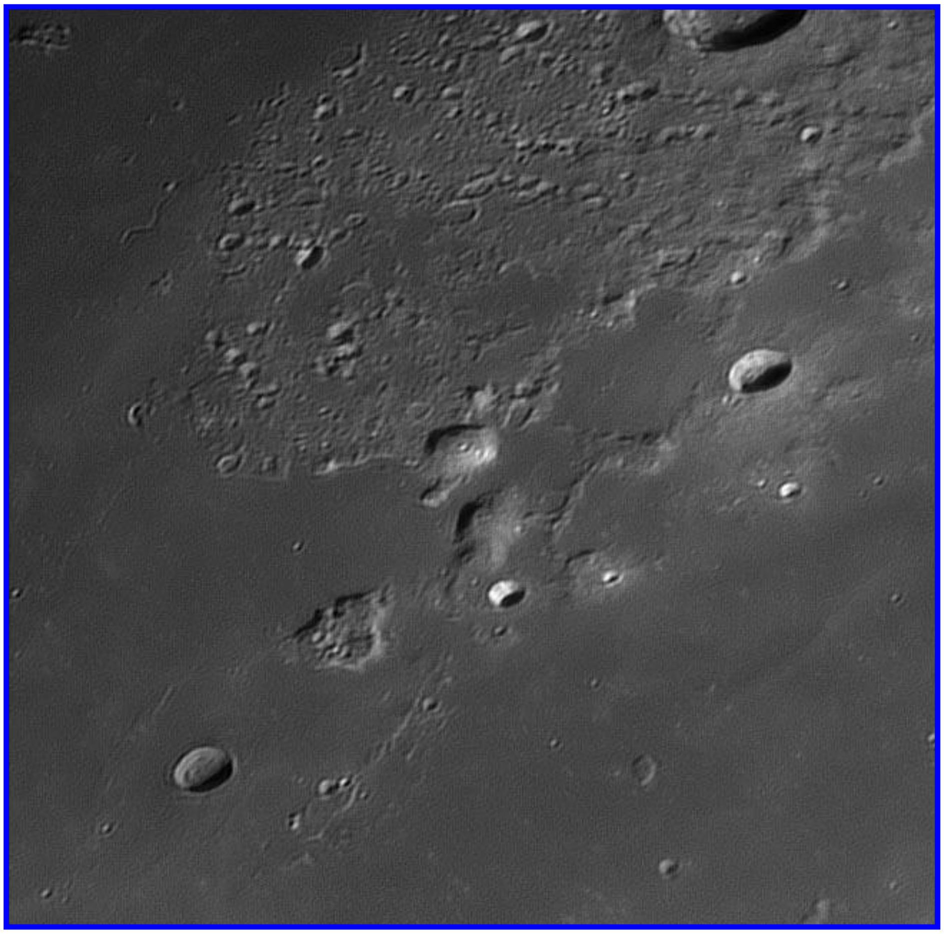
***Mons Rumker,** Michael E. Sweetman, Sky Crest Observatory, Tucson, Arizona, USA. 11 August 2019 0817 UT. Celestron 4 inch achromatic refractor, f/10 @ f/20. Seeing 5/10, transparency 3/6.*

Recent Topographic Studies

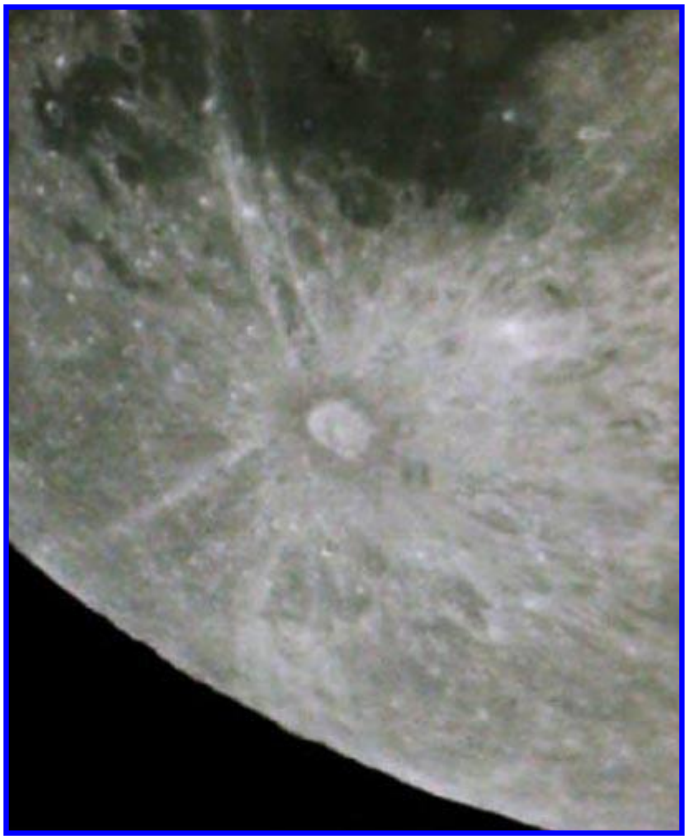
Hansteen and Gassendi Domes, *Howard Eskildsen, Ocala, Florida, USA. 24 October 2019 1007 UT, colongitude 220.9°. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 5/10, transparency 5/6.*

Aristarchus, *Jairo Chavez, Popayán, Colombia . 11 September 2019 0134 UT. 10 inch Dobsonian truss tube, Sony DSC-WX 50.*

Recent Topographic Studies

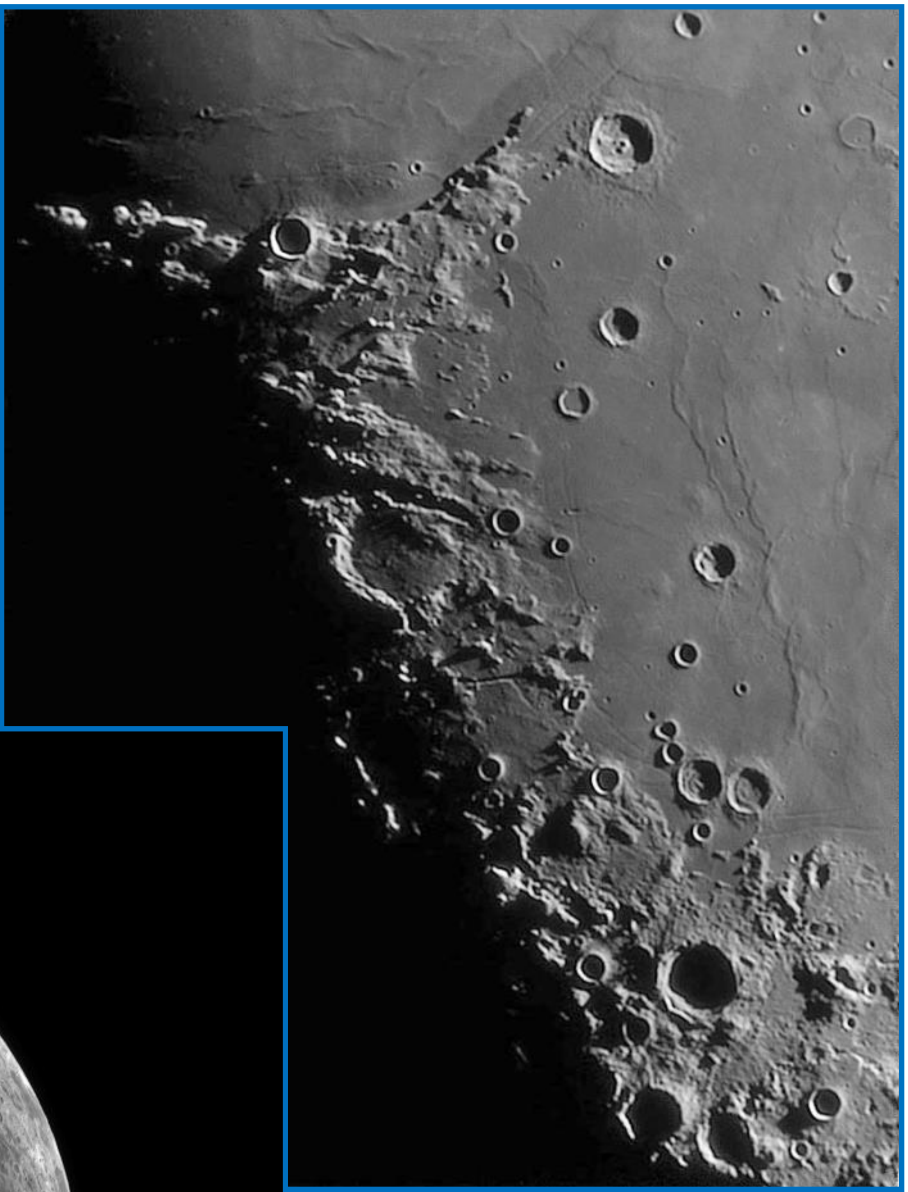


Mons Gruithuisen Gamma and Delta, *Howard Eskildsen, Ocala, Florida, USA. 11 October 2019 0055 UT, colongitude 58.1^o. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, W-25 red filter, DMK 41AU02.AS camera. Seeing 6/10, transparency 3/6.*

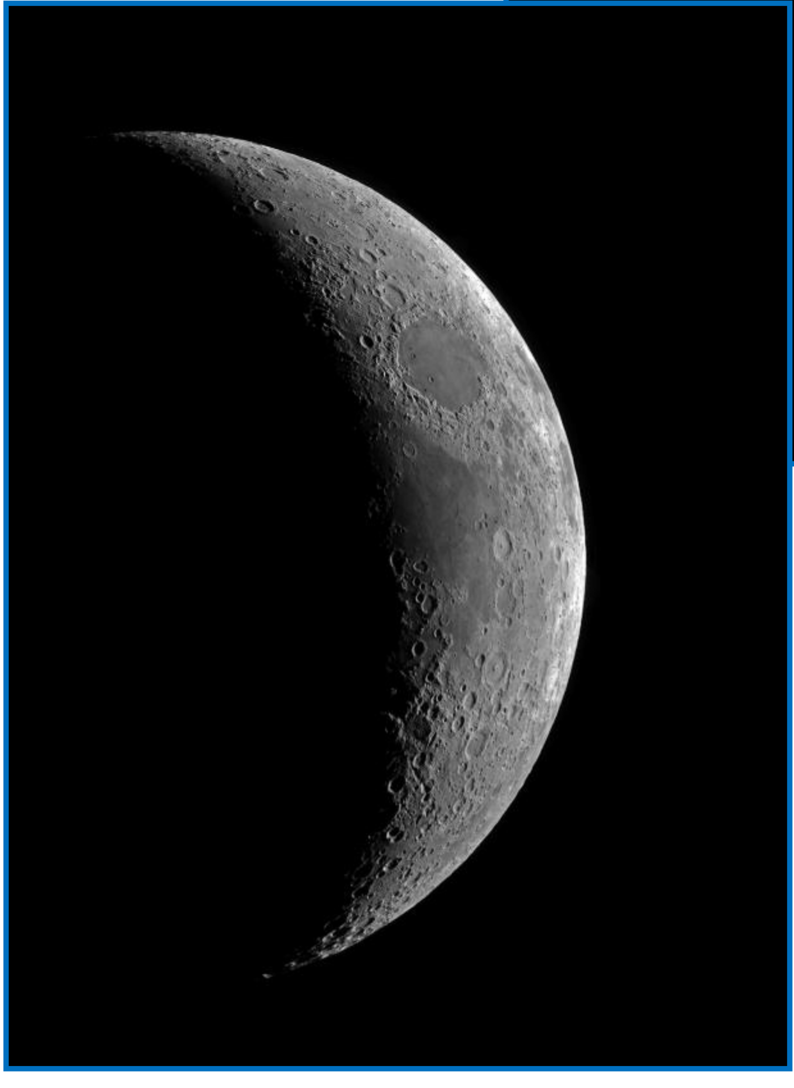


Tycho, *Roberto Podestá, Formosa, Argentina . 13 October 2019 0015 UT. 127 mm Maksutov-Cassegrain, fl 1500 mm, CCD camera.*

Recent Topographic Studies

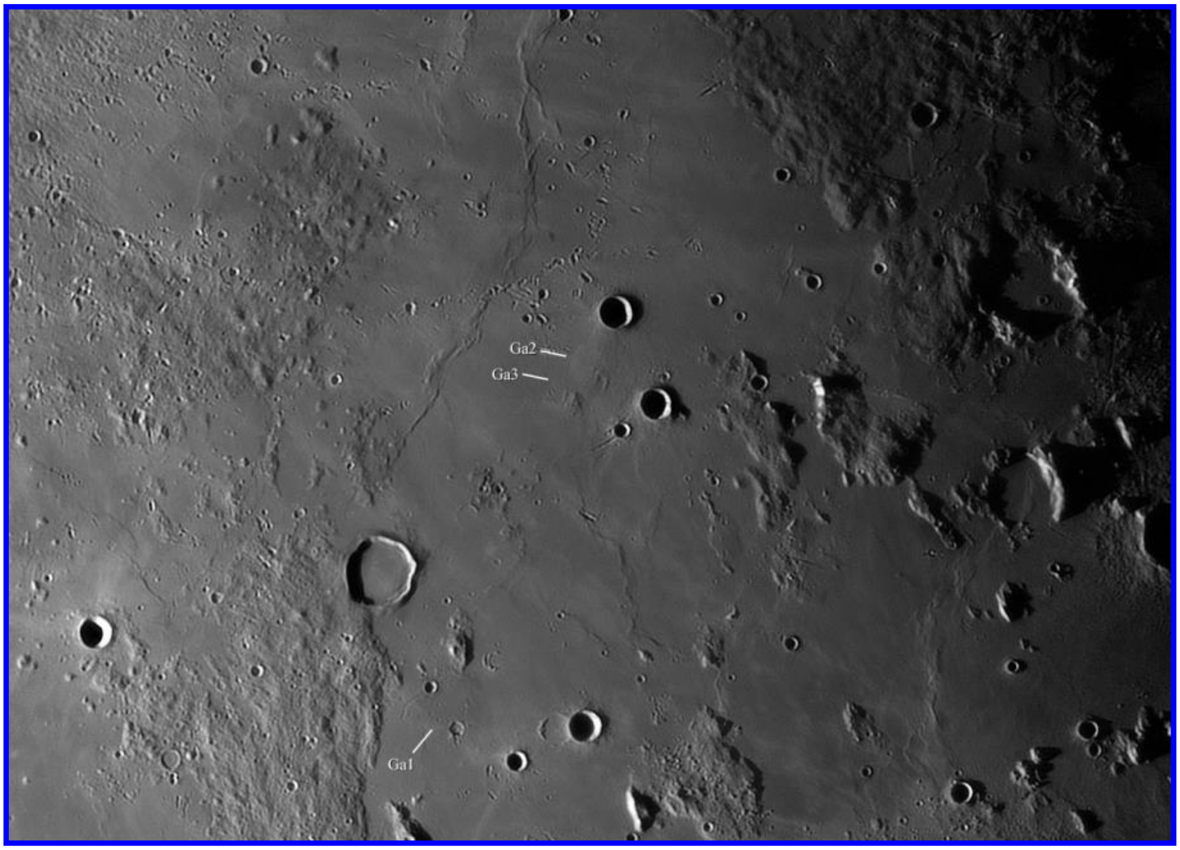


Arago Domes, Alpha and Beta, *Michael E. Sweetman, Sky Crest Observatory, Tucson, Arizona, USA. 05 October 2019 0236 UT. Celestron 4 inch achromatic refractor, f/10 @ f/20. Seeing 7-8/10, transparency 3/6.*



4-Day Old Moon, *David Teske, Louisville, Mississippi, USA. 03 October 2019 0015-0035 UT, colongitude 317.6º-318.8º. Questar 3.5 inch telescope, ASI 120mms camera, Firecapture, Registax, Photoshop. Panorama of 13 images. Seeing 5/10.*

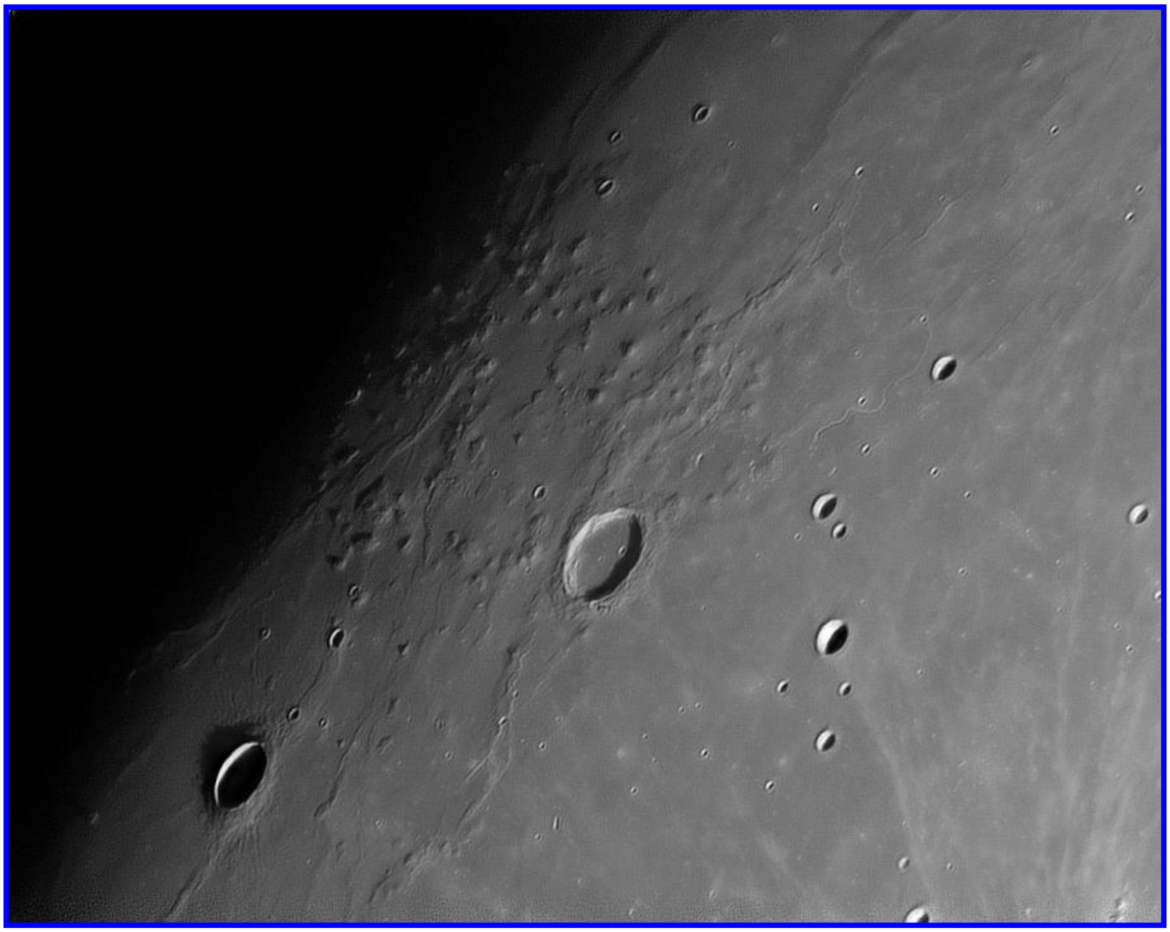
Recent Topographic Studies



***Gambart Domes**, Howard Eskildsen, Ocala, Florida, USA. 21 October 2019 0949 UT, colongitude 184.1°. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 9/10, transparency 4/6.*

***Bianchini** , Jairo Chavez, Popayán, Colombia . 11 September 2019 0137 UT. 10 inch Dobsonian truss tube, Moto Es Play .*

Recent Topographic Studies



Marius Domes*, Howard Eskildsen, Ocala, Florida, USA. 11 October 2019 0104 UT, colongitude 58.1º. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, W-25 red filter, DMK 41AU02.AS camera. Seeing 6/10, transparency 3/6.*

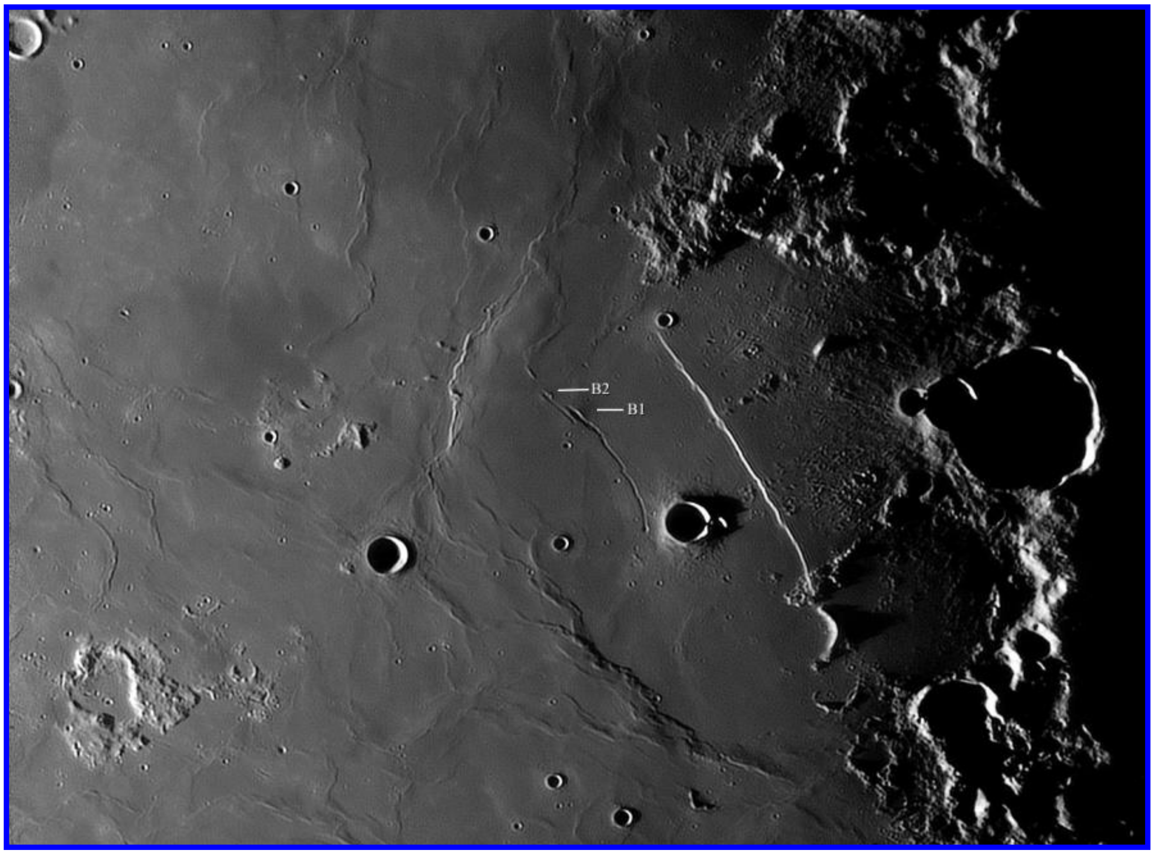
Marius Domes*, Howard Eskildsen, Ocala, Florida, USA. 12 October 2019 0104 UT, colongitude 70.3º. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, W-25 red filter, DMK 41AU02.AS camera. Seeing 7/10, transparency 4/6.*

Recent Topographic Studies

***Grimaldi Dome**, Howard Eskildsen, Ocala, Florida, USA. 12 October 2019 0114 UT, colongitude 70.3º. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, W-25 red filter, DMK 41AU02.AS camera. Seeing 7/10, transparency 4/6.*

***Proclus**, Román García Verdier, Paraná, Argentina. 15 September 2019 0344 UT. 180 mm Newtonian, QH5Y-II camera.*

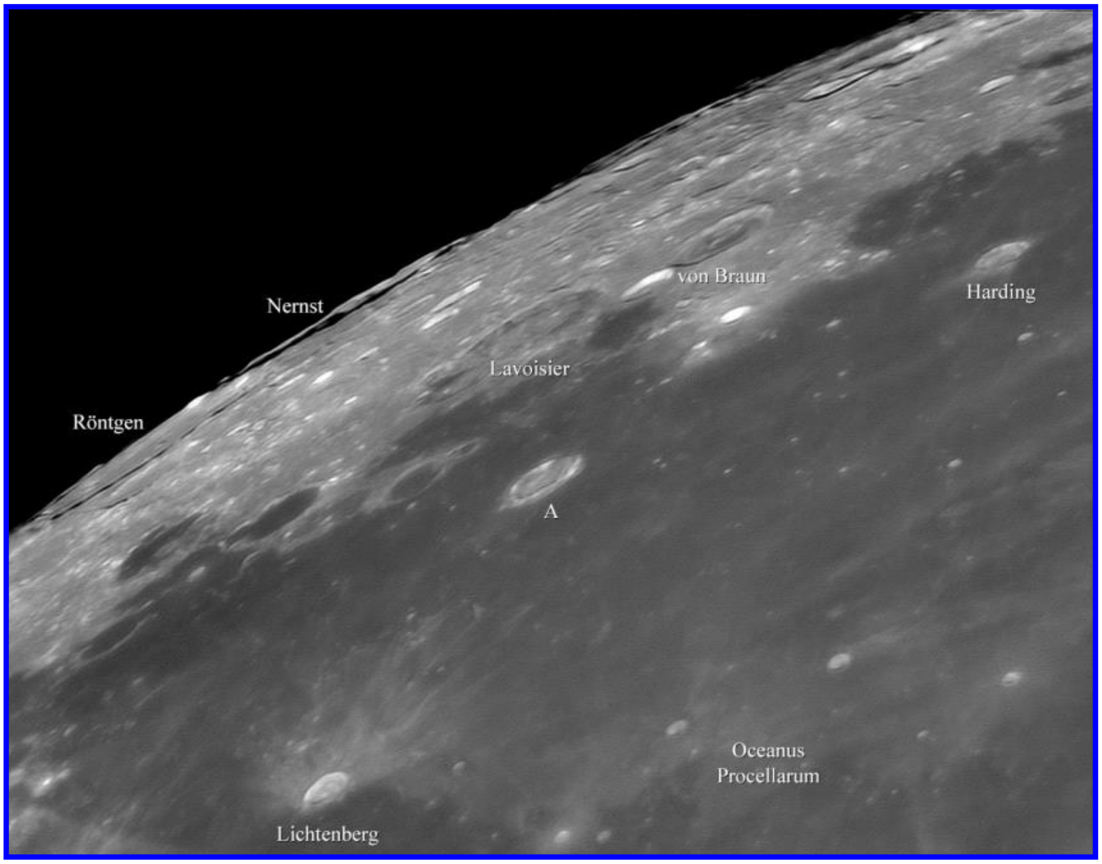
Recent Topographic Studies



***Birt Domes**, Howard Eskildsen, Ocala, Florida, USA. 21 October 2019 0945 UT, colongitude 184.1°. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 9/10, transparency 4/6.*

***Anaxagoras**, Alberto Anunziato, Paraná, Argentina. 15 September 2019 0428 UT. 180 mm Newtonian, QH5Y-II camera.*

Recent Topographic Studies



***Lavoisier Region**, Howard Eskildsen, Ocala, Florida, USA. 14 October 2019 0143 UT, colongitude 95.9°. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 5/10, transparency 4/6.*

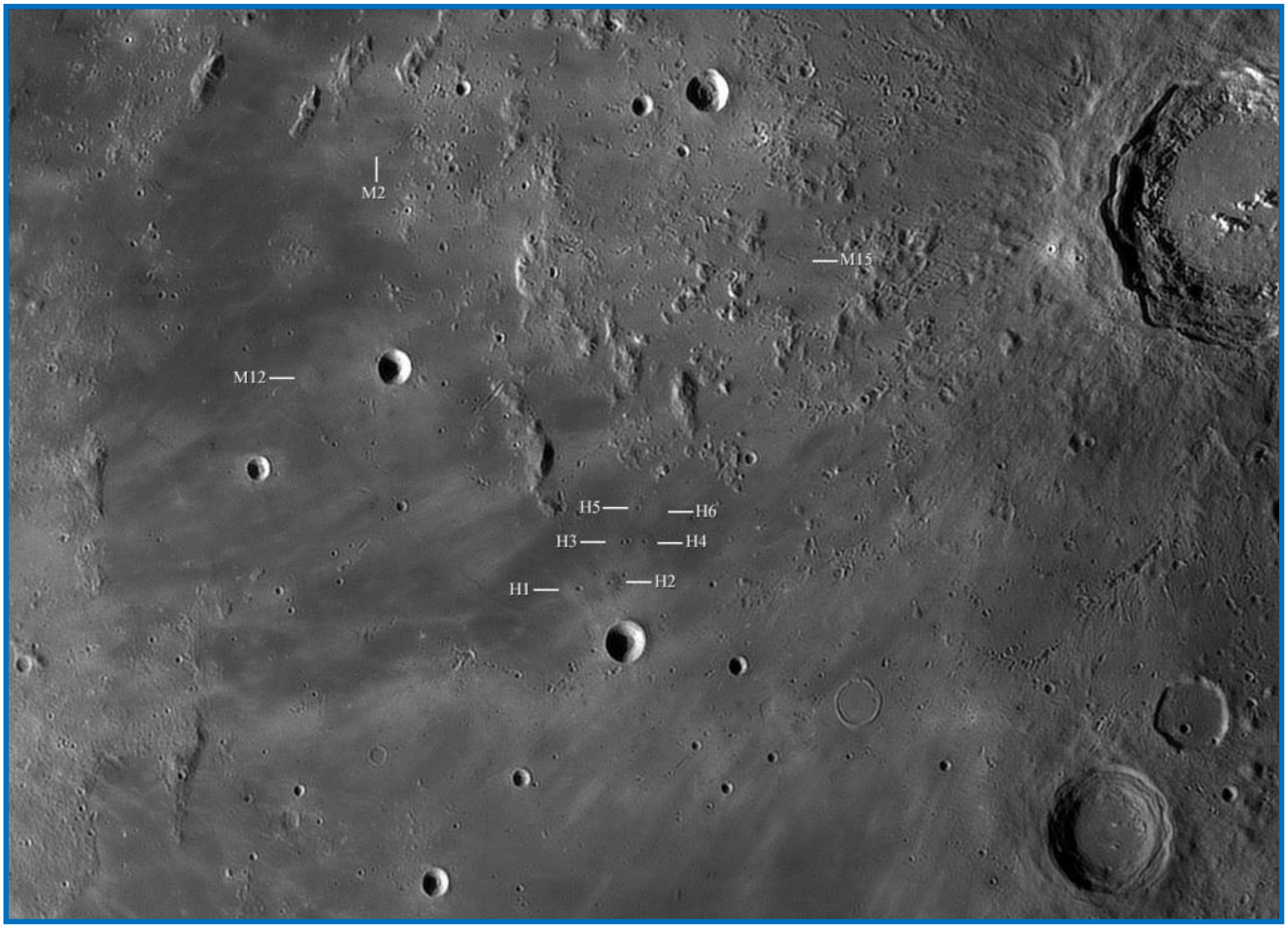
***Proclus**, Roberto Podestá, Formosa, Argentina . 13 October 2019 0014 UT. 127 mm Maksutov-Cassegrain, fl 1500 mm, CCD camera.*

Recent Topographic Studies

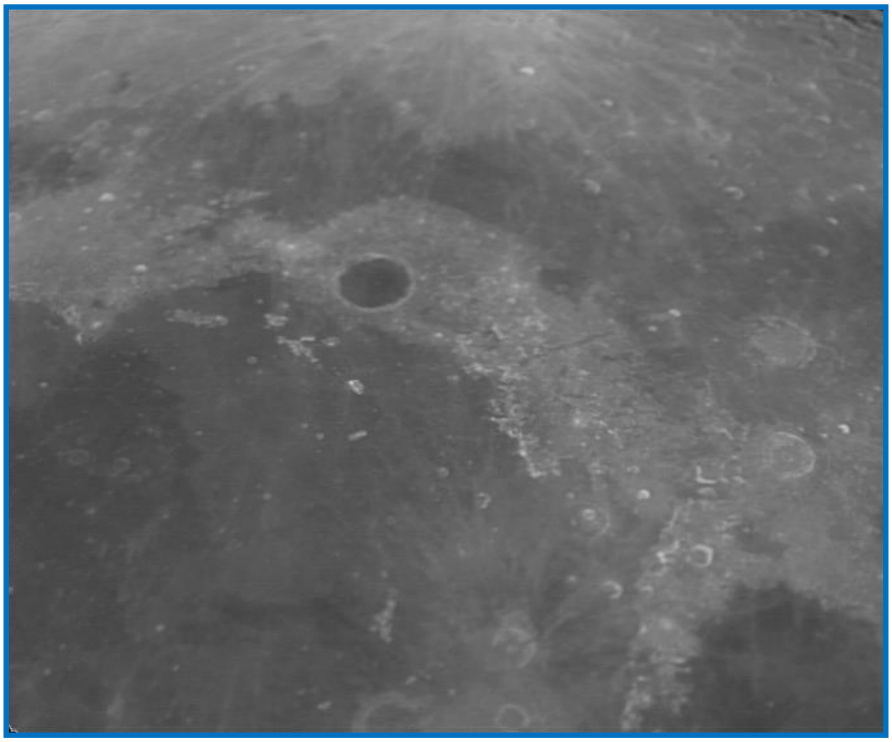
Mons Rumker, *Howard Eskildsen, Ocala, Florida, USA. 11 October 2019 0057 UT, colongitude 58.1°. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, W-25 red filter, DMK 41AU02.AS camera. Seeing 6/10, transparency 3/6.*

Mons Rumker, *Howard Eskildsen, Ocala, Florida, USA. 12 October 2019 0118 UT, colongitude 70.3°. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, W-25 red filter, DMK 41AU02.AS camera. Seeing 7/10, transparency 4/6.*

Recent Topographic Studies



Hortensius and Milichius Domes, *Howard Eskildsen, Ocala, Florida, USA. 21 October 2019 0953 UT, colongitude 184.2°. 9.25 inch Schmidt-Cassegrain, f/10, fl 2395 mm, 2 x barlow, W-25 red filter, DMK 41AU02.AS camera. Seeing 9/10, transparency 4/6.*



Plato*, Román García Verdier, Paraná, Argentina. 15 September 2019 0357 UT. 180 mm Newtonian, QH5Y-II camera.*

LUNAR GEOLOGICAL CHANGE DETECTION PROGRAM

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

2019 November

Reports have been received from the following observers for Sep: Jay Albert (Lake Worth, FL, USA - ALPO) observed: Alphonsus, Aristarchus, Atlas, Barrow, Bessel, Hase, Mons Piton, Rabbi Levi, and Torricelli B. Alberto Anunziato (Argentina – SLA) observed Agrippa, Aristarchus, Hahn, Plato, Proclus and Yerkes. Dietmar Büttner (Germany - BAA) observed Tycho. Jario Chavez (Columbia - LIADA) imaged Aristarchus, Bianchini, Gutenberg, Mare Crisium and several features. Maurice Collins (ALPO/BAA/RAS NZ) imaged earthshine, Petavius, and several features. Alexandra Cook (Spain) imaged the Moon. Pasquale D'Ambrososio (UAI – Italy) imaged the Full Moon. Valerio Fortani (Italy – UAI) imaged Bullialdus, the Full Moon and Torricelli B. Les Fry (Mid Wales, UK - NAS) imaged Montes Apenninus, Theophilus, Tycho, and several features. Kevin Kilburn (BAA) imaged several features. Nicoletta Minichino (Italy – UAI) imaged Torricelli B. Bob Stuart (Rhayader, UK – BAA) imaged Anaxagoras, Aristarchus, Arnold, Atlas, Briggs, Capella, Carpenter, Cusanus, Desargues, Endymion, Fracastorius, Hayn, Hercules, Janssen, Labus Spei, Lavoisier, Macrobius, Messier, Meton, Newcomb, Oenopides, Philolaus, Pitiscus, Posidonius, Proclus, Reiner Gamma, Tomer, Santbech, Schröter, Taruntius, Theophilus and the Full Moon. Franco Taccogna (Italy – UAI) imaged Campanus, Mare Frigoris, Montes Teneriffe, Tycho and several features. Aldo Tonon (Italy – UAI) imaged the Full Moon. Gary Varney (Pembroke Pines, FL, USA – ALPO) imaged Montes Apenninus and Triesnecker. Román García Verdier (Argentina - SLA) imaged the regions around Aristarchus, Plato and Proclus. Fabio Verza (Italy – UAI) imaged Montes Teneriffe and the Full Moon. Ivor Walton (Codnor, UK - BAA) imaged Campanus. Marcello Zurita (Brazil – APA/BRAMON/SAB) videoed earthshine.

News: Readers may be interested to know that a giant 7 meter (approx. 23 feet) diameter model of the Moon is touring the Earth's surface at the moment! I stumbled upon it by accident when I visited Gloucester, UK and went inside the cathedral (see **Fig 1**). It is a 1:500,000 scale map of the Moon and each cm on this model represents 5 km on the Moon's surface (1" = 7.9 miles). The artists web site: https://my-moon.org/ tells you where it is likely to pop up next and it is not just confined to churches or the UK! It is well worth a visit if it lands near you.

Figure 1. The “Museum of the Moon” inside Gloucester Cathedral on 2019 Oct 19 just prior to a rehearsal for a Wagner concert.

LTP reports: No additional LTP, other than the candidates discussed in the last newsletter, have been reported for September. However, concerning Kevin Kilburn’s green/blue spot seen on Galvani G, I have a few additional things to say. The UT I quoted of 21:26 UT was a typographical error on my part, and it should have read 23:26 UT. I thought that you might be interested to see in the individual red, green blue color separated components (**Fig 2**). Although I suspect the flash is either a cosmic ray, or something to do with the camera Bayer filter, it is an interesting coincidence that it lines up with the ray crater inside Galvani B. If any of you have experience with being able to remove Bayer filter patterns from the original image, I would be grateful if you could get in contact as I think this is the only way to prove that the flash might be cosmic ray related.

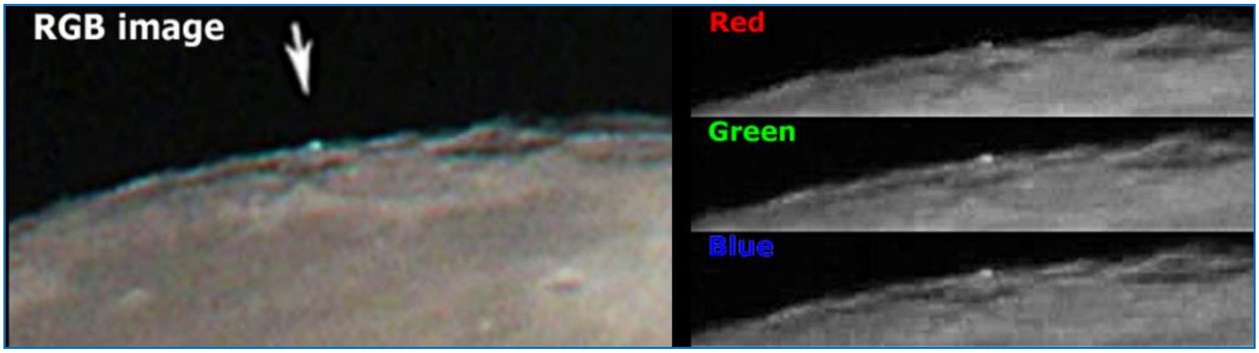


Figure 2. The limb of the Moon in the vicinity of Galvani B with north towards the top right. **(Left)** RGB image taken by Kevin Kilburn on 2019 Sep 13 UT 23:26 with some sharpening and color saturation increased – an arrow points to a blue-green spot. **(Right)** Color separated red, green and blue components.

Routine Reports: Below are a selection of reports received for Sep 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. Note that some observations sent in have not been used in this newsletter because they do not cover repeat illumination predictions. However, they will be kept in our database and used as reference images should a LTP be reported under similar illumination in the future.

I am now in the throes of a heavy teaching workload at University, and so although trying to list as many observations as possible, I will not be providing, much in the way of analysis. Instead, readers of this newsletter, are invited to read the original LTP descriptions and judge for themselves whether these repeat illumination observations explain what was originally seen. When I get some freedom in a month, or twos, time I will reassign weights, if necessary, to the original LTP reports using the [REF ##] numbers at the start of each TLP description.

Earthshine: On 2019 Sep 02 UT 07:36 Maurice Collins (ALPO/BAA/RAS NZ) imaged (**Fig 3**) the night side of the Moon under both similar phase and topocentric libration (to within ±1°) to the following reports:

[REF 01] *On 1970 May 08 at UT 23:00-23:30 Celis Quilpue, Chile, 3" refractor, x60, atmosphere turbulent) observed in the Aristarchus region a clear line(?) and several star-like points. Cameron suspects atmospheric effects due to low altitude and turbulence? The Cameron 1978 catalog ID=1259 and weight=1. The ALPO/BAA weight=1.*

[REF 02] *On 1989 Apr 09 at 02:13 was seen to be not very bright in binoculars, despite visibility of Earthshine in general as being exceptional. Darling confirmed this at 02:31UT, though it was quite bright in a 17" reflector, but Herodotus could barely be seen. Weier claimed to be able to see Aristarchus with the naked eye. At 02:08 the brightness was found to be 5.0 for several measurements. The observing team ware from the Maddison Astronomical Society, WI, USA. The Cameron 2006 catalog ID=359b and weight=3. The ALPO/BAA weight=2.*

Figure 3. Earthshine as imaged by Maurice Collins on 2019 Sep 02 UT 07:36 and orientated with north towards the top. The color saturation has been increased to 70%. An enlarged view of Aristarchus is shown in the inset in the bottom right.

Curtis: Jario Chavez (LIADA) 2019 Sep 04 UT 00:03 imaged (**Fig 4**) the Mare Crisium region which included the usually bright spot east of Picard mentioned in the following report, and under nearly similar illumination (±0.5°):

[REF 03] *On 1877 Jun 15 at UT 20:00 Birt (England, UK) observed a bright spot east of Picard. The reason why this was regarded as a LTP, according to Cameron was that it was supposed to be faint or invisible. The Cameron 1978 catalog ID=193 and the weight=3. The ALPO/BAA weight=3.*

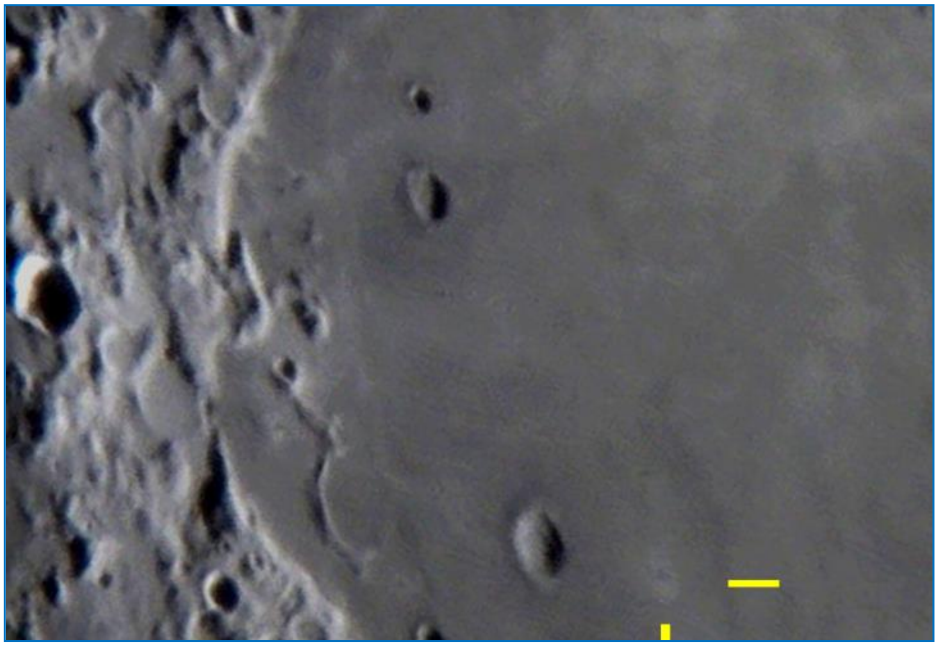


Figure 4. A "normally"{?} bright spot (Curtis crater) east of Picard in Mare Crisium, as imaged by Jario Chavez (LIADA) on 2019 Sep 04 UT 00:03 and orientated with north towards the top.

Barrow and Bessel: On 2019 Sep 06 at 01:15-01:35 and 01:45-02:05 respectively, Jay Albert (ALPO) observed visually these two craters under similar illumination (±0.5°) to the following two reports:

[Ref 04] *Barrow 1972 May 19 UT 20:17 M. Burton (UK, 13.5-inch Cassegrain reflector, x180, seeing IV-III, Transparency: Fair) noted that the E. side of the crater wall was brilliant. There was also a luminous streak across the floor from E-W. No color was detected using a Moon Blink device. ALPO/BAA weight=1.*

[Ref 05] *Bessel 1877 Jun 17 UT 22:30 Observed by Denett (England? 2.75" reflector) "Tho't he could detect a minute pt. of light shining out of dark crater. (no high peaks in Bessel to catch light.)" NASA catalog weight=3. NASA catalog ID #194. ALPO/BAA weight=3.*

For Barrow, Jay noted that "*The W (IAU; LTP description states E) side of the crater was brightly lit. I also saw the "luminous streak" running E-W across the floor. The sunlight appeared to be coming through a gap or low point in the E wall and extended all the way to the W wall. I checked Rukl chart 4 and noted no complete gap in the E wall, however there was a lower area with a small craterlet which could have been the area where the sunlight could penetrate the E wall and light up the strip across the floor. While photo #10 in the 21st Century Atlas of the Moon (Wood & Collins) was taken at a higher solar angle, it does show how light comes through this lower area with a smaller amount of shadow on each side. Accordingly, the bright W wall and luminous streak would appear to be normal at this LTP's solar angle.* "

For Bessel he found: "*Seeing at 5/10 dropped rapidly to 4/10 or less during this observation as the Moon dropped lower over the roof of my house. I intermittently caught brief glimpses of what appeared to be a minute, faint light spot at the edge of the shadow on the crater floor at the base of the bright W wall. I used 290x, then 226x and viewed from 01:45 to 02:05UT when poor seeing ended the lunar portion of my observing session.*"

NW Mare Vaporum: On 2019 Sep 07 UT 01:58 Gary Varney (ALPO) imaged (**Fig 5**) the Triesnecker area, and covered a small part Mare Vaporum, at similar illumination (to within ±0.5°) to the following report:

[REF 06] *Mare Vaporum 1969 Apr 24 UT 19:34 Observed by Bentley (England, 8" reflector, x320, S=E) "NW part of mare obscured for 4 min., gradually thinning." NASA catalog weight=3. NASA catalog ID No. 1123. ALPO/BAA weight=2.*

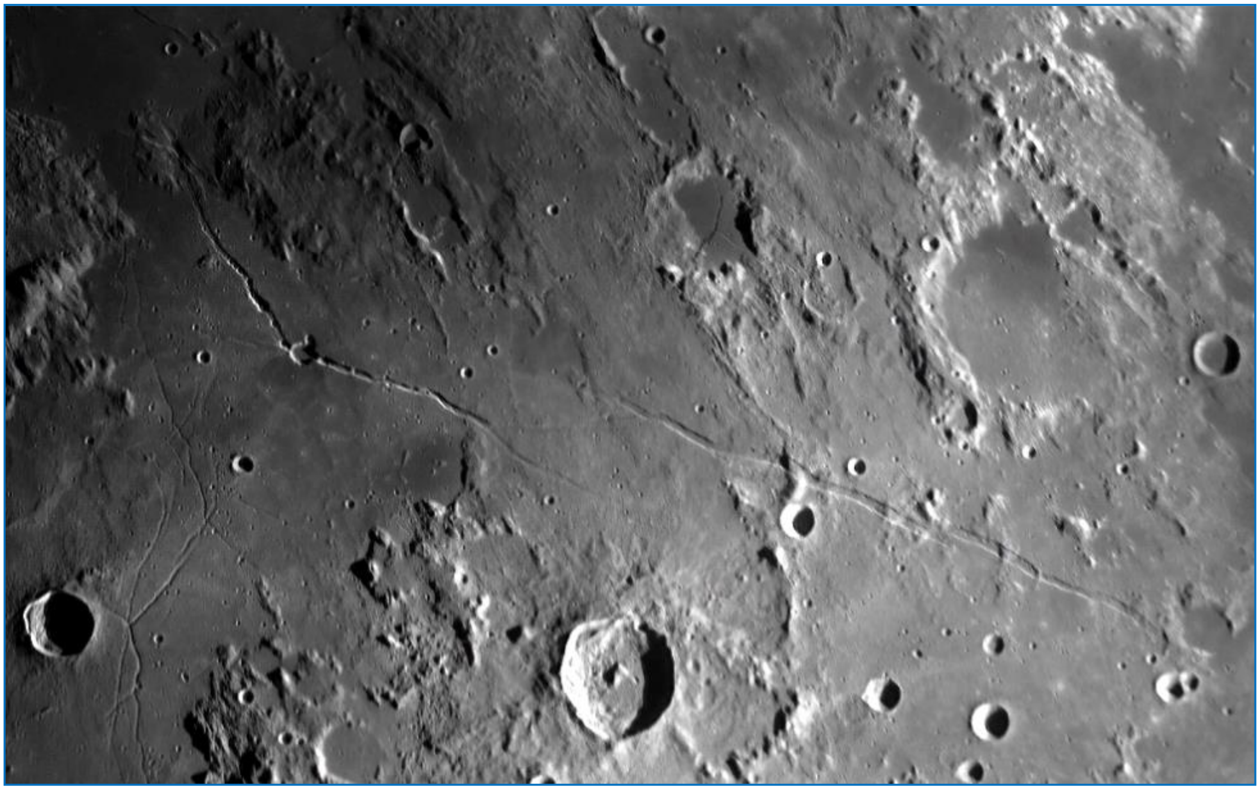


Figure 5. The Triesnecker area of the Moon as imaged by Gary Varney (ALPO) on 2019 Sep 07 UT 01:58.

Montes Teneriffe: On 2019 Sep 07 between UT 17:41 and 18:14 Fabio Verza (UAI) and Franco Taccogna (UAI) obtained a series of images (See **Fig 6**) that overlapped with a Lunar Schedule website request for the following:

[REF 07] *BAA Request: please image this area as we want to compare against a sketch made in 1854 under similar illumination. However, if you want to check this area visually (or with a color camera) we would be very interested to see if you can detect some color on the illuminated peaks of this mountain range, or elsewhere in Mare Imbrium. Features to capture in any image (mosaic), apart from Montes Teneriffe, should include: Plato, Vallis Alpes, Mons Pico and Mons Piton.*

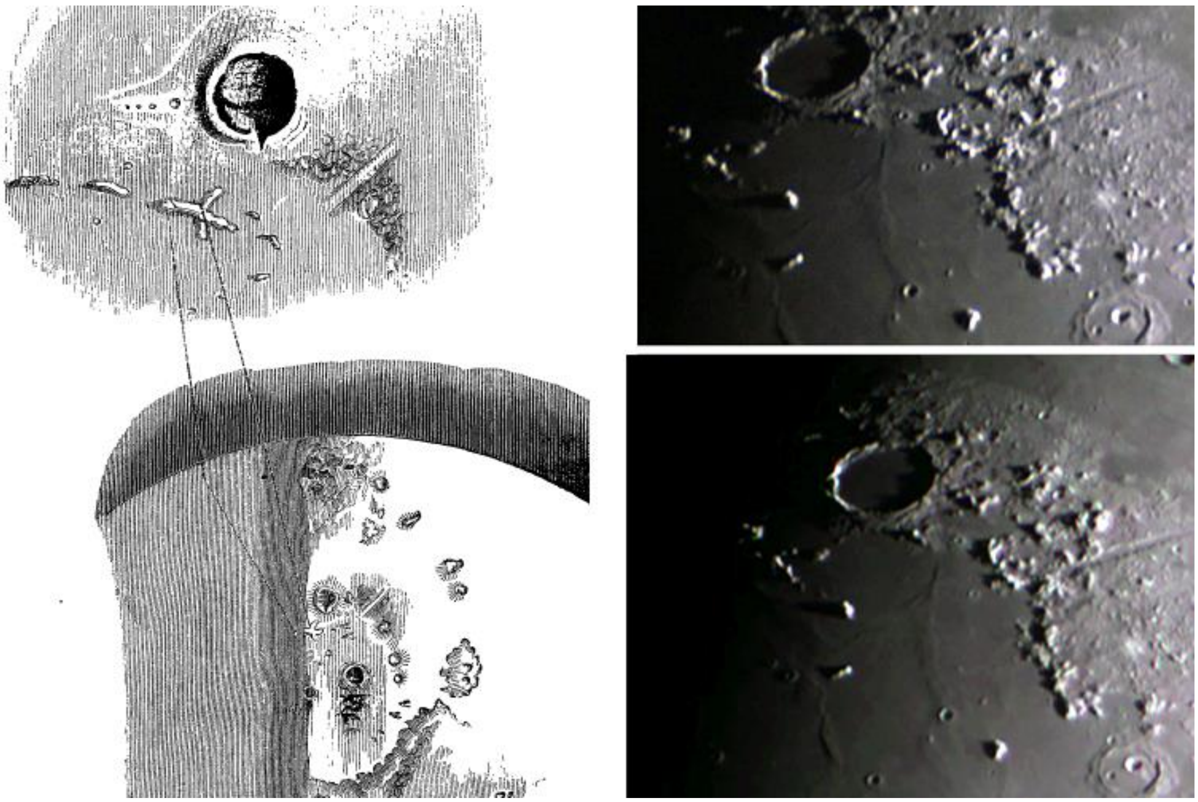


Figure 6. The Montes Teneriffe area orientated with north towards the top. **(Left)** A couple of sketches from the Monthly Notices of the Royal Astronomical Society from 1885 Vol 15, p163 depicting on 1854 Dec 27 UT 18:00-23:00 an observation of Hart and others (Glasgow, Scotland) of *"2 luminous fiery spots on bright side on either side of a ridge, contrasting color. Seemed to be 2 active volcanoes. Ridge was normal color. Spots were yellow or flame color. Never seen before in 40 yrs. of observing"*. **(Top Right)** Color image by Fabio Verza (UAI) taken on 2019 Sep 07 UT 17:41 – color normalized and color saturation increased to 50%. **(Bottom Right)** Color image by Franco Taccogna with red, green and blue channels captured respectively at 18:11, 18:13 and 18:14 UT. These were then registered together; color normalized and then had the color saturation increased to 50%.

Full Moon: On 2019 Sep 13 several UAI observers imaged the whole lunar disk close to Full Moon in order to see which were the brightest features. **Table 1** below shows a selection of features and in the last column the mean digital number value i.e. the higher this is the brighter (higher albedo) the feature has:

UT: **Observer:**	**19:33** **Taccogna**	**20:38** **Tonon**	**21:23** **D'Ambrosio**	**22:02** **Fontani**	**Mean** **DN**
Censorinus	241.2	199.5	213.5	173.3	**207**
Spot near Hell	213.8	210	213.8	185.4	**206**
Proclus	197.5	206.6	213.5	182.6	**200**
Aristarchus	188.8	177.7	208.4	170.4	**186**
Tycho	171.9	166.6	196.5	175.4	**178**
Menelaus	154.4	60	184.3	161.5	**165**
Copernicus	115.3	133.2	181.2	157.6	**147**
Kepler	104.7	128.8	168.5	151.1	**138**
Plato	54.1	76.3	111	72.3	**78**

Table 1. CCD brightness values of different craters as measured in images by UAI observers on 2019 Sep 13. Time dependent brightness variations maybe related to the image resolution/scale used affecting point-like features most.

Hahn: On 2019 Sep 15 UT 02:51 Alberto Anunziato (SLA) managed to obtain an image (**Fig 7**) of the crater Hahn following a Lunar Schedule web site request:

[REF 08] *BAA Request: On 2012 Jan 09 UT 21:01-21:08 Hahn crater was imaged by Nick Hazel (Beverley, Yorkshire, UK, Nikon D7000 with 70-300 zoom at max, with 2x teleconverter, at f9, 1/320 sec, ISO 400 - tripod mounted, mirror up), A series of images were taken. The 21:06 one showed a grey column cutting across the central floor of the crater from the west and then bisecting the eastern rim. All detail inside is completely invisible. Some (but not all) of the other images showed a more blurred view of this feature. It is possible that this was a seeing ripple effect, or just the natural appearance of shadings on the Moon at this time, however we would like to capture images of this area to be sure. Small aperture telescopes or telephoto lens similar to Nick's can be used. Try switching the tracking off to see what effect motion blur has during the exposure - to see4 if this replicates the effect.*

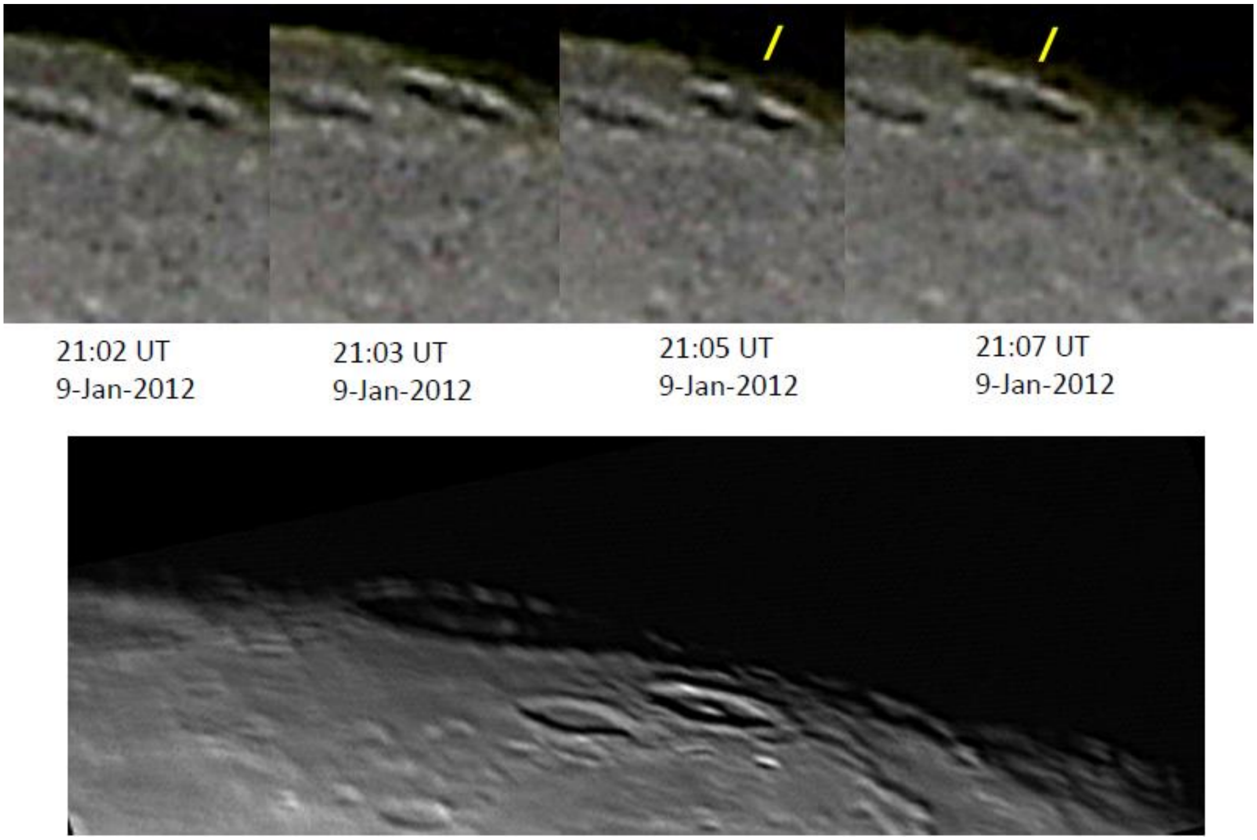


Figure 7. The crater Hahn and surrounding area, with north towards the top left. **(Top)** Image sequence by Nick Hazel, taken with a tripod mounted D7000 DSLR camera for the dates and UTs given. **(Bottom)** An image by Alberto Anunziato taken on 2019 Sep 15 UT 02:51 taken with a 180 mm reflector equipped using a ZWO ASI120MC camera.

Alberto's image (**Fig 7 – bottom)** is much sharper than the 2012 DSLR camera images (**Fig 7 – top**), and shows no sign of the plume effect. The simplest explanation for the "plume" is that it was just image data compression noise, seeing ripple, or a bird or insect flying past the Moon, otherwise some significant volume of absorbing material would be needed between the eastern crater rim and us. We shall keep the weight at 1 for now and encourage similar DSLR images to see if we can check out the compression noise effect.

Plato: On 2019 Sep 07 UT 21:34 Les Fry (NAS – see **Fig 8**) was just 3 minutes outside a repeat illumination (to within ±0.5°) observing window for the following report:

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

Figure 8. Plato located at the center of this monochrome image and orientated with north towards the top. Taken on 2019 Sep 07 UT 21:34 by Les Fry (NAS).

Promontorium Agarum: On 2019 Sep 15 UT Román García Verdier imaged (**Fig 9**) the Mare Crisium area under similar illumination and topocentric libration, to within ±1° to the following report:

[REF 10] *In 1958 Aug 20 at UT 20:00? an unknown observer noticed that Promontorium Agarum appeared filled with fog or mist. The Cameron 1978 catalog ID=510 and the weight=3. The ALPO/BAA weight=2.*

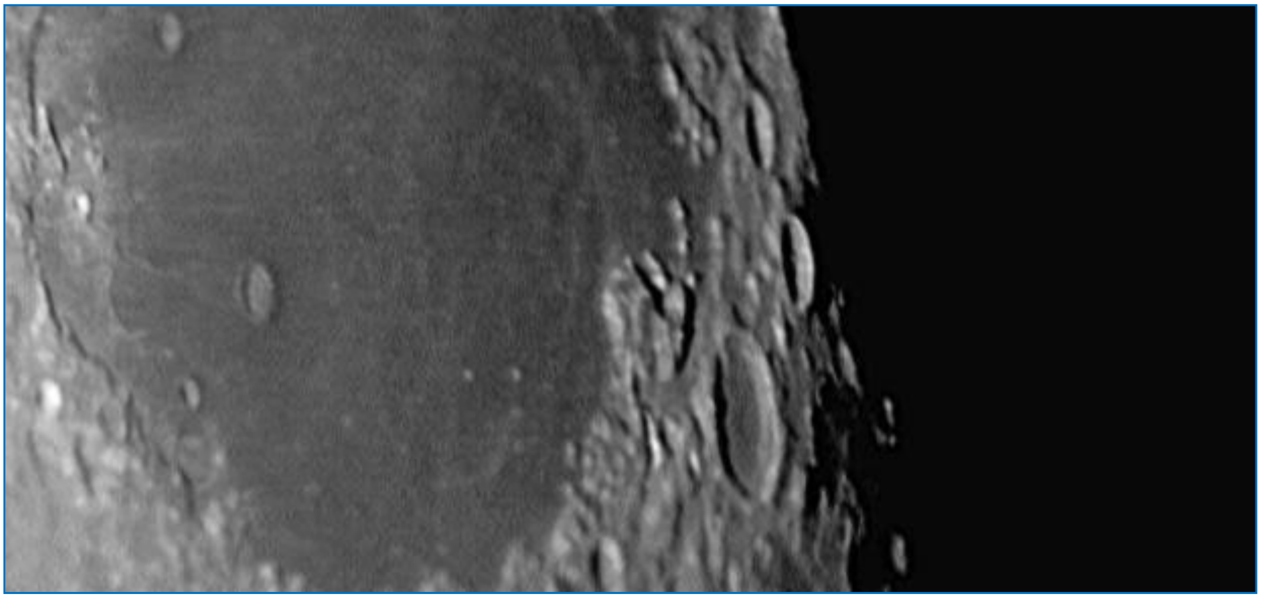


Figure 9. Promontorium Agarum located at the center of this image and orientated with north towards the top. Taken on 2019 Sep 15 UT 03:44 by Román García Verdier (SLA).

Torricelli and Torricelli B: On 2019 Sep 16 UT 20:45, 21:10 Valerio Fontani (UAI) and Nicoletta Minichino (UAI) at 21:12 UT, imaged (**Fig 10**) this area under similar illumination (to within ±0.5°) to the following report:

[REF 11] *Torricelli B 2002 Oct 23/24 UT 23:25-23:52 Observed by Clive Brook (Plymouth, UK, 60 mm OG x120 + prism) "Observed that Torricelli was very diffuse and Tor B showing shadow? observer considered a shadow perhaps a little surprising this far from the terminator. Nothing unusual seen by M. Cook at 23:52UT or by A Cook at 00:40-00:52 and indeed other craters did appear to have shadows this far from the terminator? so perhaps only unusual aspect of the original observation that could not be checked due to poor seeing by the latter observer was the fuzziness. The ALPO/BAA weight=1.*

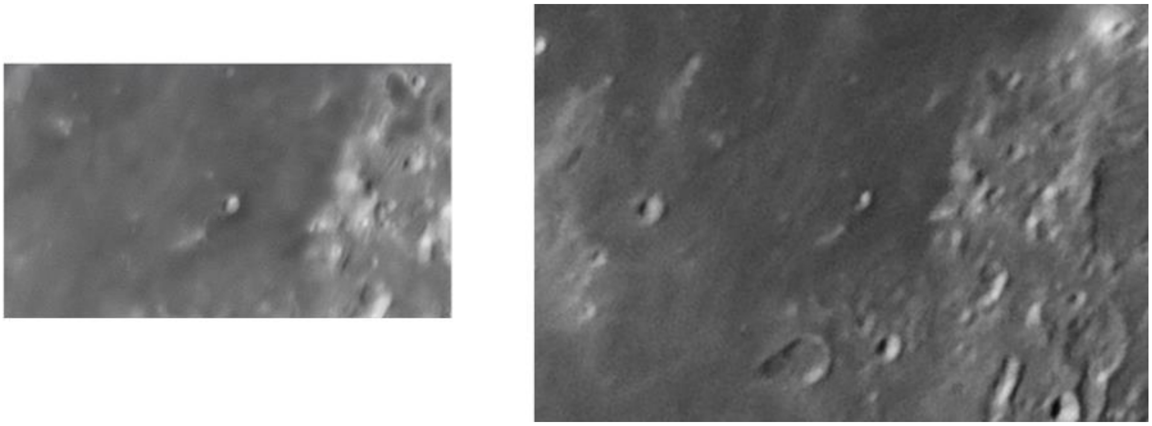


Figure 10. Images of the Torricelli B region orientated with north towards the top, taken on 2019 Oct 16. **(Left)** Image by Valerio Fontani (UAI) taken at 21:10UT with Torricelli B at the center. **(Right)** image by Nicoletta Minichino (UAI) also with Torricelli B at the center and the sideways key-hole shaped crater Torricelli at the bottom

Atlas: On 2019 Sep 17 UT 01:34 Bob Stuart (BAA) imaged Atlas and Hercules in monochrome (**Fig 11**), just 3 minutes outside the ±0.5° similar illumination window to the following report:

[REF 12] *Atlas 1969 Aug 01 UT 03:36-04:00 Observed by Pither (Nottinghamshire, England) NASA catalog reports: "Eng. moon blink in crater at 0336h close to E. wall, NE of central feature. Oval in shape & dirty brownish color & hazy. Started fading at 0345h but may have been due to dawn, Neg results on other features, (Apollo 11 watch)." 12" x450 reflector used. NASA catalog weight=3. NASA catalog LTP ID No. #1195. ALPO/BAA weight=3.*

Figure 11. Hercules and Atlas as imaged in monochrome by Bob Stuart (BAA) on 2019 Sep 17 UT 01:34. North is towards the top.

Tycho: On 2019 Sep 22 UT 02:45-03:39 Dietmar Büttner (BAA) observed visually sunset over Tycho, but was not aware that 3 hours earlier the lunar schedule web site had requested:

[REF 13] *On 1996 Feb 12 at UT 07:30-08:27 J. Sandel (Caycee, SC, USA) noted a contrast effect inside Tycho at sunset. At 07:30UT there was a slight, but definite illumination of small areas of the crater floor west of the central; peak. Also seen by T. Ferrel (Lawrenceville, GA, USA, SCT C8). This was oval in shape and grey in color - Ferrel noted some diffuseness. It brightened over 30 minutes. At 08:11UT a definite brightness fade noted in Tycho's central peak. The crater floor had increased illumination of entire crater floor. ALPO/BAA weight=3.*

Dietmar noted that Tycho was completely on the day side of the Moon, with the crater's floor fully in shadow, and its eastern inner wall brightly sunlit. More specifically time wise:

02:45 UT: central peak seen as a very weak sunlit point; at the limit of visibility.

03:03 UT: central peak a little bit brighter than before, central peak no longer just a point, but also a little bit extended; but again, at the limit of visibility

03:31 UT: central peak now seen as a weak/very weak sunlit point, again a little bit extended; at the limit of visibility

03:39 UT: central peak seen as a sunlit point; at the limit of visibility, but it was also noted that the shadow inside the crater partly not fully black, but slightly greyish. As a comparison the shadows in other nearby craters were completely black!

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

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

SUBMISSION THROUGH THE ALPO IMAGE ARCHIVE

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

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

It is helpful if the filenames follow the naming convention :

FEATURE-NAME_YYYY-MM-DD-HHMM.ext

YYYY {0..9} Year

MM {0..9} Month

DD {0..9} Day

HH {0..9} Hour (UT)

MM {0..9} Minute (UT)

.ext (file type extension)

(NO spaces or special characters other than "_" or "-". Spaces within a feature name should be replaced by "-".)
As an example the following file name would be a valid filename:

Sinus-Iridum_2018-04-25-0916.jpg
(Feature Sinus Iridum, Year 2018, Month April, Day 25, UT Time 09 hr16 min)

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

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

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

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

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

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

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

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

Digitally submitted images should be sent to:
David Teske – david.teske@alpo-astronomy.org
Jerry Hubbell –jerry.hubbell@alpo-astronomy.org
Wayne Bailey—wayne.bailey@alpo-astronomy.org

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

CALL FOR OBSERVATIONS:
FOCUS ON: Plato & Theophilus

Focus on is a bi-monthly series of articles, which includes observations received for a specific feature or class of features. The subject for the **January 2020** edition will be the Plato and Theophilus regions. 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
David Teske – david.teske@alpo-astronomy.org

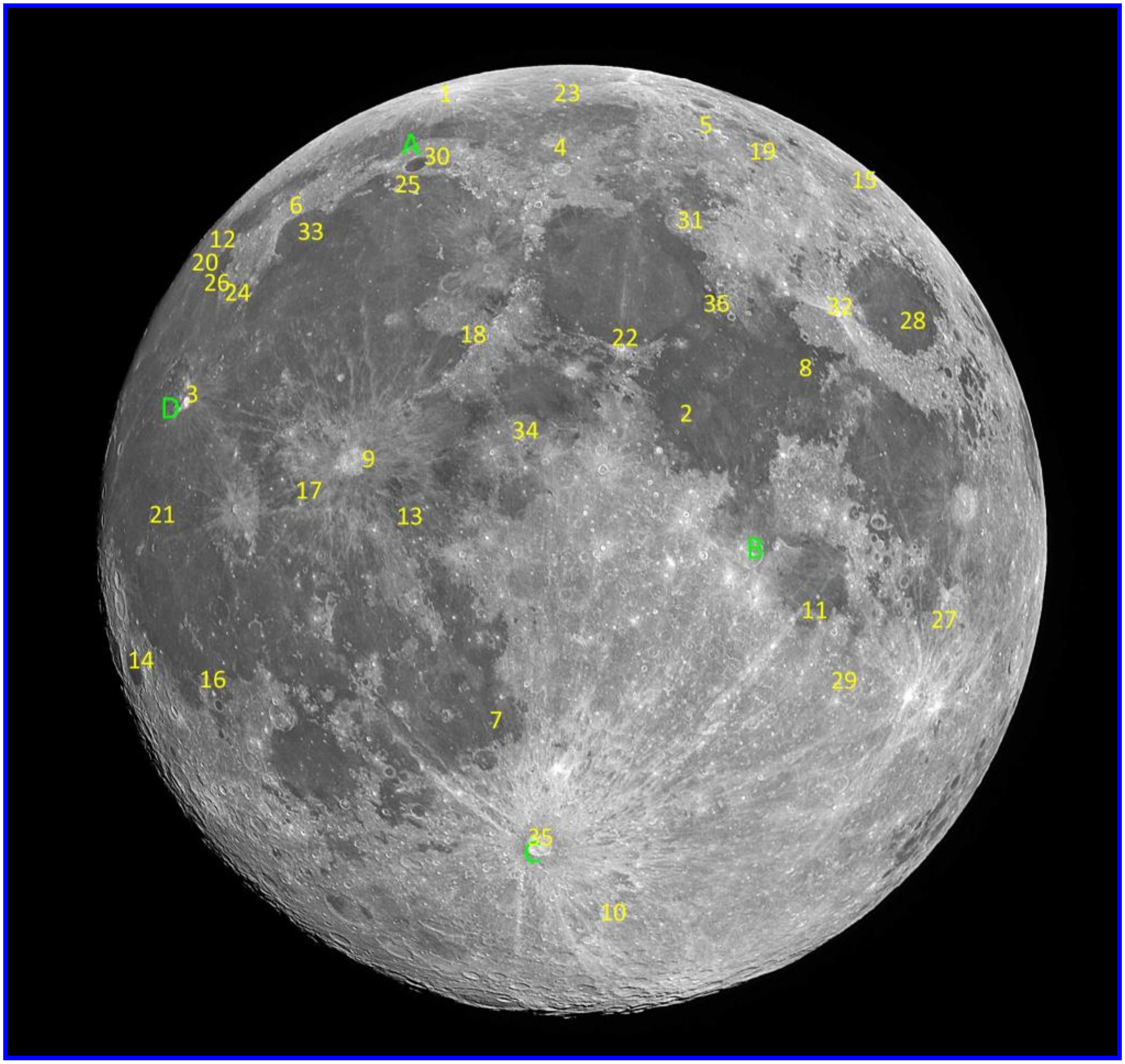
Deadline for inclusion in the Plato and Theophilus region article is December. 20, 2019

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.

Subject	TLO Issue	Deadline
Plato & Theophilus	January 2020	December 20, 2019
Tycho & Herodotus	March 2020	February 20, 2020

Key to Images In This Issue



1. Anaxagoras
2. Arago
3. Aristarchus
4. Aristoteles to Eudoxus
5. Atlas
6. Bianchini
7. Birt
8. Cauchy
9. Copernicus
10. Deluc
11. Fracastorius
12. Galvani
13. Gambart
14. Grimaldi
15. Hahn
16. Hansteen
17. Hortensius
18. Huxley
19. Lacus Mortis
20. Lavoisier
21. Marius Domes
22. Menelaus
23. Meton
24. Mons Gruithuisen
25. Mons Teneriffe
26. Mons Rumker
27. Petavius
28. Picard
29. Piccolomini
30. Plato
31. Posidonius
32. Proclus
33. Sinus Iridum
34. Triesnecker
35. Tycho
36. Vitruvius

Upcoming Focus-On targets:

A. Plato
B. Theophilus
C. Tycho
D. Herodotus