Third planet from the Sun: Earth appears as a blue and white ball in the darkness of space.
The Earth Inside and Out

A HUMAN PERSPECTIVE A quick look at a world map will convince you that the continents, landmasses above water on Earth, fit together like a huge jigsaw puzzle. South America and Africa are good examples. With imagination, you can see how other continents might fit together as well. The first person to suggest that the seven continents were once all one supercontinent was Englishman Francis Bacon in 1620. Bacon’s idea received support in the early 1900s, when scientists found rocks in Africa that matched rocks in South America. Other evidence also supported the idea of a supercontinent millions of years ago.

The Solar System

The “home address” of the earth is the third planet in the solar system of the sun, which is a medium-sized star on the edge of the Milky Way galaxy. Its distance from the sun is 93 million miles. The solar system consists of the sun and eight regular planets, as well as other celestial bodies that orbit the sun. The solar system also contains comets, spheres covered with ice and dust that leave trails of vapor as they race through space. Asteroids—large chunks of rocky material—are found in space as well. As you can see in the diagram, our solar system has an asteroid belt between the orbits of Jupiter and Mars.
The Structure of the Earth

The earth is about 24,900 miles in circumference and about 7,900 miles in diameter. Although the earth seems like a solid ball, it is really more like a series of shells that surround one another.

INSIDE THE EARTH The core is the center of the earth and is made up of iron and nickel. The outer core is liquid, but the inner core is solid. Surrounding the core is the mantle, which has several layers. The mantle contains most of the earth’s mass. Magma, which is molten rock, can form in the mantle and rise through the crust, the thin layer of rock at the earth’s surface. Study the diagram below to learn more about the earth’s interior.

ON AND ABOVE THE EARTH Surrounding the earth is a layer of gases called the atmosphere. It contains the oxygen we breathe, protects the earth from radiation and space debris, and provides the medium for weather and climate. The solid rock portion of the earth’s surface is the lithosphere, which includes the crust and uppermost mantle. Under the ocean, the lithosphere forms the seafloor. The huge landmasses above water are called continents. There are seven continents: North America, South America, Europe, Asia, Africa, Australia, and Antarctica. The hydrosphere is made up of the water elements on the earth, which include oceans, seas, rivers, lakes, and water in the atmosphere. Together, the atmosphere, the lithosphere, and the hydrosphere form the biosphere, the part of the earth where plants and animals live.

SKILLBUILDER: Interpreting Graphics

1 LOCATION Approximately how thick is the core of the earth?
2 LOCATION In what part of the earth would the lithosphere be found?
CONTINENTAL DRIFT In 1912, Alfred Wegener of Germany presented a new idea about continents—the continental drift hypothesis. It maintained that the earth was once a supercontinent that divided and slowly drifted apart over millions of years. Wegener called the supercontinent Pangaea (from a Greek word meaning "all earth"). An ocean called Panthalassa surrounded it. The supercontinent split into many plates that drifted, crashed into each other, and split apart several times before they came to their current positions. This process occurred over millions of years.

In the 1960s, scientists studying the sea floor discovered that the youngest rocks were in the middle of the ocean, at long cracks in the crust. This suggested that the new sea floor was being added, pushing the continents apart. Later in this chapter, you will learn how the rocks of Earth’s surface are broken into giant plates that move and continue to shape the earth.

200 million years ago The supercontinent now called Pangaea was surrounded by an ocean, Panthalassa.

65 million years ago The supercontinent split apart and began moving in different directions. Notice that India broke away from Antarctica and Australia and drifted toward Asia.

Today The continents continue to drift even today.

Places & Terms
Identify and explain where on the earth these terms would be found.
- continent
- crust
- mantle
- magma
- biosphere

Taking Notes
Review the notes you took for this section.

Main Ideas
a. What makes up the interior of the earth?
b. What makes up the biosphere?
c. How can the presence of seven continents on the earth’s surface be explained?

Geographic Thinking
Making Inferences How do the earth’s spheres influence one another? Think about:
- the function of the atmosphere
- the makeup of the biosphere

Making Comparisons Study the diagrams of continental drift on this page. Write a description of the location of the continents in the past in comparison with their current location.
Asteroid Hit!

For years, scientists speculated that the extinction of dinosaurs was due to one very large “environmental event.” Today we know that event was most likely the impact of an asteroid about six miles wide. Sixty-five million years ago it slammed into the earth traveling a thousand times faster than a rifle bullet. Fallout from the asteroid impact changed the environment so drastically that 50 to 70 percent of all living species on earth were wiped out.

The asteroid hit near Chicxulub (CHEEK-shoo-loob) on the Yucatán Peninsula of Mexico. It dug a crater about 62 miles (100km) across.
ASTEROIDS
- Asteroids are small planetary bodies that orbit the sun.
- There are an estimated 50,000 asteroids in our solar system.
- Asteroids range in size from 20 feet to 580 miles in diameter.
- Fragments of asteroids that reach the earth are called meteorites.

TUNGUSKA EVENT
On June 30, 1908, at about 7:30 A.M., an explosion occurred over the Tunguska region of Siberia. This event might have been an asteroid hit.
- The force of the explosion was estimated at between 10 and 20 megatons of TNT.
- The fireball and explosion were seen and felt 500 miles away.
- Five hundred thousand acres of forest were flattened and burned.
- More than 600 grazing reindeer were roasted instantly.
- No crater could be found.

The asteroid plows into the earth at 150,000 mph, vaporizing limestone and seawater. It creates an immense fireball that causes fires thousands of miles away.

The Earth’s skies are darkened for several months by 25 trillion tons of rock, dust, and smoke from the impact. Acid rain created by vaporized minerals poisons lakes and rivers. Food chains collapse, and plants and animals die.

A thick layer of carbon dioxide is trapped in the atmosphere, creating a “greenhouse effect” for perhaps a thousand years or more. Ferns, burrowing mammals, and some freshwater animals survive. Some even thrive in the new climate.

Creating a Front Page
With a small group, use the Internet to research the Chicxulub event. Then create the front page of a newspaper describing the event.
- Create a map showing the impact area.
- Add an article describing the destruction caused by the asteroid.
- Write an interview with a scientist who predicts event results.

GeoData

ASTEROIDS
- Asteroids are small planetary bodies that orbit the sun.
- There are an estimated 50,000 asteroids in our solar system.
- Asteroids range in size from 20 feet to 580 miles in diameter.
- Fragments of asteroids that reach the earth are called meteorites.
**A HUMAN PERSPECTIVE**  In July 1971, astronaut James Irwin was lifted into space on the Apollo 15 mission. As he circled the earth, he was deeply moved by the beauty of our planet. Later he wrote this:

Anyone passing through our solar system would be attracted to the blue planet. They would know that the blue color indicated water on Earth. They would know that where there is water there is probably life. They might try to meet us. We, the blue planet, stand out as a beacon to all.

The earth is unlike any other observable planet in our solar system. It is a living planet.

**Bodies of Water**

Without both freshwater and saltwater, life on this planet would be impossible. Water not only supports plants and animals, it helps distribute heat on the earth.

**OCEANS AND SEAS**  The ocean is an interconnected body of salt water that covers about 71 percent of our planet. It covers a little more than 60 percent of the Northern Hemisphere and about 81 percent of the Southern Hemisphere. Even though it is one ocean, geographers divide it into four main parts: the Atlantic Ocean, the Pacific Ocean, the Indian Ocean, and the Arctic Ocean, which is sometimes considered part of the Atlantic. The largest of the oceans is the Pacific. The waters near Antarctica are sometimes called the Southern Ocean.

**OCEAN MOTION**  The salty water of the ocean circulates through three basic motions: currents, waves, and tides. Currents act like rivers flowing through the ocean. Waves are swells or ridges produced by winds. Tides are the regular rises and falls of the ocean created by the gravitational pull of the moon or the sun. The motion of the ocean helps distribute heat on the planet. Winds blow over the ocean and are either heated or cooled by the water. When the winds eventually blow over the land, they moderate the temperature of the air over the land.

**HYDROLOGIC CYCLE**  The **hydrologic cycle** is the continuous circulation of water between the atmosphere, the oceans, and the earth. As you can see in...
The diagram above, water evaporates into the atmosphere from the surface of the oceans, other bodies of water, and from plants. The water exists in the atmosphere as vapor. Eventually, the vapor cools, condenses, and falls to earth as precipitation—rain or snow. The water soaks into the ground, evaporates to the atmosphere, or flows into rivers to be recycled.

**Lakes, Rivers, and Streams** Lakes hold more than 95 percent of all the earth's fresh water supply. The largest freshwater lake is Lake Baikal in Russia. Its volume of water equals 18 percent of all freshwater on earth. Freshwater lakes like the Great Lakes of North America are the result of glacial action thousands of years ago. Saltwater lakes result from changes in the earth's surface that cut off outlets to the sea. Saltwater lakes are created when creeks and rivers carry salts into a lake, and there is no outlet to carry the salt away. The Great Salt Lake in Utah is the remnant of a large freshwater lake—Lake Bonneville. Its water outflows were cut off, causing the remaining water to become more salty as the water evaporated. The largest saltwater lake is the Caspian Sea in Western Asia.

Rivers and streams flow through channels and move water to or from larger bodies of water. Rivers and streams connect into drainage systems that work like the branches of a tree, with smaller branches, called tributaries, feeding into larger and larger ones. Geographers call an area drained by a major river and its tributaries a **drainage basin**.

**Ground Water** Some water on the surface of the earth is held by the soil, and some flows into the pores of the rock below the soil. The water held in the pores of rock is called **ground water**. The level at which the rock is saturated marks the rim of the **water table**. The water table can rise or fall depending on the amount of precipitation in the region and on the amount of water pumped out of the ground.

**Landforms**

**Landforms** are naturally formed features on the surface of the earth. The diagram on pages 34–35 shows the different kinds of landforms.
VOLCANO
an opening in the earth, usually raised, through which gases and lava escape from the earth's interior

ISLAND
a body of land surrounded by water

STRAIT
a narrow channel connecting two larger bodies of water

FLOOD PLAIN
flat land near the edges of rivers formed by mud and silt deposited by floods

SWAMP
a lowland region that is saturated by water

DELTA
a triangular area of land formed from deposits at the mouth of a river

BUTTE
a raised, flat area of land with steep cliffs, smaller than a mesa

CAPE/ PENINSULA
a point of land extending into an ocean or lake

SEA LEVEL
level of the ocean’s surface, used as a reference point when measuring the height or depth of the earth’s surface

BAY/GULF
part of an ocean or lake partially enclosed by land

(RIVER) MOUTH
the place where a river flows into a lake or an ocean

HARBOR
a sheltered area of water deep enough for docking ships

MARSH
soft, wet, low-lying, grassy land that serves as a transition between water and land

OASIS
a spot of fertile land in a desert, fed by water from wells or underground springs
mountain	natural elevation of the earth’s surface with steep sides and greater height than a hill

steppe
a wide, treeless grassy plain

valley
low land between hills or mountains

canyon
a narrow, deep valley with steep sides

cataract
a step-like series of waterfalls

glacier
a large ice mass that moves slowly down a mountain or over land

prairie
a large, level area of grassland with few or no trees

mesa
a wide, flat-topped mountain with steep sides, larger than a butte

plateau
a broad, flat area of land higher than the surrounding land

cliff
the steep, almost vertical edge of a hill, mountain, or plain
**OCEANIC LANDFORMS** The sea floor has landforms similar to those above water. The earth’s surface from the edge of a continent to the deep part of the ocean is called the **continental shelf.** The floor of the ocean has ridges, valleys, canyons, and plains. Ridges mark places where new crust is being formed on the edges of the tectonic plates. Mountain chains similar to those on the continents themselves cover parts of the ocean floor. The longest continuous range is the Mid-Atlantic Ridge, which extends for thousands of miles north to south through the middle of the Atlantic Ocean. Islands dot the ocean surface. Islands can be formed by volcanic action, deposits of sand, or deposits of coral skeletons.

**CONTINENTAL LANDFORMS** To understand the types of landforms, study the illustration on pages 34–35. The major geographic feature that separates one type of landform from another is relief. **Relief** is the difference in elevation of a landform from its lowest point to its highest point. There are four categories of relief: mountains, hills, plains, and plateaus. A mountain, for instance, has great relief compared with a plain, which displays very little difference between its high and low points.

**Topography** is the combination of the surface shape and composition of the landforms and their distribution in a region. A topographic map shows the landforms with their vertical dimensions and their relationship to other landforms.

In the next section, you will learn how internal forces of the earth help to build and change the landforms on the earth—and how those forces affect humans.
### A Human Perspective

Sally Ride, America’s first female astronaut, wrote the following after one of her trips into space:

> I also became an instant believer in plate tectonics; India really is crashing into Asia, and Saudi Arabia and Egypt really are pulling apart, making the Red Sea even wider. Even though their respective motion is really no more than mere inches a year, the view from overhead makes the theory come alive.

From space, Ride was seeing evidence of the internal forces that have shaped the earth’s surface.

### Plate Tectonics

The internal forces that shape the earth’s surface begin beneath the lithosphere. Rock in the asthenosphere is hot enough to flow slowly. Heated rock rises, moves up toward the lithosphere, cools, and circulates downward. Riding above this circulation system are the **tectonic plates**, enormous moving pieces of the earth’s lithosphere. You can see the position of the tectonic plates in the map below.

#### SKILLBUILDER: Interpreting Maps

1. **REGION** Which plates contain the Ring of Fire?
2. **REGION** Which plates are moving away from each other?
Geographers study the movement of the plates and the changes they cause in order to understand how the earth is continually being reshaped—and how earthquakes and volcanoes occur.

**PLATE MOVEMENT** Tectonic plates move in one of four ways: 1) spreading, or moving apart; 2) subduction, or diving under another plate; 3) collision, or crashing into one another; 4) sliding past each other in a shearing motion. The diagrams below show details about plate movement.

When tectonic plates come into contact, changes on the earth’s surface occur. Three types of boundaries mark plate movements:

- **Divergent boundary**—Plates move apart, spreading horizontally.
- **Convergent boundary**—Plates collide, causing either one plate to dive under the other or the edges of both plates to crumple.
- **Transform boundary**—Plates slide past one another.

An example of a divergent boundary is the one between Saudi Arabia and Egypt. The two plates on which those countries sit are spreading apart, making the Red Sea even wider. The Red Sea is actually a part of the Great Rift Valley in Africa. If you look at the map of Africa on page A18, you will see a string of lakes along the eastern side of Africa, including Lake Tanganyika and Lake Nyasa. These lakes, along with the Red Sea, were formed in the spreading boundary.

An example of a convergent boundary can be found in South Asia. The plate where India is located is crashing into the Asian continent and building up the Himalayas. One of the most famous examples of a transform boundary is in North America—the San Andreas Fault in

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**Plate Movement and Boundaries**

**Divergent**

Magma from the mantle rises as tectonic plates spread apart. The magma cools and forms new rock.

**Convergent: Subduction**

As plates push together, one plate is forced under the other in a process called subduction. As the bottom plate starts to melt, magma rises and forms volcanoes at the surface.
California. Study the diagrams below to understand the movement of the plates and their effect on the surface of the earth.

**FOLDS AND FAULTS** When two plates meet each other, they can cause folding and cracking of the rock. The transformation of the crust by folding or cracking occurs very slowly, often only a few centimeters or inches in a year. Because the movement is slow, the rocks, which are under great pressure, become more flexible and bend or fold, creating changes in the crust. However, sometimes the rock is not flexible and will crack under the pressures exerted by the plate movement. This fracture in the earth’s crust is called a fault. It is at the fault line that the plates move past each other.

**Earthquakes**

As the plates grind or slip past each other at a fault, the earth shakes or trembles. This sometimes violent movement of the earth is an earthquake. Thousands of earthquakes occur every year, but most are so slight that people cannot feel them. Only a special device called a seismograph (SYZ•muh•graf) can detect them. A seismograph measures the size of the waves created by an earthquake.

**EARTHQUAKE LOCATIONS** The location in the earth where an earthquake begins is called the focus. The point directly above the focus on the earth’s surface is the epicenter. The map on page 37 outlines the major plate boundaries. Nearly 95 percent of all recorded earthquakes occur around those boundaries. Plate movement along the Pacific Rim

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**Background**

Seismographs measure earthquakes, but no accurate device for predicting quakes has been developed.
Victims of the 1995 earthquake in Kobe, Japan, wait out aftershocks. More than 5,000 people died in this quake. Why does the location of Japan make it vulnerable to earthquakes?

Earthquakes result in squeezing, stretching, and shearing motions of the earth’s crust that damage land and structures. The changes are most noticeable in places where people live. Landslides, displacement of land, fires (from broken gas lines), and collapsed buildings are major outcomes of the ground motion. Aftershocks, or smaller-magnitude quakes, may occur after an initial shock and can sometimes continue for days afterward.

An earthquake is the sudden release of energy in the form of motion. C.F. Richter developed a scale to measure the amount of energy released. The Richter Scale uses information collected by seismographs to determine the relative strength of an earthquake. The scale has no absolute upper limit. Most people would not notice a quake that measured 2 on the scale. A 4.5 quake will probably be reported in the news. A major quake has a measurement of 7 or more. The largest quake ever measured was 9.5 in Southern Chile on May 22, 1960.

Sometimes an earthquake causes a tsunami, a giant wave in the ocean. A tsunami can travel from the epicenter of a quake at speeds of up to 450 miles per hour, producing waves of 50 to 100 feet or higher. Tsunamis may travel across wide stretches of the ocean and do damage on distant shores. For example, the 1960 quake in Chile and the nearby ocean floor created a tsunami that caused damage in Japan, almost half a world away. In December 2004, a tsunami from a quake in the Indian Ocean struck areas of Southeast Asia, South Asia, and East Africa. An estimated 225,000 people were immediately killed, and another 1.2 million were forced to leave their homes.

Volcanoes

Volcanoes are among the most spectacular of natural events. Magma, gases, and water from the lower part of the crust or the mantle collect in underground chambers. Eventually the materials pour out of a crack in the earth’s surface called a volcano. Most volcanoes are found along the tectonic plate boundaries.

When the magma flows out onto the land slowly, it may spread across an area and cool. Magma that has reached the earth’s surface is called lava. The most dramatic volcanic action is an eruption, in which hot lava, gases, ash, dust, and rocks explode out of vents in the earth’s crust. Often a hill or a mountain is created by lava. The landform may also be called a volcano.

Volcanoes do not erupt on a predictable schedule; they may be active over many years and then stop. Sometimes they remain inactive for
long periods of time—as long as hundreds of years—before becoming active again.

RING OF FIRE The **Ring of Fire**, a zone around the rim of the Pacific Ocean, is the location of the vast majority of active volcanoes. You can see the zone on the map on page 37. Eight major tectonic plates meet in this zone. Volcanic action and earthquakes occur frequently there. Other volcanoes are located far from the margins of tectonic plates. They appear over “hot spots” where magma from deep in the mantle rises and melts through the lithosphere, as in volcanoes in the Hawaiian Islands.

Hot springs and geysers are indicators of high temperatures in the earth’s crust. Hot springs occur when ground water circulates near a magma chamber. The water heats up and rises to the surface. The hot springs and pools of Yellowstone Park are examples of this type of activity. A geyser is a hot spring that occasionally erupts with steam jets and boiling water. Old Faithful, a geyser in Yellowstone, erupts regularly, but most geysers are irregular in their eruptions. Countries with hot springs and geysers include the United States, Iceland, and Japan.

Not all volcanic action is bad. Volcanic ash produces fertile soil. In some parts of the world, the hot springs, steam, and heat generated by the magma are tapped for energy. In Iceland, for example, volcanic heat and steam are used for heating and hot water in the city of Reykjavik.

Internal forces have a major role in shaping the earth. In the next section, you will learn how external forces also change the landscape.

**Seeing Patterns**

Why do the United States, Iceland, and Japan have geysers?
A HUMAN PERSPECTIVE In Egypt, a seasonal dry wind is called khamsin (“fifty”) for the number of days the season occurs. During khamsin, wind-driven sandstorms kill and injure people, close businesses and airports, and strip topsoil and seed from the ground. Sandstorms are not limited to the desert areas of Africa and Southwest Asia. For instance, a five-hour storm recently blasted Jingchang, China, causing millions of dollars of damage and killing about 300 people. Sandstorms are among the external forces that change the shape of the earth and affect the lives of the people in their paths.

Weathering

In the last section, you learned about forces within the earth that changed the land. External forces, such as weathering and erosion, also alter landscapes and in some instances create the soil that is needed for plant life. Weathering refers to physical and chemical processes that change the characteristics of rock on or near the earth’s surface. Weathering occurs slowly over many years and even centuries. Weathering processes create smaller and smaller pieces of rock called sediment. Sediment is mostly identifiable as either mud, sand, or silt, which is very fine particles of rock.

MECHANICAL WEATHERING Processes that break rock into smaller pieces are referred to as mechanical weathering. Mechanical weathering does not change the composition of the rock—only its size. For example, when ice crystals build up in the crack of a rock, they can actually create enough pressure to fracture the rock into smaller pieces. All sorts of agents can break apart rocks. Frost and even plant roots dig into crevices in the rock, splitting it. Human activities, like road construction or drilling and blasting in mining, are also mechanical weathering forces. Eventually, the smaller broken material will be combined with organic material to become soil.
**Chemical Weathering** Chemical weathering occurs when rock is changed into a new substance as a result of interaction between elements in the air or water and the minerals in the rock. Decomposition, or breakup, can happen in several ways. Some minerals react to oxygen in the air and begin to crumble. That is what happens when iron rusts, for example.

Other minerals break down when combined with water or carbon dioxide, which form weak acids within the rock. When sulfur and nitrogen oxides mix with water, acid rain is formed. The increase of acid rain in the 20th century is believed to be speeding up some decomposition. The location and the climate in which the rocks are located have a great deal to do with how rocks decompose. Climates that are warm and moist will produce more chemical weathering than do cool dry areas. Rocks in cold dry and hot dry areas generally experience more mechanical weathering than chemical weathering.

**Erosion**

**Erosion** occurs when weathered material is moved by the action of wind, water, ice, or gravity. For erosion to occur, a transporting agent, such as water, must be present. Glaciers, waves, stream flow, or blowing winds cause erosion by grinding rock into smaller pieces. Material moved from one location to another results in the lowering of some locations and increased elevation in others. For example, water might carry topsoil from a hill into a river and gradually cause the river to become more narrow. Erosion in its many forms reshapes landforms and coastal regions, as well as riverbeds and riverbanks.

**WATER EROSION** One form of water erosion occurs as water flows in a stream or river. The motion picks up loose material and moves it downstream. The greater the force of water, the greater the ability of the water to transport tiny rock particles, or sediment. Another form of erosion is abrasion, the grinding away of rock by transported particles. The heavier the load of sediment, the greater the abrasion on the banks and riverbed. A third eroding action of water occurs when the water dissolves chemical elements in the rock. The composition of the rock changes as a result.

Most streams erode both vertically and horizontally—that is, the valley cut by a stream gets deeper and wider, forming a V-shaped valley. As the water slows, it drops the sediment it is carrying. When a river enters the ocean, the sediment is deposited in a fan-like landform called a *delta*.

Wave action along coastlines also changes the land. Waves can reduce or increase beaches. Sediment deposited by wave action may build up sandbars or islands. Wave action is so powerful that in some locations, it erodes about three feet of beach per year. For some unfortunate people, a beach house with an ocean view making comparisons

**Why would chemical weathering be rare in a desert area?**

**BACKGROUND**

The term *delta* is used because the shape of the landform resembles the Greek letter delta (Δ).
may end up in the ocean as a result of wave action erosion.

**WIND erosion** In many ways, wind erosion is similar to water erosion because the wind transports and deposits sediment in other locations. Wind speeds must reach 11 miles per hour before fine sediment can be moved. The greater the speed of the wind, the larger the particles moved. Dust storms are capable of carrying as much as 6,000 tons of sediment per cubic mile of air. As the wind slows, the sediment is dropped.

Depending on the type of wind-borne sediment, new landforms—such as sand dunes miles from seashores and rocks sculpted into fantastic forms—may be produced. Deposits of *loess* (LOH•uhs), wind-blown silt and clay sediment that produce very fertile soil, are found across the world. In northern China, for example, the deposits are several hundred feet deep. Extensive areas of loess are found in the Mississippi Valley in the United States and in the grasslands of Argentina.

**GLACIAL erosion** A *glacier* is a large, long-lasting mass of ice that moves because of gravity. Glaciers form in mountainous areas and in regions that are routinely covered with heavy snowfall and ice. In mountain regions, glaciers move downslope as a result of gravity. Glaciers such as ice caps and ice sheets move from the highest point on land toward the lowest point.

Glaciation is the changing of landforms by slowly moving glaciers. As a glacier moves, several types of erosion occur. Rocks caught underneath the glacier are ground into finer and finer particles. Some particles are so small that they are called rock flour, which is one component of soil. Massive glaciers also cut U-shaped valleys into the land. On top of or within the ice are other rocks carried by the glacier. When the glacier melts, these rocks are left behind. Rocks left behind by a glacier may form a ridge or a hill called a *moraine*. Moraines can be found on the sides, down the center, or at the leading edge of a glacier.

Inside or under the glacier may be tunnels formed by running water. These tunnels fill up with sediment dropped by the water. When the ice melts, it leaves a long snakelike ridge called an esker. Sometimes blocks of ice are trapped in the sediment. They melt slowly and leave behind a dent or a depression in the ground. These depressions are called kettles. The kettles may be filled with water forming a small lake.
Building Soil

Weathering and erosion are a part of the process of forming soil. Soil is the loose mixture of weathered rock, organic matter, air, and water that supports plant growth. Organic matter in the soil helps to support the growth of plants by providing needed plant food. Water and air share tiny pore-like spaces in the soil. When it rains, the pores are filled with water. As the water evaporates, drains away, or is used by the plants, the pores are filled with air. The texture of the soil, the amount of organic material called humus, and the amount of air and water in the soil all contribute to the soil’s fertility—it’s ability to nurture plants.

**SOIL FACTORS** When geographers study soil, they look at five factors:

- **Parent material** The chemical composition of the original rock, or parent rock, before it decomposes affects its fertility.
- **Relief** Steeper slopes, such as mountainsides, are eroded easily and do not produce soil quickly.
- **Organisms** Organisms include plants, small animals like worms, ants, and bacteria that decompose material. They help to loosen soil and supply nutrients for plants.
- **Climate** Hot climates produce a soil different from that produced by cold climates. Wet climates and dry climates produce soils that are different from each other as well.
- **Time** The amount of time to produce soil varies, but a very rough average is about 2.5 cubic centimeters per century.

The variety of soils—and the climates in which they are found—determine the types of vegetation that can grow in a location. Agricultural activities, such as farming, ranching, and herding, depend on this complex relationship. In the next chapter, you will learn about the climate and vegetation on the earth and how it affects human life.

**Background**

In some soils, as many as a million or more bacteria inhabit each cubic centimeter of soil.
Reviewing Places & Terms

A. Briefly explain the importance of each of the following.

1. continent
2. magma
3. hydrologic cycle
4. landform
5. relief
6. tectonic plate
7. earthquake
8. volcano
9. weathering
10. erosion

B. Answer the questions about vocabulary in complete sentences.

11. How are continents and tectonic plates related?
12. Where is magma found?
13. Lava is a form of which term listed above?
14. What is an example of a landform?
15. What does relief tell you about a landform?
16. What is the purpose of the hydrologic cycle?
17. What causes earthquakes?
18. How are magma and volcanoes related?
19. What are the two types of weathering?
20. What must be present for erosion to occur?

Main Ideas

The Earth Inside and Out (pp. 27–31)

1. What layers are found in the earth’s interior?
2. What is the continental drift theory?

Bodies of Water and Landforms (pp. 32–36)

3. How does water reach a drainage basin?
4. What is topography?

Internal Forces Shaping the Earth (pp. 37–41)

5. What are three types of plate boundaries?
6. How are the Richter scale and a seismograph used?
7. What is the Ring of Fire?

External Forces Shaping the Earth (pp. 42–45)

8. What is the difference between weathering and erosion?
9. What are three transporting agents of erosion?
10. Why are there many different types of soil?
Critical Thinking

1. Using Your Notes
Use your completed chart to answer these questions.

- **a.** Why is water a critical element on the earth?
- **b.** How do internal and external forces shape the earth?

2. Geographic Themes

- **a.** MOVEMENT How does the movement of wind, water, or ice reshape the earth’s surface?
- **b.** HUMAN–ENVIRONMENT INTERACTION How do volcanoes and earthquakes affect human life?

3. Identifying Themes
What might be the hazards of living near the Ring of Fire? Which of the five themes apply to this situation?

4. Determining Cause and Effect
What is the relationship between tectonic plates, earthquakes, and volcanoes?

5. Making Comparisons
How is a valley created by water different from a valley created by a glacier?

Geographic Skills: Interpreting Charts

### Ten Most Deadly Earthquakes in the 20th Century

Use the information in the chart to answer the following questions.

1. **LOCATION** Which location suffered two deadly earthquakes in the 20th century?
2. **MOVEMENT** How is the magnitude of a quake related to loss of life?
3. **PLACE** What reasons might there be for so great a loss of life in Tangshan, China?

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Deaths</th>
<th>Magnitude*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976, July 27</td>
<td>Tangshan, China</td>
<td>255,000</td>
<td>8.0</td>
</tr>
<tr>
<td>1920, Dec. 16</td>
<td>Gansu, China</td>
<td>200,000</td>
<td>8.6</td>
</tr>
<tr>
<td>1927, May 22</td>
<td>Nan-Shan, China</td>
<td>200,000</td>
<td>8.3</td>
</tr>
<tr>
<td>1923, Sept. 1</td>
<td>Yokohama, Japan</td>
<td>143,000</td>
<td>8.3</td>
</tr>
<tr>
<td>1908, Dec. 28</td>
<td>Messina, Italy</td>
<td>83,000</td>
<td>7.5</td>
</tr>
<tr>
<td>1932, Dec. 25</td>
<td>Gansu, China</td>
<td>70,000</td>
<td>7.6</td>
</tr>
<tr>
<td>1970, May 31</td>
<td>Northern Peru</td>
<td>66,000</td>
<td>7.8</td>
</tr>
<tr>
<td>1935, May 30</td>
<td>Quetta, India</td>
<td>50,000</td>
<td>7.5</td>
</tr>
<tr>
<td>1990, June 20</td>
<td>Western Iran</td>
<td>40,000</td>
<td>7.7</td>
</tr>
<tr>
<td>1988, Dec. 7</td>
<td>Armenia</td>
<td>25,000</td>
<td>7.0</td>
</tr>
</tbody>
</table>

*Magnitude of earthquakes measured on the Richter scale developed in 1935.


GeoActivity

Using a base map of the world and an atlas, plot the locations of the ten most deadly earthquakes. Write a sentence describing the pattern you see in the locations.

MULTIMEDIA ACTIVITY

- **hmhsocialstudies.com**

Use the links at hmhsocialstudies.com to do research about volcanic action. Focus on a variety of volcanic activities, including eruptions, geysers, hot springs, and island formation.

Creating a Multimedia Presentation

Put together a presentation about volcanic activity. Include diagrams of several different types of activity and give examples of locations where the activity takes place.