

Earth's Structure and Processes

8-3 The student will demonstrate an understanding of materials that determine the structure of Earth and the processes that have altered this structure. (Earth Science)

8-3.1 Summarize the three layers of Earth – crust, mantle, and core – on the basis of relative position, density, and composition.

Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/future knowledge: Students in 3rd grade (3-3.5, 3-3.6) focused on Earth's surface features, water, and land. In 5th grade (5-3.2), students illustrated Earth's ocean floor. The physical property of density was introduced in 7th grade (7-5.9). Students have not been introduced to areas of Earth below the surface. Further study into Earth's internal structure based on internal heat and gravitational energy is part of the content of high school Earth Science (ES-3.2).

It is essential for students to know that Earth has layers that have specific conditions and composition.

Layer	Relative Position	Density	Composition
<i>Crust</i>	Outermost layer; thinnest under the ocean, thickest under continents; crust & top of mantle called the <i>lithosphere</i>	Least dense layer overall; Oceanic crust (basalt) is more dense than continental crust (granite)	Solid rock – mostly silicon and oxygen Oceanic crust - basalt; Continental crust - granite
<i>Mantle</i>	Middle layer, thickest layer; top portion called the <i>asthenosphere</i>	Density increases with depth because of increasing pressure	Hot softened rock; contains iron and magnesium
<i>Core</i>	Inner layer; consists of two parts – outer core and inner core	Heaviest material; most dense layer	Mostly iron and nickel; outer core – slow flowing liquid, inner core - solid

It is not essential for students to know specific depths or temperatures of the layers. Students do not need to explain the heat transfer systems within the layers.

Assessment Guidelines:

The objective of this indicator is to *summarize* major points about the layers of Earth; therefore, the primary focus of assessment should be to generalize major points about the crust, mantle, and core of Earth. However, appropriate assessments should also require students to *compare* the layers; *classify* by sequencing the layers using property information; or *identify* the layer with a certain set of properties.

Earth's Structure and Processes

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8-3.2 Explain how scientists use seismic waves – primary, secondary, and surface waves – and Earth's magnetic fields to determine the internal structure of Earth.

Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/future knowledge: Seismic waves and Earth's magnetic fields are new material for this grade. Earth's internal structure (8-3.1) was also new content. The understanding of waves is also part of the 8th grade indicator 8-6.1-3 and can enhance the understanding of seismic waves in this context.

It is essential for students to know that earthquakes produce three types of waves with different behaviors as they travel through materials.

Primary (P) waves

- Move out from the earthquake focus, the point where the energy is released
- Travel the fastest of the three waves
- Move through solid and liquid layers of Earth
- Push and pull rock creating a back-and-forth motion in the direction the wave is moving (*longitudinal wave*)

Secondary (S) waves

- Move out from the earthquake focus
- Move slower than primary waves
- Can only move through solid rock
- Move at right angles to primary waves causing rocks to move up and down and side to side (*transverse wave*)

Surface waves

- Form when P and S waves reach the surface
- Can cause the ground to shake making rock sway from side to side and roll like an ocean wave

Scientists use the principle that the speed and direction of a seismic wave depends on the material it travels through. Because of the behavior of these different waves, scientists have indirect evidence for the solid inner core and liquid outer core of Earth; because earthquake waves travel faster through the mantle than through the crust, scientists know that the mantle is denser than the crust.

It is also essential for students to know that the movement of materials in the outer core of Earth is inferred to be the cause of Earth's magnetic field. A compass needle will align with the lines of force of Earth's magnetic field. Iron and nickel are metals that easily magnetize, and are inferred to be the metals in Earth's core.

It is not essential for students to know how to measure an earthquake with the Richter or Mercalli scale. The study of Earth's magnetosphere is also not necessary here.

Earth's Structure and Processes

8-3 The student will demonstrate an understanding of materials that determine the structure of Earth and the processes that have altered this structure. (Earth Science)

Assessment Guidelines:

The objective of this indicator is to *explain* how scientists use data from seismic waves and Earth's magnetic field; therefore, the primary focus of assessment should be to construct a cause-and-effect model of what data from these sources allow scientists to determine about Earth's internal structure. However, appropriate assessments should also require students to *summarize* how seismic waves and magnetic field data can be used to infer what the inside of Earth looks like; *interpret* a diagram of seismic wave properties; *compare* the waves as to movement or effect on Earth material; *identify* a layer of Earth's interior based on evidence presented; or *recall* how a compass will behave within the Earth's magnetic field.

Earth's Structure and Processes

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8-3.3 Infer an earthquake's epicenter from seismographic data.

Taxonomy level: 2.5-B Understand Conceptual Knowledge

Previous/future knowledge: In the 3rd grade (3-3.8), students were introduced to earthquakes as a rapid process that changes Earth's surface. In 5th grade (5-3.1), earthquakes are explained as a natural process that can have effects on both Earth's land and oceans. The measuring of earthquake waves involving the interpretation of seismic data is a new concept for this grade. Understanding of the properties of waves as part of 8-6.3 will help students to read and interpret seismographic data.

It is essential for students to know the *epicenter* is the point on Earth's surface directly above where the energy is released in an earthquake; energy that reaches the surface is greatest at this point.

- The energy spreads outward in all directions as vibrations called *seismic waves*. Seismic waves can be measured and recorded by a *seismograph*.
- The vibration record, called a *seismogram*, looks like jagged lines on paper.
- Measuring the time between the arrival of the P and S waves determines the distance between the recording seismograph and the earthquake epicenter.
- *Triangulation* identifies the epicenter of an earthquake. The location of an earthquake's epicenter is found by plotting circles on a map from the records of three seismograph stations and finding the point where the three circles intersect.

It is not essential for students to determine the magnitude of an earthquake based on seismographic data.

Assessment Guidelines:

The objective of this indicator is to *infer* an earthquake's epicenter; therefore, the primary focus of assessment should be to draw a logical conclusion as to an earthquake's epicenter given data from seismographs. However, appropriate assessments should also require students to *recognize* that a seismogram is used to determine the distance from the earthquake epicenter to the seismograph; or *interpret* a diagram with seismographic data plotted; or *recognize* how seismic waves move from the focus of the earthquake.

Earth's Structure and Processes

8-3 The student will demonstrate an understanding of materials that determine the structure of Earth and the processes that have altered this structure. (Earth Science)

8-3.4 Explain how igneous, metamorphic, and sedimentary rocks are interrelated in the rock cycle.

Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/future knowledge: Rocks were introduced in 1st grade (1-4.1, 2) as materials from Earth that can be classified by their physical appearance. In 3rd grade (3-3.1), students classified rocks as sedimentary, igneous, and metamorphic based on their properties. No additional study of rocks has been done since 3rd grade. The concept of a rock cycle is new to this grade. The classification of minerals and rocks based on physical and chemical properties is part of high school Earth Science (ES-3.7)

It is essential for students to know that there are three large classifications of rocks – igneous, metamorphic, and sedimentary. Each type of rock is formed differently and can change from one type to another over time.

Igneous

- Forms when molten rock (magma) cools and hardens.
- If cooling takes place slowly beneath Earth's surface, the igneous rock is called *intrusive*.
- If the cooling takes place rapidly on Earth's surface, the igneous rock is called *extrusive*.

Metamorphic

- Forms when rocks are changed into different kinds of rocks by great heat and/or pressure – they are heated, squeezed, folded, or chemically changed by contact with hot fluids.

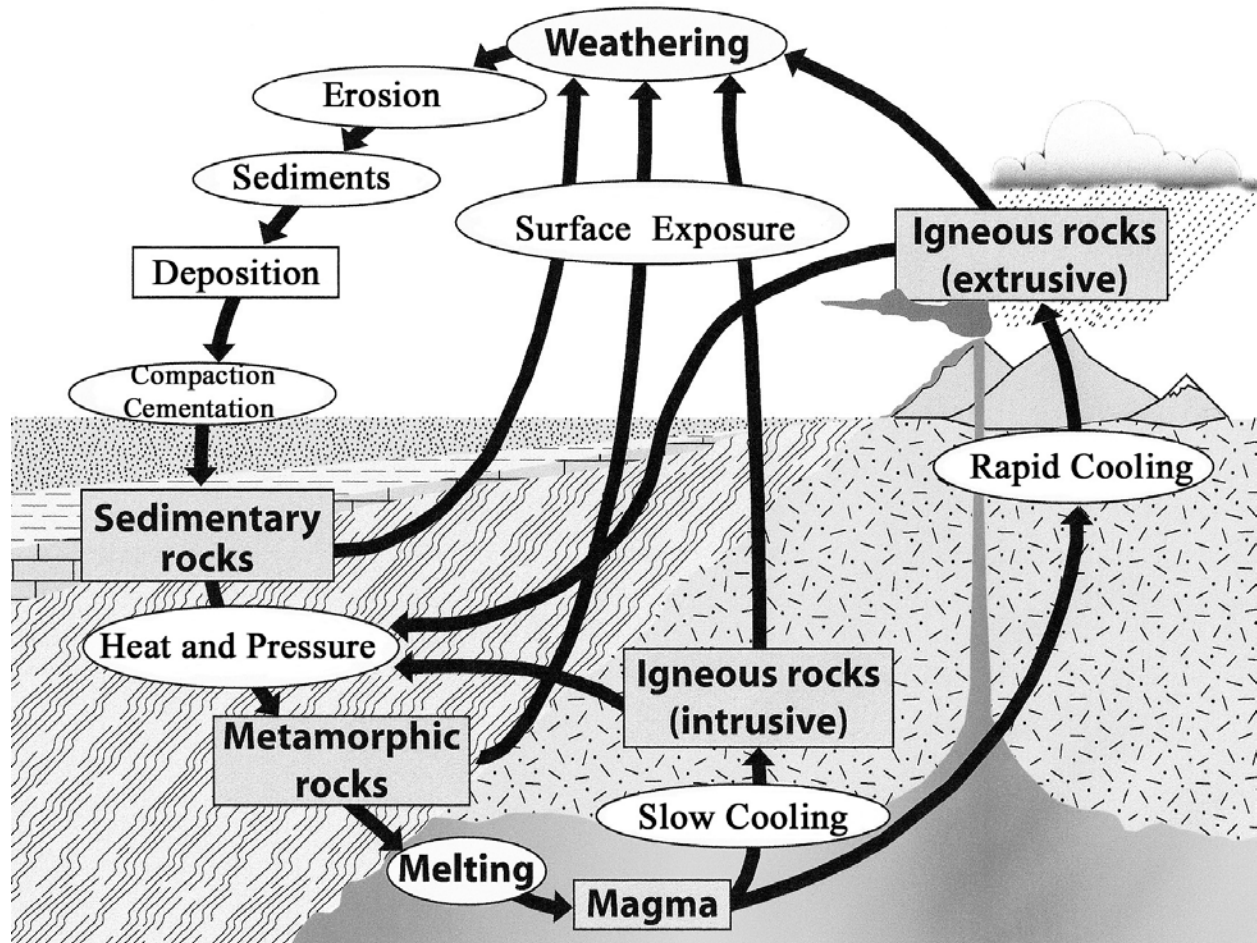
Sedimentary

- Forms from the compaction and/or cementation of rock pieces, mineral grains, or shell fragments called *sediments*.
- Sediments are formed through the processes of weathering and erosion of rocks exposed at Earth's surface.
- Sedimentary rocks can also form from the chemical depositing of materials that were once dissolved in water.

Earth's Structure and Processes

8-3 The student will demonstrate an understanding of materials that determine the structure of Earth and the processes that have altered this structure. (Earth Science)

The rock cycle is an ongoing process. The sample diagram illustrates the series of natural processes that can change rocks from one kind to another:



It is not essential for students to classify individual rocks, chemical composition, or the minerals from which they are made, based on their properties.

Assessment Guidelines:

The objective of this indicator is to *explain* the interrelationships of the three rock types; therefore, the primary focus of assessment should be to construct a cause-and-effect model about the forming of a rock based on the process(es) involved. However, appropriate assessments should also require students to *interpret* a rock cycle diagram; *compare* how rocks can be changed by particular processes; or *identify* a rock type by the method with which it is formed.

Earth's Structure and Processes

8-3 The student will demonstrate an understanding of materials that determine the structure of Earth and the processes that have altered this structure. (Earth Science)

8-3.5 Summarize the importance of minerals, ores, and fossil fuels as Earth resources on the basis of their physical and chemical properties.

Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/future knowledge: In 3rd grade (3-3.2), students identified common minerals based on their properties; they also gave examples of how Earth materials were used (3-3.7). In 7th grade (7-4.6), Earth resources were classified as renewable or nonrenewable. Understanding the importance of minerals, ores, and fossil fuels based on their properties is new to this grade; ores have never been introduced.

It is essential for students to know that Earth resources (minerals, ores, and fossil fuels) have properties that make them important and useful. Properties that determine the usefulness of an ore or mineral may be identified using a chart, diagram or dichotomous key. The two types of properties are:

- *Physical properties*; for example, hardness, luster, color, texture, the way a mineral splits, or density
- *Chemical properties*; for example, the ability to burn, the reactivity to acids

Three common Earth resources that have importance based on their properties are:

Minerals

- Natural, solid materials found on Earth that are the building blocks of rock; each has a certain chemical makeup and set of properties that determine their use and value.

Ores

- Minerals that are mined because they contain useful metals or nonmetals.

Fossil fuels

- Natural fuels that come from the remains of living things; fuels give off energy when they are burned.

It is not essential for students to classify individual minerals for the purpose of identification, but understanding the meaning of the physical properties by examining some common minerals would be helpful.

Assessment Guidelines:

The objective of this indicator is to *summarize* the importance of certain Earth resources; therefore, the primary focus of assessment should be to generalize major points about the importance of minerals, ores, and fossil fuels because of their physical and chemical properties. However, appropriate assessments should also require students to *interpret* a chart of important/useful Earth resources; *exemplify* Earth resources that are minerals, ores, or fossil fuels; or *identify* properties that would make an Earth resource important.

Earth's Structure and Processes

8-3 The student will demonstrate an understanding of materials that determine the structure of Earth and the processes that have altered this structure. (Earth Science)

8-3.6 Explain how the theory of plate tectonics accounts for the motion of the lithospheric plates, the geologic activities at the plate boundaries, and the changes in landform areas over geologic time.

Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/future knowledge: The theory of plate tectonics is new material for this grade.

It is essential for students to know that the theory of plate tectonics explains why and how large sections of Earth's crust, called *lithospheric plates*, move. A hypothesis of continental drift was developed before the present theory of plate tectonics. It was based on continent shape, fossil evidence, rock, and climate clues. This hypothesis later led to the theory of plate tectonics when evidence was found as to why the plates could move. Plate tectonics explains how many Earth features form.

Motion of the Lithospheric Plates

- Plates float on the upper part of the mantle.
- Convection currents can cause the asthenosphere to flow slowly carrying with it the plates of the lithosphere.
- This movement of plates changes the sizes, shapes, and positions of Earth's continents and oceans.

Geologic Activities at Plate Boundaries

Divergent boundary—where two plates are moving apart

- most located along mid-ocean ridge (sea-floor spreading);
- new crust forms because magma pushes up and hardens between separating plates.

Convergent boundary—where two plates come together and collide

- activity depends upon the types of crust that meet;
- more dense oceanic plate slides under less dense continental plate or another oceanic plate – *subduction zone*, some crust is destroyed;
- two continental plates converge, both plates buckle and push up into mountain ranges;

Transform boundary—where two plates slide past each other

- crust is neither created nor destroyed;
- earthquakes occur frequently along this type of boundary.

Changes in Landform areas over Geologic Time

- Plates move at very slow rates – from about one to ten centimeters per year;
- At one time in geologic history the continents were joined together in one large landmass that was called Pangaea.
- As the plates continued to move and split apart, oceans were formed, landmasses collided and split apart until the Earth's landmasses came to be in the positions they are now;

Earth's Structure and Processes

8-3 The student will demonstrate an understanding of materials that determine the structure of Earth and the processes that have altered this structure. (Earth Science)

- Evidence of these landmass collisions and splits comes from fossils, landform shape, features, and rock structures, and climate change;
- Landmass changes can occur at hot spots within lithospheric plates;
- Earth's landmasses will continue to move and change during the geologic time of the future.

It is not essential for students to know name specific plates, but interpreting a world map of plates with direction of motion would be helpful.

Assessment Guidelines:

The objective of this indicator is to *explain* how the theory of plate tectonics accounts for changes in the landforms of Earth; therefore, the primary focus of assessment should be to construct a cause-and-effect model of why the plates move, what type of motion takes place as plates collide, and what changes result in the landforms of Earth. However, appropriate assessments should also require students to *interpret* diagrams that show varying aspects of these factors; *compare* the activities at plate boundaries or the shape/movement of landmasses over time; or *classify* a plate boundary based on the motion of plates and/or landforms that result.

Earth's Structure and Processes

8-3 The student will demonstrate an understanding of materials that determine the structure of Earth and the processes that have altered this structure. (Earth Science)

**8-3.7 Illustrate the creation and changing of landforms that have occurred through geologic processes (including volcanic eruptions and mountain-building forces).
Taxonomy level: 2.2-B Understand Conceptual Knowledge**

Previous/future knowledge: Volcanic eruptions as a natural process were introduced in 3rd grade (3-3.8). In 5th grade (5-3.1), volcanic eruptions were explained as to how they affect Earth's oceans and land. Mountain-building forces are new to this grade as is the concept of how these processes create and change landforms. Additional crustal changes due to forces from plate tectonic activity are part of high school Earth Science (ES-3.4).

It is essential for students to know that the landforms of Earth can be created or changed by volcanic eruptions and mountain-building forces.

Volcanic Eruptions

- Volcanic eruptions are constructive in that they add new rock to existing land and form new islands. Volcanic eruptions can be destructive when an eruption is explosive and changes the landscape of and around the volcano.
- *Magma* from the mantle rises to Earth's surface and flows out an opening called a *vent*.
- Magma that reaches Earth's surface is known as *lava*.
- The vent as well as the mountain that forms around it from cooled lava, ash, cinders, and rock is called a *volcano*.
- Most volcanoes occur along plate boundaries; an area in the Pacific Ocean where volcanoes are common is called the Ring of Fire.

Mountain-building forces

- Forces, or stresses, that cause rocks to break or move are:
 - *Tension*—forces that pull rocks apart
 - *Compression*—forces that push or squeeze rocks together
 - *Shearing*—forces that cause rocks on either side of faults to push in opposite directions
- Forces or stresses (for example, *tension* and *compression*) on rocks in the lithosphere can cause them to bend and stretch.
 - This bending and stretching can produce mountain ranges.
 - If pressure is applied slowly, *folded mountains* form.
- Forces or stresses (for example, *tension*, *compression*, or *shearing*) great enough to cause rocks to break can create *faults*. Faults are places in Earth where the rocks break. There are three types of faults:
 - *Normal fault* – caused by tension forces
 - *Reverse fault* – caused by compression forces
 - *Strike-slip fault* – caused by shearing forces
- If normal faults uplift a block of rock, a *fault-block mountain* forms.

Earth's Structure and Processes

8-3 The student will demonstrate an understanding of materials that determine the structure of Earth and the processes that have altered this structure. (Earth Science)

It is not essential for students to know the various types of volcano cones and how they form or the landforms that result when magma fails to reach the surface. The formation of anticlines, synclines, and plateaus are not essential at this time.

Assessment Guidelines:

The objective of this indicator is to *illustrate* the creation and changing of landforms due to volcanic eruptions and mountain-building forces; therefore, the primary focus of assessment should be to give illustrations of these concepts or use illustrations to show understanding of landforms resulting from volcanic eruptions and mountain-building forces through diagrams, pictures, and word descriptions. However, appropriate assessments should also require student to *interpret* diagrams that show varying aspects of these concepts; *compare* the various stresses and the resulting landforms; or *recognize* the basic components of a volcano's structure that contribute to the creation or changes of the landscape.

Earth's Structure and Processes

8-3 The student will demonstrate an understanding of materials that determine the structure of Earth and the processes that have altered this structure. (Earth Science)

8-3.8 Explain how earthquakes result from forces inside Earth.

Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/future knowledge: Students were introduced to earthquakes in 3rd grade (3-3.8). Further study on the effects of earthquakes continued in 5th grade (5-3.1). The explanation of earthquakes as related to internal forces within Earth is new to this grade.

It is essential for students to know that the forces and stresses (8-3.7– tension, compression, and shearing) along faults can build up as blocks of rock are pushed (compression or shearing) or pulled apart (tension). If the pressure or stress becomes too great, the rock breaks at a weak point along the fault and energy is released.

- The energy spreads outward in all directions as vibrations called seismic waves.
- The focus of the earthquake is the point in the crust, or mantle, where energy is released.
- The epicenter is the point on Earth's surface directly above the focus; energy that reaches the surface is greatest at this point.

It is not essential for students to explain the magnitude or intensity of an earthquake; factors that affect the amount of damage done by an earthquake are also not necessary at this time.

Assessment Guidelines:

The objective of this indicator is to *explain* how earthquakes result from forces inside Earth; therefore, the primary focus of assessment should be to construct a cause-and-effect model that shows how internal forces along a fault can cause an earthquake. However, appropriate assessments should also require students to *compare* the focus or epicenter of an earthquake in terms of location and energy.

Earth's Structure and Processes

8-3 The student will demonstrate an understanding of materials that determine the structure of Earth and the processes that have altered this structure. (Earth Science)

8-3.9 Identify and illustrate geologic features of South Carolina and other regions of the world through the use of imagery (including aerial photography and satellite imagery) and topographic maps.

Taxonomy levels: 1.2-A Remember Factual Knowledge;
2.2-B Understand Conceptual Knowledge

Previous/future knowledge: This indicator contains new conceptual material.

It is essential for students to know that geologic features on Earth can be identified and visually modeled through the use of aerial photography, satellite imagery, and topographic maps.

Imagery

- Highflying aircraft and satellites high above Earth use sensors and cameras to gather information about Earth's landforms and resources.
- Computers create images from the data; scientists identify specific features by the combination of colors and shapes that the feature makes on the satellite image.

Geologic features (for example, mountains, river and tributary flow, lakes, farmland, forests, Carolina bays, or coastal features) can be identified using South Carolina satellite images and aerial photographs, as well as other imagery from regions of the world.

Topographic maps

- These are maps that use symbols to portray the land as if viewed from above.
- They provide information on elevation, relief, and slope of the ground surface, as well as the location of roads, buildings, swamps, and other features, natural and man-made.
- Along with the scale and symbols, the contour lines and the contour interval are critical to understanding the topographic map.

Geologic features can be identified on a topographic map using the contour lines and interval spacing as well as the symbols on the map. Geologic features can also be illustrated the geologic feature with a three-dimensional model or profile based on the topographic data.

It is not essential for students to know how satellite imagery and aerial photographs use the electromagnetic spectrum to capture the information.

Assessment Guidelines:

One objective of this indicator is to *identify* features on Earth using aerial photography, satellite images, and topographic maps; therefore, the primary focus of assessment should be to locate this information on the appropriate materials. Another objective of this indicator is to *illustrate* geologic features found on aerial photography, satellite images, and topographic maps; therefore, the primary focus of assessment should also be to give illustrations of these concepts or use illustrations to show understanding of these materials. However, appropriate assessments should also require students to *recall* the shape or illustrated property of the geologic feature; *identify* symbols and colors used on these images or maps; or *compare* features, details, or contours on one topographic map with another in a different landform region.