Name ________________________________

COSMORPHOLOGY - May 2009

Geologic landforms

Purpose: By studying aerial photographs you will learn to identify different kinds of geologic features based on their different morphologies and learn the processes involved in their formation.

The four major geologic processes (gradation, impact cratering, tectonism, and volcanism) each produce distinct landforms. A landform can be identified based on its shape and form (also called morphology). Volcanism is the eruption of melted rock (called magma) and its associated gases onto the surface of the Earth. Volcanism commonly produces volcanoes and volcanic flows. Tectonism involves the movement of rock by fracturing and faulting, which results in earthquakes. Gradation involves the erosion, transportation, and deposition of surface materials. On Earth, running water, wind, gravity and ice are the major agents of gradation. Impact cratering occurs when material from outside the Earth's atmosphere (such as meteoroids and comets) strike the surface. The aerial photographs in this exercise will help you to recognize landforms and the geological processes that formed them. These processes act on other planets, where they can generate similar landforms.

This activity is based on Exercise Two from NASA's Activities in Planetary Geology for the Physical and Earth Sciences (EG-1998-03-1089-HQ).

For descriptions, be complete, clear, and brief. Describe as if the reader cannot see the picture.

QUESTIONS

Volcanism

1. Examine the cinder cone of Mount Capulin, New Mexico, shown in Figure 1. The depression at its summit is referred to as a volcanic caldera.
   A. Describe the general shape of the cone and the volcanic caldera at the top.

   B. What do you think formed the white spiral line from the base of the cone to the crater rim? Why?

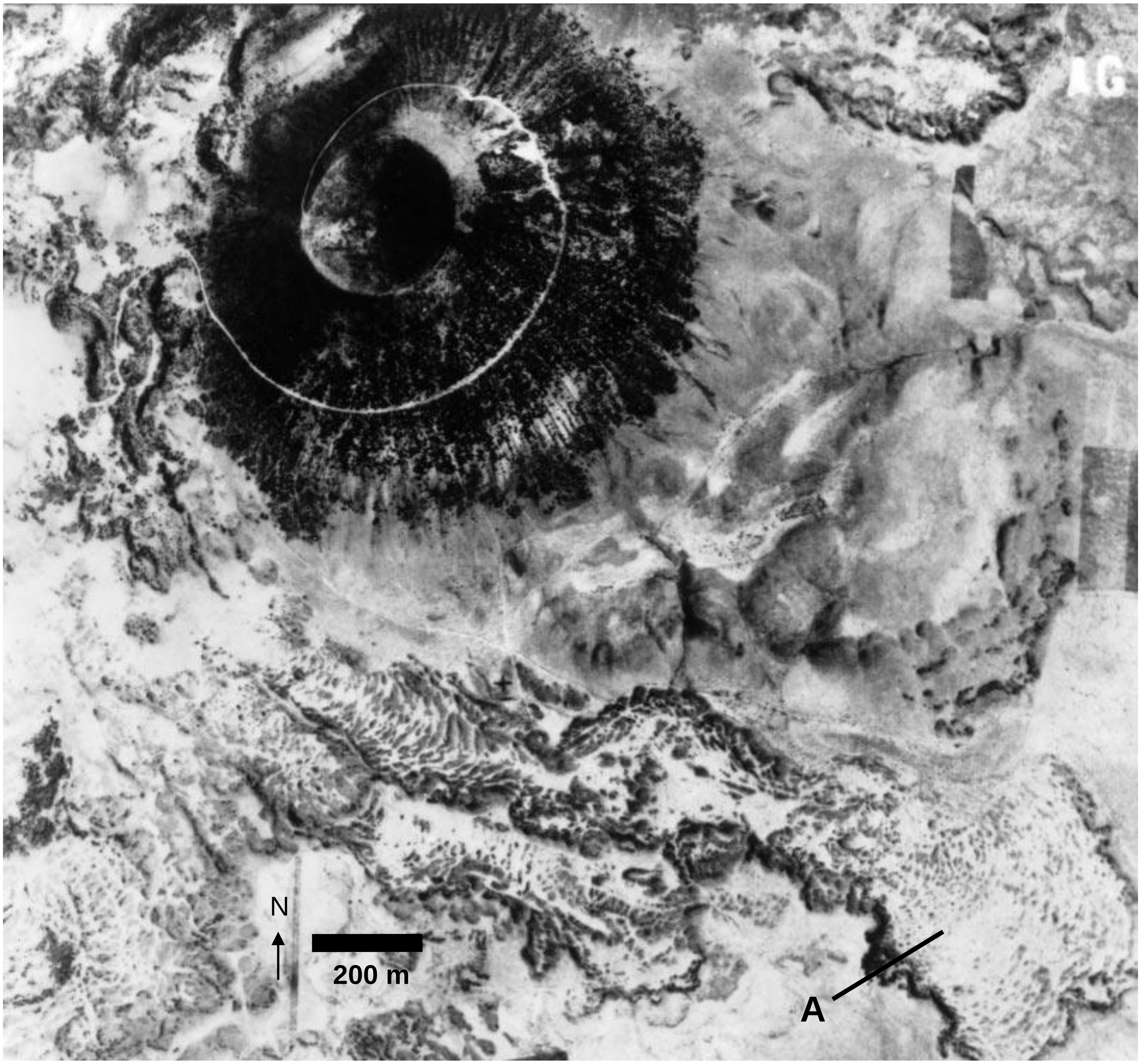
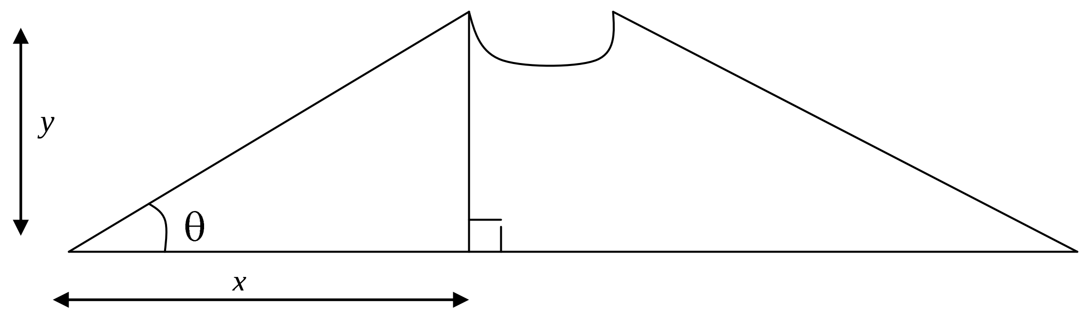


Figure 1: Mount Capulin, New Menico; aerial photograph (University of Illinois Catalog of Stereogram Aerial Photographs #105.)

2. Based on the elevation of Mt. Capulin (334 m) and the information provided by the aerial photo, the slope of the volcano's sides can be calculated. Geologists use the word slope to mean the angle between the ground and level (labeled with θ). This simple sketch of Mt. Capulin will help.



   A. Using your ruler and the scale bar on Figure 1, determine (in meters) the distance *x*, measured from the base of the cone to the edge of the crater at the top of the cone.

   B. The height *y* of the cone is 334m. Use trigonometry to estimate the average slope of the volcano's sides.

3. Examine the lava flow on the lower right of the image labeled A.
   A. Does its surface appear rugged or smooth? How can you tell?

   B. Trace the flow back to its point of origin. Where is the probable source of the flow (be specific)?

Figure 2: Mt. Tavurur. Vertical view of a composite volcano on the eastern Pacific island of New Britain, Papua, New Guinea. (Univ. of Illinois Catalog of Stereogram Aerial Photograph, #102.)

4. Study Mt. Tavurur volcano, New Guinea, in Figure 2. Compare it to Mt. Capulin in terms of shapes, textures, etc.
   A. How is the volcano similar to Mt. Capulin?

   B. How is it different?

5. Mt. Tavurur has erupted many times during its formation.
   A. How does the shape of the summit crater support this statement?

   B. Based on this, how many times do you think Mt. Capulin erupted? Why?

6. As you did for Mt. Capulin, estimate the slope of Mt. Tavurur's flanks. Draw and label a sketch similar to the one provided for Mt. Capulin. The height of Mt. Tavurur is 225m. Measure length *x* from the edge of the volcano at the ocean to the rim of the summit crater.

Tectonism

Southern California is cut by many faults. These are usually visible on aerial photographs as straight or gently curving linear features, often forming distinct divisions between landforms. Examine Figure 3, an oblique view of the San Andreas fault (arrows). A fairly straight valley trends from the bottom toward the top of the photo. (The dark line to the left of the fault is a canal lined with vegetation.) Over time, the ground to the left of the fault is moving away from us with respect to the ground to the right of the fault.

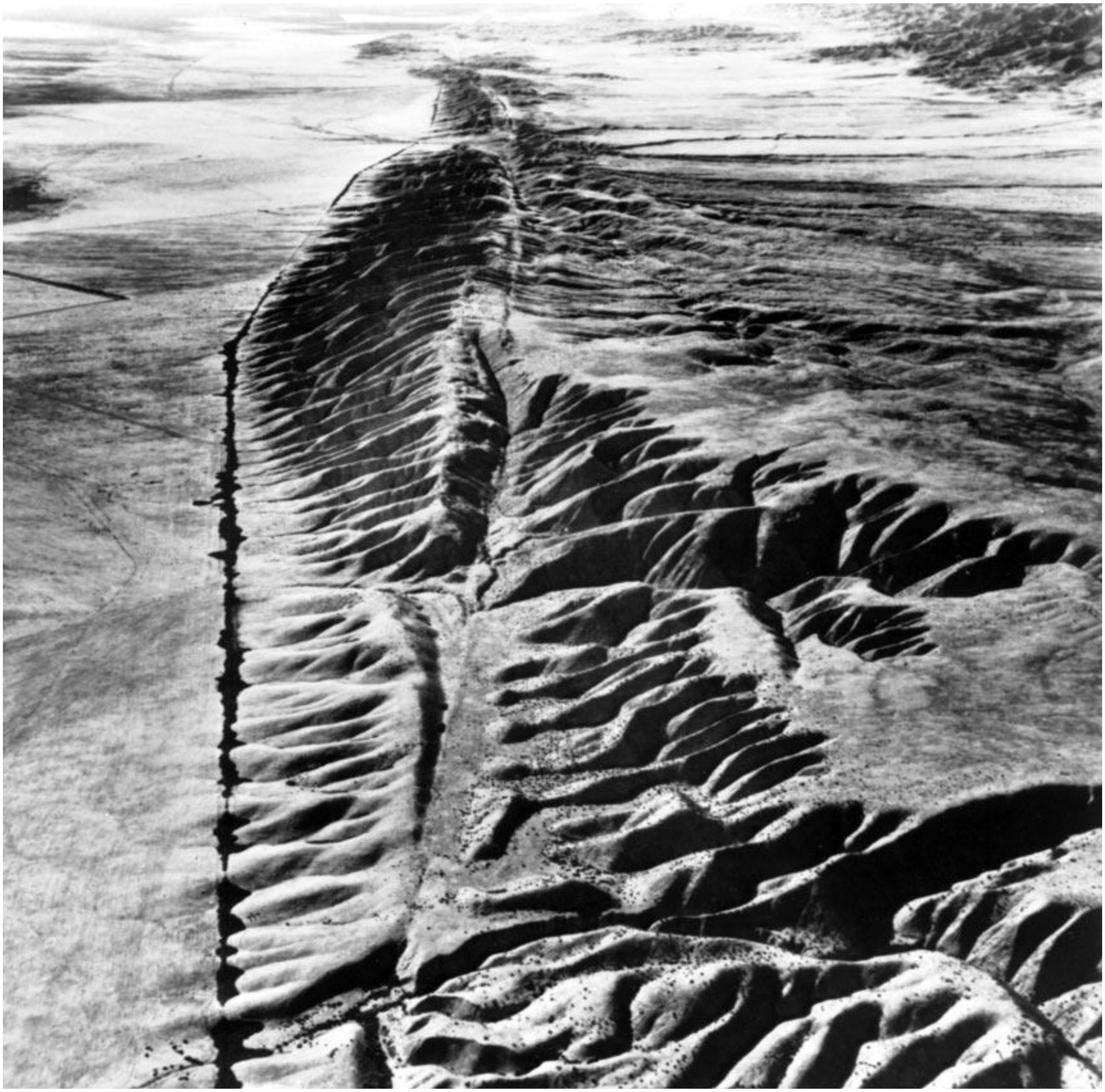


Figure 3: Oblique aerial view of a part of the San Andreas fault north of Los Angeles. North is to the top right. The forefround is approximately 3.5 km across. (photograph by Robert E. Wallace, U.S. Geological Survey.)

7. In what way does the fault affect the morphology of the mountains in this photo (describe what it looks like and how it happens)?

8. Tear a piece of paper in half. Place the two halves side by side and draw a line from one piece across onto the other. Making certain that the edges of the pieces remain in contact, slide the paper on the left away from you and the paper on the right towards you. This motion illustrates what occurs along the San Andreas Fault and how it affects the features along it. This type of fault is called a strike-slip fault.
   A. What would have happened if the line on the paper were actually a road crossing a fault?

   B. Are there any features like this in Figure 3? Where?

One landform distinctive to tectonism is called a graben (see Figure 4). A graben is a valley bounded on both sides by normal faults. The movement along these faults is vertical, with the central block moving downward in relation to the sides.

9. For block B to have enough space to move down, what has to occur to blocks A and C in Figure 4?

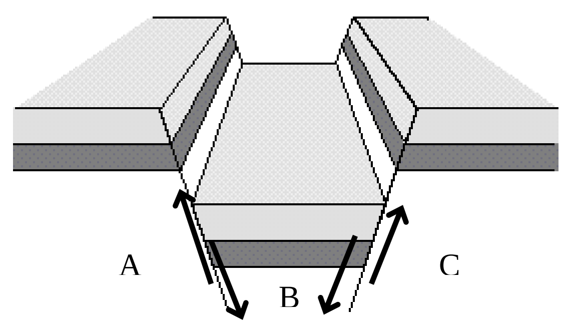


Figure 4: Diagram of a graben

Gradation

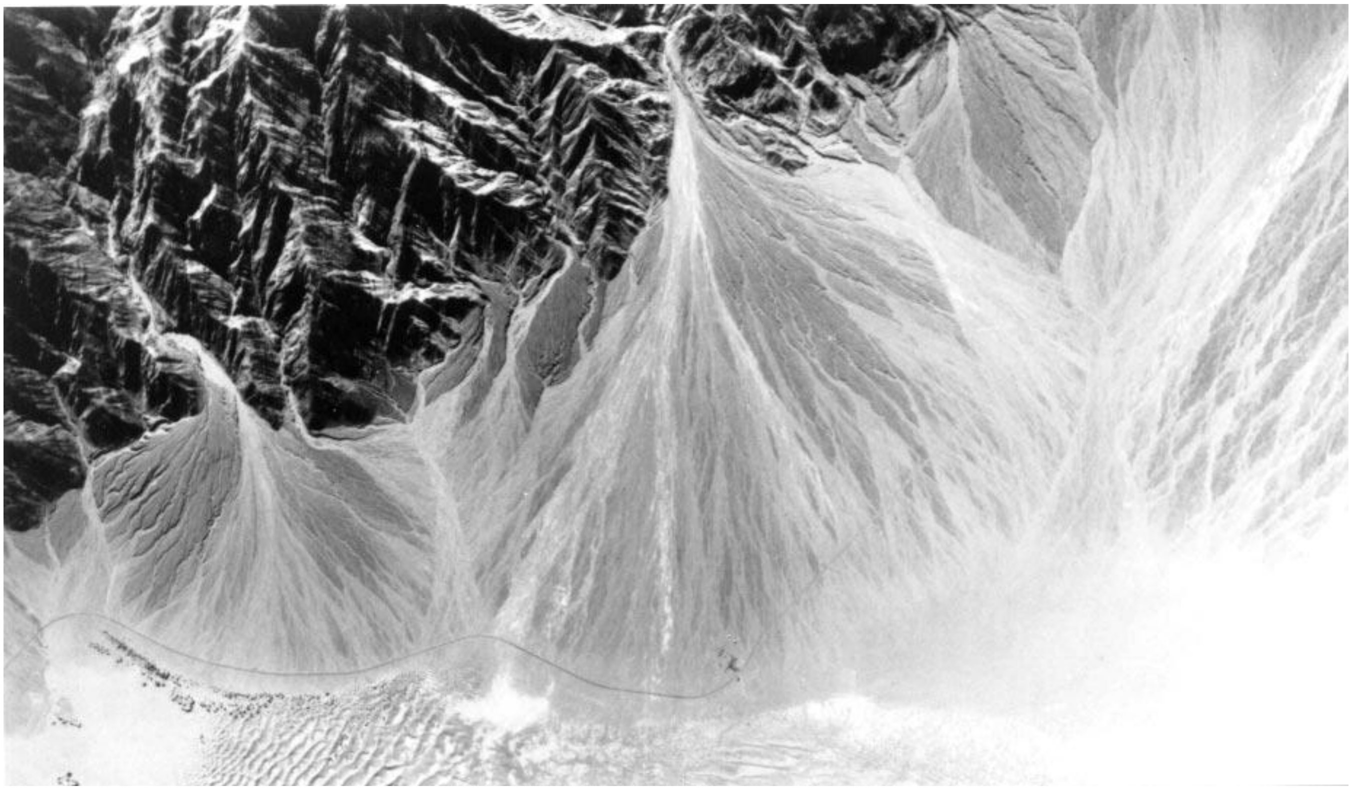


Figure 5: Vertical view of alluvial fans near Stovepipe Wells, Death Valley, California. Panamint mountains lie to the south. North is to the bottom left. (Univ. of Illinois Catalog of Stereogram Aerial Photographs, # 125.)

10. Figure 5 is a vertical photo of alluvial fans at Stovepipe Wells, Death Valley, California. These features result from the build up of alluvium (gravel, sand, and clay) that accumulates at the base of mountain slopes. "Fan" describes the general shape of the feature
    A. What is the source of the alluvium that makes up the fans?

    B. Which agent of erosion (wind, water, and/or gravity) was primarily responsible for generating the alluvium (i.e., breaking the mountains into gravel, sane, and clay)?

    C. What other feature (besides the alluvial fans) does this alluvium form? (Hint: Look at the very bottom of the image near the left.)

Figure 6: The Delta River, a braided stream in central Alaska. North is to the top. (U.S. Navy photograph coutesy of T. L. Péwé, Arizona State University.)

11. Figure 6 is a photograph of the Delta River, a braided stream in central Alaska. This river carries melt water and silt from glaciers to the Pacific Ocean. Rivers of this type are usually shallow. Because they are laden with sediments, they often deposit the sediments to form sandbars. These sandbars redirect the river flow, giving the river its branching, braided appearance.
    A. In what ways is the Delta River an agent of gradation that works to change the surface?

    B. Do the individual river channels appear to be permanent, or do they change position with time? How do you know? (Hint: Do you see any old channels? Where?)

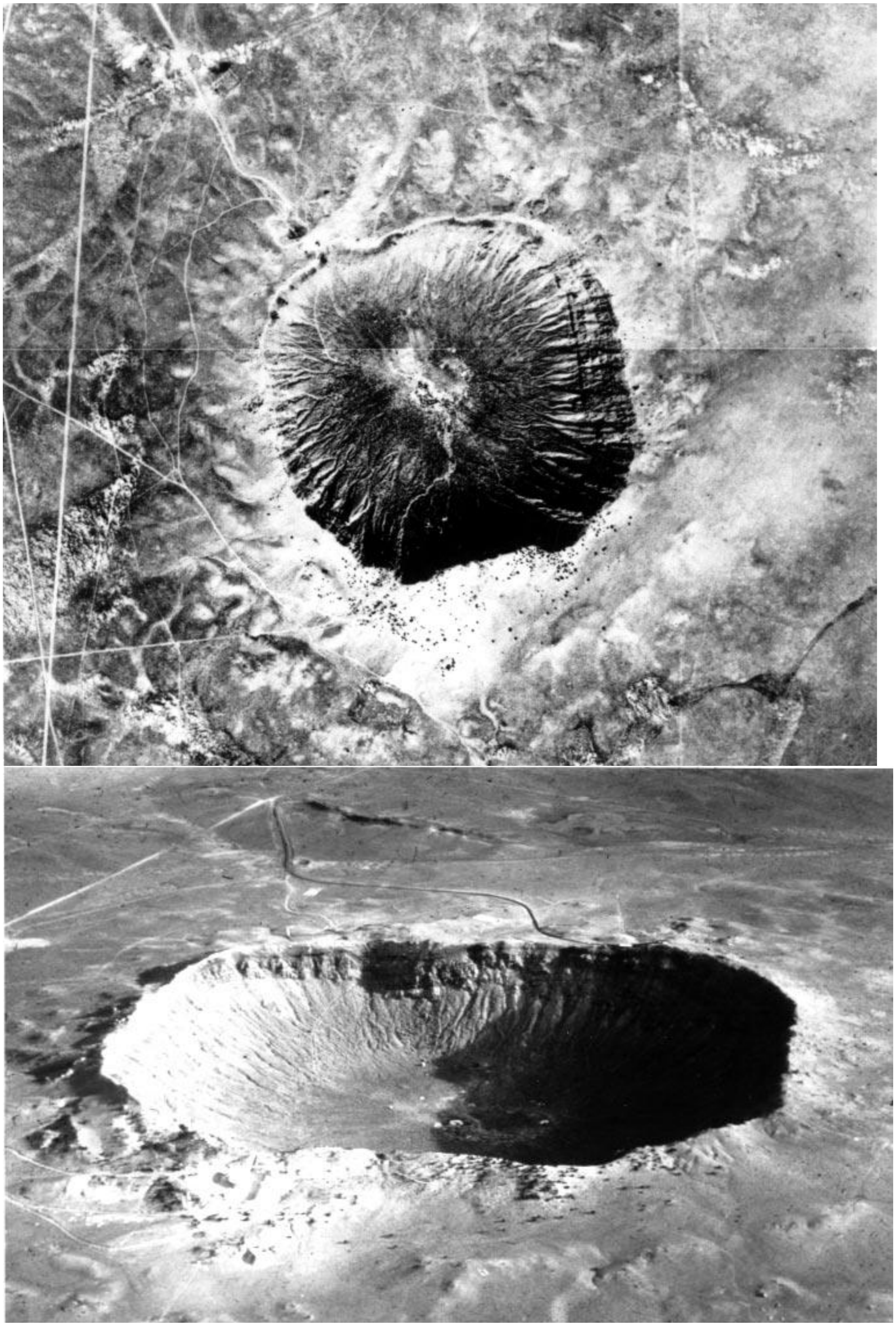


Figure 7: Meteor Crater, Arizona. (A) vertical view, (B) oblique view. One of the best preserved impact craters in the world., Meteor Crater was formed about 20,000 years ago. North is to the top. (A, Univ. of Illinois Catalog of Stereogram Aerial Photographs #5; B, Photograph coutesy U.S. Geological Survey.)

Impact Craters

12. Examine the photographs of Meteor Crater, an impact crater in Arizona. Figure 7 (a) is a vertical aerial photograph, and Figure 7 (b) is an oblique view.
    A. Describe the crater's general shape.

    B. Meteor Crater is one of the best preserved craters in the world. However, it has been eroded somewhat. List some evidence for this.

13. The meteor that impacted here was about 25m across. Measure the diameter of Meteor Crater. How many times bigger than the meteor is the crater?

14.
    A. Describe how the morphology of Meteor Crater is different from the volcanic landforms shown in Figures 1 and 2.

    B. How is it similar?

Figure 8: Roter Kamm crater, Namibia. This impact crater is 2.5 km across and formed more than one million years ago. North is to the top. (Photograph coutesy Robert Deitz; from meteoritics, vol. 2, pp. 311-314, 1965.)

15. Examine the view of Roter Kamm impact crater, Namibia, Figure 8.
    A. Describe its morphology.

    B. Compared to Meteor Crater, does it look fresh or eroded? Explain.

16.

A. How is Roter Kamm crater different from the volcanic landforms of Figures 1 and 2?

B. How do they look similar?

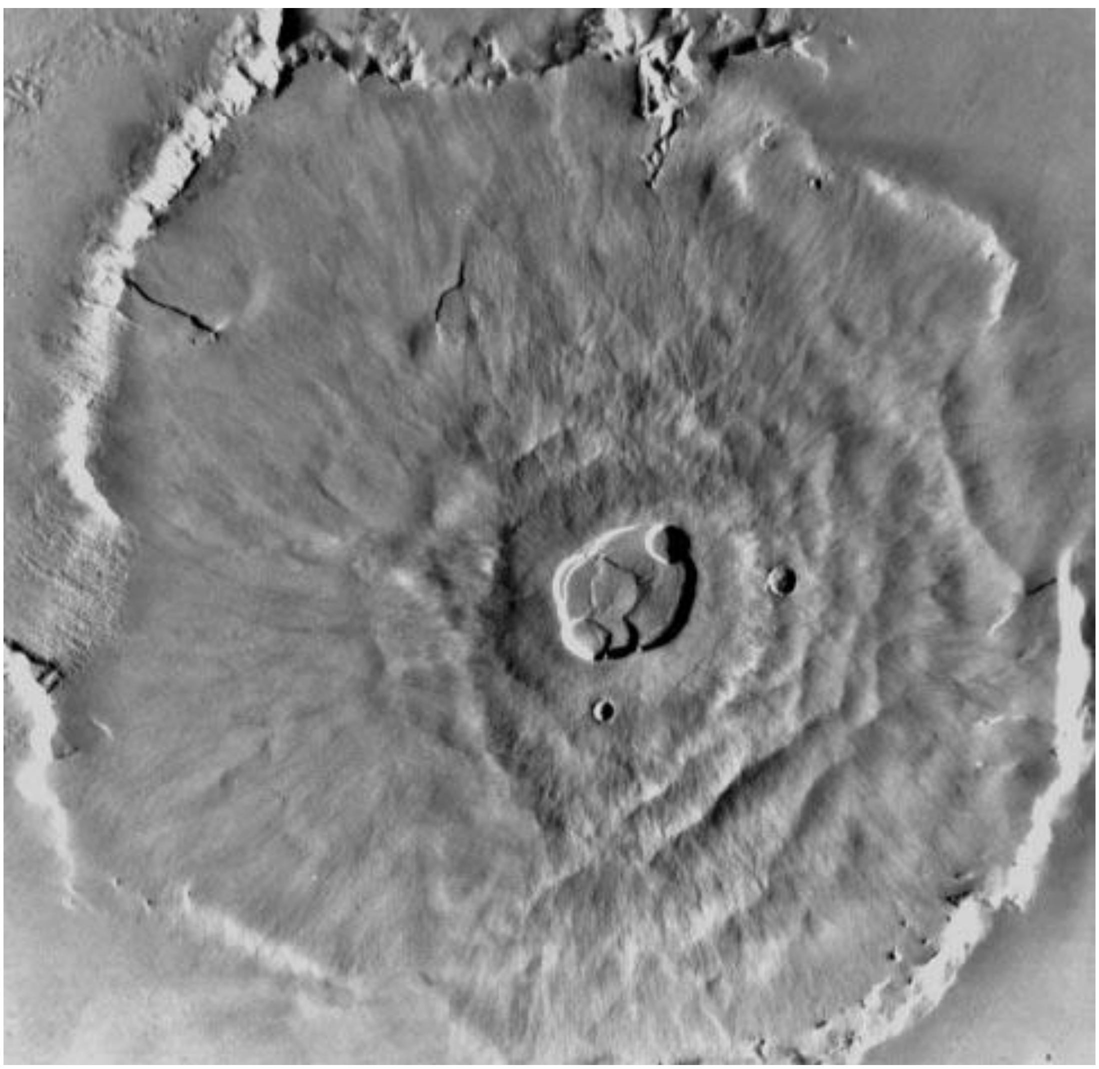


Figure 9: Martian shield volcano, Olympus Mons. The summit caldera is about 80 km in diameter. (Viking MDIM mosaic 211-5360)

17. Figure 9 show Olympus Mons, a shield volcano on Mars 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. Examine the caldera and describe its shape.

    B. How many times do you think Olympus Mons erupted? Why?

18. Examine figure 10: Valleys west of Chryse Planitia. Similar to some river systems on Earth, these maritian channels have a branching pattern.
    A. In what direction did the water flow?

    B. Are the craters you observe older of younger than the valleys? Why do you think so?

Figure 10: Valleys on western Chryse Planitia near the Viking Lander 1 site. The large crater at the top right is 28 km in diameter. North is to the lower left. (Viking mosaic P-17598.)

Figure 11: Appollinaris Patera and surrounding region of Mars centered at 10 S, 190 W. (Viking MDIM Volume 4.)

Examine Figure 11: 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 process that created them.

19. Compare Apollinaris Patera (marked A on Figure 11) to Olympus Mons (Figure 9). How are they similar, and how are they different?

20. What process do you think formed Apollinaris Patera? How can you tell?

21. What process do you think formed Reuyl crater (marked B on Figure 11)? Justify your answer.

22. 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?

23. 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.)

24. Based on your observations, what is the probably order of occurrence of A, B, C, and D in Figure 11 (i.e., which came first, second, third, last)? Give evidence for your answer.