# HOW ARE LANDFORMS CREATED AND CHANGED?

Landforms are created by different natural forces. Some are within Earth, and some are on the surface of Earth. Landforms can also be changed by humans. These changes can be disastrous for us. Knowing how landforms are created and changed can help us predict how they might change in the future. This can help us protect the environment and our ways of life.

## EARTH'S MOVING PLATES

**Plate tectonics** is the theory that Earth's crust is made up of several rigid pieces, or plates, that are pushed by forces inside the planet. This surface crust, also called the **lithosphere**, is made up of seven large plates along with some smaller ones (**Figure 1.8**). The plates vary from 100 to 200 km in thickness.

**plate tectonics** the theory that Earth's surface is made up of rigid plates that are pushed by forces inside the planet

**lithosphere** the outer, solid layer of Earth made up of moving plates

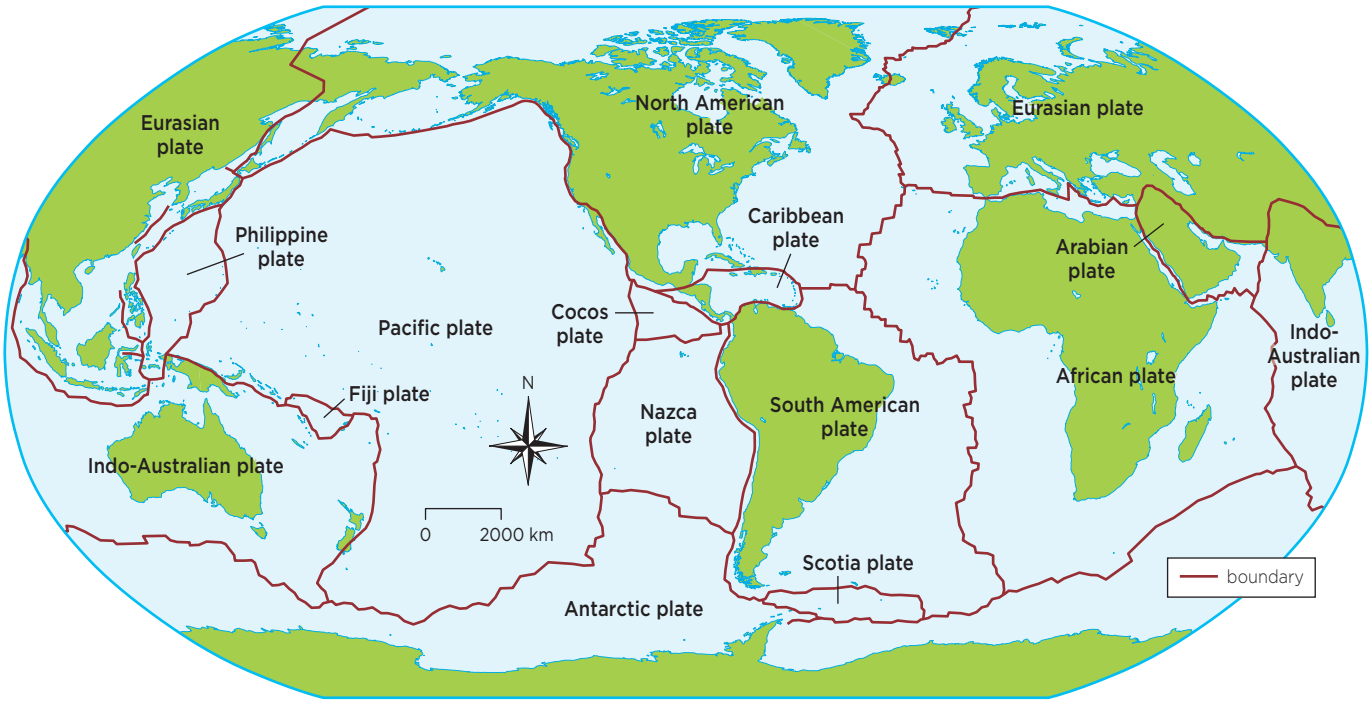


**FIGURE 1.8** These are the plates that make up Earth's surface.

**FIGURE 1.9** Lava flowing from Tolbachik Volcano in Kamchatka, Russia

I wonder how far lava can travel?

The plates move constantly. Their movement is caused by convection flows underneath them. **Convection flow** is the circular motion that occurs when warmer material rises and is replaced by cooler material. The plates float on the **asthenosphere**, which is a layer of semi-molten rock under the lithosphere. As it heats, it becomes less dense and lighter. It flows upward. It is replaced underneath by the flow of cooler semi-molten materials. This material heats up and then flows upward. In turn, it is replaced. This creates a circular motion. The plates, which sit on top of the flows of material, are pushed along as if they are on a conveyor belt. The major plates carry both the continents and the ocean floors.

As you can see in **Figure 1.10**, where the plates of the lithosphere pull apart from each other, magma erupts through the Earth's surface as lava **(Figure 1.9)**, creating volcanic mountains. Where the plates collide or rub together, they create mountains and sometimes earthquakes.

convection flow a circular motion created when warmer material rises and draws down cooler material, which replaces it

asthenosphere soft weak layer under the lithosphere upon which the tectonic plates move

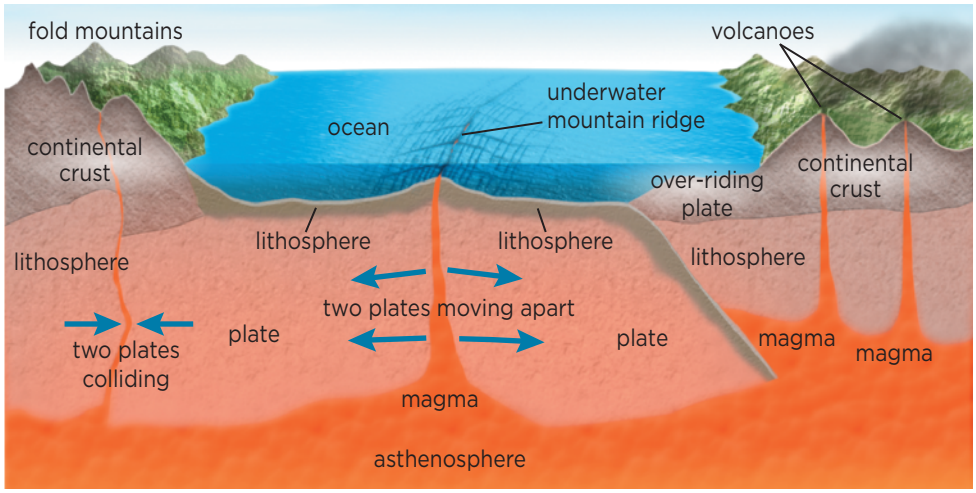


**FIGURE 1.10** This diagram shows how plate tectonics work.

# PLATES BUILD MOUNTAINS

Most mountains are built at the edges of plates. There are three main categories of plate boundaries (**Figure 1.11**).

## DIVERGENT PLATE BOUNDARIES

divergent boundary a place where two plates of the lithosphere move away from each other

**Divergent boundaries** are places where two plates of the lithosphere are moving apart (**Figure 1.11A**). They are usually located on the ocean floors. Here, magma moves upward between the plates, creating new rock. Volcanic activity is common in these areas. The Mid-Atlantic Ridge is an example. There continues to be volcanic activity along this underwater ridge.

## TRANSFORM PLATE BOUNDARIES

transform boundary a place where side-by-side plates grind past each other

Why might people living in the area of this fault continue to live there despite the risks?

Plates that are side by side grind past each other at **transform boundaries** (**Figure 1.11B**). This creates friction, which often creates earthquakes. The San Andreas Fault near San Francisco, California, is a transform fault that is about 1300 km long. Scientists at the University of California are trying to calculate when there will be another slip along this fault, causing another large earthquake.

## CONVERGENT PLATE BOUNDARIES

convergent boundary a place where two plates of the lithosphere come together

Some plates push together at **convergent boundaries.** When two continental plates meet, the constant pressure against each other causes the edges of the plates to compress and push up (**Figure 1.10**). They become fold mountains. When an underwater plate and a continental plate collide, the ocean plate is forced under the continental plate, creating a trench. The pressure along the trench creates earthquakes. Magma from below bursts to the surface through the broken layers nearby, creating a volcano (**Figure 1.11C**).

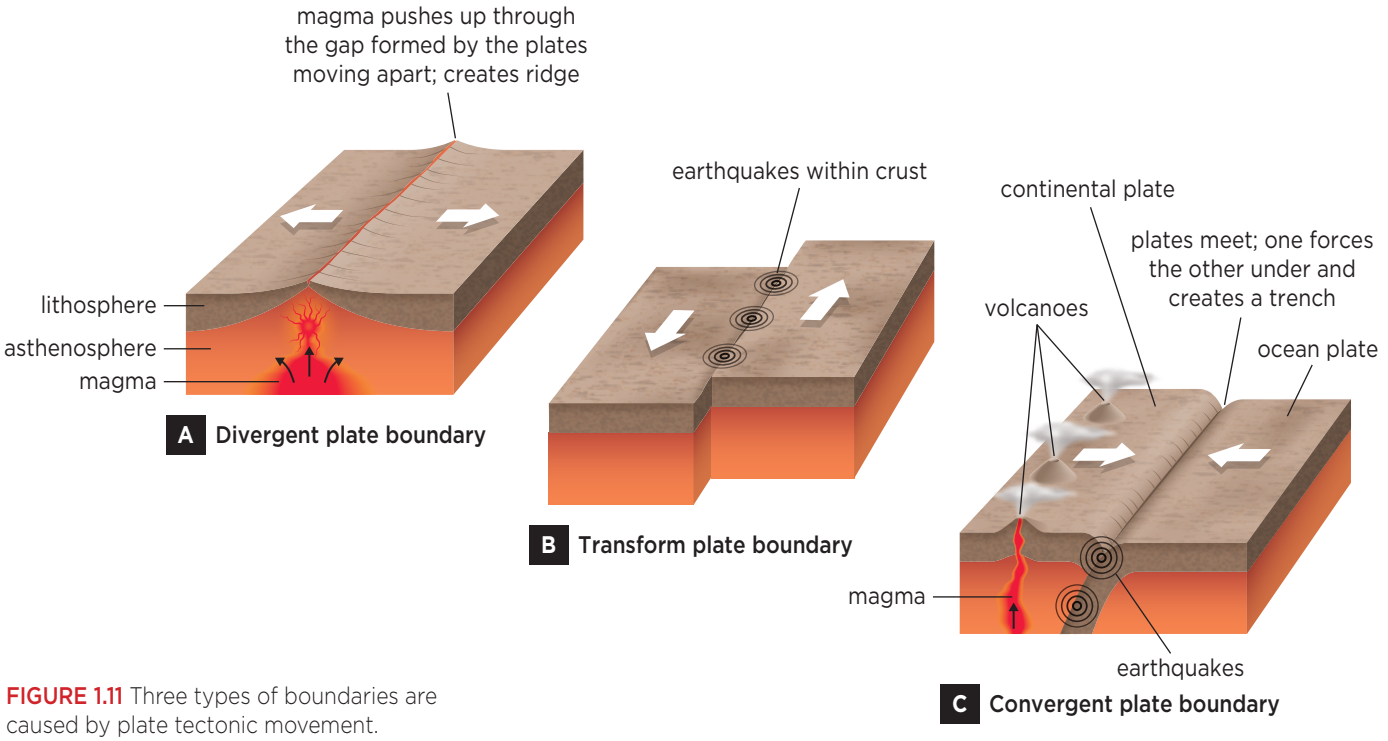


FIGURE 1.11 Three types of boundaries are caused by plate tectonic movement.

FOCUS ON

# PATTERNS AND TRENDS

When looking at landforms, geographers examine patterns and trends. Patterns are arrangements or similarities in characteristics. Trends are patterns in how something is changing or developing.

As you learn about landforms in Unit 1—and about other characteristics of the natural environment—think about the patterns that exist and ask questions about them, such as the following:

- What causes these patterns?
- Do all places have similar patterns?
- How do these patterns affect the lives of people living there?

## LOOKING FOR PATTERNS AND TRENDS

Seeing and naming patterns and trends is important because it helps us think about them in certain ways, for example, as groups for comparing and contrasting. These ways of thinking can lead us to learn more about the world around us.

For example, when we look at the western coast of North America, we see more than one mountain range. When we see a pattern like this, we ask why.

Here is a second example. The Ring of Fire is a large area in the Pacific Ocean where most of the world's volcanoes are located and where most of the world's earthquakes occur. When we see this pattern, we ask if there are similar causes to earthquakes, volcanoes, and tsunamis.

## EARTHQUAKES IN CANADA

Scientists at Natural Resources Canada detect about 4000 earthquakes a year. We only feel about 50 of those earthquakes. **Figure 1.12** shows the locations of all the large earthquakes in Canada between 1660 and 2009. British Columbia has experienced more earthquakes than any other place in Canada.

## TRY IT

1. Look over the Major Landform Regions around the World map in **Figure 1.2.** Answer the following questions:
   - What landform type do you live near?
   - What parts of the world have this landform type, and what parts do not?
   - What type of pattern is shown by the landform?
2. Looking at **Figure 1.12**, what pattern can you identify? What do you suppose caused that pattern? What does that pattern mean for the people of Canada?

**Large Earthquakes in Canada, 1660–2009**


**FIGURE 1.12** This map shows the general locations of all large earthquakes in Canada between 1660 and 2009. Magnitude is one measure used to describe the amount of energy released during an earthquake. None greater than 10 have ever been recorded.

## EROSION CREATES LANDFORMS

**weathering** the breaking down of rocks by physical or chemical processes

**erosion** the wearing away of Earth's surface by wind, water, or glacial action

Erosion creates landforms, such as valleys and plains. **Weathering** is a natural force that breaks down rock into small particles. **Erosion** then moves materials from one place on Earth's surface to another. It takes place through the action of water, ice, wind, and living organisms. The process of weathering begins when rocks in the lithosphere break down into small particles. Weathering takes place in two ways:

- **physical action:** the wind and water disintegrate the rocks
- **chemical action:** acids in water dissolve the rock into particles

How could people create erosion?

### WATER EROSION

As water flows across the surface of Earth, it erodes the rock, picking up small pieces of weathered material and carrying them away. Over time, the water erodes deeper into the rock. Eventually this forms valleys (**Figure 1.13**).

When moving water reaches a lake or sea, it slows down. Any eroded material it carries settles in the waterway. It builds up at the bottom of the lake or sea. Sometimes the action of plate tectonics pushes this flat underwater layer of land above sea level. It becomes a plain. This is how the Great Plains in the southern parts of Alberta, Saskatchewan, and Manitoba were formed. Sometimes the sea level drops and the flat sea bottom becomes dry, forming a plain.

**FIGURE 1.13** The Grand Canyon, in the United States, is a type of valley. It was caused by many factors, including water and ice erosion, wind erosion, and the force of the Colorado River running through it.

I wonder how long ago the Grand Canyon was formed?

**FIGURE 1.14** A fjord in Norway. This fjord was caused by glacial erosion.

I wonder how much material a glacier moved to create this fjord?

## ICE EROSION

During the ice ages, ice sheets, or glaciers, slowly moved across Earth's surface, scraping the top layers of rock. In some places, such as Norway, they carved long, narrow, and deep valleys, which are called fjords (**Figure 1.14**).

The glaciers carried along the particles they broke off. When the glaciers eventually stopped, the particles were deposited at the glacier's front edge. Even though most of the glaciers are gone, you can still see glacial deposits, which are usually a jumble of boulders, rocks, sand, and silt.

What evidence can I use to figure out how glacial deposits were formed?

## WIND EROSION

Where the land surface is bare, the wind picks up weathered particles and carries them along. The stronger the winds, the larger the size and quantity of the particles they can move. When the wind speed dies down, the materials are deposited as sand dunes (**Figure 1.15**).

**FIGURE 1.15** The wind creates ripples in the desert sands of Morocco.

I wonder how plants affect wind erosion?

## PEOPLE CREATE AND CHANGE THE LAND

In what ways have people changed landforms where you live?

There are now more than 7 billion people on Earth. People can affect landforms and landscapes temporarily, such as when we cut down trees or build roads. We also affect them more permanently through activities such as mining.

### CREATING LIVING SPACES

People change the surface of the land to create better living spaces, including places for homes, agriculture, and transportation networks. It is easier to build structures on solid, flat land. In some cities, water bodies are filled in to create flat spaces to build homes and businesses. Construction crews cut down hills or fill in valleys to create level surfaces for roads and railways.

### MEETING BASIC NEEDS

We need food, water, and shelter to survive. Sometimes people have changed the land in order to grow more food. To increase harvests, farmers in some parts of Asia cut steps or terraces into hillsides. They plant rice in these flat fields. To prevent rainwater racing down the slopes and eroding the soil, the farmers control the flow of water into, and out of, the terraces. They give each field just enough water to get the most growth.

The rice terraces in the Philippines, shown in **Figure 1.16**, cover 10 000 km$^2$ of mountainside, which is almost double the area of the province of Prince Edward Island.

**FIGURE 1.16** Rice terraces in Banaue, Philippines

I wonder what some of the challenges are of this type of farming?

**FIGURE 1.17** An open pit diamond mine in the Northwest Territories in Canada

I wonder if this land will ever go back to the way it was?

## MINING

People need resources from Earth, such as minerals, in order to make tools, cars, computers, buildings, and other useful items. They mine rich mineral deposits for ores, such as iron, silver, and gold. You will read more about this in Chapter 8. In some cases, miners dig down into Earth's surface, creating huge open pits (**Figure 1.17**), which destroy the original shape of the land. Other mines are dug deep underground. Rocks and other materials that are extracted are left behind, changing the land's surface. In some places, such as the Appalachian region in the United States, miners use explosives to blow off the tops of entire mountains. This makes it easier to reach the coal underneath.

## CHECK-IN

1. **COMMUNICATE** Choose a way to demonstrate that you understand how the plates of Earth's surface are able to move. Be sure to include these words: *convection currents*, *asthenosphere*, *divergent plate boundary*.
2. **SPATIAL SIGNIFICANCE** Why do volcanoes and earthquakes occur at the edges of plates? Write an explanation for this question. Include a diagram, or create a comic strip to answer this question.
3. **EVALUATE AND DRAW CONCLUSIONS** Create a chart that compares water, ice, and wind as causes of erosion. Put these methods of erosion in order from most important to least important for the area where you live.