14 The Ocean Floor

Big idea

Water Planet

Q: What is at the bottom of the ocean?

VIRGINIA SCIENCE STANDARDS OF LEARNING

ES.1.a, ES.1.b, ES.1.c, ES.1.d, ES.6.a, ES.10.b, ES.10.d. **See lessons for details.**

Below is a familiar scene in sunlit seawater, but what lies beyond in the darkness of deep waters?

HOW DOES PARTICLE SIZE AFFECT SETTLING RATES?

Procedure

1. Fill two large transparent containers with water. Place two samples of sediment, one clay and one sand, on separate sheets of white paper. Examine the sediments with a hand lens. Determine which sediment sample has larger-sized particles. Record your observations.
2. Carefully measure 1 tbsp of the clay sample. Hold the spoon directly above the first container and pour the clay into the water. Using a stopwatch, time how long it takes for the entire clay sample to reach the bottom of the container and settle. Record the time.
3. Repeat Step 2 using the second container and the sand sample. Be sure to hold the spoon the same distance from the container as you did in the clay sample.

Think About It

1. **Draw Conclusions** Which sample had smaller particles? Which sample took longer to settle in the water? Explain the general relationship between sediment size and settling rates.
2. **Predict** Both of these sediments enter ocean water from rivers. Predict which type of sediment would be found closest to the coast. Which will be found farther away? Explain.

14.1 The Vast World Ocean

Key Questions

How much of Earth's surface is covered by ocean?

How can the world ocean be divided?

How does the topography of the ocean floor compare to that on land?

What types of technology are used to study the ocean floor?

Vocabulary

- bathymetry
- submersible

Reading Strategy

Build Vocabulary Draw a table similar to the one below that includes all the vocabulary terms listed for the section. As you read the section, define each term in your own words.

Vocabulary Term	Definition
bathymetry	a. ___?___
submersible	b. ___?___

HOW DEEP is the deepest part of the ocean? How much of Earth is covered by ocean? What does the ocean floor look like? Humans have long been interested in fi ding answers to these questions. However, it was not until relatively recently that these questions could be answered. Suppose, for example, that all of the water were drained from the ocean. What would we see? Plains? Mountains? Canyons? Plateaus? You may be surprised to fi d that the ocean conceals all of these features, and more.

Geography of the Oceans

Look at **Figure 1.** You can see why the "blue planet" or the "water planet" are appropriate nicknames for Earth. **Nearly 71 percent of Earth's surface is covered by the world ocean.**

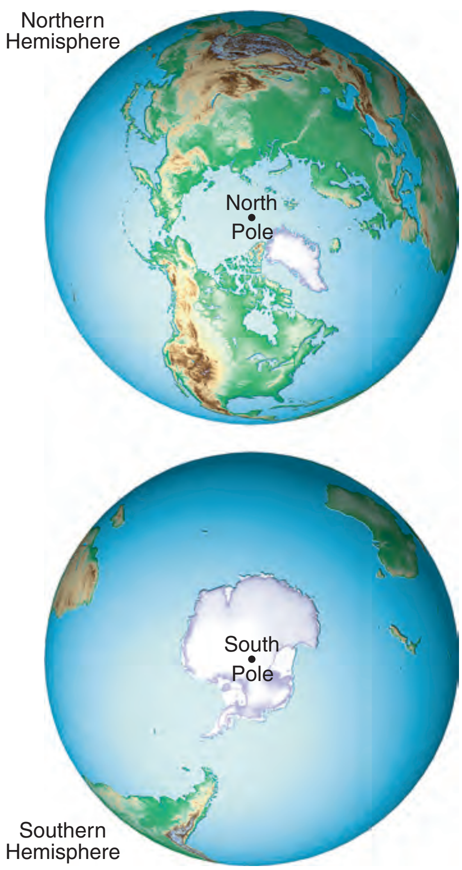


FIGURE 1 The World Ocean These views of Earth show how a single interconnected world ocean covers much of Earth.

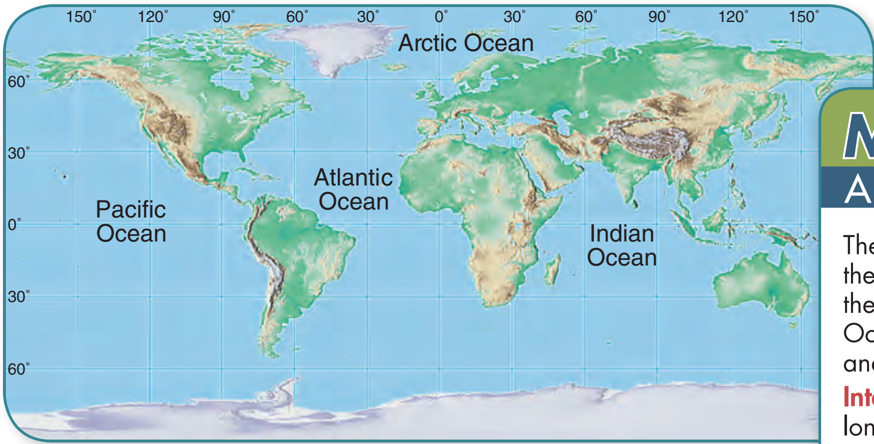


FIGURE 2 **Distribution of Land and Water**

MAP IT! ACTIVITY

The map in Figure 2 shows the four main ocean basins—the Pacific Ocean, the Atlantic Ocean, the Indian Ocean, and the Arctic Ocean.

Interpret Maps What is the longitude of the easternmost point of the Pacific Ocean? What is the longitude of the westernmost point of the Atlantic Ocean?

Although the ocean makes up a much greater percentage of Earth's surface than the continents, it has only been since the late 1800s that the ocean became an important focus of study. New technologies have allowed scientists to collect large amounts of data about the ocean. As technology has advanced, the field of oceanography has grown. *Oceanography* is a science that draws on the methods and knowledge of geology, chemistry, physics, and biology to study all aspects of the world ocean.

The area of Earth's surface is about 510 million square kilometers. Approximately 360 million square kilometers consists of oceans and smaller seas such as the Mediterranean Sea and the Caribbean Sea. Continents and islands comprise the remaining 150 million square kilometers. **The world ocean can be divided into four main ocean basins—the Pacific Ocean, the Atlantic Ocean, the Indian Ocean, and the Arctic Ocean.** The locations of these ocean basins are shown in **Figure 2.**

The Pacific Ocean is the largest and deepest ocean basin. In fact, it is the largest single geographic feature on Earth. It covers more than half of the ocean surface area on Earth and has an average depth of 3940 meters.

The Atlantic Ocean is about half the size of the Pacific Ocean, and is not quite as deep. It is a relatively narrow ocean compared to the Pacific. The Atlantic and Pacific Oceans are bounded to the east and west by continents.

The Indian Ocean is slightly smaller than the Atlantic Ocean, but it has about the same average depth. Unlike the Pacific and Atlantic oceans, the Indian Ocean is located largely in the Southern Hemisphere.

The Arctic Ocean is about 7 percent of the size of the Pacific Ocean. It is only a little more than one-quarter as deep as the rest of the oceans.

Reading Checkpoint *What are the four main ocean basins?*

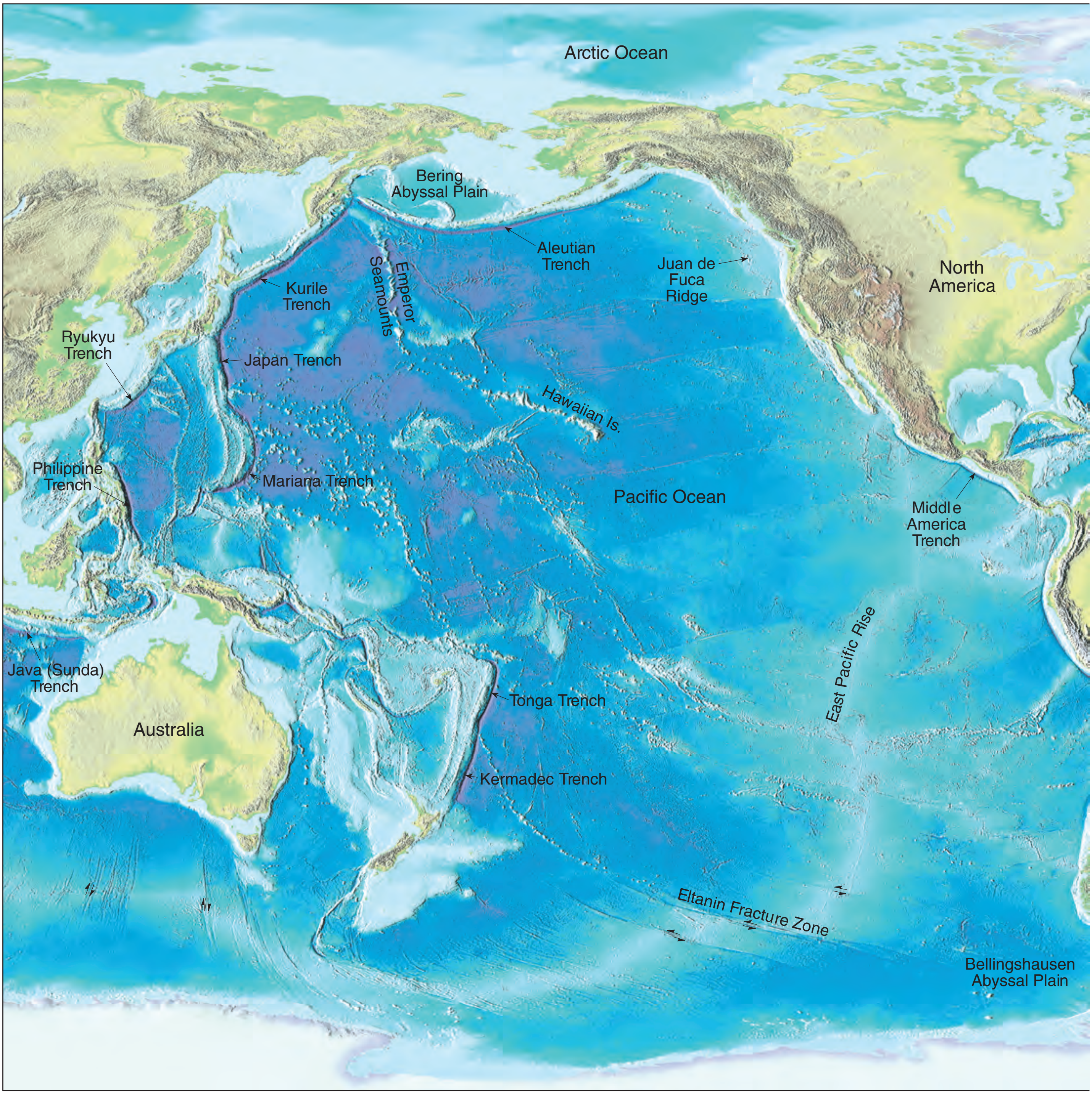
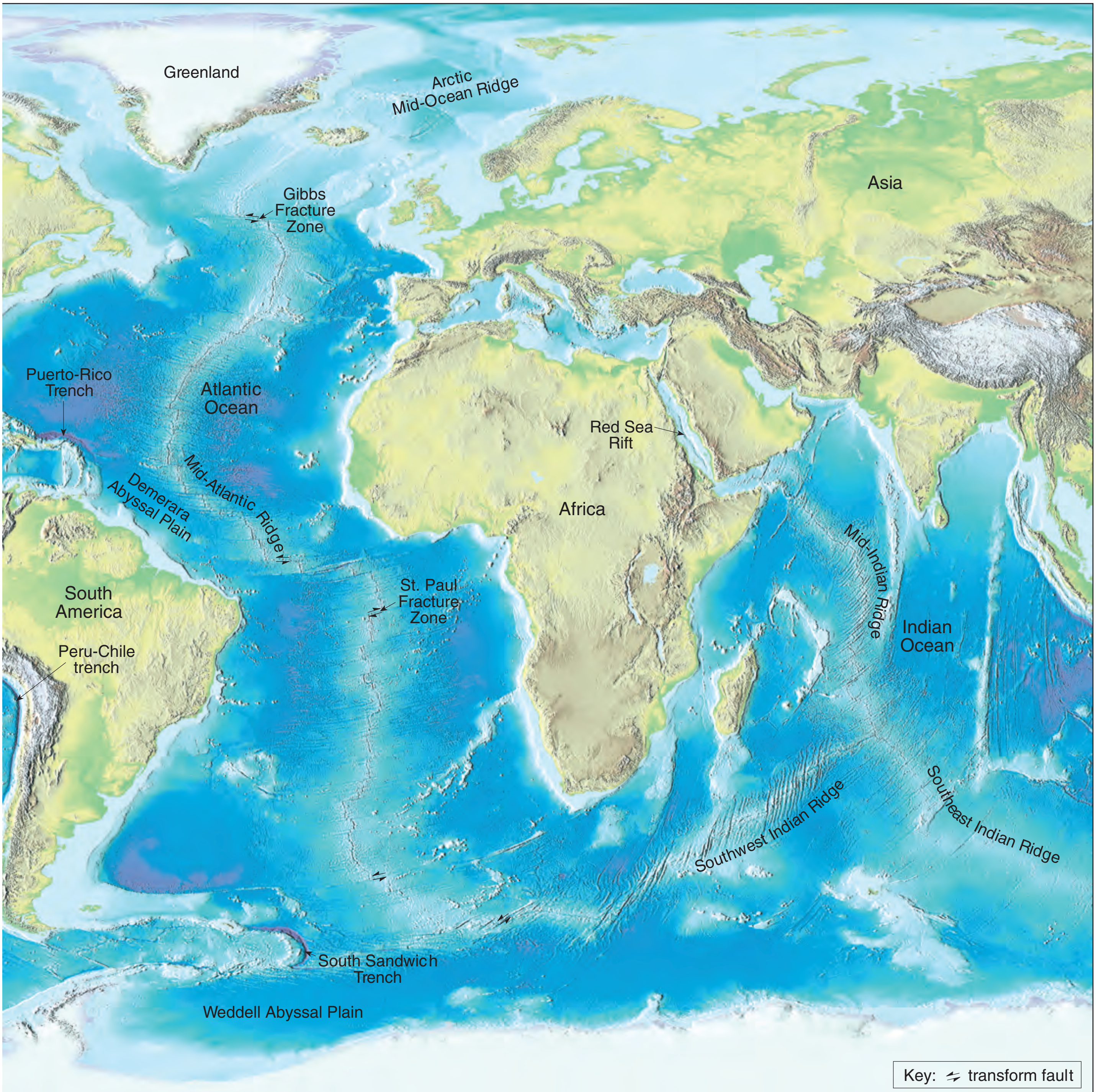


FIGURE 3 A Map of the Ocean Floor The ocean floor contains mountain ranges, trenches, and flat regions called abyssal plains. **Interpret Diagrams** *List all of the features you can identify in the figure.*

Mapping the Ocean Floor

If all the water were drained from the ocean basins, chains of volcanoes, tall mountain ranges, trenches, and large plateaus would be revealed. **The topography—shape and landforms—of the ocean floor is as diverse as that of continents.** The topographic features of the ocean floor are shown in **Figure 3.**

Considering that it is not possible to drain the ocean, how do scientists know what the ocean floor looks like? An understanding of ocean-floor features came with the development of techniques to



to measure the depth of the oceans. **Bathymetry** (*bathos* = depth, *metry* = measurement) is the measurement of ocean depths and the charting of the topography of the ocean floor.

The fi st understanding of the ocean floor's topography did not unfold until the historic three-and-a-half-year voyage of the HMS *Challenger*. From December 1872 to May 1876, the *Challenger* expedition made the fi st study of the global ocean ever attempted by one group. The ship's crew and researchers traveled through every ocean except for the Arctic for a total of 127,500 kilometers.

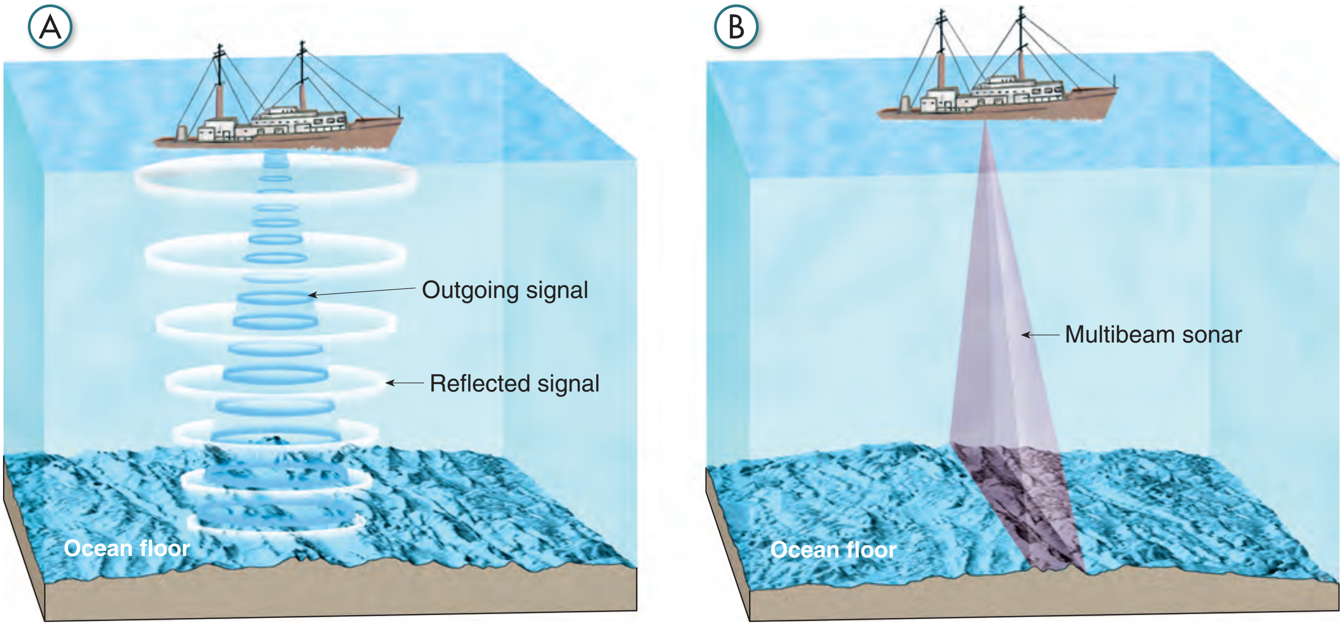


FIGURE 4 Sonar Methods
A By using sonar, oceanographers can determine the depth of the ocean floor in a particular area.
B Modern multibeam sonar obtains a profile of a narrow swath of ocean floor every few seconds.

Throughout the voyage, the scientists sampled various ocean properties. They measured water depth by lowering weighted ropes that were kilometers long. Modern-day researchers no longer have to wait for long ropes to be dropped overboard to reveal ocean depths. **Today's technology—particularly sonar, satellites, and submersibles—allows scientists to study the ocean floor in a more efficient and precise manner than ever before.**

Sonar In the 1920s, a technological breakthrough occurred with the invention of sonar, a technique that uses sound to detect objects or to aid navigation. Sonar is an acronym for **so**und **na**vigation and **r**anging. Some types of sonar are also referred to as echo sounding. Sonar can be used to measure ocean depths by transmitting sound waves toward the ocean bottom, as shown in **Figure 4A.** With simple sonar, a sensitive receiver detects the echo reflected from the bottom. Then a clock precisely measures the time interval to fractions of a second. Depth can be calculated from the speed of sound waves in water—about 1500 meters per second—and the time required for the energy pulse to reach the ocean floor and return. The depths determined from continuous monitoring of these echoes are plotted. In this way a profile of the ocean floor is obtained.

In the last few decades, researchers have designed even more sophisticated sonar that can be used to map the ocean floor. In contrast to simple sonar, multibeam sonar uses more than one sound source and listening device. As shown in **Figure 4B,** this technique obtains a profile of a narrow strip of ocean floor rather than obtaining the depth of a single point every few seconds.

These profiles are recorded every few seconds as the research vessel advances. When a ship uses multibeam sonar to map a section of ocean floor, it travels through the area in a regularly spaced back-and-forth pattern. Not surprisingly, this method is known as "mowing the lawn."

Satellites Measuring the shape of the ocean surface from space is another technological breakthrough that has led to a better understanding of the ocean floor. After compensating for waves, tides, currents, and atmospheric effects, scientists discovered that the ocean surface is not perfectly flat. Gravity attracts water toward regions where massive ocean floor features occur. Therefore, mountains and ridges produce elevated areas on the ocean surface. Features such as canyons and trenches cause slight depressions.

The differences in ocean-surface height caused by ocean floor features are not visible to the human eye. However, satellites are able to measure these small differences by bouncing microwaves off the ocean surface. **Figure 5** shows how the outgoing radar pulses are reflected back to a satellite. The height of the ocean surface can be calculated by knowing the satellite's exact position. Devices on satellites can measure variations in ocean surface height as small as 3 to 6 centimeters. This type of data has added greatly to the knowledge of ocean-floor topography. Cross-checked with traditional sonar depth measurements, the data are used to produce detailed ocean-floor maps, such as the one shown in Figure 3.

Reading Checkpoint *How do satellites help us learn about the shape of the ocean floor?*

PLANET DIARY

For links about **Mapping the Ocean Floor,** visit PlanetDiary.com/HSES.

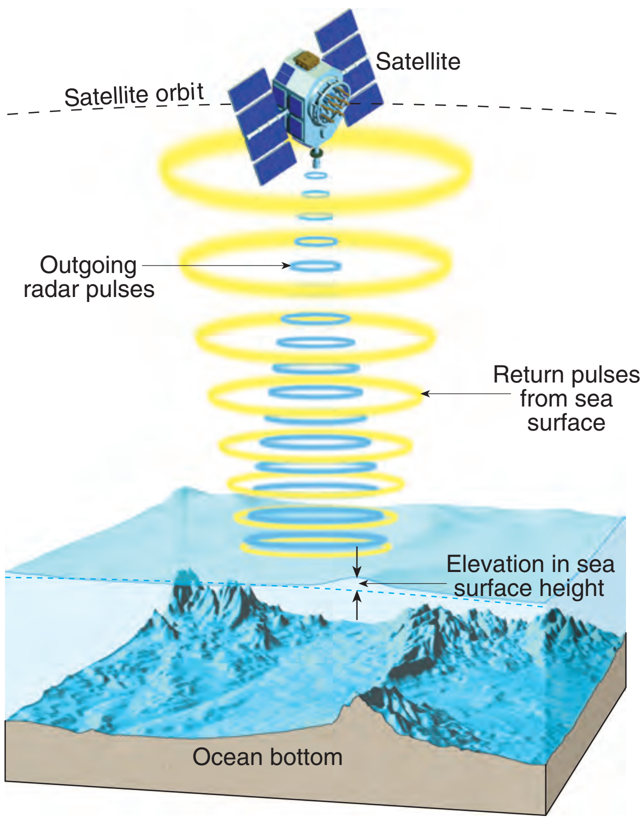


FIGURE 5 Satellite Method Satellites can be used to measure ocean surface height. The data collected by satellites can be used to predict the location of large features on the ocean floor. This method of data collection is much faster than using sonar.

Submersibles A **submersible** is a small underwater craft sed for deep-sea research. Submersibles are used to collect data about areas of the ocean that were previously unreachable by humans. Submersibles are equipped with a number of instruments ranging from thermometers to cameras to pressure gauges. The operators of submersibles can record video and take photographs of creatures that live in the deep ocean. They can also collect water samples and sediment samples for analysis.

The fi st submersible was used in 1934 by William Beebe. He descended to a depth of 923 meters off f Bermuda in a steel sphere that was tethered to a ship. Since that time, submersibles have become much more sophisticated. In 1960, Jacques Piccard descended in the untethered submersible *Trieste* to 10,912 meters below the ocean surface into the Mariana Trench. *Alvin* is a sumbersible owned by the United States Navy that can descend about 4500 meters and carry a crew of three.

Today, many submersibles are unmanned and operated remotely by computers. These remotely operated vehicles (ROVs) can remain underwater for long periods. They collect data, record video, use sonar, and collect sample organisms with remotely operated arms. Autonomous underwater vehicles (AUVs) collect data about the seafloor, search for landmines, or search for potential mining sites without receiving commands from the surface.

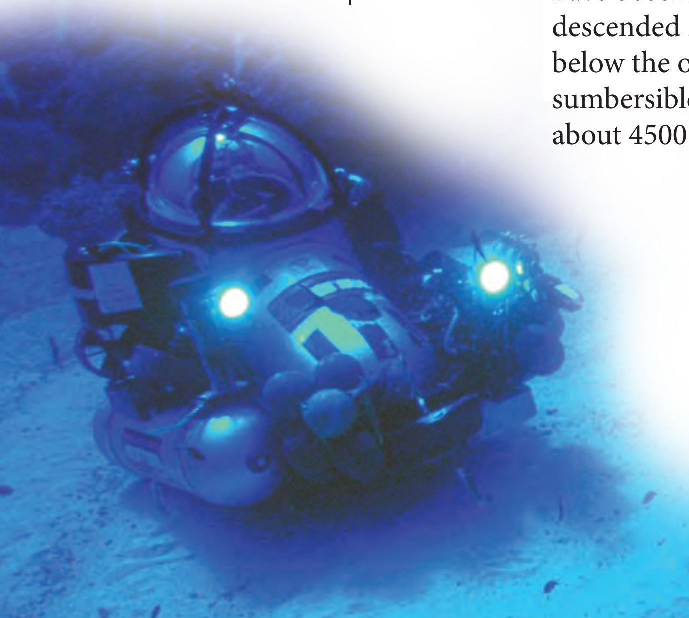


FIGURE 6 Submersible The *DeepWorker* can reach depths of 600 meters and carries one passenger. Many of its functions are controlled by a computer at the surface so that the passenger can concentrate on exploration.

14.1 Assessment

Review Key Concepts

1. Compare the area of Earth's surface covered by ocean with the area covered by land.
2. Name the four ocean basins. Which of the four ocean basins is the largest? Which is located almost entirely in the Southern Hemisphere?
3. How does the topography of the ocean floor compare to that on land? Name three topographic features found on the ocean floor.
4. What types of technology are used to study the ocean floor?
5. Describe how sonar is used to determine ocean floor depth.

Think Critically

6. **Compare and Contrast** Compare and contrast the use of satellites and submersibles to collect data about the topography of the ocean floor.
7. **Infer** Why are deep-sea exploration and data collection difficult?

MATH PRACTICE

8. **Calculate** Assuming the average speed of sound waves in water is 1500 meters per second, determine the water depth in meters if a sonar signal requires 4.5 seconds to hit the bottom and return to the recorder.

14.2 Ocean Floor Features

ES.10 The student will investigate and understand that oceans are complex, interactive physical, chemical, and biological systems and are subject to long- and short-term variations. Key concepts include **d.** features of the sea floor as reflections of tectonic processes.

OCEANOGRAPHERS studying the topography of the ocean floor have divided the floor into three major regions. **The ocean floor regions are the continental margins, the ocean basin floor, and the mid-ocean ridge.** The map in **Figure 7** outlines these regions for the North Atlantic Ocean. The profile at the bottom of the illustration shows the varied topography.

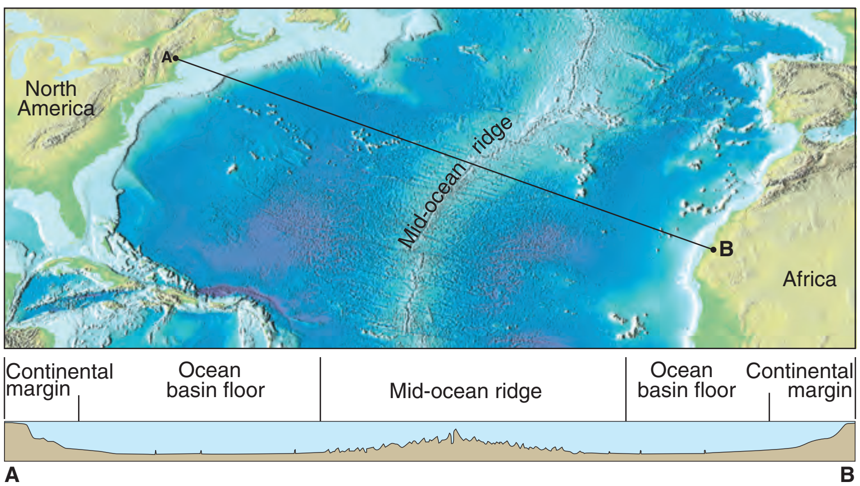


FIGURE 7 Topography of the North Atlantic Ocean Basin Beneath the map is a profile of the area between points A and B. The profile has been exaggerated 40 times to make the topographic features more distinct.

Continental Margins

The zone of transition between a continent and the adjacent ocean basin floor is known as the **continental margin.** **In the Atlantic Ocean, thick layers of undisturbed sediment cover the continental margin. Th s region has very little volcanic or earthquake activity.** This is because the continental margins in the Atlantic Ocean are not associated with plate boundaries. The continental margins in the Pacific Ocean are associated with plate boundaries. **In the Pacific Ocean, oceanic crust is plunging beneath continental crust. Th s force results in a narrow continental margin that experiences both volcanic activity and earthquakes.** **Figure 8** on the next page shows the features of a continental margin found along the Atlantic coast.

Key Questions

- ***What are the three main regions of the ocean floor?***
- ***How do continental margins in the Atlantic Ocean differ from those in the Pacific Ocean?***
- ***How are deep-ocean trenches formed?***
- ***How are abyssal plains formed?***
- ***What is formed at mid-ocean ridges?***

Vocabulary

- continental margin
- continental shelf
- continental slope
- submarine canyon
- turbidity current
- continental rise
- ocean basin floor
- abyssal plain
- seamount
- mid-ocean ridge
- seafloor spreading

Reading Strategy

Outline Before you read, make an outline of this section. Use the orange headings as the main topics and the blue headings as subtopics. As you read, add supporting details.

I. Continental Margins
  A. Continental Shelf
  B. Continental Slope
  C. ____?____
II. ____?____
  A. ____?____

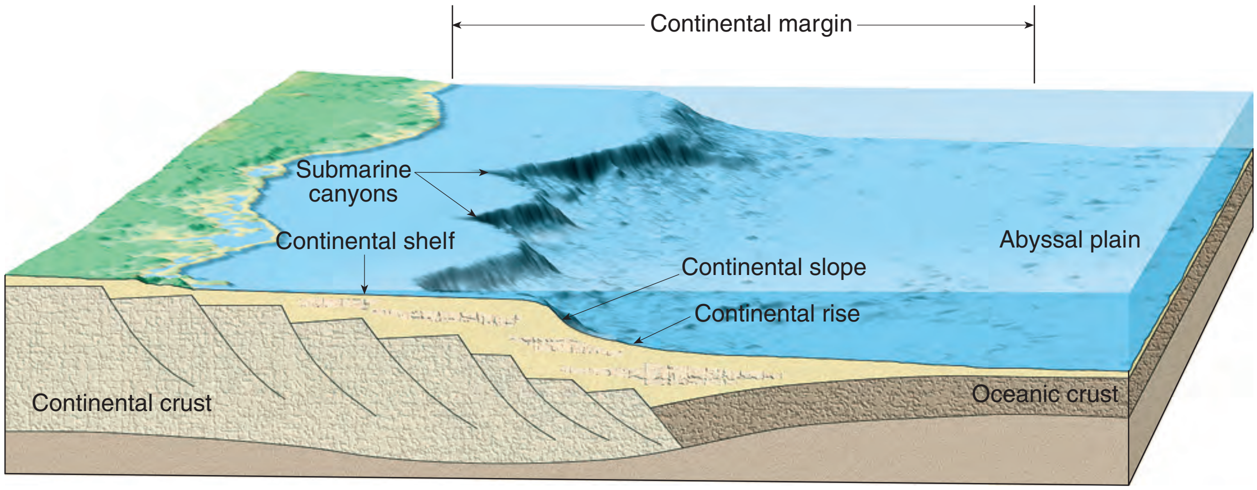


FIGURE 8 Atlantic Continental Margin The continental margins in the Atlantic Ocean are wider than in the Pacific Ocean and are covered in a thick layer of sediment.
Compare and Contrast *What are two ways in which an illustration of the continental margin in the Pacific Ocean would differ from this illustration of the continental margin in the Atlantic Ocean?*

Continental Shelf What if you were to begin an underwater journey eastward across the Atlantic Ocean? The fi st area of ocean floor you would encounter is the **continental shelf,** which is the gently sloping submerged surface extending from the shoreline. The shelf is almost nonexistent along some coastlines. However, the shelf may extend seaward as far as 1500 kilometers along other coastlines. On average, the continental shelf is about 80 kilometers wide and 130 meters deep at its seaward edge. The average steepness of the shelf is equal to a drop of only about 2 meters per kilometer. The slope is so slight that it cannot be detected by the human eye.

Continental shelves have economic and political significance. **Continental shelves contain important mineral deposits, large reservoirs of oil and natural gas, and huge sand and gravel deposits.** The waters of the continental shelf also contain important fishing grounds, which are significant sources of food.

Continental Slope Marking the seaward edge of the continental shelf is the **continental slope.** This slope is steeper than the shelf, and it marks the boundary between continental crust and oceanic crust. The continental slope can be seen in Figure 8. Although the steepness of the continental slope varies greatly from place to place, it averages about 5 degrees. In some places the slope may exceed 25 degrees. The continental slope is a relatively narrow feature, averaging only about 20 kilometers in width.

Deep, steep-sided valleys known as **submarine canyons** are cut into the continental slope. These canyons may extend to the ocean basin floor. Some of these canyons appear to be extensions of river valleys, but many of them do not line up in this manner.

Figure 9 shows how submarine canyons may form. Most information suggests that submarine canyons have been eroded, at least in part, by turbidity currents. **Turbidity currents** are occasional movements of dense, sediment-rich water down the continental slope. The currents form when sand and mud on the continental shelf and slope are disturbed—perhaps by an earthquake—and become suspended in the water.

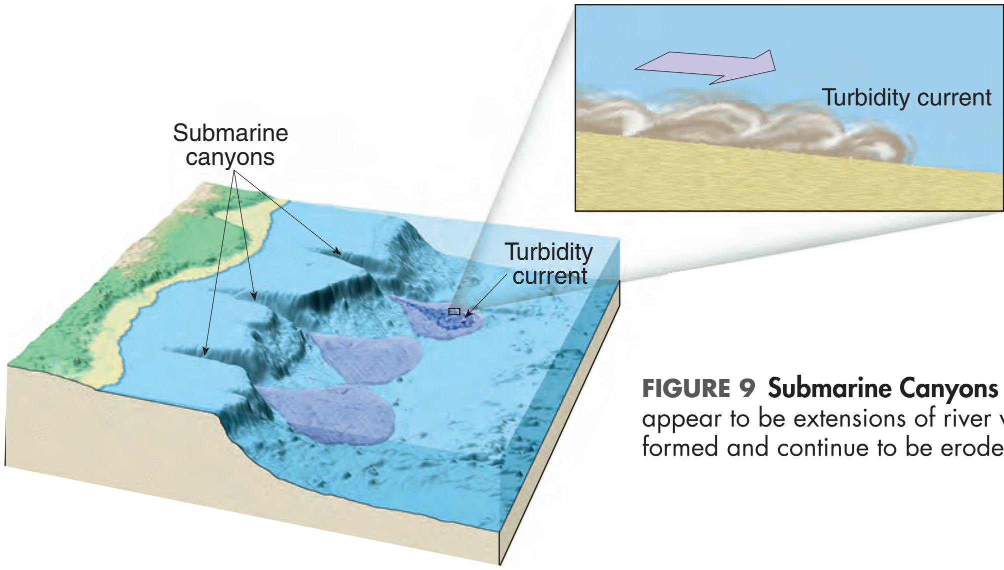


FIGURE 9 Submarine Canyons Some submarine canyons appear to be extensions of river valleys. Others were formed and continue to be eroded by turbidity currents.

Because muddy water is denser than normal seawater, it flows down the slope and erodes and accumulates more sediment. Erosion from these muddy torrents is thought to be the major force in the formation of most submarine canyons. Narrow continental margins, such as the one along the California coast, are marked with many submarine canyons.

Turbidity currents are known to be an important mechanism of sediment transport in the ocean. Turbidity currents erode submarine canyons and deposit sediments on the deep-ocean floor.

Continental Rise In regions where trenches do not exist, the steep continental slope merges into a more gradual incline known as the **continental rise.** The continental rise consists of a thick layer of sediment that moved downslope from the continental shelf to the deep-ocean floor. Here the steepness of the slope drops to about 6 meters per kilometer. Whereas the width of the continental slope averages about 20 kilometers, the continental rise may be hundreds of kilometers wide.

Reading Checkpoint *Compare and contrast the continental slope and continental rise.*

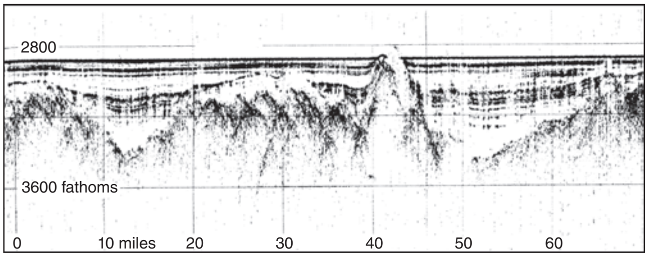
Ocean Basin Floor

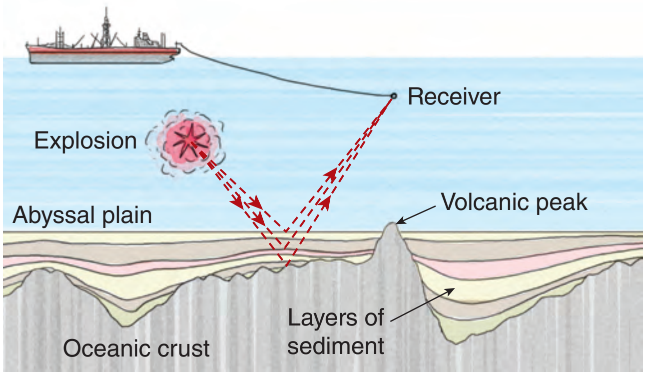
Between the continental margin and mid-ocean ridge lies the **ocean basin floor.** The size of this region—almost 30 percent of Earth's surface—is comparable to the percentage of land above sea level. This region includes very flat regions known as abyssal plains, deep-ocean trenches, and tall volcanic peaks called seamounts and guyots.

INQUIRY
APPLY IT!

Q: ***Have humans ever explored the deepest ocean trenches? Does anything live there?***

A: Humans have indeed visited the deepest part of the oceans—where there is crushing high pressure, complete darkness, and near-freezing water temperatures. In January 1960, U.S. Navy Lt. Don Walsh and explorer Jacques Piccard descended to the bottom of the Challenger Deep region of the Mariana Trench in the deep-diving submersible *Trieste.* It took more than five hours to reach the bottom at 10,912 meters—a record depth of human descent that has not been broken. They did see some organisms that are adapted to life in the deep such as a small flatfish, a shrimp, and some jellyfish.





Geologist's Sketch

FIGURE 10 Abyssal Plain Cross Section Rock structures beneath the ocean floor can be mapped with seismic reflection profiles. The procedure is similar to sonar, but sounds are produced by explosions. This seismic reflection profile and matching sketch is of a portion of the Madeira abyssal plain in the eastern Atlantic. They reveal how the irregular oceanic crust is buried by sediment.

Abyssal Plains **Abyssal plains** are deep, extremely flat features. In fact, these regions are possibly the most level places on Earth. Abyssal plains have thick accumulations of fine sediment that have buried an otherwise rugged ocean floor, as shown in **Figure 10.** **The sediments that make up abyssal plains are carried there by turbidity currents or deposited as a result of suspended sediments settling.** Abyssal plains are found in all oceans of the world. However, the Atlantic Ocean has the most extensive abyssal plains because it has few trenches to catch sediment carried down the continental slope.

Deep-Ocean Trenches Deep-ocean trenches are long, narrow creases in the ocean floor that form the deepest parts of the ocean. Most trenches are located along the margins of the Pacific Ocean, and many exceed 10,000 meters in depth. A portion of the Mariana Trench—the Challenger Deep—has been measured at 11,022 meters below sea level and is the deepest known place on Earth.

Trenches form at sites of plate convergence where one moving plate descends beneath another and plunges back into the mantle. Earthquakes and volcanic activity are associated with these regions. The volcanic activity along the margins of the Pacific Ocean is the reason why the region is often called the *Ring of Fire.*

Seamounts and Guyots The volcanic peaks that dot the ocean floor, but are not tall enough to break through the ocean surface, are called **seamounts.** These steep-sided cone-shaped peaks are found on the floors of all the oceans. However, the greatest number have been identified in the Pacific. Some seamounts form at volcanic hot spots. An example is the Hawaiian-Emperor Seamount chain, shown in Figure 3. This chain stretches from the Hawaiian Islands to the Aleutian trench.

Once seamounts reach the surface, they form islands. Over time, running water and wave action erode these volcanic islands to near sea level. Over millions of years, the islands gradually sink and may disappear below the water surface. This process occurs as the moving plate slowly carries the islands away from the elevated oceanic ridge or hot spot where they originated. Once the inactive volcano is again submerged, the structure is called a *guyot.*

Reading Checkpoint *What are abyssal plains?*

Mid-Ocean Ridges

The **mid-ocean ridge** is an interconnected system of mostly underwater mountains that have developed on newly formed ocean crust. This system is the longest topographic feature on Earth's surface. It exceeds 70,000 kilometers in length. The mid-ocean ridge winds around the globe similar to the way a seam winds over the surface of a baseball.

The term *ridge* may be misleading because the mid-ocean ridge is not narrow. It has widths from 1000 to 4000 kilometers and may occupy as much as one half of the total area of the ocean floor. Another look at Figure 3 shows that the mid-ocean ridge is broken into segments. These are offset by large transform faults where plates slide past each other horizontally, resulting in shallow earthquakes.

Iceland is actually a section of the mid-Atlantic ridge that is above sea level. **Figure 11** shows a diver swimming in an Icelandic lake between the North American and Eurasian Plates.

FIGURE 11 Mid-Atlantic Ridge This diver is swimming in fresh water, but he is swimming along the Mid-Atlantic Ridge in Iceland between the North American Plate and the Eurasian Plate. Iceland experiences relatively frequent volcanic activity due to its location at a site of seafloor spreading.

Seafloor Spreading A high amount of volcanic activity takes place along the crest of the mid-ocean ridge. This activity is associated with seafloor spreading. **Seafloor spreadin** occurs at divergent plate boundaries where two lithospheric plates are moving apart. **New ocean floor is formed at mid-ocean ridges as magma rises between the diverging plates and cools.**

Hydrothermal Vents Hydrothermal vents form along mid-ocean ridges. These are zones where mineral-rich water, heated by the newly formed oceanic crust, escapes through cracks in oceanic crust. As the super-heated, mineral-rich water comes in contact with cold water, minerals containing metals such as sulfur, iron, copper, and zinc precipitate and form chimney-like structures.

14.2 Assessment

Review Key Concepts

1. What are the three main regions of the ocean floor?
2. How do continental margins in the Atlantic Ocean differ from those in the Pacific Ocean?
3. What are abyssal plains? How are abyssal plains formed?
4. What are trenches? How are deep-ocean trenches formed?
5. What is formed at mid-ocean ridges?

Think Critically

6. **Compare and Contrast** Compare and contrast seamounts and guyots.
7. **Apply Concepts** Explain how turbidity currents are related to submarine canyons.

BIGIDEA WATER PLANET

8. **Describe** Imagine you are about to take an underwater journey in a submersible across the Atlantic Ocean. Write a paragraph describing the ocean floor features you will see on your journey.

EARTH & ITS SYSTEMS

Explaining Coral Atolls—Darwin's Hypothesis

Coral atolls are ring-shaped structures that often extend several thousand meters below sea level. Corals are soft-bodied, colonial animals that are about the size of an ant. Corals get some nutrients and oxygen from photosynthetic algae that live within their bodies. Most corals protect themselves by precipitating a hard external skeleton made of calcium carbonate. Their skeletons fuse into large structures called coral reefs, which grow over many centuries.

The Habitat of Corals

Corals, like most animals, require specific environmental conditions to survive. Although some types of coral, called deep-sea coral, can grow and produce reefs deep below the ocean surface, the corals that produce atolls cannot. These corals require clear sunlit water—for the photosynthetic algae—and water temperatures of 18°C to 30°C. As a result, reef growth is limited beyond a depth of 45 meters.

Darwin's Observations

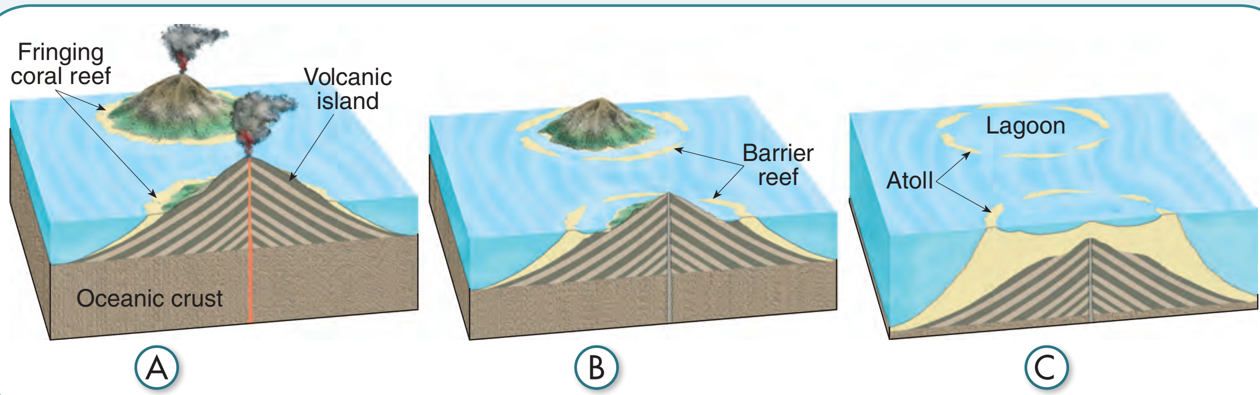
So how can these corals build thick atolls that extend thousands of meters deep? The naturalist Charles Darwin was one of the first to formulate a hypothesis on the origin of atolls. From 1831 to 1836, he sailed aboard the British ship HMS *Beagle* during its famous voyage around the world. In various places Darwin noticed a series of stages of coral-atoll development. Development begins with a fringing reef that forms along the sides of a volcanic island, as shown in **Figure 12.** As the volcanic island slowly sinks, the fringing reef becomes a barrier reef. An atoll forms when the volcano sinks completely underwater but the coral reef remains near the surface.

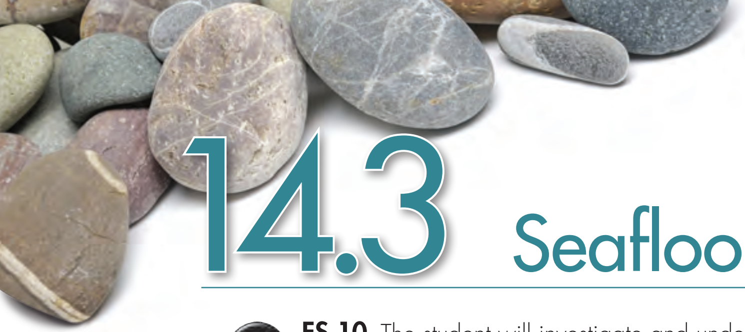
Darwin's Hypothesis

Figure 12 is a drawing that summarizes Darwin's hypothesis about atoll formation. As a volcanic island slowly sinks, the corals continue to build the reef upward. When the base of the reef gets too deep, the coral animals abandon their old calcium carbonate skeletons and move upward where they produce new ones. This explains how living coral reefs, which are restricted to shallow water, have built structures that now exist in much deeper water.

The theory of plate tectonics supports Darwin's hypothesis of atoll formation. Plate tectonics explains how the elevation of a volcanic island changes over long periods of time and how the island eventually disappears. As the hot seafloor moves away from the mid-ocean ridge, it becomes denser and sinks, which lowers the elevation of volcanic islands that are rooted in the seafloor. Darwin's hypothesis is also supported by evidence from drilling that shows volcanic rock is beneath the oldest and deepest coral reef structures.

FIGURE 12 Formation of a Coral Atoll A A fringing coral reef forms around a volcanic island. **B** As the volcanic island sinks, the fringing reef slowly becomes a barrier reef. **C** Eventually, the volcano is completely underwater and a coral atoll remains.





14.3 Seafloor Sediments

ES.10 The student will investigate and understand that oceans are complex, interactive physical, chemical, and biological systems and are subject to long- and short-term variations. Key concepts include **b.** importance of environmental and geologic implications.

EXCEPT FOR steep areas of the continental slope and the crest of the mid-ocean ridge, most of the ocean floor is covered with sediment. Some of this sediment has been deposited by turbidity currents. The rest has slowly settled onto the seafloor. The thickness of ocean-floor sediments varies. Some trenches act as traps for sediment originating on the continental margin. The accumulation may approach 10 kilometers in thickness. In general, however, accumulations of sediment are about 500 to 1000 meters.

Generally, coarser sediments, such as sand, cover the continental shelf and slope while fi er sediments, such as clay, cover the deep-ocean floor. Various types of sediment accumulate on nearly all areas of the ocean floor in the same way dust accumulates in all parts of your home. Even the deep-ocean floor, far from land, receives small amounts of windblown material and microscopic parts of organisms.

Types of Seafloor Sediments

Ocean-floor sediments are usually mixtures of the various sediment types. **Ocean-floor sediments can be classified according to their origin into three broad categories: terrigenous sediments, biogenous sediments, and hydrogenous sediments.** Over millions of years, marine sediments such as sand or the shells and skeletons of ocean organisms can form sedimentary rock. For example, chalk is a form of limestone made up mostly of the tiny shells of one-celled ocean organisms.

Terrigenous Sediment

Terrigenous sediment is sediment that originates on land. **Terrigenous sediments consist primarily of mineral grains that were eroded from continental rocks and transported to the ocean.** Larger particles such as gravel and sand usually settle rapidly near shore. Finer particles such as clay can take years to settle to the ocean floor and may be carried thousands of kilometers by ocean currents. Clay accumulates very slowly on the deep-ocean floor. To form a 1-centimeter abyssal clay layer, for example, could take 50,000 years. In contrast, on the continental margins near the mouths of large rivers, terrigenous sediment accumulates rapidly and forms thick deposits. In the Gulf of Mexico, for instance, the sediment is many kilometers thick.

Key Questions

What are the three types of ocean-floor sediments?

What does terrigenous sediment consist of?

What is the composition of biogenous sediment?

How is hydrogenous sediment formed?

Vocabulary

- terrigenous sediment
- biogenous sediment
- calcareous ooze
- siliceous ooze
- hydrogenous sediment
- manganese nodule

Reading Strategy

Summarize Make a table like the one below that includes all the headings for the section. Write a brief summary of the text for each heading.

Seafloor Sediments
I. Types of Seafloor Sediments • Terrigenous sediments originated on land. • Biogenous sediments are biological in origin. • ___?___

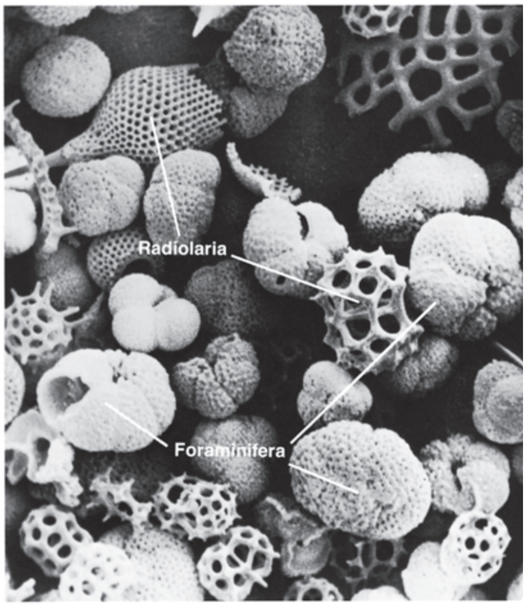


FIGURE 13 Biogenous Sediments
The microscopic shells of radiolarians and foraminifers are examples of biogenous sediments. This photomicrograph has been enlarged hundreds of times.

Biogenous Sediment **Biogenous sediment** is sediment that is biological in origin. **Biogenous sediments consist of shells and skeletons of marine animals and algae.** This debris is produced mostly by microscopic organisms living in surface waters. Once these organisms die, their hard shells sink, accumulating on the seafloor.

The most common biogenous sediment is calcareous ooze. **Calcareous ooze** is produced from the calcium carbonate shells of organisms and has the consistency of thick mud. When calcium carbonate shells slowly sink into deeper parts of the ocean, they begin to dissolve. In ocean water deeper than about 4500 meters, these shells completely dissolve before they reach the bottom. As a result, calcareous ooze does not accumulate in the deeper areas of ocean basins.

Other biogenous sediments include siliceous ooze and phosphate-rich material. **Siliceous ooze** is composed primarily of the shells of single-cell organisms, such as diatoms and radiolarians, that contain silica. The shells of these organisms are shown in **Figure 13.** Phosphate-rich biogenous sediments come from the bones, teeth, and scales of fish and other marine organisms. **Figure 14** shows the distribution of different types of sediment.

Reading Checkpoint *Name two types of biogenous sediments.*

Hydrogenous Sediment **Hydrogenous sediment consists of minerals that crystallize directly from ocean water through various chemical reactions.** These sediments make up only a small portion of the overall sediment in the ocean. They do, however, have many different compositions and are distributed in many different environments. Some of the most common types of hydrogenous sediment are listed below.

- **Manganese nodules** are hard lumps of manganese, iron, and other metals. These metals precipitate around an object such as a grain of sand. The nodules can be up to 20 centimeters in diameter and are often scattered across large areas of the deep ocean floor.
- Calcium carbonates form by precipitation directly from ocean water in warm climates. If this material is buried and hardens, a type of limestone forms. Most limestone, however, is composed of biogenous sediment.
- Evaporites form where evaporation rates are high and there is restricted open-ocean circulation. As water evaporates from such areas, the remaining water becomes saturated with dissolved minerals that precipitate. Collectively termed "salts," some evaporite minerals do taste salty, such as halite, or common table salt. Other salts do not taste salty, such as the calcium sulfate minerals anhydrite ($CaSO_4$) and gypsum.

INQUIRY APPLY IT!

Q: *Do we use diatoms in any products?*

A: Diatoms are used in filters for refining sugar and cleaning water in swimming pools. They also are mild abrasives in household cleaning products, polishing products, and facial scrubs; and absorbents for chemical spills.

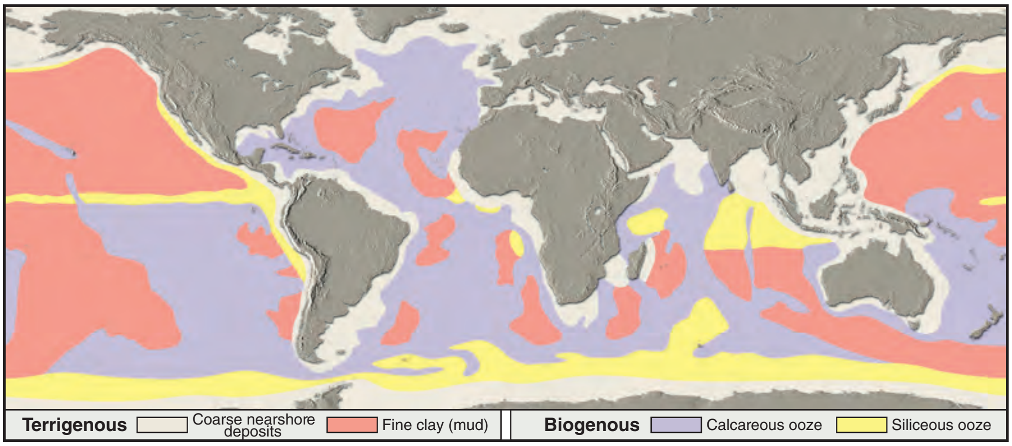


FIGURE 14 Distribution of Seafloor Sediments Coarse-grained terrigenous deposits dominate continental margin areas. Fine-grained clay, or mud, is more common in the deepest areas of the ocean basins.
Infer ***Why are fine-grained sediments more common in the deepest areas of the ocean basins?***

Seafloor Sediment and Climate Data Most seafloor sediments contain the remains of organisms that once lived near the sea surface. When these organisms die, their shells slowly settle to ocean floor as sediment. These sediments can provide data about changes in worldwide climate over time, because the numbers and types of organisms that live near the ocean surface change in predictable ways when the climate changes.

For researchers to examine the sediments, ships with drills extract deep cores of sediments. Then researchers examine the layers of sediment and draw conclusions about how the climate has changed over time based on the type of and amount of remains they discover in the samples.

14.3 Assessment

Review Key Concepts

1. What are the three types of seafloor sediments?
2. What does terrigenous sediment consist of?
3. What is the composition of biogenous sediment?
4. How is hydrogenous sediment formed?
5. Why are seafloor sediments useful in studying past climates?

Think Critically

6. **Compare and Contrast** Compare and contrast calcareous ooze and siliceous ooze.
7. **Predict** Would you expect to find more evaporites in an area of warm water that receives large amounts of sunlight such as the Red Sea or in an area of cold water that receives less sunlight such as the Greenland Sea?

CONNECTING CONCEPTS

8. **Apply Concepts** An oceanographer is studying sediment samples from the Bahama Banks. The sediments have a high amount of calcium carbonate. They are labeled biogenous but are later found to contain no shells from organisms that typically make up calcareous ooze. What other explanation is there for the origin of these sediments?

14.4 Resources from the Seafloor

ES.6 The student will investigate and understand the differences between renewable and nonrenewable resources. Key concepts include **a.** fossil fuels, minerals, rocks, water, and vegetation.

Key Questions

Which ocean resources are used for energy production?

How are gas hydrates formed?

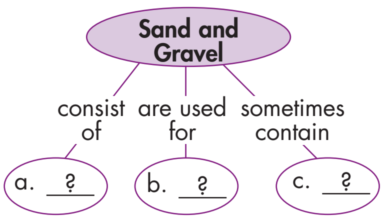
What other resources are derived from the ocean?

Vocabulary

- gas hydrate

Reading Strategy

Identify Details Copy the concept map below. As you read, complete it to identify details about resources from the ocean.



THE OCEAN FLOOR is rich in mineral and energy resources. Recovering them, however, often involves technological challenges and high costs. As technology improves we are able to access some of these resources more efficiently. However, the ocean's resources are fi ite and need to be managed carefully.

Energy Resources

Most of the value of nonliving resources in the ocean comes from their use as energy products. **Oil and natural gas are the main energy products currently being obtained from the ocean floor.** Other resources may be used as a source of energy in the future.

Oil and Natural Gas The ancient remains of organisms are the source of today's deposits of offshore oil and natural gas. These organisms were buried within sediments before they could decompose. After millions of years of exposure to heat from Earth's interior and pressure from overlying rock, the remains were transformed into oil and natural gas. The percentage of world oil produced from offshore regions has increased from trace amounts in the 1930s to more than 30 percent today. Part of this increase is due to advances in the technology of offshore drilling platforms.

Major offshore reserves exist in the Persian Gulf, in the Gulf of Mexico, off he coast of southern California, and in the North Sea. Additional reserves may be located off he north coast of Alaska and in the Canadian Arctic, Asian seas, Africa, and Brazil. One environmental concern about offshore exploration is the possibility of oil spills caused by accidents during drilling, such as the spill that resulted from the *Deepwater Horizon* explosion in April 2010. The oil polluted the waters of the Gulf of Mexico and caused massive environmental damage to the coasts of Alabama and Mississippi.

FIGURE 15 Accessing Resources Offshore drilling rigs tap the oil and natural gas reserves of the continental shelf. These platforms are near Santa Barbara, California. **Infer** ***What changes to the marine environment may occur as a result of drilling for oil?***

FIGURE 16 Gas Hydrates
A A sample from the ocean floor has layers of white, icelike gas hydrate mixed with mud.
B Gas hydrates evaporate when exposed to surface conditions, releasing natural gas that can be burned.

Gas Hydrates Compact chemical structures made of water and natural gas are called **gas hydrates**. The most common type of natural gas is methane, which produces methane hydrate. Gas hydrates occur beneath permafrost areas on land and under the ocean floor at depths below 525 meters.

Most oceanic gas hydrates are formed when bacteria break down organic matter trapped in ocean-floor sediments. The bacteria produce methane gas along with small amounts of ethane and propane. These gases combine with water in deep-ocean sediments and are trapped.

Vessels that have drilled into gas hydrates have brought up samples of mud mixed with chunks of gas hydrates similar to the one shown in **Figure 16A.** These chunks evaporate quickly when they are exposed to the relatively warm, low-pressure conditions at the ocean surface. Gas hydrates resemble chunks of ice but ignite when lit by a flame, as shown in **Figure 16B.** The hydrates burn because methane and other flammable gases are released as gas hydrates evaporate.

An estimated 20 quadrillion cubic meters of methane are locked up in sediments containing gas hydrates. This amount is double the amount of Earth's known coal, oil, and natural gas reserves combined. One drawback to using gas hydrates as an energy source is that they rapidly break down at surface temperatures and pressures. In the future, however, these ocean-floor reserves of energy may help fill our energy needs.

Reading Checkpoint *What happens when gas hydrates are brought to the surface?*

FIGURE 17 **Evaporative Salts**
Common table salt, or halite, is harvested from the salt left behind when ocean water evaporates. About 30 percent of the world's salt is produced from seawater that has evaporated.

Other Resources

Other major resources from the ocean floor include evaporative salts, sand and gravel, and manganese nodules. These materials are used in construction, food processing, and manufacturing technological devices.

Evaporative Salts When seawater evaporates, salts increase in concentration until they are no longer dissolved. When the concentration becomes high enough, the salts precipitate out of solution and form salt deposits. These deposits can then be harvested, as shown in **Figure 17.** The most economically important salt is halite (NaCl)—common table salt. Halite is widely used for seasoning, curing, and preserving foods. It is also used in agriculture, in the clothing industry for dyeing fabric, and to de-ice roads.

Sand and Gravel The offshore sand-and-gravel industry is second in economic value only to the offshore oil industry. Sand and gravel, which include rock fragments that are washed out to sea and shells of marine organisms, are mined by offshore barges using suction devices. The difference between sand and gravel is particle size—gravel particles are larger than sand particles. Sand and gravel are used for many purposes including landfill, to fill in beaches, and to make concrete.

Some materials of high economic value are associated with off hore sand and gravel deposits. Diamonds, for example, are recovered from gravels off hore of South Africa and Australia. Sediments rich in tin have been mined from some off hore areas of Southeast Asia. Some Florida beach sands are rich in titanium.

INQUIRY QUICK LAB

EVAPORATIVE SALTS

Materials

- 400 mL beaker • 100 mL water • table salt
- tablespoon • balance • glass stirrer

Procedure

1. Place the empty beaker on the balance and add between 3 and 5 tablespoons of the salt. Measure the combined mass of the beaker and the salt. Record the measurement and remove the beaker from the balance.
2. Add 100 mL of water to the beaker and stir until the salt is dissolved.
3. Place the beaker in a warm, sunny area and allow the water to evaporate.
4. When all of the water has evaporated, place the beaker and its remaining contents on the balance and record the measurement.

Analyze and Conclude

1. **Compare** How did the mass of the beaker and salt before the water was added compare to the mass of the beaker and salt after the water evaporated?
2. **Draw Conclusions** What happened to the salt when the water evaporated?
3. **Predict** How could the oceans be used as a source of salt?

Manganese Nodules As described earlier, manganese nodules are hard lumps of manganese and other metals that precipitate around a smaller object. **Figure 18** shows manganese nodules on the deep-ocean floor. They contain high concentrations of manganese and iron, and smaller concentrations of copper, nickel, and cobalt, all of which have a variety of industrial uses. Cobalt, for example, is important because it is required to produce strong alloys with other metals. These alloys are used in high-speed cutting tools, powerful permanent magnets, and jet engine parts. With current technology, mining the deep-ocean floor for manganese nodules is possible, but the cost is so high that it would not be profitable.

Manganese nodules are widely distributed along the ocean floor, but not all regions have the same potential for mining. Good locations for mining must have a large amount of nodules that contain an optimal mix of copper, nickel, and cobalt. Sites like this are limited. In addition, it is difficult to establish mining rights far from land. Also, there are environmental concerns about disturbing large portions of the deep-ocean floor.

FIGURE 18 Manganese Nodules These manganese nodules lie thousands of meters beneath the ocean surface on the Pacific Ocean floor south of Tahiti. **Apply Concepts** *How do manganese nodules form?*

14.4 Assessment

Review Key Concepts

1. What are the main energy resources from the ocean?
2. How are gas hydrates formed?
3. What drawbacks are associated with harvesting ocean resources for energy use?
4. What other resources besides energy resources are derived from the ocean?
5. What are the uses of evaporative salts?
6. What are manganese nodules? Why is it difficult to recover them from the ocean?

Think Critically

7. **Make Generalizations** How does technology influence the availability of resources from the ocean?
8. **Infer** Near-shore mining of sand and gravel can result in large amounts of sediments being suspended in water. How might this affect marine organisms living in the area?

CONNECTING CONCEPTS

9. **Explain** Why are most sand and gravel deposits found on the continental shelf? What type of sediment is sand and gravel?

INQUIRY
EXPLORATION LAB

Modeling Seafloor Depth Transects

Problem How can the topography of an ocean basin be determined?

Materials shoe box, modeling clay, aluminum foil, pencil, scalpel, graph paper, ruler

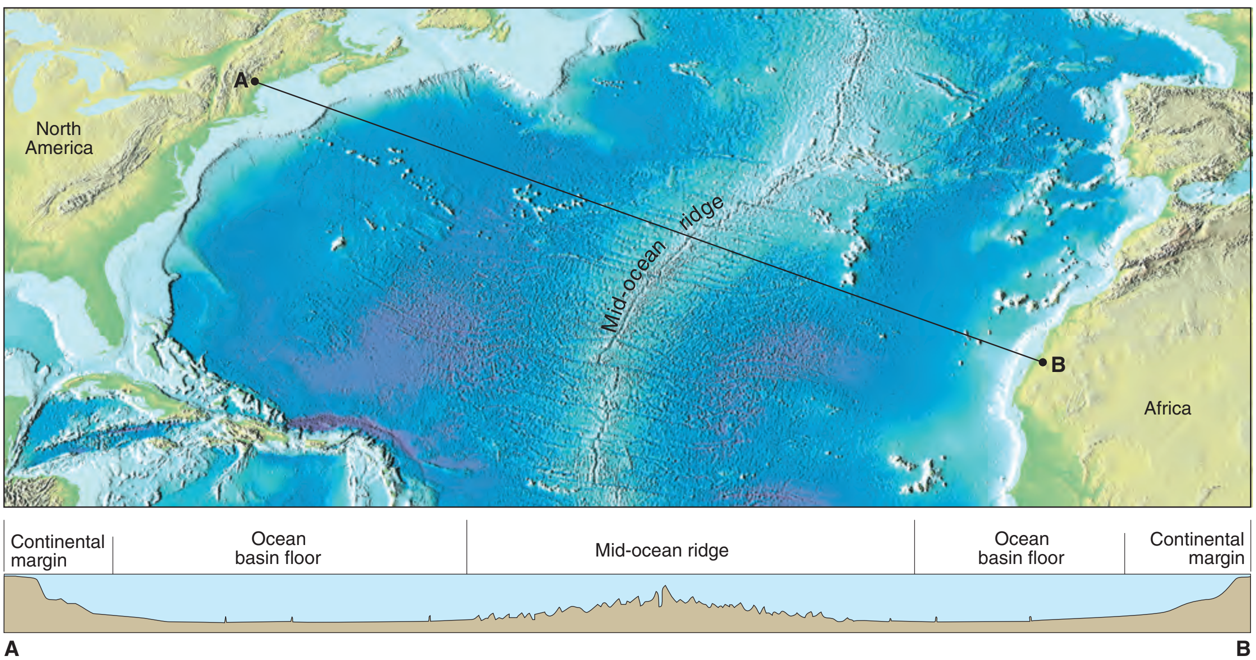
Skills Measure, Graph, Infer, Draw Conclusions

Connect to the Big idea Oceanographers use a number of methods to determine the depth and topography of the ocean floor. Technology, such as sonar, satellites, and submersibles, have allowed scientists to produce detailed maps of the ocean floor in each ocean basin. In this lab, you will model a seafloor depth transect to determine the topography of an ocean basin created by your classmates.

Procedure

Part A: Making a Model of the Seafloor

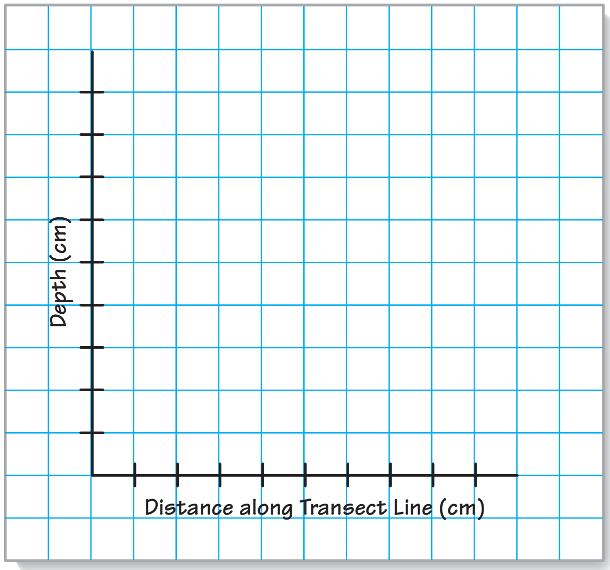
1. Look at Figure 3, Figure 8, and the fi ure below to determine which area of the ocean floor you will model. Be sure to identify the specific features that would be found in the area. For example, a model of the continental margin would include the continental shelf, continental slope, continental rise, and some submarine canyons. A model of the ocean basin floor would include abyssal plains, deep-sea trenches, seamounts, and guyots. Do not discuss your plan with students outside your group.
2. Once you have determined which area you will model, use the clay to make a contoured model of the seafloor inside the shoe box.
3. Obtain a piece of aluminum foil that is large enough to cover the top of the shoe box and fold over the sides of the box about an inch all the way around.
4. Spread the foil flat on your lab table. Place the ruler lengthwise on the foil, parallel to the edge of the foil. The line formed by the edge of the ruler will be your transect line.
5. Use a pencil to make tick marks on the foil piece every centimeter along the entire length of the foil.



6. Hold the foil in place over the top of the box. Remove the top of the box and set the foil piece down in place of the top. Secure the foil in place on top of the box by turning down the foil over the sides of the box. Be sure the foil is taut.
7. Exchange boxes with another group from your class. Do not remove foil from the box that you receive.

Part B: Completing a Depth Transect

8. Label your graph paper. The x-axis will be "Distance along Transect Line" in centimeters, and the y-axis will be "Depth" in centimeters. Make tick marks along the x-axis once every centimeter. Make tick marks along the y-axis every half of a centimeter. **NOTE:** You may also use a computer to produce your graph.
9. Use the scalpel to carefully make a slit in the foil along the fi st centimeter mark. **CAUTION:** *The scalpel is extremely sharp. Handle it carefully.* After cutting the foil, gently place the ruler through the slit until it makes contact with the clay in the box. Be sure to hold the ruler straight and take the depth measurement. Record your data on the graph.
10. Repeat Step 9 for each point along the foil. When you are done, you should have a depth profile for the entire length of the box along your transect line.
11. Remove the foil from the box and examine the topography of the model.



Analyze and Conclude

1. **Infer** Based on your contour profile, what part of the ocean floor was being modeled? Check your answer with the group that created the model. Were you correct? Why or why not?
2. **Compare** How does the profile on your graph compare with the contour of the model? Are there any major features in the model that did not appear on your graph? Why or why not?
3. **Analyze Data** What could you have done to make your profile match the topography more accurately?
4. **Explain** Before sonar was used to measure ocean depth, a less sophisticated method was used. A long line of rope with a lead weight on the end was tossed over the side of a ship and lowered until the weight hit the bottom. How is this method similar to what you did in the lab? How can the rope method lead to inaccuracies when trying to build an ocean-floor profile?

ES.1 The student will plan and conduct investigations in which **a.** volume, area, mass, elapsed time, direction, temperature, pressure, distance, density, and changes in elevation/depth are calculated utilizing the most appropriate tools; **b.** technologies, including computers, probeware, and geospatial technologies, are used to collect, analyze, and report data and to demonstrate concepts and simulate experimental conditions; **c.** scales, diagrams, charts, graphs, tables, imagery, models, and profiles are constructed and interpreted; and **d.** maps and globes are read and interpreted, including location by latitude and longitude.

14 Study Guide

Big idea Water Planet

14.1 The Vast World Ocean

Nearly 71 percent of Earth's surface is covered by the world ocean.

The world ocean can be divided into four main ocean basins—the Pacific Ocean, the Atlantic Ocean, the Indian Ocean, and the Arctic Ocean.

The topography—shape and landforms—of the ocean floor is as diverse as that of continents.

Today, technology—particularly sonar, satellites, and submersibles—allows scientists to study the ocean floor in a more efficient and precise manner than ever before.

bathymetry (397)
submersible (400)

14.2 Ocean Floor Features

The ocean floor regions are the continental margins, the ocean basin floor, and the mid-ocean ridge.

In the Atlantic Ocean, thick layers of undisturbed sediment cover the continental margin. This region has very little volcanic or earthquake activity.

In the Pacific Ocean, oceanic crust is plunging beneath continental crust. This force results in a narrow continental margin that experiences both volcanic activity and earthquakes.

Continental shelves contain important mineral deposits, large reservoirs of oil and natural gas, and huge sand and gravel deposits.

The sediments that make up abyssal plains are carried there by turbidity currents or are deposited as a result of suspended sediments settling.

Trenches form at sites of plate convergence where one moving plate descends beneath another and plunges back into the mantle.

New ocean floor is formed at mid-ocean ridges as magma rises between the diverging plates and cools.

continental margin (401)
continental shelf (402)
continental slope (402)
submarine canyon (402)
turbidity current (402)
continental rise (403)
ocean basin floor (403)
abyssal plain (404)
seamount (404)
mid-ocean ridge (405)
seafloor spreading (405)

14.3 Seafloor Sediments

Ocean-floor sediments can be classified according to their origin into three broad categories: terrigenous sediments, biogenous sediments, and hydrogenous sediments.

Terrigenous sediments consist primarily of mineral grains that were eroded from continental rocks and transported to the ocean.

Biogenous sediments consist of shells and skeletons of marine animals and algae.

Hydrogenous sediment consists of minerals that crystallize directly from ocean water through various chemical reactions.

terrigenous sediment (407)
biogenous sediment (408)
calcareous ooze (408)
siliceous ooze (408)
hydrogenous sediment (408)
manganese nodule (408)

14.4 Resources from the Seafloor

Oil and natural gas are the main energy products currently being obtained from the ocean floor.

Most oceanic gas hydrates are formed when bacteria break down organic matter trapped in ocean-floor sediments.

Other major resources from the ocean floor include evaporative salts, sand and gravel, and manganese nodules.

gas hydrate (411)

14 Assessment

Review Content

Choose the letter that best answers the question or completes the statement.

1. Approximately what percentage of Earth's surface is covered by oceans?
   a. 40 **c.** 60
   b. 50 **d.** 70
2. Which ocean basin is the largest?
   a. the Atlantic **c.** the Pacific
   b. the Indian **d.** the Arctic
3. The use of sound waves to determine the depth of the ocean is called
   a. submarine sounding.
   b. sonar.
   c. satellite altimetry.
   d. submersible sounding.
4. The gently sloping submerged surface that extends from the shoreline toward the ocean basin floor is the continental
   a. shelf. **c.** rise.
   b. slope. **d.** margin.
5. Submarine canyons are thought to have been formed by
   a. tsunamis. **c.** sunken ships.
   b. turbidy currents. **d.** subduction.
6. Important mineral deposits, including large reservoirs of oil and natural gas, are associated with
   a. the ocean basin floor.
   b. the continental shelf.
   c. abyssal plains.
   d. the continental rise.
7. Calcareous ooze is an example of
   a. terrigenous sediment.
   b. biogenous sediment.
   c. hydrogenous sediment.
   d. a combination of hydrogenous and terrigenous sediment.
8. Sediments that consist of mineral grains that were eroded from continental rocks are called
   a. terrigenous. **c.** hydrogenous.
   b. biogenous. **d.** hydrates.
9. What could gas hydrates be used for?
   a. as landfill
   b. to make concrete
   c. as a source of energy
   d. as a source of cobalt and copper
10. Economically valuable materials such as diamonds, tin, and platinum are associated with which ocean floor resource?
    a. oil and natural gas
    b. sand and gravel
    c. evaporative salts
    d. manganese nodules

Understand Concepts

11. Why is Earth called the "blue planet"?
12. What is bathymetry? What techniques do scientists use to discover more about the bathymetry of ocean basins?
13. Why is multibeam sonar more efficient than simple sonar at collecting data from the ocean floor?
14. Compare and contrast the size and topography of the Atlantic Ocean basin to that of the Pacific Ocean basin.
15. What is a continental shelf? What economic significance do continental shelves have?
16. Compare and contrast deep-ocean trenches and mid-oceanic ridges.
17. In which ocean basin are most trenches found? Why?
18. What is the difference between terrigenous sediments and biogenous sediments?
19. Explain the process by which hydrogenous sediments are formed.
20. Why is it uncommon to fi d calcareous ooze in deep-ocean basins?
21. From which area of the ocean basin are the resources of oil and natural gas harvested?
22. What current disadvantages exist to using gas hydrates as a form of energy?
23. What are the uses for sand and gravel harvested from the continental shelf?

Think Critically

24. Interpret Visuals Reexamine Figure 1. Why do you think that the Northern Hemisphere is called the "land hemisphere" and the Southern Hemisphere is called the "water hemisphere"?

25. Communicate A friend says that because of gravity we can learn about the topography of the ocean floor. Explain why this is true.

26. Infer The continental margin of the Atlantic Ocean is often referred to as a "passive" continental margin whereas Pacific Ocean continental margins are referred to as "active." Infer what the characteristics of passive and active continental margins would be.

27. Infer There is usually very little sediment accumulation found at mid-ocean ridges. Why do you think this is true?

28. Apply Concepts Imagine you have been asked to invent a device that would be used to retrieve manganese nodules. What characteristics would the device have in order to successfully achieve this goal?

Math Skills

29. Calculate Assuming the average speed of sound waves in water is 1500 meters per second, determine, in seconds, how long it would take a sonar signal to hit the bottom and return to the recorder if the water depth is 7500 meters.

30. Calculate The rate of seafloor spreading in the Atlantic Ocean has been estimated to be about 2.5 centimeters per year. By how many centimeters will the Atlantic Ocean basin increase over a period of 7 years?

31. Calculate If the settling rate of very fi e sand in the open ocean is 360 meters per day, how many days will it take for the sediment to reach the ocean floor at a depth of 4 kilometers?

Concepts in Action

Use the table below to answer Questions 32 and 33.

The table shows the kind of data that a simple sonar echo sounder would provide. The sonar is taken along a transect line in the Pacific Ocean. The stations are approximately 500 meters apart from each other.

Sonar Data

Station Number	Depth (in meters)	Station Number	Depth (in meters)
1	5500	7	3110
2	5550	8	3285
3	4540	9	3490
4	4000	10	4000
5	3675	11	4675
6	3355	12	5000

32. Make Graphs Plot these points on a sheet of graph paper.

33. Interpret Graphs The data recorded in the table was taken over a portion of the ocean basin floor in the Pacific Ocean. What ocean basin feature could be between stations 2 and 12?

Performance-Based Assessment

Research Choose a resource that is harvested from the ocean. Research information about how the resource is formed, where in the ocean it is harvested, what methods and equipment are used in the harvesting of the resource, what it is used for, and if there are any negative impacts on the marine environment as a result of harvesting the resource. Present the results of your research to your class in the form of an oral presentation.

Virginia SOL Test Prep

Tips for Success

Avoiding Careless Mistakes Students often make mistakes when they fail to examine a test question and possible answers thoroughly. Read the question carefully and underline key words that may change the meaning of the question, such as *not, except, excluding,* and so on. After choosing an answer, reread the question to check your selection.

Which of the following is *not* one of the four major topographic features of the ocean basin floor?

A deep-ocean trench
B abyssal plain
C submarine canyon
D seamount

(Answer: C)

Choose the letter that best answers the question.

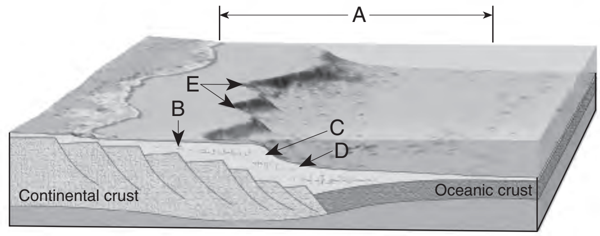
1 Which of the following is *not* true of deep ocean trenches?

A They are long and narrow depressions in the ocean floor.
B They are sites where plates plunge back into the mantle.
C They are geologically very stable.
D They may act as sediment traps. ES.10.d

2 Movements of sediment-rich water down the continental slope are known as—

F streaming currents
G longshore currents
H turbidity currents
J avalanches ES.10.b

Use the diagram below to answer Questions 3 and 4.



3 Which letter represents the continental margin?

A A
B B
C C
D D ES.10.b

4 Which letter represents the continental rise?

F A
G B
H C
J D ES.10.b

5 Which of the following is the *best* description of abyssal plains?

A extremely flat regions of ocean floor
B long, narrow creases in the ocean floor
C areas where two lithospheric plates are moving apart
D gently sloping submerged surfaces along a shoreline ES.10.b

6 How do offshore oil deposits form?

F The ancient remains of microscopic organisms are exposed to heat and pressure for millions of years.
G Heat energy and minerals are released through the mid-ocean ridges that circle Earth's oceans.
H Minerals, such as halite, contained in ocean water precipitate and sink to the ocean floor.
J Bacteria rapidly break down minerals contained in ocean-floor sediments. ES.6.a

If You Have Trouble With . . .

Question	1	2	3	4	5	6
See Lesson	14.2	14.2	14.2	14.2	14.2	14.4