Lab 1: Geologic landforms and mapping   Name: ______________________________
1/22/2014

Introduction
At a global scale, only the largest planetary landforms and regions are visible and can be identified. Such landforms include large volcanoes, canyons, impact craters, plains regions, mountains, and highlands. Although the Earth, Moon and planets formed at the same time (about 4.5 billion years ago) their surfaces differ in age. This difference is due to variations in the level of geologic activity on each body since their formation. The four main geologic processes (volcanism, tectonism, gradation [aka erosion/transport/deposition], and impact cratering) have worked to alter the original surfaces, but Mars is the only planetary body where all of these processes can be readily studied.

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. 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. Aeolian (wind) activity is a continuing process of gradation, and sand and dust particles carried by the wind form dunes and windstreaks. 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.

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.

Mercury

1. Examine **Figure 1.1.** Mercury has no atmosphere, orbits the sun at .46 the distance of Earth, and has a radius of 2440km (for reference, Earth's radius is 6370km)

a. What landforms and regions do you observe on the surface of Mercury?

b. Based on the number of craters, do you think the surface of Mercury is older, younger, or about the same age as the plains on the Moon?

Venus
Venus is often referred to as Earth's "sister planet" due to its similar size, although it would not be a very pleasant place to visit due to its intense heat and noxious atmosphere. It orbits the Sun at .73 the distance of Earth, and has a radius of about 6050km. Its atmosphere is 90 times thicker than the Earth's and is primarily carbon dioxide (96.5%), nitrogen (3.5%), and sulfur dioxide (0.015%) (compare that to Earth's 78% nitrogen, 21% oxygen, and .93% argon, 0.039% carbon dioxide). Venus is an example of a positive runaway greenhouse effect. Its average surface temperature is 462 °C / 860 °F, (Earth: 15 °C / 59 °F)

2. Examine **Figure 2.1**, which shows two impact craters on Venus. They are surrounded by smooth volcanic plains, which are dark on the radar image. The crater rims are easily identified, as are the **ejecta** deposits.
    a. Describe the differences between Wheatley crater (larger, toward the bottom) and the smaller crater near the top in terms of texture.

    b. Describe the features concentrated near the top of the image. What do you think these are?

3. The right side of **Figure 2.2** shows a rift zone on Venus. Although the rift zone appears almost flat in the image, the topography of this area is more like the Grand Canyon of Arizona, with steep cliffs and deep valleys.

    Note the darker toned material. What do you think it is? Is it younger or older than the rift? How do you know?

4. **Figure 2.3** shows an area of "complex ridged terrain," the term used for some mountains and highlands on Venus. This area has been fractured, faulted, rifted, uplifted, and surrounded by younger smooth (dark) plains. The deformed area is very bright in the radar image because the complex structures have produced very rough terrain.

    Does the tectonic activity that formed the complex ridged terrain appear to have affected the volcanic plains? What does this indicate about the tectonic activity in this area and the age of the volcanic plains?

Mars
Mars has a thin atmosphere, seasonal dust storms and polar ice caps (notice the bright south polar ice cap near the bottom of the figure). It orbits the sun at 1.6 times the distance as Earth, and has a radius of about 3380km. At one time, Mars had liquid water on its surface, although today Mars is too cold to have liquid water and only has ice.

5. Examine **Figure 3.1.** The darker spots within the bright region of the upper left of the image (marked A-D) are large volcanoes. Images sent back from surface landers and other remotely acquired data show that the lighter toned areas are relatively dusty and the darker toned areas are sandy or bare rock. Near the center of the image is Valles Marineris (marked E), a large canyon system of probable tectonic origin.
    a. List similarities and differences in the features found on Mars compared to those on the Moon, Venus, and Mercury.

    b. Why is the surface of Mars different from the Moon? Include at least two major geologic processes in your explanation.

    c. Based on the number of impact craters, which part of Mars is older, the northern or the southern region?

6. Examine **Figure 3.2.** 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.
    a. How does Olympus Mons compare in size and morphology to volcanoes on Earth (cite an example of a terrestrial volcano)? What does this tell us about the history of the eruption?

    b. Do you think the surface of Olympus Mons is geologically old or young, compared to the surface of the Moon? Explain your answer.

7. Examine **Figure 3.3.** Ius Chasma is part of the western end of Valles Marineris, the largest Martian canyon. Smaller valleys join the main east-west chasm.
   a. Which of the four geologic processes described in the introduction might be responsible for the formation of Ius Chasma? Explain.

   b. How does Ius Chasma compare in size to the Grand Canyon?

8. Examine **Figure 3.4.** Valleys west of Chryse Planitia. Similar to some river systems on Earth, these Martian channels have a branching pattern.
   a. In what direction did the water flow? How do you know?

   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 crosscutting relations to justify your answer.

9. Examine **Figure 3.5.** 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.
   a. 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.

   b. Compare Apollinaris Patera (marked A) with Olympus Mons. How are they similar and how do they differ?

   c. 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.)

   d. Based on your observations, what is the probable order of occurrence of A, B, C, and D in Figure 4 (i.e., which came first, second, third, last)? Give evidence for your answer.

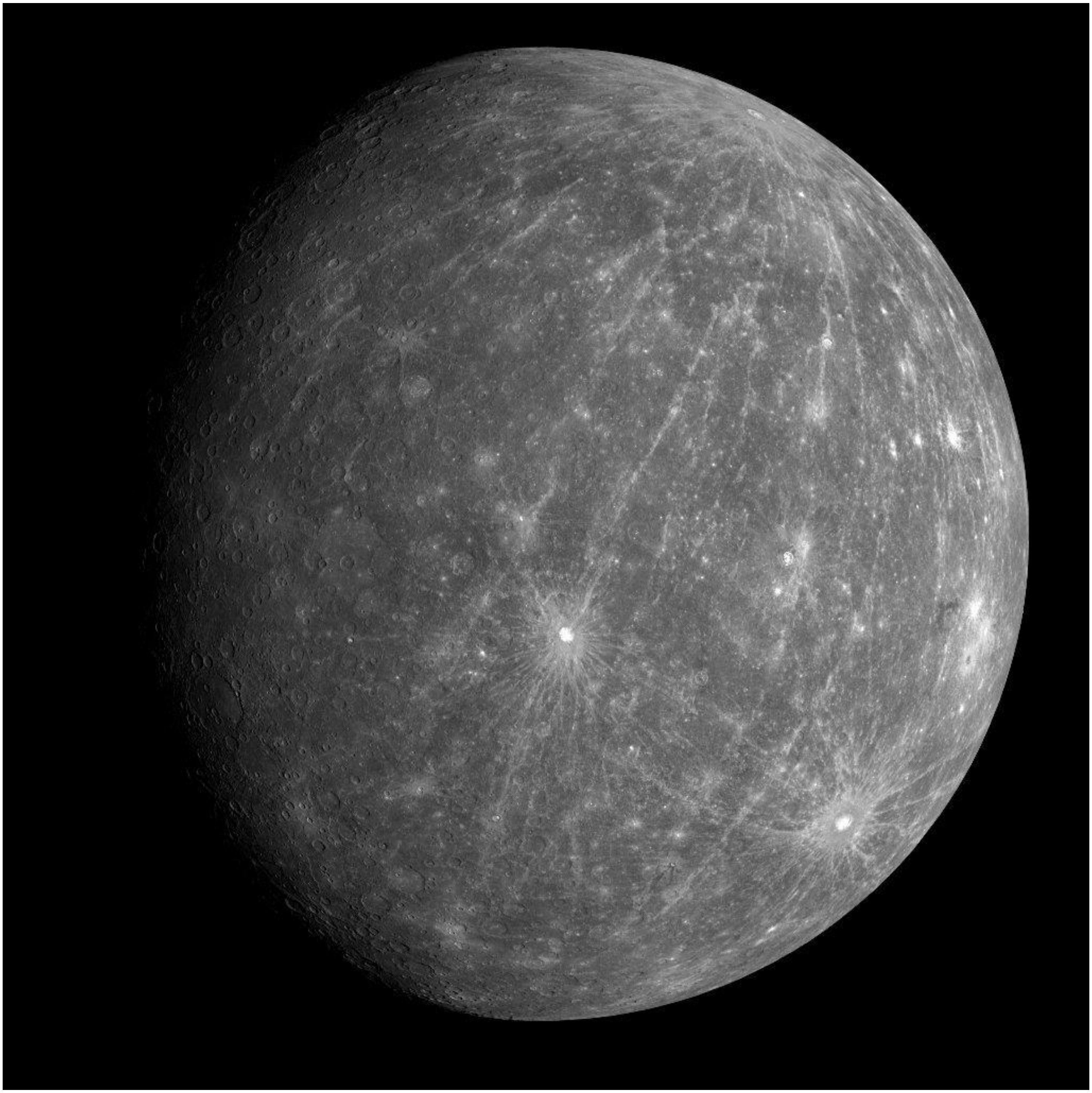

Figure 1.1. MESSENGER mosaic of Mercury

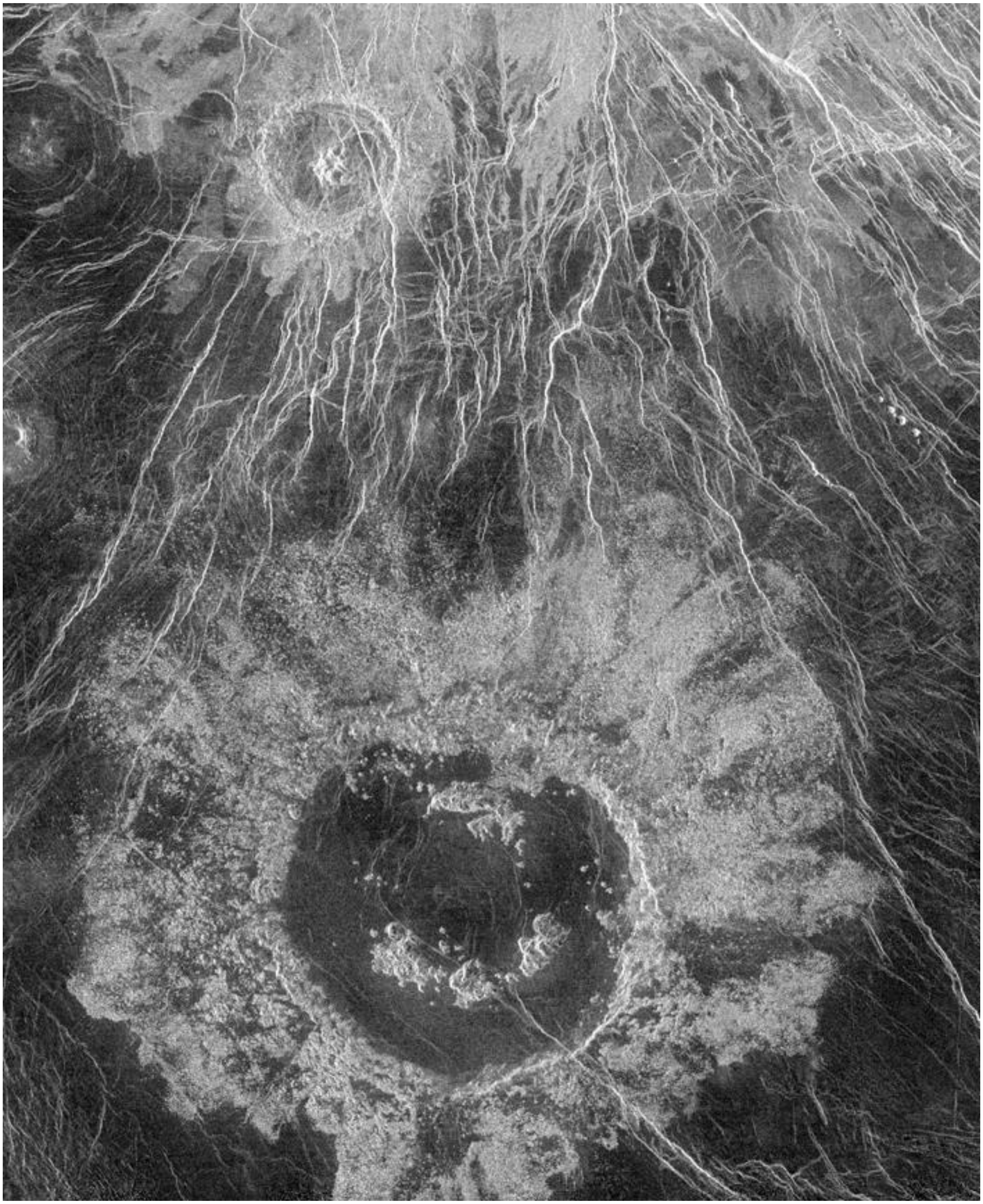

Figure 2.1. Wheatley crater (72 km diameter). Magellan radar image (Magellan C1-MIDR 15N266;1,framelets 21 and 22)

Figure 2.2. Magellan Radar Image of the Devana Chasma rift system, scale bar is 500 km. Note that the crater labeled A has been cut by the rift, with part of the crater visible on both sides of the rift. The thin linear features in the southern portion of this image are faults and fractures.

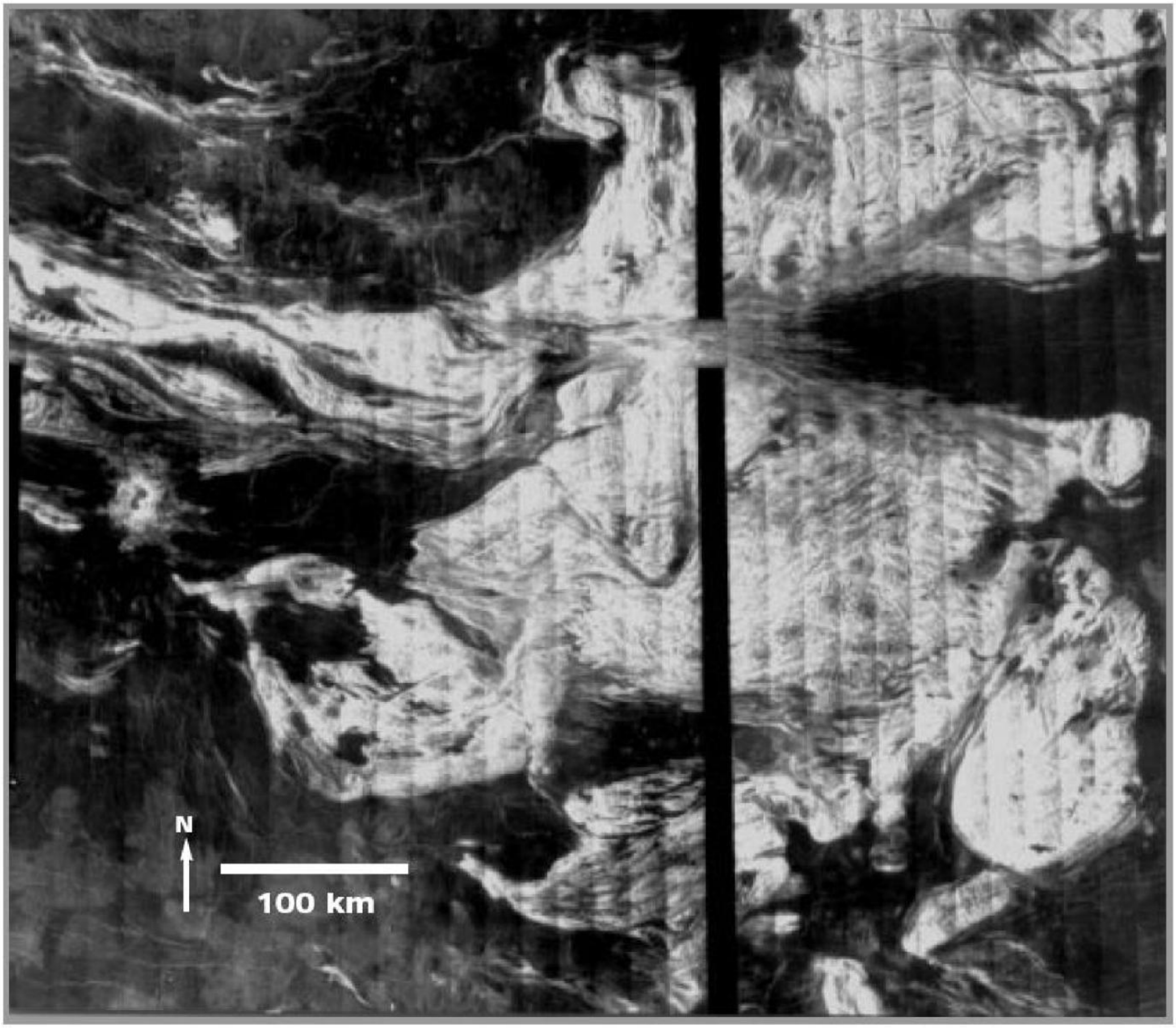

Figure 2.3. This image shows the terrain termed “complex ridged terrain” or “tesserae” on Venus. Considered by many to be the oldest surface terrain, it has been subject to extensive faulting and fracturing. It generally forms above the surrounding volcanic plains. Magellan radar image (F-MIDR 30N123)

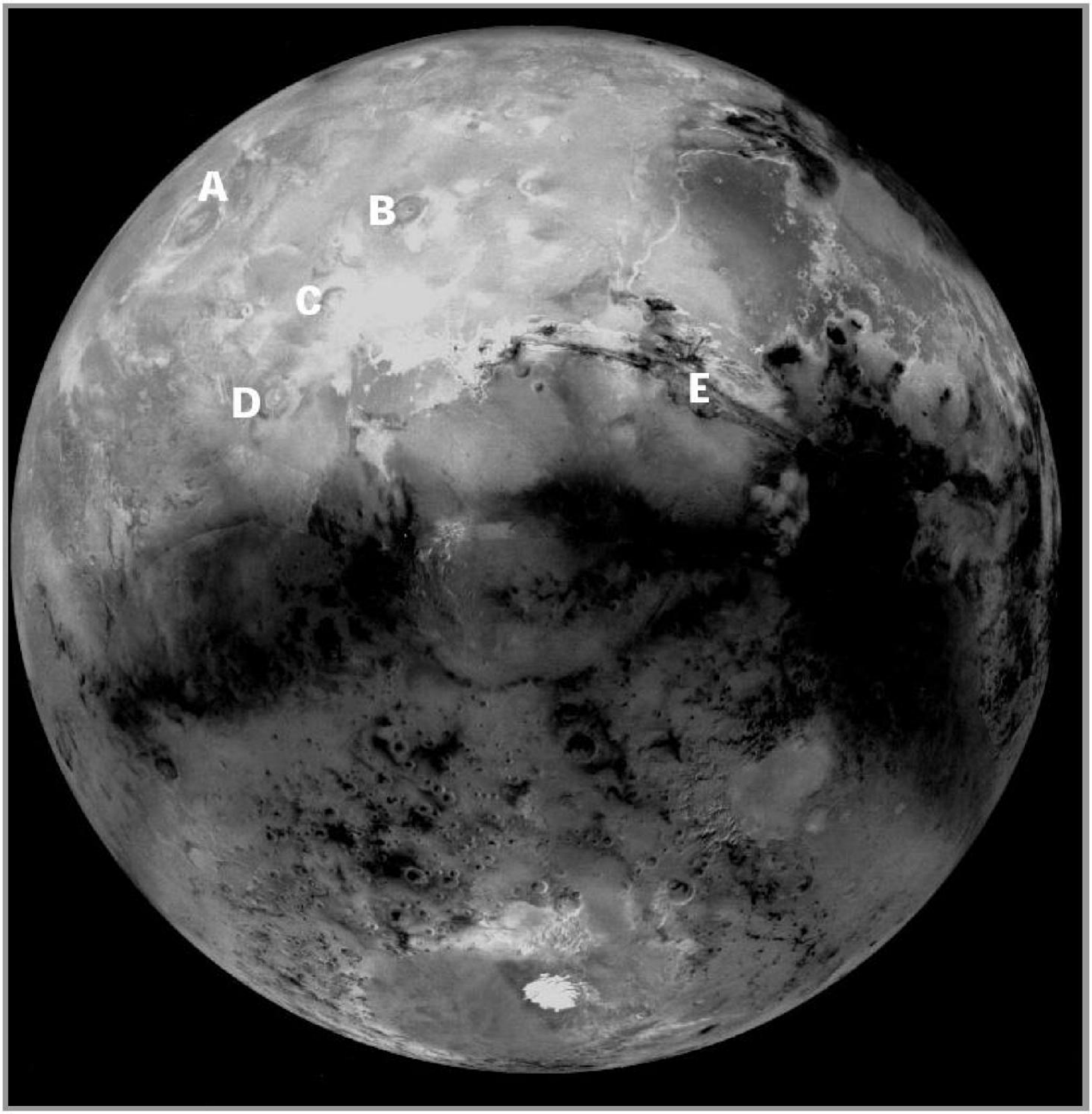

Figure 3.1. Viking Orbiter global mosaic of Mars, centered at -30°, 90°. North is to the top

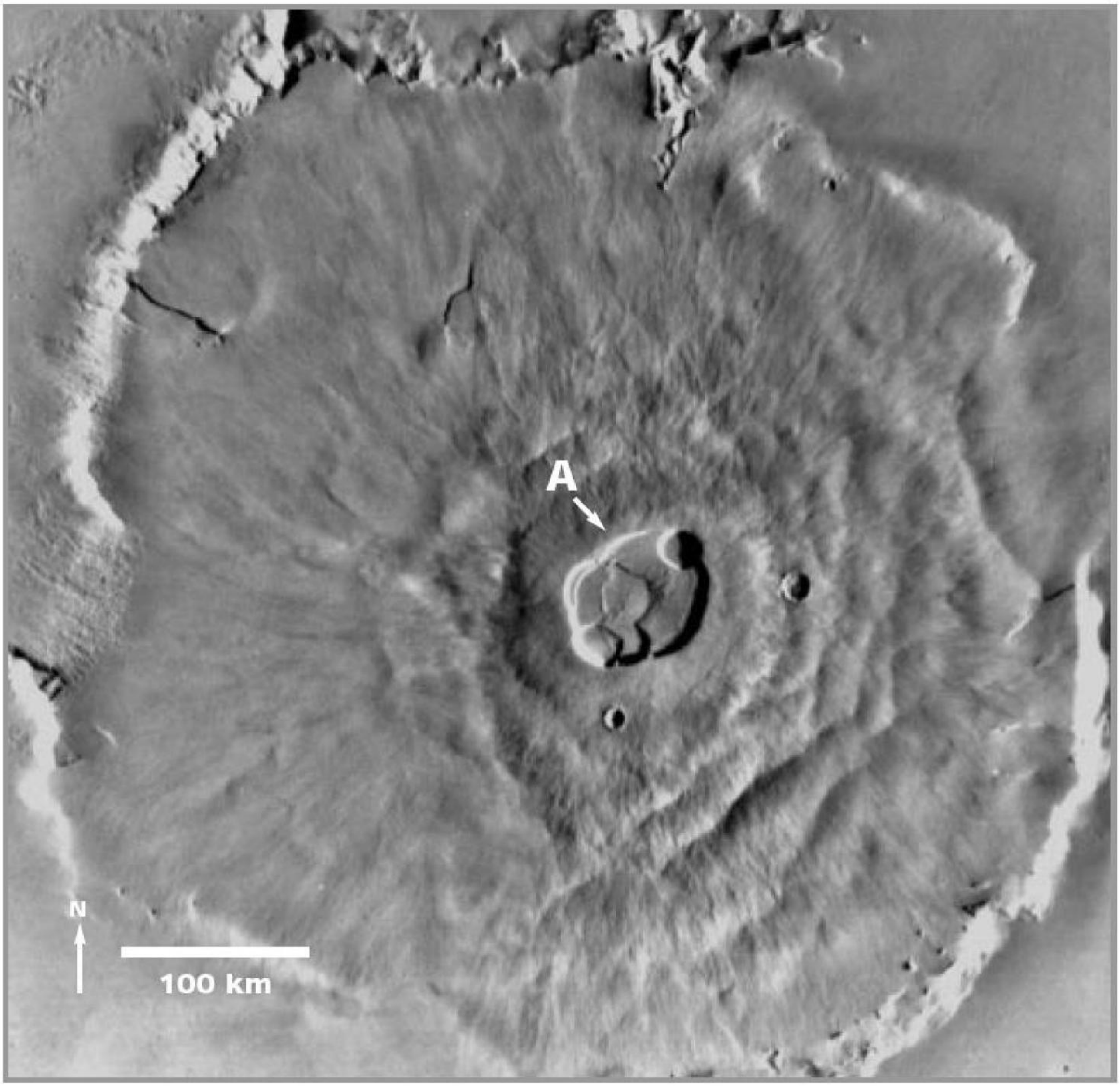

Figure 3.2. Viking mosaic of martian shield volcano Olympus Mons. Summit Caldera (A) is about 80km in diameter

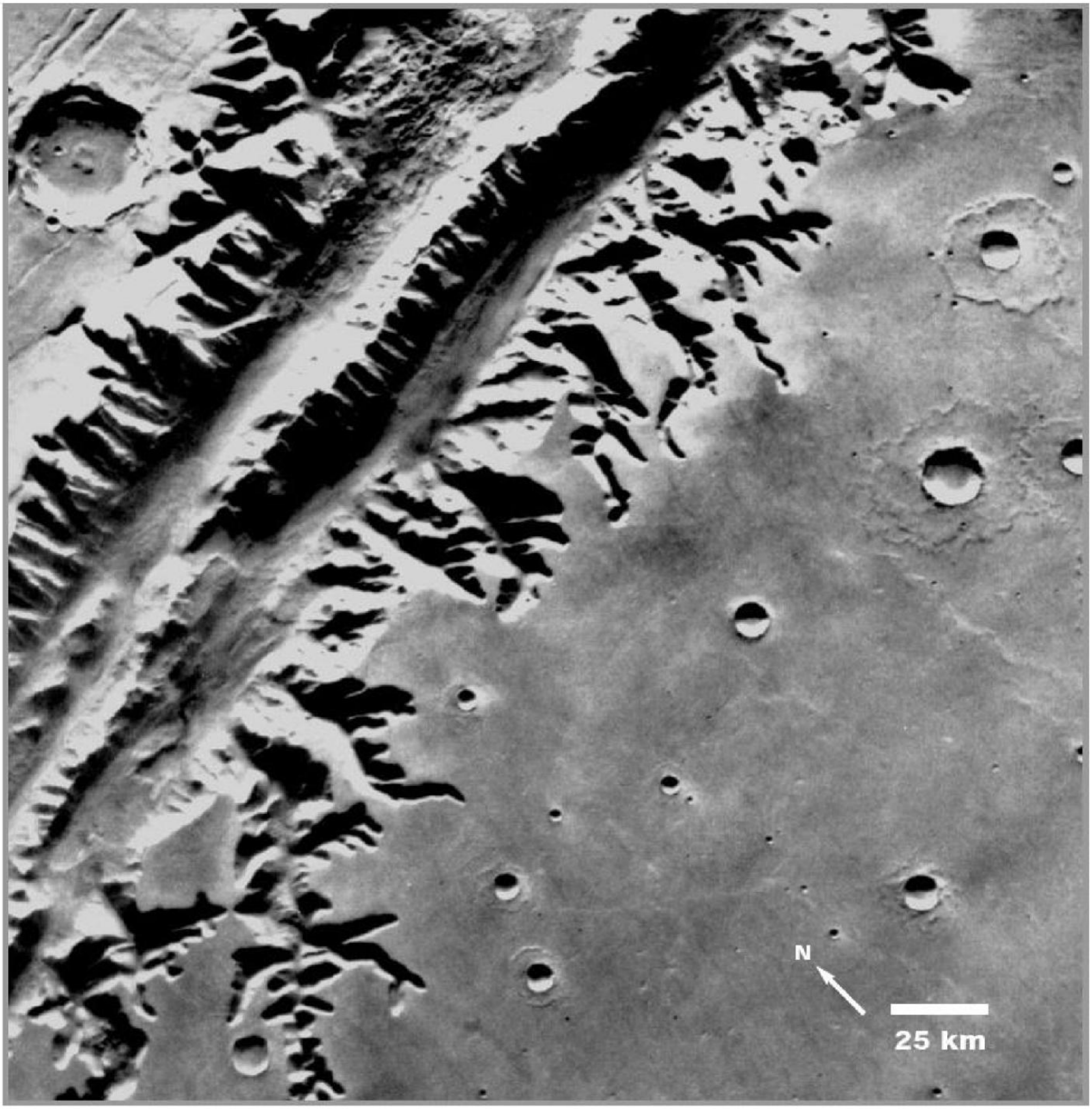

Figure 3.3. Ius Chasma, part of the Valles Marineris system

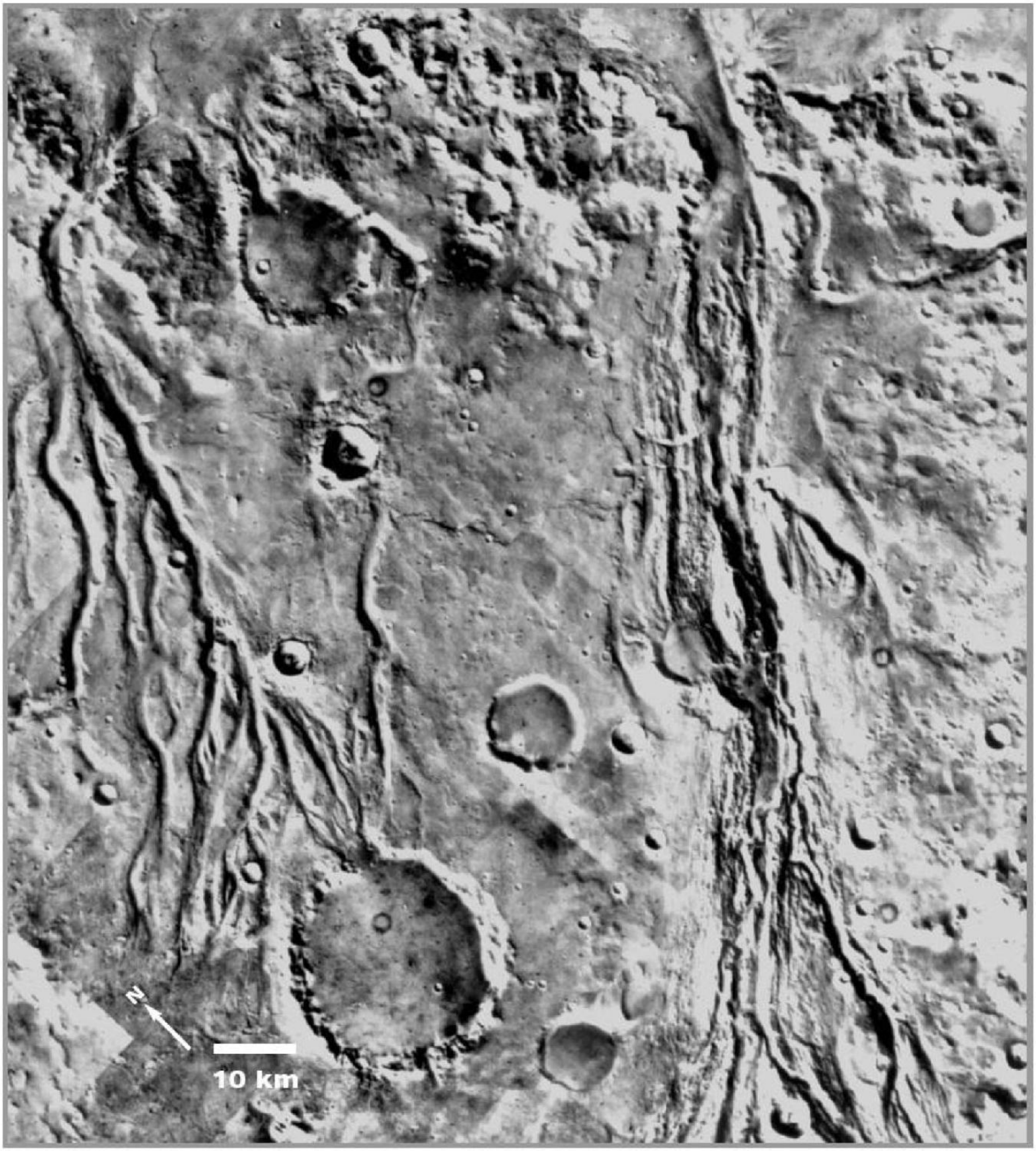

Figure 3.4. Valleys on western Chryse Planitia near the Viking Lander 1 site. The large crater at left is 28km in diameter (Viking mosaic P-17698)

Figure 3.5. Apollinaris Patera and surrounding region centered at 10° S, 190° W (Viking MDIM Volume 4)