



Exercise Two is suggested as an introductory exercise.



# Geologic Features of Mars

## Instructor Notes

### Suggested Correlation of Topics

Mars, geomorphology, gradation, impact cratering, tectonism, volcanism

### Purpose

By examining images of martian surface features, students will learn to identify landforms and interpret the geologic processes which formed them.

### Background

To perform this exercise students should have been introduced to the four geologic processes – gradation, impact cratering, tectonism, and volcanism.

In many ways Mars is similar to Earth. Martian volcanoes, although apparently extinct, are similar to those on Earth. Mars does not experience plate tectonics like the Earth, but it does have familiar tecton-

ic features, such as rift zones. Gradation on Mars is also similar to the forms observed on Earth, although liquid water is not stable on the surface of Mars today. On Mars, as on most other worlds, impact cratering is much more conspicuous than on Earth. The number, size, and freshness of craters, and their relation to other geologic features, can be used to determine the relative ages of Martian surfaces.

A more detailed description of the processes that have acted on Mars is presented in the students' introduction.

### Science Standards

- Earth and Space Science
  - Energy in the Earth system
  - Origin and evolution of the Earth system
  - Earth in the solar system



## Answer Key

1. It is approximately circular, but has numerous over-lapping craters within it and at the margins.
2. Answers will vary, but should include: a) erosion, b) tectonism (faulting).
3. Geologically young because there are few impact craters. Younger than the surface of the moon.
4. *Answers will vary.* The sharp, straight cliffs and the large dimensions suggest tectonic processes; the stream patterns on the south side are indicative of modification by running water.
5. Ius Chasma is larger by several times.
6.
  - a. Northeast (to the top of the photo).
  - b. Craters are numerous and degraded, indicating this is a relatively ancient region.
  - c. The craters are older than the valleys which cut across the center rims. However, there are also a few fresh, young craters superposed on the channels, indicating that these impacts occurred after channel formation.
7.
  - a. The diffuse streaks of bright material are found on the southeast side of craters.
  - b. The wind blew from the northwest.
8.
  - a. Like Olympus Mons, Apollinaris Patera has radial flow patterns and a basal scarp (cliff). Apollinaris Patera has more craters, a large flow trending to the south, and a less complex caldera than that of Olympus Mons. Olympus Mons is a much larger edifice.
  - b. Volcanism, considering its characteristics described above.
  - c. Impact formed Reuyl crater, indicated by the ejecta pattern and central peak.
  - d. Gradation by running water, indicated by the meandering pattern and tributary channels.
  - e. Water that once flowed through Ma'adim Vallis may have deposited sedimentary material onto the floor of Gusev crater.
9. Answers will vary. D, A (C), C (A), B. D is a very old degraded crater. The flows from A are modified at their southern part by sediments from crater D due to flow of water in channel C. So A preceded C. (This is very difficult to see and students may reverse the order of these two events.) Crater B is fresh in appearance – rim is not eroded – and thus is probably very young.





# Geologic Features of Mars

## Purpose

To learn to identify landforms on the surface of Mars and the geological processes that produced them.

## Introduction

In many ways Mars is similar to Earth. The same four geologic processes that shape Earth—gradation, impact cratering, tectonism, and volcanism—have left their mark on Mars. Volcanism has produced vast lava flows, broad shield volcanoes, and plains of volcanic material. Mars has some of the largest volcanoes in the solar system, including Olympus Mons, a massive volcano many times larger than the Island of Hawaii. Olympus Mons is only one of four huge volcanoes in a 3000 km-wide region called Tharsis. These volcanoes erupted repeatedly over many millions of years, growing higher with each lava flow. Enormous collapse calderas are found on the summits of each of the volcanoes.

Gradation is the dominant geologic process acting on Mars today. Mass movement is the displacement of material by landslides or slumping through the action of gravity. Aeolian (wind) activity is also a continuing process of gradation. Sand and dust particles carried by the wind form dunes and wind-streaks. Although temperatures below freezing and low atmospheric pressures do not allow liquid water on the surface of Mars today, gradation processes involving running water were important on Mars in the past. Valley systems cut through many of the cratered terrains of Mars and have characteristics analogous to water-cut valleys on Earth.

A mystery concerning water on Mars is “Where did it go?” Some water probably seeped into the ground and is frozen there today as ice, and some likely escaped into space over time. Moreover, the polar caps contain some water ice. Mars, like the Earth, has seasons. The polar caps shrink during local summer and grow during local winter.

Although Mars does not have plate tectonics like the Earth, there are many tectonic features that show its surface has been deformed. Stresses can be caused by subsurface uplift or by the addition of mass (such as lava flows) that weigh down an area. Extensional stresses have led to the formation of great valleys such as Valles Marineris, the longest canyon system in the solar system.

As on the Moon, Mercury, Venus, and most of the outer planet satellites, impact craters are found on the surface of Mars. Craters can be used to determine the relative ages of martian surface materials; in general, older surfaces have craters which are more numerous, larger, and more degraded than those on young surfaces. Moreover, the principles of superposition and cross-cutting relations indicate that a feature which at least partly covers another feature is the younger. Thus, if a valley cuts through a crater, the crater must be older. Individual craters are degraded or destroyed over time by gradational processes and further cratering. Therefore, crisp craters with upraised rims and steep sides are young, while less distinct and eroded craters with partial rims are probably older. Through a combination of these principles, the relative ages of geologic features can be determined, and a sequence of geologic events developed.



## Questions and Procedures

Examine Figure 11.1: Olympus Mons is a shield volcano 600 km in diameter, towering 25 km above the surrounding plain. Around its base is a steep cliff as high as 6 km. It has a summit caldera some 80 km wide.

1. Examine the caldera (labeled A) and describe its shape.
2. Suggest some ways in which the scarp around Olympus Mons might have formed.
3. Do you think the surface of Olympus Mons is geologically old or young, compared to the surface of the Moon? Explain your answer.

Examine Figure 11.2: Ius Chasma is part of the western end of Valles Marineris, the largest Martian canyon. Smaller valleys join the main east-west chasm.

4. Which of the four geologic processes might be responsible for the formation of Ius Chasma?
5. Compare the size of Ius Chasma and its tributaries to the size of the Grand Canyon of Arizona. Which is larger, and by how much?

Examine Figure 11.3: Valleys west of Chryse Planitia. Similar to some river systems on Earth, these martian channels have a branching pattern.

6.
  - a. In what direction did the water flow?
  - b. Based on the number and morphology of craters, is this a relatively old or young region of Mars?
  - c. Are the craters you observe older or younger than the valleys? Use the principle of cross-cutting relations to justify your answer.

Examine Figure 11.4: The Hesperia region in the southern hemisphere consists of cratered plains which have been modified by aeolian processes. Wind-produced features, called bright windstreaks, are associated with many craters.

7.
  - a. Describe the appearance and orientation of the windstreaks.

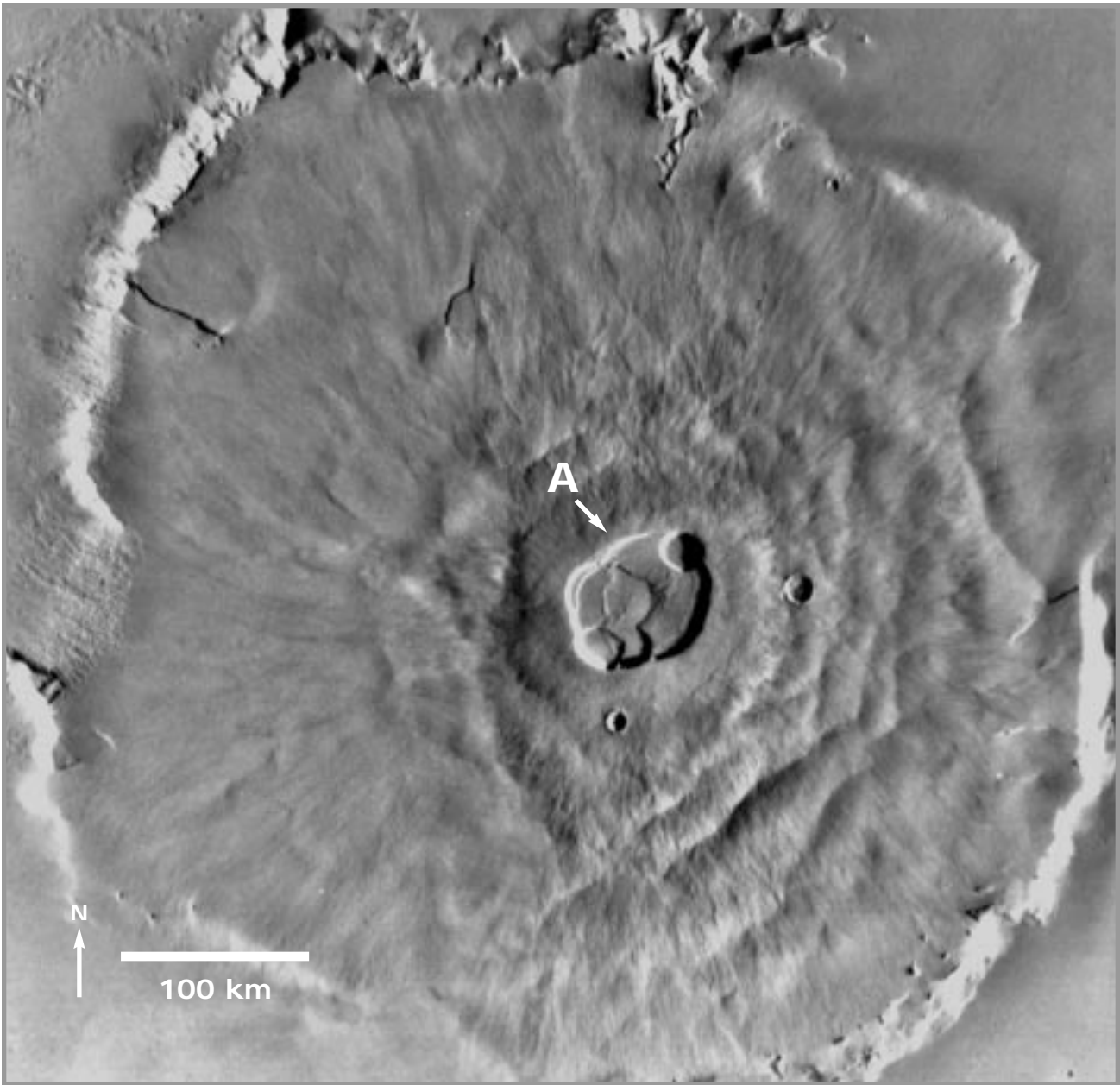


- b. If windstreaks are dust deposits formed downwind from the craters, what wind direction is indicated here? (Remember that wind direction refers to the direction from which the wind blows.)

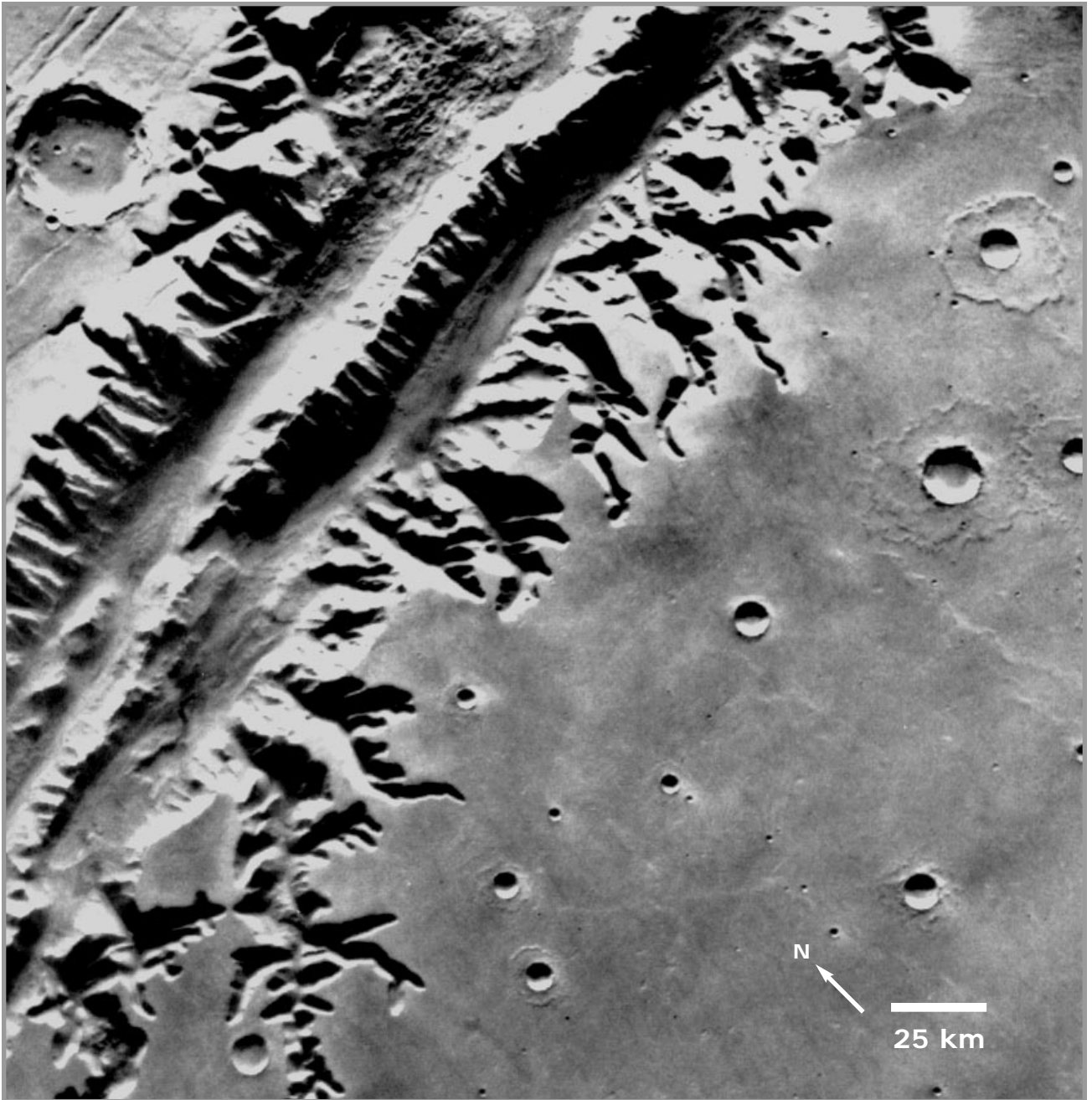
Examine Figure 11.5: Apollinaris Patera and surrounding region. All four geologic processes can act to shape a planetary landscape. For the following, you will use the knowledge from previous questions to identify Martian landforms and describe the geologic processes that created them.

8. a. Compare Apollinaris Patera (marked A on Figure 11.5) to Olympus Mons (Figure 11.1). How are they similar, and how are they different?
- b. What process do you think formed Apollinaris Patera? How can you tell?
- c. What process do you think formed Reuyl crater (marked B on Figure 11.5)? Justify your answer.
- d. Ma'adim Vallis is the channel in the southeast part of the photograph, marked C. Which of the four processes do you think formed Ma'adim Vallis? Justify your answer.
- e. Consider the relationship between Ma'adim Vallis and Gusev, the 160 km diameter crater marked D. What could be the origin of the material that comprises the floor of Gusev? (Hint: the region slopes to the north.)
9. Based on your observations, what is the probable order of occurrence of A, B, C, and D in Figure 11.5 (i.e., which came first, second, third, last)? Give evidence for your answer.

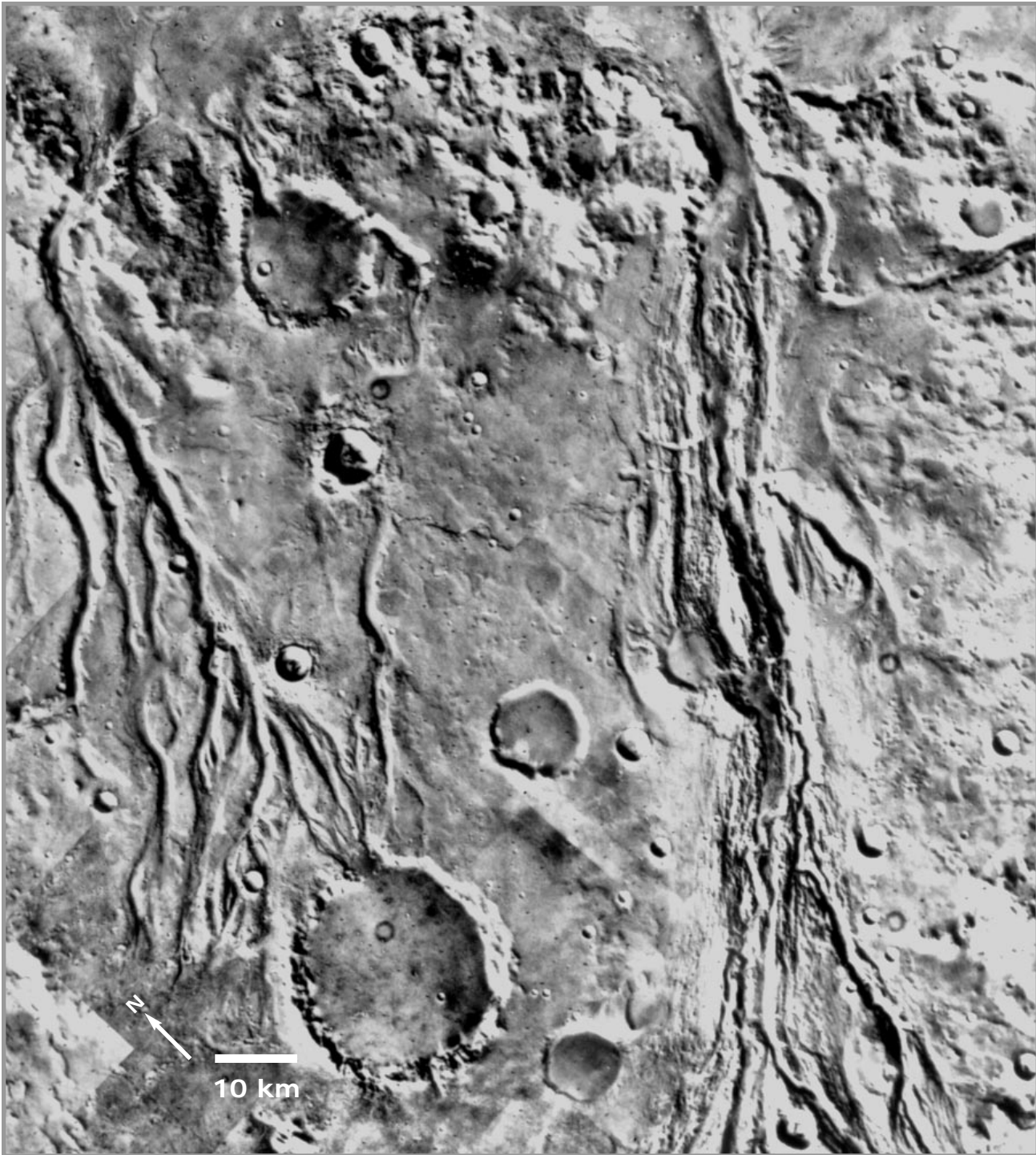




**Figure 11.1.** *Martian shield volcano, Olympus Mons. The summit caldera is about 80 km in diameter. (Viking MDIM mosaic 211-5360)*

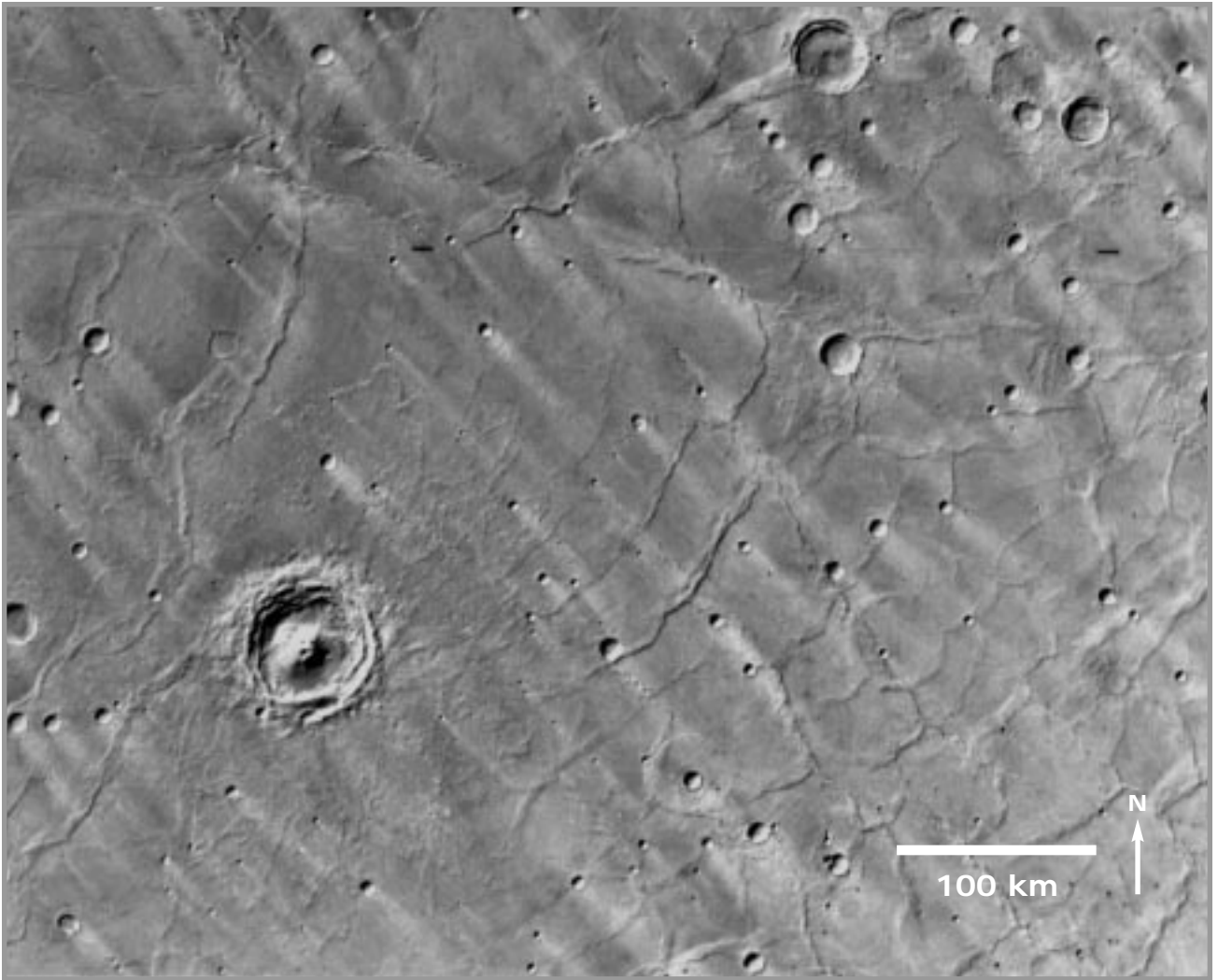


*Figure 11.2. Ius Chasma, part of the Valles Marineris system. (Viking image 645A57.)*



*Figure 11.3. Valleys on western Chryse Planitia near the Viking Lander 1 site. The large crater at left center is 28 km in diameter. (Viking mosaic P-17698.)*





*Figure 11.4. Hesperia Planum, showing bright windstreaks associated with some of the craters. Location: 24° S, 245° W. North is to the top. (Viking MDIM Volume 4.)*

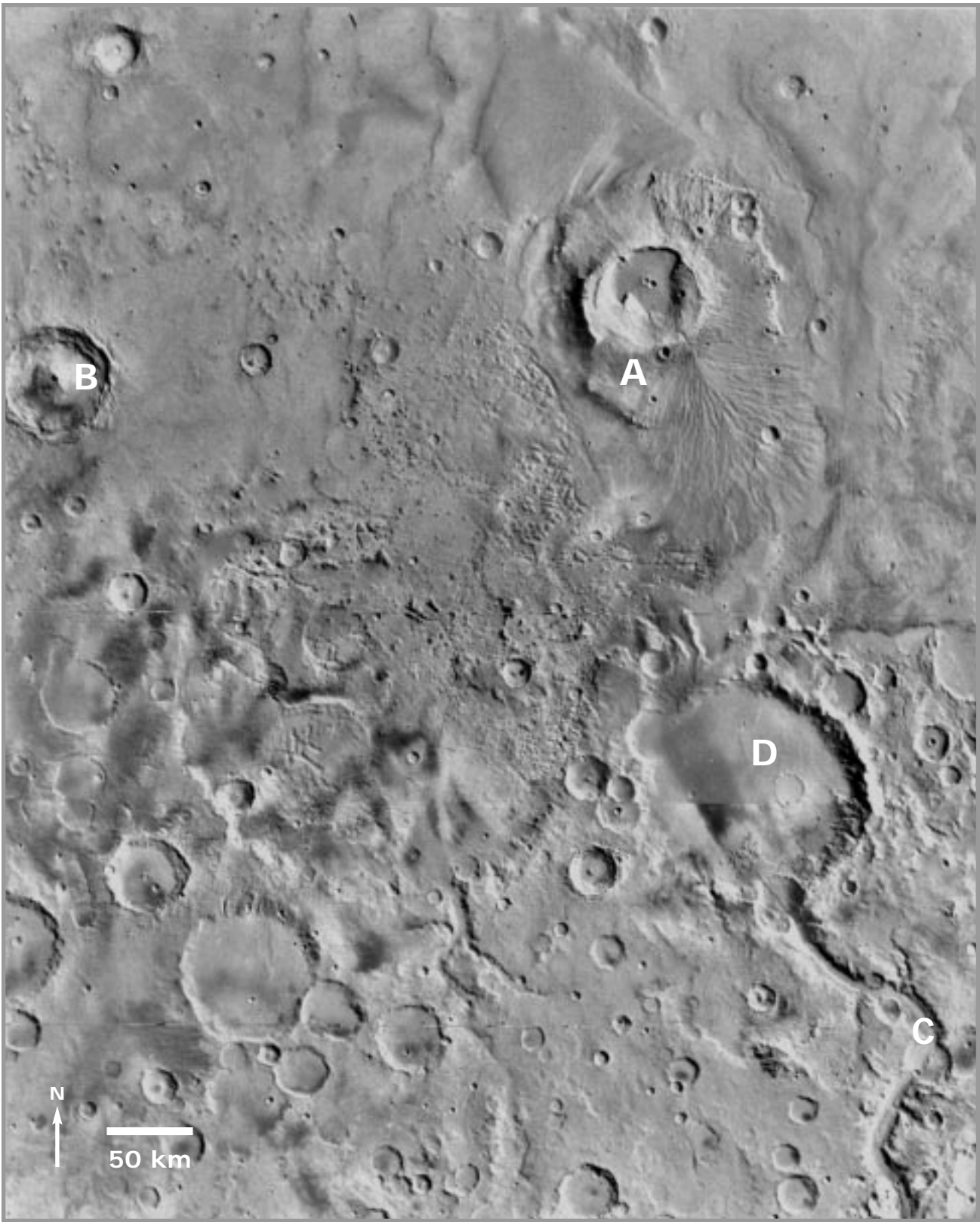


Figure 11.5. Apollinaris Patena and surrounding region centered at 10° S, 190° W. (Viking MDIM Volume 4.)