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CHAPTER 2
THE SEA FLOOR

Chapter Outline

2.1 The Water Planet
- The Geography of the Ocean Basins
- The Structure of the Earth
  - Internal Structure
  - Continental and Oceanic Crusts

2.2 The Origin and Structure of the Ocean Basins
- Early Evidence of Continental Drift
- Plate Tectonics
  - Discovery of the Mid-Ocean Ridge
  - Significance of the Mid-Ocean Ridge
  - Creation of the Sea Floor
  - Sea-Floor Spreading and Plate Tectonics
- Earth's Geologic History
  - Continental Drift and the Changing Oceans
  - The Record in the Sediments
  - Climate and Changes in Sea Level

2.3 The Geological Provinces of the Ocean
- Continental Margins
  - The Continental Shelf
  - The Continental Slope
  - The Continental Rise
  - Active and Passive Margins
- Deep-Ocean Basins

2.4The Mid-Ocean Ridge and Hydrothermal Vents

Box Readings:

2.1 *Eye on Science: Life Below the Sea Floor*

2.2 *The Hawaiian Islands, Hot Spots, and the Mantle Plumes*

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Chapter Summary

Chapter 2 summarizes the basic aspects of the geology of the sea floor and points out its relevance to marine biology. It includes numerous up-to-date maps and illustrations that are especially designed to serve as teaching aids.

The basic structural features of the ocean basins and the Earth are briefly described first. This material introduces the student to a more detailed discussion of the origin of the ocean basins and the theory of plate tectonics. Information is organized in an easy-to-follow progression: early evidence for continental drift, the discovery and significance of the mid-ocean ridges, the creation of the sea floor, for a complete portrait of plate tectonics—the mechanisms that explain it all. Plate tectonics is then used to explain features such as trenches, island arcs, and faults. The box reading on the origin of the Hawaiian Islands further illustrates the consequences of plate tectonics.

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The discussion of plate tectonics is followed by a description of the geologic history of the earth. It covers material that is relevant to current concerns about climate change. Integrated into this discussion is an introduction to the importance of marine sediments in providing evidence of past oceanic conditions. The chapter concludes with an outline of the geologic provinces of the ocean, which includes an explanation of the continental shelf, continental slope, continental rise, active and passive continental margins, and deep-ocean basins. This section highlights hydrothermal vents, the deep-sea hot springs that serve as home to a most fascinating type of marine life.

The relationships between the material covered in Chapter 2 and the discussion of various aspects of life in the sea is reviewed and further integrated throughout the book by means of marginal review notes.

Student Learning Outcomes

1. Demonstrate an understanding of the basic structure of the earth.

2. Describe the evidence to support that plate tectonics is responsible for the origin and structure of the ocean basins.

3. Diagram the geological provinces of the ocean.

4. Contrast active and passive continental margins.

Answers to Critical Thinking Questions

1. Plate tectonics works today in the same way as in the past. Can you project future positions of the continents by looking at a map of their present positions and the positions of the mid-ocean ridges (see Fig. 2.5)? What oceans are growing and which are shrinking? Where will new oceans form?

North and South America will be farther west toward the Pacific, Europe and Asia farther southeast, Australia farther northeast, and Africa farther east. The Pacific is therefore expected to be narrower and the Atlantic wider. The map in Fig. 2.9 actually indicates the direction of plate movement but it's better if students deduce these movements by the location of the mid-ocean ridges as indicated on the map in Fig. 2.5.

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2. Why are most oceanic trenches found in the Pacific Ocean?

Due to the collision of a continental plate and an oceanic plate or two oceanic plates in the Pacific Ocean, one plate is forced below the other. At these collision sites, trenches form. Volcanoes and earthquakes are also associated with these sites.

3. Scientists who study forms of marine life that lived more than 200 million years ago usually have to obtain fossils not from the sea floor, but from areas that were once undersea and have been uplifted onto the continents. Why?

Due to changing sea-level over geologic history, these fossils are now located above sea level.

4. What are some of the major pieces of evidence for the theory of plate tectonics? How does the theory explain these observations?

Scientist Alfred Wegner was the first to propose that the continents we know today were once joined into a single supercontinent he called Pangaea. He noted that the edges of the continents fit together much like puzzle pieces. Since he could not explain how these continents traveled away from one another to their current positions, his work was not supported at that time. Since that time, however, evidence to support his theory has continued to accumulate.

One of the major pieces of evidence for his theory is the discovery of mid-ocean ridge system in the ocean basins. These ridges are a continuous chain of submarine volcanoes and geologic activity is concentrated around these areas. At these ridges, oceanic crust is separating as molten rock flows from the Earth's interior. New rock is formed in this way and older rock is pushed further from the ridges. Sediments are deeper on ocean floor located away from the ridge, demonstrating that this area has had more time to accumulate these sediments. Rocks are also known to be older moving away from the ridges.

Perhaps the strongest piece of evidence to support the activities at the mid-ocean ridges is the discovery of bands, or

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stripes, on sea-floor rocks known as magnetic anomalies. These anomalies occur because as molten rock cools, magnetic particles in the rocks point towards a magnetic point on the Earth. At different times during geologic history, this magnetic point is magnetic north as it is today. At other times, the field has reversed to create a magnetic south instead. These magnetic anomalies show the direction of this magnetic field at the time they were formed. Therefore, these bands show that the sea floor was not formed all at once, but in stages over geologic time. As new sea floor is created, sea floor in other areas is destroyed as some plates are forced together by this movement. In these areas, trenches are formed. Evidence includes: the fitting together of the coasts of the continents on the opposite sides of the Atlantic Ocean, the similarity of geologic formations and fossils found on the opposite sides, a geologically active mid-ocean ridge running along the central Atlantic between the opposite coasts, bottom sediments that get thicker the farther one travels from the ridge, and rocks on the sea floor on one side of the ridge show magnetic bands that are mirror images of rocks found on the opposite side of the ridge. All of these observations are explained by sea-floor spreading from the mid-ocean ridge.

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CORRECT ANSWERS ARE LOCATED IN THE 2ND HALF OF THIS DOC.

MULTIPLE CHOICE - Choose the one alternative that best completes the statement or answers the question.

1) How much of the Earth's surface is covered by the world's ocean?
   A) 53%
   B) 65%
   C) 71%
   D) 78%
   E) 80%

2) Thelargest percentage of the world's ocean is found in the:
   A) Northern hemisphere.
   B) Southern hemisphere.
   C) Eastern hemisphere.
   D) Western hemisphere.
   E) The ocean is evenly distributed.

3) One of the following is **not** one of the world's major ocean basins:
   A) Atlantic Ocean.
   B) Arctic Ocean.
   C) Indian Ocean.
   D) Antarctic Ocean.
   E) Pacific Ocean.

4) The world's smallest and shallowest ocean is the:
   A) Atlantic Ocean.
   B) Arctic Ocean.
   C) Indian Ocean.
   D) Antarctic Ocean.
   E) Pacific Ocean.

5) The world's largest and deepest ocean is the:
   A) Atlantic Ocean.
   B) Arctic Ocean.
   C) Indian Ocean.
   D) Antarctic Ocean.
   E) Pacific Ocean.

6) Oceanographers often use the name "Southern Ocean" to refer to the body of water:
   A) Around Antarctica
   B) In the South Pacific
   C) South of the North Sea
   D) South of Florida
   E) Around the southern tip of India

7) The **Big Bang** was:
   A) The origin of the Earth's magnetic field
   B) The beginning of plate tectonics and continental drift
   C) The origin of the oceans as water condensed on Earth
   D) The giant cosmic explosion that occurred 13.7 billion years ago and created the Universe.

8) Density is:
   A) The mass of a substance per unit volume
   B) A measure of weight
   C) The mass of a substance multiplied by its percentage volume of water
   D) A measure of volume
   E) The volume occupied by a particular substance in relation to that of water

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9) There is evidence that the Earth and the rest of the solar system formed about:
   A) 5 million years ago.
   B) 1 billion years ago.
   C) 4.5 billion years ago.
   D) 10.5 billion years ago.
   E) 10 million years ago.

10) The semisolid layer of the Earth found below the crust and outside of the core is called the:
   A) Inner core
   B) Mantle
   C) Inner crust
   D) Outer core
   E) Oceanic crust

11) The Earth's magnetic field is thought to be caused by movements of liquid metal in which of the Earth's layers?
   A) Inner core
   B) Outer core
   C) Oceanic crust
   D) Mantle
   E) Continental crust

12) The thinnest layer of the Earth is the:
   A) Inner core.
   B) Outer core.
   C) Crust.
   D) Mantle.

13) Which of the following is **not true** of oceanic crust?
   A) It is thinner than continental crust.
   B) It is denser than continental crust.
   C) It is geologically younger in most places than continental crust.
   D) It lies below sea level.
   E) It consists mostly of granite.

14) Which of the following is **not true** of mid-ocean ridges?
   A) Earthquakes and volcanoes are associated with them.
   B) The sediment covering gets thinner as one moves away from them toward the continents.
   C) The rock on the sea floor is older as one moves away from them.
   D) The seafloor spreading is associated with them.
   E) All are interconnected.

15) Which of the following is **true** about lithospheric plates?
   A) Only contain continental crust
   B) Only contain oceanic crust
   C) Collide with one another at the mid-ocean ridge
   D) Float on the upper mantle
   E) Are directly connected with the inner core of the Earth

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16) Which of the following statements is **NOT** true?
A) Oceanic crust is made of a rock-type called basalt.
B) Oceanic crust is denser than continental crust.
C) Oceanic crust is thinner than continental crust.
D) Oceanic crust is older than continental crust.
E) There are significant chemical differences between oceanic and continental crust.

17) Trenches are formed in areas where:
A) A plate is lifted by another
B) A plate moves along side another in a transform motion
C) A plate splits and opens up
D) Sea floor spreading takes place
E) A plate sinks beneath another

18) The **process** by which a lithospheric plate descends into the mantle is called:
A) Continental drift
B) Induction
C) Sea floor spreading
D) Subduction
E) Faulting

19) The friction zone along the shear boundary such as the one in California between two lithospheric plates is called a:
A) Fault
B) Rift
C) Trench
D) Mid-ocean ridge
E) Sea

20) Which of these places is an example of an island arc along a trench?
A) Aleutian Islands
B) Hawaiian Islands
C) Australia
D) Galápagos Islands
E) Bermuda

21) Which is **not** a type of lithospheric plate boundary?
A) Shear boundary
B) Continental shelf
C) Trench
D) Mid-ocean ridge

22) The type of plate boundary where plates move past each other in a sort of lateral motion is called:
A) Island arc
B) Subduction zone
C) Trench
D) Convection zone
E) Shear boundary

23) Evidence of plate tectonics is provided by:
A) Magnetic anomalies/paleomagnetic evidence
B) Seafloor spreading
C) The existence of mid-ocean ridges
D) Seafloor spreading and the existence of mid-ocean ridges.
E) All of the above

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24) The name of the vast single world ocean that was present about 200 million years ago is:

A) Sinus Borealis
B) Pangaea
C) Tethys
D) Panthalassa
E) Gondwana

25) Lithogenous sediments are those that come from:

A) Plants
B) Living organisms in general
C) Deep-water volcanoes
D) Erosion of land
E) Corals

26) The outer edge of the continental margin is the:

A) Shelf break
B) Continental slope
C) Continental rise
D) Edge of the abyssal plain
E) Continental edge

27) The **steepest** part of the continental margin where it descends down to the ocean floor is known as the:

A) Shelf break
B) Continental slope
C) Continental rise
D) Edge of the abyssal plain
E) Continental edge

28) The shallow part of the continental margin that is closer to land and is a critical marine habitat because light can reach all the way to the bottom in most of it is known as:

A) Shelf break
B) Continental slope
C) Continental rise
D) Edge of the abyssal plain
E) Continental shelf

29) The west coast of South America is an active continental margin. As such, it is characterized by all of the following **except**:

A) Earthquakes
B) Volcanoes
C) Wide continental shelf
D) Steep and rocky shorelines
E) Steep continental slope

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30) The east coast of the United States is a passive continental margin that is characterized by:

A) Mountains along the coast
B) Steep and rocky shorelines
C) Narrow continental shelf
D) Offshore trench
E) Gentle continental slope

31) Black smoker stacks or columns form as a result of the accumulation of:

A) Deep-water animals
B) Lava
C) Biogenous sediments
D) Metallic sulfides minerals reacting with seawater
E) Material released from the formation of trenches

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32) Sea levels have naturally fluctuated through the vast epochs of geologic time. What is occurring now with regards to sea level?
A) Sea level is falling due to the beginning of another ice age.
B) Sea levels are projected to continue rising at this time.
C) Sea level remains stable no matter the change in Earth's climate.
D) Scientists are not able to accurately measure sea level.
E) The intensified greenhouse effect has caused sea levels to fall.

33) The most biologically rich part of the ocean is the:
A) Shelf break
B) Continental shelf
C) Continental slope
D) Continental rise
E) Deep-sea floor

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34) Volcanic islands and submarine volcanoes are found through the deep-sea floor, which is known as the _____.
A) abyssal plane
B) guyot region
C) central rift valley
D) Pangaea plane

35) Who proposed the first detailed hypothesis of continental drift (and first used the phrase), theorizing that all continents had once been joined together in a "supercontinent"?
A) Charles Darwin
B) Alfred Wegener
C) Francis Bacon
D) James Hutton

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Answer Key

Test name: CH-02

1) C
2) B
3) D
4) B
5) E
6) A
7) D
8) A
9) C
10) B
11) B
12) C
13) E
14) B
15) D
16) D
17) E
18) D
19) A
20) A
21) B
22) E
23) E
24) D
25) D
26) A
27) B
28) E
29) C
30) E
31) D
32) B
33) B
34) A
35) B

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