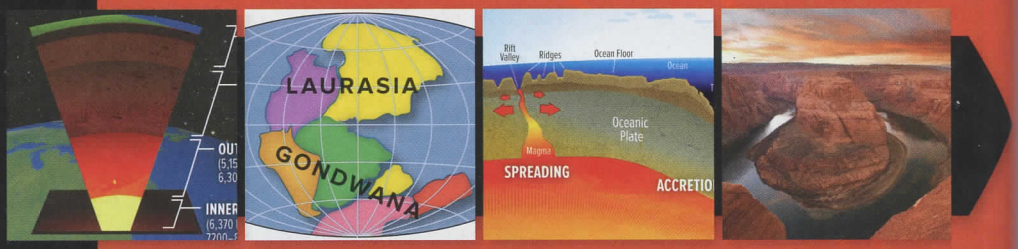
networks

There's More Online!

- DIAGRAM Forces of Change
- DIAGRAM Inside the Earth
- MAP Continental Drift
- MAP Tectonic Plate Boundaries
- INTERACTIVE SELF-CHECK QUIZ
- VIDEO Forces of Change



LESSON 2
Forces of Change

ESSENTIAL QUESTION • *How do physical processes shape Earth's surface?*

Reading HELPDESK

Academic Vocabulary

- create
- external

Content Vocabulary

- core
- mantle
- crust
- continental drift
- plate tectonics
- magma
- subduction
- accretion
- spreading
- fold
- fault
- faulting
- weathering
- erosion
- glacier
- moraine

TAKING NOTES: *Key Ideas and Details*

IDENTIFYING Use a graphic organizer like the one below to decribe the processes of plate tectonics.

Force of Change	How it Works	Example

It Matters Because

Plate tectonics acts upon the Earth's internal and external structures to help create the continents, ocean basins, and mountain ranges. Plate tectonics operates by folding, lifting, bending, and breaking parts of the Earth's surface. Other forces such as weathering and erosion also help shape the Earth's surface.

Earth's Structure

GUIDING QUESTION *How is Earth's structure related to the creation of continents, oceans, and mountain ranges?*

For hundreds of millions of years, the surface of the Earth has been in motion. Pressures generally build up slowly inside the Earth and are then released in sudden events such as volcanic eruptions and earthquakes. Other forces that change the Earth, such as wind and water, occur on the surface.

The Earth is composed of three main layers—the core, the mantle, and the crust. At the very center of the planet is a super-hot but solid inner **core**. Scientists believe that the inner core is made up of iron and nickel that is under enormous pressure. Surrounding the inner core is another band also composed of iron and nickel called the liquid outer core. Even though the liquid outer core is composed of the same elements as the inner core, it is liquid because the pressure is not as great as it is in the inner core.

Next to the outer core is a thick layer of hot, dense rock called the **mantle**. The mantle consists of silicon, aluminum, iron, magnesium, oxygen, and other elements. This dense mixture is soft enough to slowly but continually rise, cool, sink, warm up, and rise again, releasing 80 percent of the heat generated from the Earth's interior.

The outer layer is the **crust**, a hard rocky shell forming the Earth's surface. This relatively thin layer of rock ranges from about 2 miles (3.2 km) thick under oceans to about 75 miles (120.7 km) thick under mountains. The crust is broken into more than a dozen great slabs of

rock called plates that rest—or more accurately, float—on a partially melted layer in the upper portion of the mantle. The plates carry the Earth's oceans and continents.

If you had seen the Earth from space 500 million years ago, the planet probably would not have looked at all like it does today. Many scientists believe that most of the landmasses forming our present-day continents were once part of one gigantic supercontinent called Pangaea (pan•JEE•uh). The maps on the next page show that over millions of years, this supercontinent has broken apart into smaller continents. These continents in turn have drifted and, in some places, recombined. The theory that the continents were once joined and then slowly drifted apart is called **continental drift**.

The term **plate tectonics** refers to all of the physical processes that create many of the Earth's physical features. Many scientists theorize that plates moving around the globe have produced Earth's largest features—not only continents, but also oceans and mountain ranges. Most of the time, plate movement is so gradual—only about 1 inch (2 to 3 cm) a year—that it cannot be felt unless there is an earthquake strong enough to detect the movement. As they move, the plates may crash into each other, pull apart, or grind and slide past each other. Whatever their actions, plates are constantly changing the face of the planet. They push up mountains, **create** volcanoes, and produce earthquakes. Plates spread apart because **magma**, or molten rock, is pushed up from the mantle and ridges are formed. When plates bump together, one may slide under another, forming a trench.

Many scientists estimate that plate tectonics has been shaping the Earth's surface for 2.5 to 4 billion years. According to some scientists, plate tectonics will have sculpted a whole new look for the planet millions of years from now that could make it difficult for us to recognize.

Scientists, however, have not yet determined exactly what causes plate tectonics. They theorize that heat rising from the Earth's core may create slow-moving currents within the mantle. Over millions of years, these currents of molten rock may shift the plates around, but the movements in the mantle are extremely slow and difficult to detect.

core innermost layer of the Earth made up of a super-hot but solid inner core and a super-hot liquid outer core

mantle thick middle layer of the Earth's interior structure consisting of hot rock that is dense but flexible

crust outer layer of the Earth, a hard rocky shell forming Earth's surface

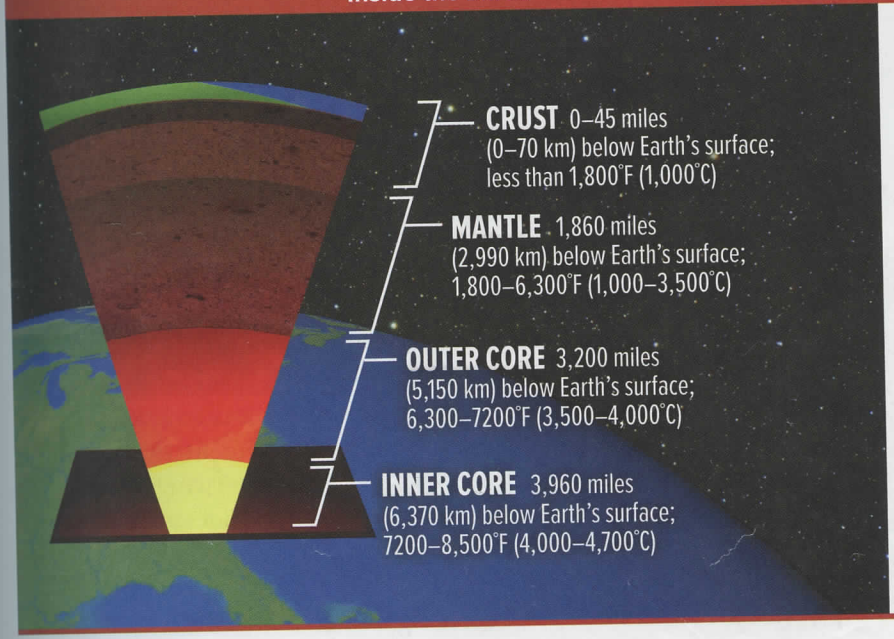
continental drift the theory that the continents were once joined and then slowly drifted apart

plate tectonics the term scientists use to describe the activities of continental drift and magma flow, which create many of Earth's physical features

create to bring into being or cause to exist

magma molten rock that is located below Earth's surface

Inside the Earth



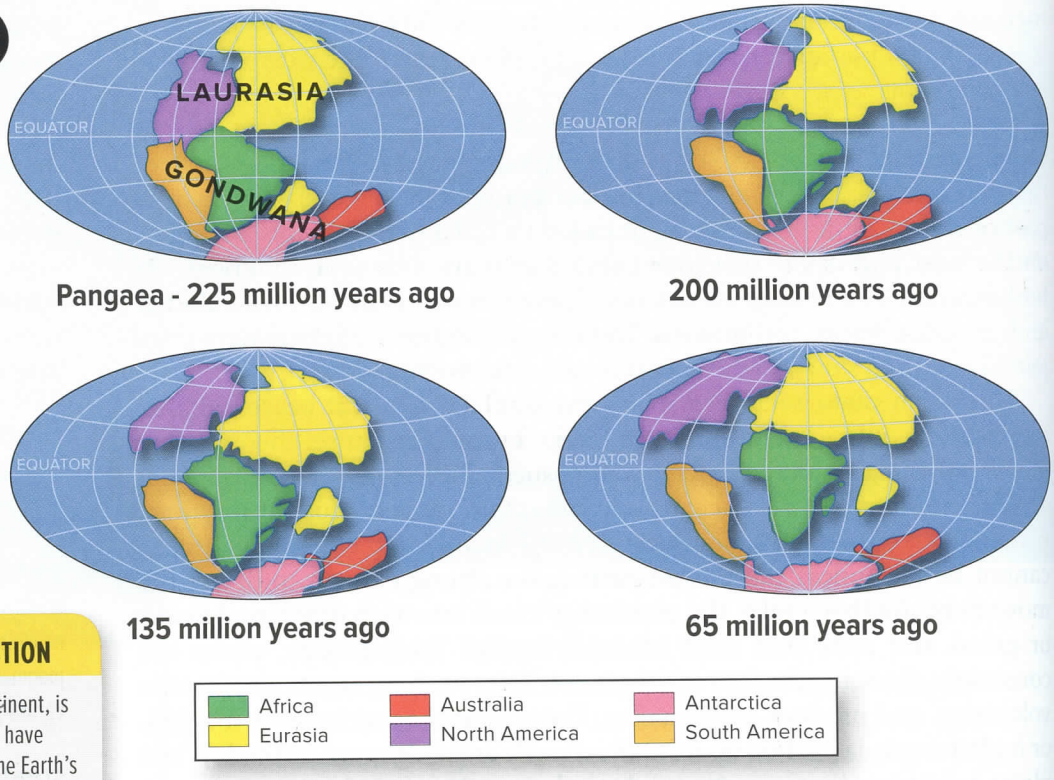
Jim Krueger/Getty Images

DIAGRAM SKILLS

The Earth is composed of three main layers—the core, the mantle, and the crust.

CRITICAL THINKING

1. ***Classifying*** Which of Earth's layers is between the crust and the outer core?
2. ***Analyzing*** How much does the temperature change from the inner core to the outer core? From the outer core to the mantle?



GEOGRAPHY CONNECTION

Pangaea, a gigantic supercontinent, is believed by many scientists to have once connected nearly all of the Earth's landmasses.

1. ***THE WORLD IN SPATIAL TERMS*** How does the first map of Pangaea compare to the map of the Earth 65 million years ago?
2. ***PHYSICAL SYSTEMS*** How does the first map of Pangaea compare with the map of plate movement?

PRIMARY SOURCE

"[W]e have a highly successful theory, called plate tectonics, that explains . . . why continents drift, mountains rise, and volcanoes line the Pacific Rim. Plate tectonics may be one of the signature triumphs of the human mind. . . ."

—Joel Achenbach, "The Next Big One," *National Geographic*, April 2006

READING PROGRESS CHECK

Describing What elements make up the inner core?

Internal Forces of Change

GUIDING QUESTION: *How does plate tectonics affect Earth's surface?*

Earth's surface has changed greatly over time. Scientists believe that some of these changes come from forces associated with plate tectonics. One of these forces relates to the movement of magma within the Earth. Others involve movements that can fold, lift, bend, or break the solid rock at the Earth's crust.

Colliding and Spreading Plates

Mountains are formed in areas where the giant plates collide. In some places, *continental plates* collide with each other. For example, the Himalaya mountain ranges in South Asia were thrust upward when the Indian landmass drifted against Eurasia. Himalayan peaks are getting higher as the Indian Plate continues to move northward and collide with the Eurasian Plate.

Mountains are also created when an *oceanic plate* collides with a continental plate. The heavier oceanic plate dives beneath the lighter continental plate in a process called **subduction** (suhb•DUHK•shuhn). The oceanic plate plunges steeply into the Earth's interior, becoming molten material. Then, as magma, it

subduction process by which oceanic plates dive beneath continental plates, often causing mountains to form on land

rises and bursts through the crust to form volcanic mountains. The Andes, a mountain system in South America, was formed over millions of years as a result of subduction as the Nazca Plate slides beneath the South American Plate.

In other cases where continental and oceanic plates meet, a different process, known as accretion, occurs. During **accretion** (uh•KREE•shuhn), pieces of the Earth's crust come together slowly as the oceanic plate slides under the continental plate at a shallow angle. This movement levels off seamounts—underwater mountains with steep sides and sharp peaks—and piles up the resulting debris in trenches. This buildup can cause continents to grow outward. Most scientists believe that much of western North America expanded outward into the Pacific Ocean over 200 million years as a result of accretion.

New land can also form when two oceanic plates converge. In this process, one plate moves under the other, often forming an island chain at the boundary. Oceanic plates can also be pushed apart in a process known as **spreading**. The resulting rift, or deep crack, allows magma from within the Earth to well up between the plates. The magma hardens to build undersea volcanic mountains or ridges and some islands. This spreading activity occurs down the middle of the Atlantic Ocean's floor, forming the Mid-Atlantic Ridge, pushing Europe and North America away from each other.

accretion slow process in which an oceanic plate slides under a continental plate, creating debris that can cause continents to grow outward

spreading process by which magma wells up between oceanic plates and pushes the plates apart

fold a bend in layers of rock, sometimes caused by plate movement

fault a crack or break in Earth's crust

faulting process of cracking that occurs when the folded land cannot be bent any further

Folds and Faults

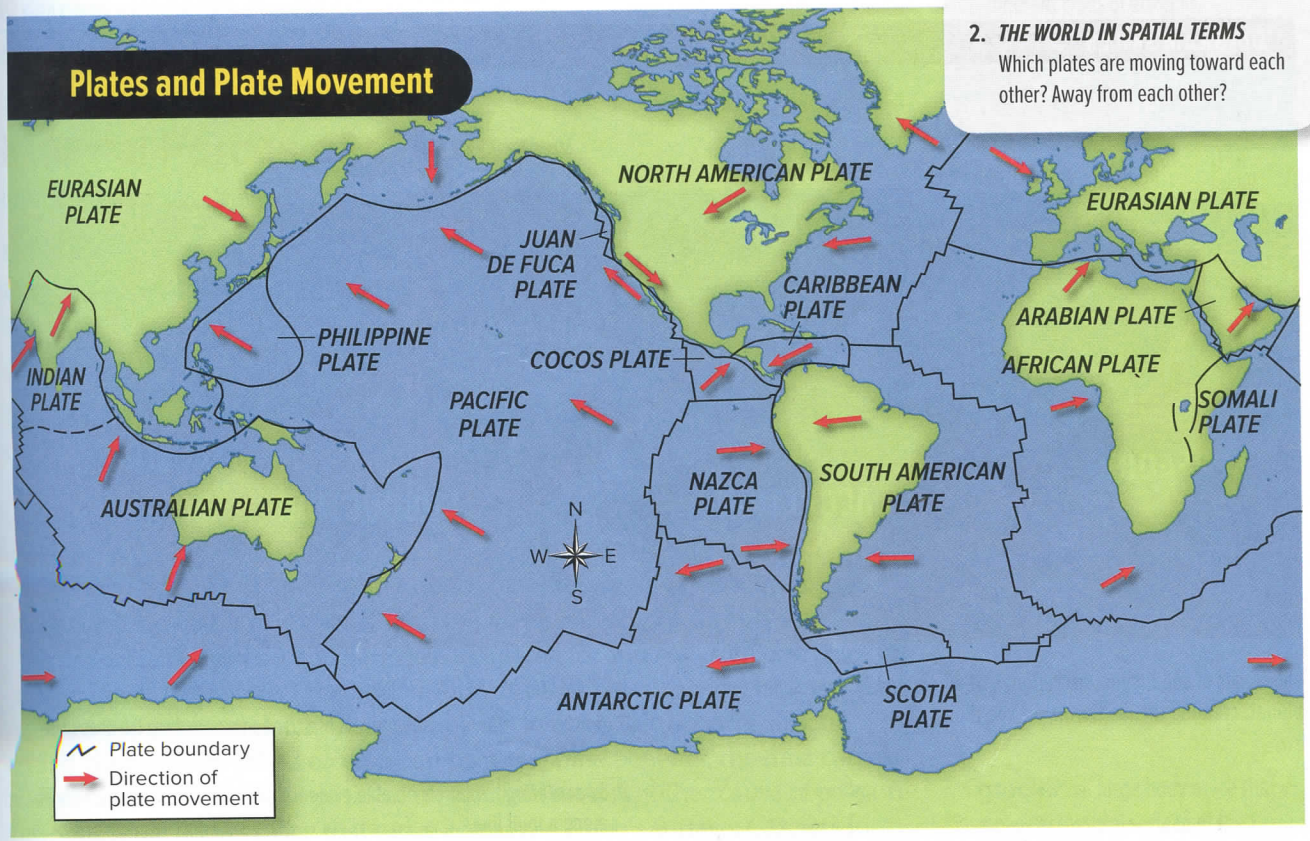
Moving plates sometimes squeeze the Earth's surface until it buckles. This activity forms **folds**, or bends, in layers of rock. In other cases, plates may grind or slide past each other, creating cracks in the Earth's crust called **faults**. One famous fault is the highly visible San Andreas Fault in California.

The process of **faulting** occurs when the folded land cannot be bent any further. The Earth's crust cracks and breaks into huge blocks. The blocks move along the faults in different directions, grinding against each other. The resulting tension builds up and is then released by shaking of the Earth's crust.

GEOGRAPHY CONNECTION

Tectonic plates make up Earth's crust.

1. ***PHYSICAL SYSTEMS*** Identify and describe physical features that are the result of plate movement.
2. ***THE WORLD IN SPATIAL TERMS*** Which plates are moving toward each other? Away from each other?



Analyzing PRIMARY SOURCES

Eyewitness: Icelandic Volcano

"I woke up on Friday with a weird feeling that something just wasn't right. It wasn't light as it normally is—we don't really have night-time at this time of year.

I looked outside and there was a thick, black cloud of ash directly above us. It was exactly like the middle of winter. What is even more surreal was the absolute bright daylight on either side of our village."

—Gina Christie, BBC News, May 17, 2010

DBQ DRAWING CONCLUSIONS

Why do you think it could have been dark at Gina Christie's house, yet bright across town?

Many of these events occur as a series of small jumps, felt as minor tremors on the Earth's surface. A few, however, occur as sudden and violent movements of Earth's surface.

Earthquakes and Volcanoes

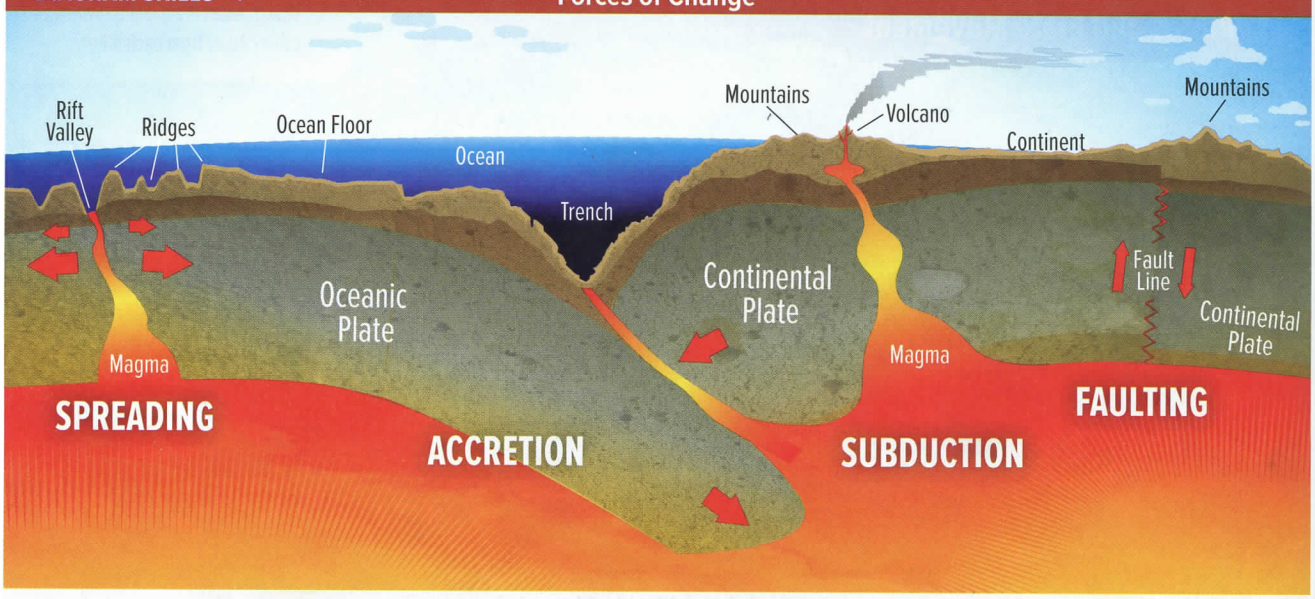
Sudden, violent movements of the lithosphere along fault lines are known as earthquakes. These shaking activities dramatically change the surface of the land and the floor of the ocean. During a severe earthquake in Alaska in 1964, a portion of the ground lurched upward 38 feet (11.6 m).

Earthquakes often occur where plates meet. Tension builds up along fault lines as the plates stick. The strain eventually becomes so intense that the rocks suddenly snap and shift. This movement releases stored-up energy along the fault. The ground then trembles and shakes as shock waves surge through it, moving away from the area where the rocks first snapped apart.

Disastrous earthquakes have occurred in Kōbe, Japan; in the U.S. cities of Los Angeles and San Francisco; near the Indonesian island of Sumatra; and in Oaxaca, Mexico. These places are located along the *Ring of Fire*, one of the most earthquake-prone areas on the planet. It is a zone of earthquake and volcanic activity around the perimeter of the Pacific Ocean. Here the plates that cradle the Pacific meet the plates that hold the continents surrounding the Pacific. North America, South America, Asia, and Australia are affected by their location on the Ring of Fire.

Volcanoes are mountains formed by lava or by magma that breaks through the Earth's crust. Volcanoes often rise along plate boundaries where one plate plunges beneath another, as along the Ring of Fire. In such a process, the rocky plate melts as it dives downward into the hot mantle. If the molten rock is too thick, its flow is blocked and pressure builds. A cloud of ash and gas may then spew forth, creating a funnel through which the red-hot magma rushes to the surface. There the lava flow may eventually form a large volcanic cone topped by a crater—a bowl-shaped depression at a volcano's mouth.

DIAGRAM SKILLS Forces of Change

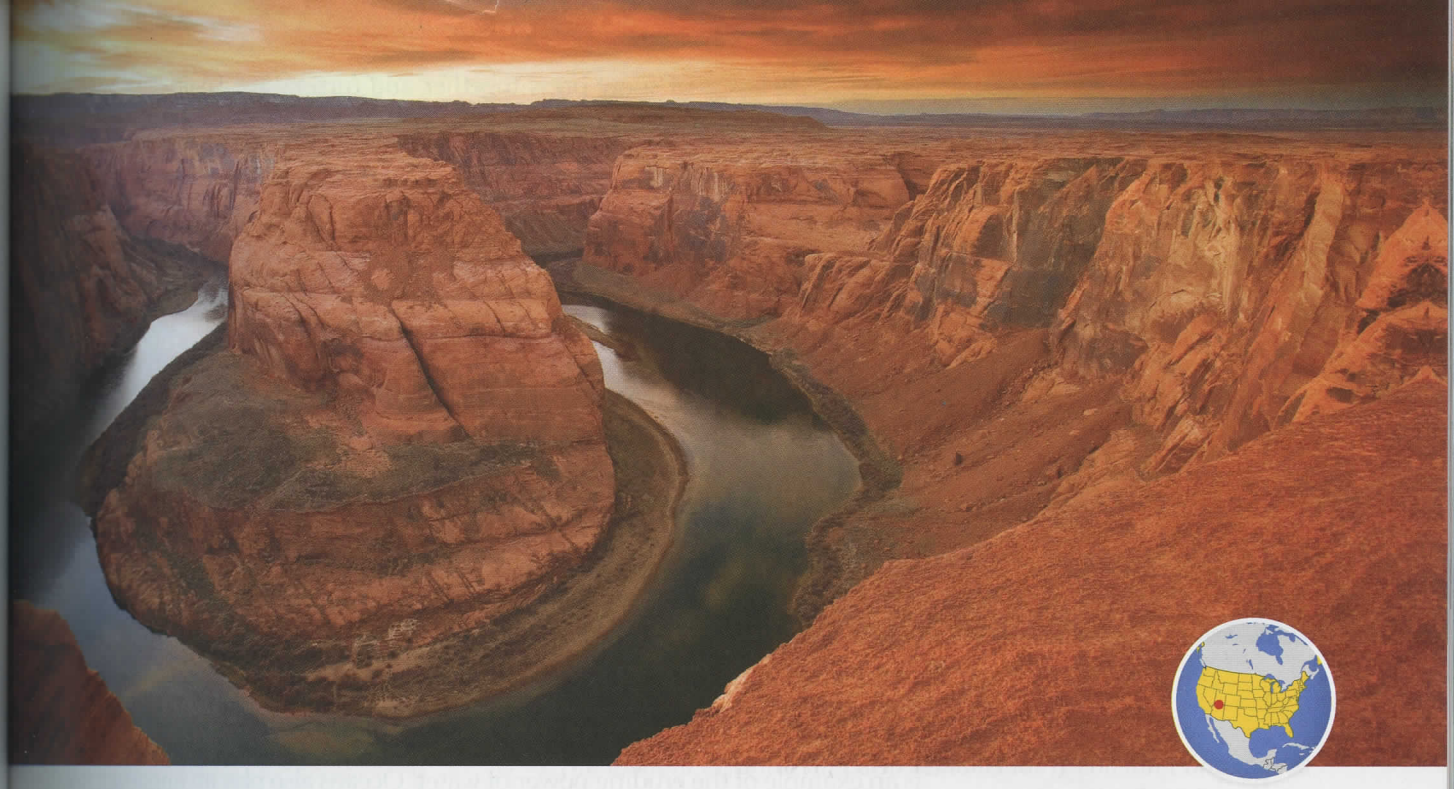


The forces of subduction, accretion, spreading, and faulting shape our planet, creating the landforms we see today.

▲ CRITICAL THINKING

1. ***Analyzing*** How does the process of accretion create deep trenches on the Earth's surface?
2. ***Speculating*** What observable evidence might you see after movement along a fault line?

Jim Kruger/Getty Images



The Colorado River has been shaping the main gorge of the Grand Canyon for thousands of years.

Volcanoes also arise in areas away from plate boundaries. Some areas deep in the Earth are hotter than others, and magma often blasts through the crust and creates volcanoes at the surface. As a moving plate passes over these hot spots, molten rock flowing out of the Earth may create volcanic island chains, such as the Hawaiian Islands. At some hot spots, molten rock may also heat underground water, resulting in hot springs or geysers like Old Faithful in Yellowstone National Park.

READING PROGRESS CHECK

Explaining How are volcanoes formed and where are they typically located?

▲ CRITICAL THINKING

1. ***Comparing and Contrasting*** How does weathering differ from erosion?
2. ***Classifying*** What are the three different types of erosion?

External Forces of Change

GUIDING QUESTION *What external forces shape Earth's surface?*

External forces, such as wind and water, also change the Earth's surface. Wind and water movements involve two processes. **Weathering** breaks down rocks, and **erosion** wears away the Earth's surface by wind, glaciers, and moving water.

external arising outside of

weathering chemical or physical processes that break down rocks into smaller pieces

erosion the movement of weathered rock and material by wind, glaciers, and moving water

Weathering and Erosion

The Earth is changed by two basic kinds of weathering. Physical weathering occurs when large masses of rock are physically broken down into smaller pieces. For example, water seeps into the cracks in a rock and freezes, expanding and causing the rock to split. Chemical weathering changes the chemical makeup of rocks. For example, rainwater that contains carbon dioxide from the air easily dissolves certain rocks such as limestone. Many of the world's caves have been and continue to be formed by this process.

Wind erosion carries small particles of dust, sand, and soil from one place to another. Plants help protect the land from wind erosion. However, in dry places where people have cut down trees and plants, winds pick up large amounts of soil and blow it away. Wind erosion can provide some benefits; the dust carried by wind often forms large deposits of mineral-rich soil. Another cause of erosion is **glaciers**, large bodies of ice that move across the Earth's surface. Glaciers form

glacier a large body of ice that moves across the surface of the Earth