



Russia's Varied Landscape: Physical Processes at Work

17

17.1 Introduction

In 1687, an English scientist named Isaac Newton proposed an amazing idea. He suggested that humans could launch a craft into space. This artificial satellite would orbit Earth, just as the moon does. Almost 300 years later, Newton's idea finally came to pass when, in 1972, Russian scientists launched a satellite known as Sputnik. Since then, a number of countries have launched more than 5,000 satellites into space. Cameras and other instruments carried by satellites have given humans a new view of Earth from space.

Geographers use these **satellite images** to study Earth. Among other things, these views of Earth from space show how landscapes develop and change over time. It may seem like mountains and valleys have always been where they are and always will be, but actually, Earth's surface is forever changing. **Physical processes**, or natural forces, are always at work on the landscape. Some physical processes build up land into mountains. Others wear down land into valleys and plains. Satellite images help scientists study the forces of change that shape these physical features.

In this chapter, you will learn about four physical processes that shape our Earth. You will also learn how those processes have changed Russia's landscape. Russia is the largest country in the world, covering almost one eighth of the world's land surface. Because of its great size, Russia has a large variety of landscapes to explore, and scientists are able to see many physical forces at work.

Essential Question

How do physical processes shape Earth's landscape?

The map at the center shows the physical landscape of Russia. The four drawings around the map represent physical processes that have shaped the Russian landscape. Two have built up the landscape. Two have worn it down. Keep this illustration in mind as you try to answer the Essential Question.

Graphic Organizer

Tectonic movement



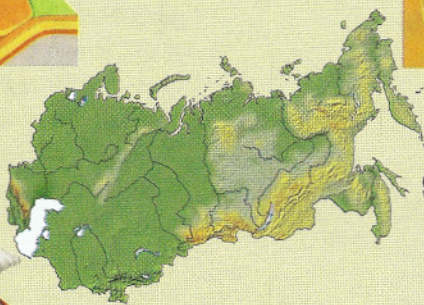
Erosion



Volcanic activity



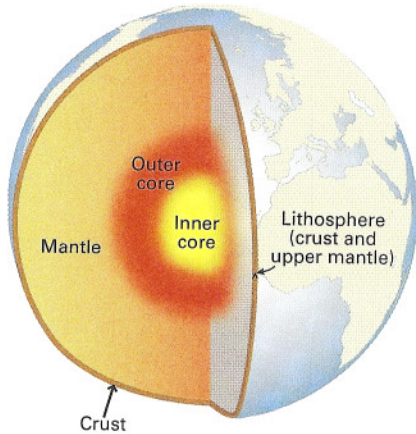
Glaciation



17.2 The Geographic Setting

Russia is a giant country that covers almost 7 million square miles, including large parts of Europe and Asia. It is so big that it includes 11 of Earth's 24 **time zones**. In contrast, the continental United States has only 4 time zones.

The western part of Russia is one large plain. At the eastern edge of this plain are the Ural Mountains, which separate Europe from Asia. East of the Urals lies Siberia, another vast plain that is part of Russia. High plateaus, icy mountains, and deep valleys surround Siberia. Physical processes have shaped this varied landscape. These processes begin deep inside our planet.



A Cutaway View of Earth

Earth may seem cool on the surface. But deep inside lies a hot liquid core. Earth's crust "floats" on this molten core. Cracks in the crust may result in volcanic activity or tectonic movement.

Inside Planet Earth The planet Earth was once a liquid fireball. While Earth has been cooling for more than 4 billion years, temperatures are still so high deep inside the planet that in some places rock and metals are a fiery liquid.

At the center of Earth lies its **core**. The core has two parts: the inner core, made up of solid iron, and the outer core, made up of liquid iron. Earth's core is the hottest part of the planet, with temperatures that may reach over 10,000 degrees Fahrenheit.

The next layer out from the core is called the **mantle**. The mantle is made up of molten, or liquid, rock called **magma** and accounts for about two thirds of Earth's mass.

The outermost part of Earth is called the **lithosphere**. The lithosphere includes a layer of solid rock and, above that, the **crust**. The crust is the only cool layer of Earth. It is where we live.

Forces Below the Crust Build Up Land Two physical processes build and shape land from below the crust. These two processes are **tectonic movement** and **volcanic activity**.

Tectonic is a Greek word that means "builder." Tectonic movement is movement inside Earth that results in changes on the planet's surface. Over millions of years, tectonic movement builds up mountains. It also triggers earthquakes.

Volcanic activity includes the formation and eruption of **volcanoes**. Like tectonic movement, volcanic activity also begins below Earth's crust. When volcanoes erupt, they can change the landscape suddenly and dramatically.

Forces Above the Crust Wear Down Land Two physical processes work above Earth's crust to reshape landscapes. These forces are **erosion** and **glaciation**. Erosion is the wearing away of Earth's surface, most commonly by the forces of wind or moving water, but also by the force of ice or gravity. Glaciation is the formation of large, thick masses of ice called **glaciers**. The weight of the ice exerts pressure that causes the glaciers to move very slowly across the land. This movement can gouge out deep valleys, carve and polish mountains, and push piles of rock and soil ahead of them. Erosion and glaciation create change very slowly.

These four physical processes have been changing Russia's landscape for millions of years. They have built its mountains and worn down its plains, canyons, and valleys. In this chapter, you will find out more about how these four physical processes have shaped not only Russia, but also the rest of our Earth.

► Geoterms

erosion the gradual wearing away of Earth's surface by the action of wind, water, ice, and gravity

glaciation the creation and movement of glaciers

physical processes natural forces that change Earth's physical features, including forces that build up and wear down Earth's surface

tectonic movement the movement of plates below Earth's surface

volcanic activity the formation and eruption of volcanoes

Physical Features of Russia

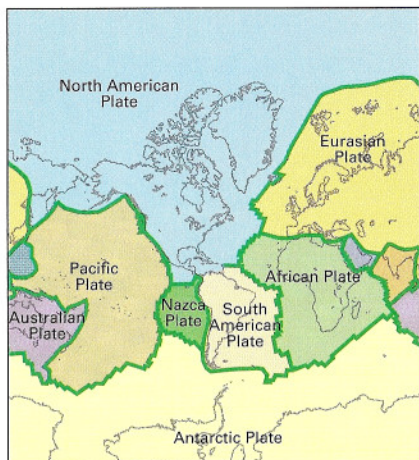


The World's Largest Country

Russia stretches from Europe across Asia to the Pacific Ocean. Tectonic activity and volcanoes have created its mountains. Erosion and glaciation have shaped its vast plains and plateaus.

17.3 How Tectonic Movement Shapes Earth

Earth's Tectonic Plates



A Crust of Moving Plates

Earth's solid crust is made up of tectonic plates. These plates float on the liquid rock that makes up the middle layer of Earth. There are at least 14 plates, some very large in area, some smaller.

Early in the morning of April 18, 1906, a terrifying earthquake shook the city of San Francisco, California, causing massive devastation. "Trolley lines snapped like threads" and buildings "crumbled like card houses," wrote one eyewitness. "The cobblestones danced like corn in a popper." Hundreds, and perhaps thousands, of people lost their lives, and hundreds of thousands more were left homeless. No one at that time understood how or why earthquakes happen. Today we know that they are caused by tectonic movement.

The Continents and Oceans Rest on Plates Scientists solved the mystery of earthquakes in the 1960s. They discovered that the lithosphere is broken into huge pieces called **tectonic plates**. Earth's lands and seas rest on these plates, which lie below the surface of the planet. The plates float like rafts on Earth's liquid mantle.

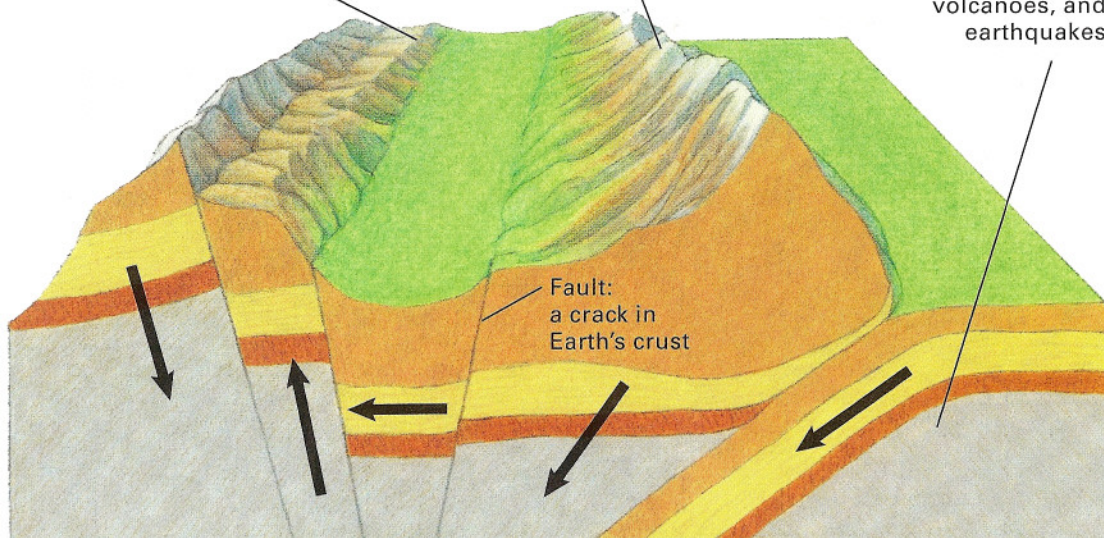
Tectonic plates move in three ways. They can move away from each other, they can move toward each other, or they can scrape sideways past each other. When two tectonic plates collide, one plate usually slides under the other.

Tectonic plates are incredibly heavy. When they meet, friction can lock them into place for long periods, allowing enormous pressure to build up below Earth's crust. When the pressure gets too great, the plates come unstuck and move with tremendous energy. We feel this sudden movement as an earthquake.

Fault-block mountain:
a mountain formed when
a block of Earth's crust
slides upward along a
fault line

Fold mountain:
a mountain formed when
colliding tectonic plates
force Earth's crust to
wrinkle or fold

Tectonic plate:
a large piece of Earth's
lithosphere that can move
to create mountains,
volcanoes, and
earthquakes



Mountain Building

Over millions of years, the slow movement of tectonic plates has created mountains. When plates collide, they push rock upward to form mountains.

The Movement of the Plates Creates Mountains When tectonic plates collide head-on, they can build mountains in two ways. The first way is when the pressure of colliding plates forces Earth's crust to fold, or wrinkle, without breaking. The resulting folds form mountains. The Appalachian Mountains in the United States and the Ural Mountains in Russia are examples of **fold mountains**.

The second way in which colliding plates create mountains is when their collision causes the crust to crack into huge blocks. The cracks between the blocks are called **faults**. As pressure builds up, the blocks of crust tilt and tip. Then some tilted blocks slide upward along **fault lines** to form mountains. The Sierra Nevada mountain range in California is made up of **fault-block mountains**, as is the West Sayan range in Russia.

17.4 Signs of Tectonic Movement in Russia

Russia covers a large part of both Europe and Asia and includes several mountain ranges. These mountain ranges tell the story of how tectonic movement can shape a landscape.

The Ural Mountains in western Russia are considered the dividing line between Europe and Asia. Even though Europe and Asia form one huge **landmass**, this division into two continents makes good geographic sense. The Urals mark the place where two tectonic plates meet beneath Earth's crust. Over millions of years, pressure from these two colliding plates has pushed the crust upward to create the Urals.

Ural Mountains The Urals slice through Russia from north to south. This long chain of mountains separates the Northern European Plain to the west from the West Siberian Plain to the east.

The Urals are fold mountains, formed as the two underlying plates caused Earth's crust to wrinkle. In some places, erosion has worn these mountains down into rolling hills. Other parts of these mountains still have rugged peaks. Mount Manaraga in the northern Ural Mountains is sometimes called Bear's Paw because of its jagged ridge.

Caucasus Mountains The Caucasus Mountains are in southwestern Russia. They run west to east on a narrow strip of land between the Black Sea and the Caspian Sea, marking a southern dividing line between Europe and Asia.

Like the Urals, the Caucasus Mountains are fold mountains. They also include volcanic formations and glaciers, which still carve the jagged landscape. Mount Elbrus, the highest peak in the Caucasus, stands at 18,510 feet and is an extinct volcano.

West Sayan Mountains The West Sayan Mountains are in southern Siberia, just west of Lake Baikal. Around Lake Baikal, major faults separate high mountains and plateaus from deep valleys and basins.

The West Sayan Mountains are fault-block mountains. In this range, erosion has worn away loose soil and rocks from the peaks. This process has left behind steep ridges and exposed layers of rock on the upper slopes of the mountains.

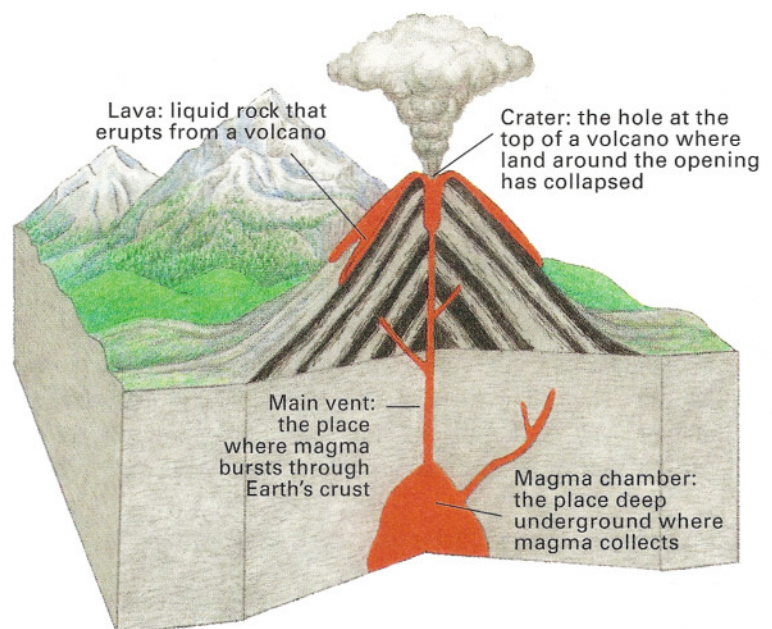


Snowy Caucasus Ridges

The Caucasus Mountains mark the southeastern edge of Europe. This mountain range was formed by moving plates around 25 million years ago.

Volcanic Activity

Inside Earth is a layer of liquid rock called *magma*. When magma reaches the surface, it creates a volcano. Volcanic eruptions can be quite violent. Lava flows and falling ash can change the surrounding landscape. Eruptions can also build up and reshape mountains.



17.5 How Volcanic Activity Shapes Earth

Like earthquakes, volcanoes can reshape the landscape with awesome force. In 1883, an erupting volcano destroyed most of Krakatau, an island in Indonesia. People heard the explosion more than 2,000 miles away. Clouds of ash flew 20 miles or more into the air, and dust from the eruption created colorful sunsets around the world. In the end, two thirds of Krakatau disappeared into a hole under the sea.

Volcanoes Form Below Earth's Surface As you read earlier, hot liquid rock called *magma* lies beneath Earth's crust. This molten rock is always moving and sometimes pushes its way to the surface through cracks in the crust. Scientists call the place where magma reaches Earth's surface a *volcano*. When magma erupts from a volcano, scientists call the liquid rock *lava*.

Volcanoes often occur along the edges of tectonic plates. The hot magma rises through the cracks between two plates. Magma can also rise at "hot spots," or weak points, in Earth's crust. Either way, the result might be a single volcano, or it could be a whole chain of volcanoes. The Hawaiian Islands are an example of a chain of volcanoes.

Volcanic Explosions Alter the Landscape Some volcanic eruptions are relatively quiet, with lava oozing out or spraying like a fountain. At other times, volcanoes can explode with enormous force, literally blowing their tops off. In 1980, a huge volcanic eruption shook Mount St. Helens in the state of Washington. Afterward Mount St. Helens was at least 1,300 feet shorter than it had been before the eruption.

Volcanoes alter the landscape in another way. Violent eruptions hurl tiny bits of rock and volcanic ash into the air in an enormous cloud. Eventually that hot ash falls to Earth, where it can dramatically change the surrounding region. If thick enough, the ash can bury vegetation and even people and buildings. Sometimes ash mixes with steam to create a fast-moving mudslide, capable of burying everything in its path. After a violent eruption, the land around a volcano may collapse, creating a large **crater**, or hole.

17.6 Signs of Volcanic Activity in Russia

Two immense tectonic plates meet under the easternmost edge of Russia. As a result, this area is one of the world's most active earthquake zones. It is also the location of several volcanoes, most of which are on the Kamchatka Peninsula.

Some of the volcanoes in this region are dormant, or inactive, meaning that they have not erupted for a very long time. Others remain active. When these volcanoes do erupt, they can change the landscape for miles around through lava flows, mudslides, and deposits of ash. They can cause numerous deaths and destroy entire cities. Some eruptions also change the shape of the volcanoes themselves.

The Kliuchevskoi Volcano The Kliuchevskoi Volcano rises to a height of 15,584 feet out of the northern part of the Kamchatka Peninsula. It is the highest volcano in Russia and also the most active, with smoke continuously billowing from its crater.

In 1994, Kliuchevskoi erupted with tremendous force. Rivers of lava flowed down the sides of the volcano, and a cloud of gray ash rose almost 12 miles into the air. Still more ash combined with melting snow to trigger major mudflows.

The Maly Semyachik Volcano The Maly Semyachik Volcano rises out of the center of the Kamchatka Peninsula. It is characterized by a large crater at the top called Troitsky Crater, which is filled with warm, bright blue water.

The Krenitsyn Volcano The Krenitsyn Volcano is on Onkotan Island, which is part of the Kuril Island chain. During one of its eruptions, part of the volcano collapsed, leaving a large hole at the base of the volcano. Once the mountain cooled, the hole filled with water, creating a lake known today as Ring Lake.

Russia's Karymsky Volcano

The Karymsky Volcano is one of 160 volcanoes located on Russia's Kamchatka Peninsula. Of these, 29 are still active. Karymsky has erupted 29 times since 1771.



17.7 How Erosion Shapes the Landscape

Landslide! A hill starts to move, sending dirt, rocks, and trees tumbling down its slope. If you lived in the house at the bottom of the hill, you would probably see this event as a terrible disaster. A geographer, however, would also see it as an example of how erosion can reshape the surface of Earth.

Wind, Water, Ice, and Gravity Cause Erosion Erosion takes place everywhere on Earth through natural forces. Wind, moving water and ice and gravity can all wear down the land around us.

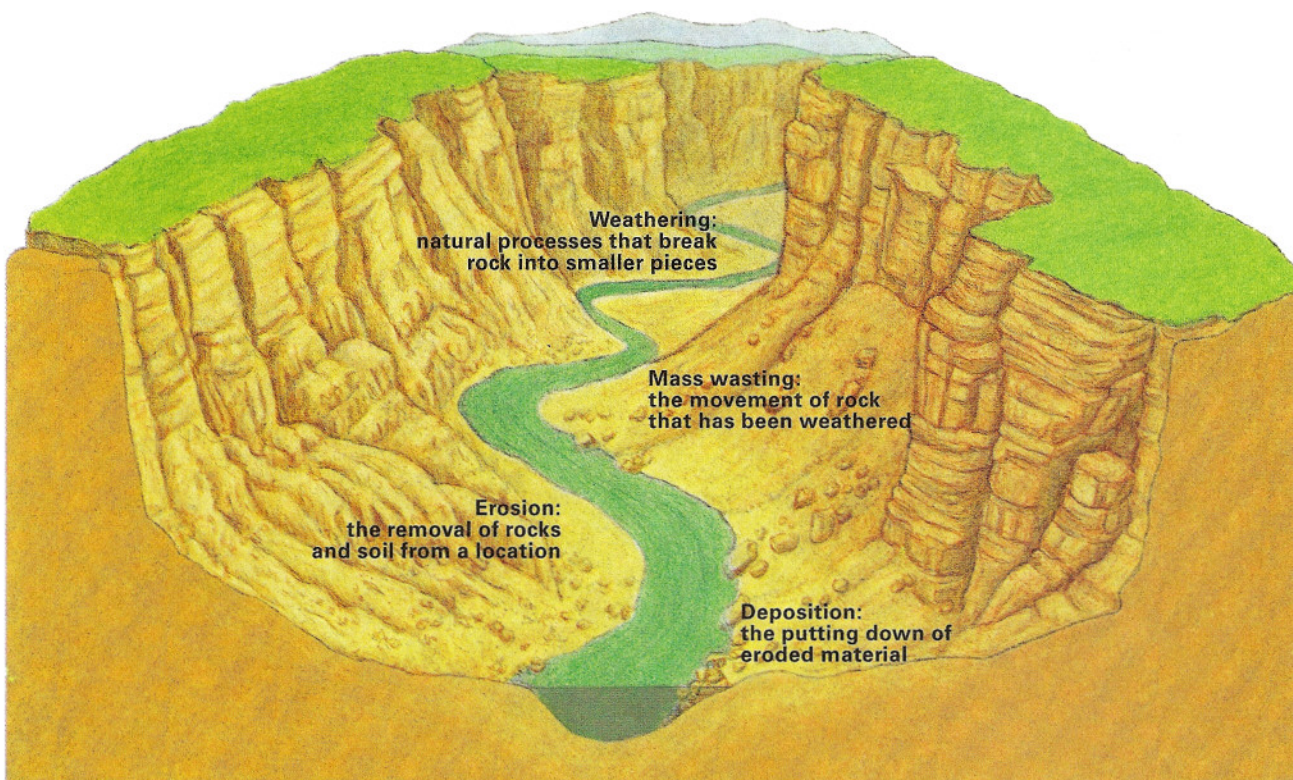
Wind erodes land by picking up tiny grains of dirt and carrying them to distant places. This process wears away the layer of soil that covers Earth's crust. Wind can also grind away rocks and hills by blasting them with gritty sand and dirt.

Moving water also shapes the land. Rivers can carve away at the surrounding land to create deep **V-shaped valleys**. The faster a river flows, the more soil it can wash away and carry downstream. Along coastlines, ocean waves can wear away the shoreline to create steep banks and cliffs. Waves can also erode soil at the base of cliffs, causing the land above to collapse. When this happens, homes built on the cliffs may slide down into the sea.

Glaciers are another force of nature that reshapes the landscape. The weight of these enormous masses of ice exerts pressure that causes the glaciers to travel slowly downhill. As they move, glaciers gradually carve out valleys and create new landforms by depositing rock and soil. Over time, glaciers can transport huge quantities of rocks and soil debris over great distances.

Sources of Erosion

Wind, water, ice, and gravity all cause erosion. Wind moves soil from one place to another. Moving water and ice create cliffs and valleys. Gravity pulls land downhill in landslides and mudslides. Erosion caused by wind and water created the Grand Canyon.



Gravity is a constant force on the landscape. Anything that is not well rooted or attached to the ground will eventually give in to the force of gravity and move downhill. This downhill movement can occur so slowly that we may not even be aware of it, or it can occur quickly, as in a landslide or mudslide.

Floods Build Up Land On flat plains, water can build up as well as wear away land. After heavy rains, rivers overflow their banks and flood the surrounding plain. When the river returns to its banks, soil carried by the floodwater is left behind on the **floodplain**. This fresh layer of soil makes floodplains good places to farm, but the floods that create floodplains also make them dangerous places to live.



17.8 Signs of Erosion in Russia

Much of Russia is made up of vast plains. On the west side of the Ural Mountains is the Northern European Plain, and on the east side of the Urals are the West and Central Siberian plains. Over millions of years, wind, water, ice, and gravity have worn away any high ground on these plains. The flat or gently rolling land of the plains today is the result of this erosion.

The Volga River Many major rivers crisscross Russia's plains. One of them, the Volga, is Europe's longest river.

The Volga wanders south across the Northern European Plain, carrying along many tons of **sediment**, or soil and sand. When it floods, the Volga leaves some of the sediment on the surrounding land, a process known as *sedimentation*. Eventually the Volga deposits any remaining sediment into the Caspian Sea, turning its waters a cloudy green.

The Volga flows through the agricultural and industrial heartland of Russia. Almost half of the Russian population lives in the Volga River basin, relying on the river for power, transportation, and irrigation. No wonder Russians call the Volga "Matushka," which means "Mother."

The Amur River The Amur River flows from the mountains of northeast China and through eastern Siberia to empty into the Sea of Okhotsk. This sea is a large arm of the Pacific Ocean on the eastern boundary of Russia. For about 1,000 miles, the Amur River forms a natural boundary between Russia and China.

Like the Volga, the Amur River has become an important part of Russia's economy. Frequent springtime floods have created flat and fertile floodplains along the river's banks, making the plains a rich agricultural area. The Amur is also a source of transportation, with large boats traveling most of its length from April to November.

The Lena River The Lena River flows northward through Siberia into the Arctic Ocean. From above, this river looks like a black snake winding its way across the plains. In late spring, ice blocks the flow of water at the mouth of the Lena, causing water to back up and flood the land.

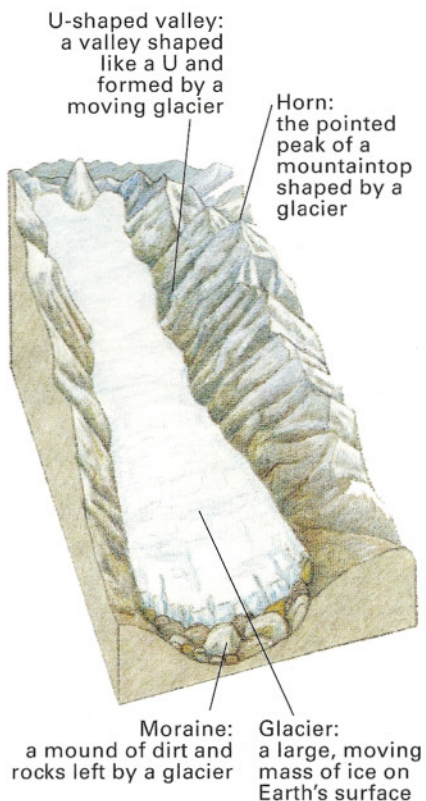
The Lena River Delta

This land along the Lena River shows signs of both flooding and erosion. Flooding built up the land that forms the Lena's banks. Erosion has worn it away.

17.9 How Glaciation Shapes the Landscape

In the coldest places on Earth, large fields of winter snow turn into ice that stays frozen all year. These masses of ice are called *glaciers*. Glaciers form over thousands of years as each new snowfall compresses the snow beneath it into a dense ice mass.

About 20,000 years ago, during the last ice age, glaciers covered one third of Earth's land surface. Most of North America was covered by ice. Gradually the glaciers retreated, changing the landscape as they moved. Today glaciers cover only one tenth of Earth's surface, but they can still shape the landscape in dramatic ways.



A Landscape Carved by Glaciers

Continental glaciers are large ice sheets that form over land with extremely cold weather. Their weight forces them to spread outward. Alpine glaciers form at the top of some mountains. Gravity pulls them downhill. Glaciers act like bulldozers, grinding and pushing land as they move. Glaciers can move between two inches and two feet a day.

Two Kinds of Glaciers Geographers have identified two kinds of glaciers. **Continental glaciers** form in huge, thick sheets in areas with extremely cold climates, such as the two polar regions. Much of Antarctica, for instance, is buried under continental glaciers. The weight of the ice sheet eventually forces the edges of the glacier to push outward in all directions. Scientists call this movement *creeping*.

A second type of glacier, the **alpine glacier**, forms in high mountain valleys where snowfall is plentiful and temperatures are low. Instead of creeping outward, these rivers of ice slide downhill. As the weight of new snow and ice grows, the glacier is pulled down the mountain by the force of gravity.

Glaciers Reshape the Land as They Move Glaciers move very slowly, but they have enormous power. They can grind the hardest rock into fine soil and push great loads of rock and dirt over long distances.

Continental glaciers erode land as they spread outward. They pick up rocks and soil as they creep, and pile them into mounds called **moraines**. Sometimes they leave behind finger-shaped holes in the land that, when the glaciers melt, become lakes. The Great Lakes of North America are an example of lakes formed by the movement of continental glaciers during the last ice age.

Alpine glaciers reshape the land as they travel downhill. Sometimes they scrape away whole hillsides, turning rounded mountaintops into pointed peaks that are called **horns**. As they move down canyons, alpine glaciers carve narrow V-shaped river valleys into broad **U-shaped valleys**. California's famous Yosemite Valley was reshaped in this way by an alpine glacier.

17.10 Signs of Glaciation in Russia

Earth has seen several long cold periods when glaciers covered vast regions. During the last of these ice ages, continental glaciers covered parts of Russia. As the climate warmed, those glaciers melted, but alpine glaciers still exist in the high mountains. Both types of glaciers have left their mark on Russia's landscape.

The Kolka Glacier The Kolka Glacier of the Caucasus Mountains is located on Mount Kazbek, one of the highest peaks in the range. In 2002, ice from a glacier overhanging the Kolka fell, triggering an **avalanche** that slid more than 11 miles. The glacial debris dammed rivers, creating several new lakes.



The Amanauzsky Glacier The Amanauzsky Glacier is located in the western Caucasus Mountains. As this glacier slides downward, it is creating a large valley between two jagged mountain ridges.

The Glaciated Yamal Peninsula The Yamal Peninsula juts into the Arctic Ocean in northwestern Siberia. Continental glaciers once scraped across this peninsula, but today summers are just warm enough to melt each winter's snowfall. The melted water then fills the holes left behind by the glaciers, creating glacial lakes.

Glaciers in the Caucasus

Glaciers have covered the Caucasus Mountains since the last ice age. But over the last century, many have been melting. Curiously, as glaciers shrink, their numbers increase. This happens when big glaciers break up into smaller ones.

17.11 Beginning to Think Globally

In this chapter, you learned how four physical processes—tectonic movement, volcanic activity, erosion, and glaciation—shape our Earth. You read about how each process is at work on the varied landscape of Russia.

Tectonic movement is the slowest of these natural processes. Over time, however, tectonic movement has reshaped Earth's surface. Scientists believe that about 200 million years ago, all of Earth's land formed one huge continent. In time, this supercontinent broke apart into tectonic plates. Scientists have studied how the movement of these lithospheric plates formed the continents we know today.

Tectonic movement is still a powerful force at work on Earth's landscape. We feel the immediate effects every time an earthquake rattles windows or a volcano starts to smoke. Over time, these events will continue to reshape Earth's surface. Keep this idea in mind as you examine tectonic plates around the world in the next section.

17.12 Global Connections

The map shows the boundaries of the world's tectonic plates as well as active volcanic and earthquake zones. Notice how many volcanoes are located around the rim, or edge, of the Pacific Ocean. Scientists call this zone of volcanic activity the Ring of Fire.

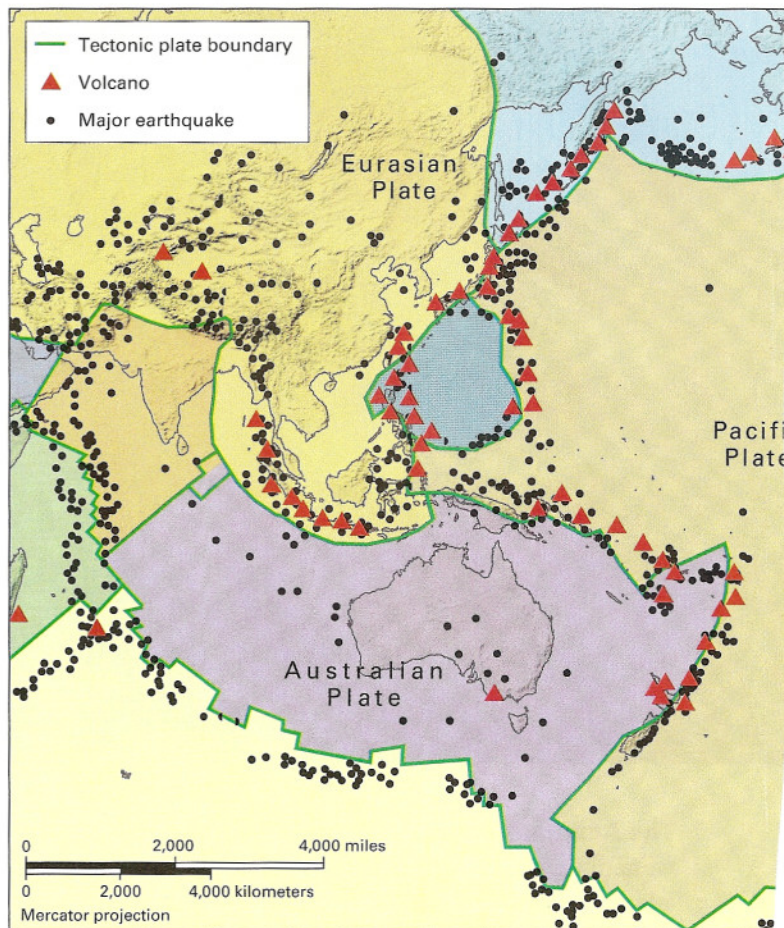
Why is the Ring of Fire located around the Pacific Rim? A vast tectonic plate called the Pacific Plate lies under the Pacific Ocean and stretches from Asia to North America. When it moves against plates around the Pacific Rim, one plate is forced under the other. As one plate sinks, friction and the Earth's heat cause part of the plate to melt and rise to the surface, forming a volcano.

Why isn't there a Ring of Fire around the edge of the Atlantic Ocean? Look closely at edges of the Atlantic Ocean in North America and Europe, and notice that there are no plate boundaries there. The North American Plate and the Eurasian Plate meet in the middle of the Atlantic Ocean. As a result, there are no colliding plates around the edge of the Atlantic—and no Ring of Fire along those coastal areas.

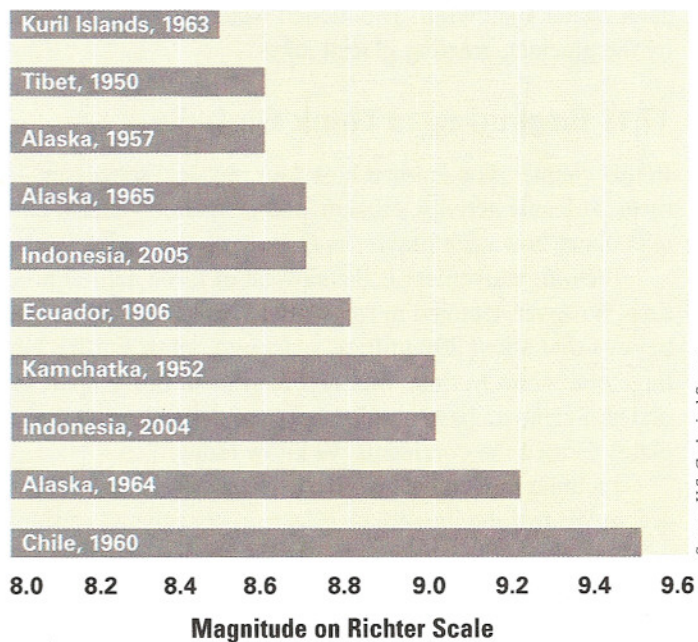
How has tectonic movement shaped human life on Earth?

Imagine our world without tectonic movement. All humankind might be living together on one flat supercontinent. Tectonic movement not only broke up the supercontinent into the continents we know today, but also built up most of Earth's mountains. In the past, both the oceans between continents and the high mountains that were hard to cross kept people isolated from one another. As a result, many individual human cultures developed over time in different landscapes.

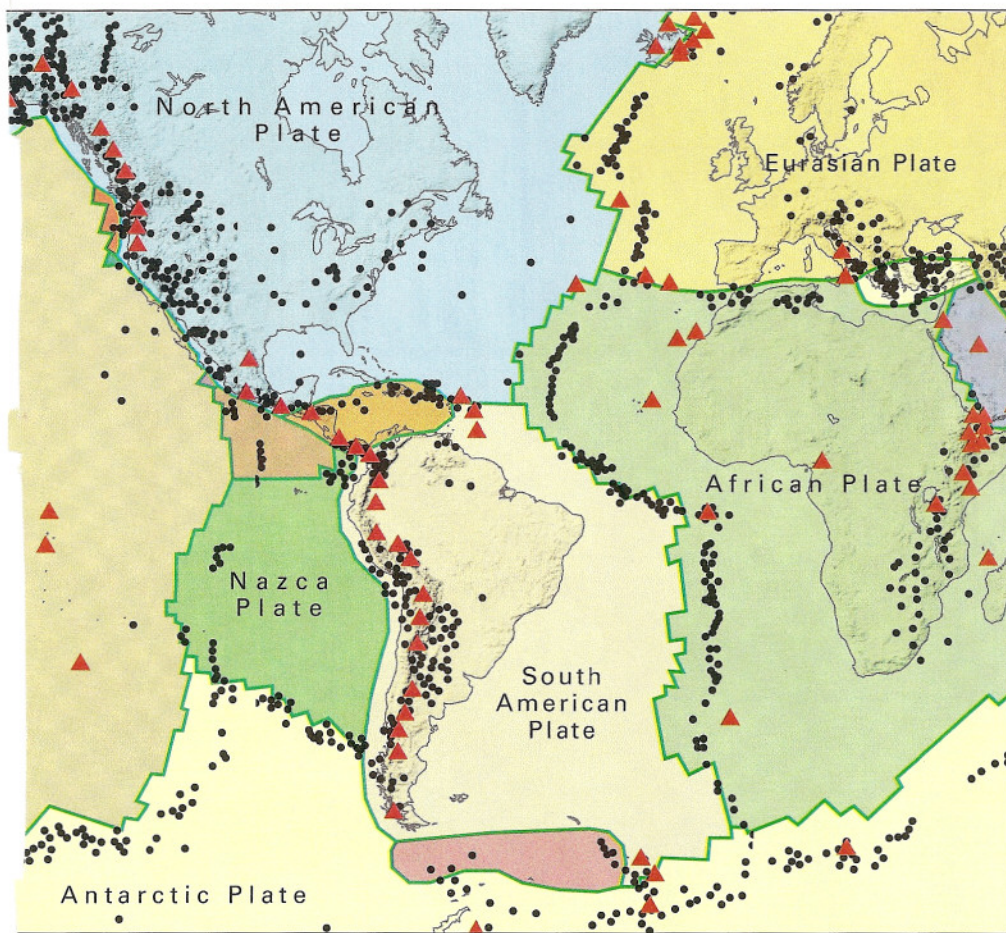
Volcanoes and Earthquakes Around the World



The Largest Earthquakes of the Twentieth Century



Source: U.S. Geological Survey.



Lava flow in Hawaii Volcanoes National Park