

**Earth Systems, Structures and
Processes**

6.E.2 Understand the structure of the earth and how interactions of constructive and destructive forces have resulted in changes in the surface of the Earth over time and the effects of the lithosphere on humans.

6.E.2.1 Summarize the structure of the earth, including the layers, the mantle and core based on the relative position, composition and density.

6.E.2.2 Explain how crustal plates and ocean basins are formed, move and interact using earthquakes, heat flow and volcanoes to reflect forces within the earth.

6.E.2.3 Explain how the formation of soil is related to the parent rock type and the environment in which it develops.

6.E.2.4 Conclude that the good health of humans requires: monitoring the lithosphere, maintaining soil quality and stewardship.

Peeling the Layers

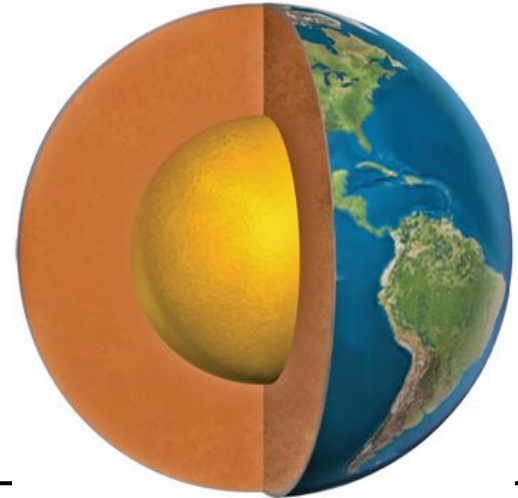
What is inside Earth?

- Earth is made of several layers.
- Each layer has its own characteristic properties.
- Scientists think about Earth's layers in two ways—in terms of chemical composition and in terms of physical properties.



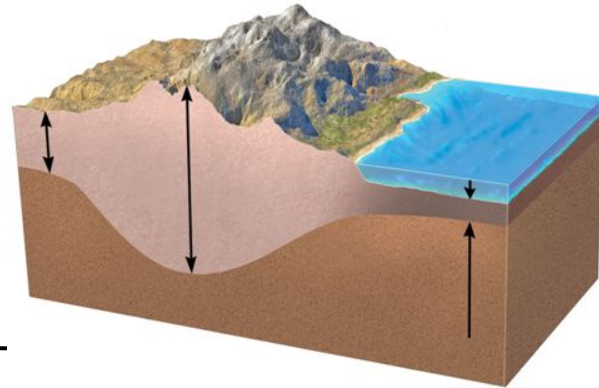
What are Earth's compositional layers?

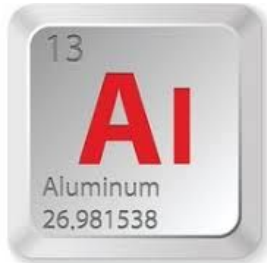
- Earth can be divided into three layers based on chemical composition: the *crust*, the *mantle*, and the *core*.



What are Earth's compositional layers?

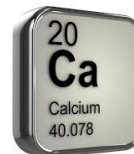
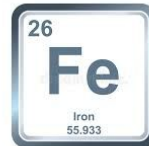
- The outermost solid layer of Earth is the **crust**.
- There are two types of crust: continental and oceanic.



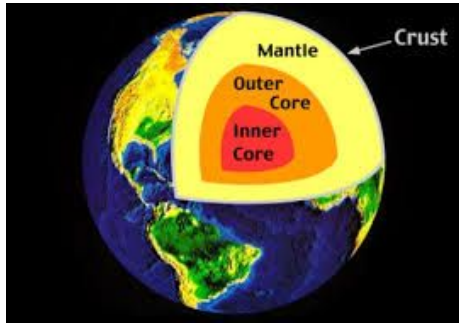


What are Earth's compositional layers?

- Both types of crust are made mostly of oxygen, silicon, and aluminum.
- Oceanic crust is denser than continental crust because it contains almost twice as much iron, calcium, and magnesium.



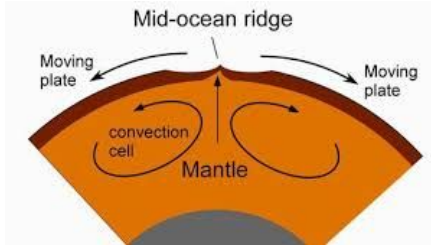
What are Earth's compositional layers?



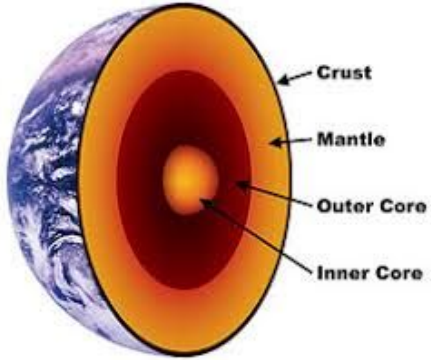
- The **mantle** is located between the crust and the core.
 - The mantle is a region of hot, slow-flowing solid rock.
 - The mantle contains more magnesium and less aluminum and silicon than the crust.
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What are Earth's compositional layers?

- **Convection** is the movement of matter that results from differences in density caused by variations in temperature.



- Convection in the mantle causes cooler rock to sink and warmer rock to rise.

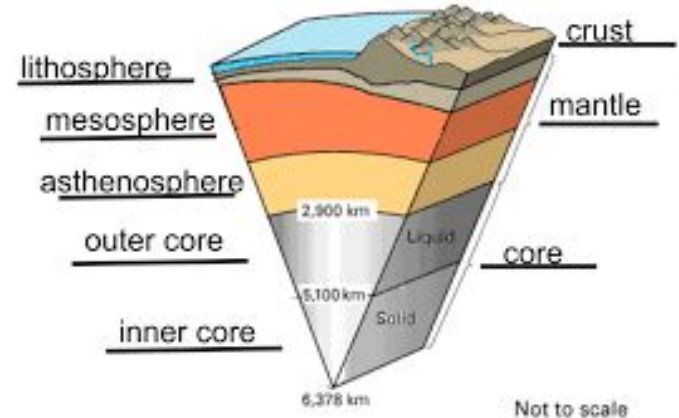


What are Earth's compositional layers?

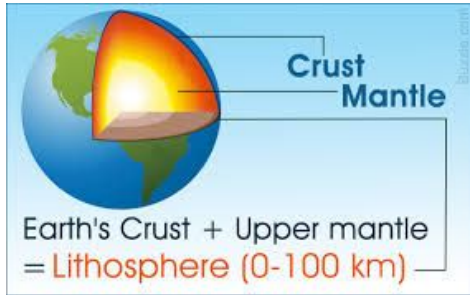
- The **core** extends from below the mantle to the center of Earth.
 - Scientists think the core is made mostly of iron and some nickel.
 - The core is the densest layer and makes up about one-third of Earth's mass.
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What are Earth's physical layers?

- Earth is also divided into layers based on physical properties, such as whether the layer is solid or liquid.
- The five physical layers are the *lithosphere*, *asthenosphere*, *mesosphere*, *outer core*, and *inner core*.



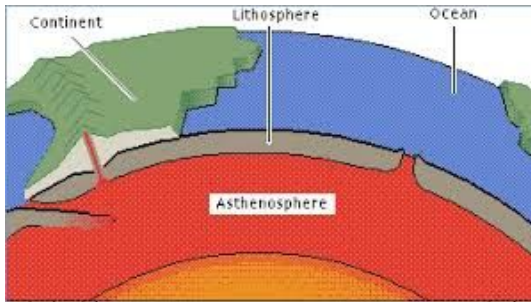
What are Earth's physical layers?



- The outermost, rigid layer of Earth is the **lithosphere**.
 - The lithosphere is made of the crust and the rigid, upper part of the mantle.
 - The lithosphere is divided into pieces called *tectonic plates*.
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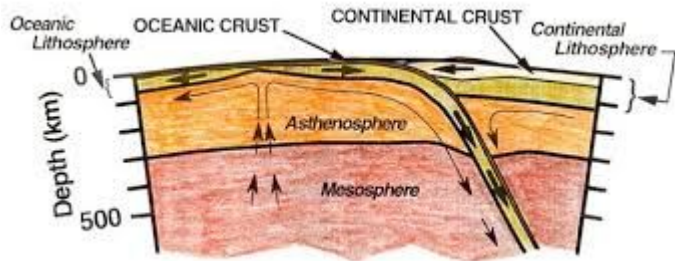
What are Earth's physical layers?

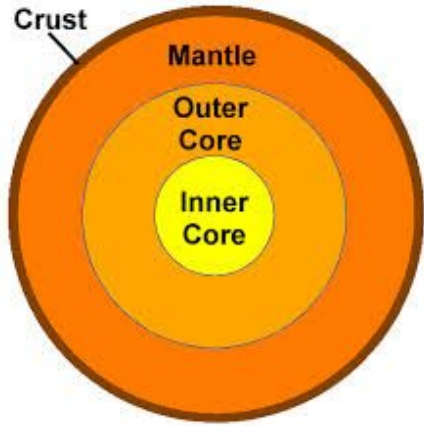
- The **asthenosphere** is the layer of weak or soft mantle made of solid rock that moves very slowly.
- The asthenosphere is located below the lithosphere.
- Tectonic plates move on top of the asthenosphere.



What are Earth's physical layers?

- The strong, lower part of the mantle is called the **mesosphere**.
- Rock in the mesosphere flows more slowly than rock in the asthenosphere.

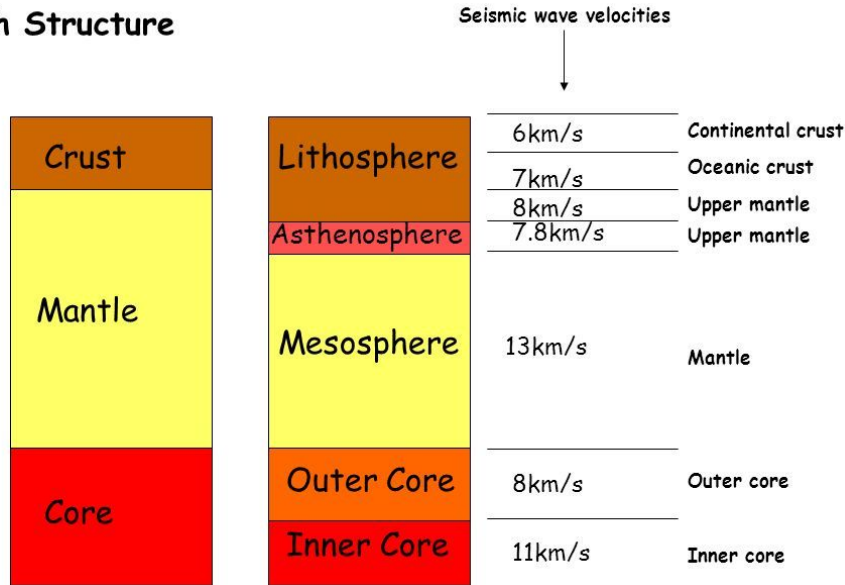




What are Earth's physical layers?

- The outer core is the liquid layer of Earth's core.
 - The outer core lies beneath the mantle and surrounds the inner core.
 - The inner core is the solid, dense center of our planet.
 - The inner core extends from the bottom of the outer core to the center of Earth.
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Earth Structure



Compositional

Mechanical

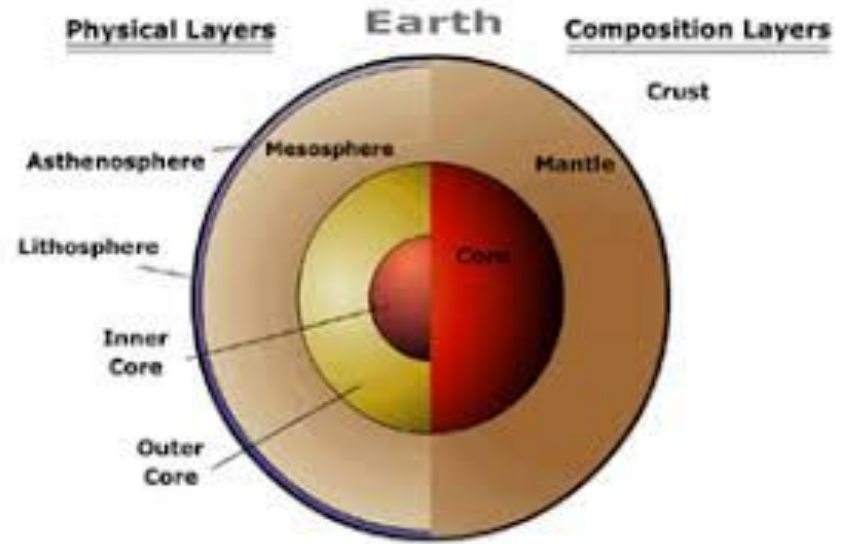


Plate Tectonics

Earthquakes, Volcanoes & Soil
Formation

Puzzling Evidence

What evidence suggests that continents move?

- In the late 1800s, Alfred Wegener proposed his hypothesis of continental drift.
 - According to this hypothesis, the continents once formed a single landmass, broke up, and drifted.
-

What evidence suggests that continents move?

- Several lines of evidence support Wegener's hypothesis.
 - Fossils of the same species are found on continents on separate sides of the Atlantic Ocean.
 - The locations of mountain ranges and rock formations and evidence of ancient climatic conditions also support Wegener's hypothesis.
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What is Pangaea?

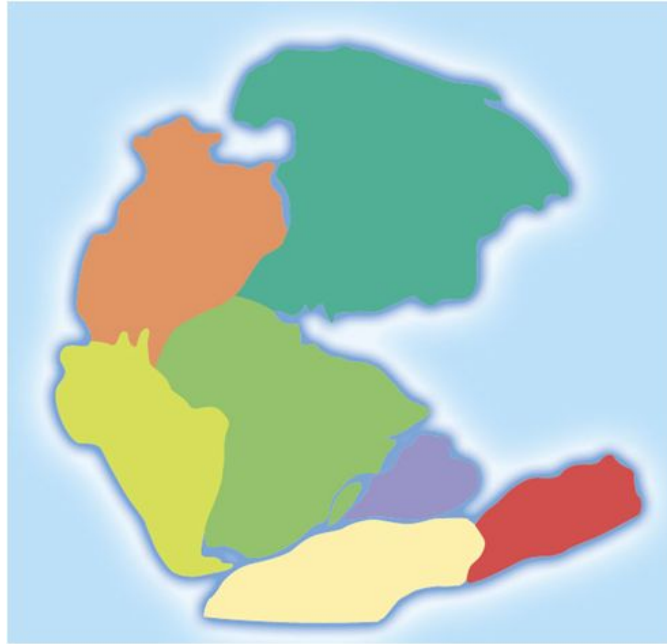
- About 245 million years ago, the continents were joined in a single large landmass called **Pangaea**.
- About 200 million years ago, a large rift formed and Pangaea began to break into two continents, *Laurasia* and *Gondwana*.
- Then, Laurasia began to drift northward, and a new rift separated Laurasia into the continents of North America and Eurasia.



What is Pangaea?

- At the same time, Gondwana also broke into two continents.
 - One continent contained land that is now the continents of South America and Africa.
 - The other continent contained land that is now Antarctica, Australia, and India.
-

What is Pangaea?



What discoveries support the idea of continental drift?

- For many years, scientists did not accept Wegener's ideas because they could not determine how continents moved.
 - In the mid-1900s, scientists began mapping the sea floor and discovered huge, underwater mountain ranges called mid-ocean ridges.
 - The discovery of mid-ocean ridges eventually led to the theory of plate tectonics, which built on some of Wegener's ideas.
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What discoveries support the idea of continental drift?

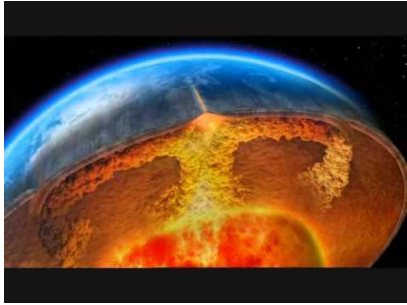
- Rock samples from the sea floor revealed that the youngest rock is closest to the ridge, while the oldest rock is farthest away.
 - Even the oldest oceanic crust is young compared to continental crust.
 - Also, sea-floor rock contains magnetic patterns.
-

What discoveries support the idea of continental drift?

- To explain the age and magnetic patterns of sea-floor rocks, scientists proposed a process called sea-floor spreading.
 - In this process, molten rock from inside Earth rises at the ridges and forms new oceanic crust.
 - Older crust is pushed away from the ridge, and the sea floor slowly spreads apart.
-

What discoveries support the idea of continental drift?

- Scientists also discovered huge trenches in the sea floor where oceanic crust sinks into the asthenosphere.
 - Older crust is thus being destroyed at the ocean trenches at the same rate as new crust is forming at the ridges.
 - In this manner, Earth remains the same size.
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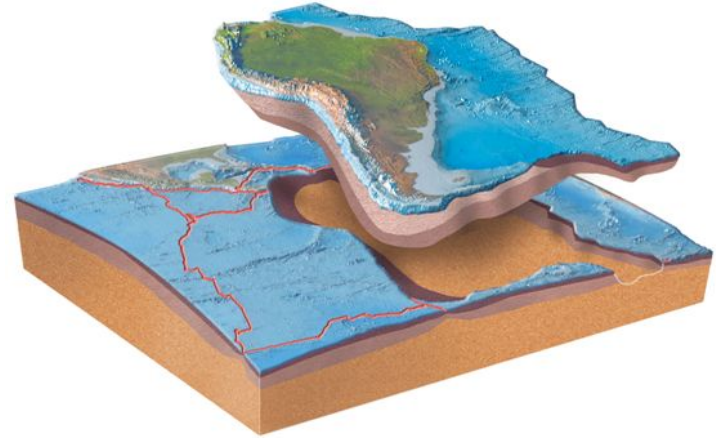
A Giant Jigsaw

What is the theory of plate tectonics?

- Scientists began to form a new theory to explain continental drift, mid-ocean ridges, and sea-floor spreading.
 - **Plate tectonics** is a theory that describes large-scale movements of Earth's lithosphere.
 - It explains how and why features in Earth's crust form and continents move.
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What is a tectonic plate?

- The lithosphere is divided into pieces called **tectonic plates**, which move around on top of the asthenosphere.



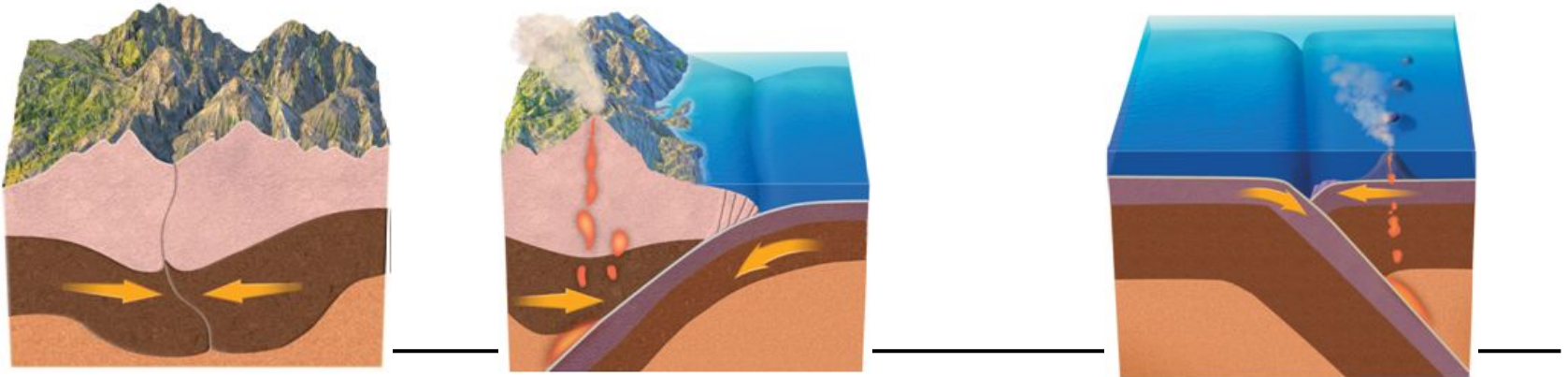
Boundaries

What are the three types of plate boundaries?

- Plate boundaries may be on the ocean floor, around the edges of continents, or even within continents.
 - The three types of plate boundaries are convergent boundaries, divergent boundaries, and transform boundaries.
 - Each type is associated with characteristic landforms.
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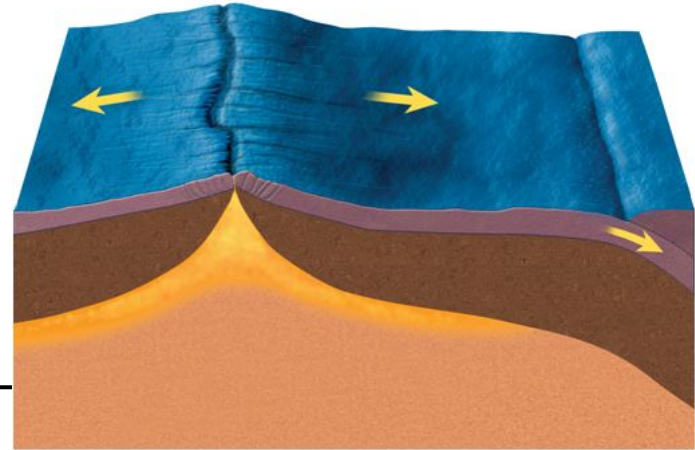
What are the three types of plate boundaries?

• **Convergent boundaries** form where two plates collide. This can happen in three ways, depending on the types of crust involved.



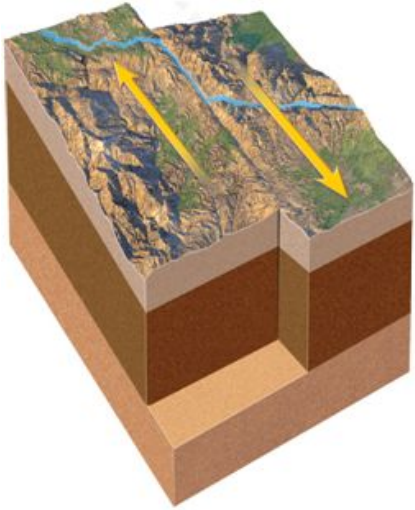
What are the three types of plate boundaries?

- At a **divergent boundary**, two plates move away from each other, and magma rises to form new lithosphere at mid-ocean ridges.



What are the three types of plate boundaries?

- A boundary at which two plates move past each other horizontally is called a **transform boundary**. At transform boundaries, the motion of the two plates often produces earthquakes.





Hot Plates

What causes tectonic plates to move?

- Scientists have proposed three mechanisms to explain how tectonic plates move: mantle convection, ridge push, and slab pull.
 - Hotter parts of the mantle rise as cooler, denser parts sink. This kind of movement of material due to differences in density is called **convection**.
 - Mantle convection drags the overlying tectonic plates.
-

What causes tectonic plates to move?

- The mechanism called ridge push moves plates away from mid-ocean ridges as rock cools and becomes more dense.
 - Newly formed rock at a mid-ocean ridge is warm and less dense than older, adjacent rock, which slopes downward away from the ridge.
 - As the newer rock cools and becomes denser, it moves down the slope, pushing the rest of the plate away from the mid-ocean ridge.
-

What causes tectonic plates to move?

- In the mechanism called slab pull, a plate moves because it is pulled along when its denser edge sinks beneath Earth's surface.
 - The leading edge of a sinking plate is colder and denser than the mantle, so it sinks. The rest of the plate follows.
 - Many scientists think slab pull is the most important mechanism driving plate motion.
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Earthquake

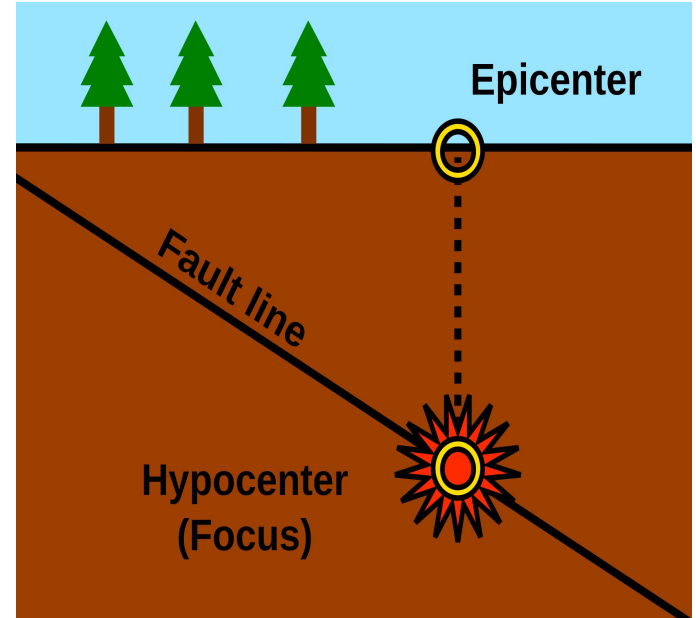
Let's Focus

What is an earthquake?

- **Earthquakes** are ground movements that occur when blocks of rock in Earth move suddenly and release energy.
 - The energy is released as seismic waves that cause the ground to move.
-

What is an earthquake?

- The **focus** is a place within Earth along a fault where the first motion of an earthquake occurs.
- The place on Earth's surface directly above the focus is called the **epicenter**.
- Seismic waves flow outward from the focus in all directions.



What causes earthquakes?

- Most earthquakes occur near a **tectonic plate boundary**, which is where two or more tectonic plates meet.
 - The movement of tectonic plates breaks Earth's crust into a series of **faults**, which are breaks in Earth's crust along which blocks of rocks move.
 - The release of energy that accompanies the movement of rock along a fault causes an earthquake.
-

What causes earthquakes?

- Stress on the rock causes **deformation**, which is the process by which the rock becomes deformed and changes shape.
 - As the stress on rock increases, the energy stored in it increases.
 - When the stress is released, the rock may return to its original shape.
-

What causes earthquakes?

- When rock returns to nearly the same shape after the stress is removed, the process is called *elastic deformation*.
 - The return of rock to its original shape after elastic deformation is called **elastic rebound**.
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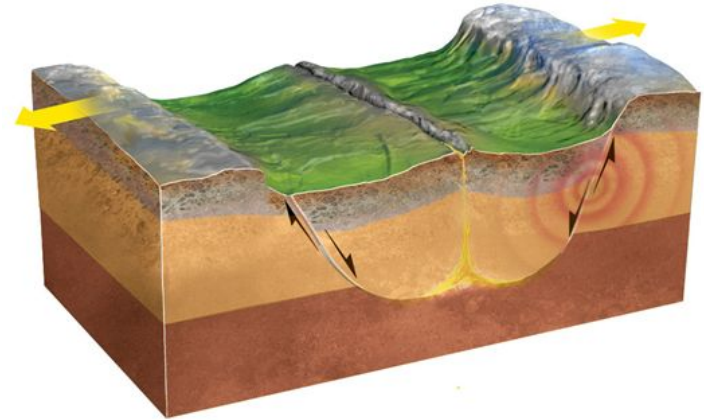
Unstable Ground

Where do earthquakes happen?

- Most earthquakes happen at or near tectonic plate boundaries.
 - At tectonic plate boundaries, stress builds up from tectonic plates colliding, separating, or grinding past each other.
 - There are three main types of tectonic plate boundaries: divergent, convergent, and transform.
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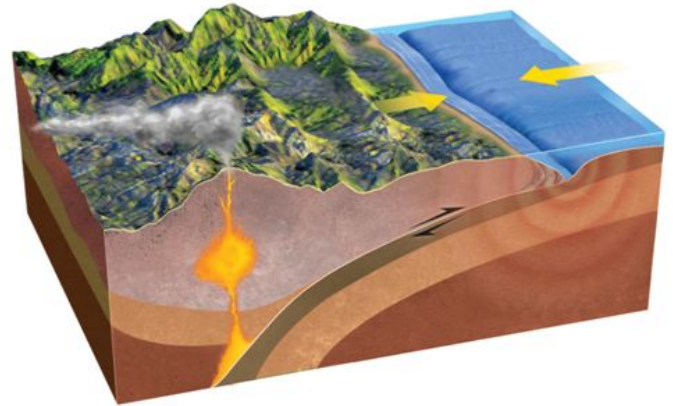
Where do earthquakes happen?

- At divergent boundaries, *tension* stress causes normal faults to form. Earthquakes tend to be shallow because the crust is thin.



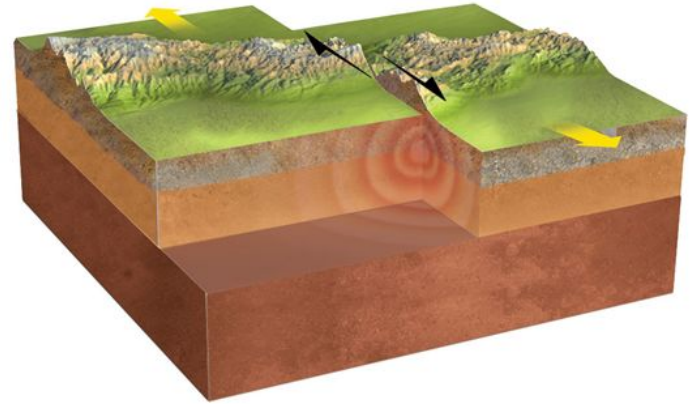
Where do earthquakes happen?

- At convergent boundaries, rock is squeezed, and the stress is called *compression*. Reverse faults are formed, and earthquakes can be strong and deep.



Where do earthquakes happen?

- At transform boundaries, *shear stress* pushes tectonic plates in opposite directions. Earthquakes tend to be relatively shallow.



What are some effects of earthquakes?

- Most earthquakes do not cause damage, but some strong earthquakes can cause major damage and loss of life, especially in areas closest to the epicenter.
 - When the shaking of an earthquake is more than structures can withstand, major destruction can occur.
 - Much of the injury and loss of life after an earthquake is caused by structures that collapse.
-

What are some effects of earthquakes?

- An earthquake under the ocean can cause a vertical movement of the sea floor, displacing an enormous amount of water and generating a tsunami.
 - A *tsunami* is a series of extremely long waves that can travel across the ocean at speeds of up to 800 km/h.
 - As the waves reach the shoreline, the height of the waves increases. The huge waves can cause major destruction.
-

Killer Quake

- In 2004, an earthquake generated a tsunami that wiped out half the population of Banda Aceh, Indonesia.
 - The tsunami traveled outward from the epicenter in the Indian Ocean. Banda Aceh was very close to the epicenter.
 - The destruction to parts of Asia was so massive that geographers had to redraw the maps of some countries.
-

A photograph of a volcano erupting at night. The volcano is a dark, conical shape with glowing orange and red lava flows running down its slopes. A large, bright yellow and orange plume of fire and ash rises from the summit, illuminating the surrounding dark sky. The word "Volcanoes" is written in a large, black, sans-serif font across the center of the image, partially overlapping the eruption plume.

Volcanoes

Magma Magic

What is a volcano?

- A **volcano** is any place where gas, ash, or melted rock come out of the ground.
 - Many volcanoes are *dormant*, meaning an eruption has not occurred in a long period of time.
-

What is a volcano?



- Volcanoes form as rock below Earth's surface melts. The melted rock, called **magma**, is less dense than solid rock, so it rises to the surface.
 - **Lava** is magma that has reached Earth's surface. Lava and ash erupt from a **vent**, or an opening of a volcano.
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What are the kinds of volcanic landforms?

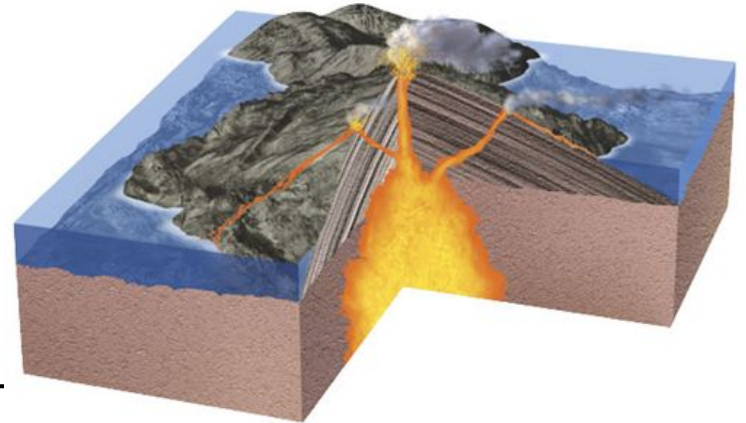
- The location of a volcano and composition of magma determine the type of volcanic landforms created.
 - Volcanic landforms include shield volcanoes, cinder cones, composite volcanoes, lava plateaus, craters, and calderas.
-

What are the kinds of volcanic landforms?

- Volcanic mountains are built from materials ejected from a volcano.
 - The shape and explosiveness of a volcano depend on the lava's *viscosity*, or resistance to flow.
 - *Pyroclastic material*, or hot ash and bits of rock, may also be ejected into the atmosphere.
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What are the kinds of volcanic landforms?

- *Shield volcanoes* are volcanoes with broad bases and gently sloping sides.
- They are the result of mild eruptions.



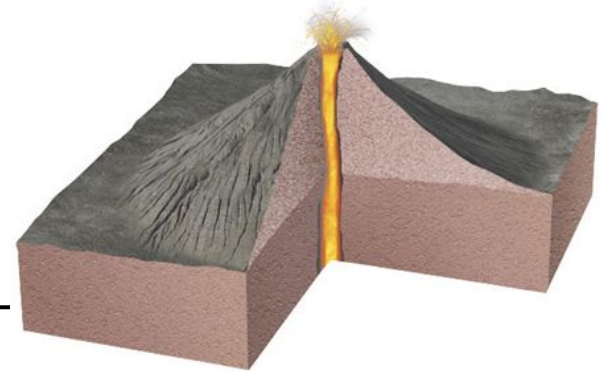
What are the kinds of volcanic landforms?

- *Cinder cones* are small volcanoes with steep slopes.
- They form from ash and pieces of solidified lava that fall around a small vent.

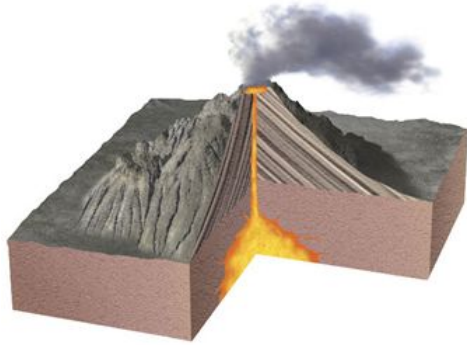
2) Cinder-cone volcanoes



Formed by thick lava that is thrown high up in the air and fall as chunks or cinders.
(Form as cone shape with narrow base and steep sides)

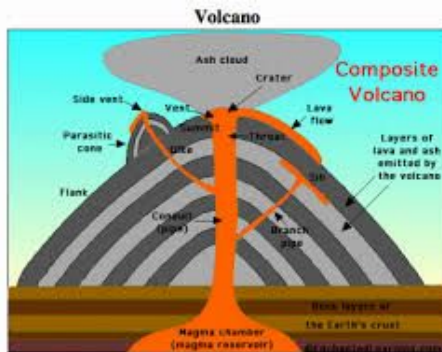


What are the kinds of volcanic landforms?

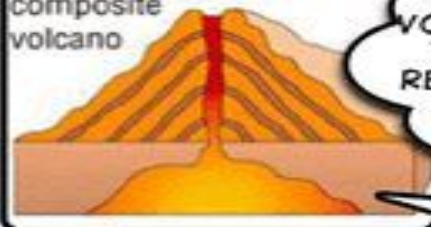


- *Composite volcanoes* are built from alternating layers of hardened lava flows and pyroclastic material.

- They generally develop into large, steep mountains.

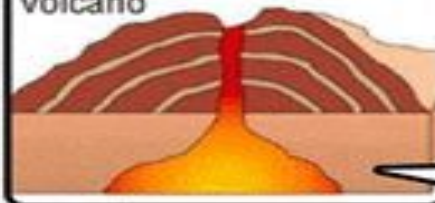


composite volcano



THREE TYPES OF VOLCANOES, BASED ON THE TYPE OF MATERIAL THAT REACHES THE SURFACE AND THE TYPE OF ERUPTION THAT TAKES PLACE

cinder volcano



COMPOSITE VOLCANOES
EMIT A STIFF, RAPIDLY SOLIDIFYING LAVA WHICH FORMS HIGH, STEEP-SIDED CONES

shield volcano



CINDER CONE VOLCANOES
REGULARLY THROW OUT ASH AND BUILD UP FLATTER DOMES CALLED CINDER CONES

SHIELD VOLCANOE
LAVA DOES NOT EJECT VIOLENTLY, BUT FLOWS OVER THE CRATER RIM FORMING A BROAD LOW PROFILE

What are the kinds of volcanic landforms?

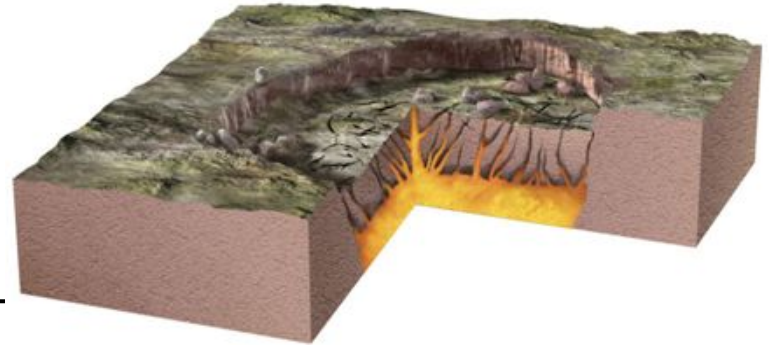
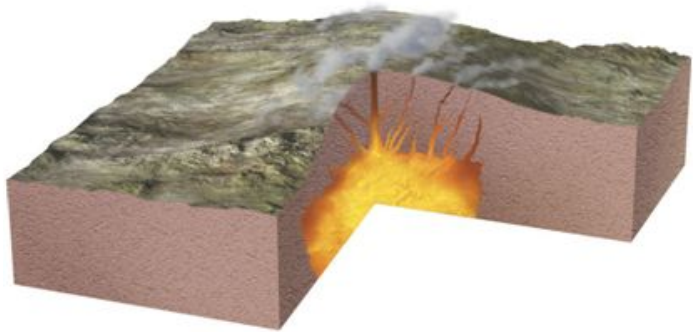
- Fissure eruptions happen when lava flows from giant cracks, or *fissures*, in Earth's surface.
 - Because fissures have no central opening, lava flows out the entire length of the fissure.
 - Fissure eruptions produce a flattened layer of cooled lava called a *lava plateau*.
-

What are the kinds of volcanic landforms?

- A *volcanic crater* is an opening or a depression at the top of a volcano.
 - A crater is caused by eruptions.
 - Inside the volcano, molten rock can form an expanded area of magma called a *magma chamber*.
-

What are the kinds of volcanic landforms?

- When the magma chamber empties, the roof of the chamber can collapse, leaving a large basin-shaped depression called a *caldera*.



Eruption!

Where do volcanoes form?

- **Tectonic plates** are giant sections of lithosphere on Earth's surface. Volcanoes can form at plate boundaries or within the middle of a plate.



Where do volcanoes form?

- At *divergent plate boundaries*, where two plates are moving away from each other, fissure eruptions are likely to occur.
 - At *hot spots*, which are far from any plate boundaries, shield volcanoes, fissure eruptions, and cinder cones can occur.
-

Where do volcanoes form?

- At *convergent plate boundaries*, composite volcanoes can occur.
 - Composite volcanoes produce the most violent eruptions.
 - The *Ring of Fire* is a name for the numerous explosive volcanoes that form on convergent plate boundaries surrounding the Pacific Ocean.
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Where do volcanoes form?

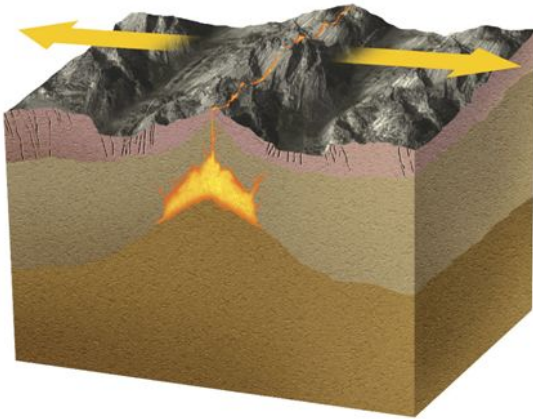
- At divergent boundaries, the crust stretches and gets thinner.
 - As a result, the pressure on the mantle rock below decreases, and magma rises through fissures in the lithosphere.
 - Divergent plate boundaries create fissure eruptions and shield volcanoes.
-

Where do volcanoes form?

- Most divergent boundaries are on the ocean floor. When eruptions occur in these areas, undersea volcanoes develop.
 - These volcanoes and other processes lead to the formation of a long, underwater mountain range known as a *mid-ocean ridge*.
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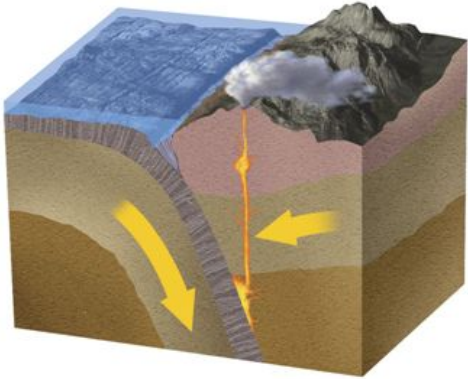
Where do volcanoes form?

- When a divergent boundary is located in the middle of a continent, the crust stretches until a rift valley is formed.



Where do volcanoes form?

- At convergent boundaries, one plate usually sinks beneath the other. The mantle above the sinking plate can melt to form magma.
- The magma rises to the surface and forms volcanoes.

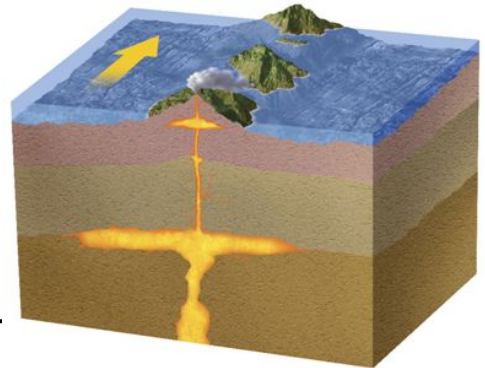


Where do volcanoes form?

- Magma at convergent boundaries has a high concentration of fluids, which form gas bubbles.
 - Because the magma has a high viscosity, the bubbles cannot escape easily. As the bubbles expand, the magma rises faster.
 - Eventually, the magma erupts explosively, forming composite volcanoes or calderas.
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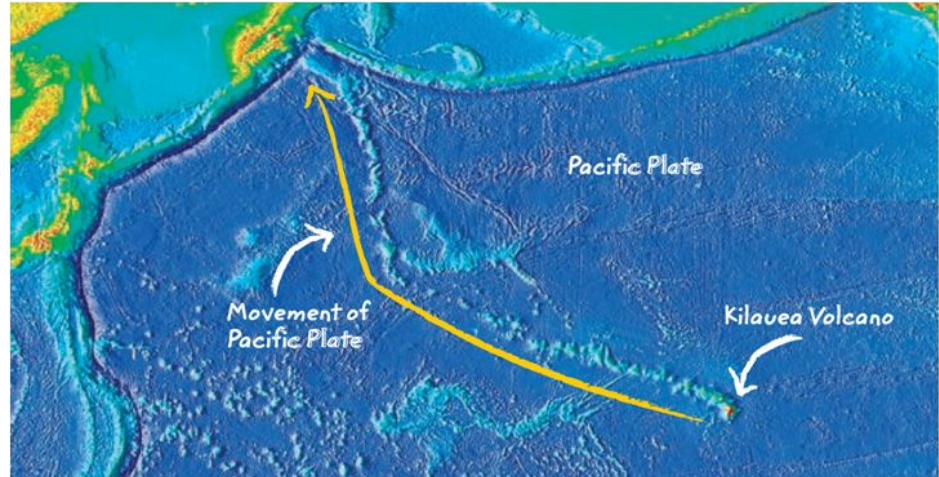
Where do volcanoes form?

- **Hot spots** are locations far from plate boundaries where a *mantle plume*, a column of extremely hot mantle rock, rises and produces volcanoes.



Where do volcanoes form?

- Chains of volcanoes can form over time as a tectonic plate moves over a mantle plume.



Living Near a Volcano

- Many people around the world live near a volcano because the surrounding soils are fertile for growing a variety of crops.
 - Volcanic rocks can be used in making jewelry, concrete, water filtration systems, and other applications.
 - However, an eruption can produce destructive earthquakes, fire, ash, and lava flows, destroying property and taking lives.
-



A close-up photograph of a person's open palm holding a mound of dark brown, crumbly soil. The soil is piled in the center of the hand, with some particles scattered on the fingers. The background is a blurred, light-colored surface, possibly concrete or gravel. The text "Soil Formation" is overlaid in a bright green, sans-serif font across the middle of the image. Two horizontal white lines are positioned above and below the hand.

Soil Formation

The Dirt on Soil

What causes soil to form?

- **Soil** is a loose mixture of rock fragments, organic matter, water, and air that can support the growth of vegetation.
 - The first step in soil formation is the weathering of *parent rock* into smaller pieces.
 - Eventually, very small particles from parent rock are mixed in with organic matter to form soil.
-

What causes soil to form?

- Rock is broken down by weathering and plant root growth to form sediment.
 - The type of sediment in soil depends on what rocks are in the area. This helps to explain why soils differ from place to place.
-

What causes soil to form?

- Some microorganisms, such as bacteria and fungi, decompose the remains of plants and animals.
 - These remains are decayed organic matter called **humus**. It contains nutrients that plants need to grow.
 - Larger animals, such as earthworms and moles, loosen and mix the soil as they burrow, increasing the air in the soil and its ability to drain water.
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Thick Tops, Rocky Bottoms

What factors determine how long it takes for soils to form?

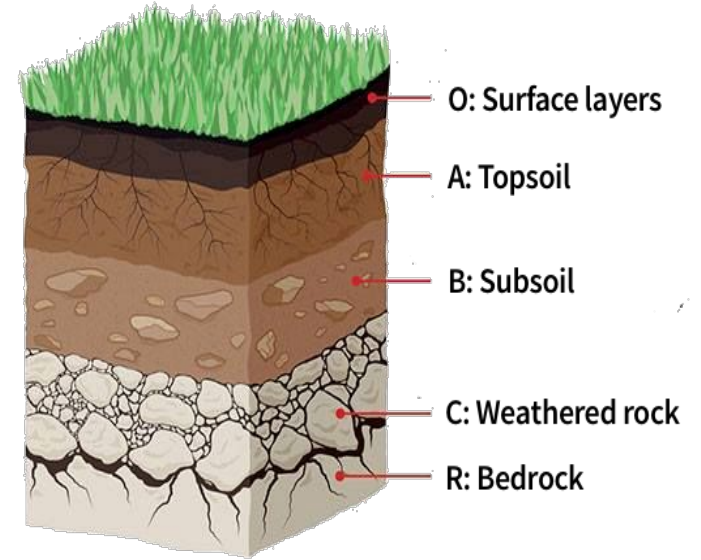
- Four main factors determine how long it takes for soil formation and development.
 - These factors include parent rock type, climate, topography, and plants and animals.
 - Rock type: The rate of weathering depends on the structure of the rock and minerals that make up the rock.
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What factors determine how long it takes for soils to form?

- Climate: Soil usually develops more quickly in warm, wet areas than in cold, dry areas.
 - Topography: Soils usually develop faster in flatter areas where sediments are not easily eroded.
 - Plants and animals: Without a lot of plants and animals, soil tends to develop slowly.
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What are the main soil horizons?

- different layers is called a **soil profile**.
- Each layer in the soil profile that has different physical properties is called a **soil horizon**.
- The main horizons include the A horizon, B horizon, and C horizon.



What are the main soil horizons?

- The A horizon is the topmost layer of soil, often referred to as *topsoil*. It contains the most humus.
 - The B horizon lies under the A horizon and has less humus. Water carries material from the A to the B horizon, in a process called *leaching*.
 - The C horizon lies below the B horizon and directly above the parent rock. It contains the largest rock fragments and usually no organic matter.
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All About Soil

What are some properties of soil?

- Soil properties are used to classify different soils. These properties include soil texture, color, chemistry, pore space, and fertility.
- *Soil texture* describes the relative amounts of differently sized soil particles.

Soil particles are classified as sand (largest particles), silt, or clay (smallest particles).

What are some properties of soil?



- Soil color depends on the minerals and organic matter that make up the soil.
 - Soil pH is a measure of how acidic or basic the soil is. Soil pH depends on the minerals, sediment, and organic matter found in the soil.
 - *Pore space* describes the spaces between soil particles. Water and air are found in the pore spaces of soils.
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What are some properties of soil?

- *Soil fertility* describes how well a soil can support plant growth.
 - Soil fertility depends on the climate and topography of the area, and the amount of humus, minerals, and nutrients in the soil.
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