1.5 hours

Geologic Landforms Seen on Aerial Photos

Instructor Notes

Suggested Correlation of Topics

Geomorphology, gradation, impact cratering, tectonism, volcanism, photography

Purpose

The objective of this exercise is to introduce students to landforms produced by the four major geologic processes using aerial photographs.

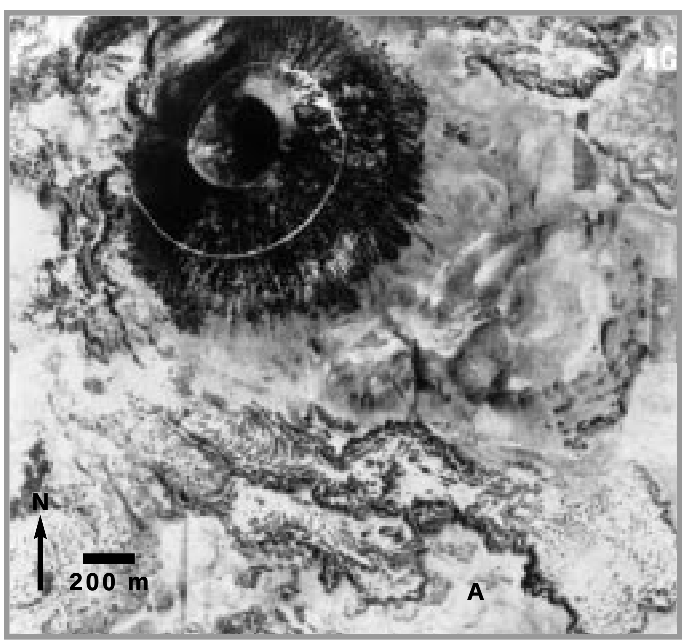
Materials

Ruler (metric)

Background

Geologic processes often result in distinctive landforms or surface features. For example, steep, conical hills with small summit craters are distinctive as volcanic in origin. Aerial photographs, commonly taken from airplanes, are used to study landforms on Earth. Depending on the camera used and the height of the airplane, areas shown in the photograph can range in size from a city block to an entire city. Aerial photographs are either “vertical” (viewed straight down on terrain from above) or “oblique” (viewed to the side).

In this exercise, students will study a series of aerial photographs of different terrains on Earth. In answering questions about the areas, they will become acquainted with landforms resulting from the four major geologic processes. Students should be introduced to these processes (gradation, impact cratering, tectonism, and volcanism) before beginning this exercise. A very brief statement about the four geologic processes is provided in the student section. Questions 2 and 6 require student knowledge of simple trigonometry.



Answer Key

1. **a.** The volcano has a circular base and a circular crater. The sides of the cone are gullied from erosion.

   b. A road.

2. **a.** ~564 m.

   b. 30.6°.

3. **a.** They are somewhat rugged.

   b. The source of the lava is probably at the base of the cinder cone near the road.

4. **a.** They are both generally conical in shape, with a central depression at the top.

   b. Mt. Tavurur is much larger, and its crater is more irregular.

5. The crater is scalloped, suggesting that it has been reshaped several times by multiple eruptions.

6. x=~446 m, 27.7°.

7. The slopes of a volcano may be affected by the following: Single versus multiple eruptions, type of material (ash versus lava), viscosity ("runnyness") of the lava (dependent on its temperature and composition), length of lava flows, erosion by wind or rain after volcano is formed.

8. It cuts through the mountains and is expressed as a depression or trough. The rocks along the fault were ground together and weakened, so that they were more easily eroded than the rocks away from the fault.

9. **a.** A road would have been cut and separated.

   b. There are at least two off-set features (drainage valleys) along the fault: near the middle of the photo, and near the bottom of the photo (harder to see the offset) .

10. Blocks A and C must move apart in the horizontal plane (← →). The area is undergoing extensional stresses.

11. **a.** The alluvium is material eroded from the mountains.

    b. All three erosional agents have acted to produce materials eroded from the mountains, but water was the main agent.

    c. All three agents, but mostly water.

    d. It would be eroded by the agents of wind, water, and gravity. For example, sand dunes are visible alongside the fans, evidence of erosion by the wind.

12. **a.** It removes material from its banks, and carries material from one place to another. It deposits material to form sandbars (erosion, transportation, deposition).

    b. The channels change position with time. Dry and semi-dry (ponds present) channels are visible in the foreground of the photo.

13. **a.** It is roughly circular, with squared sides.

    b. The walls are gullied, indicating erosion by running water. The flat bottom suggests it has been infilled.

14. About 48 times. (Crater diameter is about 1200 m.)

15. **a.** Meteor Crater is much wider and the sides are not as steep. Impact craters excavate (occur at ground level and dig out below ground level), volcanic cones and craters are built up above ground level (positive relief features).

    b. They have the same circular shape and have a crater in the center.

16. **a.** Circular. Somewhat subdued appearance: the rim appears worn, and not very distinct. The center of the crater seems to have been partly filled in with sediment and sand dunes.

    b. Meteor Crater appears to be more distinct and deeper than Roter Kamm.

17. **a.** The crater is much wider and not nearly as high or steep.

    b. They are both very circular and have raised rims.

18. **a.** River valley—gradation

    b. Graben—tectonism (rivers are flowing into this graben)

    c. Lava flow—volcanism

    d. Cinder cone—volcanism

    e. Lava flow—volcanism

    f. Lava flow in a pre-existing river valley—gradation, followed by volcanism

Answer Key, continued

g. Graben—tectonism (lava flows have entered parts of this graben)

19. Near letter G, volcanic material flowed into the pre-existing graben valley in two separate places. The flow spread out in a fan shape.

20. _3_ River and stream valleys formed

_5_ dark (black) volcanic materials were deposited

_4_ medium gray volcanic flows were deposited

_1_ light gray plains formed

_2_ tectonism produced grabens

21. On Earth they have been obliterated by tectonic processes and agents of gradation (wind and

Name ______________________________

Geologic Landforms Seen on Aerial Photos

Purpose

By studying aerial photographs you will learn to identify different kinds of geologic features, tell how they differ from one another, and learn the processes involved in their formation.

Materials

Ruler (metric)

Introduction

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, or its **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 recognize landforms and the geological processes that formed them. These processes act on other planets, where they can generate similar landforms.

Questions

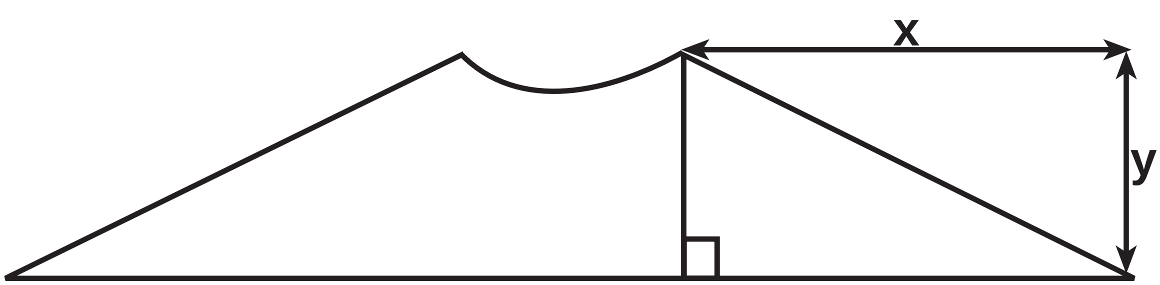
Volcanism

1. Examine the **cinder cone** of Mount Capulin, New Mexico, shown in Figure 2.1. The depression at its summit is referred to as a volcanic crater.

   a. Describe the general shape of the cone and the volcanic crater at the top.

   b. What is the white spiral line from the base of the cone to the crater rim?

   Based on the elevation of Mt. Capulin (334m) and the information provided by the aerial photo, the slope of the volcano's sides can be calculated. This simple sketch of Mt. Capulin will help.



2. **a.** Using your ruler and the scale bar on Figure 2.1, 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.

Examine the lava flow labeled A.

3. **a.** Does its surface appear rugged or smooth?

   b. Trace the flow back to its point of origin. Where is the probable source of the flow?

Study Mt. Tavurur volcano, New Guinea, in Figure 2.2.

4. **a.** How is the volcano similar to Mt. Capulin?

   b. How is it different?

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

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.

Sketch area

7. List some factors that might affect the slope of a volcano.

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 2.3, an oblique view of the San Andreas fault (arrow). 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.

8. In what way does the fault affect the morphology of the mountains in this photo?

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**.

9. **a.** What would have happened if the line on the paper was actually a road crossing a fault?

   b. Are there any features like this in Figure 2.3?

One landform distinctive to tectonism is called a **graben** (see Figure 2.4). 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.

10. For block B to have enough space to move down, what has to occur to blocks A and C in Figure 2.4?

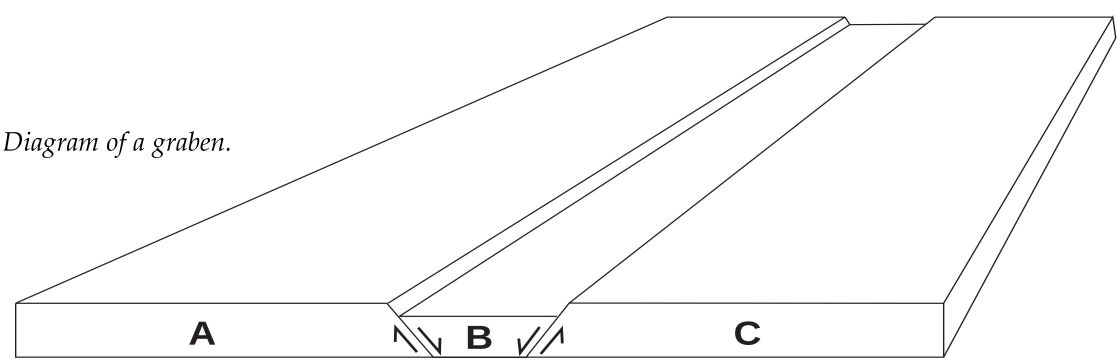


Figure 2.4. *Diagram of a graben.*

Gradation

Figure 2.5 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.

11. **a.** What is the source of the alluvium that makes up the fans?

    b. Which agents of erosion (wind, water, and/or gravity) might have generated the alluvium?

    c. Which agent(s) deposited it?

    d. Once deposited, how might the alluvium be further eroded?

Figure 2.6 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.

12. **a.** How 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?

Impact Craters

Examine the photographs of Meteor Crater, an impact crater in Arizona. Figure 2.7 (a) is a vertical aerial photograph, and Figure 2.7 (b) is an oblique view.

13. **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.

14. 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?

15. **a.** Describe how the morphology of Meteor Crater is different from the volcanic landforms shown in Figures 2.1 and 2.2.

b. How is it similar?

Examine the view of Roter Kamm impact crater, Namibia, Figure 2.8.

16. **a.** Describe its morphology?

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

17. **a.** How is Roter Kamm crater different from the volcanic landforms of Figures 2.1 and 2.2?

    b. How do they look similar?

Synthesis

Different processes produce landforms that are different in morphology. Linear, straight features are generally tectonic in origin. More sinuous features (such as river valleys) are typically formed by gradational processes. Volcanism forms flows in irregular patches and cones.

A part of central Arizona is shown in Figure 2.9. Represented here are landforms shaped by three of the four principal geologic processes. For each labeled landform, identify its type and the process that formed it.

18. A.

    B.

    C.

    D.

    E.

    F.

    G.

19. Identify a place in the photograph where a pre-existing graben has affected the morphology of a later volcanic flow. Sketch what you see, and describe in words what happened. (Use the sketch area on the next page.)

Sketch area

20. Determine the sequence of events that affected this region. Order the events below from first occurring (1) to most recent (5).

___ river and stream valleys formed

___ dark (black) volcanic materials were deposited

___ medium gray volcanic flows were deposited

___ light gray plains formed

___ tectonism produced grabens

21. Large impacting objects such as asteroids have rarely fallen to Earth in the last few million years, but billions of years ago they were very common. Assuming that throughout the geologic history of Earth, as many impacts have occurred as on the Moon, then why do we see so few craters on the Earth today, while so many remain visible on the Moon?

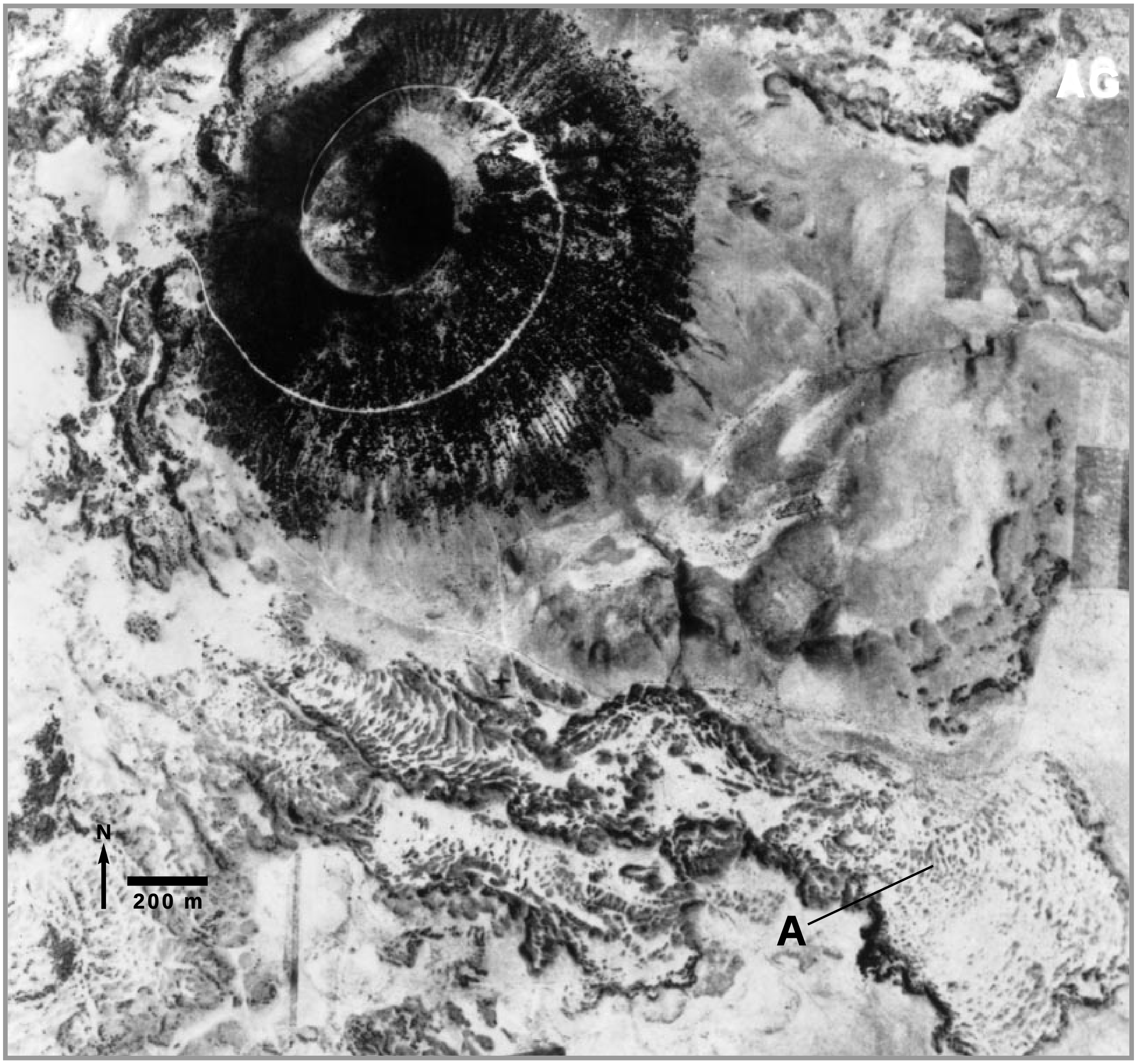


Figure 2.1. *Mount Capulin, New Mexico; vertical aerial photograph. (University of Illinois Catalog of Stereogram Aerial Photographs #105.)*

Figure 2.2. *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 Photographs, #102.)*

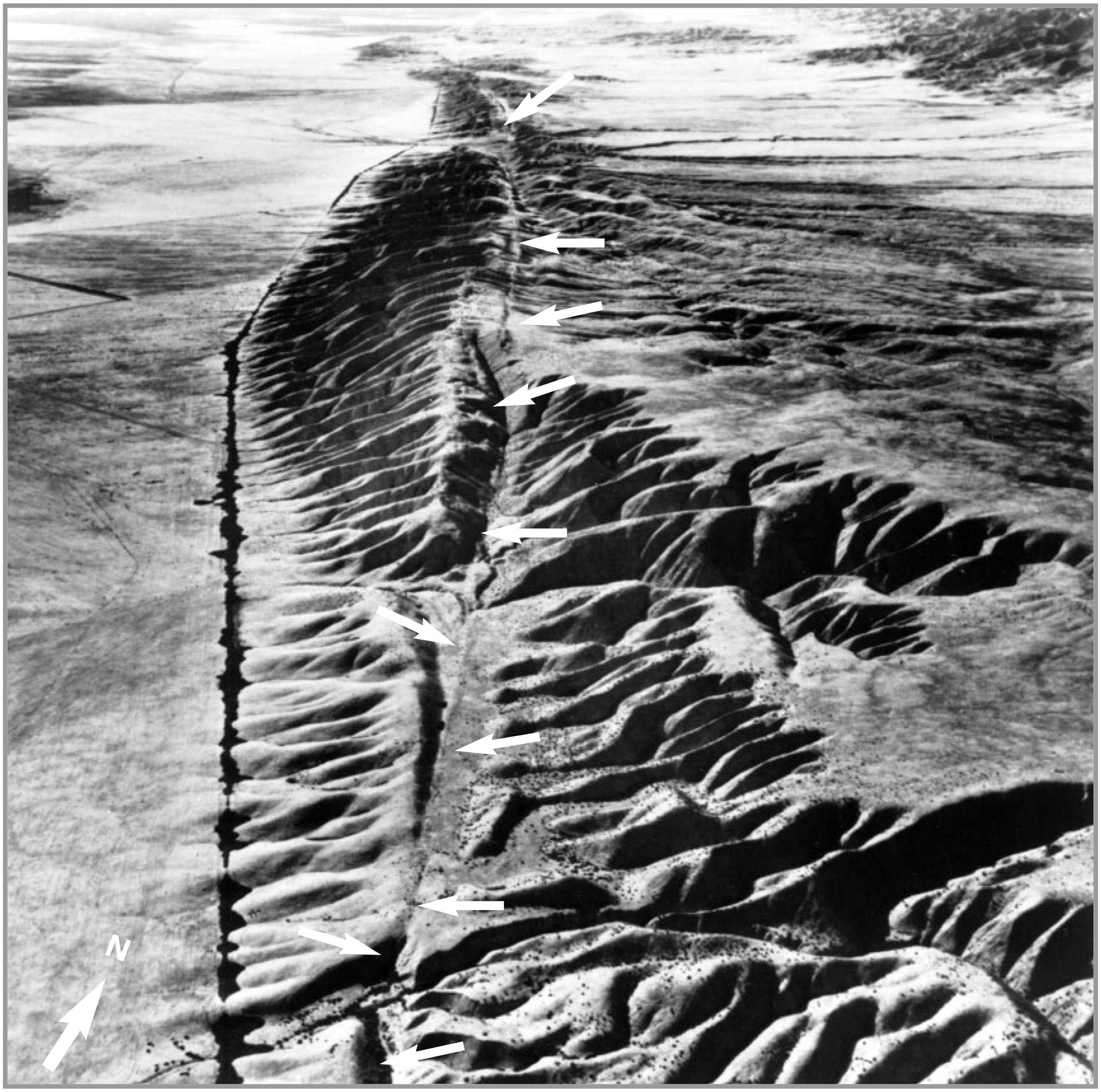


Figure 2.3. *Oblique aerial view of a part of the San Andreas fault north of Los Angeles. North is to the top right. The foreground is approximately 3.5 km across. (photograph by Robert E. Wallace, U.S. Geological Survey).*

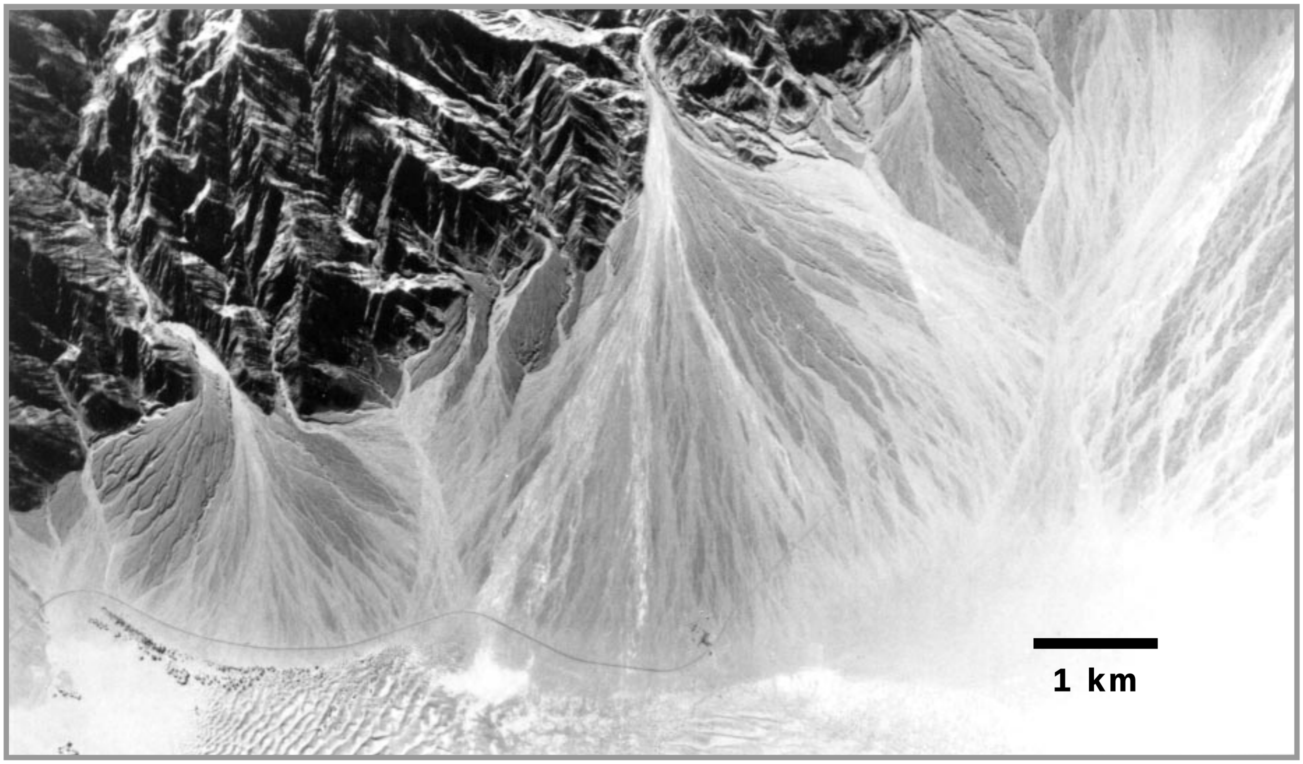
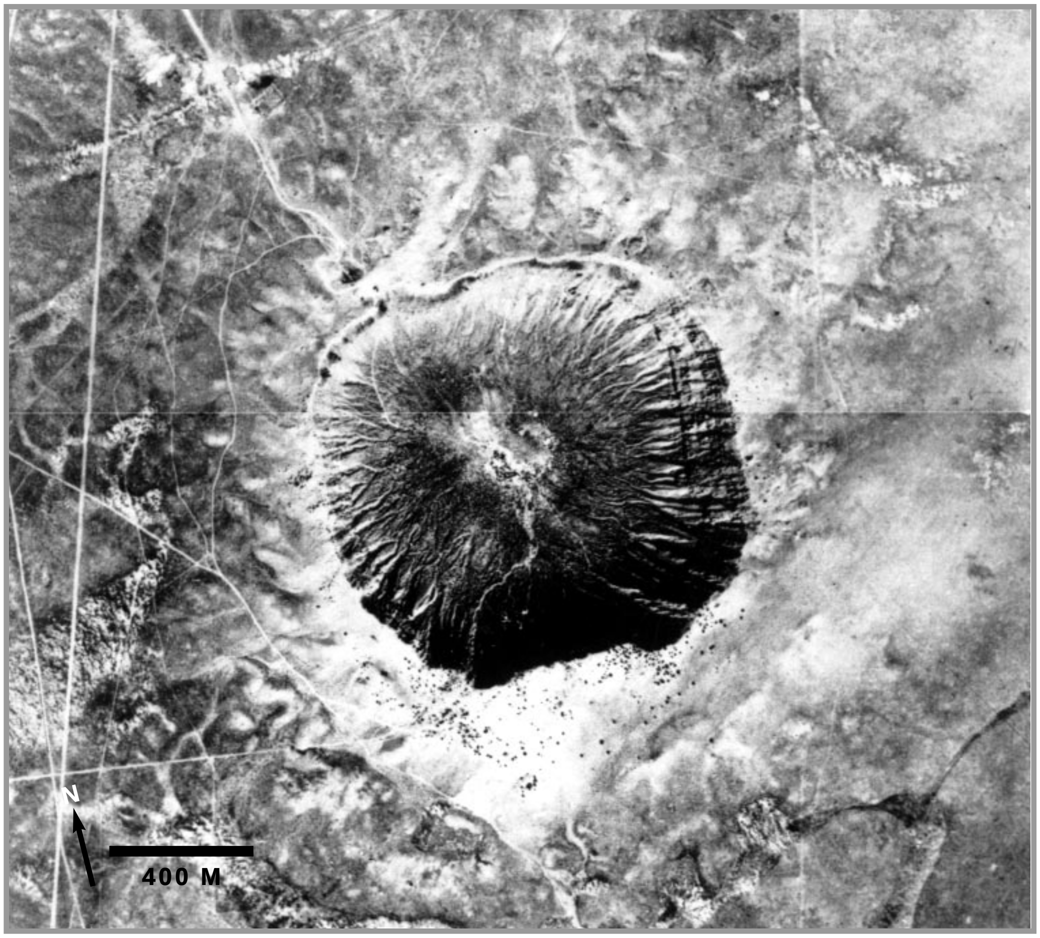
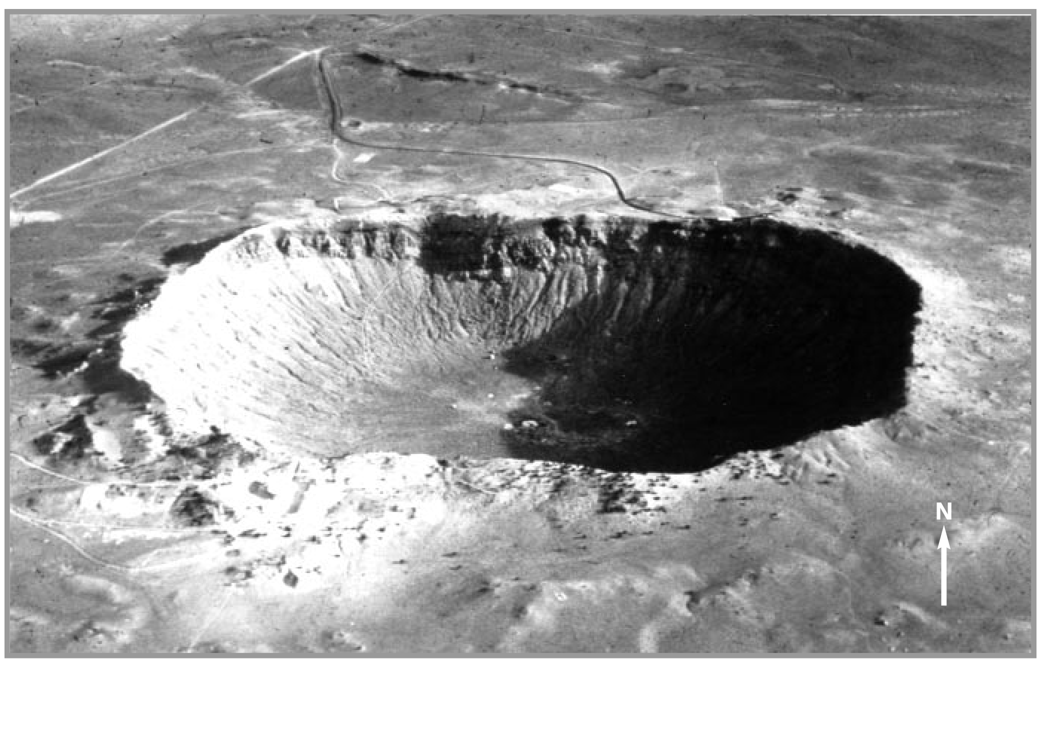


Figure 2.5. Vertical view of alluvial fans near Stovepipe Wells, Death Valley, California. Panamint mountains lie to the south. North is to the bottom left. (University Of Illinois Catalog of Stereogram Aerial Photographs, #125).

Figure 2.6. The Delta River, a braided stream in central Alaska. North is to the top. (U.S. Navy photograph courtesy of T. L. Péwé, Arizona State University).





Figures 2.7.a., 2.7.b. *Meteor Crater, Arizona: (a) vertical view, (b) oblique view. One of the best preserved meteor impact craters in the world, Meteor Crater was formed about 20,000 years ago. North is to the top. (a, University of Illinois Catalog of Stereogram Aerial Photographs, #5; b, Photograph courtesy U.S. Geological Survey.)*

Figure 2.8. *Roter Kamm crater, Namibia. This impact crater is 2.5km across and formed more than one million years ago. North is to the top. (Photograph courtesy Robert Deitz; from Meteoritics, vol. 2, pp. 311-314, 1965.)*

Figure 2.9. Mosaic of Landsat frames showing north-central Arizona. North is to the top.