Activity Two: Sculpting Lunar Geology

Educator Notes

Learning Objectives

In this activity, students will be designing a scale replica of a portion of the Moon's surface near its South Pole region. Students will compare and contrast the Earth with the Moon and work in cooperative teams to plan their replica. The goal of this activity is to help students consider lunar geology when choosing the optimal site for a human landing system.

Students will use the engineering design process to

- Identify the similarities and differences between the surfaces of the Earth and Moon, with an emphasis on geologic features.
- Create a scale replica of a portion of the surface of the Moon.
- Propose how they could improve their replica given more time and materials.

Investigation Overview

Students are asked to make a scale replica of a portion of the surface of the Moon and label geologic features. If they participated in the previous activity, Choose Your Landing Site, they should make the scale replica of the landing site they chose during that activity. Otherwise, students are free to choose any location near the South Pole region of the Moon, making sure their replica includes at least four geologic features. Students can use the materials of their choice to make their scale replica.

Suggested Pacing

1 to 3 hours

National STEM Standards

Disciplinary Core Ideas • MS-ESS2-2 Earth's Systems: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. *Crosscutting Concepts* • Scale, Proportion, and Quantity: Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. • Stability and Change: Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale.	*Science and Engineering Practices* • Analyzing and Interpreting Data: Analyzing data in 6–8 builds on K–5 experiences and progresses to extend quantitative analysis, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Developing and Using Models: Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.
Technology (ISTE)	
Standards for Students • Knowledge Constructor: Students critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts, and make meaningful learning experiences for themselves and others. • Computational Thinker: Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.	*Standards for Students (continued)* • Developing and Using Models: Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Creative Communicator: Students communicate clearly and express themselves creatively for a variety of purposes using the platforms, tools, styles, formats, and digital media appropriate to their goals.
Mathematics (CCSS)	
Content Standards by Domain • CCSS.MATH.CONTENT.7.RP.A.2.A: Decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin. • CCSS.MATH.CONTENT.6.RP.A.1: Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.	

Activity Preparation

The educator should

- Read the introduction and background information, Educator Notes, and fact sheets to become familiar with the activity.
- Assemble construction materials at one station per team.
- Preload any websites or videos needed for the presentation.
- Print out or provide digital copies of the Landform Fact Sheet, the Landform Identification Worksheet, and images.

Note: Consider collaborating with an art educator on this activity to make it more interdisciplinary.

Materials

- Printouts:
  - Student notebooks or journals
  - Images of Earth and Moon surfaces
  - Photographs of landforms
  - Landform Fact Sheet (provided)
  - Landform Identification Worksheet
- Various modeling materials:
  - Common household materials such as flour, baby powder, or powdered milk
  - Natural materials such as sand, rocks, or pebbles
  - Craft materials such as chalk or modeling clay
- A container for the surface replica (e.g., a 9- by 13-inch baking pan or 11- by 17-inch cookie sheet)
- Newspaper, garbage bags, or dropcloth for the floor

Safety

Use appropriate safety precautions for tool use.

Introduce the Activity

- Inform students that this activity is about the surface of the Moon and that you want to find out how much they already know. Have students write down everything they know about the Moon in approximately 60 seconds, and then compare what is written with the entire group.
  - Tell students that we have been to the Moon and we are going again. Discuss the past Apollo missions. https://www.nasa.gov/mission_pages/apollo/missions/index.html
  - Ask students the following questions:
    - What is the name of the mission that went to the Moon for the very first time?
    - The names of the astronauts?
    - The date?
  - Discuss the Apollo 11 mission. https://www.nasa.gov/mission_pages/apollo/apollo-11.html
- Watch Apollo 11: Landing on the Moon. https://www.youtube.com/watch?v=nOcDftgR5UQ
- Tell students that they will be making a scale replica of a portion of the surface of the Moon and labeling geologic features.

Criteria	Constraints
Replica must be of a location near the Moon's South Pole region.	Replica may not exceed the size of the specified container (e.g., a 9- by 13-inch baking pan or 11- by 17-inch cookie sheet).
Replica must have at least four major geologic features.	
Replica must be built to scale and include a scale legend (e.g., 1 scale centimeter = 100 real kilometers).	

Facilitate the Activity

Ask

- Display the provided picture of the Moon and ask students what they notice about it. Have students hypothesize what the dark and light areas could be and how they got there.
- Ask students to write a short creative narrative or draw a picture that explains their theory about the creation of the Moon. Have them share their narrative or picture with the group.
- Watch the NASA video "Evolution of the Moon." https://www.youtube.com/watch?v=UIKmSQqp8wY.
- Discuss what caused the light and dark areas of the Moon.

Imagine

- Have students imagine it is 4.5 billion years ago. Have them discuss these questions at their team tables:
  - If the Moon is getting hit by meteorites, is the Earth also getting hit?
  - Why (or why not)?
- Have a whole-group discussion, sharing out team thoughts on meteorite impacts.
- Share the images of Earth and Moon surfaces:

- The Earth and the Moon are basically the same age and have experienced a lot of the same things, yet they do not look the same. Have a student-led discussion about why the Earth's and Moon's surface look different. Some possible guiding questions:
  - Why does the Moon have so many more craters than Earth?
    - https://www.nasa.gov/multimedia/imagegallery/image_feature_25.html
    - https://spaceplace.nasa.gov/craters/en/
  - How often does the Moon get struck by meteorites? How often does Earth?
    - https://www.nasa.gov/vision/universe/solarsystem/13jun_lunarsporadic.html
    - https://www.nasa.gov/press-release/goddard/2016/lro-lunar-cratering
  - Does the Moon have volcanoes?
    - https://science.nasa.gov/science-news/science-at-nasa/2014/13oct_moonvolcano
  - Does the Moon have an atmosphere?
    - https://www.lpi.usra.edu/features/100517/moon-atmosphere/
  - Do the Moon and the Earth have the same geologic features?

Brain Booster

An asteroid named 2004 MN4 was once thought to be on a crash course with Earth. The projected date of impact was April 13, 2029. NASA scientists have been watching 2004 MN4 and no longer think it will collide with Earth, although its course changes a little every day. If 2004 MN4 continues as predicted, it will come close to Earth but will not make an impact. It will be closer to us than the Moon is. It will even be closer than our own satellites. 2004 MN4 is a quarter-mile wide and will be visible as it passes. NASA scientists are still tracking it to make sure the course does not change.

Learn more: https://www.jpl.nasa.gov/news/news.php?feature=7390

On Location

Did you know there is a place where the lunar samples from the Apollo missions are stored? Geologic samples returned from the Moon by the Apollo lunar surface exploration missions (1969 to 1972), along with associated data records, are physically protected, environmentally preserved, and scientifically processed in a special building called the Lunar Sample Laboratory Facility dedicated for that purpose at the Johnson Space Center in Houston, Texas.

Learn more: https://www.youtube.com/watch?v=7d2qLhrrmi0

Landing Humans on the Moon

The atmosphere and active tectonic plates on Earth have erased most of its craters over the last 4.5 billion years, but the Earth has other geologic features. Some geologic features are shared by Earth and the Moon, and some are unique to each. Have students create a Venn diagram to compare and contrast the features they believe the Earth and the Moon share and the ones that are unique to each. At the end of the lesson, return to the given diagrams and see how many features the students listed correctly and which features are missing.

Plan

- Split students into small teams of no more than four. Provide each team with the student section of this activity (Directions, Landform Identification Sheet, Landform Fact Sheet, and Lunar Landform sheets). Have each team look at the numbered landforms and identify them using the Landform Fact Sheet and the Suggested Student Readings at the end of this section. For additional assistance, they can research each geologic feature on the computer. Students will put an "X" under the corresponding number of the feature on the Landform Identification Sheet.
- After 15 to 20 minutes, bring the teams back together and discuss the landform features. If there are discrepancies in identification, call on teams to explain how they arrived at their answers.
- Discuss:
  - Were some landforms easier to identify than others?
  - What other observations were made?
  - Did shadows help make some landforms easier to see?
- Now that students have identified several types of landforms, return to the discussion of going back to the Moon.
  - When are we going back to the Moon? Watch the video "What Is Artemis?" https://www.youtube.com/watch?v=YOG3tAkPpPE
  - Discuss the Artemis mission and lead the discussion into the geologic features that may exist around the landing site for the mission.
- Explain the project to students. If students did the "Choose Your Landing Site" activity, they have already chosen a location and will now be creating a scale replica of their chosen landing site. If students have not yet done that activity, student teams can choose any location near the lunar South Pole region that contains at least four geologic features.
- Be sure every team member is assigned a student role (see the Teamwork section at the beginning of this guide for recommendations).
- Students can use materials of their choice to create a scale replica of a portion of the Moon's surface and features. Students should be sure to label the landing site and at least four geologic features in their project, leaving one of the labels blank.
- Now that students know what is expected of them, give them time to choose their location, choose the most appropriate materials to replicate the Moon's surface and features, do any other necessary research, and plan out their design.

Create

- After gathering necessary materials, student teams will begin creating scale replicas of their chosen landing site. Students may need time to redesign or adjust if the first attempt does not go as planned.
- Completed projects should have three labeled features and one feature with a blank label. The scale, landing site, and team name should be clearly marked.
- If students are having a problem making the replica to scale, drawing it on graph paper to scale can help in visualizing the site.

Test

- Have students compare their replica to the location it is supposed to replicate. Ask students to reflect using the following questions and have them record their findings in a journal.
  - Does the replica look like the image?
  - Does the replica have all the correct landforms?
  - Is the replica to scale, and is there a legend for the scale?

- What compromises were made because of the limitations of the materials?
- Where on the replica is the best place to land astronauts? Why?

Improve

- From their reflection, have students propose how they could improve their scale replicas given more time and materials.

Share

- Display the replicas and have students perform a gallery walk. Students should identify each person's unlabeled feature. After the gallery walk, discuss the unidentified features.
- Make a display of student projects in a public area.

Extension

- Have students create posters of the features or explanations of the activity to display along with the replicas.
- Use the NASA activity "Blue Marble Matches" to explore the topography of Mars. https://www.nasa.gov/stem-ed-resources/blue-marble-matches.html
- Optional: Share student results on social media using #NextGenSTEM. Be sure to include the module and activity name.

Reference

Field Trip to the Moon
https://www.nasa.gov/pdf/217785main_FTM_Educator_Guide.pdf

Resource

Blue Marble Matches
https://www.nasa.gov/stem-ed-resources/blue-marble-matches.html

Suggested Student Readings

Our Solar System
https://solarsystem.nasa.gov/solar-system/our-solar-system/in-depth/

NASA Planetary Science
https://science.nasa.gov/solar-system

A New Map of the Moon
https://www.nasa.gov/multimedia/imagegallery/image_feature_2110.html

NASA's LRO Creating Unprecedented Topographic Map of Moon
https://www.nasa.gov/mission_pages/LRO/news/lola-topo-map.html

Lunar Rocks and Soils From Apollo Missions
https://curator.jsc.nasa.gov/lunar/index.cfm#

Lunar Regolith
https://curator.jsc.nasa.gov/lunar/letss/regolith.pdf

Activity Two: Sculpting Lunar Geology

Student Handout

Your Investigation

You will be creating a scale replica of a portion of the Moon's surface that could be an ideal human landing site, and you will identify the geologic features in your scale replica.

Criteria	Constraints
Replica must be of a location near the Moon's South Pole region.	Replica may not exceed the size of the specified container (e.g., a 9- by 13-inch baking pan or 11- by 17-inch cookie sheet).
Replica must have at least four major geologic features.	
Replica must be built to scale and include a scale legend (e.g., 1 scale centimeter = 100 real kilometers).	

Ask

- Observe the picture of the Moon provided. Discuss the characteristics you see and predict what could have caused them.
- Use creative writing or a descriptive drawing explaining where the Moon came from and what it is made up of. Be prepared to share your creations.
- Watch the NASA video "Evolution of the Moon." https://www.youtube.com/watch?v=UIKmSQqp8wY.
- Discuss why the Moon has light and dark areas.

Imagine

- Imagine it is 4.6 billion years ago.
  - If the Moon is getting hit by meteorites, is the Earth also getting hit?
  - Why (or why not)?
- Look at the provided pictures of the Earth and Moon.
- The Earth and the Moon are basically the same age and have experienced a lot of the same things, yet they do not look the same.
- Discuss the following questions with your team. Write down your ideas and be prepared for a whole-group discussion.
  - Why does the Moon have so many more craters than Earth?
  - How often do you think the Moon or Earth gets struck by meteorites?
  - Does the Moon have volcanoes?
  - Does the Moon have an atmosphere?

On Earth, the atmosphere and the movement of tectonic plates have erased most of the craters over the last 4.6 billion years, but that does not mean the Earth does not have geologic features. Some geologic features are shared by the Earth and the Moon, and some are unique to each.

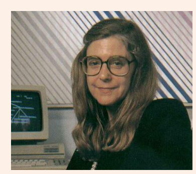
Fun Fact

In 2020, NASA conducted a Lunar Loo Challenge to get involved in solving the age-old issue and very popular question, "How do astronauts go to the bathroom?" NASA's Human Landing System program is looking for a next-generation device that is smaller, more efficient, and capable of working in both microgravity and lunar gravity.

Learn more: https://www.nasa.gov/lunar-loo-challenge

Career Corner

Back in August 1961, before computers were part of everyday life, Margaret Hamilton and her team developed the building blocks of software engineering. Hamilton led the Software Engineering Division of the Massachusetts Institute of Technology (MIT) Instrumentation Laboratory that developed the guidance and navigation system for the Apollo spacecraft.



Margaret Hamilton

NASA honored Hamilton in 2003 with a special award recognizing the value of her innovations in the Apollo software development. In 2016, President Barack Obama awarded her the Presidential Medal of Freedom.

Learn more: https://www.nasa.gov/feature/margaret-hamilton-apollo-software-engineer-awarded-presidential-medal-of-freedom

Plan

Working in a team, you will be given eight Lunar Landform sheets that show geologic features of the Moon. The features are numbered on the photographs and you will need to identify them and record your findings on the Landform Identification Sheet. You may use the Landform Fact Sheet, Suggested Student Readings, and the internet to assist you. When completed, be ready to defend all answers.

Next, the team will work to create a scale replica of a portion of the Moon.

- Choose the area that you will replicate. If you completed the activity "Choose Your Landing Site," use the chosen landing site for this activity. If you did not do that activity, choose a location near the lunar South Pole region.
  - The location should have at least four different major geologic features.
  - Label three of the four major geologic features. The fourth label should be left blank for a later activity.
  - The replica should be in a container.
  - Determine which materials the team will be using to represent the lunar surface.
  - Be sure that each person in the team has a role or job in the project.
  - A sketch or plan of the replica should be turned in with the final project.
- Have your image available for reference when creating your replica.
- Research as needed for location, elevation, and surface features:
  - Lunar South Pole Atlas
    - https://www.lpi.usra.edu/lunar/lunar-south-pole-atlas/
  - Elevation
    - https://www.nasa.gov/exploration/multimedia/highlights/2010-09B.html
    - https://www.nasa.gov/multimedia/imagegallery/image_feature_2110.html
  - Lunar regolith
    - https://curator.jsc.nasa.gov/lunar/index.cfm#
    - https://curator.jsc.nasa.gov/lunar/letss/regolith.pdf

Create

- Create your lunar replica. If it is not working as planned, do not be afraid to redesign and start again with the materials at hand, using the time that you have left. Be sure to label three of the four features and leave the fourth feature blank. Make sure the team's name is visible on the project.

Test

- Once your replica is complete, discuss these questions with the team:
  - Does the replica look like the image?
  - Does the replica have all the correct landforms labeled?
  - Is the replica to scale, and is there a legend for the scale?
  - What compromises did your team make because of material limitations?
  - Where on the replica might be a good place to land astronauts?

Improve

- From your reflection, propose how you would improve your scale replicas if you had more time and materials.

Share

- Go around to each team's replica. In your journal, write the name of the team and what the unidentified feature is.

Landform Identification Sheet

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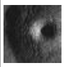
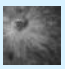
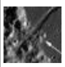
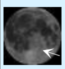
 Cinder Cone																				
 Crater Ejecta																				
 Dome																				
 Highlands																				
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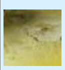 Lava Flow																				
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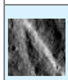
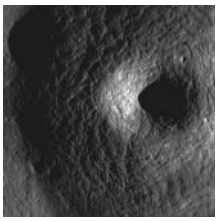
 Wrinkle Ridge																				

Landform Fact Sheet

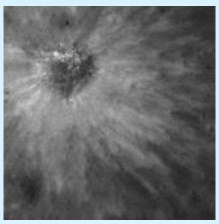
Central Crater Uplift

Mountain in the center of large (greater than 40 kilometers in diameter) impact craters



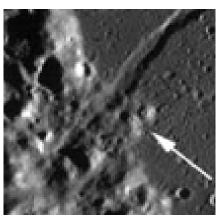
Cinder Cone

A low, broad, dark, cone-shaped hill formed by an explosive volcanic eruption



Crater Ejecta

Material thrown out from and deposited around an impact crater



Dome

A low, circular, rounded hill that is suspected to be a volcanic landform

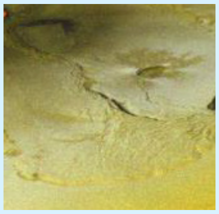
Highlands

Bright-appearing areas composed of countless overlapping craters (ranging from 1 meter to over 1,000 meters) that formed when meteorites crashed into the Moon

Impact Crater

A roughly circular hole created when something, such as a meteorite, struck the Moon's surface

Landform Fact Sheet



Lava Flow

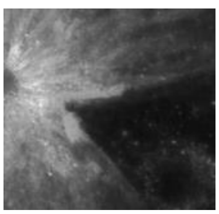
A breakout of magma from underground onto the surface

Maria

Areas that formed when lava flows filled in low places. The low places are mostly inside huge basins that were formed by large meteor impacts. The maria cover 16 percent of the Moon's surface.

Multi-Ringed Basin

Huge impact crater surrounded by circular mountain chains



Ray

Bright streak of material blasted out from an impact crater

Rille

A channel in the lunar maria formed by an open lava channel or a collapsed lava tube

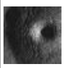
Terraced Crater Walls

Steep walls of an impact crater with "stair steps" created by slumping due to gravity and landslides

Wrinkle Ridge

A long, narrow, wrinkly, hilly section in the maria

Landform Identification Sheet Answer Key

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
 Central Crater Uplift													X							X
 Cinder Cone										X										
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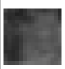 Dome																X				
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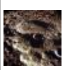
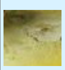
 Impact Crater								X	X											
 Lava Flow														X						
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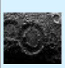 Multi-Ringed Basin				X																
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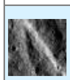
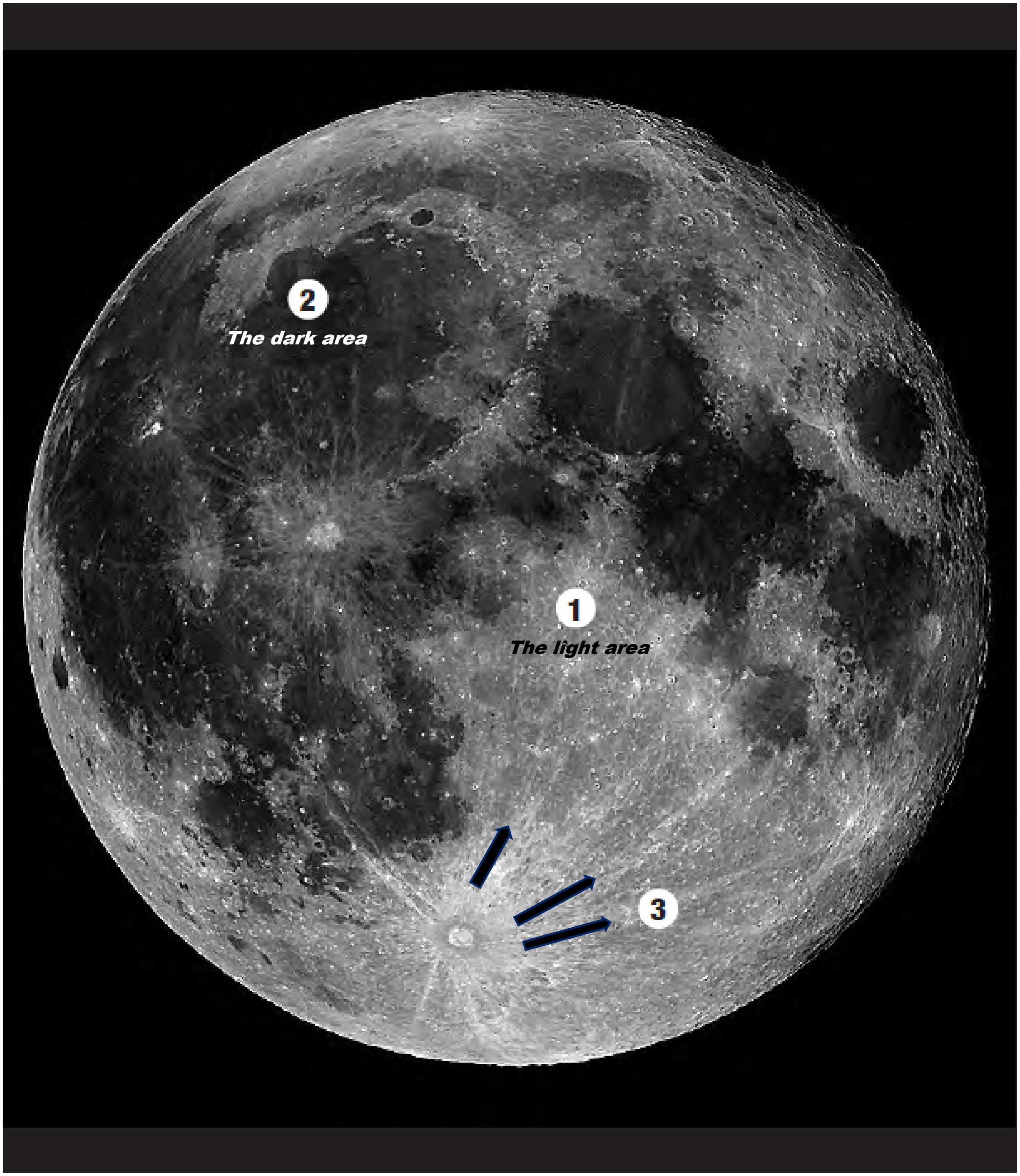
 Wrinkle Ridge															X					

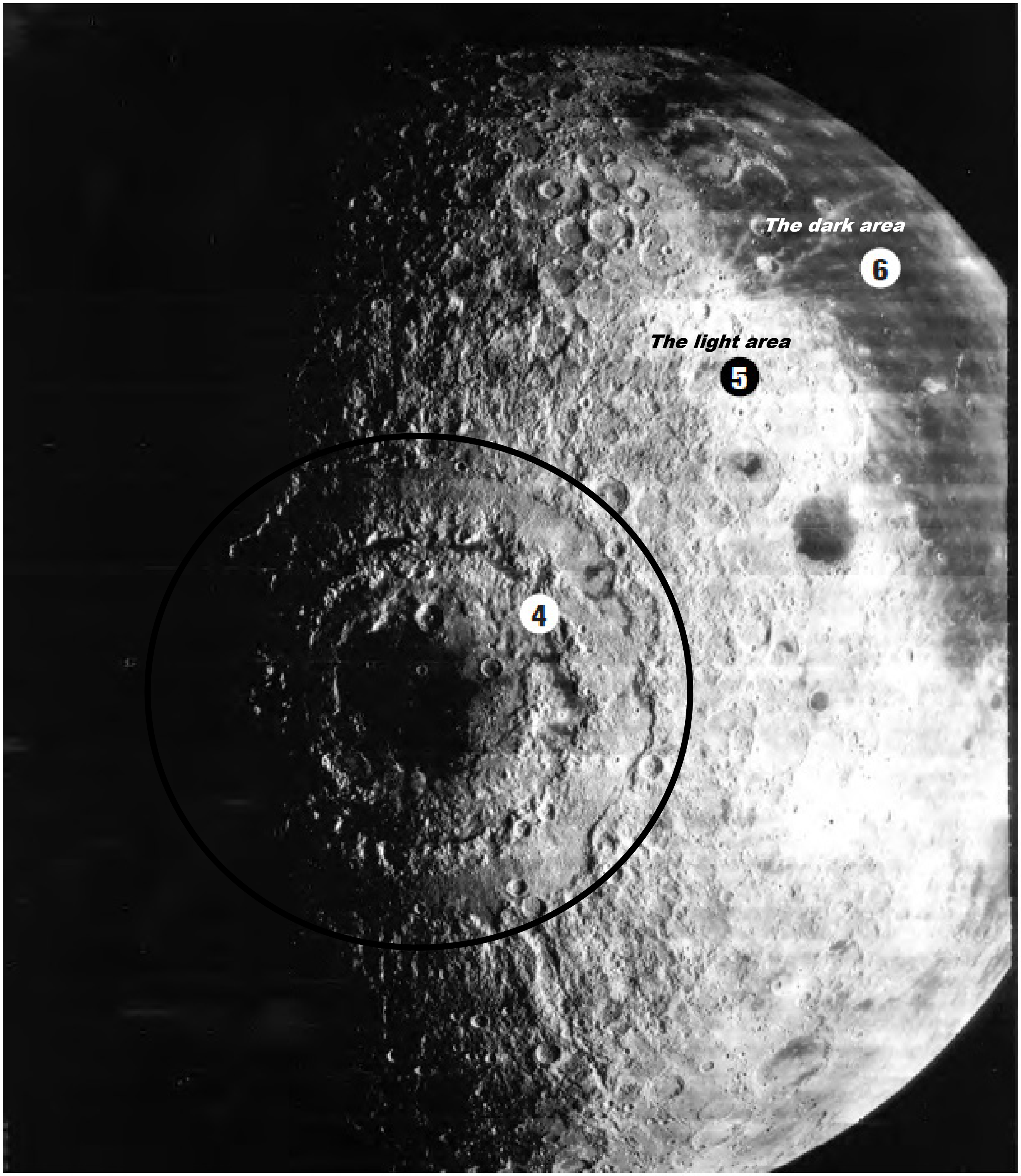
Lunar Landforms: Sheet 1

The Moon



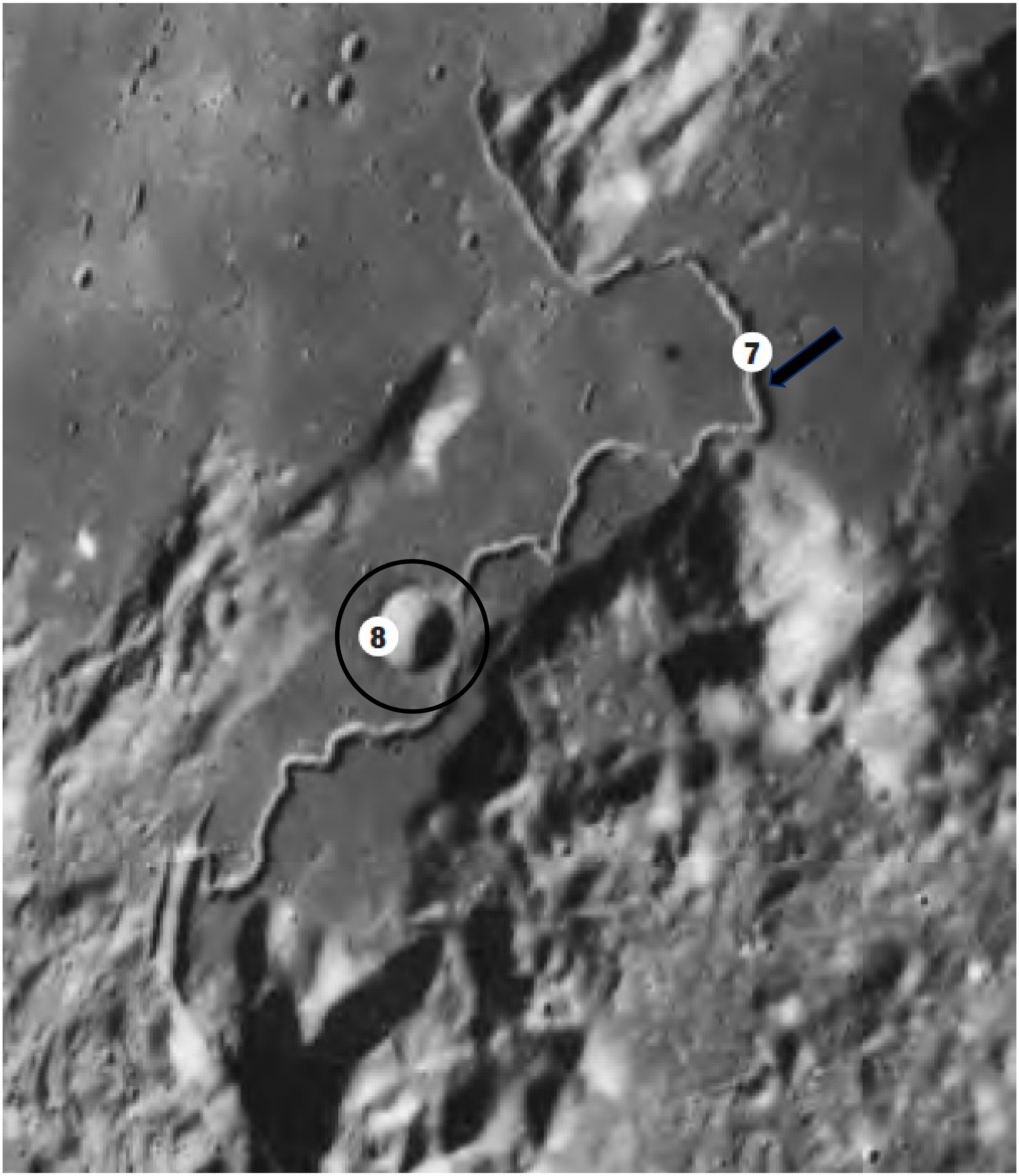
Lunar Landforms: Sheet 2

Orientale



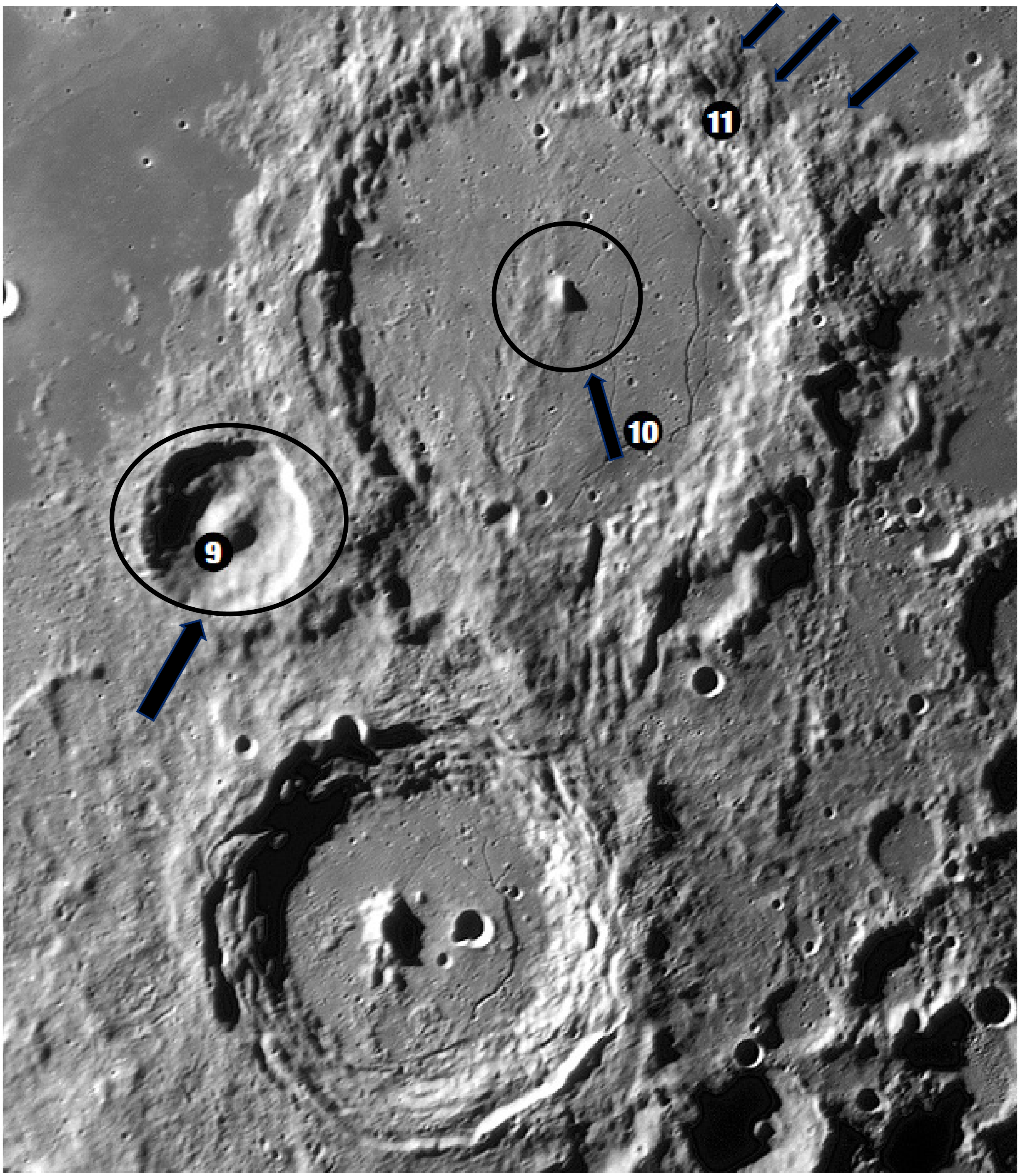
Lunar Landforms: Sheet 3

Apollo 15 Landing Site



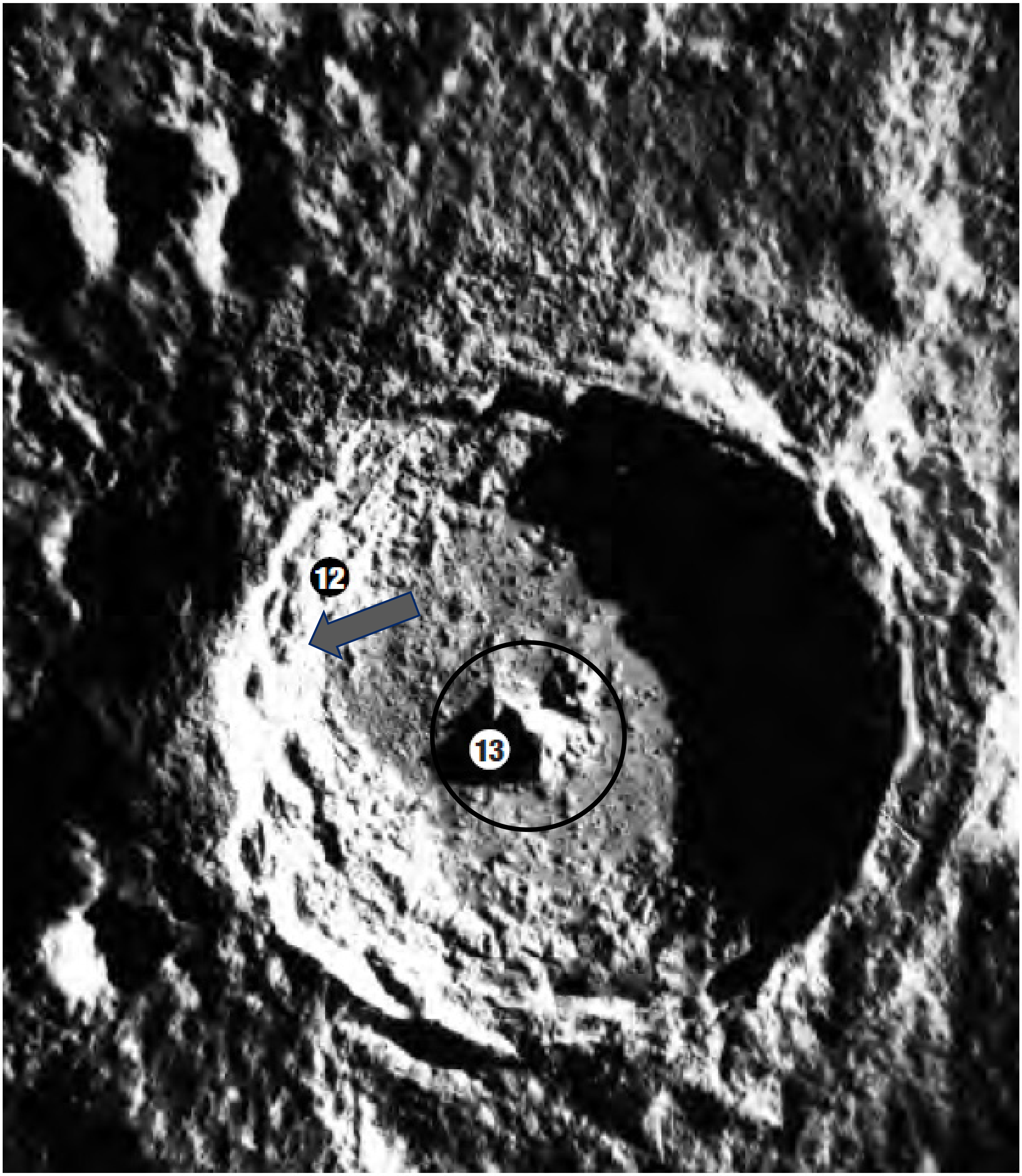
Lunar Landforms: Sheet 4

Alphonsus



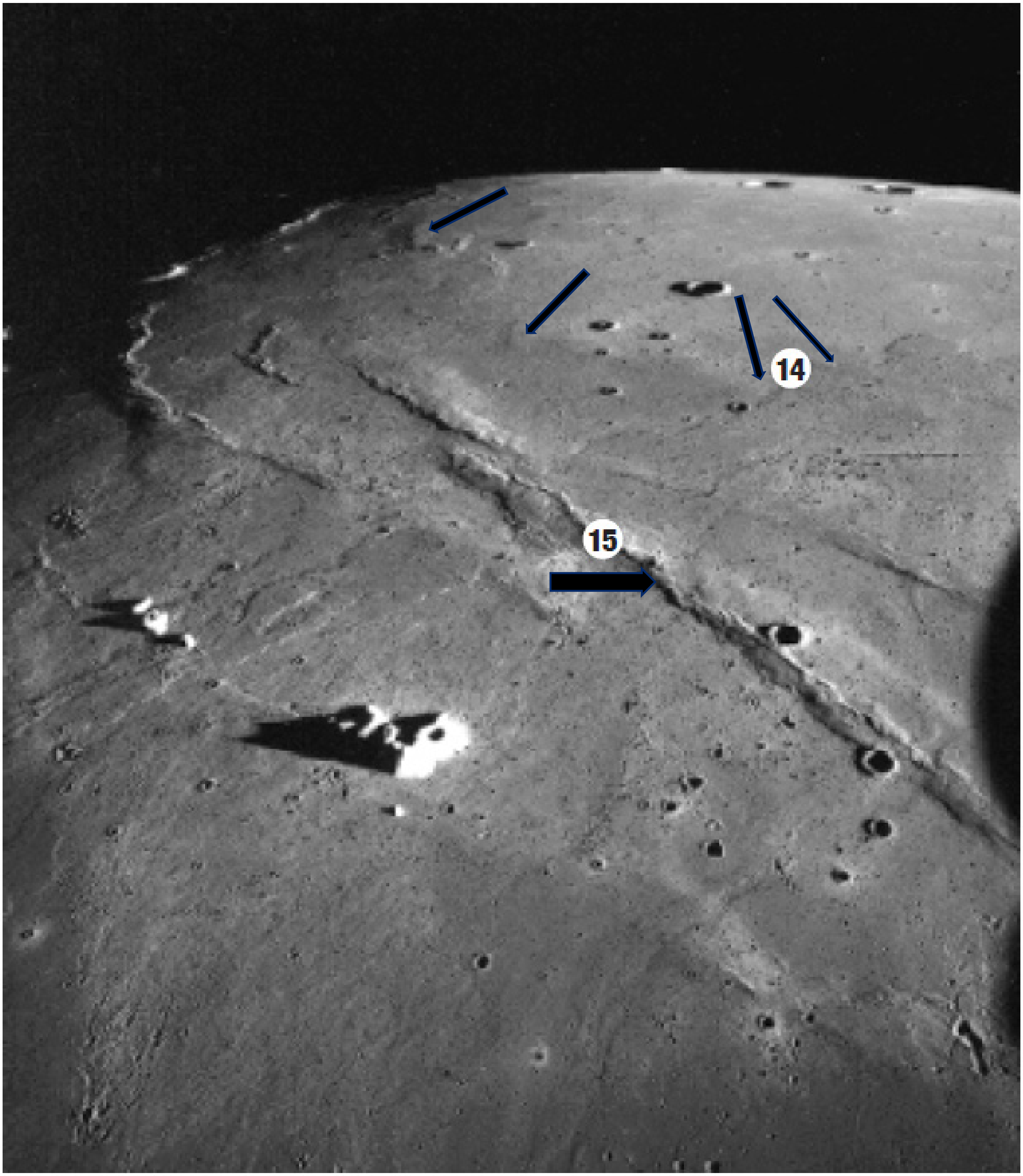
Lunar Landforms: Sheet 5

Tycho



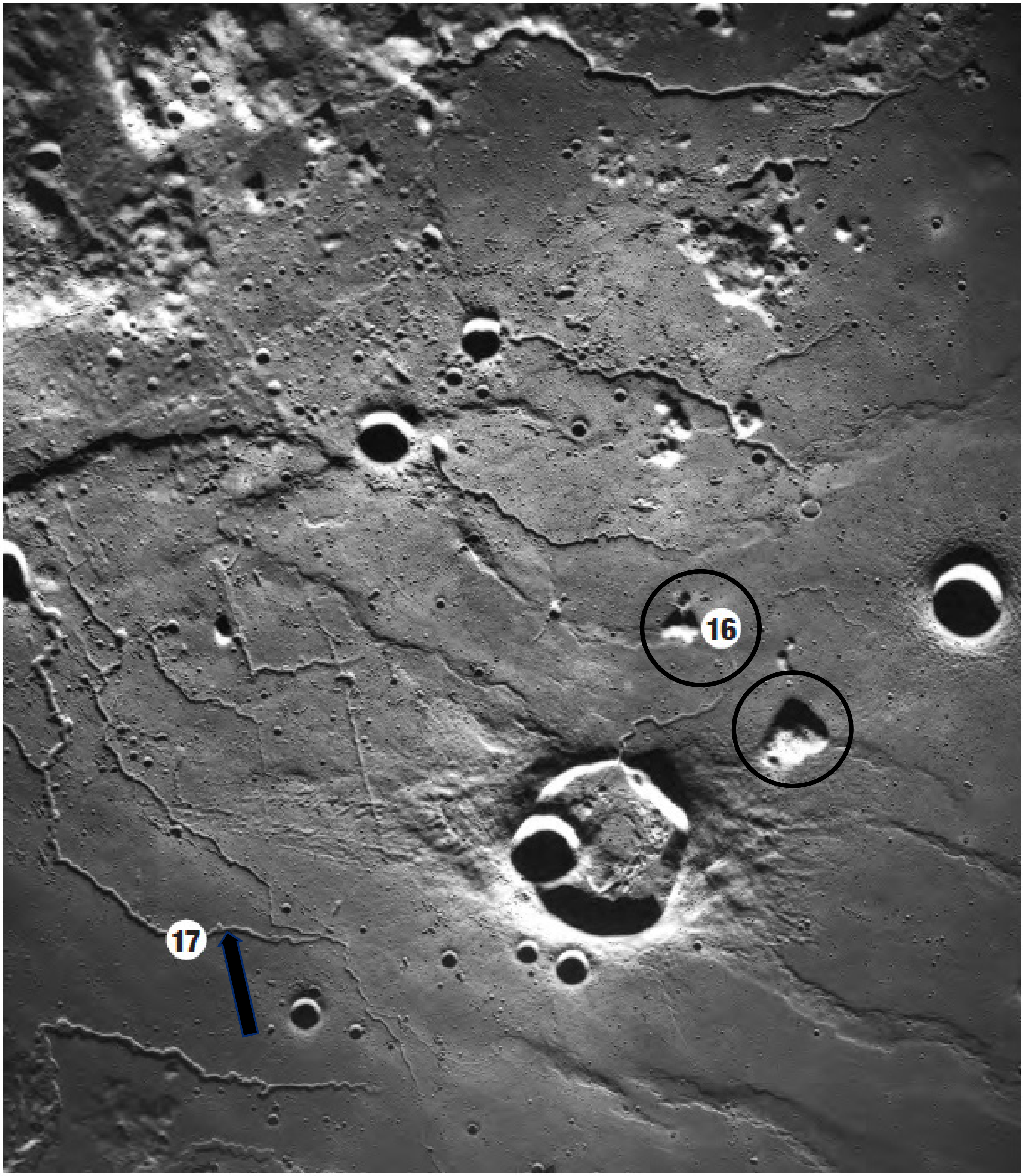
Lunar Landforms: Sheet 6

Mare Imbrium



Lunar Landforms: Sheet 7

Ocean of Storms



Lunar Landforms: Sheet 8

Copernicus