Chapter 9: Building and Shaping Earth's Surfaces

 

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Guiding Question: If you are wondering how Hawaii began as an erupting volcano and ended up a lush and beautiful island, then you will love this chapter! We are going to be sure we know how the Earth's surface has changed since it was one single continent and how it continues to change – then let's read about it and learn what causes these changes!

Learning Outcomes

At the end of this chapter, the students will be able to:

1. Describe the Earth's spheres
    a. Describe the features of each of Earth's spheres
        i. Hydrosphere (water cycle)
        ii. Lithosphere
        iii. Atmosphere
        iv. Biosphere
    b. Review the stages of soil formation on Earth' surface
    c. Explain the overall concept of how the geosphere is impacted by constructive and destructive forces
2. Explain constructive forces
    a. Major continents
    b. Mountain Building (folds and faults)
    c. Volcanoes
3. Explain destructive forces
    a. Earthquakes
    b. Processes of weathering, erosion, deposition, mass wasting
        i. Glaciers
        ii. Water movement
        iii. Wind movement

Georgia Standards of Excellence Alignment

Essential Vocabulary

- Hydrosphere
- Lithosphere

- Geosphere
- Atmosphere
- Layers of the soil
- Constructive forces
- Destructive forces
- Faults
- Leaching
- Weathering
- Erosion
- Deposition
- Mass Wasting

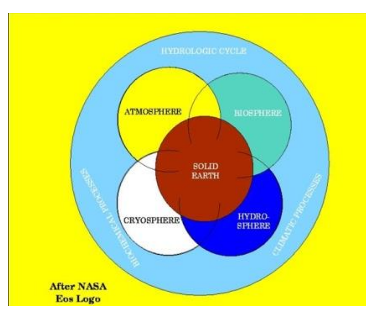
Overview and Introduction to Essential Equations

The environment we live in depends on may interdependent parts: our earth, our water, and our air. These are called spheres and while each has specific characteristics, they are all important in impacting the biosphere. The biosphere is where we, and all living things, cohabitate. In this chapter we will be looking at each of those spheres and see how each influences the other. The Earth's crust is always changing, resulting in changes in the features that we see around us. This includes mountains, beaches, plains, and valleys. Many factors impact these changes, including the water and air around us. During this chapter, we will think about the following essential ideas and questions:

- *What are the main characteristics of each of Earth's spheres?*
- *Why is it important that Earth's spheres all work together?*
- *What kinds of constructive and destructive forces are evident in each of the Earth's spheres?*
- *What are the main types of constructive and destructive forces?*
- *How do constructive and destructive impact the lithosphere?*

When you look around and observe the spheres, you will now dive deeper into learning about each of them and how they all work together. Let's start with the big picture.

X.1 An Overview of Earth's Spheres



https://lsintspl3.wgbh.org/en-us/lesson/buac20-il-whatisfeedback/7?as_guest=True

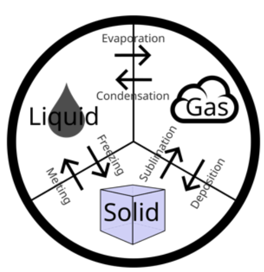
https://earthsci.org/processes/weather/earth_systems/earth_systems.html

The Earth, almost a sphere, is surrounded by several layers that each have very specific characteristics. Each of the layers has an impact on the constructive and destructive forces that change the features of the Earth. The layers we will study include the lithosphere (sometimes referred to as the geosphere), the hydrosphere, biosphere, and the atmosphere. Let's start with a general overview of each layer before we dig deeper into each one. Since approximately 70% of the Earth's lithosphere is covered in water, the hydrosphere is a major player in the study of the spheres. The hydrosphere includes oceans, and smaller water bodies such as lakes, ponds, rivers and streams. The size of the body of water is not important, all water on Earth's lithosphere is considered part of the hydrosphere. All the hydrosphere is impacted by the water cycle. That layer of water covers the Earth's solid part which is classified as the lithosphere. For the purposes of defining this layer, scientists consider the depth to be about 100 kilometers. The lithosphere has many different types of features, from mountains on the continents as well as mountains under the oceans. These features impact the thickness of the lithosphere. The atmosphere consists of all the gases that surround the Earth itself. It is separated into five layers based on the temperatures of each layer and each has a specific role to play in protecting the biosphere. The layer humans are most familiar with is the troposphere, but we will explore the others later in the chapter. Finally, the last layer we will learn about is the biosphere. The biosphere contains all the living things that occupy the Earth. The most important idea to remember about the spheres is that they are all related to each other and are interdependent when maintaining life as we know it and forming the features of the Earth's surface.

X.2 The Hydrosphere

The total amount of water on the Earth is considered to be the hydrosphere. It does not matter if it is liquid water, solid ice or gaseous water vapor – it is all considered the hydrosphere. It also includes any water that is under the Earth's surface. As you know, the amount of water on Earth is basically the same amount that was here when the Earth was formed. The state of the water may have changed, but the amount has been cycled and recycled for billions of years. This happens in the water cycle. However, before we review the water cycle, let's look at some interesting properties of water.

Water is a very special molecule. It is considered an inorganic molecule made of two elements: oxygen and hydrogen. It has very specific physical and chemical properties. Pure water is considered a universal solvent because it is able to dissolve more substances than any other liquid. For example, it is transparent, odorless, and tasteless. While it is described as almost colorless, even though when we look at a pool of water or the ocean, we often describe water as being a shade of blue. Due to its properties, at Earth's normal temperature, water can exist as a solid, liquid, and a gas (or vapor).

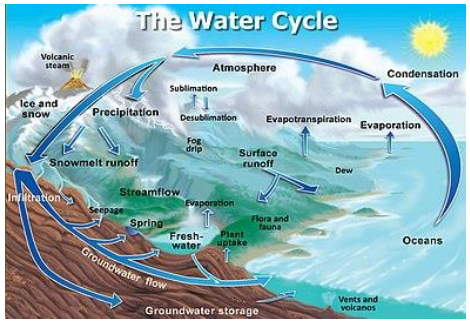


https://en.wikipedia.org/wiki/Water#/media/File:States_of_Matter.svg

Those states of matter are easy to observe on a daily basis. In fact, we can observe solid (glacier), vapor (clouds), and liquid (oceans) forms at many locations on Earth. Also, recall that the liquid form of water can, in fact, be freshwater or salt water. One interesting fact about water is that it becomes less dense when it is frozen. We usually consider the density of water to be 1.0 g/cm^3 in the liquid state and 0.9 g/cm^3 in the frozen state. This is a very important characteristic because, during cold months, frozen water would float on a lake and keep the plants and animals in the lake protected from the harsh temperatures. It also expands as it freezes – which is why frozen water sometimes makes pipes explode in cold weather! That freezing process also destroys rocks through a process called frost wedging. Frost wedging occurs when water goes into a small crack in the rock, freezes and expands, resulting in making the crack larger or even breaking the rock into smaller pieces. Eventually this is a destructive force that changes the Earth's surface.

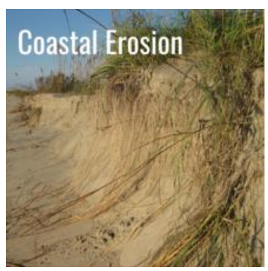
The *water cycle*, or hydrologic cycle, is the process that enables water to go from one state of matter to another. The water cycle enables the amount of water on Earth to remain fairly constant. While the "steps" of the water cycle are widely known, let's review each. And, remember, the water cycle is a cycle – it has no real beginning or end – it is continuous! One important concept about the water cycle is that is involves energy – without temperature changes, the water cycle would not occur. There are specific "processes" that are associated with the water cycle: *evaporation, condensation, precipitation* are the major processes. In addition, *transpiration, infiltration, runoff and sublimation* are part of the water cycle.

During the water cycle, there is an ongoing exchange of water. Water from the oceans, ponds, rivers, lakes is heated by the Sun and, when the temperature reaches the boiling point, it evaporates from the surface and enters the atmosphere (*evaporation*). A type of evaporation, called *transpiration*, comes from plants and animals and that also enters the atmosphere. When the water vapor enters the atmosphere, it condenses into clouds (*condensation*). Those clouds get bigger and heavier and the water vapor condenses and returns to Earth as *precipitation*. That precipitation has several forms, depending on the temperature of the water. The main type of precipitation is rain, but it also exists as snow, hail and sleet. Returning water can also form fog and dew. As the precipitation hits the Earth it can *runoff* the surface of the Earth and flows into rivers and other bodies of water. That runoff causes erosion and can change the shape of the Earth's surface. Some of that water enters the ground surface and infiltrates the soils (*infiltration*) to be stored underground. Another action that may occur is when snow or ice change into water vapor without even becoming a liquid (*sublimation).* Finally, water can be stored as lakes, groundwater, and aquifers. Even though 71% of the Earth is covered by the oceans, the amount of freshwater available for human consumption (potable water) is very small. Examine the following illustration to see the interdependence of the steps of the water cycle:



https://en.wikipedia.org/wiki/File:Watercyclesummary.jpg

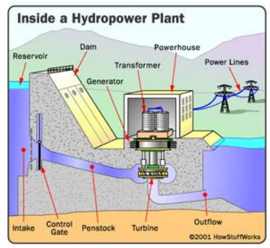
Now that you have examined the characteristics of the hydrosphere, let's look at how destructive and constructive forces act in the hydrosphere. The action of water in storms has destroyed our beaches and many land forms. For example, beach (or coastal) erosion is caused by the action of waves on the coastlines of the United States, including Georgia. This causes the loss of land and has been seen to impact homes and communities that are built along the beaches. Both chemical and mechanical erosion occur at the coastlines as the waves break apart the different rocks and cause the coastline to lose land back into the oceans. This destructive force causes the loss of land due to wave action, tides and the impact of storms such as hurricanes and flooding. This is known as storm surge, which is when high levels of water are pushed along the coastline ahead of hurricanes or other types of tropical storms. This can result in extreme flooding along the coastline, thus causing the coast to erode and be destroyed.



https://www.usgs.gov/media/images/coastal-erosion-more-severe-under-climate-change

While not strictly defined as destructive forces, humans have a huge impact on the Earth's supply of water. The worst impact is water pollution. Humans fertilize farm land, and runoff causes the surface fertilizers to enter the water cycle. Industrial wastes often enter the water cycle around major industrial areas. Some industrial wastes are very warm and when that warm water enters the lakes and rivers, it changes the environment of that area, impacting the growth of aquatic plants and animals. Humans have also legislated over water rights. In Georgia, the use of water in the Apalachicola-Chattahoochee-Flint River Basin has been in dispute since the 1990s. Georgia, Alabama and Florida have been disputing over who "owns" the water from this river basin and if Georgia was using too much of the water (overconsumption). After years in the courts, the final decision was in favor of Georgia.

Another important use of water is the production of electricity through hydroelectric power. This is one of the oldest ways to produce renewable energy because it uses the flow of moving water to produce electricity. Most of the time, the original source of water, maybe a river, is collected behind a dam. The water that is stored behind the dam forms a reservoir and is stored, or potential energy. One of the largest dams in Georgia is located in Murray County and is called Carters Dam. It is the tallest earthen dam east of the Mississippi River! The reservoir is higher than the river and the elevation difference allows the water to flow and towards a water plant. The natural force of gravity allows this to happen. That water flows (kinetic energy) through a pipe that spins the blades of a turbine, spins a generator and electricity is produced. A transformer inside the power house takes the current and converts it to higher voltage current. That electricity comes out and is sent to power lines and, eventually, to our homes. This type of electricity production is very affordable, making this one of the most affordable types of renewable energy. Examine the illustration showing the steps in producing electricity and trace the process:

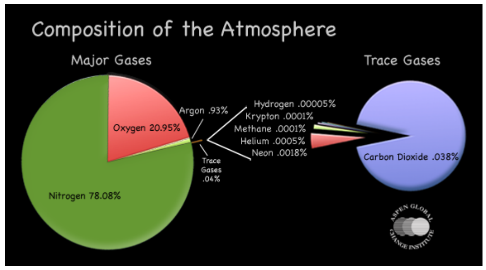


https://science.howstuffworks.com/environmental/energy/hydropower-plant1.htm

Although this type of energy is affordable and renewable, there are some disadvantages. There are not a great deal of available reservoirs and they are located in specific areas (by rivers large enough to support hydroelectric power production). In addition, there are some environmental issues associated with these power plants, like impact on water temperatures and water chemistry. The hydrosphere contributes to building and forming Earth's surface through the motion of water (erosion and deposition). Let's examine the next one of Earth's spheres that impacts the formation of the Earth' features: the atmosphere.

X.3 Atmosphere

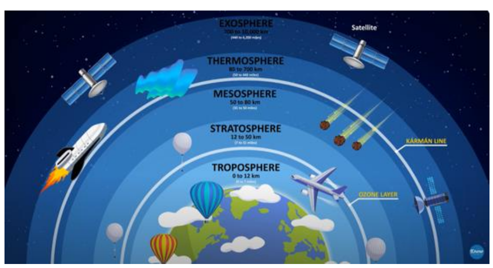
Look around you and what do you see? You are standing in a gas that is called the atmosphere. It is just one of the three (or four with the biosphere) spheres that contribute to supporting life on Earth. This mixture of gases and solids actually has several functions. For example, it is composed of gases that support life on Earth. It serves as a layer of protection from outer space and the ultraviolet rays that come from the Sun. While we stand in the gases that make up the atmosphere, we sometimes do not consider that it is, in fact, a mixture of gases and solids. For example, many people would think that oxygen is the most abundant gas in the atmosphere but forget that, if that was true, lighting a match would result in combustion! To ensure living organisms are safe, the composition of the atmosphere is, in fact, 78% nitrogen. Nitrogen is an extremely stable gas in its diatomic form, having three bonds and making it a perfect gas to dilute oxygen and other gases in the atmosphere. In addition to the nitrogen and oxygen, the atmosphere contains carbon dioxide, argon, and water vapor (in addition to small amounts of other gases). This balance of elements and substances, supports the biosphere and was the foundation of life when the Earth was forming. When you examine the graph below, it is easy to identify the composition of the atmosphere and be amazed at the small amounts of the trace gases that are its composition:



http://apes2k15-earthsystemsandresources.weebly.com/composition-and-structure.html

It is interesting to note that many of the gases have specific uses. For example, oxygen is essential for living organisms like humans. Carbon dioxide is used by plants to make food that supports living organisms. Plants, you recall, are the first step in food web and depend on the Sun for energy. The plants complete a process called photosynthesis with the carbon dioxide and produce, as a waste, oxygen. Another of the trace gases, argon, is used in light bulbs. All these gases are in a balance that supports the biosphere. When humans pollute the atmosphere, the balance of the atmosphere's composition is changed which impacts the ecological balance of the biosphere.

The atmosphere is composed of five layers. Each layer has specific characteristics and functions. These layers compose the atmosphere and, from the closest to Earth outward, are called the troposphere, stratosphere, mesosphere, thermosphere and the exosphere. They are characterized by temperature, chemical composition, movement, and density. It is interesting to note that there is an area between each layer called the "pause." In that area, which serve as transitions between the layers, the greatest changes occur in the characteristics of each layer. When you examine this illustration, it looks like there is a distinct "edge" to each layer, but remember, these layers "blend" into each other at the "pause."



https://view.genially.com/65b8f5f61610070014c2e40c/interactive-image-layers-of-atmosphere

Let's start with the troposphere to learn about the different layers. It is the layer that supports the biosphere and is where almost all weather occurs. It begins at Earth' surface and goes up between 6 and 20 km, depending on the location. For example, it is thickest at the equator and thinnest at the poles. Think about the shape of the Earth to understand that the troposphere has different depths, depending on the location. Also, consider the amount of the Sun's energy at each of the locations and how the thickness of the troposphere might serve as a protection from the Sun's energy. Again, the composition is 78% nitrogen and 21% oxygen, with the remaining parts being water vapor and trace elements. The troposphere contains a great deal of water vapor which helps regulate the temperature of the Earth, making it perfect for cloud formation. As you have probably noticed, the Earth's temperature has changed a good deal and that is, in part, to increased amounts of carbon dioxide and water vapor in the atmosphere. In addition, the density and temperatures of the troposphere decreases as the altitude increases. There is no ozone in the troposphere. It is separated from the stratosphere by a small layer called the tropopause.

The tropopause blends into the second layer called the stratosphere. It is about 30 km thick, or between 20 and 50 km, above the Earth's surface. While the higher you go in the troposphere, the lower the temperature, this does not happen in the stratosphere. In the stratosphere, the temperature increases as you go up the stratosphere. While the temperature increases, the air density decreases, making it thinner than at sea level. As a result, the air currents in this layer are fairly stable, making it a perfect layer for commercial airlines to fly in to avoid turbulence. Ozone, which is in the stratosphere, heats up the layer as it absorbs the Sun's energy. That stability impacts the ozone layer because ozone-destroying chemicals (chlorofluorocarbons or CFCs) stay in the layer for a long time and cause "holes" in the ozone layer. There are other objects, besides commercial airlines, in the stratosphere. This is where weather balloons can be found. The layer between the stratosphere and mesosphere is the stratopause, another transition area.

The mesosphere, which is 50 – 85 km thick (about 35 km), is the "middle layer" of the atmosphere. One very important function of this layer is that meteors can be found in the mesosphere where the gases slow them down and help them burn up. It is the coldest layer of the atmosphere, reaching -130° C, and gets colder as you get higher in the layer. There are clouds made of ice crystals in this layer, called noctilucent clouds. It even has very strong zonal winds which are influenced by the gravitational pull of the Moon. Another type of wave is called planetary waves which cause changes in weather on Earth's surface. Research balloons and satellites tend to not stay in orbit in this layer, making it less studied than the lower layers. The mesopause separates the layer from the thermosphere.

The thermosphere is a very thick layer, from 85 to 600 km above the Earth. The air in this layer is extremely thin. However, the Sun's energy is absorbed in the layer and causes large temperature changes (hence, the name thermosphere). The temperature changes so much, it can go from -120° C to 2000° C near the top of the layer. You need to recall, however, there are few air molecules in the layer so it does not feel as warm as you would think. It is in this layer where the auroras occur, making a special light show caused by colliding particles. This is a result of the ionosphere, a layer of ionized air in the lower part of the thermosphere. Satellites and the International Space Station orbit the Earth in the thermosphere. The transition between the thermosphere and exosphere is called the thermopause.

The exosphere is the outermost layer of the atmosphere. It extends past the thermosphere and seems to fade into outer space. Satellites also use this layer to orbit, really float around, the Earth. The temperature tends to vary greatly, varying from night to day. This may be because the molecules are so thin, keeping the temperature very cold. It is, in fact, the first layer that protects the Earth from meteors, asteroids and cosmic rays. Now that you have studied about the atmosphere, use this table to review the main characteristics:

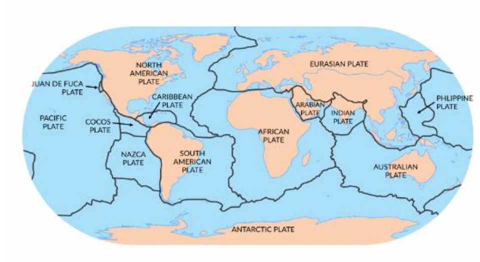
Summary of Layers of Atmosphere			
Region	Altitude Range (km)	Temperature Range(0°C)	Important Characteristics
Troposphere	0-11	15 to -56	Weather occurs here
Stratosphere	11-50	-56 to -2	The ozone layer is present here
Mesosphere	50-85	-2 to -92	Meteors burn in this layer
Thermosphere	85-800	-92 to 1200	Auroras occur here

https://byjus.com/physics/atmosphere/

Just to recap, the hydrosphere changes the Earth's surface through actions like erosion, while the atmosphere can change the Earth's surface through weather events like floods and hurricanes, which are both a result of water and wind. The weather that occurs in the troposphere has significant destructive and constructive impact on the features of the Earth. Most of the events that occur in the troposphere are destructive forces that break down Earth's surface. Let's look at the surface of the Earth and discover how constructive and destructive forces impact the surface features of the Earth.

X.4 The Lithosphere

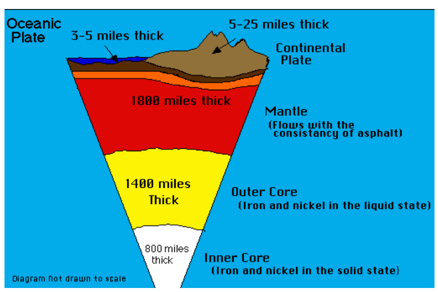
While the lithosphere is considered all the land or solid part of the Earth, you will recall that it is made up of the brittle crust and the top part of the mantle. It is defined as all the mountains, rocks, stones top soil and sand found on Earth. Scientists indicate that it measures about 100 kilometers in depth. However, we all know the Earth is a solid ball. To that point, the solid layers really begin with the core, the mantle and the crust. The three layers are called the *geosphere* and extend from the Earth's surface all the way to the core, or the center of the Earth. Remember, Earth is made up of several layers. The layers are classified according to the chemical composition of each and are the core, mantle and crust. The most abundant elements found in the lithosphere are oxygen, iron, silicon, and calcium. According to mechanical properties used to identify the layers, Earth's layers are the lithosphere, asthenosphere, lower mantle, outer core and inner core. Each has specific characteristics. For example, the lithosphere is considered the solid rock or outer layer that we live on – in other words, the crust. It is the coolest part of the Earth, as well as the most rigid. The crust, which varies in depth, has many features and is composed of the lithospheric plates that are responsible for the creation of the mountains and other Earth features, including features such as ocean basins. The plates "float" on a plastic like layer called the asthenosphere. The asthenosphere is viscous and the area where the crust and asthenosphere meet is called the lithosphere-asthenosphere boundary (LAB) Most if the time, these plates move smoothly on the asthenosphere, but sometimes, they rub against each other and stick until the pressure builds and makes the plates move abruptly. The result can be an earthquake. The plates make up the seven major continents and many ocean plates. There are seven major identified plates: African, Antarctic, Eurasian, Indo-Australian, North American, Pacific and South American. The largest, and youngest, plate is the Pacific plate. When you examine the illustration of the plates, you can see that many of the major continents have a specific tectonic plate supporting it.



https://earthhow.com/7-major-tectonic-plates/

The other idea you should consider, is that these plates and their motion is closely related to the rock cycle. The rock cycle and tectonic movement is responsible for mountain formation and seafloor spreading. For example, when two continental plates collide, most of the time the plates will crumble and fold until the rocks are forced upward and form mountains. The stronger the collision, the more likely the higher the mountain. Mountain formation will be discussed later in the chapter under constructive forces.

As you can probably guess, the crust is thicker where there are mountains and thinner where there are ocean basins. The mountain layers, on the continental crust, can be as much as 25 miles thick but the crust under the ocean, the oceanic crust, can be as thin as 3 – 5 miles.



https://volcano.oregonstate.edu/earths-layers-lesson-1

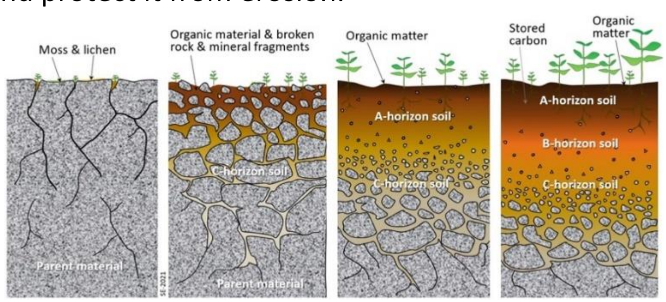
The crust is made of rocks and minerals that are integral parts of making soil. Some scientists classify the soil and dirt layer as the pedosphere (“ped” means foot so this is the layer we walk on). Soil is composed of rocks and minerals, organic materials, microorganisms, air and water. You know about rocks, minerals, air and water, so, just in case you forgot, organic materials are dead and decaying materials of once living organisms. Now that you know its components, let’s see how soil, the pedosphere, is formed by both mechanical and chemical weathering.

There are three factors that impact soil formation and its types: the bedrock, climate and time. Bedrock is the layer of rock under the soil and is considered the raw material of soil formation. As bedrock undergoes weathering, soil can be formed. The most fertile soil is produced when the bedrock has a wide variety of minerals. Soil is made of a wide variety of minerals, organic material and air pockets throughout the soil. It is defined as the material that contains these parts and goes down about some thirty centimeters of the surface, and can support plant growth. As the bedrock is weathered, the minerals that become part of the soil are mostly clay minerals and quartz. The bedrock is often called the parent material of the soil.

However, it is also important to note that erosion and deposition of different materials can also be incorporated into soil formation. The final type of soil is dependent on the bedrock and any transported materials. For example, sandy soils are generally formed when the parent material has minerals such as granite, sandstone or loose sand. Soils with high levels of clay are produced from quartz-poor materials.

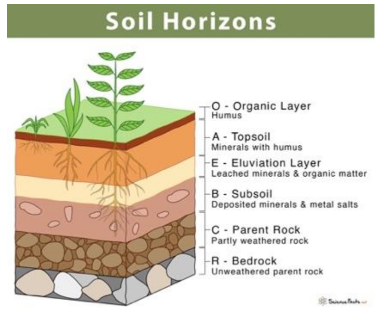
Climatic extremes do not produce rich, fertile soil. Cold climates tend to produce rocky and "thin" soil. The colder temperatures do not provide enough time for organic materials to decay and stay in the soil. While warm climates may produce thick soil, generally the soil produced in warm climates does not have high levels of minerals. The warm climates tend to "leach" important minerals from the soil. Leaching is when water runs through the soil and existing minerals are washed away when they dissolve in the water. Most people think that rainforests would have rich fertile soils. However, rainforests tend to have the worst soil because there is little time for organic materials to decay in all that moisture. Soils formed in warm climates tend to be richer in clay – think about the soil in South Georgia. It is red clay soil. Finally, hot and dry areas do not have rich soil because of the lack of both water and organic materials. The best climate that produces the best soil is temperate climates. Temperate climates allow organic materials to break down over time and no extremes of moisture (rain, etc.) allows the minerals to stay in the soil as it is being formed.

Finally, it takes a long time for thick, fertile soil to form. The time it takes for bedrock to break down into mineral rich layers allows fertile soil horizons to form. Some soils can take up to thousands of years to form rich, fertile soil. Let's look at the process that takes so long. For example, rock needs to be weathered and broken up. Small plants like mosses and lichen are called pioneer plants because they are the first to star breaking up bedrock. They can grow in the smallest cracks and their small roots (not really roots but that is another story) excrete enzymes that chemically weather the bedrock. As more and more plants start to grow into the rock, the rock breaks up into smaller pieces. The moss and lichen die and add organic material to the weathered rock. Eventually, over a long time, the process continues, insects and worms enter the developing soil and die, adding more minerals to the soil. By the time the process continues, the more likely the rich soil forms. The ongoing process allows the soil to make thicker layers until the final result is a soil that supports plant growth. The roots of the plants hold the soil in place and protect it from erosion.



https://environmental-geology-dev.pressbooks.tru.ca/wp-content/uploads/sites/73/2021/07/soil-evolution-diagram-2.jpg

As you can see, the layers of soil are classified into soil horizons. The top layer is dominated by organic material, and is called horizon "O." The next horizon is "A" and is a layer of partially decayed organic materials mixed with minerals and commonly called top soil. The layer is also called the humus layer because of the insects, worms, bacteria, fungi and other components found in this layer. Layer "E" has nutrients from layer "O" and "A." Layer "E" is mostly found in forest areas. Layer "B," called the subsoil, has less humus but does have minerals and a great deal of water. In South Georgia, farmers mix topsoil and this subsoil while plowing fields. "C" horizon is parent rock, which is partly weathered bedrock. Finally, horizon "R" is bedrock. Bedrock consists of rocks that have not yet been weathered.



https://www.sciencefacts.net/soil-horizons.html

Now that you know how soil is formed, let's think about some characteristics of soil. For example, soil can be different colors, textures, and fertility, depending on its components. Color is impacted by the organic material, such as the amount of plant life, microorganisms, and organic materials that live in the soil, like fungi and worms. Soil texture is impacted by the size of the particles. For example, sand is the largest sized particle and the texture feels gritty and rough. Silt is a smaller sized particle and, when wet, feels silky and smooth. Clay particles are smaller than silt and, when wet, feels sticky. The textures also impact fertility. Sandy soils do not hold water or nutrients, making the soil not very fertile. Silt and clay hold nutrients and water, making the soil more fertile. That is important because fertile soil grows plants and plants feed humans and animals.

Earth's land forms are impacted by both constructive and destructive forces. As soil is eroded and rocks and minerals are weathered (destructive forces), these sediments are often deposited as deltas and other land forms (constructive forces). Earthquakes destroy land features while volcanoes often build them up. Now that you know more about the lithosphere, we will look at another of Earth's spheres. Just remember, we will be showing the interdependence of all the spheres later in the chapter and how these spheres contribute to forming and reforming Earth's surface though destructive and constructive forces.

X.5 Biosphere

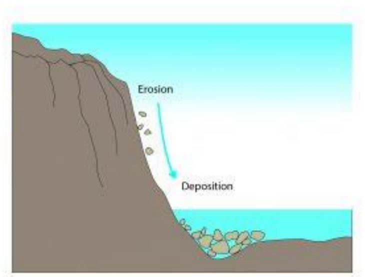
While the biosphere is a sum of all the systems on Earth, it has no activity such as earthquakes, volcanoes, or destructive weather. It does contain all biotic and abiotic factors. We are including it here because all living things are impacted by the constructive and destructive forces that change Earth's surface. For example, when an area is impacted by a volcano, the living organisms near that volcano may have to move or adapt to the new environment. The volcanic activity can transform habitats and impact the availability of resources. We will examine the impact of constructive and destructive forces later. Examine the following illustration and reflect on the various interdependent factors that are a result of these types of forces. Examine the colors of the soil and explain how the color differences might be an example of soil formation. Also, the area where the water and soil meet might be an example of erosion (a destructive force). There are several other examples that you could discuss.

https://byjus.com/chemistry/what-is-biosphere/

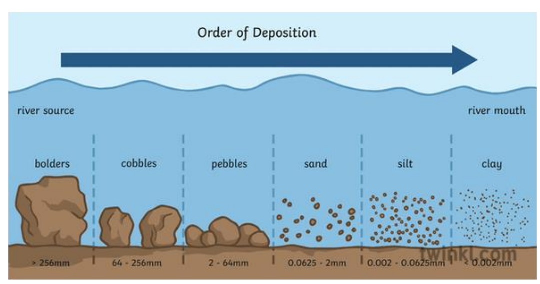
After reflecting on the interactions that occur in the biosphere, let's look more closely at the types of forces.

X.6 Constructive Forces

We are ready to look at constructive forces as a whole. Constructive forces are processes that cause the Earth's surface to build up or rise. There are at least three major types of constructive forces, including crustal deformation, volcanoes and deposition of sediments. Deposition is closely related to erosion. When landforms are broken down or eroded to produce sediments, these sediments are generally moved and deposited in a new area. Yes, erosion is destructive but deposition is constructive. Deposition occurs as a result of water, wind, ice, or gravity transporting sediments to new locations. When strong winds or water move small particles (called sediments) that have been eroded, as the force behind the water/wind decreases, the force of gravity slows the water/wind forces and the particles are dropped in the new locations. This can happen along coastlines, along rivers and streams, as well as in deserts.

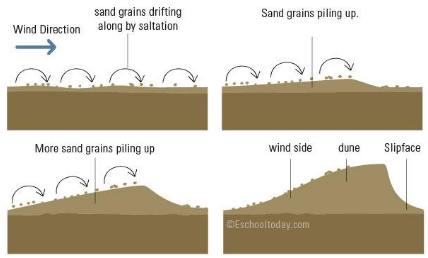


https://epiccvfe.berkeley.edu/glossary/deposition/



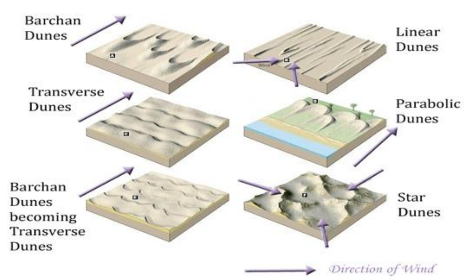
https://ausearthed.blogspot.com/2020/08/gravity-settling.html

While deposition mostly happens with water, that is not always the case. Wind and glaciers also contribute to deposition. Wind deposition impacts dune formation along the beaches and deserts. Sand dunes are exactly what they sound like: deposits of sand that can vary in height and shape. For example, in deserts sand dunes can be small or very large. All dunes are a result of the direction and strength of the winds that occur in the region. Examine the following image to see how the wind produces sand dunes:



https://eschooltoday.com/learn/sand-dune/

There are six major type of dunes that are located all over the world, but depend on wind s and other environmental factors. These are barchan, star, linear, parabolic, and reversing dunes. Barchan dunes, sometimes called transverse dunes, are crescent shaped, with a steep face whose tip points away from the wind. They result because the winds blow in one direction and allow small amounts of sand to move quickly across empty desert lands. Barchan dunes are the most common types of sand dunes. Star dunes are pyramid shaped and the tallest type of dunes. The winds that produce these dunes are strong and blow in many directions. These dunes are produced when there are large amounts of sand available for the dune formation, allowing them to form upward and outward. Linear dunes are the longest type of sand dune and have ridges that cause them to look symmetrical. Linear dunes are formed when strong winds blow in two directions. Parabolic sand dunes are inverted, crescent shaped dunes that sometimes appear u-shaped. These form when some vegetation appears. These dunes require moderate amounts of sand and strong winds. Finally, reversing dunes are formed when the winds change directions and are balanced in strength and the length of time the winds blow, allowing it to grow vertically. Examine the figure that shows the different types of dunes and how the wind direction impacts the formation:



https://socratic.org/questions/what-are-the-different-types-of-sand-dunes

Another type of deposition is called a loess. A loess is mineral rich and is moved by the wind and, sometimes, glaciers. The dust and silt that make up the loess has been transported for thousands of years and deposited all over the world. The dust and silt are deposited and build up like dunes, which, over time, harden to form hills. In the US, the thickest deposits are along the Missouri River, mostly in Iowa. The result of these deposits, which erodes slowly, is fertile agricultural soil. It is full of rich minerals, tills easily, drains well, and is perfect for planting crops.

Mountains are produced by constructive forces. Orogenesis is the name for the processes that build mountains. There are several ways mountains can be formed. These are from volcanic eruptions and from tectonic faults and/or collisions. For example, when two continental plates collide, most of the time the plates will crumble and fold until the rocks are forced upward and form mountains. The stronger the collision, the more likely the higher the mountain. In some cases, the plates collide and the denser plate goes under the less dense plate. The process is called subduction. When this happens, the plates tend to buckle and fold resulting in a mountain formation that is classified as a fold mountain. Mountains result from compressional forces that change Earth's crust. These forces cause the crust to be pushed upward, so the height of the mountain results from the intensity of the compressional forces. There is an upward folding of the crust. That upward folding is called the anticline, while the syncline is the downward fold. This is why most mountains are formed along continental plates and result from convergent plate movement. Our Appalachian Mountains are very old fold mountains. Other examples of famous fold mountains include the Rockies, the Alps and the Andes.

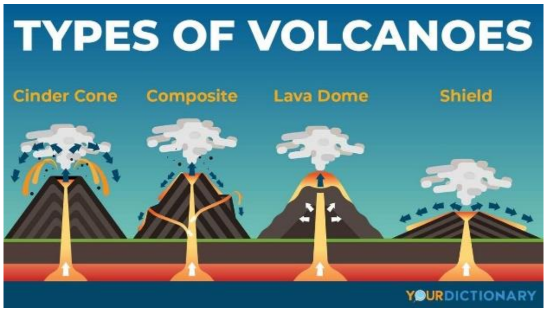
Another mountain type is called a fault-block mountain. A fault-block mountain is formed when a fault-block is raised or tilted. Rocks slip past each other at areas called faults. Again, this type of mountain results from tectonic activity. There are different kinds of faults, including normal faults, reverse faults and strike-slip faults. The Sierra Nevada mountains are an example of a block mountain in the U.S. Most of the world's mountains are located along two major mountain belts called the Circum-Pacific belt, which formed the Rockies and the Andes. The second belt is the Eurasian-Melanesian belt which formed the Himalayan mountains. Mountains are also formed by volcanic activity, like Mt. Fuji in Japan.

A third type of constructive force is volcanoes. Volcanoes are the most destructive nature disaster known to man. Volcanoes are openings, sometimes called vents, in the Earth's crust. The eruptions that are emitted from a volcano can include lava, steam, tephra, and different materials. Lava is molten rock that was magma when it was underground, but is lava when on the surface of the Earth. While underground, the magma is found in the asthenosphere and it can flow closer to the crust before erupting through the volcano. The magma collects in and is "stored" in magma chamber below a potential volcano. Several other structures are linked to these magma chambers. Dikes are tubular bodies produced when magma enters fractures that cut across rock layers in existing sedimentary rock beds. If the magma enters the layers between sedimentary rock, sills are formed parallel to existing sedimentary rock beds. Remember from the chapter on Rocks and minerals, that lava forms igneous rock when it cools.

Volcanic eruptions can be explosive or relatively quiet, depending on the type of magma. When the magma is thin, the eruption tends to be quiet because the magma flows smoothly and easily. However, when the magma is thick and contains large amounts of silicon, oxygen, and dissolved gases. This should make perfect sense, since the more gases in the magma, the greater the pressure that builds up before the volcanic eruption. That pressure causes more explosive eruptions that cause the lava to break into pieces or fragments, which are called tephra. Tephra is composed of small rocks, ash, and cinders that erupt and cause serious environmental conditions both near and far from the volcano. Tephra is classified by size of the fragments that are emitted from the volcano. The largest pieces are called a bomb and block, while the smallest is called ash.

Most of the world's volcanic activity occurs along the Pacific Plate knows as the Ring of Fire. There are more than 180 active volcanoes located on the Ring and they are associated with plate boundaries. The volcanic activity starts with a crack in the crust as magma moves toward the surface of the Earth. The path of the lava is generally along the crack which opens to the surface.

Volcanoes are classified by shape. There are four major types of volcanoes which are each characterized by shape. The main types are cinder cone, composite, lava domes, and shield volcanoes. Each has specific shapes and characteristics.



https://www.yourdictionary.com/articles/volcanoes-characteristics

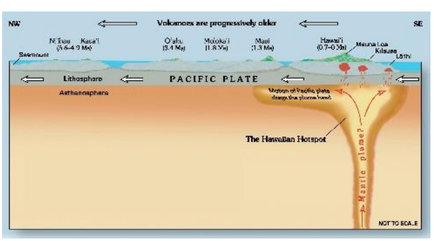
Cinder cone volcanoes are built up structures that consist of ejected lava fragments and are usually less than 300 meters high. They are considered the simplest type of volcano because they have a single vent. They are generally produced from single eruptions that last a few weeks and rarely longer than a few years. The lava is blown violently into the air and the fragments that come back to Earth are called cinders which accumulate and become the sides of the volcano. As you can see from the illustration, the top of the volcano looks like a bowl-shaped crater. There are thousands of cinder cone volcanoes in western North America. For example, Wizard Island in Crater Lake (Oregon) and Koko Crater (Hawaii). In fact, there are about 35 cinder cone volcanoes in the US located mostly in Oregon, California, Arizona, New Mexico. There are times that the magma in the magma chamber and pipeline solidifies, it stops up the volcano and it does not erupt again. When that happens, the volcano becomes inactive. It is interesting to note that, if cinder cones erupt and the lava builds up over time, a composite volcano can result.

Composite volcanoes are conically shaped with a steep summit and gradually sloping sides. They are sometimes called stratovolcanoes and are actually seen as some of the most famous mountains in the world. Many of the mountains we see today are composite volcanoes. Examples are Mount Fuji (Japan), Mount St. Helens (Oregon) and Mount Shasta (California). These types of volcanoes have a central vent and a series of dikes that allow lava to flow from several sites along the sides of the volcano. It is interesting to note that the dikes provide additional strength to the eruptions of the volcano, making them very dangerous. In history, one of the most famous eruptions was Mount Vesuvius (Italy) which destroyed the entire city of Pompeii and killed thousands. Composite volcanoes are taller than cinder cones, sometimes as tall as almost 7000 meters. The tallest composite volcano is *Ojos del Salado* (6893 m), in the Andes Mountains. Another example, Mount Rainer (Washington) is the tallest composite volcano in the US. As composite volcanoes age, the lava under the mountain is used up and the top of the volcano becomes weak enough to collapse and forms a large depression called a caldera. Over time, the caldera can fill with water and form lakes.

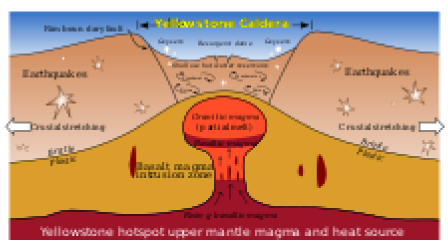
Another type of volcano is a Lava Dome. They may be the most versatile in shape which, indeed, helps to classify the different types of lava domes. Depending on its shape, the lava dome can be a coulee, peleean dome, upheaved plug or torta dome. Coulees are formed by the thick and slow moving lava that flows slowly down the slope. Peleean domes are circular with flat tops, tall vertical spines and very steep sides. Upheaved plug domes are rare and have pistol like extrusions. Finally, torta lava domes, or low lava domes, are the most common. They look like a cake (torta), being circular and flat topped. The lava does not erupt violently and slowly piles up to make these different shaped domes. In fact, some scientists classify these lava domes as eruption phenomenon rather than "real volcanoes." Lava dome volcanoes are commonly found in the South American Andes. One US example is Katmai Volcano in Alaska.

The last type of volcano is the Shield volcano. These volcanoes tend to be shaped a broad, slightly domed structures that slightly resemble a warrior's shield. They are formed mostly from liquid lava flows. These volcanoes build up slowly because the lava is highly fluid and this results in gently sloping sides. These volcano's lava flows from the central vent and a system of rift zones that allows it to flow slowly and overlap to construct the signature shield form. This allows them to build up slowly, spread over large distances and they cool in thin sheets. Most of the largest volcanoes on Earth are shield volcanoes. Many have grown from the ocean floor to form islands or seamounts. The largest shield volcano is Mauna Loa (Hawaii), though technically, the Hawaiian Islands are formed from a hot spot.

One special type of constructive force is classified as a hot spot. This is an area under the crust where the magma is hotter than the surrounding magma. This causes the crust to melt and become thinner. This is called a mantle plume and results in significant volcanic activity. Hot spots occur far from plate boundaries which is what makes them so interesting. The volcanos that form at hot spots do not form chains, but do have volcanic activity. A perfect example of a hit spot are the volcanos that form the Hawaiian Islands. Hot spots can occur in the oceans as well as on the continents. Yellowstone, mostly in Wyoming, is a continental hot spot in the US.

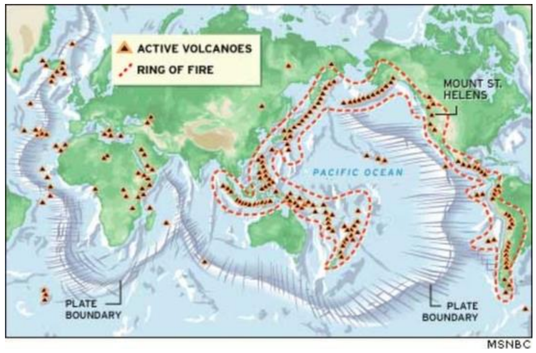


https://en.wikipedia.org/wiki/Hotspot_%28geology%29



https://en.wikipedia.org/wiki/Yellowstone_hotspot

Imagine being the first scientist to observe volcanic activity. That person may have started to locate and track the positions of the volcanoes and concluded that the major volcanoes were located along the tectonic plates – most especially around the plates located on the rim of the Pacific Ocean. Today scientists call that The Ring of Fire because of the high number of volcanoes associated with that tectonic movement. Many of the explosive, or active volcanoes, occur where one tectonic plate is sinking below another. Other volcanoes occur along the mid-ocean ridge. Still other volcanoes occur in the middle of the ocean floor (hot spots). However, no matter where the volcano occurs, they are still one of Earth's major constructive forces. Look at the map of the Ring of Fire and see how they could also be related to destructive forces:



https://www.nbcnews.com/id/wbna6152440

The Ring of Fire is interesting because about 67% of the world's volcanoes and 90% of the Earth's earthquakes occur on the Ring. In numbers, this means more than 450 volcanoes are located on the Ring. Of the approximate 1500 earthquakes recorded a year, 90% occur on the Ring. The Ring is about 40,000 meters long and touches about 15 countries which can explain why there are volcanic events all over the world.

Given the extent of volcanic activity that occurs around the world, let's consider how that activity may destroy the plants and kill the animals in the immediate region around the volcano. Lava and tephra destroy the area and plants will be destroyed. The beneficial ecological impact of the volcanic activity is that volcanic soil is very fertile, allowing the plants to recover once the area has cooled back down. The recovery time for the plants can be anywhere from months to years, depending on the level of destruction and the amount of rain that falls in the devastated area.

Other factors that impact the Earth's surface include lava flow, rock formation, and changes in the landscape. Lava, as it flows, is destructive because it burns and clears the area of the flow. The lava is so hot that it actually melts the rock it flows over. As a result, new igneous rock is formed. The interesting part is that cooled volcanic rock is often glassy or can be filled with bubbles. An example of this texture is pumice, which is so light it floats on water. The lava flow can also change the landscape, making new islands and changing the current landscape. An interesting idea is that constructive forces may also be destructive forces. As you will see in the next section, volcanoes are also considered destructive forces.

X.7 Destructive Forces

The destructive forces are the natural forces that manage to cause destruction of the preexisting landscape. Besides volcanoes, which we have studied, these forces are erosion, weathering and earthquakes. Let's examine each of the destructive forces. Erosion and weathering are responsible for many of the changes that change the Earth's surface.

Erosion is closely associated with deposition. After all, when substances are moved from one area to another, the final result is that those materials are deposited somewhere. Erosion is responsible for the movement of weathered materials and the formation of areas such as deltas. Let's see how weathering produces materials that can be eroded and deposited.

Weathering is the process that manages to break apart the rocks and is mostly classified as a chemical or mechanical activity. During chemical weathering, new substances are formed.

That means the chemical composition of the original rock is changed and new materials are formed. It can occur at different rates, depending on the composition of the rocks as well as the climate of the area. This generally occurs when the rocks at Earth's surface are exposed to substances such as water. Water is an important agent of chemical weathering (as well as erosion). Water can combine with gases in the atmosphere and form substances that decompose rock. For example, water and carbon dioxide can produce carbonic acid and decompose the rock. The original rock then makes a secondary rock type that can be moved to other areas. Acid rain, resulting from sulfur dioxide and water combining, is another substance that causes chemical weathering. Acid rain causes damage to buildings, sculptures, bridges and paint. In areas with high concentrations of acid rain, such as large cities, the damage can be extensive. An example of chemical weathering can be seen on the oldest structure in New York City: Cleopatra's Needle in Central Park. If you look closely at the picture on the left, you can see the hieroglyphics that were originally on the obelisk when it was placed there is 1881. The picture on the right shows the effect of weathering from acid rain, wind and cold/hot weather on the Needle.

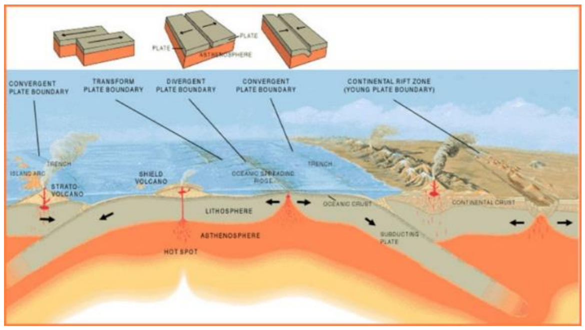
https://www.scoutingny.com/the-oldest-outdoor-manmade-object-in-new-york-city-cleopatras-needle/

While chemical weathering results in new materials, mechanical weathering causes the rocks to be broken down into smaller particles. Each smaller piece has the same composition as the original rock. Three processes can break down rock using mechanical weathering: frost wedging, shoreline/salt weathering, thermal expansion, and unloading. Mechanical weathering also results from biological activity. During frost wedging, water enters the small openings in the rock. When the temperature is lowered, the water freezes and expands, cracks and breaks the rock into smaller pieces. Eventually, the cycle produces sediments that are moved by water and wind. This process often causes potholes in the roads. A specialized type of weathering occurs at our beaches. The salt compounds in seawater are often deposited along the shores of our beaches. The ocean's action (waves and tides) spray that seawater on the rocks along the beaches and break apart the rocks into smaller pieces. Thermal expansion is closely related to the environmental conditions in the area. Rocks expand and contract according to the temperature and that causes the rocks to break apart into smaller pieces. The process of uploading is when large masses of igneous rock are exposed by erosion and entire slabs break loose. When this happens, the outer layers expand more than the underlying rock and separates from the original rock. The result of uploading is exposed domes of rock, like Stone

Mountain and Yosemite National Park. The last activity that causes mechanical weathering is caused by biological activity. This is when human, plants, and animals change rock. New plants can grow in very small patches of soil, like on the side of a mountain. As the plant grows in small cracks in the rock, soil is formed and the rocks are broken into smaller pieces (or sediments). These two forces, weathering and erosion, are forces that break down rocks and cause changes in Earth's surface. A much greater destructive force is earthquakes.

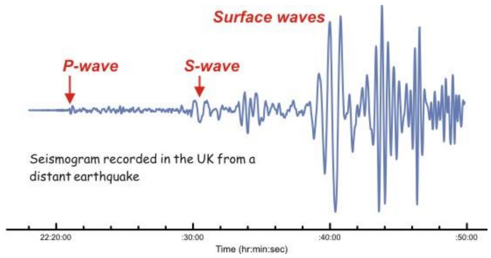
Earthquakes occur when faults slip past each other and release certain amounts of energy. Most earthquakes occur along the faults of the upper part of the Earth's crust. Earthquakes generally occur along these areas that are weak areas in the Earth's crust. The size of the fault impacts the potential strength of the earthquake. For example, large fault lines can produce major earthquakes. These fault lines rarely occur as straight lines, but, rather are branched and have smaller fractures. The irregular edges allow the sections of land to be locked in placed, but there is ongoing pressure in those areas. The pressure seems to squeeze the Earth's crust together, build up and deforms the crustal rocks. The rocks bend and, when enough pressures builds up, can snap and break apart. The stress releases a great deal of energy when the rocks break apart. The rocks slip and the stress is released. The result is an earthquake. In reality, the vibrations from the earthquake seem to last a long time but they do not. On occasion, the vibrations can produce aftershocks that can be felt for several days after a severe earthquake. There may be up to 500,000 earthquakes that occur, but only about 100,000 are felt on the Earth's surface. About 100 earthquakes actually cause damage. Let's think about the boundaries or faults where these earthquakes occur.

There are four major types of boundaries: divergent, convergent, transform, and hotspot. Let's examine each of these boundaries. First, *divergent boundaries* occur when two tectonic plates move apart (diverge). As these boundaries move, it is common for earthquakes to occur. It is also along these divergent boundaries that magma rises from the Earth's mantle to the surface, cooling and becoming solid as new oceanic crust is formed. In many cases, this occurs under the ocean and accounts for seafloor spreading and build up. The fact that little sea floor has been found to be over 180 million years old supports this theory. This accounts for the recycling of crust and the young seafloor. An example is, as mentioned before, the Mid-Atlantic Ridge. While divergent boundaries do not often occur on the continents, an example is the East African rift valleys. There are scientists who believe the African continent may be splitting and its northern portion moving towards Europe and into the Mediterranean Sea. The result might be a new ocean basin on the African continent. As indicated, divergent boundaries move apart, while *convergent boundaries* move together. Convergent plates are not always made of the same materials. If one plate is denser than the other, the heavier plate may slide under the lighter, less dense plate. This is called subduction. Subduction of the oceanic plates can result in deep ocean trenches. Sometimes two plates, one continental and one oceanic come together and subduction occurs, the impact can cause the edges of one or both plates to buckle up and mountains result from that impact. This occurred along South America and resulted in the Andes mountain range. If the two converging plates are the same density, such as the Eurasia and Indian plates, come together. This happened about 60 million years ago and resulted in the Himalayas. Volcanos and earthquakes are common along convergent boundaries. The Pacific Ring of Fire is a great example of a convergent boundary. The third type of boundary results when two plates slide past each other. These are called transform fault boundaries. The transform fault areas are always moving, although usually very slowly. The irregularities in the rock face along the fault prevent the rocks from moving rapidly. However, eventually the rocks either give way or are worn away and the transform boundary moves abruptly. The plates move past each other quickly and abruptly. The result is an earthquake. An example is the San Andrea's fault. Faults move past each other, but can also move up or down. When they move up or down, it appears as cliff like areas. Examine the three major type of faults in this illustration:



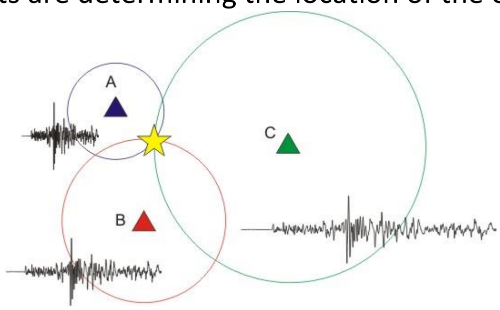
https://oceanexplorer.noaa.gov/facts/plate-boundaries.html

When earthquakes occur, one plate moves past another and that movement releases energy which produces certain types of waves. These waves, called seismic waves, are produced and come out from the site called the focus. The focus, or hypocenter, of an earthquake is where the initial earthquake activity takes place. The focus can be near the Earth's surface or deeper in the Earth's crust. The epicenter is located on Earth's surface, directly above the focus. The earthquake, sometimes known as a seismic event, produces two types of waves. One type of wave travels around the outer layer of Earth and is called a surface wave. These waves break down slowly as they travel distances away from the epicenter, resulting in great amount of damage. The other wave is called a body wave and they travel through the interior of the Earth. Since the body waves are traveling within the Earth, these waves encounter materials that have different densities and composition and make the waves bend. The waves are further classified as primary waves (p-waves) and secondary waves (s-waves). P-waves are compressional (like a slinky), meaning they travel parallel to the rock and they travel faster than s-waves. P-waves push and pull rocks in the direction the wave is traveling. This causes the ground to compress and stretch, causing the ground under structures to buckle and fracture. The energy from s-waves travels perpendicular to the surface, like transverse waves. These waves cause the ground to move up and down and produces a great amount of shaking. S-waves can also move from side to side. This up and down, side to side movement is very destructive to existing buildings. While p-waves can travel through all types of materials, including air, s-waves can only travel through solids. Both types of waves are measured by instruments called seismographs. These instruments are important in locating the focus of an earthquake by measuring the difference in the arrival times of the p- and s-waves. The following is an example of what the seismography records:



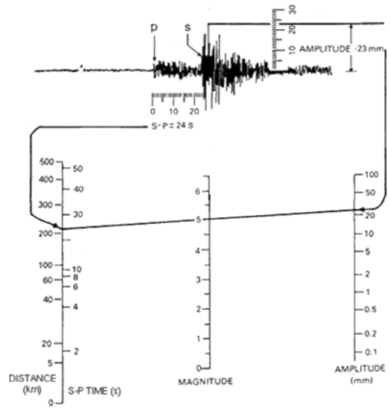
http://earthquakes.bgs.ac.uk/education/eq_guide/eq_booklet_how_we_measure.htm

Data from at least three stations must be collected to locate the epicenter of the earthquake. That means, in order to calculate the best guess location of the epicenter, allowing scientists to infer the focus location under the crust. The seismograph makes a record of the vibrations from the p- and s-waves. P-waves arrive at the seismograph first because they move faster than s-waves. Using the time difference between the arrival of the p- and s-waves, helps the seismologists locate the epicenter of the earthquake. Here is an example of how the collection data looks when seismologists are determining the location of the epicenter:



http://earthquakes.bgs.ac.uk/education/eq_guide/eq_booklet_locating_eqs.htm

Finally, earthquake size is measured by intensity and magnitude. The intensity is the measure of the amount of shaking at a given location based on the amount of damage. In order to standardize those measures, seismologists established a scale to define intensity levels. This is called the Modified Mercalli Intensity Scale. This scale measures the earthquake's effect on people, the environment and the earth's surface. However, the measure seemed subjective, so seismologists developed another, less subjective, measurement. The improved measurement is called the magnitude of the earthquake. Magnitude is the size of the Earthquake, measuring the shaking of the quake. Calculating the magnitude of an earthquake is based on data collected by the seismograph that measures the amount of energy released at the source of the quake. Magnitude is measured by the Richter scale and is based on the amplitude of the largest seismic wave recorded by the seismograph. The scale ranges from zero and has no upper limit. Each level of the Richter scale means the earthquake is ten times stronger than the previous level. Measuring the magnitude is done by using multiple data points. First, there are several scales that are needed to complete he final measure. For example, one scale is used to measure the amplitude (see figure below) and the seismologist uses the scale to plot the first point. The second scale measures the difference between the p- and s-wave time and plots the second point on that scale. A line is drawn from one point to the other and the line crosses the third scale, which is the magnitude scale. Where the line crosses the middle scale is calculated as the magnitude of the earthquake. Examine the illustration below to review how magnitude is calculated:



https://www.usgs.gov/media/images/eq-magnitude-energy-release-and-shaking-intensity-7

While comparing the two scales is not really reliable, this table can provide a better understanding of the two scales and the amount of shaking verse the damage done by different earthquakes.

Richter Scale	Mercalli Intensity	Shaking	Description/Damage
1.0 - 3.0	I	Not felt	Not felt except by a very few under especially favorable conditions.
3.0 - 3.9	II	Weak	Felt only by a few persons at rest,especially on upper floors of buildings.
	III	Weak	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
4.0 - 4.9	IV	Light	Felt indoors by many, outdoors by few. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
	V	Moderate	Felt by nearly everyone. Some windows broken. Unstable objects overturned.
5.0 - 5.9	VI	Strong	Felt by all. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
	VII	Very strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures.
6.0 - 6.9	VIII	Severe	Damage slight in specially designed structures; considerable damage in ordinary buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, monuments, walls.
	IX	Violent	Damage considerable in specially designed structures. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
7.0 and higher	X	Extreme	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
	XI	Extreme	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
	XII	Extreme	Total damage. Lines of sight and level are distorted. Objects thrown into the air.

https://www.kansascityfed.org/oklahomacity/oklahoma-economist/2016q1-economic-damage-large-earthquakes/

As a point of reference, there is a fault line along the South Carolina coast that has produced a number of earthquakes. The most recent was June 29, 2022. On that day, two earthquakes occurred, with magnitudes of 3.5 and 3.6. Using the table above, those would be considered weak earthquakes with some vibrations felt by some of the South Carolina citizens near Elgin, S.C. On June, 2024, two smaller earthquakes were recorded in north Georgia (1.7 and 2.5 magnitude). While none of these earthquakes posed significant danger in S.C. or Ga., this demonstrates that earthquakes happen closer to home than we think. The largest recorded earthquake in the United States was a magnitude 9.2 that struck Prince William Sound, Alaska on Good Friday, March 28, 1964, which is not surprising since Alaska is the most earthquake prone state in the U.S.

X.8 Understanding the Systems

It is important to note that there are many different constructive and destructive forces changing Earth's surface. Each of the spheres that comprise the Earth are responsible for different of these forces. For example, the hydrosphere causes different kinds of erosion, which in turn build up different formations. The hydrosphere also has a major role in the water cycle which results in other activities, including chemical weathering due to acid rain. The atmosphere produces weather that results in erosion, chemical and mechanical weathering. The lithosphere, earth's land, is changed by dramatic forces such as volcanoes and earthquakes. Finally, the biosphere, where plants and animal live, also impacts changes in the Earth's surface.

Summary

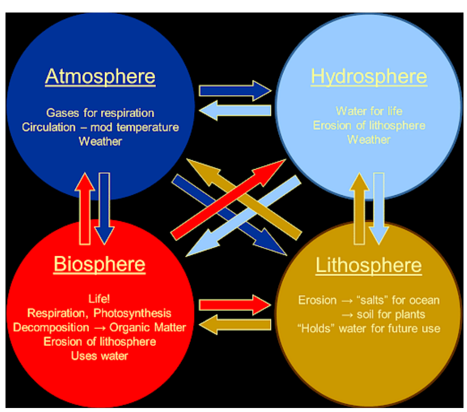
The Earth is composed of several spheres, and each play specific roles in constructive and destructive forces that help change the Earth's surface. Imagine being the first scientists to observe either volcanoes or earthquakes. They might have wondered what cause each of the actions, but also how they could find out more about these constructive and destructive forces. They probably had no idea about the tectonic plates, the Ring of Fire, or how the Earth's structure was responsible for either of these activities. As scientists learned more about these constructive and destructive forces, they continue to study the events and, with advances in technology, will continue to learn more about both.

Let's review the information from the chapter in the following table:

Summary of Constructive and Destructive Forces	
Constructive Force: a process that raises or builds up the surface features of the Earth of lithosphere	Destructive Force: a process that lowers or tears down the surface features of the Earth of lithosphere
Examples: 1. Deposition: deltas, sand dunes 2. Volcanoes: island formation 3. Tectonic Plates: mountains 4. Faults: mountains, valleys, cliffs	Examples: 1. Erosion: water, wind 2. Weathering: chemical or mechanical 3. Earthquakes: damage of ground 4. Tectonic Plates: mountains 5. Faults: mountains, valleys, cliffs

Review

Review this graphic organizer and explain how this shows the interdependence of the Earth's spheres:



Questions

1. What occurs in the troposphere and why is that important?

2. Describe the composition of the atmosphere.
3. Why is the mesosphere the most important layer in the atmosphere?
4. Make a table that identifies the types of constructive and destructive forces. Why are there overlaps?
5. Compare and contrast constructive and destructive forces.
6. Compare and contrast mount types.
7. What evidence of plate tectonics is supported by the Ring of Fire?
8. Why are earthquakes so destructive?
9. Explain the difference between epicenter and focus.
10. Why are volcanoes considered constructive and destructive?

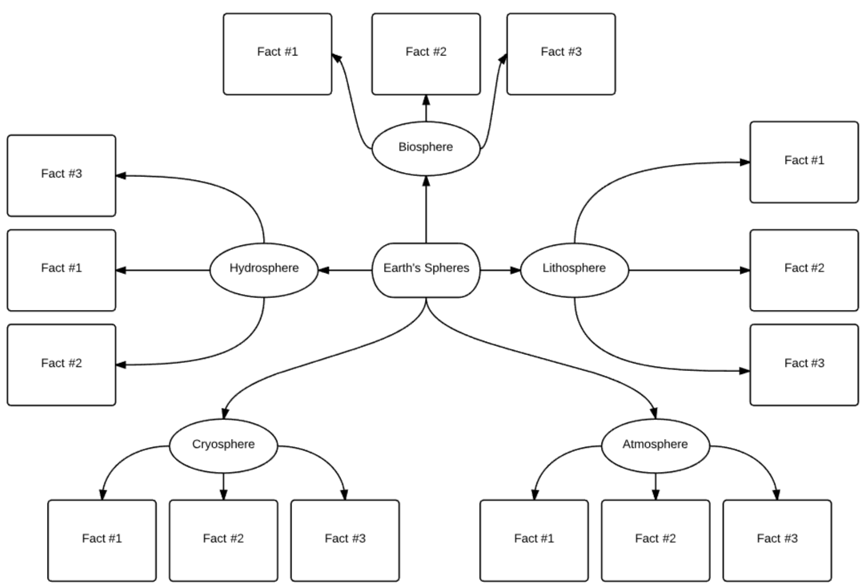
Labs

- Lab: How Much Freshwater is There?
- Lab: Weathering Lab
- Lab: Model of Dunes: Use this activity to make models of dunes: https://www.doi.gov/sites/doi.gov/files/usgs-dune-models.508.pdf
- Lab: Plotting the Evidence (graphing) lab

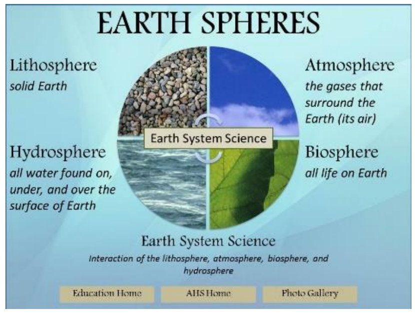
Activities:

1. WebQuest: Quake Quest
2. Use this site to view some neat earthquake videos: https://www.createwebquest.com/earthquake-exploration#google_vignette
3. Quick review about the spheres and their interdependence: https://www.youtube.com/watch?v=EH1kat51jJY&list=PLRgeXrZuuUfzCFOwLNfAsLOhksKp3xz4&index=3

4. Complete the graphic organizer:

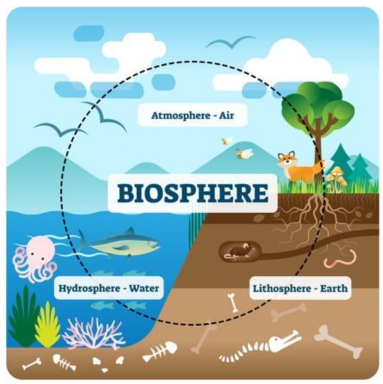


5. Using the following illustration, explain the four major spheres and how they work together to ensure life on Earth can survive. Use the link to help you review the content: Earth's Spheres- http://www.cotf.edu/ete/ESS/ESSspheres.html



https://fitz6.wordpress.com/2016/11/10/thursday-nov-10th-what-are-the-characteristics-of-the-earths-spheres/

6. Using the illustration write a short description explaining how interdependence is demonstrated below:



https://www.australianenvironmentaleducation.com.au/education-resources/what-is-the-biosphere/

Instructional Activities

Use the following activities to reinforce learning:

a. You Tube summary lesson: Put students in groups of four. Assign each a specific topic (e.g., seismic waves, measuring earthquake intensity and damage, causes of earthquakes, catastrophic events following earthquakes, etc.) . Have each person research the individual topic and find some engaging YouTube links and have the student do a flip book from the information learned. Be sure they include the YouTube clips.
b. Graphic organizer: Have the students use the graphic organizer template and complete it using information from the topics in the chapter (Earth's spheres or constructive or destructive forces)
c. Reflection activity: Develop a series of reflective prompts and use them as discussion points.
d. WebQuest activity: Use the earthquake WebQuest activity and develop others using that as a model. You can modify the model by having the students design a flip book on the different topics from the content reviewed using the WebQuest. Add a few challenging items to the WebQuest.

References

Chapter 9: Building and Shaping Earth’s Surfaces

https://education.nationalgeographic.org/resource/lithosphere/
https://soil.evs.buffalo.edu/index.php/Soil_Horizons
https://www.ffa.org/ag-101/ag-101-soil-horizons/
https://passel2.unl.edu/view/lesson/293965be23a0/3
https://en.wikipedia.org/wiki/Water
https://www.energy.gov/eere/water/how-hydropower-works
https://www.noaa.gov/jetstream/atmosphere/layers-of-atmosphere
https://web.physics.ucsb.edu/~lgrace/chem123/troposphere.htm
https://scied.ucar.edu/learning-zone/atmosphere/stratosphere
https://byjus.com/physics/atmosphere/
https://oceanservice.noaa.gov/facts/stormsurge-stormtide.html
https://education.nationalgeographic.org/resource/many-effects-flooding/
https://en.wikipedia.org/wiki/Deposition_(geology)
https://iasnext.com/depositional-landforms-by-wind-blows-physical-geography-upsc/
https://education.nationalgeographic.org/resource/loess/
https://www.usgs.gov/programs/VHP/about-volcanoes
https://volcano.oregonstate.edu/faq/how-do-volcanoes-affect-plants-and-animals
https://en.wikipedia.org/wiki/Weathering#Chemical_weathering
https://www.usgs.gov/programs/earthquake-hazards/earthquake-magnitude-energy-release-and-shaking-intensity