

 **CELESTRON®**

# **LUNAR** LANDSCAPES

**THE PHOTOGRAPHY OF ROBERT REEVES**



## ROBERT REEVES

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Hello! My name is Robert Reeves and for the past 57 years I have had a love affair... with the Moon! I want to thank Celestron for giving me the opportunity to share this passion with you.

I took my first lunar image in 1959 just as our space program was awakening to the possibilities of exploring our natural satellite. In the next decade, the Moon captured the world's imagination as astronauts and cosmonauts pushed the boundary of humanity ever upward, culminating with Apollo 11 and Neil Armstrong's epic first step onto another world. By the 21st century, the steady progress in astrophotography equipment brought the Moon into the realm of the amateur astronomer. Superior telescopes and electronic cameras allow amateur astronomers to image the Moon from their backyards in greater detail than professional astronomers could in the heyday of the Apollo explorations.

I thus argue that NOW is the golden era of amateur lunar observation. We have the advantage of high performance, yet affordable equipment that allows us to image the Moon in stunning detail, even from a light polluted backyard.

I invite you to join me in exploring Luna, our neighboring world. Dramatic telescopic lunar vistas are as much pure cosmic art as they are a science lesson. Fly to the Moon through your telescope and feel the artistic passion that has inspired centuries of poetry and prose. Fly to the Moon through your telescope and experience the joy of exploring another world.



## FULL MOON

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The full Moon is more than visual poetry swimming against a dark sky. The full Moon is the time when we can see the entire surface of Luna and contemplate the history of how the face of the Moon evolved. In the friendly face of the Man-in-the-Moon lies four and one-half billion years of geological evolution that may have begun with a fiery titanic collision between two worlds.

It is theorized that early in the solar system's existence, both the proto-Earth and another Mars-sized planet fought for orbital supremacy in the region of modern Earth's orbit. Eventually our proto-Earth and the other planet, provisionally known as "Theia", collided with a blast that vaporized both worlds. Both the modern Earth and its new Moon then rapidly accreted from the swirling cloud of debris.

The next time you gaze at a full Moon, try to imagine the staggering sight it must have been nearly four billion years ago as the blasts from giant asteroid impacts carved out the face of the Moon. The seemingly eternal and peaceful face of Luna was once a fierce cosmic battleground. But today, the Man-in-the-Moon shines his friendly face toward Earth and reminds us all is well on that distant world.

**IMAGER:** Robert Reeves

**OBJECT:** Full Moon

**TELESCOPE:** Celestron 11" EdgeHD

**CAMERA:** Celestron Skyris 274M



## MOON PHASE

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The ever-changing phases of the Moon were the first celestial phenomena noticed by ancient peoples. Prehistoric carvings on 20,000 year old bone fragments demonstrated that even before civilizations evolved, humans recorded the passage of time through the phases of the Moon. Although modern civilizations no longer track the passage of time through the Moon's phases, today's calendar has its roots in the lunar cycle.

The phases of the Moon occur because the Moon revolves around the Earth. While the Moon keeps the same face toward Earth, the constantly changing perspective between the Moon, Earth, and the Sun continuously alter the illumination of its surface.

But the cosmos is not so simple that that it can be easily defined by a set of numbers. The fact is the Moon's orbit is very elastic, constantly changes, and

can vary in length by over half a day over the course of a year. The classical lunar month and Earth/Moon distance figures are an average of a constantly changing orbit.

The next time you look at a peaceful Moon in the sky, remember our natural satellite does not move with clock-like repetition from month to month. The Moon's orbit is as dynamic and ever-changing as the phases that entertain us each night.

**IMAGER:** Robert Reeves  
**OBJECT:** Phases of the Moon  
**TELESCOPE:** Celestron 11" EdgeHD  
**CAMERA:** Celestron Skyris 274M

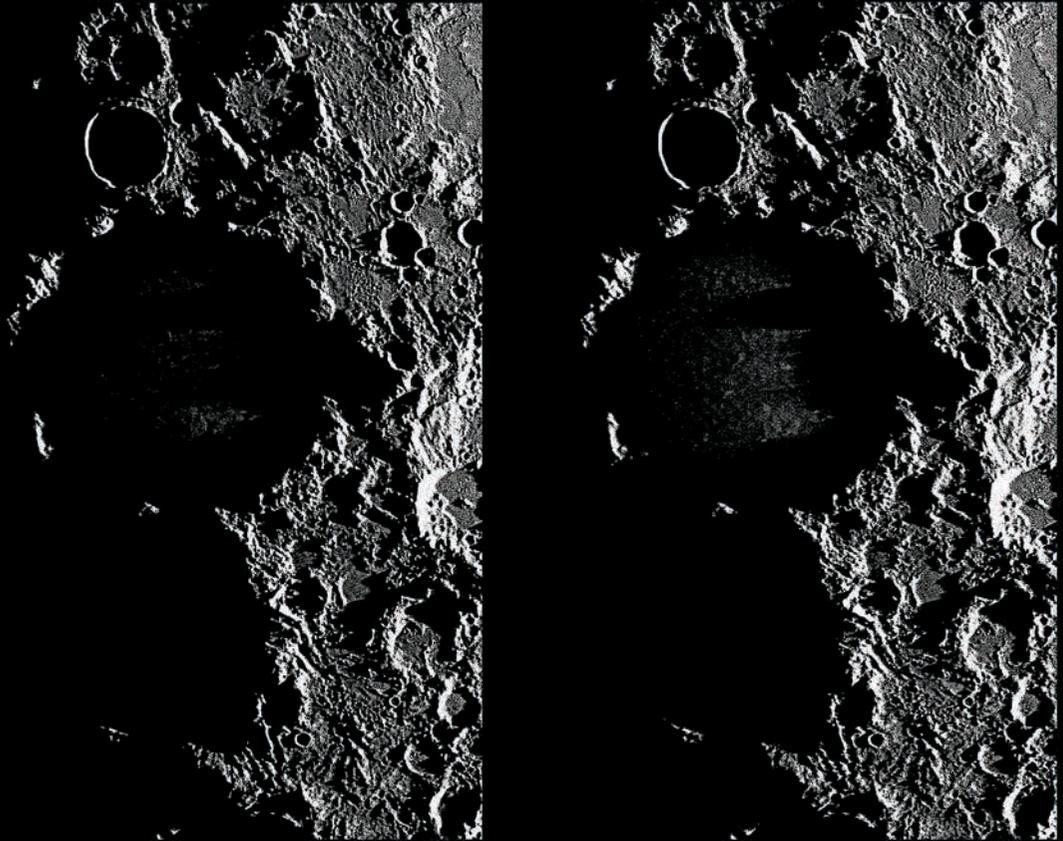
## PTOLEMAEUS SUNRISE

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The notion that the Moon is static and unchanging is challenged by the spectacle of sunrise sweeping across the crater Ptolemaeus, located near the center of the Moon's visible disk. This sequence of images was taken over a two hour period on the evening of March 27, 2015, and shows the Moon does indeed change before our eyes if we take the time to look.

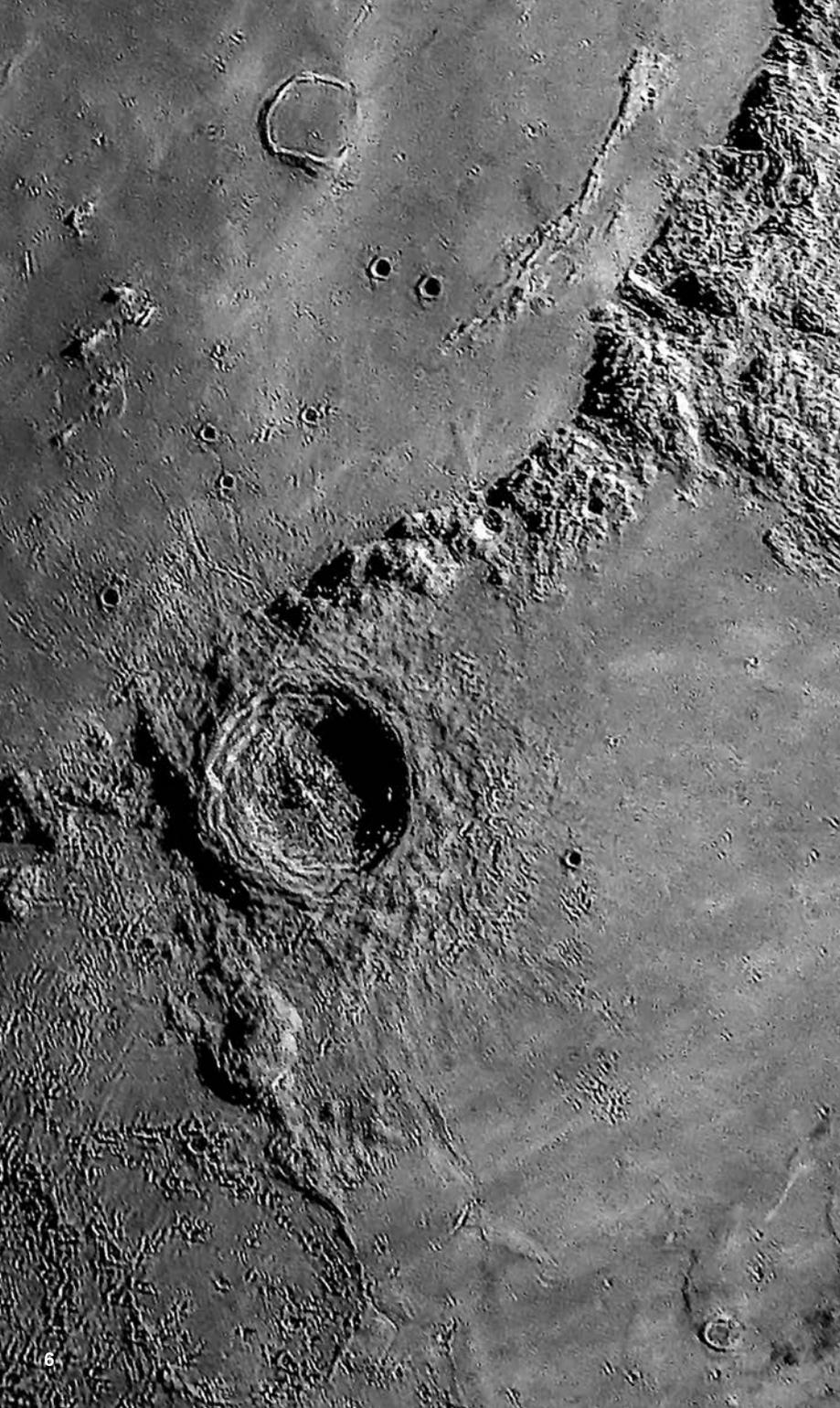
The crater Ptolemaeus spans 154 kilometers and was formed four billion years ago before the creation of the great basins that hold the dark lunar maria. Today, the floor of Ptolemaeus is surprisingly smooth compared to most craters. The crater's interior was buried between 3.8 and 3.9 billion years ago when the titanic blasts that created the basins heaved massive amounts of debris and rock across the face of the Moon. Ptolemaeus was so inundated by the storm of debris that even its high central peak was obscured. Today, the smooth floor of Ptolemaeus is punctuated by dozens of tiny craterlets that formed since the ancient crater was drastically modified.

As sunrise progresses in this sequence of images, dark fingers of saw tooth shadow slowly recede as the Sun rises above the rough eastern rim of Ptolemaeus. Sunrise on the Moon is a slow spectacle. On Earth, the Sun takes two minutes to fully rise above the horizon. The Moon, however, rotates much slower than Earth with a lunar day spanning nearly one Earth month. Because of the Moon's much slower rotation rate, the Sun requires nearly an hour to fully rise above the lunar horizon, providing us with a lazy spectacle as the shadows slowly recede.





**IMAGER:** Robert Reeves  
**OBJECT:** Ptolemaeus crater  
**TELESCOPE:** Celestron 11" EdgeHD  
**CAMERA:** Celestron Skyris 274M



## ERATOSTHENES

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At the upper right we see the lunar Apennine Mountains arcing toward the crater Eratosthenes. There are 20 mountain ranges visible on the Moon. Unlike mountains on Earth that rise as a result of global forces crushing together the tectonic plates of our planet's crust, lunar mountains are the result of monstrous ancient asteroid collisions with the Moon. Lunar mountain ranges are in fact the rims of the great basins created by these collisions. Lunar mountains thus surround many of the basins that host the large circular dark maria that form the face of the Man-in-the-Moon.

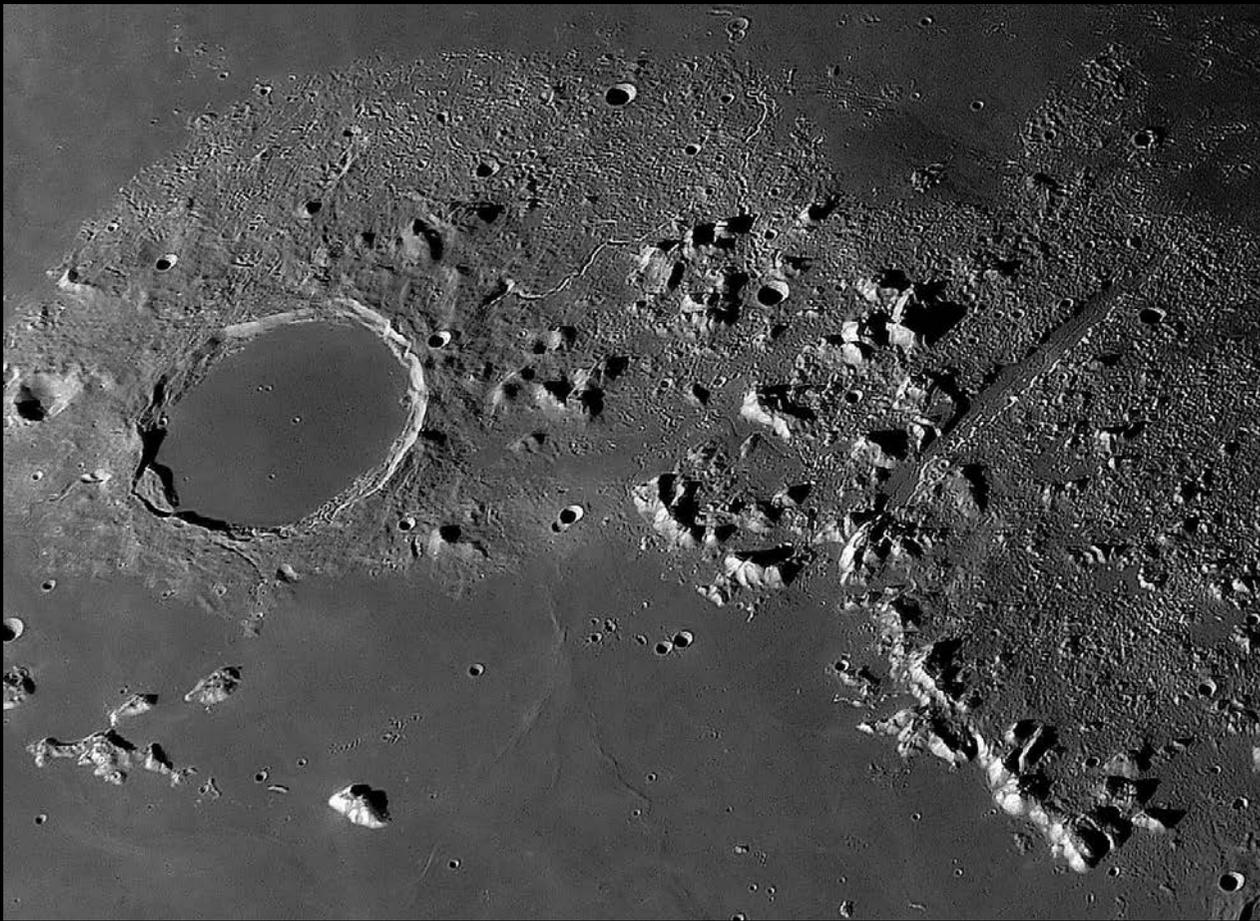
A lunar basin is any crater larger than 300 kilometers in diameter. The large basins on the near side of the Moon were created nearly four billion years ago when the Late Heavy Bombardment rained hundreds of large asteroids onto the lunar surface. Because lunar mountains were created by forces unleashed by an asteroid collision, they were formed in a matter of minutes, as opposed to terrestrial mountains, which are pushed up over a period of millions of years.

Most lunar mountain chains bear the same names as terrestrial mountain chains, thus we see the lunar Alps, Caucasus, and Apennines circling the eastern rim of Mare Imbrium, the lunar sea seen as the Man-in-the-Moon's left eye. The rims of lunar basins that form mountains are the highest regions on the Moon. Considering the Moon is only one quarter the diameter of Earth, lunar mountains are proportionately giants compared to terrestrial mountains.

Today, the Moon looks peaceful and serene, but the history of its evolution is filled with violent forces that destroyed as well as created. When you sweep a telescopic view along the mountains of the Moon, remember the unimaginable forces unleashed by the cosmic collision that created the mountains.

**IMAGER:** Robert Reeves  
**OBJECT:** Eratosthenes crater  
**TELESCOPE:** Celestron 11" EdgeHD  
**CAMERA:** Celestron Skyris 274M





## PLATO / ALPINE VALLEY

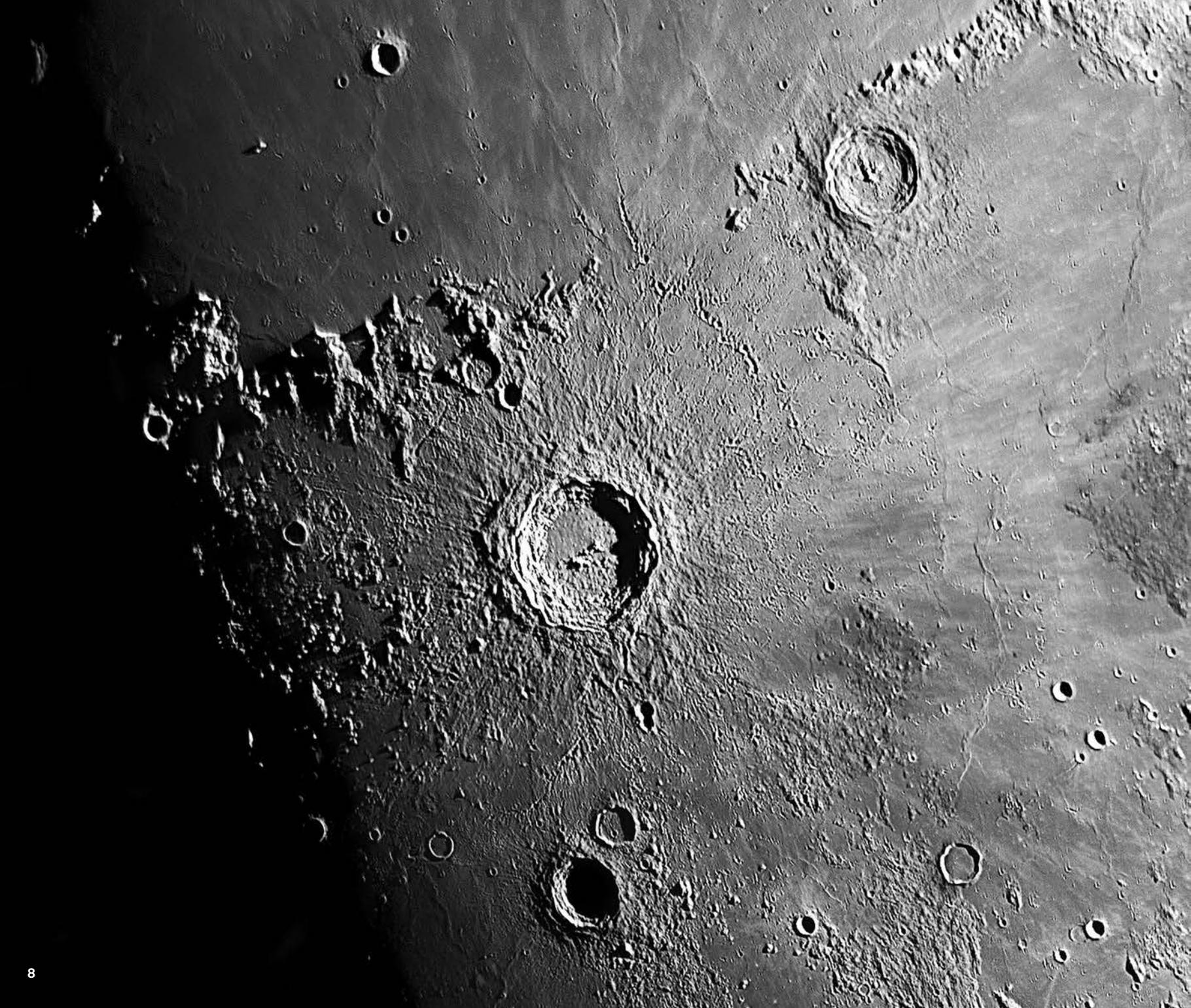
The floor of Plato appears as flat as an ice skating rink and immediately challenges our preconceived notions of what we are viewing. Plato's strange, almost featureless floor further intrigues us by seeming to be much higher than the floors of other similar sized craters. Indeed, the floor appears nearly the same elevation as the basalt fields of Mare Imbrium to the south, but none of the Imbrium lava flows have breached Plato's walls. This leads to the inescapable conclusion that the lavas that flooded Plato welled up from below the crater.

The floor of Plato is not as featureless or flat as it appears. Numerous tiny craterlets dot the floor and the larger of them are considered a test of how good the telescopic seeing conditions are. If four small central craterlets are easily seen, the seeing is considered good. If more are noticeable, the seeing is extraordinary. When the Moon is tilted just right, sunrise shadows extending from Plato's eastern rim across the interior floor can take on a curious hook shape, an effect created by the shadow falling on an uneven surface.

Though not one of the Moon's larger landmarks, Plato has a unique blend of science and strangeness and holds a special place in the hearts of lunar observers.

**IMAGER:** Robert Reeves  
**OBJECT:** Plato crater  
**TELESCOPE:** Celestron C8  
**CAMERA:** Celestron Skyris 132M





## COPERNICUS

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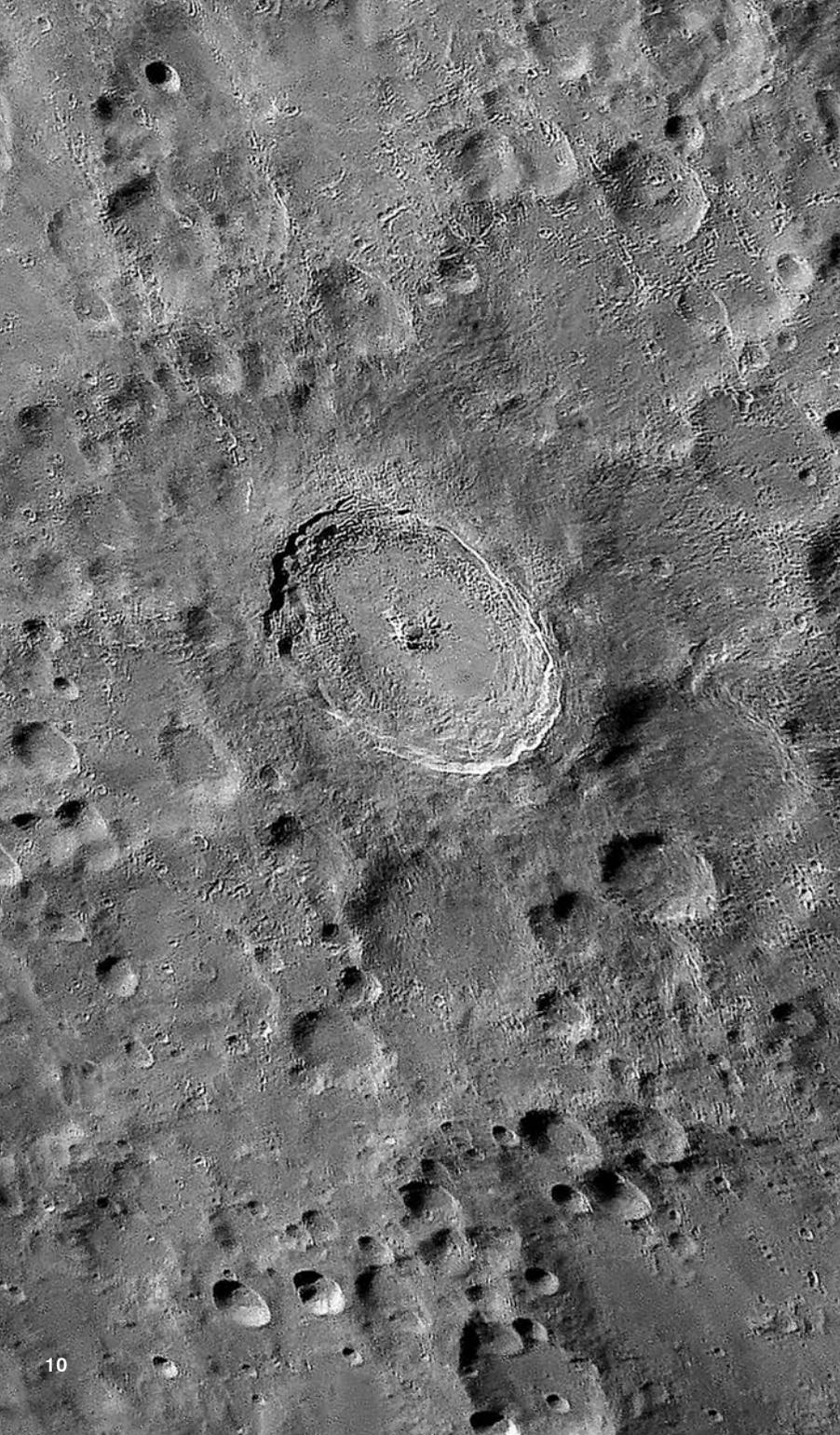
Known centuries ago as the “Monarch of the Moon”, Copernicus has a dual personality. At low Sun elevations, deep shadows reveal stunningly beautiful detail in its terraced walls and central peak. Chains of secondary craters gouged into the lunar surface by debris thrown from the impact that created Copernicus streak radially away from the grand crater. Hundreds of tiny pits fan outwards from its rim and pockmark the territory around Copernicus, giving testimony to the power of the blast that excavated Copernicus less than a billion years ago.

Under high noontime Sun, the Copernicus region transforms into a blossom of rays spreading equally in all directions. Without shadows, the interior of Copernicus becomes featureless while the ray structure, seen best under high Sun, becomes the second largest ray system on the Moon. Because Copernicus is fortuitously placed on a darker mare region, the contrast of its bright ray system makes the “Monarch” a favorite of both novice and experienced lunar observers.

The accompanying image is a compromise between low Sun revealing the Copernican structure, and noontime Sun highlighting the fabulous ray structure.



**IMAGER:** Robert Reeves  
**OBJECT:** Copernicus crater  
**TELESCOPE:** Celestron 11" EdgeHD  
**CAMERA:** Celestron Skyris 274M



## TYCHO

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The crater Tycho is not visible to the naked eye, but evidence of its existence can be seen at full Moon. Tycho possesses the largest ray system on the Moon. This ray system is visible to the naked eye and seems to focus to a point on the southern face of the Moon, the location of Tycho itself!

At 87 kilometers across, Tycho is a magnificent crater that spans an area equal to the largest metropolitan cities on Earth and displays all the features typical of large lunar craters; a central peak, flat floor, terraced walls, and secondary craters. What sets Tycho apart from other similar sized craters is its spectacular ray system stretching 3,000 kilometers across the Moon's face.

Tycho was created by the oblique impact of a projectile arriving from the west, thus the crater's ejecta and ray structure streams primarily to the east. Territories to the east of Tycho are eroded by hundreds of small secondary craters while the western region remains smoother.

A study of the Baptistina family of asteroids suggests that projectiles from this series of asteroids were responsible for both the Tycho impact on the Moon and the later Earth impact that created the Chicxulub crater in the Yucatan 65 million years ago. The worldwide repercussions from the Yucatan impact are suspected to be one of the causes of the extinction of the dinosaurs. If there is a connection between these two events, when we look at Tycho and its magnificent fan of rays across the southern face of the Moon, we are looking at one of the reasons mankind evolved on this Earth.

**IMAGER:** Robert Reeves  
**OBJECT:** Tycho crater  
**TELESCOPE:** Celestron 11" EdgeHD  
**CAMERA:** Celestron Skyris 274M



## ALPHONSUS / ARZACHEL

Located near the center of Moon's visible disk, the craters Alphonsus (top) and Arzachel (bottom) are part of the famous trio that includes Ptolemaeus to the north. Alphonsus dates between 3.8 to 3.9 billion years old while Arzachel is probably a billion years younger. The floor of Alphonsus is unusually smooth while its central peak is unusually small. This signifies the 118 kilometer wide crater was partially buried by waves of debris showered from the massive impacts occurring during the Moon's Late Heavy Bombardment era. Younger Arzachel escaped such treatment. Ninety-eight kilometer wide Arzachel's was instead smoothed by volcanic flows. Arzachel also displays a strangely offset central peak.

Both Alphonsus and Arzachel are known as floor fractured craters, that is, there are huge cracks on their otherwise smooth floor. These cracks, designated Rima Alphonsus and Rima Arzachel, were created by ancient volcanism that pushed up from below each crater. Further evidence of volcanism is seen inside the eastern rim of Alphonsus where four dark halos surround small craters either on or near Rima Alphonsus. A fifth dark halo lies along the western wall. These are dark volcanic ash deposits that erupted onto the floor of Alphonsus over a billion years ago.

For more than half a century, Arzachel has held a place in my heart, not because the crater is special, but because of a paperback science fiction book I read as a young boy in 1960. In this book, whose name has long ago faded from my memory, both American and Russian astronauts have landed on the Moon. Both parties encountered difficulties that imperiled their return to Earth. Though bitter political rivals on Earth, the crew of both nationalities learned that only by cooperating could they survive the harsh lunar environment and return together to the safety of our blue and green planet. The action in this story took place within Arzachel crater.

**IMAGER:** Robert Reeves

**OBJECT:** Alphonsus and Arzachel craters

**TELESCOPE:** Celestron 11" EdgeHD

**CAMERA:** Celestron Skyris 274M



## RUPES RECTA

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One of the most arresting lunar features is the mysterious Straight Wall, seen here just above image center. This linear feature is known by the technical name of Rupes Recta. In the era prior to spacecraft exploration of the Moon, Straight Wall was envisioned as a sheer cliff. At sunrise, it casts a shadow, but as the Sun rises higher in the lunar sky the face of Straight Wall shines brightly. Rupes Recta is thus seen as either a “black line” feature or a “white line” feature, depending on the time of the lunar day.

Modern views of Rupes Recta from spacecraft in orbit around the Moon show its cliff face is not as formidable as once thought. The feature is actually a geological formation known as a graben, or a region where the land slumps between two parallel faults. Straight Wall is actually more of a steep slope, inclined less than 30 degrees in some places. It is shallow enough that a spirited future astronaut might traverse its slopes on foot.

Due south of ancient Thebit crater we see another similar sized shallow crater that has not been buried under basalt. Although this feature is 235 kilometers across, it did not gain an official name until 1948 when it was named after the 20th century French astronomer Henri Deslandres. Prior to its official naming, Deslandres crater was known as “Hell Plain” due to the crater Hell prominently located inside its western rim.

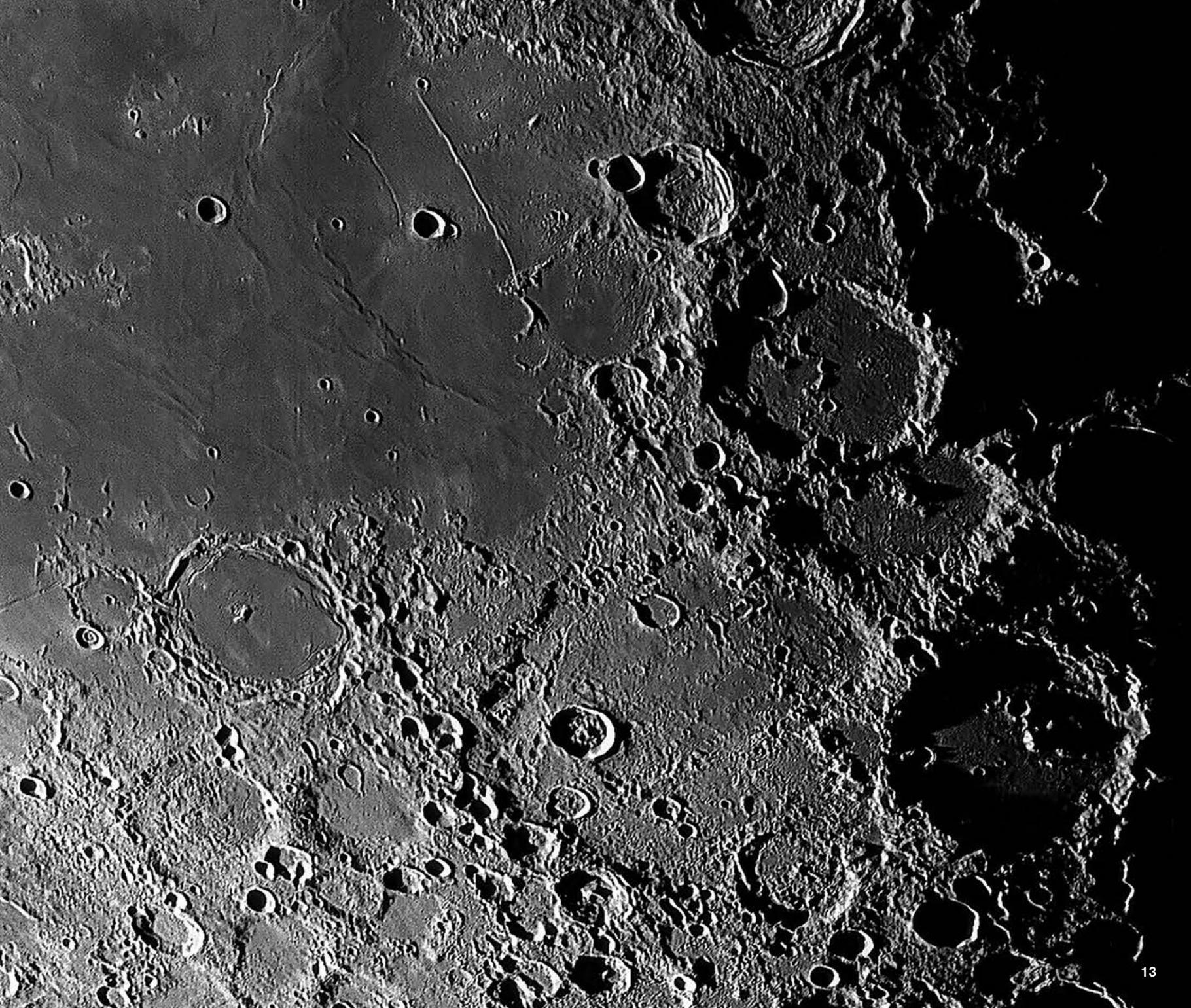


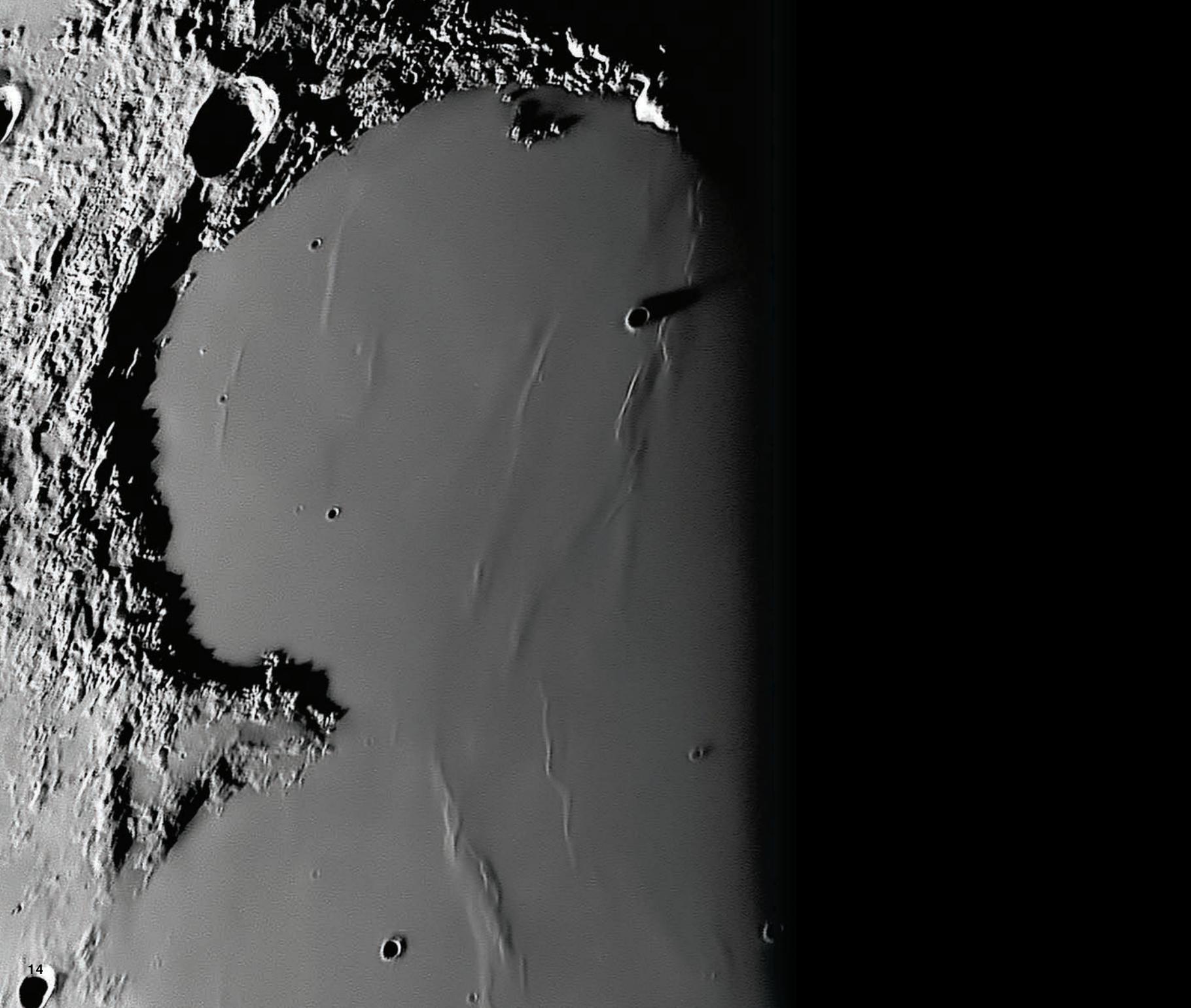
**IMAGER:** Robert Reeves

**OBJECT:** Rupes Recta

**TELESCOPE:** Celestron C11

**CAMERA:** Celestron Skyris 132M





## SINUS IRIDUM

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Sinus Iridum, which is Latin for Bay of Rainbows, appears like a horseshoe bay on the northwestern shore of Mare Imbrium. Spanning 400 kilometers across its wide mouth, Sinus Iridum merges into the smooth plains of Mare Imbrium. By chance, the asteroid impact that blasted circular Sinus Iridum out of the lunar surface crashed down on the rim of the Imbrium Basin after the basin itself was formed. Because the Iridum impact occurred on the tilted rim of the Imbrium Basin, the “seaward” side of Iridum is sloped toward the center of the Imbrium Basin.

As a result, the subsequent lava eruptions that filled the Imbrium Basin to form dark Mare Imbrium also breached the lower portions of the Iridum Basin’s rim. As eruptions continued to create Mare Imbrium, the lava flows continued to spill into the smaller basin, eventually burying the lower side of the rim and merging the interior of Sinus Iridum with the smooth surface of Mare Imbrium.

The cliff-like rim of Sinus Iridum rises above the smooth basalt floor to create the Jura Mountains. The northern range of Jura Mountains plunge into Mare Imbrium creating a peninsula dubbed Promontorium Laplace. To the south, the Juras terminate at Promontorium Heraclides. The crater Bianchini lies at cliff’s edge along the northern Jura Mountains.



**IMAGER:** Robert Reeves  
**OBJECT:** Sinus Iridum  
**TELESCOPE:** Celestron 11” EdgeHD  
**CAMERA:** Celestron Skyris 274M

## HYGINUS / ARIADAEUS RILLES

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Rilles, or cracks and channels in the Moon's surface, are fascinating features that add variety to the never-ending clusters of craters and the broad lunar maria. Rilles are known by their Latin name of Rima, or Rimae if there are more than one. In this view near the center of the Moon's disk, we see three of the four different types of rilles that course over the lunar surface.

Prominent at the center of the image is the diagonal slash of the 220 kilometer long Rima Ariadaeus. Appearing much like a highway excavation, Ariadaeus is an example of a linear rille created by tectonic faults in the lunar crust. More linear rilles in the form of Rimae Hypatia lie at the lower right near the famed Apollo 11 landing site on Mare Tranquillitatis. To the northeast of Ariadaeus lies the gull wing shaped Rima Hyginus, an example of a volcanic rille. The small crater Hyginus at the center of the bent rille is one of the few craters on the Moon that is not impact origin. Hyginus crater is a volcanic collapse pit. A number of smaller volcanic pits can be seen along the stretch of Rima Hyginus. South of Rima Hyginus we see tangled jumble of Rimae Triesnecker, an example of irregular branching rilles.



**IMAGER:** Robert Reeves

**OBJECT:** Hyginus, Ariadaeus, and Triesnecker rilles

**TELESCOPE:** Celestron C11

**CAMERA:** Celestron Skyris 274M



## HOW THESE IMAGES WERE TAKEN

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In an era when someone can hold a cell phone camera to a telescope eyepiece and take a lunar photo that rivals the efforts of skilled astrophotographers just a generation ago, it is hard to believe the technology of lunar photography remained static for one and one half centuries since 1840 when the American physician John Draper exposed a Daguerreotype through his telescope.

Modern lunar photography further evolved in the past ten years when the technique of stacking many individual video images into a single higher resolution image became the norm. The perfection of electronic image stacking technology has allowed the backyard amateur telescope to exceed the planetary imaging capabilities of large professional telescopes during the film era.

The images shown in this book were processed in a series of software suites. With the exception of Photoshop Creative Cloud, all the needed software is free! Now that Photoshop CC is a \$10 per month subscription software, the price barrier has been eliminated and everyone can operate with the same software.

Image capture with a planetary camera like the Celestron Skyris 236 is controlled through the freeware program FireCapture. This program has enhancements to the normal camera controls that make it more astronomically friendly.

After a video sequence is captured, typically two to three thousand frames, the freeware AutoStakkert2 is used to select the best frames and stack them into a single image. Typically, I set the software to stack the best 500 out of 3000 video frames. AutoStakkert2 will then reduce a seven gigabyte video sequence into a single .TIF image.

The output from AutoStakkert2 is then imported into RegiStax 6 for enhancement of fine details using the software's wavelet function. Not all images require wavelet enhancement and the function should be used experimentally to see if it actually improves the image.

Once stacking is complete and any wavelet processing is performed, the .TIF image is imported into Photoshop CC. The big secret for fabulous lunar images is Photoshop's "Shake Reduction" filter, located under <Filter>, <Sharpen>, <Shake Reduction>. Using this filter is like taking your lunar images under seeing conditions that were twice as good!

Further enhancements in Photoshop CC include using the "Camera Raw" filter, located under <Filter>, <Camera Raw> to adjust the exposure, suppress burned out highlights, and adjust shadow detail.

Electronic artifacts, or nonexistent detail, often creep into images stacked from many video frames, thus additional Photoshop processing is as much about removing false detail as it is about enhancing real detail. Work with the clone tool will remove artifacts and false detail.

The techniques of modern electronic imaging allow the backyard astrophotographer to achieve stunning science-grade lunar images with affordable cameras and modest telescopes. The golden era of lunar photography is truly NOW!

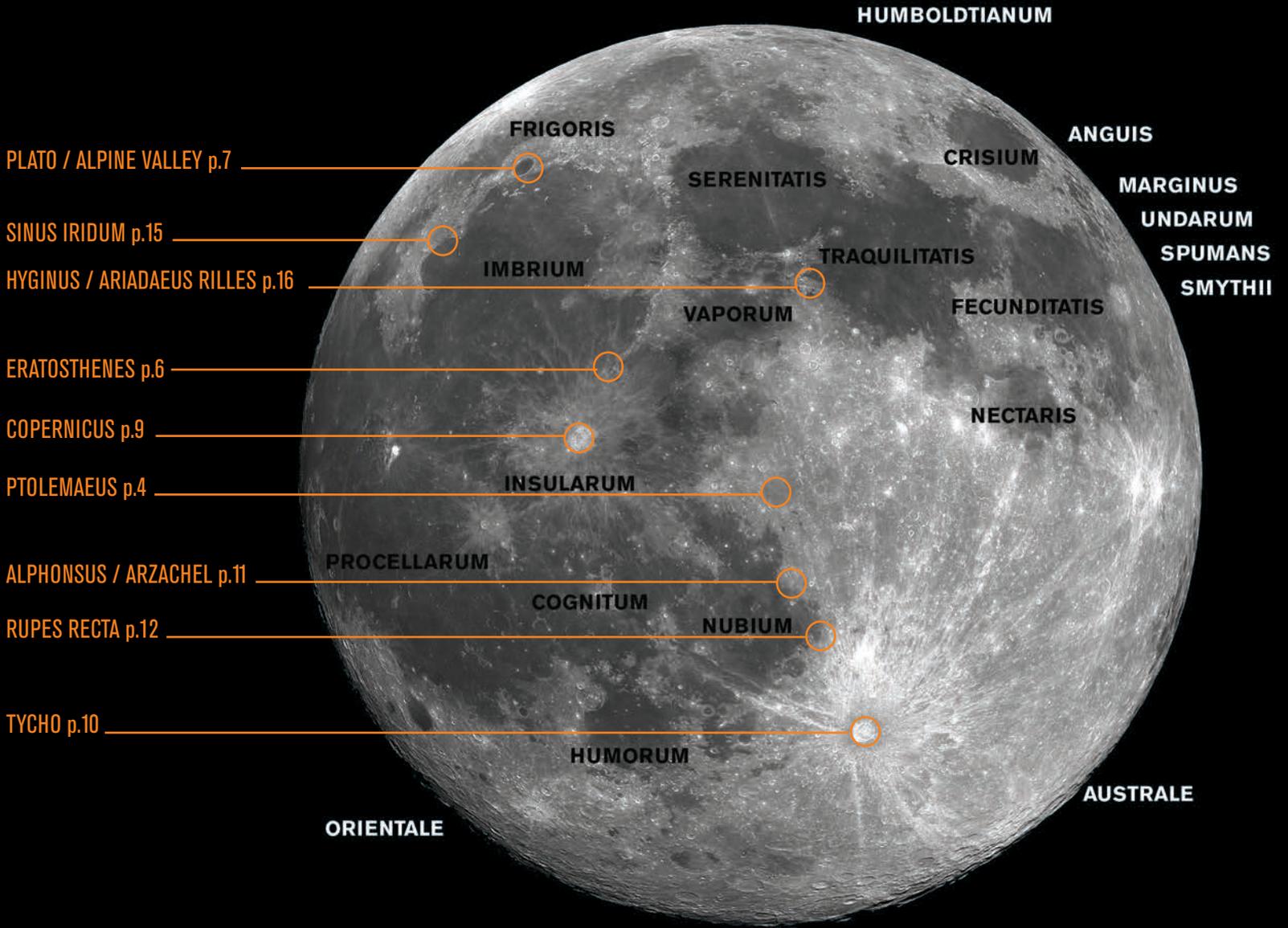
**SKYRIS™**  
IMAGING CAMERA





# MAP OF THE MOON

## MARIA AND FEATURES





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