

## CHAPTER 9

# GEOLOGY AND CLIMATE: GLACIERS, DESERTS, AND GLOBAL CLIMATE TRENDS

### Important Concepts

1. A *glacier* is a mass of ice that moves or flows under its own weight in response to the pull of gravity. The two types of glaciers are *alpine glaciers* (also known as mountain or valley glaciers) and *continental glaciers* (also known as ice caps or ice sheets). Alpine glaciers are by far the most numerous today, but the continental glaciers covering Greenland and Antarctica contain a much greater volume of ice.
2. Glaciers are very effective agents of erosion, sediment transport, and sediment deposition. They produce a number of characteristic erosional and depositional landforms by which a glaciated terrain can be recognized.
3. At its maximum extension, the Pleistocene glaciation in North America covered essentially all of Canada and much of the northern United States. Glacial sediments and erosional activity (especially during the Pleistocene epoch) have shaped much of the topography and near-surface geology of northern North America.
4. Movements of air, or *wind*, take place in response to pressure differences in the atmosphere, which are related to temperature differences. Different regions of the earth are characterized by different prevailing wind directions.
5. Wind erosion consists of either *abrasion* (the erosion of a solid object by the impact of windblown particles) or *deflation* (the wholesale removal of loose sediment by the wind). Surface features produced by wind erosion and/or deposition include *ventifacts*, *desert pavement*, *dunes*, and *loess* deposits.
6. A *desert* is an extremely arid region that is incapable of supporting appreciable life. Most of the world's major deserts fall in belts close to 30 degrees north and south of the equator. The distribution of deserts may change in the future because of changes in the global climatic pattern or shifting of landmasses due to plate tectonics.
7. *Desertification* refers to the relatively rapid development of deserts on arid-but-marginally habitable land caused by the impact of human activities such as deforestation, agriculture, and overgrazing. Much of the western half of the United States is vulnerable to desertification.
8. Evidence of past climatic conditions on earth is recorded in sediments and sedimentary rocks and by atmospheric gases, volcanic ash, and other materials trapped in glacial ice.
9. Possible causes of ice ages include variations in the sun's energy output, changes in the tilt of the earth's rotation axis, the breakup of Pangaea and the accompanying changes in oceanic circulation patterns, and the partial blockage of incoming solar radiation by increased amounts of dust and/or volcanic ash in the atmosphere.
10. An increased level of atmospheric carbon dioxide (CO<sub>2</sub>), and the presence of water vapor, methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), and chlorofluorocarbons in the atmosphere, enhance the "greenhouse effect" by trapping infrared (heat) energy within the atmosphere. Possible consequences of global warming include changes in the global climatic pattern and melting of the ice caps, resulting in a significant rise in sea level.

## Key Terms

ablation	global warming
abrasion	greenhouse effect
alpine glacier	Ice Age
calving	La Niña
continental glacier	loess
deflation	moraine
desert	outwash
desertification	rain shadow
drift	rock flour
dune	slip face
El Niño	striations
equilibrium line	till
glacier	ventifact

## Multiple Choice

1. The most extensive glaciers in the United States are found in
  - a. Washington.
  - b. Alaska.
  - c. Wyoming.
  - d. Montana.
2. The Antarctic ice sheet is an example of a/an
  - a. alpine glacier.
  - b. mountain glacier.
  - c. continental glacier.
  - d. valley glacier.
3. The formation of icebergs as the advancing edge of a glacier flows out over water is called
  - a. calving.
  - b. ablation.
  - c. abrasion.
  - d. plucking.
4. The landform that marks the farthest advance of a glacier is called
  - a. an end moraine.
  - b. a terminal moraine.
  - c. a drift moraine.
  - d. a boundary moraine.
5. Winds originate mainly in response to
  - a. pressure differences in the atmosphere.
  - b. the earth's rotation.
  - c. the evaporation of the world's oceans.
  - d. alternating periods of day and night.

6. Ventifacts are formed by near-surface
- deflation.
  - ablation.
  - abrasion.
  - drift.
7. Desert pavement
- is a hard surface of sun-baked clay that forms in desert areas.
  - is formed of sand grains cemented together by calcium carbonate.
  - consists of rocks that are resistant to the effects of wind erosion and surface runoff.
  - is a layer of windblown sand overlying coarser sediments.
8. Which of the following conditions did not contribute to the Dust Bowl of the 1930s?
- overgrazing by livestock
  - drought
  - removal of native vegetation
  - change in direction of the prevailing wind
9. The slip face of a migrating dune faces the southeast if the wind blows steadily from the
- southeast.
  - southwest.
  - northeast.
  - northwest.
10. The loess that covers parts of the central United States
- was deposited by glacial melt water.
  - was deposited during the Dust Bowl era.
  - is an accumulation of windblown silt from the nation's desert areas.
  - is of volcanic origin.
11. Extremely arid lands or deserts cover \_\_\_\_\_ percent of the world's total land surface.
- 4
  - 7
  - 11
  - 30
12. All of the following are possible consequences of desertification except
- erosion.
  - drought.
  - loss of soil fertility.
  - loss of soil structural quality.
13. The division of geologic time commonly called the Ice Age is the
- Pliocene Epoch.
  - Miocene Epoch.
  - Holocene Epoch.
  - Pleistocene Epoch.

14. Evidence indicates that
- the earth has experienced a single Ice Age that ended about 10,000 years ago.
  - ice ages are relatively recent events in earth's history.
  - there have been at least six ice ages going back a billion years or more.
  - the first Ice Age began with the breakup of Pangaea about 200 million years ago.
15. Atmospheric levels of carbon dioxide have risen primarily because of
- the use of chlorofluorocarbons.
  - rising global temperatures.
  - the explosive eruptions of large volcanoes.
  - the burning of carbon-rich fuels.
16. Since the beginning of the Industrial Age, the amount of atmospheric carbon dioxide has increased about \_\_\_\_\_ percent.
- 6
  - 15
  - 25
  - 50
17. If all the earth's ice caps melted, sea levels could rise by as much as \_\_\_\_\_ meters.
- 4
  - 23
  - 75
  - 250
18. Which of the following gases absorbs infrared radiation and thus enhances the greenhouse effect?
- carbon dioxide
  - methane
  - nitrous oxide
  - All of the above are correct.
19. During the "Little Ice Age"
- glaciers covered much of northern North America.
  - severe droughts occurred in many parts of the world.
  - sea levels were significantly lower than they are today.
  - winters in North America were actually warmer than those of today.
20. The suppression of deep, cold, upwelling ocean currents off the west coast of South America results in the event known as
- La Jornada.
  - El Diablo.
  - El Chichón.
  - El Niño.

### Fill In the Blanks

1. A \_\_\_\_\_ is a mass of ice formed from compacted, recrystallized snow that moves over land under its own weight.

2. \_\_\_\_\_ is glacial erosion that occurs as ice freezes onto rock and tears away rock fragments as the ice moves on.
3. \_\_\_\_\_ is sediment deposited by melting glacial ice.
4. A \_\_\_\_\_ is a landform made of till.
5. Wind \_\_\_\_\_ is a type of natural sandblasting in which wind-transported sediments strike an object and wear it away.
6. \_\_\_\_\_ is the wholesale removal of loose sediment by wind erosion.
7. A \_\_\_\_\_ is a low mound or ridge of fine-grained material (usually sand) deposited by the wind.
8. \_\_\_\_\_ is a deposit of windblown silt.
9. A \_\_\_\_\_ \_\_\_\_\_ is an area of low rainfall on the leeward side of a mountain range that is caused by loss of moisture from air passing over the mountains.
10. \_\_\_\_\_ is the conversion of habitable arid lands to uninhabitable desert as a result of land-use practices such as farming and grazing of livestock.

### **True or False**

Indicate whether the following statements are true or false. If false, correct the statement to make it true.

- \_\_\_\_\_ 1. Most of the glaciers in the world today are continental glaciers.
- \_\_\_\_\_ 2. Approximately 75% of the earth's fresh water is stored as glacial ice.
- \_\_\_\_\_ 3. The equilibrium line on a glacial surface indicates the line of farthest glacial advance.
- \_\_\_\_\_ 4. A valley carved by a glacier is typically V-shaped.
- \_\_\_\_\_ 5. The Great Lakes were formed by continental glaciers that covered the northern United States during the last Ice Age.
- \_\_\_\_\_ 6. Many of the world's major deserts occur in belts close to 30 degrees north and south of the equator.
- \_\_\_\_\_ 7. Deposits of loess in the United States are concentrated around the Mississippi River drainage basin.
- \_\_\_\_\_ 8. Because of their water content, the polar ice caps cannot be considered a type of desert.

- \_\_\_\_\_ 9. Desertification involves the expansion of desert regions as a result of forces originating within the desert.
- \_\_\_\_\_ 10. The shoreline of the eastern United States has remained remarkably unchanged over the last 15,000 years.

## Review Questions

1. What is a moraine? How can the distribution of moraines be used to reconstruct the advance and retreat of past glaciers?
2. What is an ice age? Discuss the proposed causes of the last (Pleistocene) Ice Age.
3. What is desertification? What are the potential causes of desertification?
4. Explain the phenomenon of greenhouse effect. What are the possible causes and the potential effects?
5. What is an El Niño event and what are its apparent effects?

## Surfing the Net

Global Change Master Directory, a source of worldwide climate information with numerous links to other sites (NASA):  
<<http://gcmd.gsfc.nasa.gov/>>

Site-specific satellite images of various environmental changes (U.S. Geological Survey):  
<<http://edcwww.cr.usgs.gov/earthshots/slow/tableofcontents>>

Excellent source of slides and images related to a wide spectrum of environmental hazards (Earth Observing System, EOS):  
<[http://eosps0.gsfc.nasa.gov/eos\\_edu.pack/toc.html](http://eosps0.gsfc.nasa.gov/eos_edu.pack/toc.html)>

Special report on Emission Scenarios by the Intergovernmental Panel on Climate Change released in 2000 (SEDAC):  
<<http://sres.ciesin.columbia.edu/>>

Online version of USGS publication “Deserts: Geology and Resources” (U.S. Geological Survey):  
<<http://pubs.usgs.gov/gip/deserts/gov>>

A major site for environmental change data (Carbon Dioxide Information Analysis Center, CDIAC):  
<<http://cdiac.esd.ornl.gov/>>

Climate Change Impacts on the U.S.A., a national assessment report released in 2000 (SEDAC):  
<<http://sedac.ciesin.org/NationalAssessment>>

## CHAPTER 9 ANSWER KEY

### Multiple Choice

- |                   |       |                     |       |
|-------------------|-------|---------------------|-------|
| 1. c (figure 9.3) | 6. c  | 11. a (figure 9.23) | 16. c |
| 2. c              | 7. c  | 12. b               | 17. c |
| 3. a              | 8. d  | 13. d               | 18. d |
| 4. b              | 9. d  | 14. c               | 19. b |
| 5. a              | 10. c | 15. d               | 20. d |

### Fill In the Blanks

- |             |                     |
|-------------|---------------------|
| 1. glacier  | 6. Deflation        |
| 2. Plucking | 7. dune             |
| 3. Till     | 8. Loess            |
| 4. moraine  | 9. rain shadow      |
| 5. abrasion | 10. Desertification |

### True or False

1. False. Most of the world's present-day glaciers are alpine glaciers.
2. True
3. False. The equilibrium line on a glacial surface is the line where there is no net gain or loss of material.
4. False. A valley carved by a glacier is typically U-shaped.
5. True
6. True
7. True
8. False. The polar regions are a kind of desert, because water in the form of ice is unavailable to plant life.
9. False. Desertification does not involve the expansion of desert regions as a result of forces originating within the desert. Rather, desertification is the conversion of dry-but-habitable land to desert as a result of human impacts.
10. False. Until about 6000 years ago, the shoreline of the eastern United States retreated westward because of the melting Ice Age ice sheets and a corresponding rise in sea level.