Chapter 25

The Geology of the Cenozoic Era

GUIDED STUDY

The text chapter should be studied one section at a time. Before you read, preview each section by skimming it, noting headings and boldface items. Then read the appropriate section objectives from the following outline. Keep these objectives in mind and, as you read the chapter section, search for the information that will enable you to meet each objective. Once you have finished a section, write out answers for its objectives.

The Divisions of the Cenozoic (pp. 526-527)

1. Explain the basis for subdivision of the original Tertiary and Quaternary Periods into smaller time periods called Epochs, as suggested by Charles Lyell.

2. What event separates the Pleistocene Epoch from that of the Holocene Epoch?

3. What final changes completed the breakup of Pangaea into the continental configuration of the modern world?

4. Describe the formation of the Alpine orogen. What continents and continental fragments were involved, and how did these results change the original configuration of Eurasia, Gondwana, and the Tethys Sea?

5. Describe the Messinian salinity crisis and its effects on the Miocene history of the Mediterranean sea.

6. What process brought about the separation of Arabia from Africa? How did this process affect tectonic activity in southeastern Africa?

A Global Perspective (pp. 527-540)

7. Describe the tectonic activity that occurred during the formation of the Himalayas in central Asia.
8. What events brought about the tectonic activity of the modern Pacific Rim, and the formation of Central America?

9. Describe the possible events that led to abnormally warm worldwide climates of the Eocene Epoch.

10. Discuss how changes in oceanic circulation and asteroid impacts could have caused the later Tertiary plunge in worldwide temperatures.  

11. Discuss how the closure of Panama between the Americas may have set the stage for the Late Tertiary chill and for Pleistocene ice ages.

12. Describe the methods used to identify both glacial and interglacial stages within the Pleistocene ice ages.

13. Discuss the effects of glaciation both on sea level and also the effects of glacial rebound on the land.

14. What geologic events occurred along the eastern margin of North America during the Cenozoic Era?

15. Contrast the causes of volcanic activity in the Columbia Plateau, Snake River Plain, and the Yellowstone Plateau with that of the Cascade Range.

CHAPTER REVIEW

When you have finished reading the chapter, work through the material that follows to review it. Complete the sentences. As you proceed, evaluate your performance for each section by consulting the answers on pages 232. Do not continue with the next section until you understand each answer. If you need to, review or reread the appropriate section in the textbook before continuing.

Introduction (pp. 525-526)

1. Only 18,000 years ago, ice sheets covered areas where modern cities such as ______ _______ ____ now stand, as well as New England, the American Midwest, and all of ____________.

2. Prior to this ice age, features such as the ____ _______ and Cape Cod were missing from the American landscape.

3. Louis Agassiz used evidence gathered from alpine glaciation to suggest that once much of Europe was covered by glaciers during what he called an ____.  

4. Cenozoic climate change can be attributed to the effects of the final breakup of ______________. Other events such as the closing of the Tethys Sea,
resulted in building of the great mountains of __________.

Divisions of the Cenozoic (pp. 526-527)

5. The Cenozoic Era was traditionally divided into the _______ and __________ periods by Arduino in the mid-eighteenth century.
6. The Tertiary System was defined from marine sediments of the _______ basin of central France.
7. The epochs of the Tertiary and Quaternary periods were defined on the basis of fossil invertebrates they contained that represented ____________ __________.
8. The _______ System was defined from northern France and later subdivided by Lyell into the _______ and ________ epochs.
9. The Holocene boundary is linked to the abrupt _______ _______ at the end of the Pleistocene, which occurred about ________ years ago.

A Global Perspective (pp. 527-540)

10. At the beginning of the Cenozoic, the final breakup of Pangaea was completed, with the separation of __________ from South America and Australia, and with the separation of North America from __________.
11. Tectonic processes of the Cenozoic Era were largely responsible for the gradual _________ in climate, which eventually led to an ice age.
12. The collisions between fragments of Gondwana and Eurasia created a continuous zone of mountain building called the _______________ _____.
13. This was the tectonic result of the closing of the _______ ______, and produced the eventual isolation of the modern Mediterranean Sea.
14. The Alps Mountains of France, Switzerland, Austria, and Italy, are part of the __________ __________, which also includes the Apennine, Balkan, Carpathian, Caucasus, and Pyrenees Mountains.
15. The collision of Europe with numerous ____________ crumpled the Tethys sea floor into emerging mountains and deep basins.
16. Submarine landslide deposits called_______ filled the deep basins.
17. _______ form when elongate folds were pushed northward horizontally and stacked on each other by thrust faults.
18. Continued northward movement of Africa towards Europe formed the restricted body of water called the _______________ ______.
19. In the Late Miocene, the supply of seawater to the region was eliminated by a combination of converging continents and lowered sea level during the ___________ ______. ______.
20. During the Pliocene Epoch, a ______ _______ led to the detachment of Africa form the Arabian Peninsula.
21. The slowest arm to open of the three-way rift was the ______ _______ _____.
22. The collision of ________ with___________ produced the Himalayan orogen.
23. The northern part of the Indian subcontinent was a _______ _______ where shallow to deep water sediments were deposited.
24. The southern margin of Eurasia (Tibet) was a _______ _______ _____, where subduction of the Tethys sea floor produced felsic magmas that intruded the continental margin.
25. Seaward of the magmatic arc, sediments were deposited in a _______ ______, and oceanic sediments were also deposited as an _________ ______ from material scraped from the subducted plate.
26. When the northern margin of India reached the _______ zone bordering Eurasia (Tibet), the thicker continental crust slowed the subduction process to a halt.
27. ___________ of the forearc basin and accretionary wedge were squeezed up between the two continents, along with slices of ___________ ________.
28. The leading edge of the Indian continent was dragged beneath Tibet, but the Indian crust ____________, and these slices were thrust upward and backward along with the sediments of the former passive margin.
29. The folded and upthrust sediments of the passive margin and accretionary wedge now form the towering ___________.
30. Collision between India and Asia continues today, as India moves northward about ___ centimeters per year. The mountains continue to rise, but ________ tends to wear them down nearly as fast.
31. Fragments of the once large _________ plate exist today as the Nazca, Cocos, and Juan de Fuca plates.
32. Mid-ocean ridges in the Pacific Ocean are found only in its southeastern regions, as the ________ _________.
33. Subduction along the western coast of South America has produced the ________ ________, where uplift, folding, faulting, volcanism, and intrusive activity continue along the entire margin of the continent today.
34. Formation of a subduction zone between North and South America caused crustal blocks to accumulate in the arc, gradually building ________ ________. This landbridge between the Americas was complete ____ million years ago.
35. Cenozoic climates were characterized by a lack of __________, in contrast to those of the Mesozoic.
36. The high global temperatures of the Early Tertiary were probably brought on by the release of ________ ________ from oceanic sediments, or by a catastrophic ________ ________ in the Caribbean region.
37. The worldwide drop in temperatures that occurred at the beginning of the Oligocene Epoch was caused by __________ ________.
38. The separation from Antarctica from South America and _________ prevented warm equatorial waters from reaching the southern continent, because it became encircled by a polar ________ ________.
39. Ice sheets that formed on the Antarctic continent ________ away incoming solar radiation, further cooling the land.
40. The rise of the Himalayan mountain range altered atmospheric circulation and also accelerated rates of erosion, which removed ______ ________ from the atmosphere.
41. An alternative explanation for late Cenozoic cooling involved the impacts of two late Eocene __________, one landing in the Chesapeake Bay area, and another in Siberia.
42. Closure of the __________ between North and South America caused a change in the circulation of oceanic currents, resulting in a profound cooling of the waters of the ________ ________.
43. The ________ __________ began with the first southward advance of glaciers 1.6 million years ago, and ended with their last retreat about 13,000 years ago.
44. Cycles of glaciation include both the advance of glaciers, which is indicated by tills and outwash deposits, and the retreat of glaciers, which is indicated by ______ containing plant debris.
45. The four principle stages of glaciation in North America were each named for the southernmost ________ to which the ice advanced. The warmer ________ ________ stages were named for the locations where the soils that formed after glacial retreat were particularly well developed.
46. The tests of __________ ________ are used to provide a record of glaciation.
47. The lighter O16 isotope is preferentially removed during evaporation, leaving the heavier 18O concentrated in oceanic waters during __________. During warmer periods, the concentration of the heavier 18O isotope relative to the lighter 16O isotope is considerably less.

48. The isotope record suggests cooling trends that were marked by periods of glacial advance were gradual events taking 10-15,000 years, whereas __________ came on abruptly, in as little as a few tens of years.

49. The presence of the ice caps changed climates in some regions, causing some usually dry areas such as inland basins in the desert to experience abundant rainfall, producing __________.

50. During peak glaciation, the two principle ice sheets that covered North America were the __________ ice sheet to the northeast, and the __________ ice sheet to the northwest.

51. The chronology of the __________ is particularly well known, because it is the most recent glacial age.

52. The last pulse of the most recent ice age was called the __________, which ended abruptly about 11,600 years ago.

53. During the maximum extent of glaciation, worldwide sea level dropped by about _____ meters. At this stage the landbridge between North America and _______ was dry land, and permitted migration of animals and humans.

54. The tremendous weight of the ice sheets depressed the land surface by as much as 300 meters. Today these lands are still rising, a process known as __________. 

55. Evidence that includes modern glacial deposits, leaf fossils, pollen, and tree-ring chronologies provide a good record of the __________ climate.

56. Between A.D. 900 and A.D. 1300, an interval of favorable climate called the __________ allowed the Vikings to establish settlements on Iceland and Greenland.

57. Between A.D. 1300 and A.D. 1850, a cool interval called the __________ caused Viking settlements on Greenland to be abandoned, and alpine glaciers to advance far down their valleys.

58. In eastern North America, erosion of the Appalachian Mountains occurred because of periodic _______, and the sediments shed from this erosional process continued to build out the Atlantic and Gulf _______.

59. The lack of clastic sediments supplied to the Atlantic margin south of Georgia, and the warm subtropical waters of Florida made it an ideal site for late Cenozoic deposition of __________.

60. The end of Laramide deformation in western North America came at the end of the __________.

61. Fine-grained rocks containing oil shale, and well-preserved fossils of Eocene Age belong to the __________, which represents lake deposits.

62. The modern Rockies, Sierra Nevada, and Teton Range were produced by uplifts that occurred between the Late _______ and Early _______ epochs.

63. Uplift of the Colorado Plateau produced numerous normal faults, along which __________ occurred.

64. Volcanism in the Columbia and Snake River Plain areas was probably the result of a __________ over which the North American Plate passed in the Late Tertiary to Early Quaternary Periods.

65. Volcanic activity in the Cascade Range to the west of the Columbia Plateau is due to the nearby ______ of the Juan de Fuca Plate beneath North America.

66. Mountains and valleys of the Basin and Range province were formed by __________, which probably resulted from the conversion of the nearby Pacific margin from a subduction zone to a transform margin.

67. The Juan de Fuca Ridge and the East Pacific Rise are connected along the western margin of North America by the __________

68. A small body of water called the __________ covered the continental interior in the early Paleocene. The __________ covered parts of the Atlantic and Gulf Coastal plains during the early Tertiary Period.

69. The Long Island aquifer represents glacial _______ sediments, whereas Cape Cod represents the position of a glacial _______.

**PRACTICE TESTS**

After you thoroughly understand the correct answers of the Chapter Review, answer the following questions and check them with the answers on pages 233-234. If your
answer is incorrect, consult the appropriate pages of the text.

**Multiple Choice Questions**

Circle your answers to the following questions.

1. The evidence of glaciation that exists in New York City’s Central Park is:
   a. a moraine.
   b. an outwash plain.
   c. a collection of glacial erratics.
   d. bedrock pavement with parallel grooves.

2. Louis Agassiz proposed that great ice sheets covered much of:
   b. Europe.
   c. Africa.
   d. Australia.

3. The Tertiary and Quaternary systems were originally proposed by:
   a. Darwin.
   b. Lyell.
   c. Arduino.
   d. Agassiz.

4. Collision between Gondwana and Europe produced the:
   a. Alpine-Himalayan belt.
   b. circum-Pacific belt.
   c. Andean Cordillera.
   d. East African rift.

5. The Carpathian Mountains of Europe are part of which orogenic belt?
   a. Alpine-Himalayan belt.
   b. the circum-Pacific belt.
   c. the Andean Cordillera.
   d. the East African rift.

6. The Messinian salinity crisis caused which body of water to completely dry up?
   a. the Gulf of Mexico.
   b. the Red Sea.
   c. the Mediterranean Sea.
   d. the Atlantic Ocean.

7. The second arm of the three-way rift between Arabia and Africa opened as the:
   a. Gulf of Aden.
   b. Red Sea.
   c. the Dead Sea transform fault.
   d. the East African rift.

8. The Himalayan orogeny was the result of the collision of India with
   a. Africa.
   b. Eurasia.
   c. Australia.
   d. Antarctica.

9. The Andean Cordillera of South America was formed by subduction of the:
   a. Farallon and Cocos plates.
   b. Farallon and Juan de Fuca plates.
   c. Farallon and South American plates.
   d. Farallon and Nazca plates.

10. The dramatic temperature drop that occurred at the beginning of the Oligocene Epoch was due to the:
    a. separation of Australia from Antarctica.
    b. separation of South America from Antarctica.
    c. The rise and weathering of the Himalayan mountains.
    d. All of the above.

11. The warmer interglacial stages were named for:
    a. the region where soils were best developed.
    b. the westernmost states they advanced to.
    c. the southernmost states they advanced to.
    d. the northernmost states they retreated to.

12. The concentration of O18 isotope is highest relative to that of O16:
    a. during warmer interglacial stages.
    b. during colder glacial advances.
    c. in polar glaciers.
    d. in polar seas.

13. The cyclicity of glaciation during the Pleistocene was about:
    a. 1 million years.
    b. 500,000 years.
    c. 100,000 years.
    d. 10,000 years.

14. The Laurentide ice sheet covered most of:
    a. Europe.
    b. Canada.
    c. Siberia.
    d. Antarctica.

15. Which glacial stage can be accurately dated using carbon dating?
    a. the Kansan stage.
    b. the Nebraskan stage.
    c. the Illinoian stage.
    d. the Wisconsinan stage.

16. The last major glacial advance was called the:
    a. Younger Dryas.
    b. Little Ice Age.
    c. Medieval warm period.
    d. glacial rebound.
17. During glacial advances, sea level was:
   a. much higher than that of today.
   b. slightly higher than that of today.
   c. slightly lower than that of today.
   d. much lower than that of today.

18. Viking settlements of Greenland were devastated by the:
   a. Younger Dryas.
   b. Little Ice Age.
   c. Medieval warm period.
   d. glacial rebound.

19. Geologic events in eastern North America primarily involved:
   a. erosion.
   b. subduction.
   c. rifting.
   d. volcanic activity.

20. Sediments shed from the Laramide uplifts of western North America were deposited:
   a. on broad coastal plains.
   b. as submarine landslides.
   c. in intermontaine basins.
   d. in large salt lakes.

21. The major ranges of the Rocky Mountains of western North America were rejuvenated by:
   a. thin-skinned thrusts.
   b. rifting.
   c. volcanism.
   d. recent uplift.

22. During the Pliocene Epoch, the Colorado Plateau was uplifted approximately:
   a. 100 meters.
   b. 1000 meters.
   c. 2000 meters.
   d. 4000 meters.

23. Cenozoic volcanism on the Columbia Plateau was probably initiated by:
   a. buoyant subduction.
   b. an underlying hot spot.
   c. microplate accretion.
   d. rifting.

24. The Yellowstone Plateau was built by the:
   a. oldest volcanic activity in the region, at about 15 million years ago.
   b. youngest volcanic activity in the region, at about 600,000 years ago.
   c. volcanic activity intermediate in age, at about 10 million years ago.
   d. None of the above.

25. The former Pacific-Farallon ridge can be connected between the Juan de Fuca ridge to the north and the East Pacific rise to the south by the:
   a. San Andreas transform.
   b. Juan de Fuca plate.
   c. Cocos plate.
   d. Nazca plate.

26. Sea level rise is mostly due to:
   a. melting of glaciers and ice sheets.
   b. accelerated rates of sea-floor spreading.
   c. accelerated rates of continental erosion, causing subsidence.
   d. expansion of ocean waters from rising global temperatures.

27. Martha’s Vineyard and Nantucket Island were formed by:
   a. volcanism
   b. folding.
   c. glacial deposition.
   d. glacial erosion.

True or False Items

Write true or false on the line in front of each statement.

_____ 1. New York City was buried beneath glaciers only 18,000 years ago.
_____ 2. Charles Lyell proposed the Tertiary and Quaternary Periods.
_____ 3. The epochs of the Tertiary were based upon the proportion of living species found fossilized in each strata.
_____ 4. The modern Mediterranean Sea was formed by the closure of the Tethys Sea.
_____ 5. The Alpine orogen was the result of subduction of oceanic crust beneath the continental crust of Europe.
_____ 6. The second arm to open of the three-way rift separating Arabia from Africa was the Dead Sea transform.
_____ 8. Folded and upthrusted sediments of the accretionary wedge and continental margin today form the towering Himalayas.
_____ 9. The Andean Cordillera formed by subduction of the Juan de Fuca plate beneath South America.
_____ 10. Central America was formed by the accumulation of crustal blocks rafted to the subduction zone an accumulated into the magmatic arc.
_____ 11. Land deposits reveal a much more detailed record of glacial ages, because the glaciers existed on land.
12. Warming trends within glacial ages were slow, often requiring 10,000-15,000 years to develop.

13. The presence of ice caps in some regions caused abundant local precipitation in normally dry desert areas, forming pluvial lakes.

14. The Wisconsinan stage is the only glacial stage young enough to use radiocarbon dating techniques for determining its age.

15. The landbridge between Asia and North America was only visible during the warmer, interglacial stages.

16. Glacial rebound is most prominent in regions just south of the maximum glacial advance.

17. The major mountain ranges of western North America were eroded away in the early Tertiary, but later rejuvenated by uplift.

18. The Colorado Plateau was uplifted during the Laramide orogeny.

Essay Questions

Write a brief essay on a separate sheet of paper answering each of the following questions.

1. Describe the Messinian salinity crisis.
2. Explain the formation of the Himalayas.
3. Discuss the tectonic events that led to the ice age at the end of the Cenozoic.

CHALLENGE TEST

Answer these questions the day before an exam as a final check on your understanding of the chapter’s terms and concepts. Check your responses with the answers on pages 234-235. If your answer is incorrect, consult the appropriate pages of the text.

Completion

Fill in the correct answers.

1. A drastic climate change that produced a vast ice sheet covering much of Europe and Asia was first proposed by ______ ______.

2. The present time period in which we live (2001) belongs to the ______ _____.

3. A series of subduction zones nearly encircling the Pacific Ocean is known as the ______ _____.

4. The Alpine orogen has a complex history of _______ and _______ that resulted from the closing of the Tethys Sea.

5. The Tethys seafloor was crumpled into deep marine basins, which filled with flysch deposits from ______ _______.

6. The Messinian salinity crisis resulted in the deposition of over 2000 meters of _______ and _______ on the floor of the then-dry Mediterranean Basin in the Late Miocene Epoch.

7. A triple junction led to the detachment of ______ from ______ during the Pliocene Epoch.

8. The Himalayas, were formed by _______ of India and Eurasia.

9. During the Late Mesozoic and Early Cenozoic, the Farallon plate was almost entirely_______ beneath the North American plate.

10. Global warmth during the _______ _______ may have been generated by release of greenhouse gases from marine sediments, or by catastrophic volcanic eruptions in the Caribbean region.

11. The final breakup of ________ in the later Tertiary set up an encircling polar current around Antarctica.

12. The _______ _______ cut off oceanic circulation between the Atlantic and Pacific oceans, hastening global cooling.

13. The tests of planktonic foraminifera used to study the record of past glaciations are found in deep sea _______ ______.

14. The expansion of the_______ ______ in Africa during the ice ages suggests cooler temperatures provided less precipitation.

15. The Little Ice Age came to an end around _____, and global temperatures have been rising ever since.

16. Sediments eroded from the rising Laramide uplifts was shed into nearby _______ ______.

17. The resumption of volcanic activity in western North America may have resulted from the change in the ______ of subduction of the Farallon plate.

18. Sea level rise today is about______ centimeters per century.
Multiple-Choice Questions

Circle the correct answer.

1. The great Pleistocene Ice Age was caused primarily by:
   a. the closing of the Tethys Sea.
   b. the final breakup of Gondwana.
   c. the uplift of the Rocky Mountains.
   d. the building of the great mountain ranges of Europe.

2. The epochs of the Tertiary were defined on the basis of their:
   a. rock types. c. fossil content.
   b. rock thicknesses. d. radiocarbon dates.

3. A newer classification of the Cenozoic separates the Cenozoic into two periods; the Paleogene and the:

4. The modern Mediterranean Sea was formed by the northward migration of Africa into:
   a. India c. Asia.
   b. Antarctica. d. Eurasia.

5. The Pliocene detachment of the Arabian Peninsula from Africa was accomplished by:
   a. a submarine landsliding. c. rifting.
   b. continental collision. d. subduction.

6. The northern continental margin of India drifted into which tectonic feature along the southern margin of Eurasia?
   a. a rift zone. c. a foreland basin.
   b. a backarc basin. d. a subduction zone.

7. The ancient plate that was completely subducted underneath the North American plate by the early part of the Cenozoic Era was called:
   a. the Nazca plate.
   b. the Farallon plate.
   c. the Juan de Fuca plate.
   d. the Cocos plate.

8. Central America was formed when crustal fragments drifted north into a:
   a. a rift zone. c. a foreland basin.
   b. a backarc basin. d. a subduction zone.

9. The final breakup of Gondwana caused the continent of Antarctica to become surrounded by a:
   a. cold polar current.
   b. warm equatorial current
   c. cool equatorial current.
   d. warm polar current.

10. The four principal stages of Pleistocene glacial advance were named from:
    a. the northernmost states they retreated to.
    b. the westernmost states they advanced to.
    c. the southernmost states they advanced to.
    d. the region where soils were best developed.

11. The record of glacial advances and retreats is preserved best in:
    a. glacial sediments.
    b. the tests of planktonic foraminifera.
    c. pollen deposits.
    d. outwash sediments.

12. The cold, moist climate near the glaciers produced pluvial lakes such as:
    a. the Great Lakes.
    b. the Great Salt Lake.
    c. the Green River Lake.
    d. Lake Bonneville.

13. Glacial rebound is still occurring today in:
    a. Scandinavia.
    b. southern Europe.
    c. Northern Africa.
    d. Antarctica.

14. Volcanic activity in the Colorado Plateau region can be attributed to earlier:
    a. intrusion. c. normal faulting.
    b. thrust faulting. d. folding.

15. A continental hot spot probably underlies:
    a. the Yellowstone Plateau.
    b. the Columbia Plateau.
    c. the Snake River Plain.
    d. the Cascade Range.

16. Extension in the Basin and Range province was probably produced by:
    a. subduction.
    b. conversion from subduction to transform faulting.
    c. thrust faulting.
    d. a continental hot spot.

17. The Tejas transgression of the early Tertiary Period inundated:
    a. the Great Plains.
    b. the Great Lakes region.
    c. the upper Midwest.
    d. the Atlantic and Gulf coastal plains.

18. Long Island, New York is formed of a glacial:
    a. terminal moraine.
    b. outwash plain.
    c. grooved bedrock pavement.
    d. none of the above.
True or False Items

Write true or false on the line in front of each statement.

_____ 1. Louis Agassiz was the first to notice that moraines, erratic boulders, and scoured bedrock of the Swiss Alps was the work of ancient glaciers.

_____ 2. The closing of the Tethys seaway had the greatest effect in bring on a late Cenozoic ice age.

_____ 3. The Paleogene and Neogene periods were intended to provide a more equal length in periods of the Cenozoic Era.

_____ 4. A series of subduction zones nearly encircling the Pacific Ocean resulted from the collision of Gondwana with Eurasia.

_____ 5. The Messinian salinity crisis involved the filling of the Mediterranean basin with sea water.

_____ 6. The first arm to open of the three-part rift separating Arabia from Africa formed the Gulf of Aden.

_____ 7. The collision of India with Eurasia produced the Himalayan orogeny.

_____ 8. The Early Eocene global climate maximum was probably the result of the final breakup of Gondwana.

_____ 9. The rise of the Himlayas was responsible in part for global cooling, as the chemical weathering of these great mountains removed carbon dioxide from the atmosphere.

_____ 10. Lush, dense forests were a consequence of the cooler, drier Oligocene climate.

_____ 11. Initial correlation of glacial ages between regions utilized till and outwash deposits.

_____ 12. The warmer interglacial stages are named for the farthest north soil deposits that can be located of that age.

_____ 13. High O18 concentrations in the shells of planktonic foraminifera indicate glacial climates.

_____ 14. The Cordilleran ice sheet was the largest in North America, covering most of northeastern Canada.

_____ 15. The Vikings settled Greenland during the Little Ice Age.

_____ 16. The Green River Formation sediments represent lake deposits of an intermontane basin.

_____ 17. The oldest eruptions from the hot spot beneath western North America occurred on Yellowstone Plateau about 15 million years ago.

ANSWERS

CHAPTER REVIEW

1. New York City; Canada
2. Great Lakes
3. ice age
4. Gondwana; Europe
5. Tertiary; Quaternary
6. Paris
7. still-living species
8. Quaternary; Pleistocene; Holocene
9. climate change; 10,000
10. Antarctica; Europe
11. deterioration
12. Alpine-Himalayan belt
13. Tethys Sea
14. Alpine orogen
15. microplates
16. flysch
17. Nappes
18. Mediterranean Sea
19. Messinia salinity crisis
20. triple junction
21. East African rift
22. India; Eurasia
23. passive margin
24. volcanic island arc
25. forearc basin; accretionary wedge
26. subduction
27. Sediments, oceanic crust
28. fractured
29. Himalayas
30. 5; erosion
31. Farallon
32. East Pacific Rise
33. Andean Cordillera
34. Central America; 3.5
35. consistency
36. methane gas; volcanic eruption
37. tectonic activity
38. Australia; ocean current
39. reflected
40. carbon dioxide
41. asteroids
42. landbridge; Arctic Ocean
43. Pleistocene Epoch
44. soils
45. state; interglacial
46. planktonic foraminifera
47. glaciation
48. warmer intervals
49. pluvial lakes
50. Laurentide; Cordilleran
51. Wisconsinan Stage
52. Younger Dryas
53. 140; Asia
54. glacial rebound
55. Holocene
56. Medieval warm period
57. Little Ice Age
58. uplift; coastal plains
59. carbonates
60. Eocene Epoch
61. Green River Formation
62. Miocene; Pleistocene
63. volcanic activity
64. hot spot
65. subduction
66. extension
67. San Andreas transform
68. Cannonball Sea; Tejas transgression
69. outwash; moraine

PRACTICE TESTS

Multiple-Choice Questions

1. d  
2. b  
3. c  
4. a  
5. a  
6. c  
7. b  
8. b  
9. d  
10. d  
11. a  
12. b  
13. c  
14. b  
15. d  
16. a  
17. d  
18. a  
19. c  
20. c  
21. d  
22. c  
23. b  
24. b  
25. a  
26. d  
27. c

True or False Items

1. True.
2. False. Arduino proposed the Tertiary and Quaternary periods in the mid-eighteenth century.
3. True.
4. True.
5. False. The Alpine orogen resulted from the collision of numerous microplates with Europe.

Essay Questions

1. The northward migration of the African plate caused the closure of circulation from the Tethys Sea on its northeastern side, where Arabia and Eurasia converged together. On the west, circulation with the Atlantic Ocean was restricted as well to a narrow gap between Spain and Africa. In the Late Miocene, this restriction was completely closed off from convergence and a global lowering of sea level. As a result, the Mediterranean Sea experienced nearly complete evaporation. Periodic rise in sea level filled the basin with seawater, only to be evaporated again during sea level drop. The lowered base level cause the few rivers entering the basin to down cut their channels hundreds of meters. The total accumulation of evaporites deposited during the Messinian salinity crisis measures over 2000 meters.

2. The formation of the Himalayas can be described in a series of four stages:
  a. The initial stage of formation of the Himalayas involved rifting between India and Gondwana. Ocean ridges formed to the south and west of the Indian continent, and a subduction zone formed along the southern edge of Eurasia near what is now Tibet. The northern border of India was a passive margin, where marine sediments were accumulating. The southern edge of Eurasia involved India and Gondwana.
  b. Subduction underneath Tibet produced great volumes of felsic magma that intruded the continental margin, or were erupted as ash-flow tuffs. Seaward of the volcanic arc, sediments were deposited in the forearc basin,
and above the subduction zone an accretionary wedge formed from sediments scraped off the subducted oceanic plate.
b. The second stage of formation of the Himalayas occurred near the end of the Paleocene Epoch, when the northern margin of India approached the subduction zone bordering Tibet. The subduction then slowed and finally ceased, as the thick continental crust reached the subduction zone.
c. The third stage of the formation of the Himalayas occurred when the forearc basin and accretionary wedge sediments were squeezed up between the colliding plates, along with slivers of oceanic crust. The leading edge of the Indian continent was initially subducted beneath Tibet, but the continental crust of India fractured, sending the upper slices of crust backward to the south and upward into the sedimentary rocks that had formed along the passive margin.
d. The final stage of the formation of the Himalayas is the continued compression of the crust caused by the continental collision, which forces the folded and upthrust sediments of the passive margin and the accretionary wedge to rise still higher today. India still moves northward at a rate of 5 centimeters per year, but erosion of the mountain range is probably tearing the peaks down as fast as they rise.

3. The most critical factors in the climatic deterioration of the Cenozoic climate appears to be the final breakup of Gondwana, which isolated the Antarctic continent from warm equatorial oceanic currents. Separation of South America and Australia from Antarctica left open total global circulation of cold polar waters around the continent, forever removing the warm currents that formerly traveled to it all the way from the equator. The closure of the Isthmus of Panama provided the final factor, as the warm equatorial currents were no longer connected, and the waters were deflected northward as the warm Gulf Stream. Because of its greater salinity, this current was unable to complete its flow to the Arctic Ocean, and it returned south as a dense, cold current to the equator. Because of this factor, the Arctic Ocean has become cold and isolated as well, and the northward positioning of landmasses makes glacier formation inevitable.

CHALLENGE TEST

Completion

1. Louis Agassiz
2. Holocene Epoch
3. circum-Pacific belt
4. folding; faulting
5. submarine landslides
6. gypsum; halite
7. Africa; Arabia
8. collision
9. subducted
10. Early Tertiary
11. Gondwana
12. Isthmus of Panama
13. sediment cores
14. Sahara Desert
15. 1850
16. intermontaine basins
17. angle
18. 10

Multiple-Choice Questions

1. b
2. c
3. a
4. d
5. c
6. d
7. b
8. d
9. a
10. c
11. b
12. d
13. a
14. c
15. a
16. b
17. d
18. a

True or False Items

1. False. Louis Agassiz was the first to propose that an ice age produced the continental glaciers and their effects.
2. False. The final breakup of Gondwana was responsible for the late Cenozoic ice age.
3. True.
4. False. The circum-Pacific belt of subduction zones resulted from the westward movement of tectonic plates.
5. False. The Messinian salinity crisis involved the drying up of the Mediterranean Sea during the Miocene Epoch.
6. True.
7. True.
8. False. The early Eocene global climate maximum was probably the result of the greenhouse effect from the release of methane frozen in deep sea sediments.
10. False. Open grasslands were a consequence of the cooler, drier climates of the Oligocene Epoch.
11. True.
12. False. The warmer interglacial stages are named for the site at which their development is the best.
13. True.
14. False. The Laurentide ice sheet was the largest, covering all of northeastern Canada.
15. False. Vikings settled Greenland during the Medieval warm period.
16. True.