



Impact Cratering on a Rainy Day

Instructor Notes

Suggested Correlation of Topics

Craters on the planets and satellites, gradation, impact mechanics

Purpose

The objective of this exercise is to illustrate the way in which planetary surfaces are modified by multiple impacts and how surfaces can be dated through analyses of craters. The effects of multiple impacts and illumination angle are explored.

Materials

Per student group: watering can, duct tape, pin, fine mesh screen, water, 4 large petri dishes, very fine sand, portable light source (flashlight or flood lamp)

Background

Impact craters are found on terrestrial planets and nearly all satellites. Many surfaces have large numbers of craters. This indicates that the surface is very old, as it has accumulated craters over a long time period.

This exercise demonstrates the effect of continuous cratering, using sand and 'raindrop' impactors. Craters formed early will be degraded, or even removed, by subsequent crater formation. After a period of time the surface will reach equilibrium, in which old craters are destroyed as rapidly as new craters are formed. This exercise also explores the effect of illumination angle in viewing and identifying craters. More detail is shown when the illumination angle is low and features cast shadows than when the illumination angle is high. Advanced students and upper grades can attempt to answer the optional starred (*) questions, which apply what they have observed in this exercise and other general planetary background information to more complex planetary surfaces.

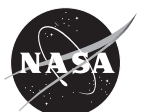
Figures 6.1 and 6.2 show sample experiments.

Science Standards

- Earth and Space Science
 - Earth's history

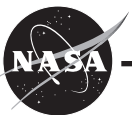
Mathematics Standards

- Geometry



Answer Key

1.
 - a. During a slow, steady rain, many craters will be similar in size.
 - b. Although craters typically are not clustered, a few clusters may develop. They may overlap.
2.
 - a. The large crater formed by the finger becomes degraded (eroded) by the rain impacts.
 - b. It becomes less sharp and distinct.
 - c. It would probably disappear.
 - d. There are more overlapping craters in this dish.
3.
 - a. The large craters become degraded (eroded). Yes.
 - b. Tiny craters should be found in both dishes, with the dish exposed for four minutes having the greater number.
 - c. The change in appearance between the surfaces in these two dishes is not as distinct as the change between the previous two surfaces. Students may say the dishes appear almost identical. The longer the surface is exposed to cratering, the more difficult it becomes to distinguish the "age" difference between them (the surfaces are approaching equilibrium).
4.
 - a. Small craters are nearly invisible. Little detail visible.
 - b. Shadows help define many surface features. Small craters are more obvious.
 - c. Shadows are long, hiding some small craters.
 - d. Very long shadows. Edge of dish blocks the view of some craters.
5.
 - a. A range of crater sizes in various states of preservation; large number of craters per unit area; similarity of terrain at different locations.
 - b. Younger; it is much less heavily cratered.
 - *c. 6.3 : mainly impact cratering, some volcanism in dark areas near limb. 6.4: volcanic plain with relatively few impact craters.
- *6.
 - a. Surface features near the terminator are illuminated by low sun angle and show more topographic detail. However, very near the terminator less topography is discernible than at a slight distance from the terminator. When the shadows cover half or more of the crater floor, the illumination is too low.
 - b. The surface near the limb is illuminated by a nearly overhead sun and the craters appear "washed out" (lacking detail); however, the different albedo variations of the surface are visible.



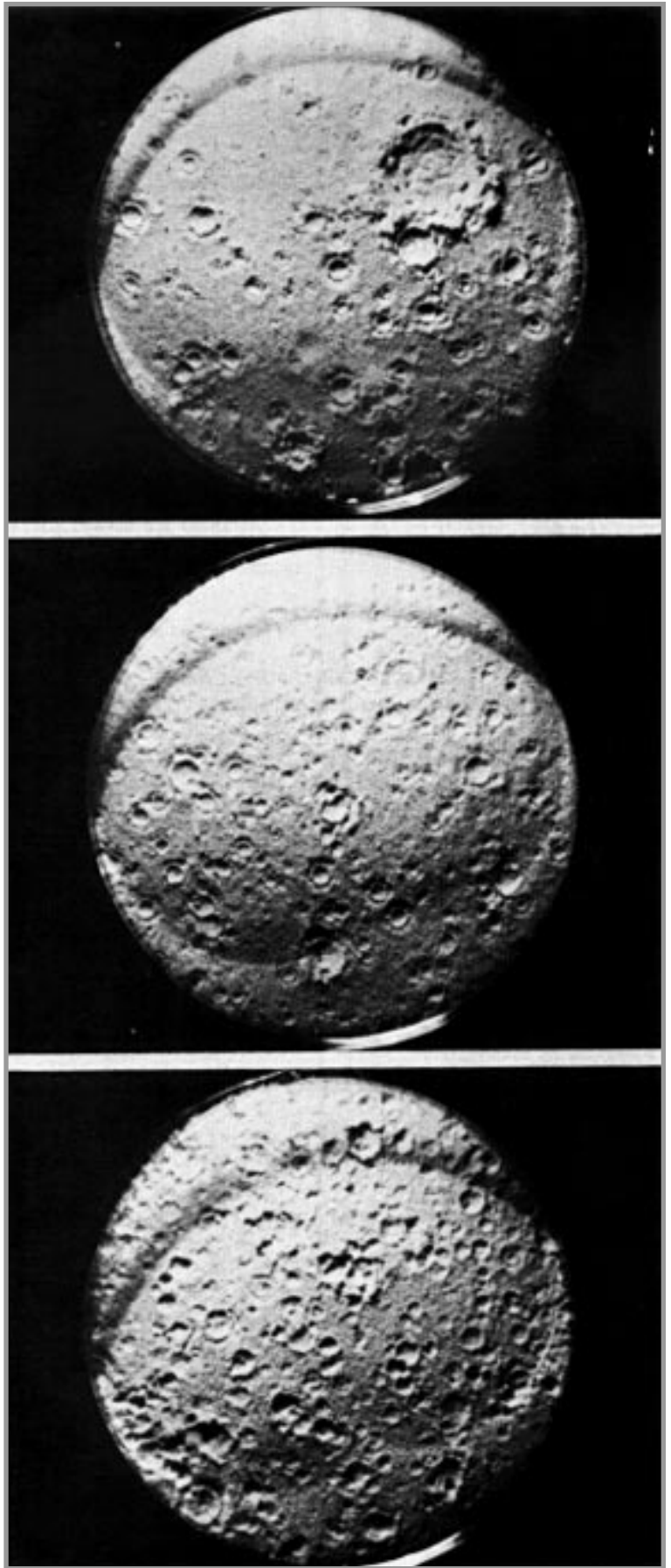


Figure 6.1. Different sand surfaces exposed for different lengths of time to rain: 5 seconds (top), 30 seconds (middle), and 2 minutes (bottom).

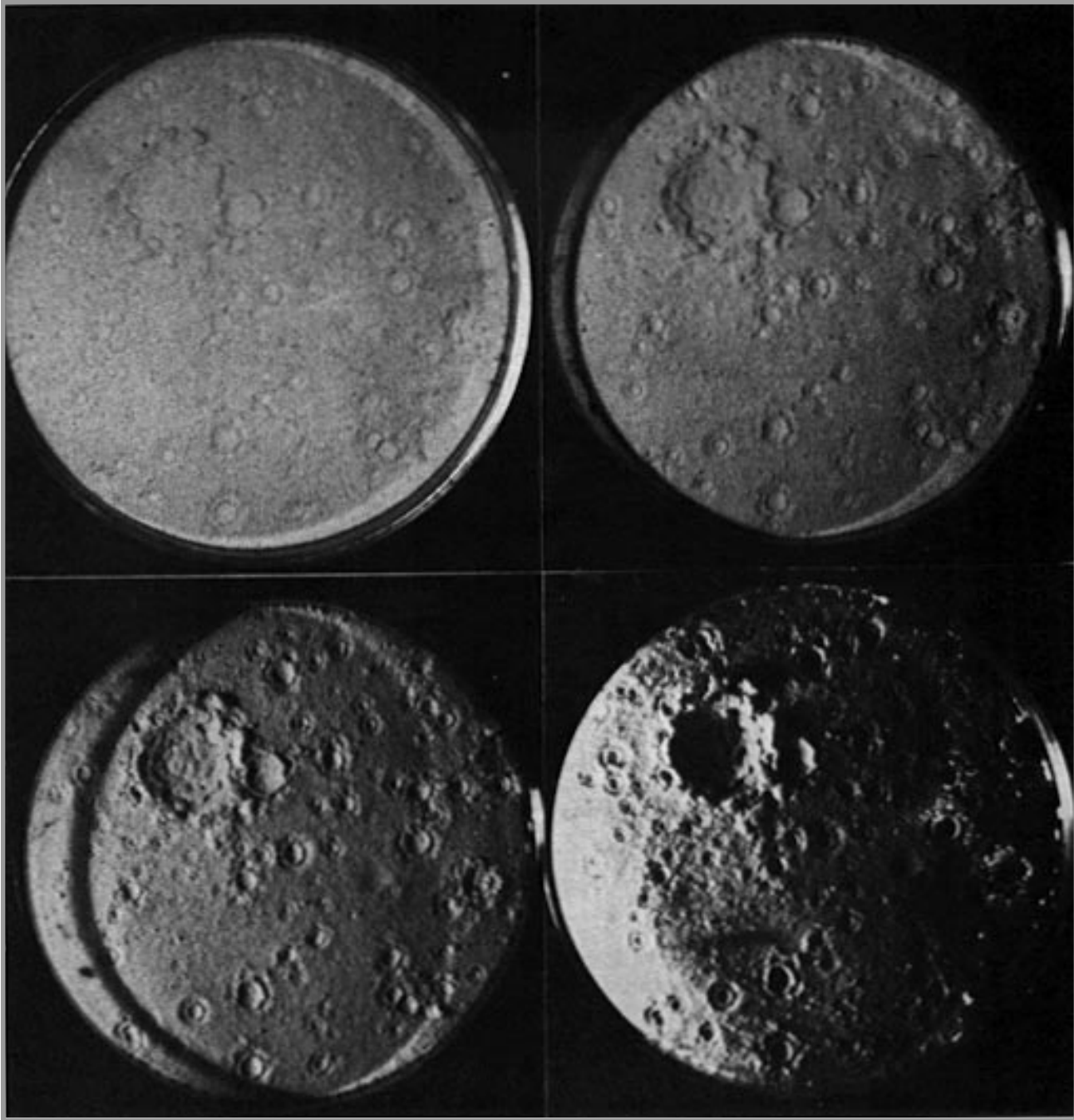


Figure 6.2. Illustration of the effect of lighting angle on the identification of surface features. The craters are illuminated from directly overhead (upper left), 60° from the horizontal (upper right), 30° from the horizontal (lower left) and 5° from the horizontal (lower right).



Impact Cratering on a Rainy Day

Purpose

To learn how planetary surfaces are modified by multiple impacts and how surfaces can be dated by analysis of craters. In addition, to understand the effects of illumination angle on the detection of craters.

Introduction

Impact craters are formed when meteoroids, asteroids, or comets impact planetary surfaces. As the number of impact craters increases on a surface, the appearance of the surfaces changes. After a period of time, **equilibrium** is reached, in which old craters are destroyed as quickly as new craters form.

Materials

For each student group: Watering can, duct tape, pin, fine mesh screen, 4 petri dishes, very fine sand, flashlight.

Procedure and Questions

- A. Place a piece of duct tape over the end of the watering can. Using the pin, poke one or two holes in the tape. Fill the can with water, but don't make it too heavy to hold for long periods of time. Fill each petri dish with fine sand. Place one dish on the floor on top of a drop cloth or newspaper.
- B. When making "raindrops" pour the water from the can very slowly, as single drops. Make each drop from the can hit the mesh screen to break it into smaller drops. Move the screen so that the drops are hitting dry screen as much as possible. As the holes of the screen fill with water, move the screen around so drops fall on dry spots of screen. This activity works best if one person holds the watering can and a second person holds screen. Holding the watering can at chest level, with the screen ~30 cm below the spout, "rain" on the petri dish for about 5 seconds, or until several craters have formed.

1.
 - a. How do the crater sizes vary?
 - b. Are the craters clustered together? Do they overlap?

Save all your "rained" on dishes for use in Question 4.

Make a crater in the second dish with your finger. Place this dish in the rain for approximately 30 seconds.

2.
 - a. What does the surface look like?
 - b. What happened to the large crater you formed?



- c. What do you suppose would happen to the large crater if you left it in the rain for 5 minutes (10 times as long)?
- d. Are there more or fewer overlapping craters here than in the first dish?

Make another “finger” crater in each of the other two dishes. Place one dish in the rain for two minutes; the other for four minutes. Make sure you pour the water slowly or you will form a lake in the petri dish!

- 3. a. What has happened to the large craters? Does this agree with your prediction from question 2c?
- b. Which dish has the most small craters?
- c. Is there a marked difference between the two dishes, allowing you to easily tell which dish spent the most time in the rain?

The **angle of illumination** affects the visibility of surface features. Surfaces lit from directly overhead (noon time) appear different from those lit at an angle, as during sunrise or sunset. Line up the four petri dishes with their raindrop craters. Turn off the overhead lights. Use the flashlight and shine the light across the surface of the dishes, estimating the illumination angle. Try shining the light from the following angles and describe what you see. Examine the dishes from two locations—from the position of the flashlight and from directly above the dishes.

- 4. a. 90° (directly above the craters)
- b. 45°
- c. 20°
- d. 10°

Examine Figures 6.3 and 6.4.

- 5. a. Based on Figure 6.3, list the evidence you see on the Moon for long term impact cratering.
- b. Is the surface shown in Figure 6.4 older or younger than the surface seen in Figure 6.3? How can you tell?



*c. What geologic process(es) formed the surface seen in Figure 6.3? What process(es) formed the surface seen in Figure 6.4?

Figure 6.3 shows both the **limb** and the **terminator** of the Moon. The limb is the horizon, seen in the upper left corner. The terminator is the boundary between the day and night side, seen in the lower right. When examining spacecraft images, scientists are concerned with many aspects of the surface imaged. One aspect of interest is **topography**, the ruggedness of the surface. Another aspect is **albedo**, a measure of how the surface reflects light; albedo is a function of the composition and physical properties (such as grain size) of the surface.

*6. a. What part of Figure 6.3 gives the best topographic information? Is the illumination angle at this location high or low?

b. What part of Figure 6.3 gives the best albedo information? Is the illumination angle at this location high or low?



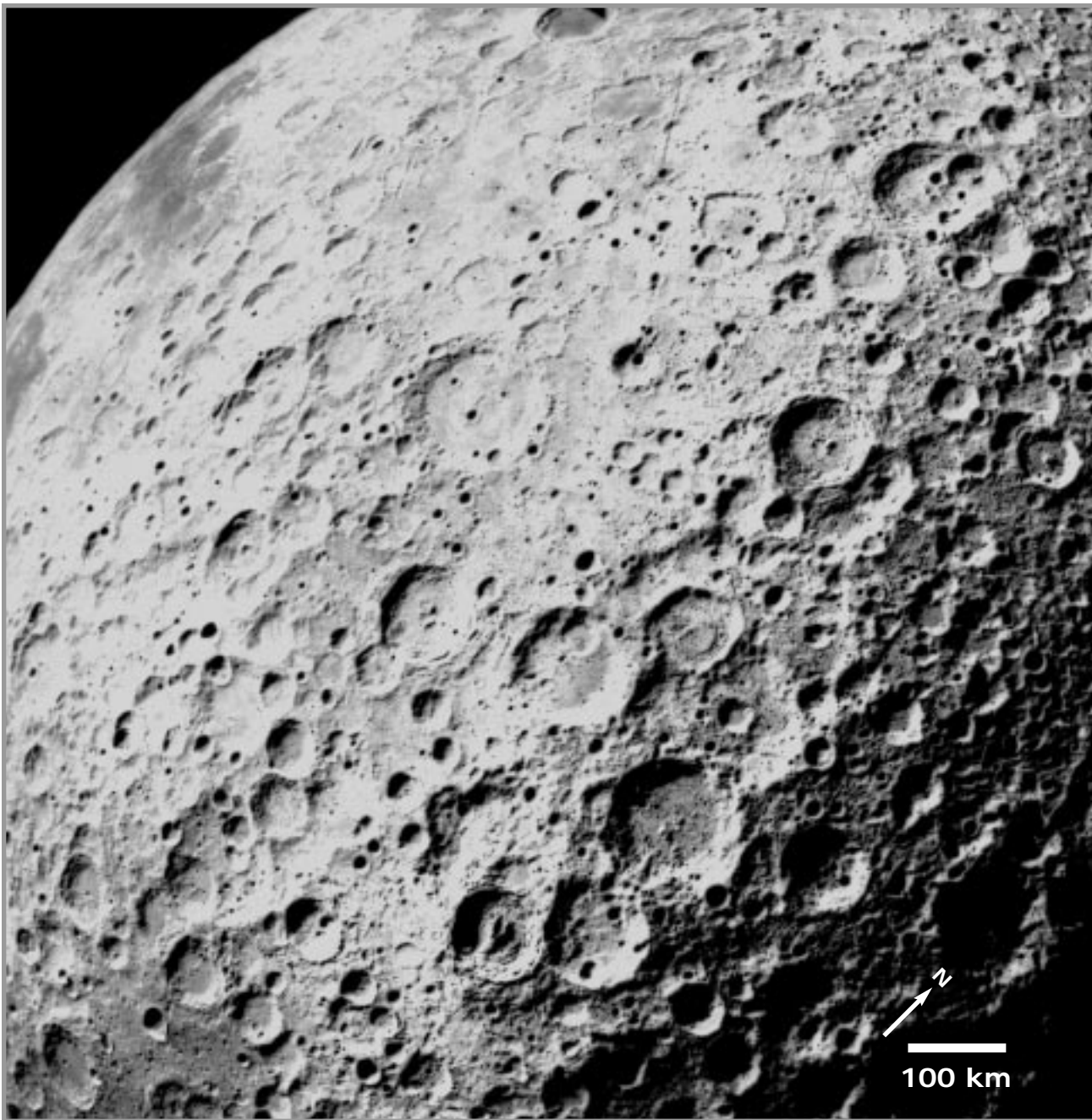


Figure 6.3. Photograph of the lunar highlands. Mare Marginis is the darker surface visible on the limb (lunar horizon, upper left). (Apollo metric photograph AS16 3003.)

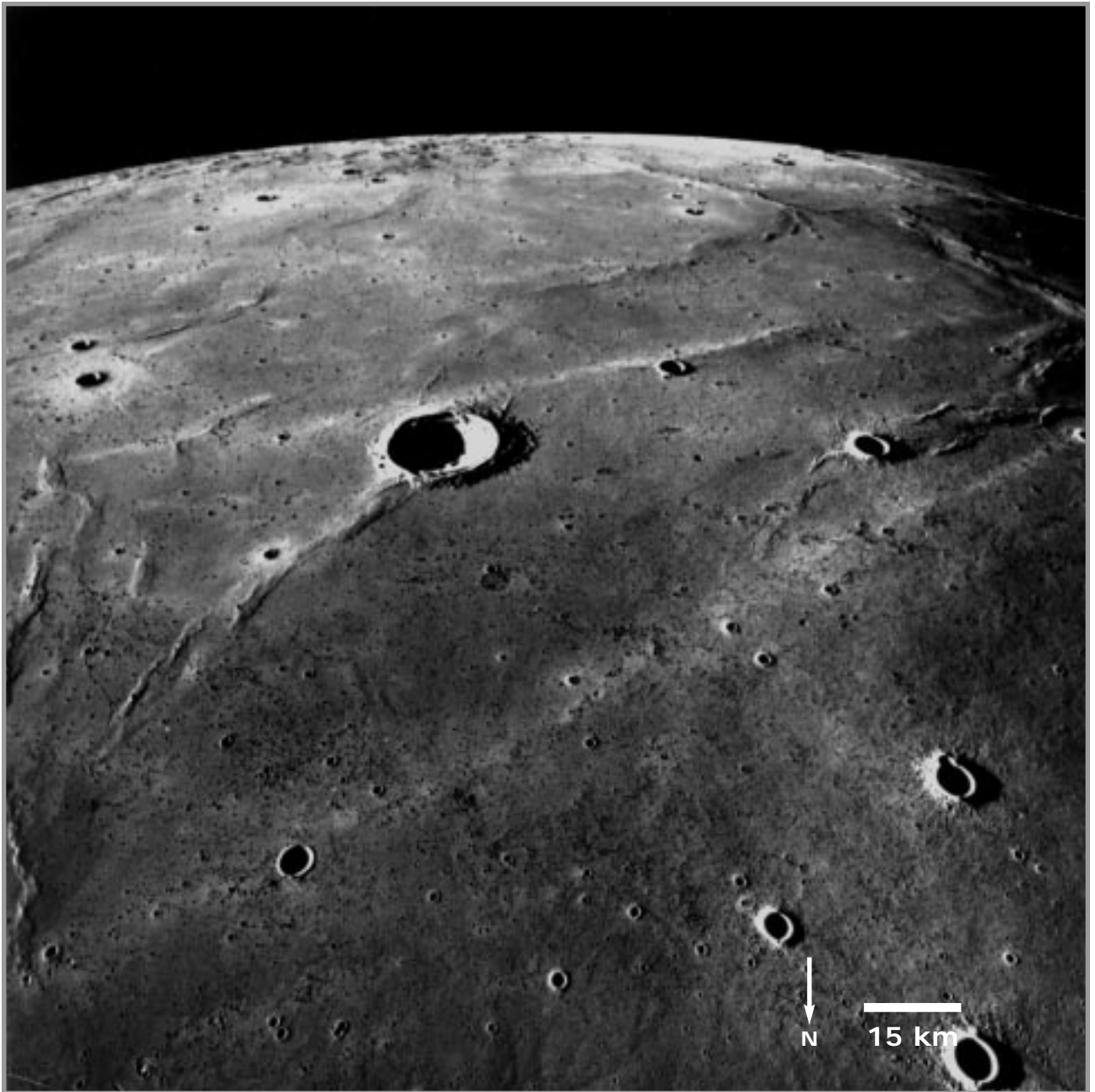


Figure 6.4. Photograph of lunar maria, looking south across Oceanus Procellarum. The large crater is Schiaparelli. (Apollo metric photograph AS15 2617.)