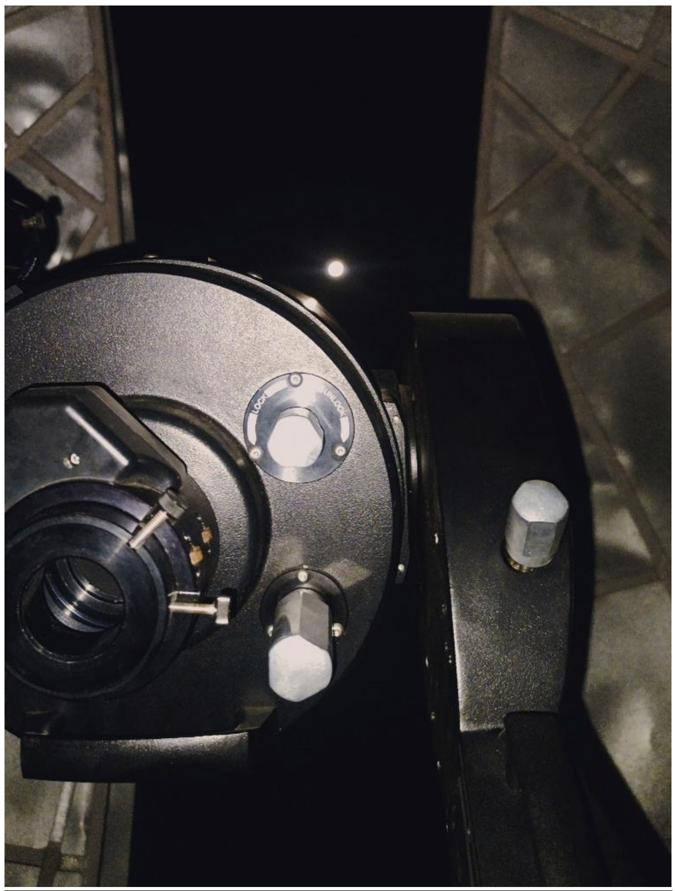
# Observational Astronomy Certificate Course

## Lunar Astrophotography



Submitted as a project work for the completion of the certificate course

by

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# INTRODUCTION

For thousands of years, the Moon, Earth's celestial partner, has captured people's attention. Our fascination with the Moon has driven scientific research and exploration from ancient societies observing its phases to contemporary space missions examining its surface. Within the field of observational astronomy, lunar astrophotography presents an exceptional opportunity to explore the mysteries surrounding our closest celestial neighbour.

The goal of this lunar astrophotography project is to investigate the Moon's surface using observational astronomy as a lens. We intend to obtain detailed photos of lunar features and reveal the mysteries that lie within by utilizing the capability of a 12-inch Cassegrain reflecting telescope and imaging technology. We aim to further our knowledge of the history and evolution of the moon, and image processing techniques by methodical planning, data collecting, and thorough examination.

Beyond its scientific significance, this project also served as a hands-on learning experience for us. We gained practical skills in observational techniques, image processing, and data analysis, which helped us enhance our understanding of both technical and theoretical aspects of astronomy.

Let us embrace the spirit of exploration and the magic of discovery as we set out on this moon astrophotography journey. One pixel at a time, we shall solve the mysteries of the Moon as we investigate the depths of space together.

## HISTORY

The development of human civilization and our understanding of the universe are intrinsically connected to the thousands of years-long histories of lunar observation and photography. Throughout history, people have been fascinated by and in awe of the Moon, giving its phases and motions supernatural meaning.

Using careful observation of the Moon's cycles, early civilizations including the Mesopotamians, Egyptians, and Greeks created lunar calendars to record time and agricultural seasons. Prominent for their accomplishments in astronomy, the Babylonians observed lunar eclipses and created mathematical models to forecast cosmic occurrences.

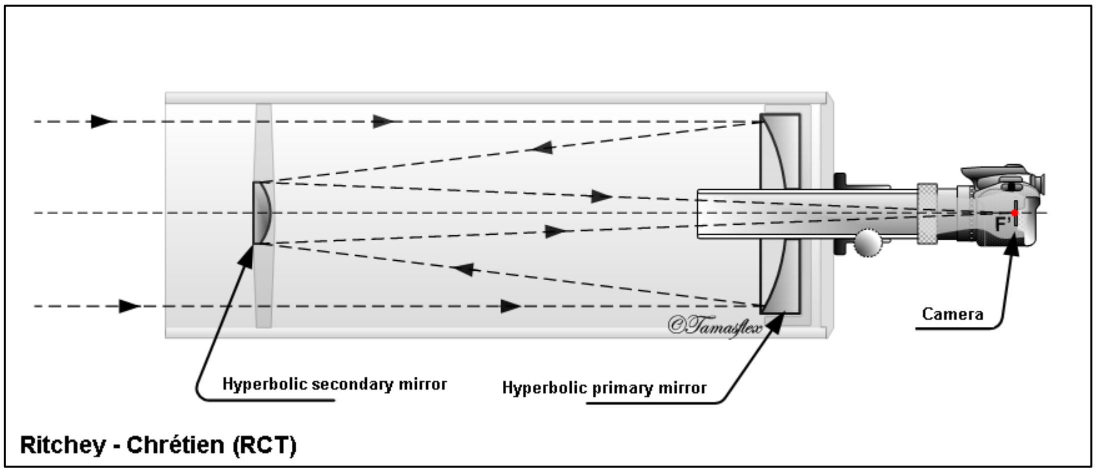
Similarly, a new age of scientific investigation was brought in by the revolutionary work of astronomers such as Johannes Kepler and Galileo Galilei during the Renaissance. Galileo's telescopic views challenged the widely held belief that the Moon is a perfect celestial body by revealing the Moon's rough surface. The Moon's orbit around Earth might be understood theoretically thanks to Kepler's equations of planetary motion.

Astronomy was transformed when the photography method was developed in the 19th century, allowing scientists to take detailed pictures of celestial objects for the first time. The first image of the Moon, taken by Louis Daguerre in 1839, was grainy but revolutionary, opening the door for further lunar photography.

With the development of digital imaging technologies and space-based observatories, lunar photography and observation are still evolving today. Professional and amateur astronomers work together to advance our knowledge of the geology, morphology, and history of the Moon, preserving the heritage of lunar exploration for future generations.

# EQUIPMENTS AND TECHNIQUES

- Facility used: 12-inch Cassegrain Ritchey-Chrétien (RC) Telescope at St. Joseph's University.
- Cassegrain reflector: In the Cassegrain reflector system, light rays are directed towards a primary concave mirror. Light reflected by the concave mirror is made to incident on a convex mirror. The reflection by the convex mirror determines focus. In Cassegrain reflectors chromatic aberration is less.
- Ritchey-Chrétien Telescope (RCT): The Ritchey-Chrétien Telescope is a variant of Cassegrain reflector. In RCT, hyperbolic primary & secondary mirrors are used. RCT's have very less off-axis aberration. Hubble space telescope, ESO VLT use the RC design.




Credits: [Wikimedia Commons]

- The photos & videos of the moon were captured by smartphones using a mount attached to the telescope.
- Devices used: Realme X7 Max, Samsung Galaxy M32.
- Moon filter was also used to reduce the glare and increase the contrast. With the help of the filter, the surface of the moon can be more effectively studied, more minute details were obtainable.
- Many parameters like ISO, saturation, contrast, white balance, shutter speed were adjusted in the phone camera to get desired result and details on the moon.
- 44 mm lens eyepiece was used for observation.


44 mm eyepiece and moonlight filter.

## PLANNING AND PREPARATION

- The observation location was St Joseph's University, Bengaluru
- Having an altitude of about 900 meters above sea level, the elevated terrain of Bengaluru makes it a good spot for Astronomical observations.
- The period of observations was 5 days, starting from $23^{rd}$ March to $27^{th}$ March, 2024. This was the time after the $1^{st}$ quarter and the $3^{rd}$ quarter when the Gibbous was waxing and waning. The observations were made such that the images of the moon were obtained on the day of the full moon and two days before and after the full moon.
- The Temperature varied from 31 to 35 degree Celsius in the night.
- The relative Humidity was 51% on average.
- The barometric pressure was ranging from 752 to 758 mm of Hg.
- The high barometric pressure and low relative humidity added to the quality of observations recorded.
- Precautions: The project was conducted by a group of 4 and arrangements were made for accommodation for the students staying far away from the observatory, Prior permission was taken from the course coordinator to ensure no hassle between the security staff and the students.

# DATA COLLECTION

Procedure

- The slit of the dome was aligned with the position of the moon
- The moon was found in the finder's scope using the telescope remote that controls the telescope's altitude and azimuth.
- The moon filter was added to reduce the amount of light received, failure of which might lead to important details being unclear.
- The moon was located in the telescope by looking through the eyepiece.
- A mount, with a phone, was fixed on the telescope near the eyepiece which enabled us to align the camera of the phone to the eyepiece.
- The USB of a Bluetooth device was connected to the phone which enabled us to click pictures of the moon without touching the phone, thereby moving the camera out of focus.
- Ample number of pictures and videos of the moon were taken in order to get a wide range of frames required to process later on.
  The aperture was set at f/11, the ISO at 100, and the exposure time at 1/400.

# DATA PROCESSING

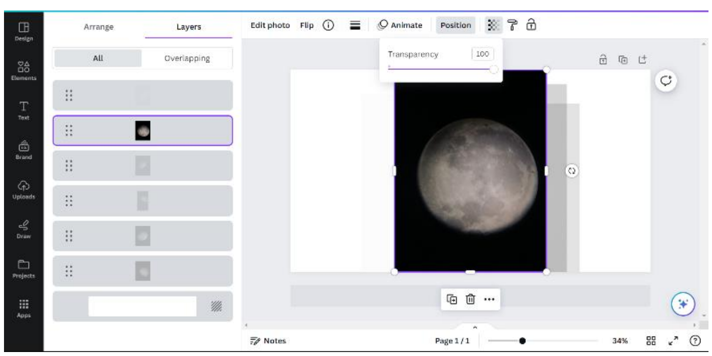
In lunar astrophotography, data processing is the post-capture adjustment and improvement of the pictures taken during the observation periods. After being taken with telescopes and cameras, lunar photographs frequently need to be processed to enhance details, increase quality, and extract pertinent information about the Moon's surface features.

In this project, we took the following steps to process the collected data:

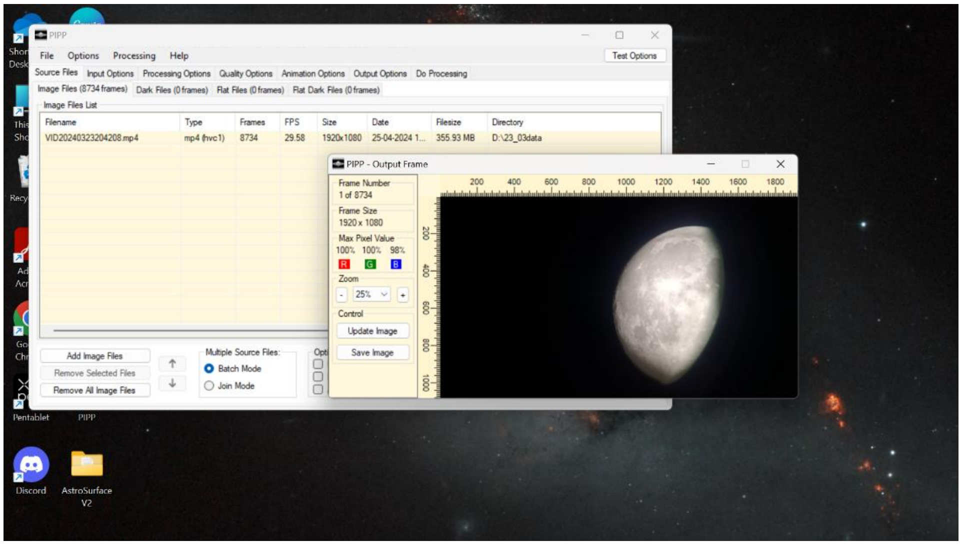
1. To create a clean and enriched set of data, the gathered material was separated by eliminating videos and photos that were hazy, unsupported, or corrupt.
2. This enriched data set was then arranged and sorted day-wise.



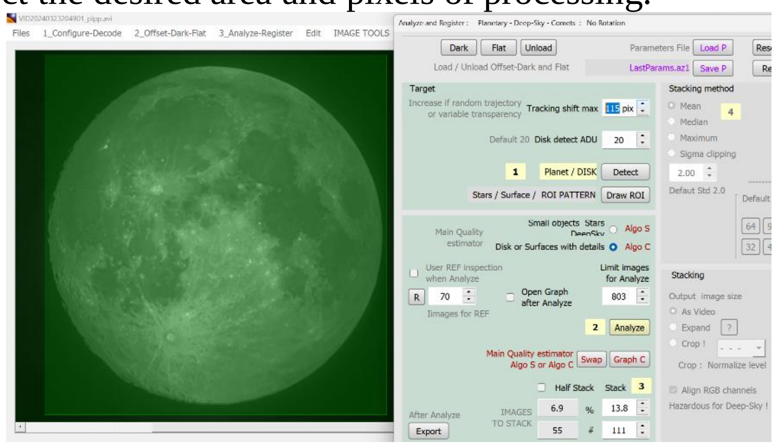
3. We used two 3 software for this project, namely CANVA (is a free graphic design platform that offers thousands of editing and designing options), PIPP (which is a program for the pre-processing of planetary images before stacking them with applications such as Registax), and Astrosurface (is a free software for processing astronomical images and videos on Windows 64-bit. It combines the functionality of three other programs, AutoStakker, Registax, and Photoshop, into one package).
4. We aimed to process the videos and images to get better and more stable frames of the moon and obtain a clear image with visible surface features. The following steps were followed for the same:
    - To pre-process the images, we used CANVA. Where the images were stacked and overlayed to get a complete picture of the moon by changing transparency levels.



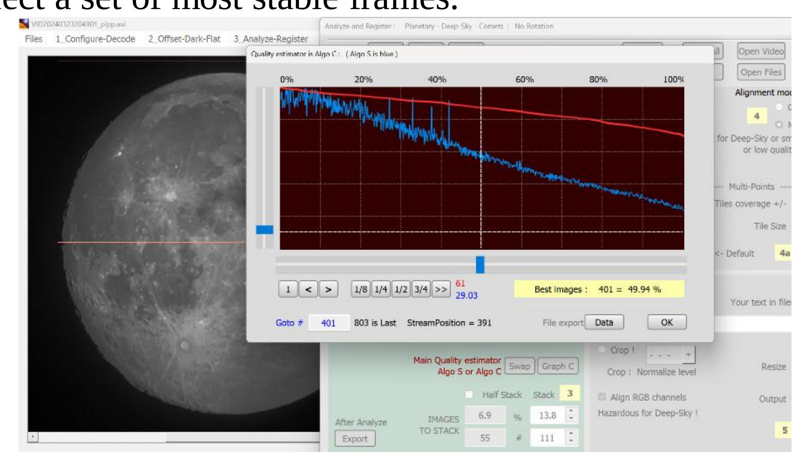
- Similarly, to pre-process the videos, we used PIPP. Which helped us extract frame-by-frame images and align them. Also, this software was used to convert the file as an .AVI format.



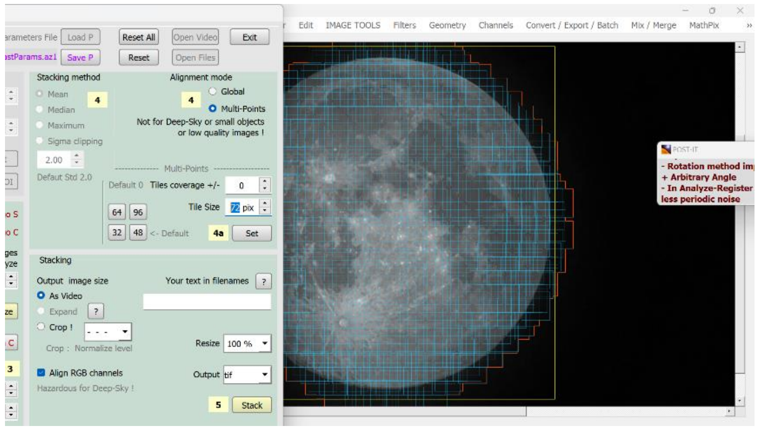

- Next, we used Astrosurface in five steps to achieve the final processed image:
    i. We first select the desired area and pixels of processing.




    ii. The frames of the selected area are analysed and a graph is obtained that helps us select a set of most stable frames.

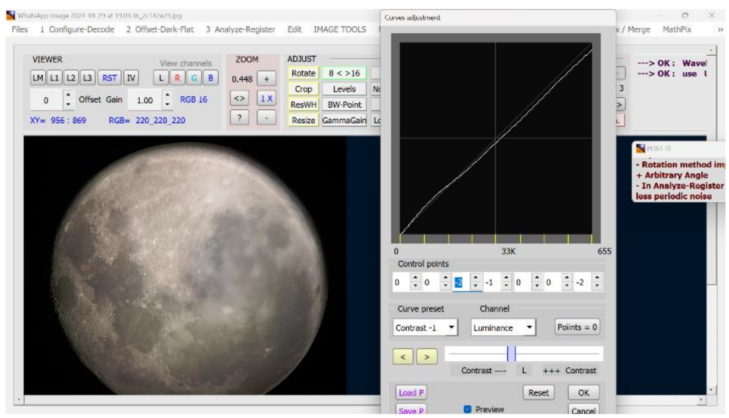



    iii. Here we align the obtained frames and set pixel-by-pixel settings.

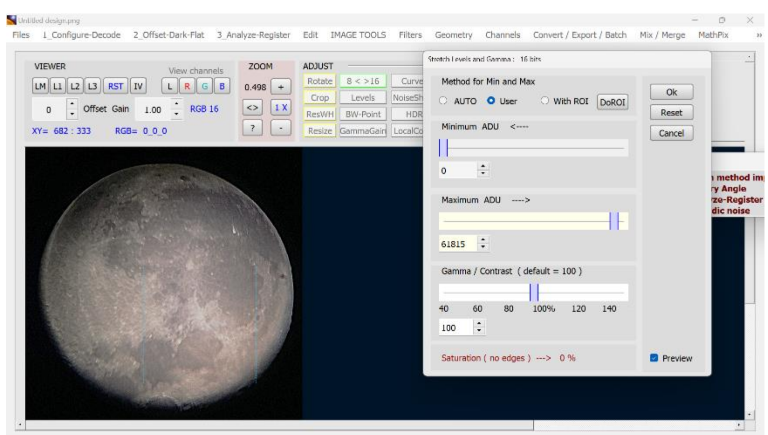


iv. The file output type was selected as .TIFF format, a name is assigned to the file and is finally stacked.

v. In the last step we edit the stacked image is edited by manipulating different setting wavelet, Wiener Deconvolution, gain, gamma, noise filter, levels, and curves.



Adjusting the curves.



Adjusting the RGB settings.

Hence, the final processed image is obtained. Overall, data processing plays a crucial role in lunar astrophotography by transforming raw image data into valuable scientific insights about the Moon's structure, history, and geological processes.

## RAW DATA VS. PROCESSED DATA

23rd March 2024

RAW PROCESSED

25th March 2024

RAW PROCESSED

26th March 2024

RAW PROCESSED

27th March 2024

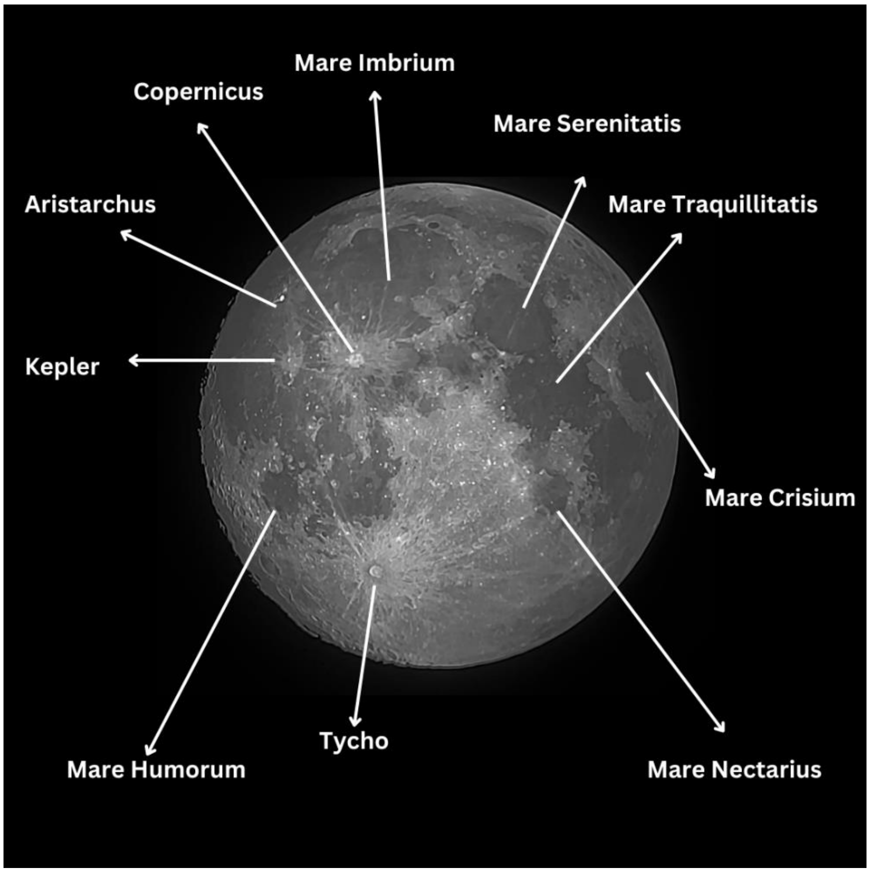
 

RAW PROCESSED

# DATA ANALYSIS

In lunar astrophotography, data analysis refers to the process of examining and interpreting the captured images and associated data to extract meaningful information about the lunar surface. This analytical phase involves several key steps:

1. For analyzing the surface features, we choose to work with the data for 23rd March 2024 as it is the best quality image obtained after processing.
2. To analyze the surface features, we used NASA's Daily Moon Guide which helped us to compare and identify different surface features which are discussed below:




3. In the image obtained, we can observe:
    i. Mare Imbrium- called the "Sea of Rains," is the second largest mare on the near side of the Moon at 697 miles.
    ii. Mare Serenitatis- also known as the "Sea of Serenity",Apollo 17 as-tronauts landed near the eastern edge of this mare.
    iii. Mare Tranquillitatis- The "Sea of Tranquility," includes the landing site for Apollo 11, the first human mission to the lunar surface. The site was chosen for its smooth, flat terrain.

iv. Mare Crisium- The "Sea of Crises" covers over 109,000 square miles (176,000 sq km) of the lunar surface.
v. Mare Nectarius- Latin for "Sea of Nectar," is one of the prominent lunar mare located on the near side of the Moon is approximately 340,000 square kilometers in area and is characterized by its relatively smooth, dark surface compared to the surrounding highlands.
vi. Mare Humorum- Latin for "Sea of Moisture", is a vast, circular impact basin with a diameter of approximately 425 kilometers (264 miles).
vii. Tycho- The Tycho crater is about 53 miles (85 km) wide and 3 miles (4.8 km) deep, with a 1.39 mile (2.25 km) high central peak. Its bright rays of ejected, pulverized rock radiate across much of the Moon's near side.
viii. Kepler- Over 185 miles (300 km) or over ten times farther than the crater's diameter are the material rays thrown by the impact that formed it. The energy of this impact event was sufficient to disperse material around the crater and excavate it from a vast depth. The material that is the deepest has just enough energy to land on the crater rim, while the stuff at the surface is expelled the furthest.
ix. Aristarchus Plateau- East of the similarly-sized but older crater Herodotus, on the southern edge of the plateau, is the Aristarchus crater, which has a diameter of 25 miles (40 km). Schroter's Valley, or Vallis Schröteri, is a valley that cuts through the plateau to the north and is around 99 miles (160 km) long. It was formed when a lava structure collapsed.
x. Copernicus- Copernicus Crater, one of the most noticeable craters on the near side, is one of the youngest craters on the Moon at only 800 million years old. It extends 57 miles (93 km). Its floor is level, its walls are terraced, and its central peaks rise to a height of 1.2 km, or 3/4 of a mile. The crater is about twice as deep as the Grand Canyon, at a depth of roughly 2.2 miles (3.7 km).

Overall, data analysis in lunar astrophotography is a multifaceted process that combines technical expertise, computational tools, and scientific intuition to unlock the secrets of Earth's celestial companion.

# CONCLUSION

Through the Lunar Astrophotography Project, we embarked on a journey to explore the intricate beauty and scientific significance of Earth's celestial companion, the Moon. Our endeavor to capture and analyze lunar images using astrophotography techniques has not only enriched our understanding of lunar geology but has also provided valuable insights into the methods and challenges of observational astronomy.

By meticulously planning observation sessions, overcoming weather constraints, and mastering the art of image processing, we successfully documented a plethora of lunar surface features, from imposing craters to delicate rilles. Our analysis and interpretation of these features have deepened our appreciation for the dynamic processes that have shaped the lunar landscape over billions of years.

We understand that our adventure has just begun as we wrap up this project. Lunar astrophotography is a field that still has a lot to learn and explore, from improving observing methods to deciphering the secrets of lunar genesis and evolution. We wish to inspire upcoming students to carry on with this research and to push the limits of observational astronomy.

Finally, we would like to express gratitude to our peers, mentors, and professors for their help and advice during this project. We hope that our quest for knowledge beneath the stars will encourage succeeding generations to look up and imagine the limitless possibilities that await them.

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