EXERCISE 5

Shaping Earth's Surface
Arid and Glacial Landscapes

The previous exercise explored the hydrologic cycle and the role of running water and groundwater in shaping the landscape in humid regions. However, when taken together, the dry regions of the world and those areas whose surfaces have been modified by glacial ice also comprise a significant portion of Earth's surface (Figure 5.1). Since desert or near-desert conditions and glaciated regions prevail over a large area of Earth, an understanding of the landforms and processes that shaped these regions is essential to the Earth scientist.

Figure 5.1 Glacial striations in bedrock, Yellowknife, Canada NWT. (Photo courtesy of Dr. Richard Waller, Keele University, UK)

Objectives

After you have completed this exercise, you should be able to:

1. Locate the desert and steppe regions of North America.
2. Describe the evolution of the landforms that exist in the mountainous desert areas of the Basin and Range region of the western United States.
3. Describe the different types of glacial deposits and the features they compose.
4. Identify and explain the formation of the features commonly found in areas where the landforms are the result of deposition by continental ice sheets.
5. Describe the evolution and appearance of a glaciated mountainous area.
6. Identify and explain the formation of the features caused by alpine glaciation.

Materials

calculator ruler hand lens

Materials Supplied by Your Instructor

stereoscope string

Terms

desert
steppe
flash flood
Basin and Range
fault-block mountains
alluvial fan
bajada
playa lake
inselberg
pediment
alpine glacier
continental ice sheet
drift
till
stratified drift
moraine
Pleistocene epoch
arête
cirque
horn
hanging valley

Desert Landscapes

Arid **(desert)** and semiarid **(steppe)** climates cover about 30 percent of Earth's land area (Figure 5.2). At first glance, many desert landscapes with their angular hills and steep canyon walls may appear to have been shaped by processes other than those that are responsible for landforms in regions with an abundance of water. However, as striking as the contrasts may be, running water is still the dominant agent responsible for most of the erosional work in deserts. Wind erosion, although more significant in dry areas than elsewhere, is only of secondary importance.

The distinct effects that running water has on humid and dry areas are the result of the same processes operating under different climatic conditions. Precipitation in the dry climates is minimal, often sporadic, and frequently comes in the form of torrential downpours that last only a short time. Consequently, in desert areas **flash floods** occur, and few streams or rivers reach the sea because the water often evaporates and infiltrates into the ground.

Evolution of a Mountainous Desert Landscape

Mountainous desert landscapes have developed in response to a variety of geologic processes. A classic region for studying the effects of running water in dry areas is the western United States. Throughout much of this **Basin and Range** region, which includes southeastern California, Nevada, western Utah, southern Oregon, southern Arizona and New Mexico, the erosion of mountain ranges and subsequent deposition of sediment in adjoining basins have produced a landscape characterized by several unique landforms (Figure 5.3).

In a large area of the Basin and Range region of the western United States **fault-block mountains** have formed as large blocks of Earth's crust have been forced upward (Figure 5.3A). The infrequent and intermittent precipitation in this desert region typically results in streams that carry their eroded material from the mountains into interior basins. **Alluvial fans** and **bajadas** often form as streams deposit sediment on the less steep slopes at the base of the mountains (Figure 5.3B). On rare occasions when streams flow across the alluvial fans, a shallow **playa lake** may develop near the center of a basin.

Continuing erosion in the mountains and deposition in the basins may eventually fill the basin and only isolated peaks, called **inselbergs**, surrounded by gently sloping sediment, remain. As the front of the mountain is worn back by erosion, a broad, sloping bedrock surface called a **pediment**, covered by a thin layer of sediment, often forms at its base (Figure 5.3C). In the final stages, even the inselbergs will disappear, and all that remains is a nearly flat, sediment-covered surface underlain by the erosional remnants of mountains.

Use Figure 5.2 to answer questions 1 and 2.

1. Where are the desert and steppe regions of North America located?

   Desert: _____

   Steppe: _____

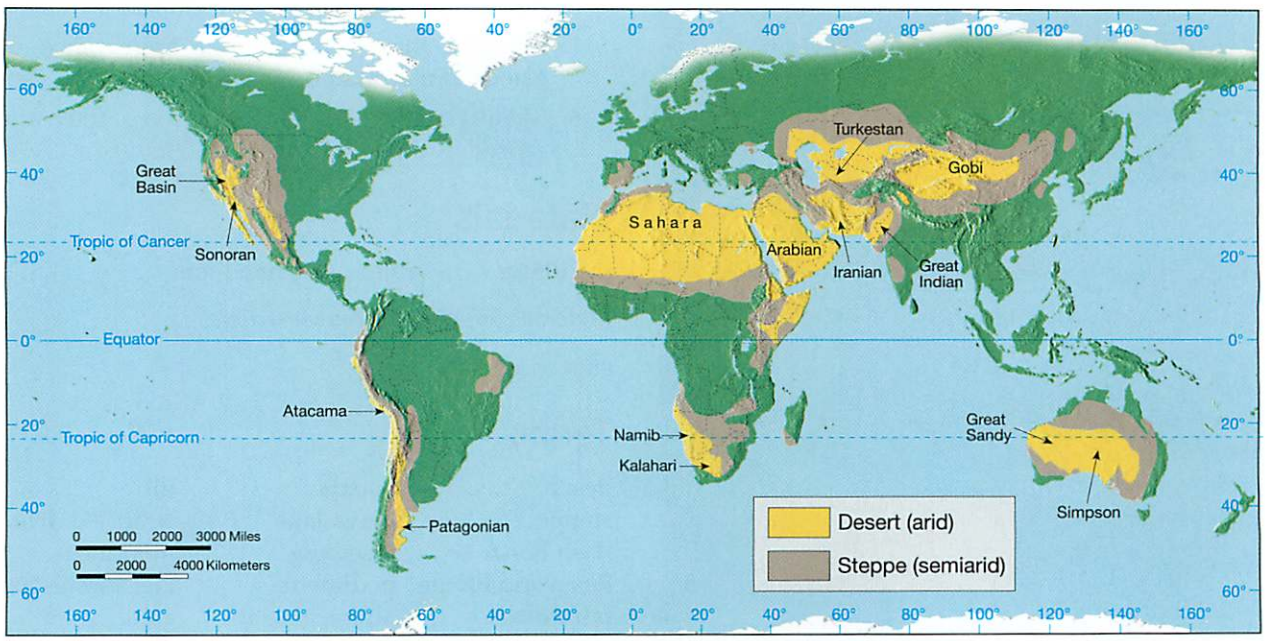


Figure 5.2 Global arid and semiarid climates cover about 30% of Earth's land surface. No other climate group covers so large an area. Low-latitude dry climates are the result of the global distribution of air pressure and winds. Middle-latitude deserts and steppes exist principally because they are sheltered in the deep interiors of large landmasses.

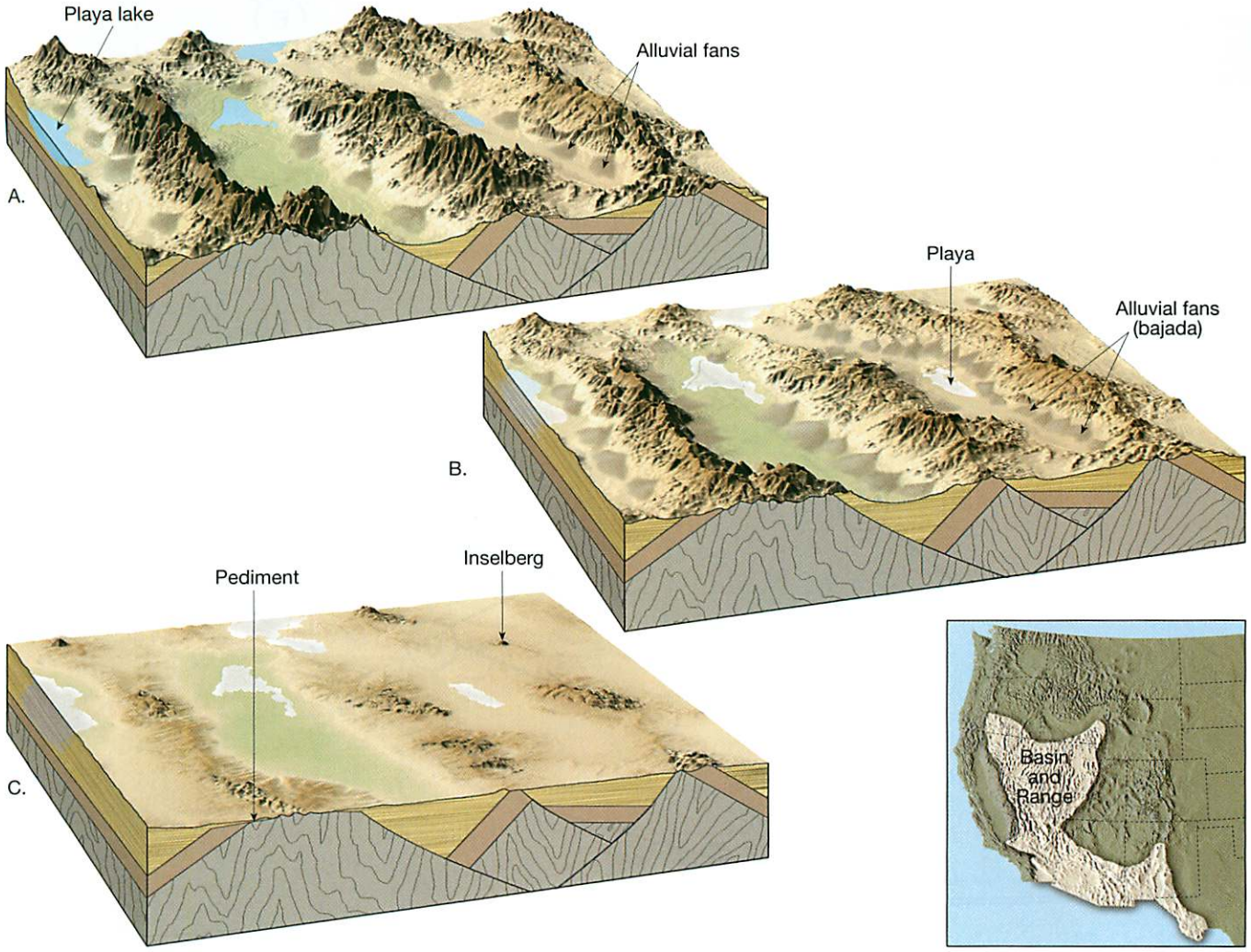


Figure 5.3 Stages of landscape evolution in a block-faulted, mountainous desert such as the Basin and Range region of the West. **A.** Early stage; **B.** Middle stage; **C.** Late stage.

2. Using an "X" to mark your selection(s), indicate which of the following statements are commonly held misconceptions concerning the world's dry lands.

_____ The world's dry lands are always hot.

_____ Desert landscapes are almost completely covered with sand dunes.

_____ The dry regions of the world encompass about 30 percent of Earth's land surface.

_____ Dry lands are practically all lifeless.

Figure 5.4 is a portion of the Antelope Peak, Arizona, topographic map that illustrates many of the features of the mountainous desert landscapes found in the western United States. Use the map and accompanying stereogram of the area (Figure 5.5) to answer questions 3–13. You may find the diagrams in Figure 5.3 helpful.

3. On the map, outline the area that is illustrated in the stereogram.

Use a stereoscope to examine the stereogram, Figure 5.5.

4. The vegetation in the area is (dense, sparse), and there are (few, many) dry stream courses. Circle your answers.
5. By examining the map, determine the total relief of the map area.

   Total relief = _____ ft
6. (Continuously flowing, Intermittent) streams dominate the area shown on the map. Circle your answer.
7. On the map, of the two lines, A or B (A, B), follows the steepest slope. Circle your answer.
8. By drawing arrows on the map, indicate the directions that intermittent streams will flow as they leave the mountains.

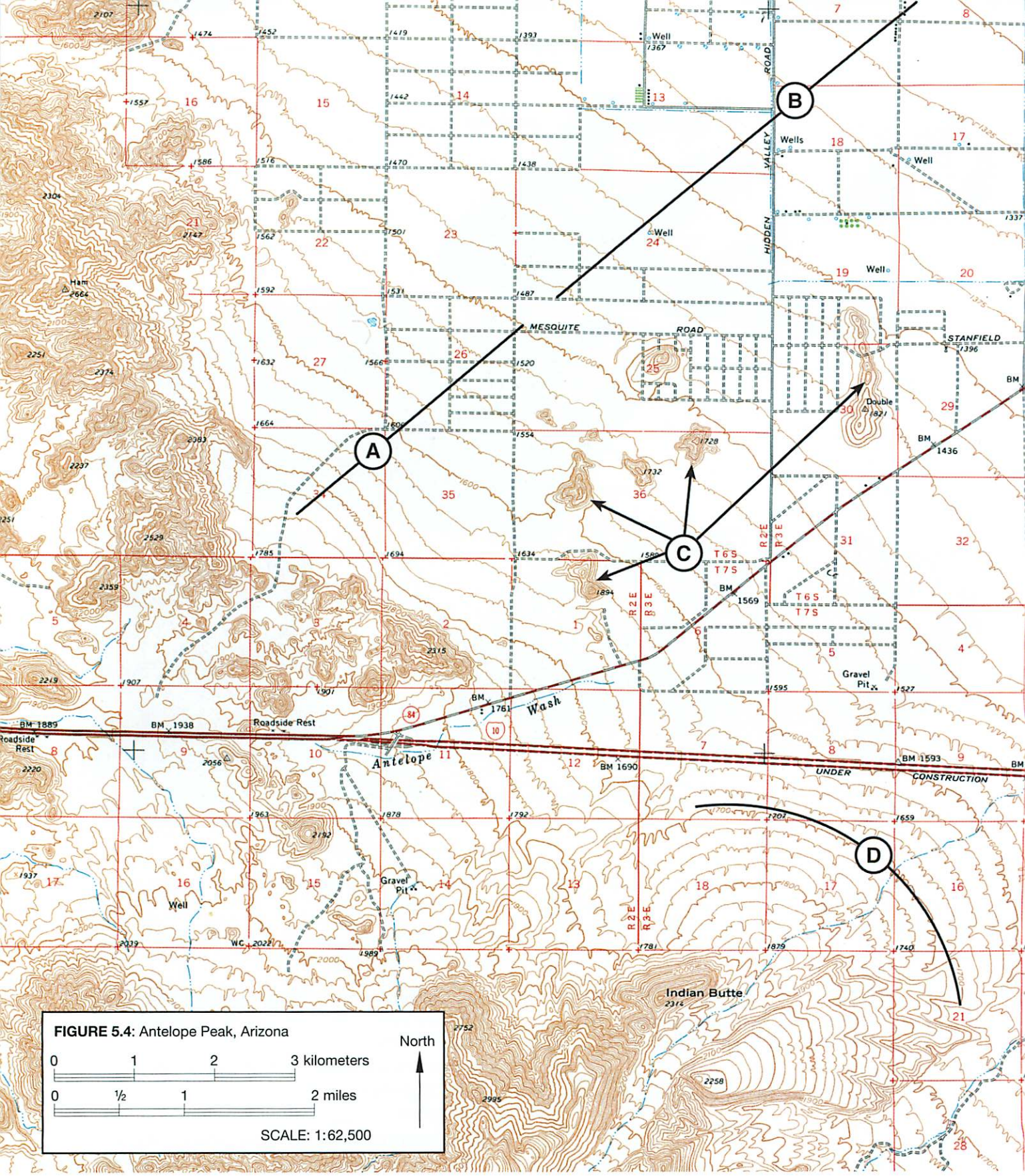


Figure 5.4 Portion of the Antelope Peak, Arizona, topographic map.
(Map source: United States Department of the Interior, Geological Survey)

CONTOUR INTERVAL 25 FEET
DATUM IS MEAN SEA LEVEL

QUADRANGLE LOCATION

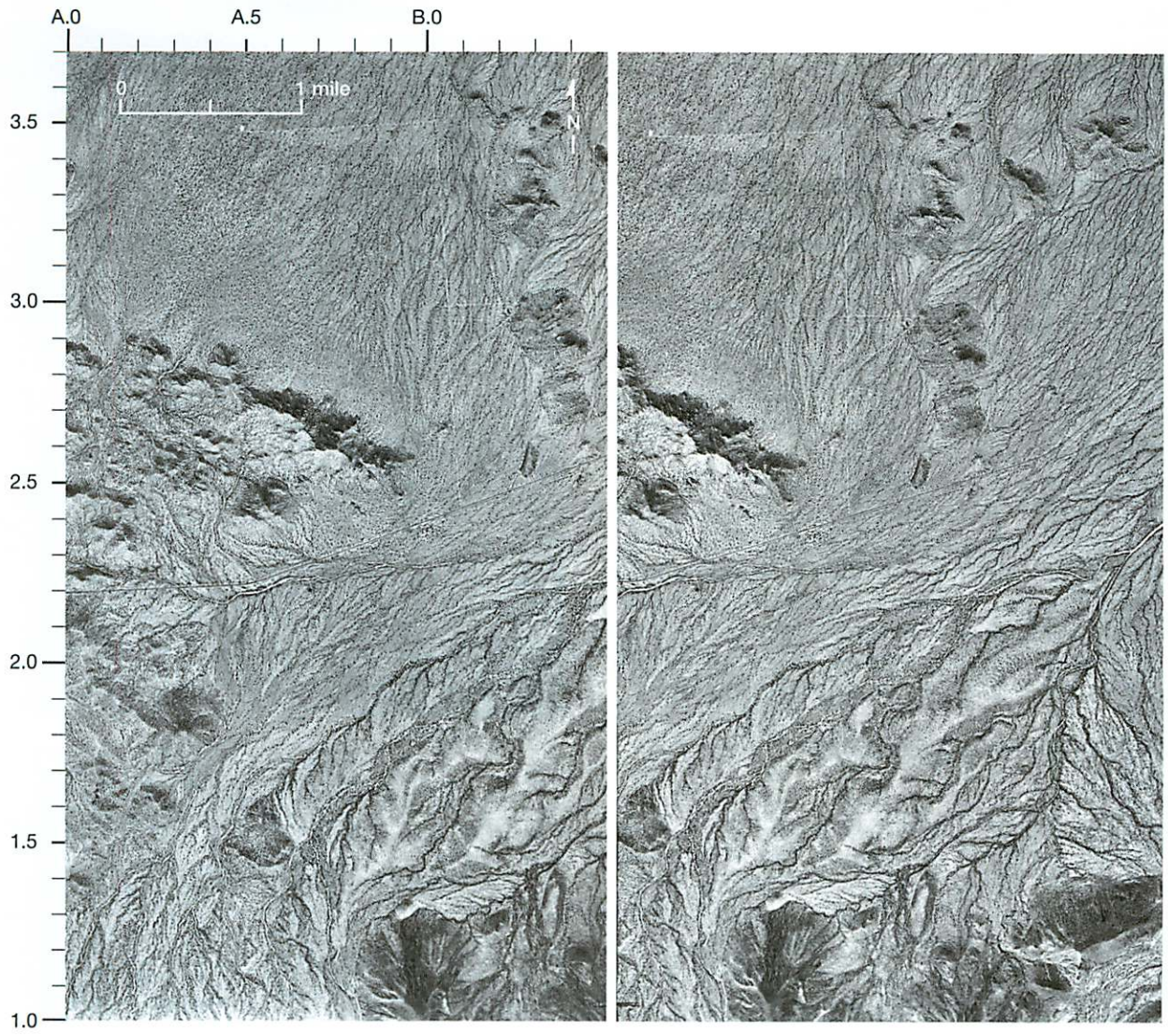


Figure 5.5 Stereogram of the Antelope Peak, Arizona, area. (Courtesy of the U.S. Geological Survey)

9. Where on the map is the most likely place that surface water may accumulate? Label the area "possible lake."

10. Identify the features indicated on the map at the following letters and briefly describe how each formed.

Letter C: _____

_____

Letter D: _____

_____

The area at letter A on the map is a bedrock surface covered by a thin layer of sediment.

11. The feature labeled A is called a(n) _____.

12. Briefly describe how the Antelope Peak area may have looked millions of years ago.

_____

_____

_____

13. Assume that erosion continues in the area without interruption. How might the area look millions of years from now?

_____

_____

_____

Glacial Landscapes

Slightly more than 2% of the world's water is in the form of glacial ice that covers nearly 10% of Earth's land area. However, to an Earth scientist, glaciers represent more than storehouses of fresh water in the hydrologic cycle. Like the other agents that modify the surface, glaciers are dynamic forces capable of eroding, transporting, and depositing sediment.

Literally thousands of glaciers exist on Earth today. They occur in regions where, over long periods of time, the yearly snowfall has exceeded the quantity lost by melting or evaporation. **Alpine**, or **valley, glaciers** form from snow and ice at high altitudes. At high latitudes, enormous **continental ice sheets** cover much of Greenland and Antarctica.

Glacial erosion and deposition leave an unmistakable imprint on Earth's surface. In regions once covered by continental ice sheets, glacially scoured surfaces and subdued terrain dominated by glacial deposits are the rule (see Figure 5.1). By contrast, erosion by alpine glaciers in mountainous areas tends to accentuate the irregularity of the topography, often resulting in spectacular scenery characterized by sharp, angular features.

Glacial Deposits and Depositional Features

The general term **drift** applies to all sediments of glacial origin, no matter how, where, or in what form they were deposited. There are two types of glacial drift: (1) **till**, which is characteristically unsorted sediment deposited directly by the glacier (Figure 5.6), and (2) **stratified drift**, which is material that has been sorted and deposited by glacial meltwater.

The most widespread depositional features of glaciers are **moraines**, which are ridges of till that form along the edges of glaciers and layers of till that accumulate on the ground as the ice melts and recedes. There are several types of moraines, some common only to alpine glaciers, as well as other kinds of glacial depositional features.

Figure 5.7 illustrates a hypothetical retreating glacier. Use Figure 5.7 to answer questions 14–16.

14. Draw a large arrow on Figure 5.7 that indicates the direction of glacial ice movement in the area. Label the arrow "ice flow."
15. On Figure 5.7, label an example of a terminal moraine, recessional moraine, and ground moraine.

Features of Continental Ice Sheets

During a division of Earth's history called the **Pleistocene epoch**, continental ice sheets, as well as alpine glaciers, were considerably more extensive over Earth's surface than they are today. At one time, these thick sheets of ice covered all of Canada, portions of

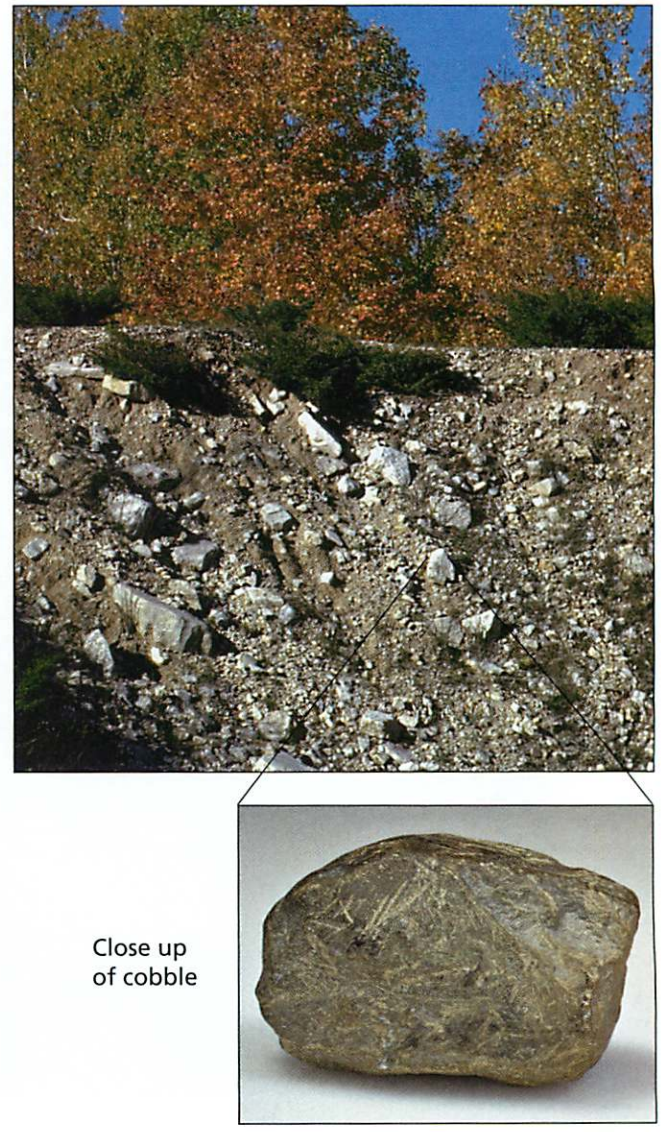


Figure 5.6 Glacial till is an unsorted mixture of many different sediment sizes. A close examination often reveals cobbles that have been scratched as they were dragged along by the glacier. (Photos by E. J. Tarbuck)

Alaska, and much of the northern United States as well as extensive areas of northern Europe and Asia (Figure 5.8). Today, the impact that these ice sheets had on the landscape is still very obvious.

Use Figure 5.8 as a reference to answer question 16.

16. By listing state abbreviations, indicate the geographic area of the continental United States that Pleistocene glaciers covered during their maximum extent.

While alpine glaciers change the shape of the land surface primarily by erosion, landforms produced by

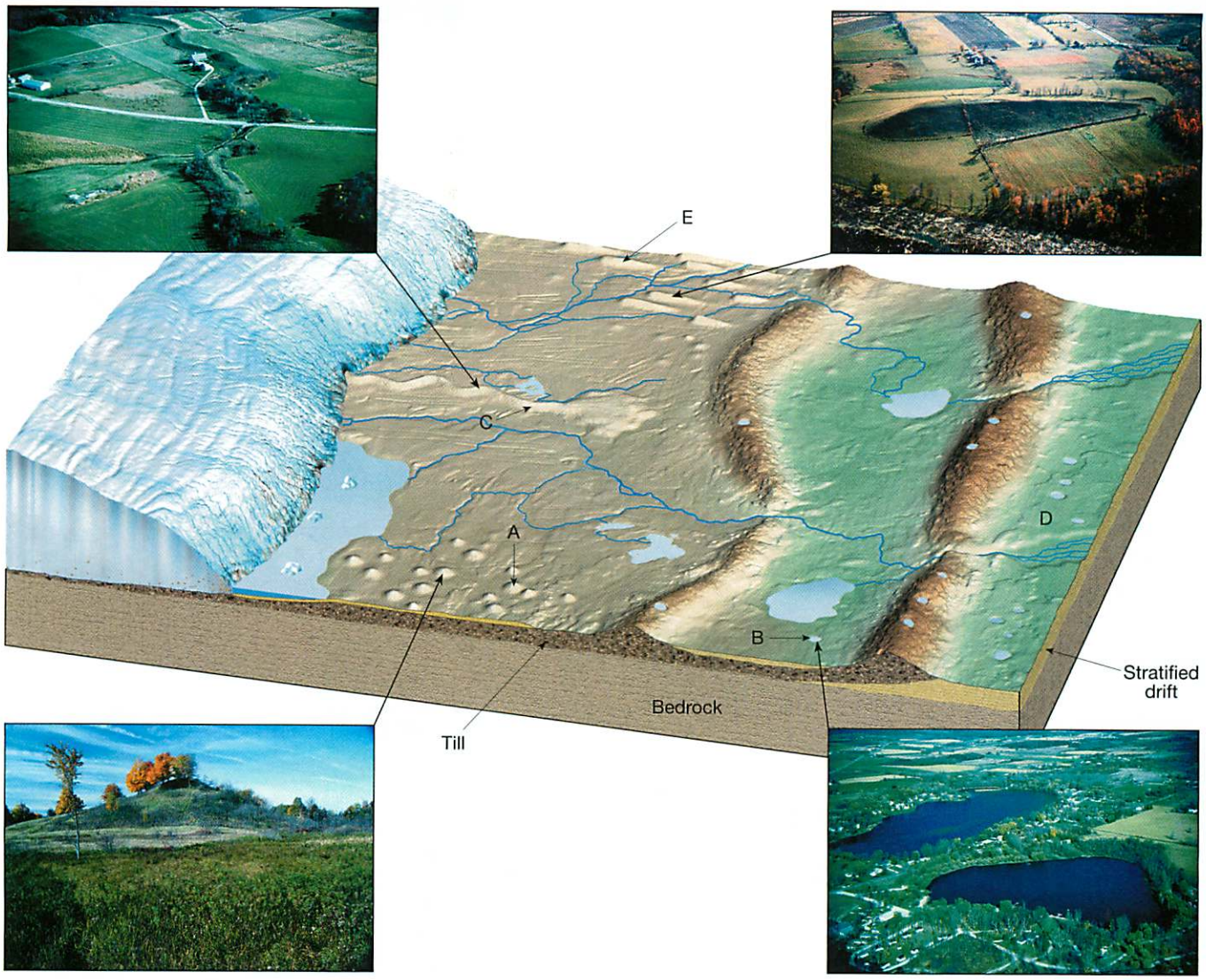


Figure 5.7 Characteristic depositional features of glaciers. (Drumlin photo courtesy of Ward's Natural Science Establishment; Kame, Esker, and Kettle photos by Richard P. Jacobs/JLM Visuals)

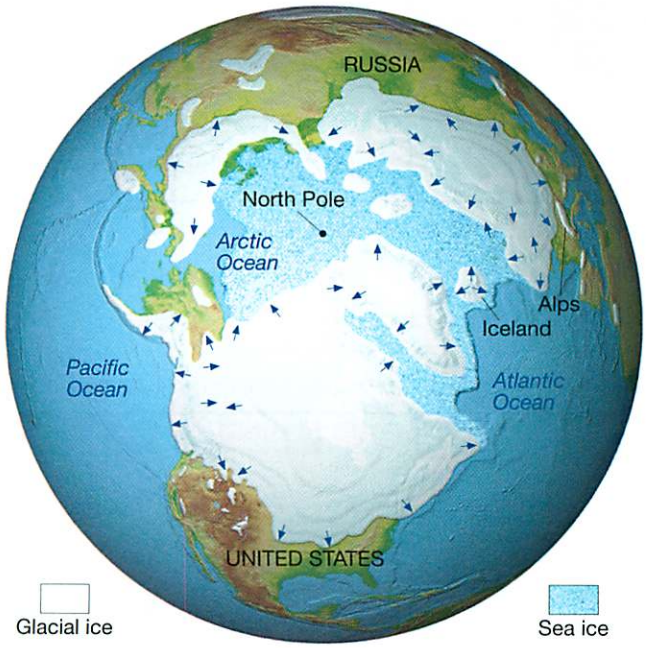


Figure 5.8 Maximum extent of glaciation in the Northern Hemisphere during the Pleistocene epoch.

Figure 5.9 Portion of the Whitewater, Wisconsin, topographic map. (Map source: United States Department of the Interior, Geological Survey)

continental ice sheets, especially those that covered portions of the United States during the Pleistocene epoch, are essentially depositional in origin. Some of the most extensive areas of glacial deposition occurred in the north-central United States. Here, glacial drift covers the surface and landscapes are dominated by moraines, outwash plains, kettles, and other depositional features.

17. Briefly describe each of the following glacial depositional features and select the letter on Figure 5.7 that indicates an example of each.

Drumlin: _____

_____ Letter: _____

Esker: _____

_____ Letter: _____

Kame: _____

_____ Letter: _____

Kettle: _____

_____ Letter: _____

Outwash plain: _____

_____ Letter: _____

Figure 5.9 is a portion of the Whitewater, Wisconsin, topographic map, which illustrates many of the depositional features that are typical of continental glaciation. Use the map and the accompanying stereogram of the area (Figure 5.10) to answer questions 18–30.

18. After examining the map and stereogram, draw a line on the map that outlines the area illustrated on the photograph.

19. The general topography of the land in the southeast quarter of the region is (higher, lower) in elevation and (more, less) irregular than the land in the northwest. Circle your answers.

20. What features on the map indicate that portions of the area are poorly drained? Where are these features located?

_____

_____

Figure 5.10 Stereogram of the Whitewater, Wisconsin, area. (Courtesy of the U.S. Geological Survey)

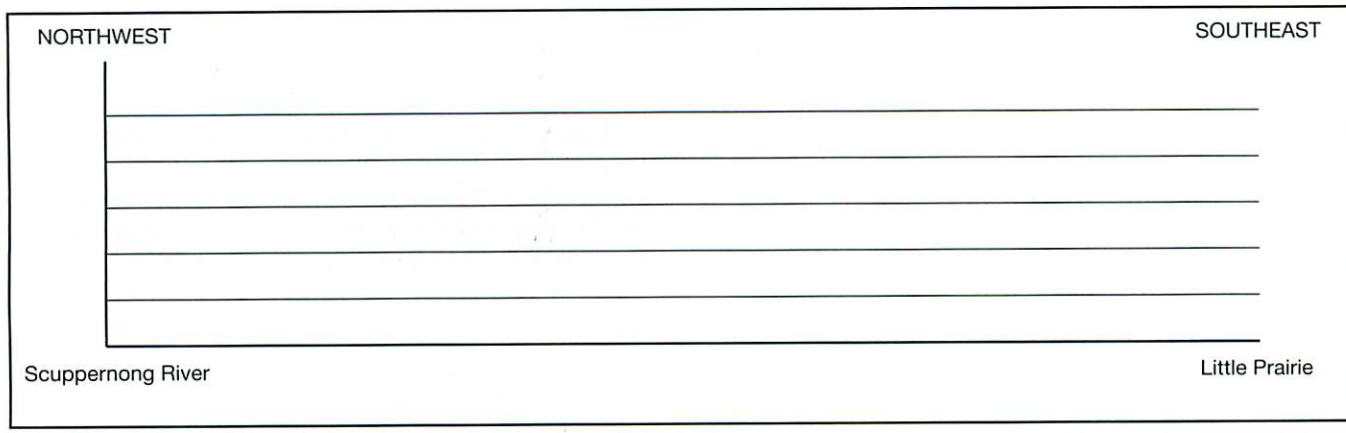


Figure 5.11 Northwest–southeast topographic profile of the Whitewater map.

Examine the elevations of the feature indicated with the letter As on the map that, in general, coincides with Kettle Moraine State Forest. Compare the elevations to those found to the northwest and southeast of the feature.

21. In Figure 5.11, sketch a northwest–southeast topographic profile along a line that extends from the Scuppernong River to near the city of Little Prairie. Indicate the appropriate elevations on the vertical axis of the profile.
22. The area that coincides with Kettle Moraine State Forest is (higher, lower) in elevation than the land to the northwest and southeast. Circle your answer.
23. The feature labeled with As on the map is a long ridge composed of till called a (kettle, moraine, drumlin). Circle your answer.
24. The streamlined, asymmetrical hills composed of till, labeled B, are what type of feature?

    _____

25. Examine the shape of the features labeled B on the map and in Figure 5.7. How can the features be used to determine the direction of ice flow in a glaciated area?

    _____

26. Use the features labeled B as a guide to draw an arrow on the map that indicates the direction of ice flow in the region.
27. Where on the map is the likely location of the outwash plain? Identify and label the area "outwash plain."

    _____

28. Identify and label the ground moraine area on the map.
29. What term is applied to the numerous almost circular depressions designated with the letter Cs on the map?

    _____

30. What is the probable origin of the material that is being mined in the gravel pits north and northeast of Palmyra?

    _____

    _____

    _____

Features of Alpine or Valley Glaciation

As they flow, alpine glaciers often exaggerate the already irregular topography of a region by eroding the mountain slopes and deepening the valleys. Figure 5.12 illustrates the changes that a formerly unglaciated mountainous area (Figure 5.12A) experiences as the result of alpine glaciation. Many of the landforms produced by glacial erosion, such as **arête, cirques, horns,** and **hanging valleys** (Figure 5.13), are identified in Figure 5.12C.

Questions 31–33 refer to Figure 5.12.

31. How has glaciation changed the shape and depth of the main valley?

    _____

    _____

Prior to glaciation, tributary streams were adjusted to the depth of the main valley.

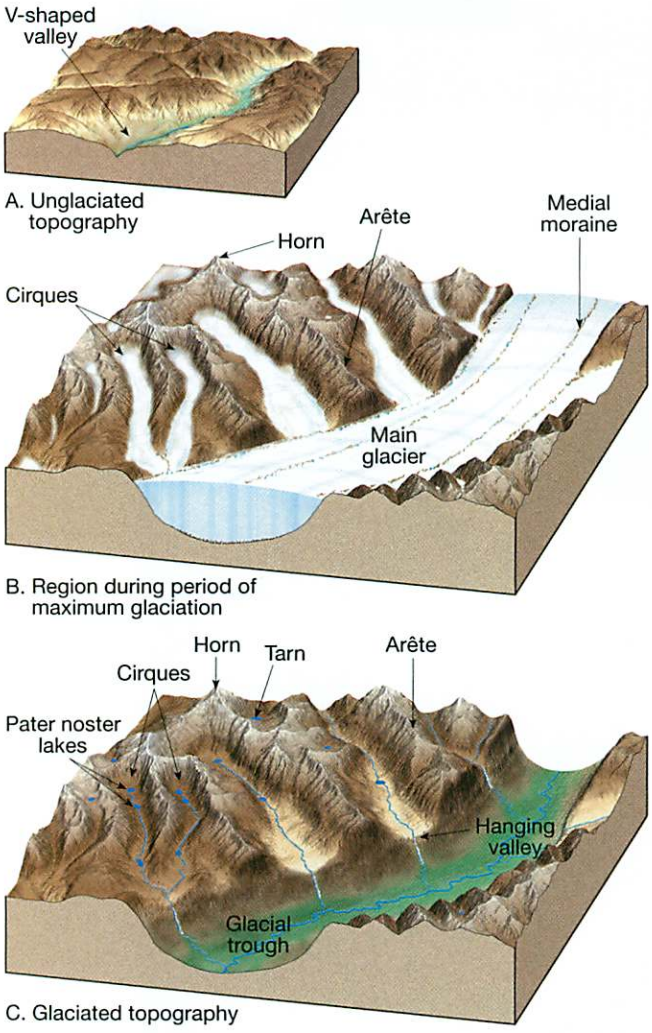


Figure 5.12 Landforms created by alpine glaciers. **A.** Landscape prior to glaciation; **B.** During glaciation; **C.** After glaciation.

32. What has been the consequence of glacial erosion on the gradients or slopes of tributary streams?

_____

_____

_____

33. Use your own words to describe how the appearance of the area has changed from what it was prior to glaciation.

_____

_____

_____

Figure 5.13 Bridalveil Falls in Yosemite National Park cascades from a hanging valley into the glacial trough below. (Photo by E. J. Tarbuck)

Figure 5.14 is an oblique aerial photograph of an area experiencing alpine glacial erosion on Mont Blanc, France. Questions 34 and 35 refer to the figure.

34. Draw arrows on the photograph that indicate the directions that the glaciers are flowing.

35. Give the name of the glacial feature described by each of the following statements as well as the letter on the photograph that labels an example of the feature. Use Figure 5.12C as a reference.

   a. Sinuous, sharp-edged ridge:

      Name: _____

      Letter of Example: _____

   b. Hollowed-out, bowl-shaped depression that is the glacier's source and the area of snow accumulation and ice formation:

      Name: _____

      Letter of Example: _____

   c. Moraine formed along the side of a valley:

      Name: _____

      Letter of Example: _____

   d. Moraine formed when two valley glaciers coalesce to form a single ice stream:

      Name: _____

      Letter of Example: _____

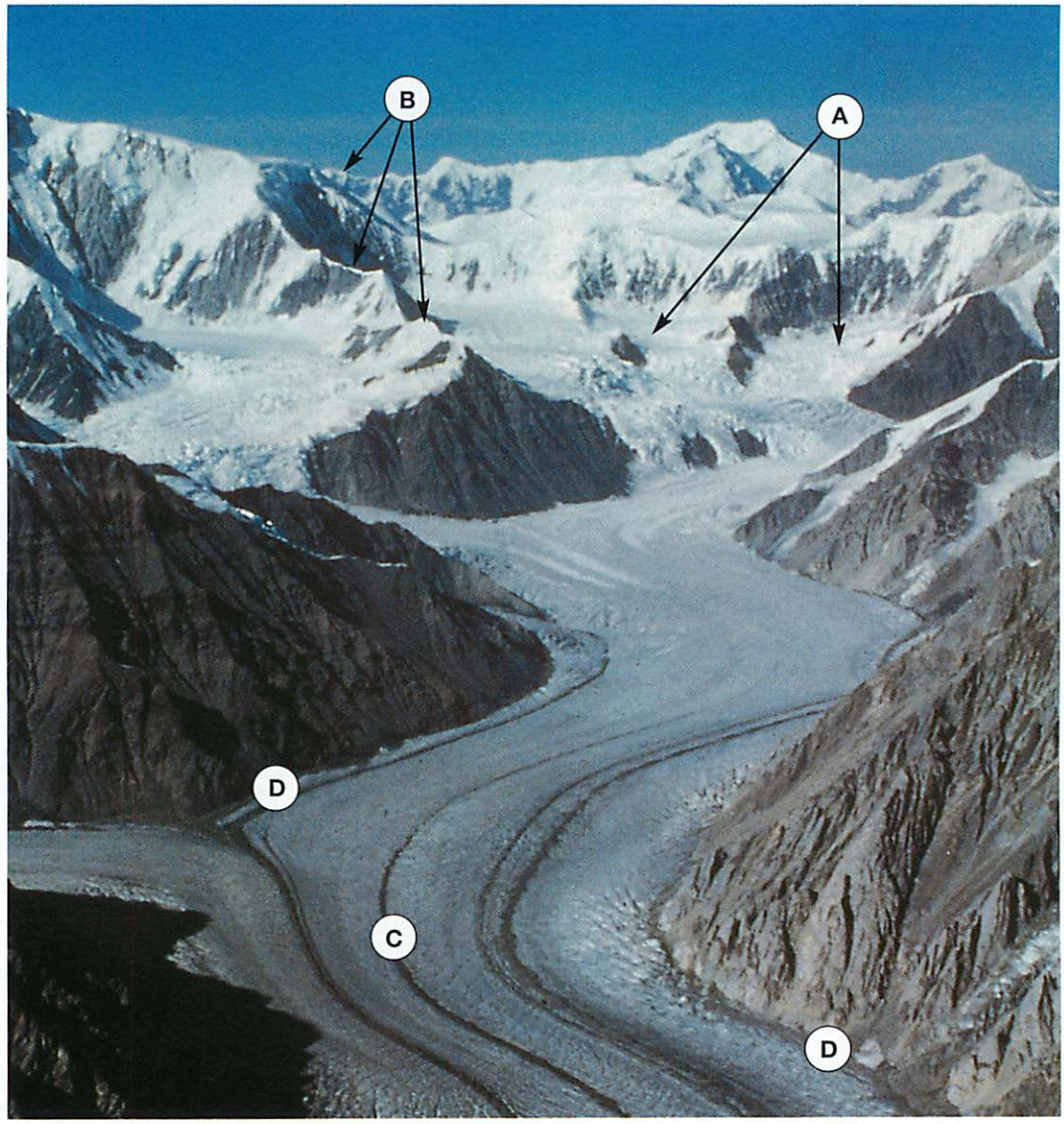


Figure 5.14 Oblique aerial photograph of alpine glaciers and glacial features, Mont Blanc, France. (Photo courtesy of U.S.G.S.)

Figure 5.15 is a portion of the Holy Cross, Colorado, topographic map, a mountainous area that underwent alpine glaciation in the past. Questions 36–41 refer to the map.

36. Following line A on the map, sketch a topographic profile of the valley of Lake Fork from Sugar Loaf Mtn. to Bear Lake on Figure 5.16. Indicate the appropriate elevations along the vertical axis of the profile.

37. Describe the shape of the profile of the valley of Lake Fork. The valley is called a glacial

_____

38. Identify the type of glacial feature indicated on the map at each of the following letters. Use Figure 5.12C as a reference.

Letter B: _____

Letter C: _____

FIGURE 5.15: Holy Cross, Colorado

0 1 2 3 kilometers

0 ½ 1 2 miles

SCALE: 1:62,500

North

Figure 5.15 Portion of the Holy Cross, Colorado, topographic map. (Map source: United States Department of the Interior, Geological Survey)

CONTOUR INTERVAL 50 FEET
DATUM IS MEAN SEA LEVEL

COLORADO

QUADRANGLE LOCATION

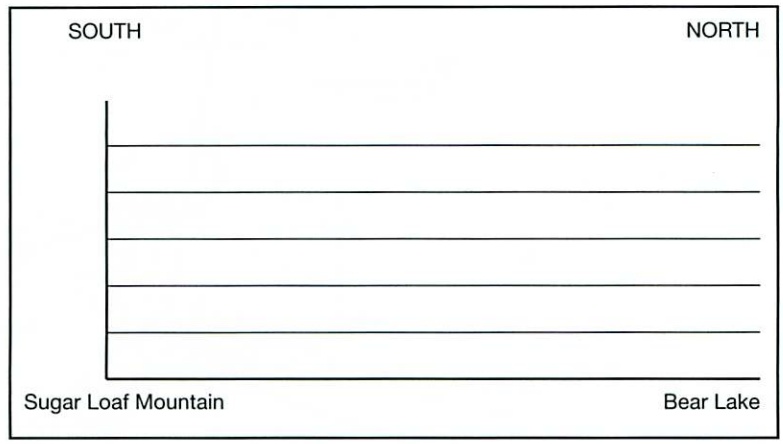


Figure 5.16 Topographic profile of the valley of Lake Fork on the Holy Cross map.

39. Letter (D, E, F, G) on the map indicates a *tarn*(s), a lake that forms in a cirque. Circle your answer.

The feature marked H on the map is composed of glacial till.

40. What type of glacial feature is designated H? How did it form?

_____

_____

41. What is the reason for the formation of Turquoise Lake?

_____

_____

Desert and Glaciers on the Internet

Investigate both desert and glacial regions by completing the corresponding online activity on the *Applications & Investigations in Earth Science* website at http://prenhall.com/earthsciencelab

Shaping Earth's Surface
Arid and Glacial Landscapes

Date Due: _____

Name: _____

Date: _____

Class: _____

After you have finished Exercise 5, complete the following questions. You may have to refer to the exercise for assistance or to locate specific answers. Be prepared to submit this summary/report to your instructor at the designated time.

1. What area of the United States is characterized by fault-block mountains with interior drainage into adjoining basins?

   _____

2. Describe the sequence of geologic events that have produced the landforms in the Antelope Peak area of Arizona.

   _____

   _____

3. What type of feature is located at each of the following letters on the Antelope Peak, Arizona, topographic map, Figure 5.4?

   Letter C: _____

   Letter D: _____

4. Toward what direction does the pediment slope on the Antelope Peak, Arizona, topographic map?

   _____

5. What is the reason for so many dry stream channels in the Antelope Peak, Arizona, area?

   _____

6. If you were working in the field, explain how you might determine whether a glacial feature is a recessional moraine or an esker.

   _____

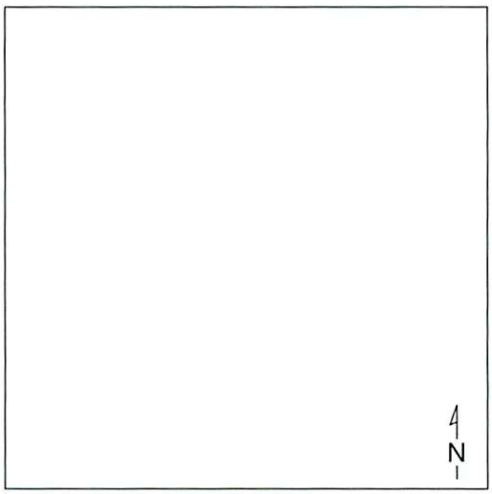
   _____

   _____

   _____

   _____

7. In the following space, sketch a map-view (the area viewed from above) of the Whitewater, Wisconsin, topographic map, Figure 5.9. Show and label the outwash plain, end moraine, area containing drumlins, and the area containing kettles and kettle lakes.



8. Assume you are hiking in the mountains. You suspect that the area was glaciated in the past. Describe some of the features you would look for to confirm your suspicion.

_____

_____

9. What was your conclusion as to the reason for the formation of Turquoise Lake on the Holy Cross, Colorado, topographic map, Figure 5.15?

_____

10. On Figure 5.17, identify and label the alpine glacial features.

Figure 5.17 Athabaska Glacier in Canada's Jasper National Park. (Photo by David Barnes/The Stock Market)