TOPIC 9

Forces That Change Earth's Surface

LESSON 1: THE BASICS

KEY CONCEPTS

- continental drift
- plate
- plate tectonics
- convection currents
- plate boundary
- weathering
- mechanical weathering
- chemical weathering
- erosion

THINK LIKE A SCIENTIST

While flying in an airplane over California, you pass the time by looking at the ground below. You have seen rugged mountains, rocky seashores, and flat areas filled with growing crops. But wait—what's that big crack in the Earth? It looks as though the ground has split open. You remember hearing someone say that part of California is moving north. You've always wondered how that could be. Is that big crack in the ground evidence of such a claim? What could have caused the ground to rip apart that way?

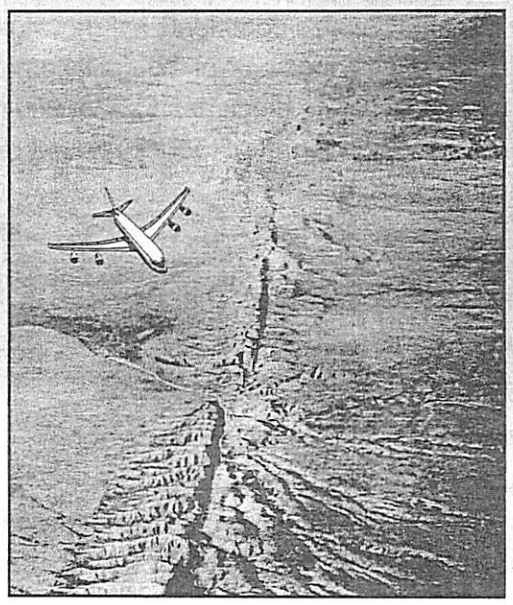
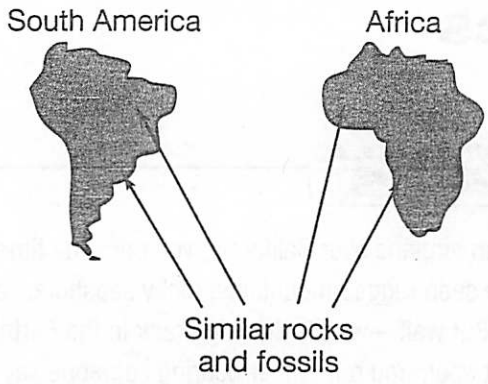


Plate Tectonics

What you saw from your airplane window was the San Andreas Fault. A *fault* is a break in the rock that makes up Earth's surface. When different parts of Earth's surface move in different directions, the ground rips apart. A fault appears. Earth's surface is broken up by many such faults.

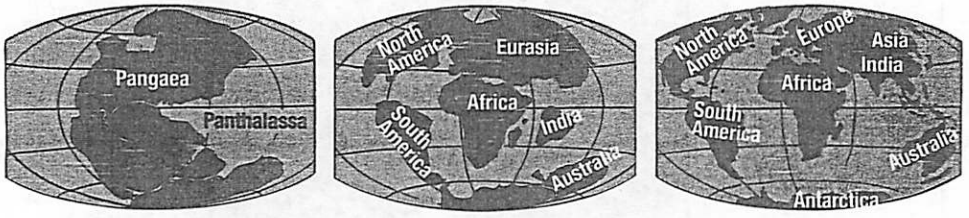
But what makes Earth's surface move in the first place? A hundred years ago, many scientists did not realize that Earth's surface moved at all. It was only when they put certain observations together that they came to that conclusion.

In the early 1900s, scientists noticed something on opposite sides of the Atlantic Ocean. Identical fossils and rock types had been found in South America and in Africa. They also wondered why the coastlines of South America and Africa seemed to fit together like puzzle pieces. Could the two continents have been joined together long ago? If so, what force had split them apart?



Similar rocks and fossils found thousands of miles away suggest that the continents were attached and then drifted apart.

Then a scientist named Alfred Wegener developed the theory of **continental drift**. This theory says that Earth's continents are moving. According to this theory, all of Earth's land was once part of a huge landmass Wegener named *Pangaea*. The landmass began to break apart about 200 million years ago. The pieces, or continents, eventually drifted to their present positions.



245 million years ago | 65 million years ago | Present

At first scientists were doubtful about continental drift. After all, just how did the continents move? Wegener was unable to say. That question remained unanswered for a while.

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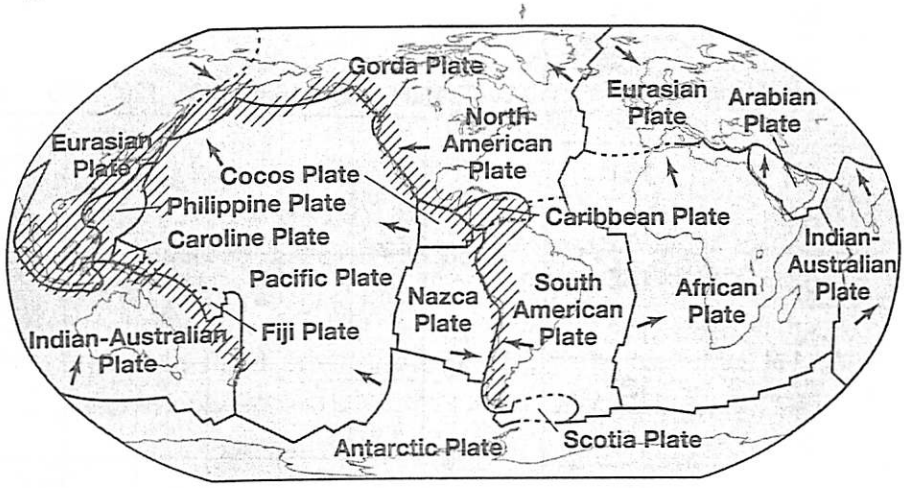
In the mid-1900s, scientists exploring the deep ocean were surprised to find a mountain range on the ocean floor. Until then, they assumed the ocean floor was flat with few features. The mountain range they found was part of an enormous system. These mountains circle the entire planet, zigzagging between continents.

The mountain range, or *mid-ocean ridge*, turned out to be a crack in Earth's surface. The pieces on each side of the crack were pulling away from each other. Melted rock from beneath the surface oozed up into the crack, creating mountains.



Earth's crust is broken into plates.

On each side of the mid-ocean ridge is a tectonic plate. **Plates** are large, rigid pieces of rock that constantly move. They carry the continents and ocean floor with them. The theory of **plate tectonics** states that Earth's surface is made up of moving plates. Many of Earth's surface features formed as a result of these plates moving and interacting.

Two plates, the North American and the Pacific, meet in California. Where they meet, Earth's crust is cracked. You saw that crack, the San Andreas Fault, from your airplane window.

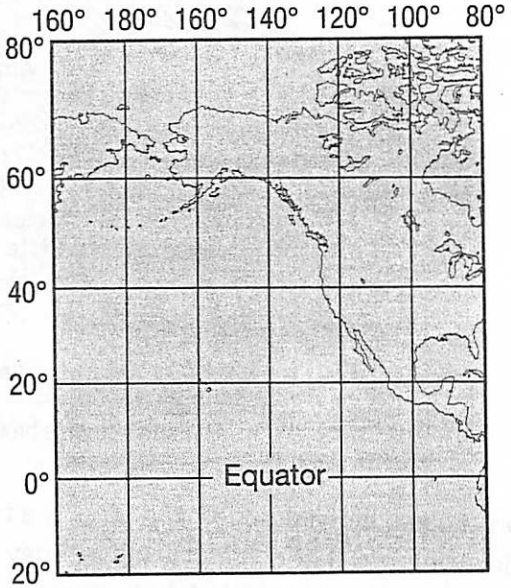
EXPLORE

The map below shows western North America and lines of latitude and longitude. The table below gives the location of earthquakes that occurred over a seven-day period in the area shown on the map. Mark a dot on the map where each earthquake occurred. Then answer the questions.

INQUIRY SKILLS

- interpreting data ✓
- drawing conclusions ✓

Latitude (°N)	Longitude (°W)
52	174
32	117
37	122
60	151
55	162
53	168
32	116
45	121
51	177
56	152
42	112
38	119
38	112
36	120
51	171
62	137



1. Where did most of the earthquakes occur?

_____

_____

2. Look at the map of tectonic plates on page 130. Compare it to your earthquake map. How do you think earthquakes and plates are related?

_____

_____

KEY CONCEPTS

- continental drift ✓
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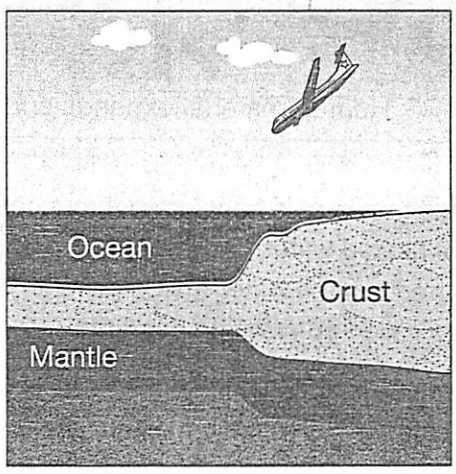
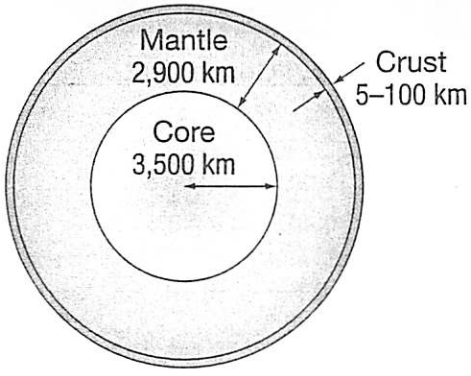
THINK LIKE A SCIENTIST

Now that you've learned about tectonic plates, you wonder what's going on under Earth's surface. What if your plane could dive down through solid rock the way a submarine dives in ocean water? You could travel right through the plates to see what is below them. You could observe the constant, slow movement of the plates. And you could answer the question, "What forces drive the movement of the plates?"

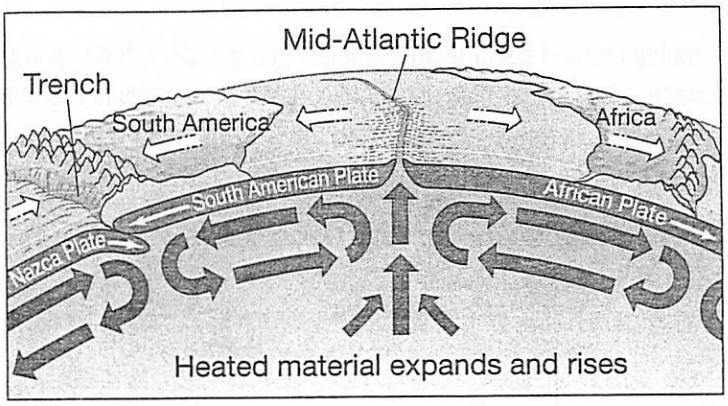


Earth's Restless Surface

If you could travel inside Earth, you would see that Earth is made up of the three main layers shown below. The outermost layer, the *crust*, is a thin, brittle rock layer. It is thicker under the continents than it is under the oceans. The thicker middle layer, the *mantle*, is mostly hot, soft rock that acts like a thick liquid. The mantle surrounds Earth's innermost layer, the *core*.



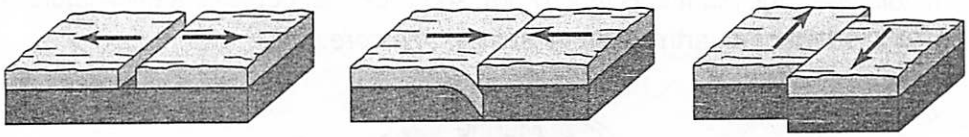
Tectonic plates sit and float on top of the mantle. This part of the mantle is a solid but soft rock that flows like a liquid. The drawing below shows how currents in the mantle move Earth's plates.



In Topic 5, you learned that heat is transferred throughout a liquid by convection. Recall that in a pot of heated water, hot water rises and cooler water sinks over and over, forming currents in the water. These currents of rising hot liquid and sinking cool liquid are called **convection currents**.

The rock in Earth's mantle is not a liquid, but it flows like one. Mantle material near Earth's center is hotter than mantle material nearer Earth's surface. The hotter material rises as the cooler material sinks. The result is slowly flowing convention currents in the mantle that move the plates riding on top.

As the plates move, they interact with one another. These interactions cause earthquakes, volcanic eruptions, and mountain building. Another result is that new features are formed on Earth's surface. The place where two tectonic plates meet and interact is called a **plate boundary**. Three types of plate boundaries are shown below.



Divergent Convergent Transform

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- continental drift ✓
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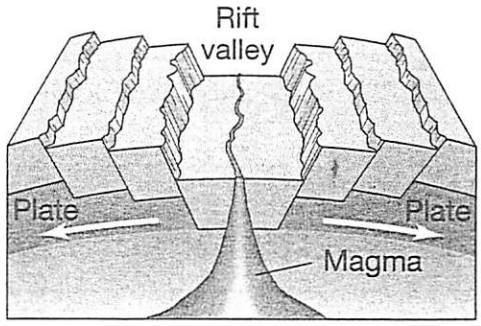
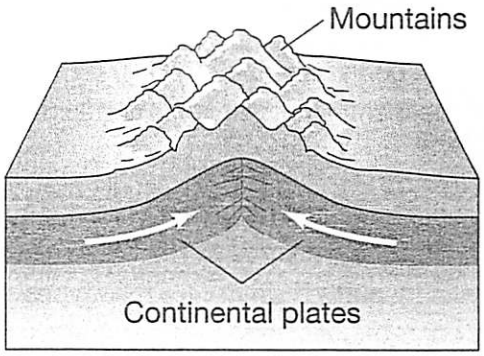
A *divergent boundary* forms where two plates move apart, or diverge. On land, you can see divergent boundaries as long, deep valleys. Under the oceans, they form mid-ocean ridges. Most of Earth's new crust forms along divergent boundaries on the ocean floor.

Divergent Boundary



A *convergent boundary* forms where two plates move together, or converge. Along these boundaries earthquakes occur, volcanoes erupt, and mountains get pushed up.

Convergent Boundary



At a *transform boundary*, two plates slip past each other. No mountains or valleys form, but faults do. The San Andreas Fault you flew over is the result of a transform boundary.

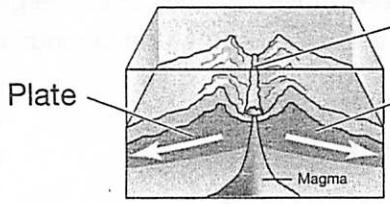
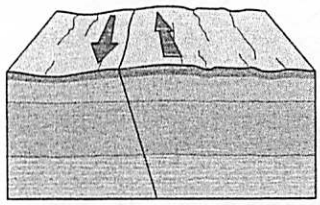
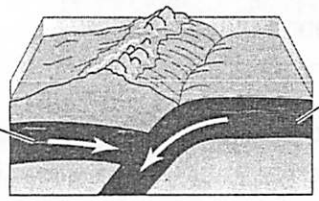
Now you know that convection currents in the mantle drive the movement of the plates. You also know that movement brings plates together or moves them apart or past each other at plate boundaries. What else can you find out about tectonic plates?

EXPLORE

Look at the pictures below. Identify the kind of plate boundary shown as a convergent, divergent, or transform boundary. Then explain how you know.

INQUIRY SKILLS

- interpreting diagrams ✓
- classifying ✓
- communicating ✓

Picture	Type of Plate Boundary	How I Know
		
		
		

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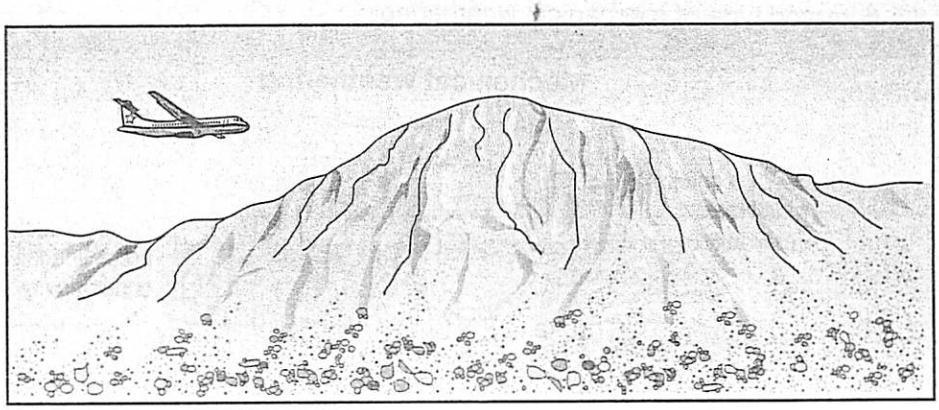
- chemical weathering ✓
- erosion

THINK LIKE A SCIENTIST

What if your plane could not only fly through rocks but into the future like a time machine? Imagine traveling into the future, say, a hundred million years from now. You could fly over Earth's surface, looking for familiar features. Mountains that you remember as being tall and sharp might look very different. Instead, you'd see smaller, round hills. You ask yourself, "What caused these changes?"



Earth's Changing Surface

Earth is constantly changing. Some processes cause Earth's surface to build up. For example, moving plates cause mountains to form and volcanoes to erupt. Other processes lower the surface and wear down features like mountains and volcanoes.

Weathering

You may think that mountains last forever, but weathering slowly wears them down. **Weathering** is a process that breaks down rock into smaller pieces. Weathering happens at or near Earth's surface. There, rocks are constantly worn away and broken down by wind, water, or chemicals.

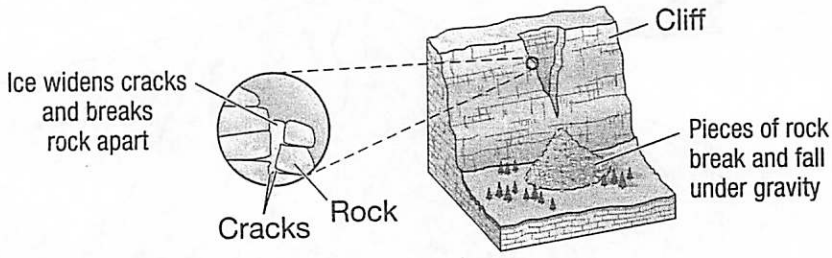
There are two types of weathering. During **mechanical weathering**, rocks get broken down into smaller pieces by physical means. The chemical composition of the rocks is not changed. With **chemical weathering**, rocks break down into smaller pieces through chemical reactions. The chemical composition of the rocks changes.

Water, wind, ice, and organisms are the main agents of mechanical weathering. *Abrasion* is the grinding and scraping away of a rock surface by other, smaller rocks. These smaller rocks are carried by moving water, wind, or ice.

Have you ever seen a plant growing in the crack of a rock? As the roots grow into the cracks of the rock and exert pressure, the rock breaks apart.

Ice can break rocks, too. First, water collects in cracks in the rock. Then the water freezes and expands, which causes the rock to slowly break apart. Later, the ice melts and freezes again. The repeated freezing and melting of water is the common type of mechanical weathering.

Mechanical Weathering



Chemical reactions can cause rocks to weaken and fall apart, forming smaller pieces. Water, acids, and air can all react with the minerals that make up rocks.

Water combines with substances in rocks. New, softer substances form that are more easily broken down by mechanical weathering.

Acids produced by fungi or in rainwater can dissolve minerals in rocks, changing their chemical composition. Also, oxygen in the air reacts with iron or other substances in rocks. Remember that when oxygen reacts with iron, rust forms. Rusting makes rocks crumble.

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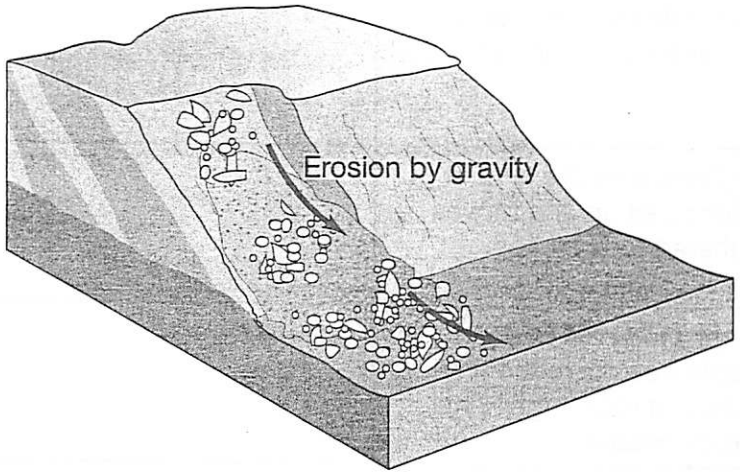
Erosion

Rocks that have broken down get picked up and carried away by water, wind, ice, or gravity. The process that picks up and moves rock is called **erosion**.

Water flowing over Earth's surface washes rocks downhill. Rivers and ocean waves move rocks from one place to another. The ice of a glacier picks up and carries away rocks as it slowly moves over the land. Over time, wind blows away tiny rock pieces on Earth's surface.

Gravity pulls pieces of rock down mountains. Chunks of rock that break off at the top of a mountain fall down, knocking off other chunks along the slope. You can often see a collection of loose rocks at the bottom of a mountain.



You can't find a plane that flies through rocks or travels into the future. But you can find out what changes Earth's surface. Plate movements, weathering, and erosion are some of the processes that build up and tear down Earth's surface features.

EXPLORE

Read each change described in the left column of the table below. In the right column, tell if the change involves mechanical weathering, chemical weathering, or erosion.

INQUIRY SKILLS

classifying ✓

Changes	Mechanical Weathering, Chemical Weathering, or Erosion?
Sand carried by the wind scrapes a rock, wearing away its surface.	
Acid in rainwater reacts with a rock, wearing a hole in it.	
As it flows over the land, a glacier picks up and moves weathered rock pieces.	
As they grow, the roots of a maple tree make the tiny cracks in a rock larger, until the rock breaks.	
A rock sitting on the ground rusts when air reacts with a mineral in the rock.	

PUTTING IT ALL TOGETHER

You are now ready to show you understand the key concepts covered in this topic. Read each question. Circle the letter of the best answer.

1. How are mechanical weathering and chemical weathering alike?
   - **A.** They both break down rocks in Earth's core.
   - **B.** They both break down rocks on Earth's surface.
   - **C.** They both break down rocks in Earth's mantle.
   - **D.** They both build up rocks on Earth's surface.

2. Earth's plates are moved by
   - **A.** the wind.
   - **B.** convection currents in the ocean.
   - **C.** convection currents in the crust.
   - **D.** convection currents in the mantle.

3. Most of Earth's new crust forms
   - **A.** along divergent boundaries.
   - **B.** on mountaintops.
   - **C.** along convergent boundaries.
   - **D.** at transform boundaries.

4. Which of the following is Earth's surface layer?
   - **A.** core
   - **B.** crust
   - **C.** mantle
   - **D.** plate

5. Which of the following reacts with rocks to cause chemical weathering?
   - **A.** acids
   - **B.** plant roots
   - **C.** rocks carried by wind
   - **D.** ice

6. Which of the following causes mechanical weathering?

   A. acid in rainwater falling on rocks

   B. acid from fungi growing on rocks

   C. rusting of rock surfaces

   D. repeated freezing and melting of water in rocks

7. The theory of continental drift says that

   A. Earth's surface is made up of moving plates.

   B. Earth's continents are moving.

   C. ocean water around the continents is drifting.

   D. the continents are worn down by erosion.

8. What is the picking up and moving of rocks called?

   A. chemical weathering

   B. mechanical weathering

   C. erosion

   D. plate tectonics

9. Which of the following causes erosion?

   A. gravity

   B. heat

   C. plants

   D. oxygen

10. Which of the following statements is true about Earth's plates?

    A. They rise and fall within Earth's mantle.

    B. They are made of soft rocks that flow like liquid.

    C. They are pieces of rock that never move.

    D. They are pieces of rock that constantly move.