

# Chapter 23

# The Ocean Basins

## Chapter Outline

### 1 The Water Planet

Divisions of the Global Ocean  
Exploration of the Ocean



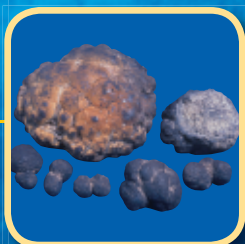
### 2 Features of the Ocean Floor

Continental Margins  
Deep-Ocean Basins



### 3 Ocean-Floor Sediments

Sources of Deep Ocean–  
Basin Sediments  
Physical Classification of  
Sediments



## Why It Matters

Oceans cover more than 70 percent of Earth's surface. Oceans interact with the atmosphere to influence weather and climate. Exploring and analyzing data about the chemistry of ocean water, the geology of the ocean floor, marine ecosystems, and the physics of water movement is critical to understanding natural processes on Earth.

## Inquiry Lab

 20 min

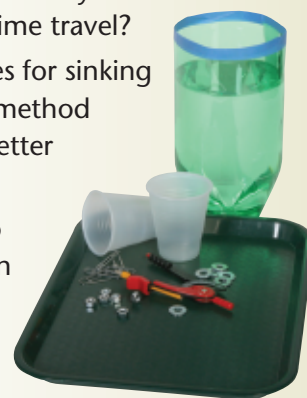
### Sink or Float?



Fill the **bottom half of 3-L soda bottle** with **water** to within about 3 inches from the top and place it on a **plastic or metal tray** to catch any spills. Using small **(3-oz) plastic cups**, with some **paper clips** and **metal nuts** for ballast, see if you can get a cup to sink with air still trapped inside, simulating a submersible. You may need something pointed to make holes in the cups.

### Questions to Get You Started

1. What is buoyancy and why is it so important for maritime travel?
2. Compare techniques for sinking the cup. Does one method consistently work better than others?
3. What challenges do engineers face when designing submersibles?



## Science Terms

**Everyday Words Used in Science** Many words used in science are familiar words from everyday speech. However, the meanings of these everyday words are often different from their meanings in scientific contexts.

**Your Turn** Before you read this chapter, write down an informal definition of what the word *margin* means to you. As you come across this word in the chapter, write the scientific definition next to your informal definition. For each definition, write a sentence that uses the word *margin* correctly.

## Classification

**Classifying Sediments** Classification is a tool for organizing objects and ideas by grouping them into categories. Groups are classified by defining characteristics. For example, the table below shows how sediments can be classified by their composition.

**Your Turn** As you read the chapter, complete a table like the one shown here for the three types of sediments described in Section 3.

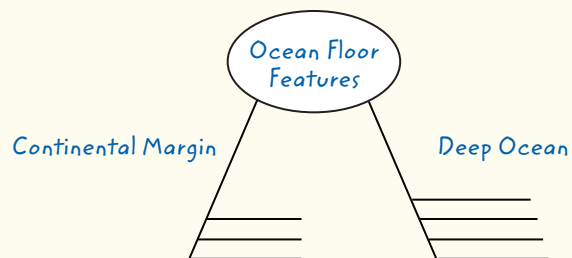
| Type of Sediment | Characteristics                                          |
|------------------|----------------------------------------------------------|
| Inorganic        | Carried from land to ocean by rivers, wind, and icebergs |
| Biogenic         |                                                          |
| Chemical         |                                                          |

## Graphic Organizers

**Spider Maps** Spider maps show how details are organized into categories, which in turn are related to a main idea. To make a spider map, follow the steps.

- 1 Write a main topic title, and draw an oval around it.
- 2 From the oval, draw legs. Each leg represents a category of the main topic.
- 3 From each leg, draw horizontal lines. Write details about each category on these lines.

**Your Turn** As you read Section 2, use a spider map to organize the information that you learn about features of the ocean floor.



For more information on how to use these and other tools, see **Appendix A**.

# The Water Planet

## Key Ideas

- Name the major divisions of the global ocean.
- Describe how oceanographers study the ocean.
- Explain how sonar works.

## Key Terms

**global ocean**  
**sea**  
**oceanography**  
**sonar**

## Why It Matters

New ways to explore the cold, dark ocean depths have revealed to us the bizarre life forms that thrive there.

Nearly three-quarters of Earth's surface lies beneath a body of salt water called the **global ocean**. No other known planet has a similar covering of liquid water. Only Earth can be called the *water planet*.

The global ocean contains more than 97% of all of the water on or near Earth's surface. Although the ocean is the most prominent feature of Earth's surface, the ocean is only about 1/4,000 of Earth's total mass and only 1/800 of Earth's total volume.

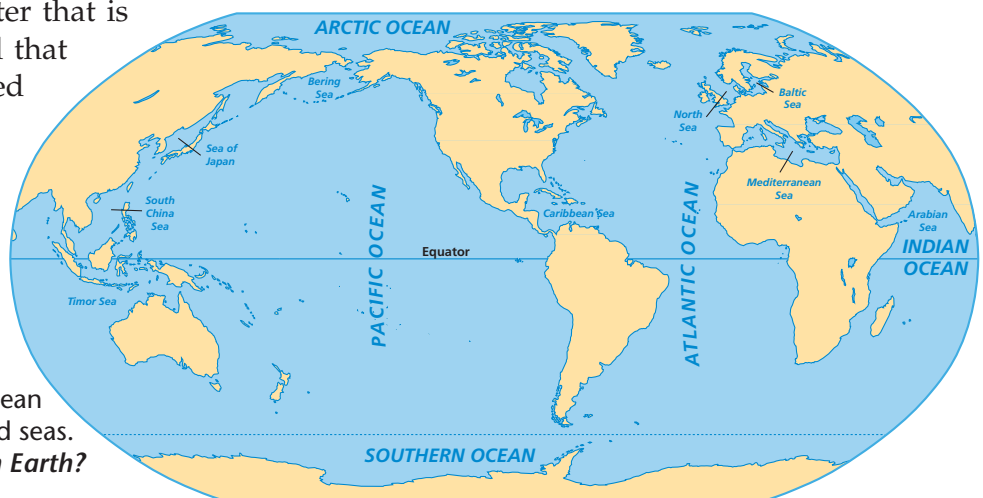
## Divisions of the Global Ocean

As shown in **Figure 1**, the global ocean is divided into five major oceans. These major oceans are the Atlantic, Pacific, Indian, Arctic, and Southern Oceans. Each ocean has special characteristics. The Pacific Ocean is the largest ocean on Earth's surface. It contains more than one-half of the ocean water on Earth. With an average depth of 4.3 km, the Pacific Ocean is also the deepest ocean. The next largest ocean is the Atlantic Ocean. The Atlantic Ocean has an average depth of 3.9 km. The Indian Ocean is the third-largest ocean and has an average depth of 3.9 km. The Southern Ocean is the fourth-largest ocean and extends from the coast of Antarctica to 60°S latitude. The Arctic Ocean is the smallest ocean, and it surrounds the North Pole.

A **sea** is a body of water that is smaller than an ocean and that may be partially surrounded by land. Examples of major seas include the Mediterranean Sea, the Caribbean Sea, and the South China Sea.

**global ocean** the body of salt water that covers nearly three-fourths of Earth's surface

**sea** a large, commonly saline body of water that is smaller than an ocean and that may be partially or completely surrounded by land



**Figure 1** The global ocean is divided into oceans and seas. *How many oceans are on Earth?*

**oceanography** the scientific study of the ocean, including the properties and movements of ocean water, the characteristics of the ocean floor, and the organisms that live in the ocean

SciLINKS

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Topic: The Oceans  
Code: HQX1069

### Academic Vocabulary

**research** (REE SUHRCH) a careful search for and study of information

## Exploration of the Ocean

The study of the physical and geological characteristics, chemical composition, and life-forms of the ocean is called **oceanography**. Although some ancient civilizations studied the ocean, modern oceanography did not begin until the 1850s.

### The Birth of Oceanography

An American naval officer named Matthew F. Maury used records from navy ships to learn about ocean currents, winds, depths, and weather conditions. In 1855, he published these observations as one of the first textbooks about the oceans. Then, from 1872 to 1876, a team of scientists aboard the British Navy ship *HMS Challenger* crossed the Atlantic, Indian, and Pacific Oceans. The scientists measured water temperatures at great depths and collected samples of ocean water, sediments, and thousands of marine organisms. The voyages of the *HMS Challenger* laid the foundation for the modern science of oceanography.

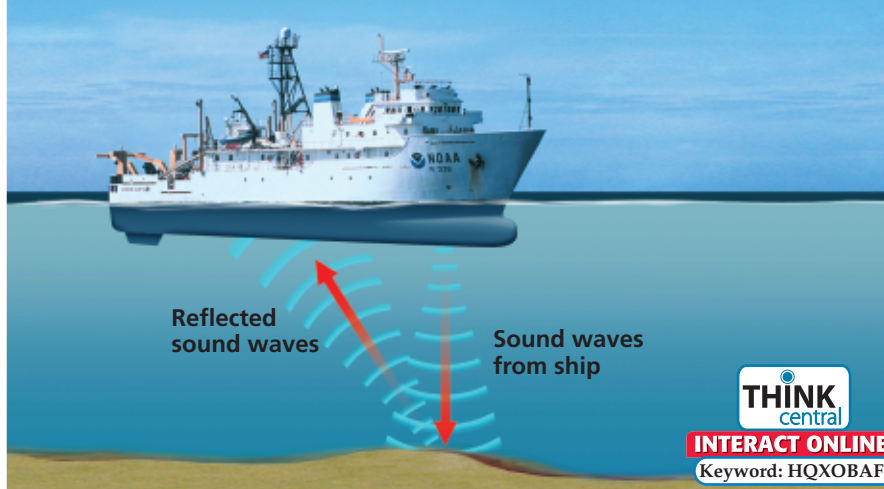
Today, many ships perform oceanographic research. In the 1990s and in the beginning of the 21st century, the research ship *JOIDES Resolution* was the world's largest and most sophisticated scientific drilling ship. Samples drilled by *JOIDES Resolution*, shown in **Figure 2**, provide scientists with valuable information about plate tectonics and the ocean floor. The Japanese ship *CHIKYU*, which is operated by the Integrated Ocean Drilling Program, is one of the most advanced drilling ships now in use.

**Reading Check** List three characteristics of the ocean that oceanographers study. (See Appendix G for answers to Reading Checks.)



**Figure 2** Reentry cones (above) are used so that core samples can later be taken from the same place on the ocean floor. Scientists aboard the research ship *JOIDES Resolution* (right) perform scientific studies of the ocean floor.





**Figure 3** Active sonar sends out a pulse of sound. The pulse, called a *ping* because of the way it sounds, reflects when it strikes a solid object.

## READING TOOLBOX

### Classification

Classify each type of tool used to collect data from oceans, including records from ships, samples taken from ships, sonar, and submersibles, as surface tools or deep-ocean tools.

## Sonar

Oceanographic research ships are often equipped with sonar. **Sonar** is a system that uses acoustic signals and returned echoes to determine the location of objects or to communicate. Sonar is an acronym for *sound navigation and ranging*. A sonar transmitter sends out a continuous series of sound waves from a ship to the ocean floor, as shown in **Figure 3**. The sound waves travel at about 1,500 m/s through sea water and bounce off the solid ocean floor. The waves reflect back to a receiver. Scientists measure the time that the sound waves take to travel from the transmitter, to the ocean floor, and to the receiver in order to calculate the depth of the ocean floor. Scientists then use this information to make maps and profiles of the ocean floor.

**sonar** *sound navigation and ranging*, a system that uses acoustic signals and returned echoes to determine the location of objects or to communicate

## Quick Lab

### Sonar



30 min

### Procedure

- 1 Use **heavy string** to tie one end of a **spring** securely to a **doorknob**. Pull the spring taut and parallel to the floor. You will need to keep the tension of the spring constant throughout the lab.
- 2 Use **masking tape** to mark the floor directly beneath the hand that is holding the spring taut. Use a **meterstick** to measure and record the distance from that hand to the doorknob.
- 3 Note the time on a **stopwatch or clock with a second hand**. Hold the spring taut, and hit the spring horizontally to create a compression wave.
- 4 Check the time again to see how long the pulse takes to travel to the doorknob and back to your hand. Record the time.
- 5 Repeat steps 2 to 4 three times. Each time, hold the spring 60 cm closer to the doorknob. Keep tension constant by gathering coils as necessary.

- 6 Calculate the rate of travel for each trial by multiplying the distance between your hand and the doorknob by 2. Then, divide by the number of seconds the pulse took to travel to the doorknob and back.



### Analysis

1. Did the rate the pulse traveled change during the course of the investigation?
2. If a pulse took 3 s to travel to the doorknob and back to your hand, what is the distance from the doorknob to your hand?
3. How is the apparatus you used similar to sonar? How is the apparatus different than sonar? Explain.



## Submersibles

Underwater research vessels, called *submersibles*, also enable oceanographers to study the ocean depths. Some submersibles are piloted by people. One such submersible is the *bathysphere*, a spherical diving vessel that remains connected to the research ship for communications and life support. Another type of piloted submersible, called a *bathyscaph*, is a self-propelled, free-moving submarine. One of the most well-known bathyscaphs is the *Alvin*. Another modern submersible, called *Nautil* (NOH teel), is shown in **Figure 4**.



**Figure 4** The submersible *Nautil* (top) carries enough oxygen to keep a three-person crew underwater for more than five hours. Deep-sea submersibles have discovered many strange organisms in the deep ocean, such as this angler fish (bottom).

Other modern submersibles are submarine robots. They can take photographs, collect mineral samples from the ocean floor, and perform many other tasks. These robotic submersibles are remotely piloted and allow oceanographers to study the ocean depths for long periods of time.

## Underwater Research

Submersibles have helped scientists make exciting discoveries about the deep ocean. During one dive in a submersible, startled oceanographers saw communities of unusual marine life living at depths and temperatures where scientists thought that almost no life could exist. Giant clams, blind white crabs, and giant tube worms were some of the strange life-forms that were discovered. Many of these life-forms have unusual adaptations that allow them to live in hostile environments. The angler fish, shown in **Figure 4**, can produce its own light, which attracts prey.

## Section 1 Review

### Key Ideas

- 1. Name** the five major divisions of the global ocean.
- 2. Explain** the difference between an ocean and a sea.
- 3. Define** *oceanography*.
- 4. Describe** two ways that oceanographers study the ocean.
- 5. Explain** how sonar works.
- 6. Describe** two aspects of the ocean that submersibles are used to study.
- 7. List** three types of submersibles.

### Critical Thinking

- 8. Evaluating Ideas** Most submarines use sonar as a navigation aid. How would sonar enable an underwater vessel to move through the ocean depths?
- 9. Analyzing Methods** Why are submarine robots more practical for deep-ocean research than submersibles designed to carry people are?

### Concept Mapping

- 10.** Use the following terms to create a concept map: *oceanography*, *submersible*, *bathysphere*, *bathyscaph*, *robot submersible*, and *sonar*.

# Features of the Ocean Floor

## Key Ideas

- Describe the main features of the continental margins.
- Describe the main features of the deep-ocean basin.

## Key Terms

**continental margin**  
**deep-ocean basin**  
**trench**  
**abyssal plain**

## Why It Matters

Shelves and basins are features not just of your kitchen but of the ocean floor—home to the tallest mountains and flattest plains on Earth.

The ocean floor can be divided into two major areas, as shown in **Figure 1**. The **continental margins** are shallow parts of the ocean floor that are made of continental crust and a thick wedge of sediment. The other major area is the **deep-ocean basin**, which is made of oceanic crust and a thin sediment layer. It forms the deep part of the ocean beyond the continental margin.

## Continental Margins

The line that divides the continental crust from the oceanic crust is not abrupt or distinct. Shorelines are not the true boundaries between the oceanic crust and the continental crust. The boundaries are actually some distance offshore and beneath the ocean and the thick sediments of the continental margin.

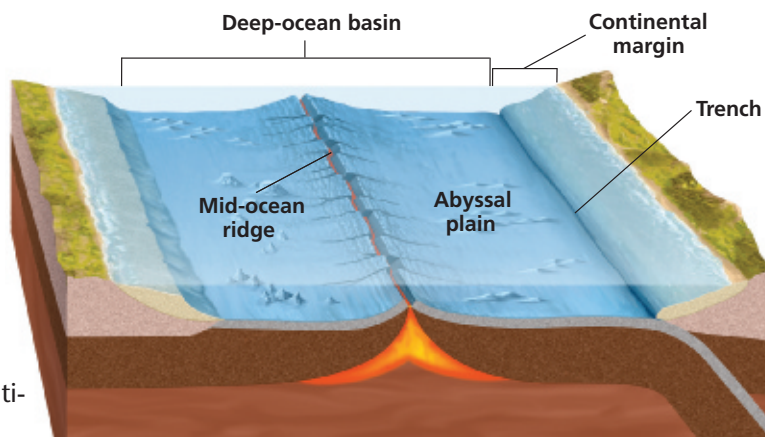
## Continental Shelf

Continents are outlined in most places by a zone of shallow water where the ocean covers the edge of the continent. The part of the continent that is covered by water is called a *continental shelf*. The shelf usually slopes gently from the shoreline and drops about 0.12 m every 100 m. The average depth of the water covering a continental shelf is about 60 m. Though underwater, a continental shelf is part of the continental margin, not the deep-ocean basin.

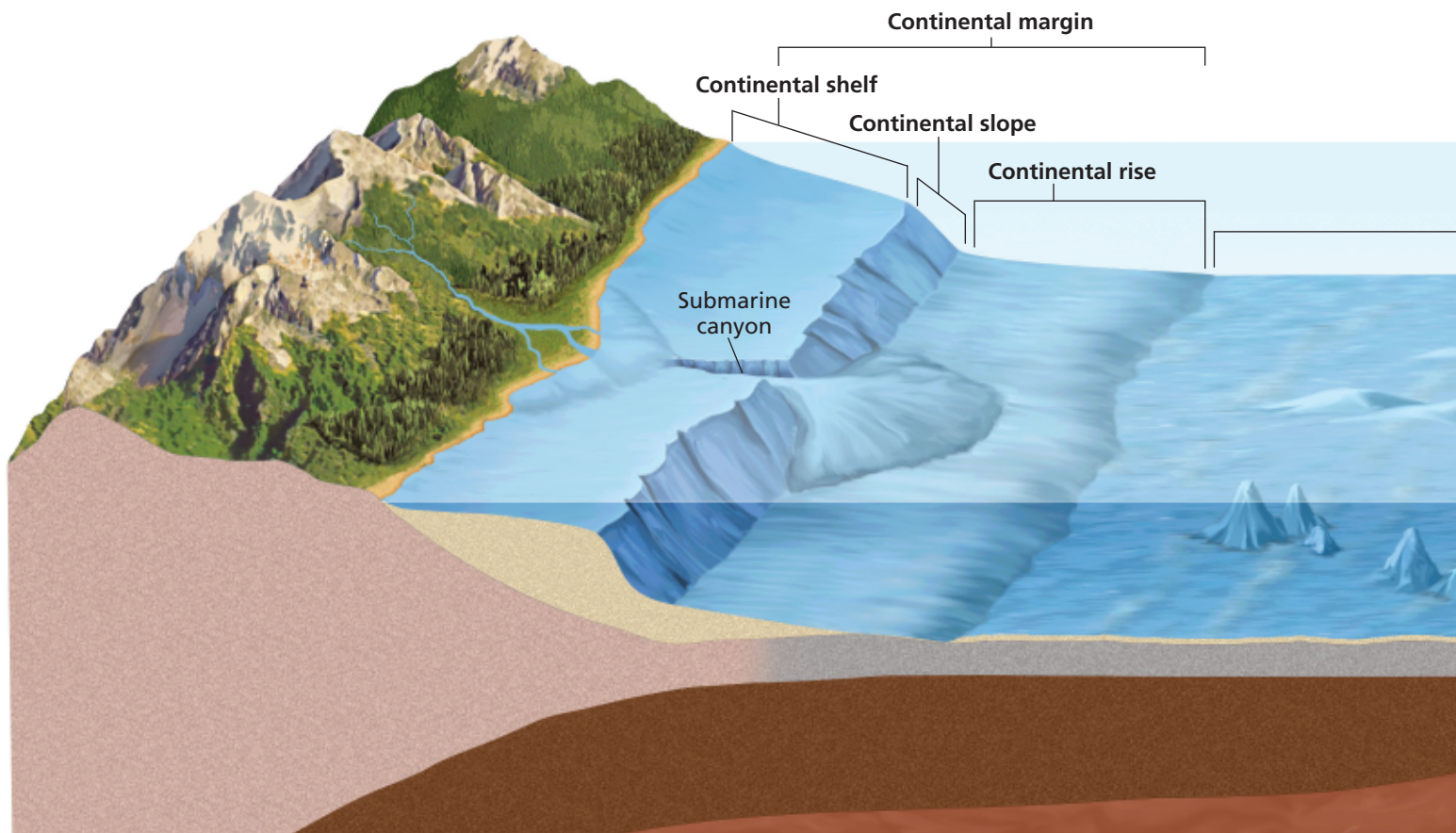
Changes in sea level affect the continental shelves. During glacial periods, continental ice sheets hold large amounts of water. So, sea level falls and exposes more of the continental shelf to weathering and erosion. But if ice sheets melt adding water to the oceans, sea level rises and covers the continental shelf.

**continental margin** the shallow sea floor that is located between the shoreline and the deep-ocean bottom

**deep-ocean basin** the part of the ocean floor that is under deep water beyond the continental margin and that is composed of oceanic crust and a thin layer of sediment



**Figure 1** The ocean floor includes the continental margins and the deep-ocean basin.



**Figure 2** The ocean floor is made of distinct areas and features.

### READING TOOLBOX

#### Everyday Words Used in Science

Use a dictionary to write alternate definitions for the multiple meaning words *shelf* and *slope*. Compare these definitions to the scientific definitions used here.

## Continental Slope and Continental Rise

At the seaward edge of a continental shelf is a steeper slope called a *continental slope*. The boundary between the continental crust and the oceanic crust is located at the base of the continental slope. Along the continental slope, the ocean depth increases by several thousand meters within an average distance of about 20 kilometers, as shown in **Figure 2**. The continental shelf and continental slope may be cut by deep V-shaped valleys. These deep valleys are called *submarine canyons*. These deep canyons are often found near the mouths of major rivers. Other canyons may form over time as very dense currents called *turbidity currents* carry large amounts of sediment down the continental slopes. Turbidity currents form when earthquakes cause underwater landslides or when large sediment loads run down a slope. These sediments form a wedge at the base of the continental slope called a *continental rise*.

## Deep-Ocean Basins

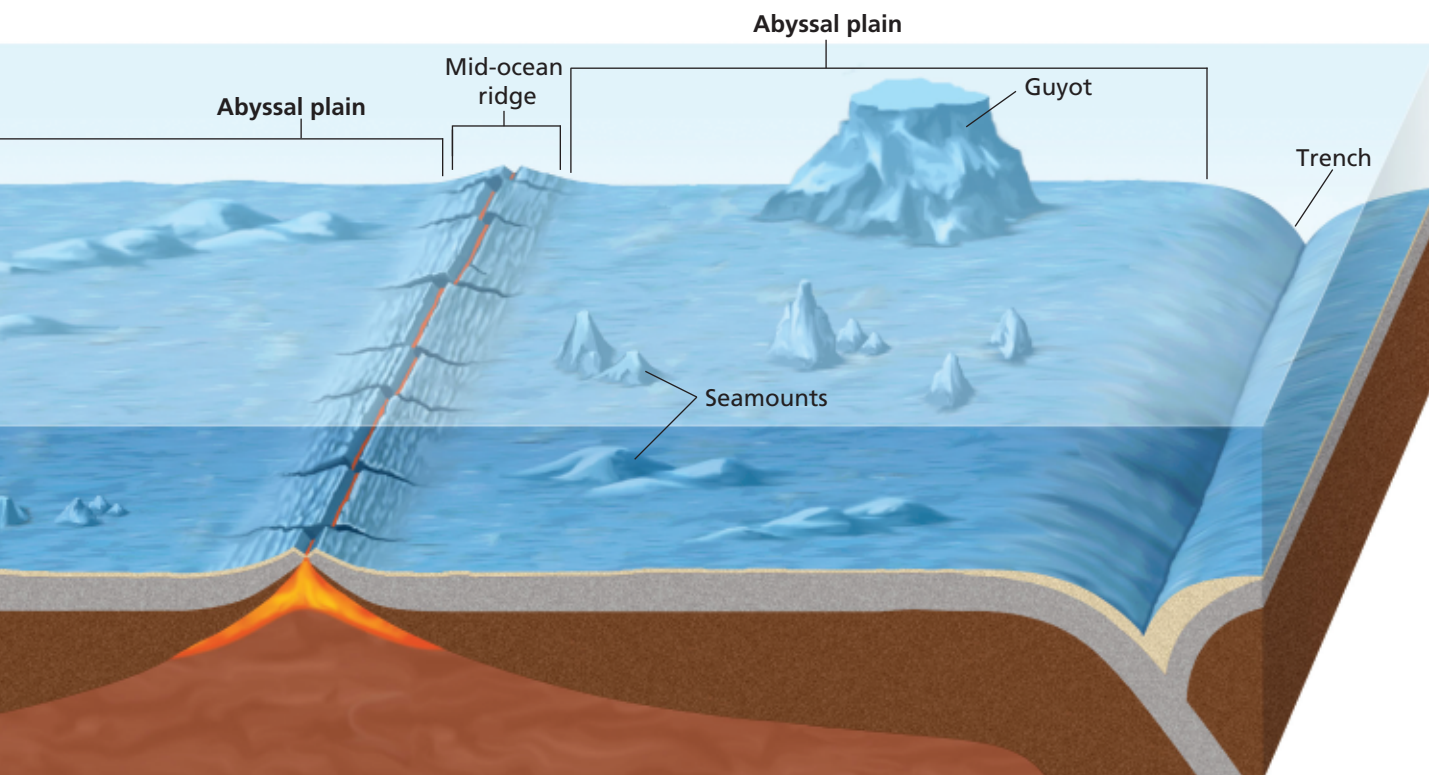
Deep-ocean basins also have distinct features, as shown in **Figure 2**. These features include broad, flat plains; submerged volcanoes; gigantic mountain ranges; and deep trenches. In the deep-ocean basins, the mountains are higher and the plains are flatter than any features found on the continents.

**Reading Check** What features are located in the deep-ocean basins?

SCILINKS

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Topic: Ocean-Floor Features  
Code: HQX1067



## Trenches

Long, narrow depressions located in the deep-ocean basins are called **trenches**. At more than 11,000 m deep, the Mariana Trench, in the western Pacific Ocean, is the deepest place in Earth's crust. Trenches form where one tectonic plate subducts below another plate. Earthquakes occur near trenches. Volcanic mountain ranges and volcanic island arcs also form near trenches.

## Abyssal Plains

The vast, flat areas of the deep-ocean basins where the ocean is more than 4 km deep are called **abyssal plains** (uh BIS uhl PLAYNZ). Abyssal plains cover about half of the deep-ocean basins and are the flattest regions on Earth. In some places, the ocean depth changes less than 3 m over more than 1,300 km.

Layers of fine sediment cover the abyssal plains. Ocean currents and wind carry some sediments from the continental margins. Other sediment is made when organisms that live in the ocean settle to the ocean floor when they die.

The thickness of sediments on the abyssal plains is determined by three factors. The age of the oceanic crust is one factor. Older crust is generally covered with thicker sediments than younger crust is. The distance from the continental margin to the abyssal plain also determines how much sediment reaches the plain from the continent. Third, the sediment cover on abyssal plains that are bordered by trenches is generally thinner than the sediment cover on abyssal plains that are not bordered by trenches.

**trench** a long, narrow, and steep depression that forms on the ocean floor as a result of subduction of a tectonic plate, that runs parallel to the trend of a chain of volcanic islands or the coastline of a continent, and that may be as deep as 11 km below sea level; also called an *ocean trench* or a *deep-ocean trench*

**abyssal plain** a large, flat, almost level area of the deep-ocean basin

## Academic Vocabulary

**layer** (LAY uhr) a separate or distinct portion of matter that has thickness



**Figure 3** The white ridges in this photo are coral reefs of an atoll that formed in the shallow waters around a volcanic island. Erosion is changing the island into a guyot.

## Mid-Ocean Ridges

The most prominent features of ocean basins are the *mid-ocean ridges*, which form underwater mountain ranges that run along the floors of all oceans. Mid-ocean ridges rise above sea level in only a few places, such as in Iceland. Mid-ocean ridges form where plates pull away from each other. A narrow depression, or rift, runs along the center of the ridge. Through this rift, magma reaches the sea floor and forms new lithosphere. This new lithosphere is less dense than the old lithosphere. As the new lithosphere cools, it becomes denser and begins to sink as it moves away from the rift. Fault-bounded blocks of crust that form parallel to the ridges as the lithosphere cools and contracts are called *abyssal hills*.

As ridges adjust to changes in the direction of plate motions, they break into segments that are bounded by faults. These faults create areas of rough topography called *fracture zones*, which run perpendicularly across the ridge.

## Seamounts

Submerged volcanic mountains that are taller than 1 km are called *seamounts*. Seamounts form in areas of increased volcanic activity called *hot spots*. Seamounts that rise above the ocean surface form oceanic islands. As tectonic plate movements carry islands away from a hot spot, the islands sink and are eroded by waves to form flat-topped, submerged seamounts called *guyots* (GEE OHZ) or *tablemounts*. An intermediate stage in this process, called an *atoll*, is shown in **Figure 3**.

## Section 2 Review

### Key Ideas

1. **Describe** the three main sections of the continental margins.
2. **Describe** where the boundary between the oceanic crust and the continental crust is located.
3. **Explain** how turbidity currents are related to submarine canyons.
4. **List** four main features of the deep-ocean basins, and describe one characteristic of each feature.
5. **Compare** seamounts, guyots, and atolls.
6. **Explain** the difference between the meanings of the terms *continental margin*, *continental shelf*, *continental slope*, and *continental rise*.

### Critical Thinking

7. **Making Inferences** The Pacific Ocean is surrounded by trenches, but the Atlantic Ocean is not. In addition, the Pacific Ocean is wider than the Atlantic Ocean, and much of the crust under the Pacific Ocean is very young. Which ocean's abyssal plain has thicker sediments? Explain your answer.
8. **Determining Cause and Effect** If sea level were to fall significantly, what would happen to the continental shelves?

### Concept Mapping

9. Use the following terms to create a concept map: *continental margin*, *deep-ocean basin*, *continental shelf*, *continental slope*, *continental rise*, *trench*, *abyssal plain*, and *mid-ocean ridge*.

# Ocean-Floor Sediments

## Key Ideas

- Describe the formation of ocean-floor sediments.
- Explain how ocean-floor sediments are classified by their physical composition.

## Key Terms

**core sample**  
**nodule**

## Why It Matters

Products you use every day contain ocean-floor sediments.

Continental shelves and slopes are covered with sediments. Sediments are carried into the ocean by rivers, are washed away from the shoreline by wave erosion, or settle to the ocean bottom when the organisms that created them die. The composition of ocean sediments varies and depends on which part of the ocean floor the sediments form in. The sediments are fairly well sorted by size. Coarse gravel and sand are usually found close to shore because these heavier sediments do not move easily offshore. Lighter particles are suspended in ocean water and are usually deposited at a great distance from shore.

## Sources of Deep Ocean–Basin Sediments

Sediments found in the deep-ocean basin, which is beyond the continental margin, are generally finer than those found in shallow water. Samples of the sediments in the deep-ocean basins can be gathered by scooping up sediments or by taking core samples. **Core samples** are cylinders of sediment that are collected by drilling into sediment layers on the ocean floor. **Figure 1** shows a core sample being studied aboard the research vessel *JOIDES Resolution*.

The study of sediment samples shows that most of the sediments in the deep-ocean basins are made of materials that settle slowly from the ocean water above. These materials may come from organic or inorganic sources.

**core sample** a cylindrical piece of sediment, rock, soil, snow, or ice that is collected by drilling



**Figure 1** A scientist studies a core sample that was brought up from the drill aboard the research ship *JOIDES Resolution*.



**Figure 2** This picture of sediment emptying out of the Mahakam River in Indonesia was taken by astronauts aboard the space shuttle *Columbia*.

## Inorganic Sediments

Some ocean-basin sediments are rock particles that were carried from land by rivers. When a river empties into the ocean, the river deposits its sediment load, as shown in **Figure 2**. Most of these sediments are deposited along the shore and on the continental shelf. However, large quantities of these sediments occasionally slide down continental slopes to the ocean floor below. The force of the slide creates powerful turbidity currents that spread the sediments over the continental rise and abyssal plains. Other deep ocean-basin sediments consist of fine particles of rock, including volcanic dust, that have been blown great distances out to sea by the wind. These particles land on the surface of the water, sink, and gradually settle to the bottom of the ocean.

Icebergs also provide sediments that can end up on the ocean basins. As a glacier moves across the land, the glacier picks up rock. The rock becomes embedded in the ice and moves with the glacier. When an iceberg breaks from the glacier, drifts out to sea, and melts, the rock material sinks to the ocean floor.

Even meteorites contribute to deep ocean-basin sediments. Much of a meteorite vaporizes as it enters Earth's atmosphere. The remaining cosmic dust falls to Earth's surface. Because most of Earth's surface is ocean, most meteorite fragments fall into the ocean and become part of the sediments on the ocean floor.

## Why It Matters

### How Do You Turn Mud into Money?

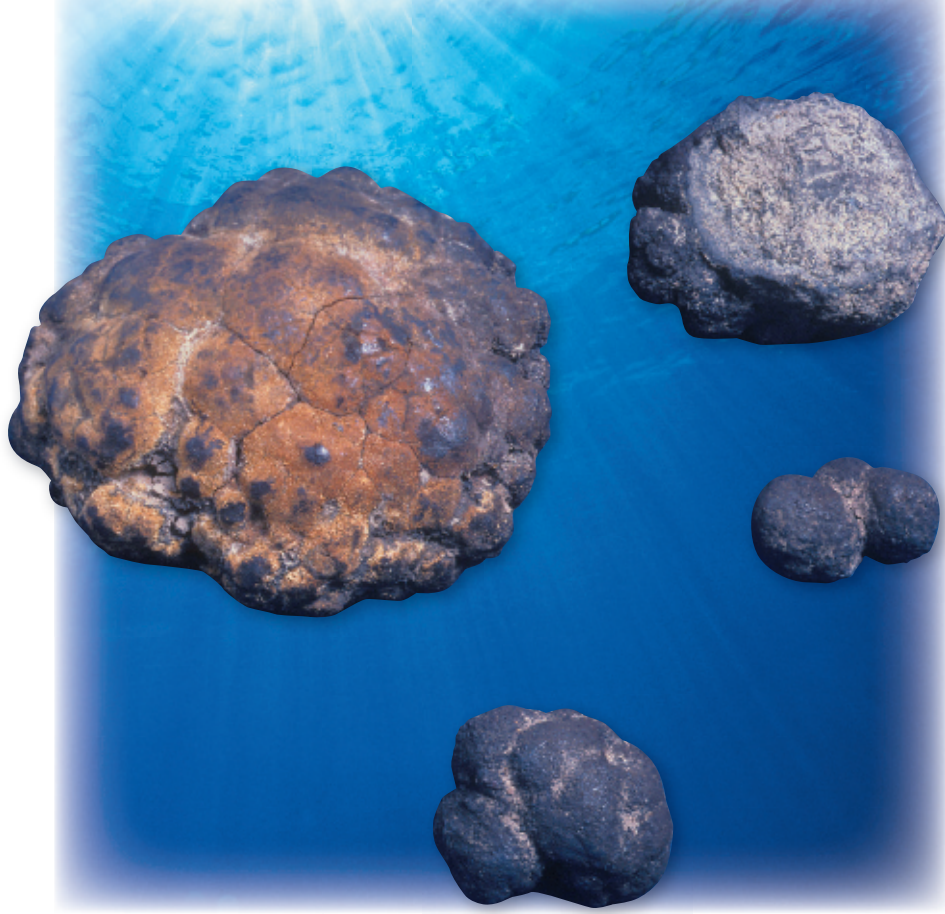
Oozy mud from underwater may not seem particularly valuable, but ocean sediments are part of a wide variety of familiar products. For example, diatomaceous earth, which comes from the hardened deposits of siliceous oozes, is added to some products for its abrasive qualities. Abrasive qualities are important in such products as toothpaste and metal polishes. Many paints also have diatomaceous earth mixed with them as fine grit.



**YOUR TURN**

#### ONLINE RESEARCH

What are some of the environmental impacts of marine mining?



**Figure 3** Nodules, such as these mined from the East Pacific Rise, are rich in a variety of minerals.

## Biogenic Sediments

In many places on the ocean floor, almost all of the sediments are *biogenic*, meaning that the sediments were originally produced by living organisms. Biogenic sediments are the remains of marine plants, animals, and other organisms. The two most common compounds that make up organic sediments are silica,  $\text{SiO}_2$ , and calcium carbonate,  $\text{CaCO}_3$ . Silica comes primarily from microscopic organisms called *diatoms* and *radiolarians*. Calcium carbonate comes mostly from the skeletons of tiny organisms called *foraminifera*.

## Chemical Deposits

When substances that are dissolved in ocean water crystallize, these materials can form mineral deposits on the ocean floor. Some of these mineral deposits are potato-shaped lumps called **nodules**. Nodules, such as the ones shown in **Figure 3**, are commonly located on the abyssal plains. Nodules are composed mainly of the oxides of manganese, nickel, copper, and iron. Other minerals, such as phosphates, are also carried in the ocean water before they crystallize and form mineral deposits on the ocean floor.

 **Reading Check** How do nodules form?

## Math Skills

### Ocean-Floor Sediments

Ocean-floor sediments are composed of an average of 54% biogenic sediments, 45% Earth rocks and dust, less than 1% precipitation of dissolved materials (nodules and phosphates), and less than 1% of rocks and dust from space. If you collected 10,000 kg of ocean-floor sediment, how many kilograms of each type of ocean-floor sediment would you expect to find?

## Quick Lab

 20 min

### Diatoms

#### Procedure

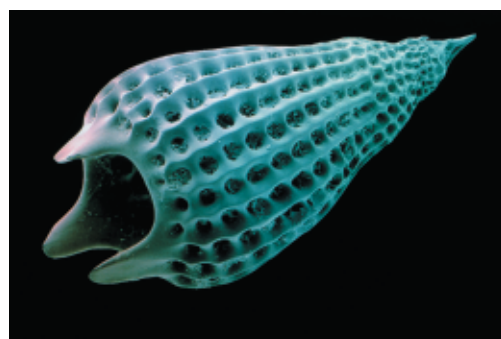
- 1 Observe **diatoms** under a **microscope**.
- 2 Sketch what you see. Make sure to note the magnification.

#### Analysis

1. What characteristics of the diatoms did you observe?
2. Propose one possible function for each of the structures you observed.

**nodule** a lump of minerals that is made of oxides of manganese, iron, copper, or nickel and that is found in scattered groups on the ocean floor

**Figure 4** The remains of diatoms (left) and radiolarians (right), both magnified hundreds of times in these photos, are important components of biogenic sediments on the ocean floor.



## READING TOOLBOX

### Spider Maps

Create a spider map that has two legs and several lines on each leg. Use the map to compare muds and ooze.



### Academic Vocabulary

**classify** (CLAH sih fie) to arrange or divide into categories according to type

SCILINKS

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Topic: Ocean-Floor  
Sediments  
Code: HQX1068

## Physical Classification of Sediments

Deep ocean-floor sediments can be classified into two basic types. *Muds* are very fine silt- and clay-sized particles of rock. One common type of mud on the abyssal plains is red clay. Red clay is made of at least 40% clay particles and is mixed with silt, sand, and biogenic material. This clay can vary in color from red to gray, blue, green, or yellow-brown. About 40% of the ocean floor is covered with soft, fine sediment called *ooze*. At least 30% of the ooze is biogenic materials, such as the remains of microscopic sea organisms. The remaining material is fine mud.

Ooze can be classified into two types. *Calcareous ooze* is ooze that is made mostly of calcium carbonate. Calcareous ooze is never found below a depth of 5 km, because at depths between 3 km and 5 km, calcium carbonate dissolves in the deep, cold ocean water. *Siliceous ooze*, which can be found at any depth, is made of mostly silicon dioxide, which comes from the shells of radiolarians and diatoms. Examples of remains of these organisms are shown in **Figure 4**. Most siliceous ooze is found in the cool, nutrient-rich ocean waters around Antarctica because of the abundance of diatoms and radiolarians in that location.

## Section 3 Review

### Key Ideas

- Describe** the formation of two different types of ocean-floor sediments.
- Summarize** how icebergs contribute to deep ocean-basin sediments.
- Explain** how substances that are dissolved in ocean water travel to the ocean floor.
- Explain** how ocean-floor sediments are classified by physical composition.
- Describe** how scientists define the word *mud*.
- Compare** the compositions of calcareous ooze and siliceous ooze.

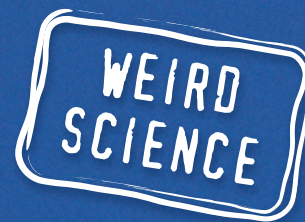
### Critical Thinking

- Making Inferences** What could you infer from a core sample of a layer of sediment that contains volcanic ash and dust?
- Applying Ideas** Some businesses have tried to develop methods of extracting nodules from the ocean. Name two factors that businesses should consider when they are determining whether extracting nodules is profitable.

### Concept Mapping

- Use the following terms to create a concept map: *nodule*, *inorganic sediment*, *biogenic sediment*, *diatom*, *chemical deposit*, and *ocean-floor sediment*.

# Underwater Aliens



Thousands of meters underwater, how can any life exist in the extreme pressure, cold, and darkness? These conditions are as inhospitable to humans as another planet might be. Yet, with ever-improving technologies for exploring the ocean depths, scientists have been discovering underwater creatures that are stranger than science fiction. Peculiar traits of deep-sea organisms represent evolutionary adaptations to the extreme pressure, cold, and darkness of their environment. These discoveries raise new scientific questions, such as did shallow water species colonize the deep ocean or vice versa?



This boxfish is one of the new exotic deep-sea creatures recently discovered by scientists exploring Southeast Asia's Celebes Sea.



Nicknamed "big red" because of its unusual deep red color, this bizarre new bell-shaped species of jellyfish is a meter in diameter and was discovered in the deep waters off the California coast.

Known for their mismatched eyes, one of which is larger than the other to scope for prey in the deep's darkness, jewel squid live 500 meters beneath the surface of the North Atlantic.



This carnivorous moonsnail lives in the Antarctic deep sea. The polyps, covering its shell, use the moonsnail as transport to food sources.



Scientists found this cartoon-like squid among other new species while mapping a deep-sea mountain range in the North Atlantic.



This tiny shrimp-like creature is an amphipod. It is nearly transparent and therefore almost invisible in the murky surroundings of the deep ocean.



## YOUR TURN

### ONLINE RESEARCH

What are some of the more unusual adaptations that allow some marine life to live at extreme ocean depths? Explain why such adaptations are helpful.

### CRITICAL THINKING

What harm might human interference from deep-sea mining have on these deep-sea creatures?

## What You'll Do

- **Observe and record** the settling rates of four different sediments.
- **Draw conclusions** about how particle size affects settling rate.
- **Identify** factors that affect settling rate of sediments besides particle size.

## What You'll Need

balance, metric column, clear plastic, 80 cm × 4 cm  
cup, paper  
pencil, grease  
ring stand with clamp  
ruler, metric  
sieve, 4 mm, 2 mm, 0.5 mm  
soil, coarse, medium, medium-fine, and fine grain  
stopper, rubber  
stopwatch  
tape, adhesive  
teaspoon  
towels, paper  
water

## Safety



# Ocean-Floor Sediments

Most of the ocean floor is covered with a layer of sediment that varies in thickness from 0.3 km to more than 1 km. Much of this sediment is thought to have originated on land through the process of weathering. Through erosion, the sediment has made its way to the deep-ocean basins. In this lab, you will use sediment samples of four particle sizes to determine the relationship between the size of particles and the settling rate of the particles in water.

## Procedure

- 1 Take one sample of sediment from each of the following size ranges: coarse, medium, medium-fine, and fine.
- 2 Plug one end of the plastic column with a rubber stopper, and secure the stopper to the column with tape. Place the column in a vertical position using the ring stand and clamp. Carefully fill the column with water to a level about 5 cm from the top, and allow the water to stand until all large air bubbles have escaped.
- 3 Use the grease pencil to mark the water level on the column. This will be the starting line.
- 4 Next, draw a line about 5 cm from the bottom of the column. This will be the finish line.
- 5 Have a member of your lab group put 1 tsp of the coarse sample into the water column. The other group member should record three time measurements as follows:
  - a. Using a stopwatch, start timing when the first particles hit the start line on the column, and stop timing when they reach the finish line. Perform this procedure three times. Record the time for each trial in a table similar to the one shown below.
  - b. Next, use the stopwatch to determine how long it takes the last particle in the sample to travel from the start line to the finish line. Perform this procedure three times. Record the time for each trial in your table.

| Soil samples | Trial 1                  | Trial 2 | Trial 3 | Average |
|--------------|--------------------------|---------|---------|---------|
| Coarse       | First time measurement:  |         |         |         |
|              | Second time measurement: |         |         |         |
| Medium       | First time measurement:  |         |         |         |
|              | Second time measurement: |         |         |         |

- 6 Determine the average time of the three trials for the first measurement. Do the same for the second measurement. Record the averages.
- 7 Pour the soil and water from the column into the container provided by your teacher. (Note: Do not pour the soil into the sink.)
- 8 Refill the plastic column with water up to the original level marked with the grease pencil.
- 9 Repeat steps 5 through 8 for the remaining sediment sizes. Record the measurements and the averages in your table.
- 10 With the plastic column filled with water, pour 20 g of unsieved soil into the column, and allow the soil to settle for 5 min. After 5 min, look at the column and record your observations of both the settled sediment and the water. Repeat step 7, and then answer the questions below.



## Analysis

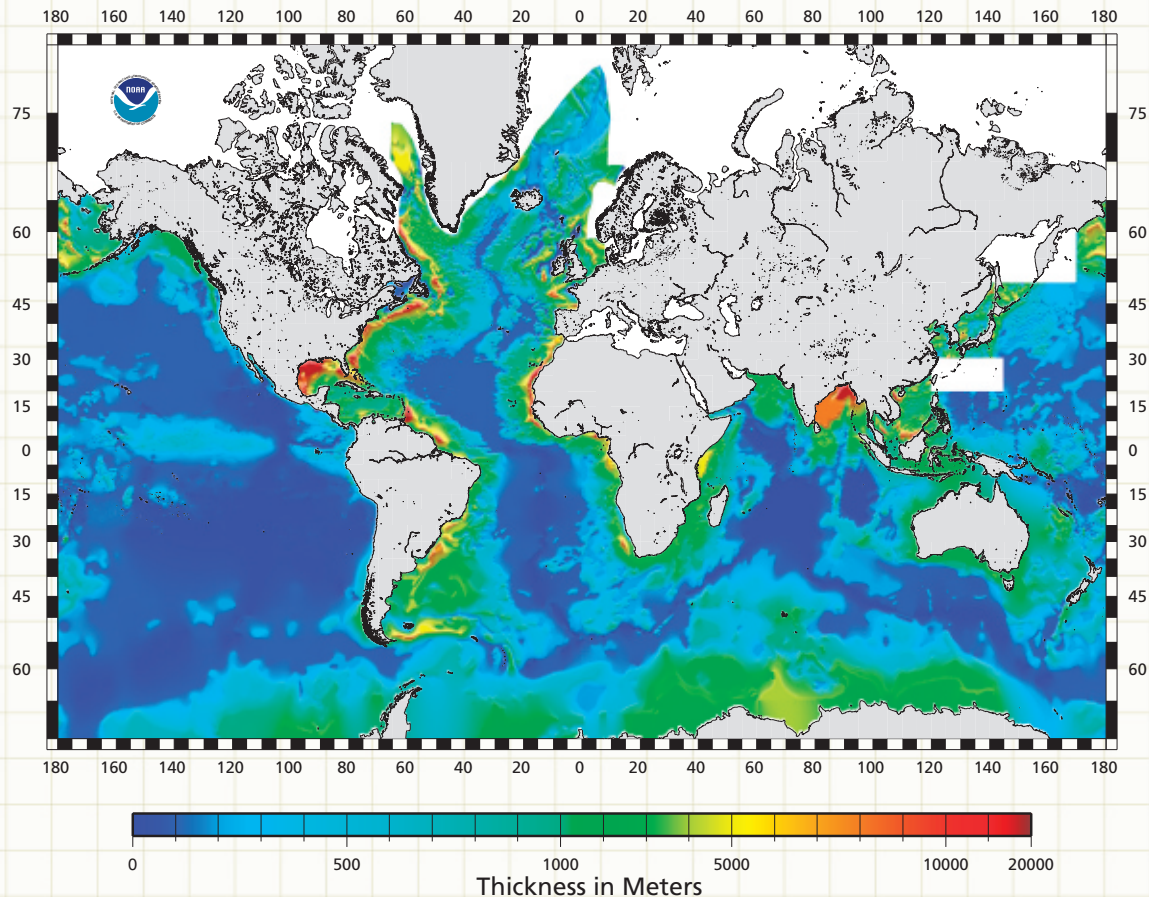
1. **Organizing Data** Which particles settled fastest? Which particles settled slowest?
2. **Making Comparisons** Compare the settling time of the medium particles with the settling time of the medium-fine particles. Do similar-sized particles fall at the same rate?
3. **Making Inferences** In step 10, why did the water remain slightly cloudy even after most of the particles had settled?
4. **Evaluating Methods** How do the results in step 10 help to explain why the deep-ocean basins are covered with a layer of very fine sediment while areas near the shore are covered with coarse sediment?
5. **Making Predictions** Other than size, what factors do you think would influence the speed at which particles fall in water? Explain your answer.

## Step 5

## Extension

**Analyzing Predictions** Obtain particles of different shapes, such as long, cylindrical grains; flat, disk-shaped grains; round grains; and angular grains. Test the settling times of these grains, and write a brief paragraph that explains how grain shape affects the settling rate of particles in water.

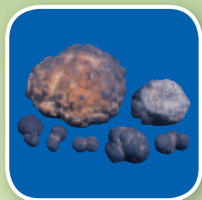
## Total Sediment Thickness of Earth's Oceans



### Map Skills Activity

This map shows the total thicknesses of sediments on Earth's ocean floors. Use the map to answer the questions below.

- Using a Key** What is the approximate thickness of the sediment located at 45°S and 45°W?
- Analyzing Data** Use latitude and longitude to identify two areas that have the thickest sediments.
- Comparing Areas** Compare the amount of sediment near the middle of the oceans with the amount of sediment on the continental margins.
- Identifying Trends** Rivers deposit massive amounts of sediment when they reach the ocean. Based on this map, at what locations would you expect to find mouths of major rivers?
- Inferring Relationships** Which coast of South America—east or west—is most likely bordered by a trench?
- Analyzing Relationships** Why does this map contain white spaces even though the key lists no thickness that corresponds with the color white?

**Section 1****Section 2****Section 3****Key Ideas****The Water Planet**

- › The global ocean can be divided into five major oceans—the Pacific, Atlantic, Indian, Arctic, and Southern Oceans—and many smaller seas.
- › Oceanography is the study of the oceans and the seas. Oceanographers study the ocean using research ships, sonar, and submersibles.
- › Sonar is a system that uses acoustic signals and echo returns to determine the location of objects or to communicate.

**Features of the Ocean Floor**

- › Continental margins include the continental shelf, the continental slope, and the continental rise.
- › Features of deep-ocean basins include trenches, abyssal plains, mid-ocean ridges, and seamounts.

**Ocean-Floor Sediments**

- › Ocean-floor sediments form from inorganic and biogenic materials as well as from chemical deposits.
- › Based on physical characteristics, deep ocean-floor sediments are classified as mud or as ooze.

**Key Terms**

**global ocean**, p. 637  
**sea**, p. 637  
**oceanography**, p. 638  
**sonar**, p. 639

**continental margin**,  
p. 641  
**deep-ocean basin**,  
p. 641  
**trench**, p. 643  
**abyssal plain**, p. 643

**core sample**, p. 645  
**nodule**, p. 647

- 1. Spider Map** Create a spider map that has two legs and several lines on each leg. Use the map to compare the global ocean and a sea.

**READING TOOLBOX****USING KEY TERMS**

Use each of the following terms in a separate sentence.

2. *oceanography*
3. *sonar*
4. *core sample*

For each pair of terms, explain how the meanings of the terms differ.

5. *trench* and *abyssal plain*
6. *submersible* and *nodule*
7. *continental margin* and *deep-ocean basin*
8. *oceanography* and *core sample*
9. *mud* and *ooze*

**UNDERSTANDING KEY IDEAS**

10. A self-propelled, free-moving submarine that is equipped for ocean research is a
  - a. turbidity.
  - b. bathysphere.
  - c. bathyscaph.
  - d. guyot.
11. A system that is used for determining the depth of the ocean floor is
  - a. a guyot.
  - b. radiolarians.
  - c. a bathysphere.
  - d. sonar.
12. The parts of the ocean floor that are made up of continental crust are called
  - a. continental margins.
  - b. abyssal plains.
  - c. mid-ocean ridges.
  - d. trenches.

13. The accumulation of sediments at the base of the continental slope is called the
  - a. trench.
  - b. turbidity current.
  - c. continental margin.
  - d. continental rise.
14. The deepest parts of the ocean are called
  - a. trenches.
  - b. submarine canyons.
  - c. abyssal plains.
  - d. continental rises.
15. Large quantities of the inorganic sediment that makes up the continental rise come from
  - a. turbidity currents.
  - b. earthquakes.
  - c. diatoms.
  - d. nodules.
16. Potato-shaped lumps of minerals on the ocean floor are called
  - a. guyots.
  - b. nodules.
  - c. foraminiferans.
  - d. diatoms.
17. Very fine particles of silt and clay that have settled to the ocean floor are called
  - a. muds.
  - b. seamounts.
  - c. guyots.
  - d. nodules.

**SHORT ANSWER**

18. What are the differences between a seamount and a guyot?
19. Explain how sonar is used to study the oceans.
20. List three ways that scientists can learn about the deep ocean.
21. How do fine sediments reach the deep-ocean bottom?
22. What effects do deep-ocean trenches have on the sediment thickness of the abyssal plain?
23. List the three main types of ocean-floor sediments, and describe how they are deposited.

## CRITICAL THINKING

- 24. Making Comparisons** The exploration of the ocean depths has been compared with the exploration of space. What similarities exist between these two environments and the attempts by people to explore them?
- 25. Making Predictions** What may be the eventual fate of seamounts as they are carried along the spreading oceanic crust?
- 26. Analyzing Ideas** A type of fish is known to exist only in one river in the central United States. Explain how the fossilized remains of this fish might become part of the sediments on the ocean floor.
- 27. Analyzing Relationships** Explain how it is possible that scientists have found some red clays on the ocean floor that contain material from outer space.

## CONCEPT MAPPING

- 28.** Use the following terms to create a concept map: *deep-ocean basin*, *continental shelf*, *mud*, *ooze*, *calcareous ooze*, *siliceous ooze*, and *sediment*.

## MATH SKILLS

### Math Skills

- 29. Making Calculations** The total area of Earth is approximately 511,000,000 km<sup>2</sup>. About 71% of Earth's surface is covered with water. Calculate the area of Earth, in square kilometers, that is covered with water.

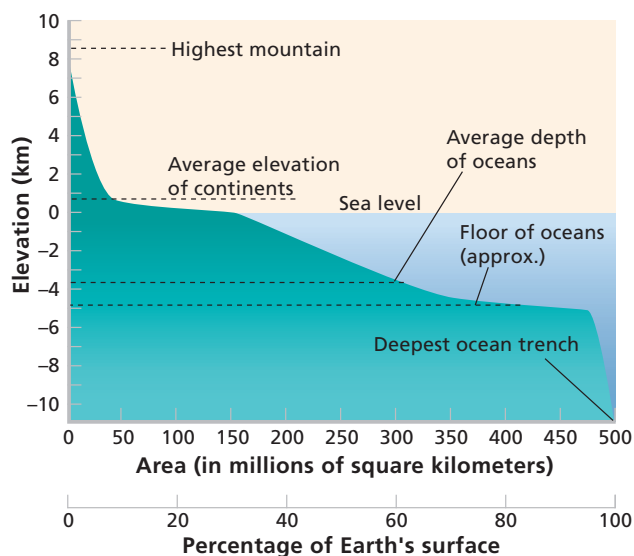
## WRITING SKILLS

- 30. Writing from Research** Prepare a brief report on the different types of submersibles. Your report should explain the special features of each type of submersible as well as how each type has contributed to oceanographers' knowledge of the oceans.

- 31. Creative Writing** Create an imaginary walking tour of the ocean basins. Your tour should begin at the edge of a continent—perhaps at a beach on the east coast of Florida. Explain exactly what tourists should look for along the continental margin and the ocean floor on their way to the western coast of Africa.

## INTERPRETING GRAPHICS

The graph below compares elevations of land and depths of oceans on Earth's surface. Use the graph to answer the questions that follow.



- 32.** What percentage of Earth's surface is covered by land?
- 33.** Which is greater: the elevation of the highest mountain above sea level or the depth of the deepest ocean trench below sea level?
- 34.** Relative to sea level, how many times greater is the average depth of the ocean than the average elevation of land?
- 35.** According to this diagram, how many millions of square kilometers of crust is under ocean water?

## Understanding Concepts

Directions (1–5): For each question, write on a separate sheet of paper the letter of the correct answer.

1. The global ocean is divided into which of the following oceans, in order of decreasing size?
  - A. Atlantic, Pacific, Arctic, Southern, Indian
  - B. Arctic, Southern, Indian, Atlantic, Pacific
  - C. Pacific, Arctic, Indian, Atlantic, Southern
  - D. Pacific, Atlantic, Indian, Southern, Arctic
2. What is the name for a vast, flat area of a deep-ocean basin?
  - F. trench
  - G. seamount
  - H. abyssal plain
  - I. mid-ocean ridge
3. What are very fine, silt- and clay-sized particles of rock found on the ocean floor called?
  - A. muds
  - B. calcareous ooze
  - C. siliceous ooze
  - D. sand
4. The study of deep-ocean sediment samples shows that
  - F. most of the sediments came from the crust.
  - G. most of the sediments settled from above.
  - H. sediments cannot be organic.
  - I. sediments cannot be inorganic.
5. Deep V-shaped valleys in the continental shelf and slope are called
  - A. continental rises.
  - B. seamounts.
  - C. submarine canyons.
  - D. turbidity currents.

Directions (6–7): For each question, write a short response.

6. The surface area of Earth is about 511,000,000 km<sup>2</sup>. About 70% of the Earth's surface is covered by water and the Pacific Ocean makes up 50% of this amount. Calculate the surface area of Earth that is covered by the Pacific Ocean.
7. What are some of the products made using ocean sediments?

## Reading Skills

Directions (8–10): Read the passage below. Then, answer the questions.

### Life on a Continental Shelf

While fish, mammals, and other forms of life can be found throughout these ocean waters, most life in the ocean is concentrated near the continental shores. The shallow waters of the continental shelf, which make up less than 10% of the ocean's total surface area, are home to an amazing array of plants, animals, and microscopic organisms.

Organisms such as coral and seaweed can grow on the ocean floor and still receive much needed sunlight that cannot penetrate deeper waters. The sunlight also makes the shallow waters much warmer than deeper abyssal waters. Algae flourishes in these warm, nutrient-rich waters and serves as food for many small ocean organisms. These organisms are in turn eaten by larger organisms. Even humans have become part of the food chain on the shelf. The vast majority of fish caught for human consumption are caught in waters above a continental shelf.

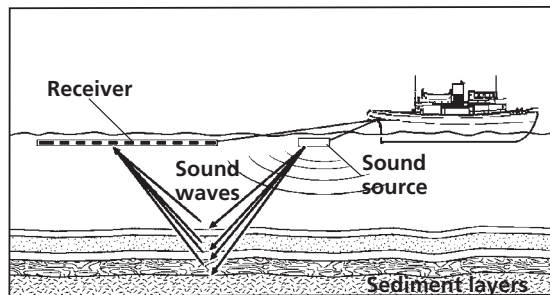
8. Which of the following statements about why humans catch so many fish in the waters over a continental shelf can be inferred from the information in the passage?
  - F. There are no fish in deeper waters.
  - G. Fish from deeper waters are inedible.
  - H. Humans do not have the technological ability to catch fish in deeper ocean waters.
  - I. There are larger and more varied fish populations over a continental shelf.
9. Which of the following factors was not mentioned in the passage as a factor that influences the concentration of organisms that live over a continental shelf?
  - A. nutrients
  - B. salinity
  - C. sunlight
  - D. water temperature
10. Why might the waters of a continental shelf have more nutrients than abyssal waters?

## Interpreting Graphics

Directions (11–13): For each question below, record the correct answer on a separate sheet of paper.

Base your answer to question 11 on this image, which shows how sonar equipment works.

### Studying the Ocean Floor with Sonar

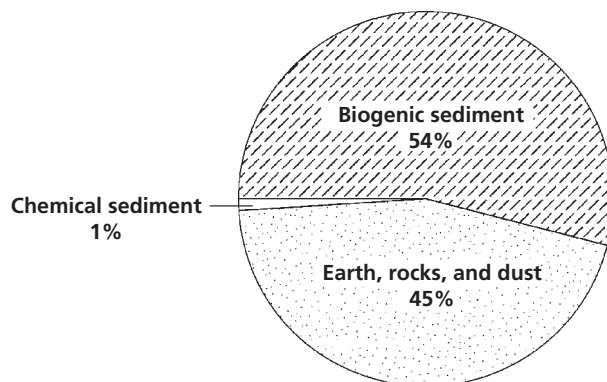


11. Which of the following best summarizes how sound waves are used?

- F. A sound source dragged behind the boat emits waves that penetrate the different layers of the sea floor and bounce back to the receiver.
- G. A sound source in front of the boat emits waves that penetrate the different layers of the sea floor and then bounce back to the receiver.
- H. A receiver dragged behind the boat emits waves that penetrate the different layers of the sea floor and then bounce back to the receiver.
- I. A receiver in front of the boat emits waves that penetrate the different layers of the sea floor and then bounce back to the receiver.

Base your answers to questions 12 and 13 on the pie graph below, which shows the composition of ocean-floor sediments.

### Composition of Ocean-Floor Sediments



12. Why is there such a large difference between the percentage of biogenic sediment and the percentage of chemical sediment?
13. How did the inorganic materials in the two kinds of inorganic sediment shown on the pie graph above form and become part of the ocean floor?

### Test Tip

Before choosing an answer to a question, try to answer the question without looking at the answer choices on the test.