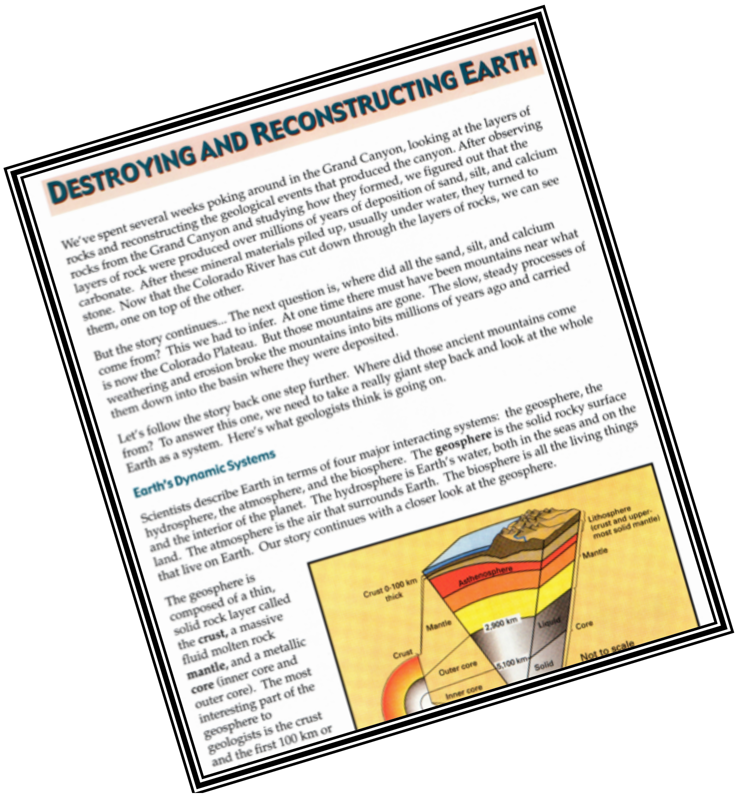
BOSTON Public Schools
Focus on Children

Office of Curriculum & Instruction

Department of Science

Close Reading and Text Dependent Questions in Science
Destroying and Reconstructing Earth (Earth History – Grade 7)

The text selection, *Destroying and Reconstructing Earth,* is found in F*OSS Student Resource book*, *Earth History,* pgs. 100-105.



DESTROYING AND RECONSTRUCTING EARTH

We've spent several weeks poking around in the Grand Canyon, looking at the layers of rocks and reconstructing the geological events that produced the canyon. After observing rocks from the Grand Canyon and studying how they formed, we figured out that the layers of rock were produced over millions of years of deposition of sand, silt, and calcium carbonate. After these mineral materials piled up, usually under water, they turned to stone. Now that the Colorado River has cut down through the layers of rocks, we can see them, one on top of the other.

But the story continues... The next question is, where did all the sand, silt, and calcium come from? This we had to infer. At one time there must have been mountains near what is now the Colorado Plateau. But those mountains are gone. The slow, steady processes of weathering and erosion broke the mountains into bits millions of years ago and carried them down into the basin where they were deposited.

Let's follow the story back one step further. Where did those ancient mountains come from? To answer this one, we need to take a really giant step back and look at the whole Earth as a system. Here's what geologists think is going on.

Earth's Dynamic Systems

Scientists describe Earth in terms of four major interacting systems: the geosphere, the hydrosphere, the atmosphere, and the biosphere. The **geosphere** is the solid rocky surface and the interior of the planet. The hydrosphere is Earth's water, both in the seas and on the land. The atmosphere is the air that surrounds Earth. The biosphere is all the living things that live on Earth. Our story continues with a closer look at the geosphere.

The geosphere is composed of a thin, solid rock layer called the **crust,** a massive fluid molten rock **mantle,** and a metallic **core** (inner core and outer core). The most interesting part of the geosphere to geologists is the crust and the first 100 km or

Look in the Student Learning Outcome Document for guidance on when this should be taught.
http://bpscurriculumandinstruction.weebly.com/student-learning-outcomes-by-grade.html

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Destroying and Reconstructing Earth

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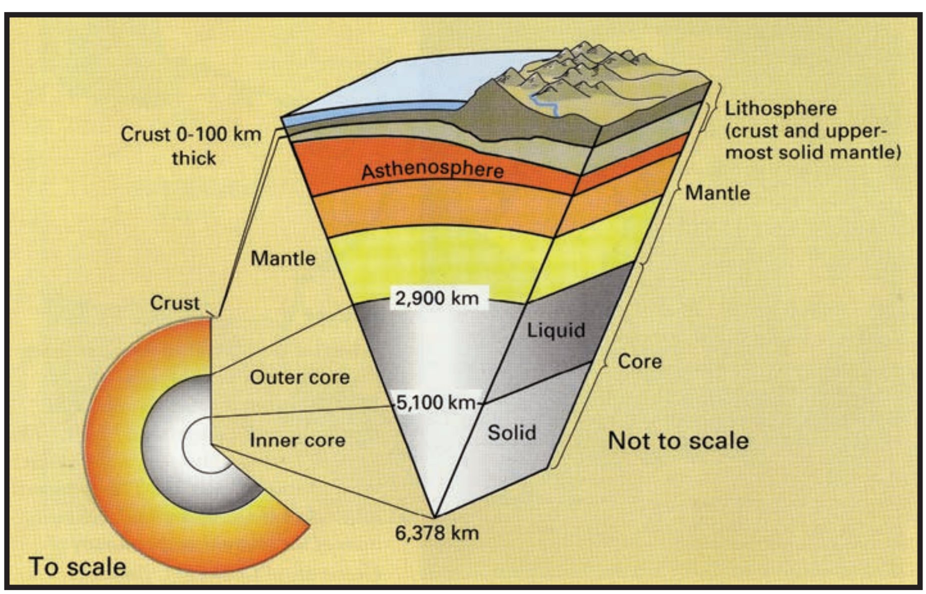
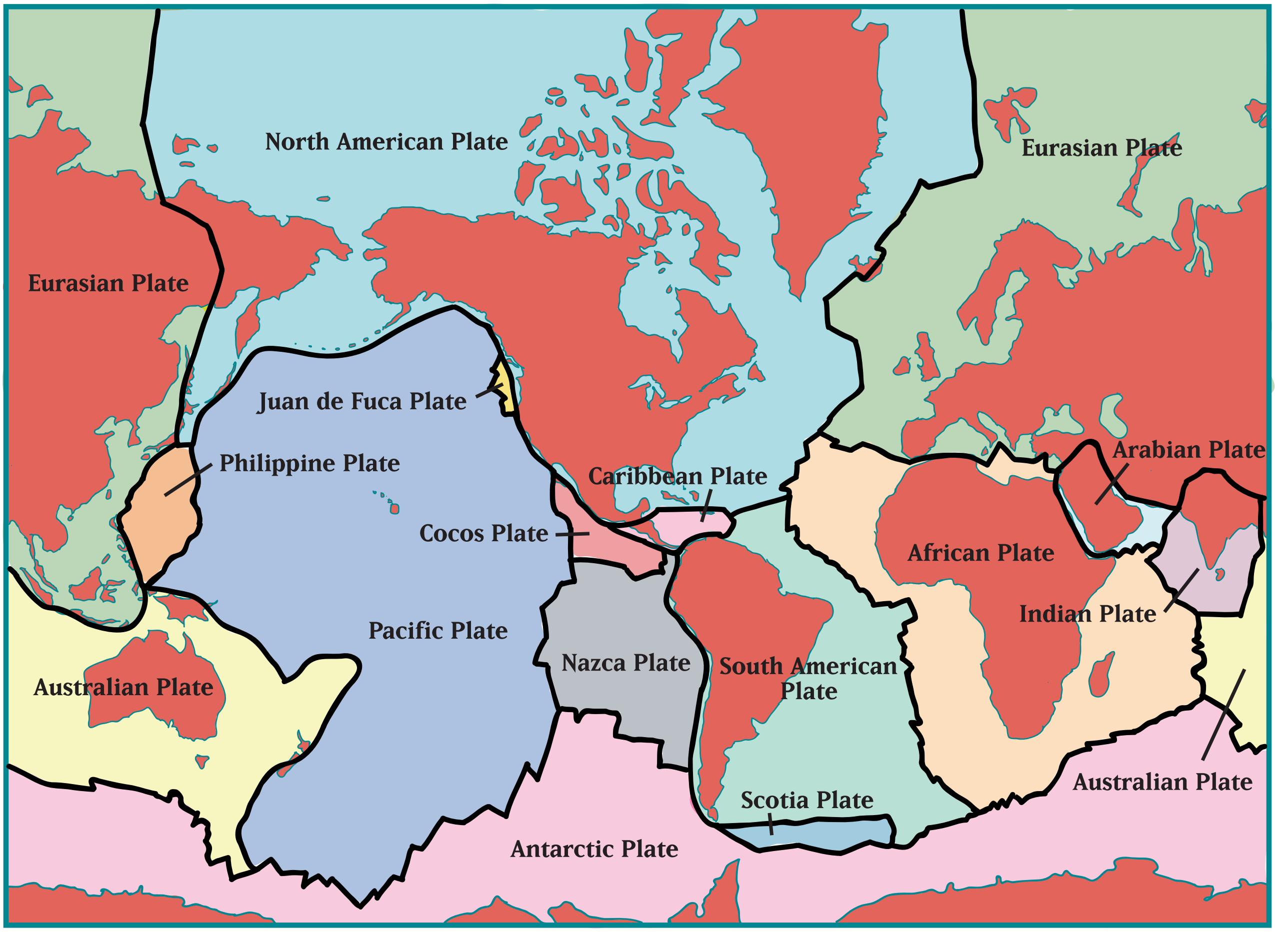


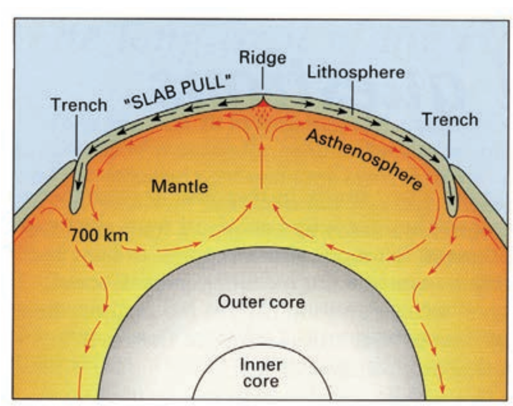
The thin oceanic crust (5 km), the thick continental crust (100 km), and uppermost part of the mantle make up the lithosphere.

The lithosphere (the part that we stand on and that covers the bottom of all the seas) seems like it should be one big, continuous covering on Earth, like the shell on an egg. But it is not. The lithosphere is broken into big slabs, like a hard-boiled egg with a broken shell. That's our picture of Earth today—a planet of molten rock covered with a bunch of solid plates of rock that fit together like puzzle pieces.



Earth's surface is broken into seven major and several more minor lithographic plates that move around slowly on Earth's face.

The lithospheric plates differ from the pieces of shell on a cracked egg in one important way. The lithospheric plates move around on Earth; the pieces of eggshell stay put. One of the larger plates is the North American Plate. All of Canada, most of the United States (except Hawaii, part of Alaska, and a slice of southern California), and most of Mexico wander across the surface of Earth together. Other large plates include the Pacific Plate, which underlies most of the Pacific Ocean, African Plate, Eurasian Plate, Indo-Australian Plate, and South American Plate.



Convection currents, created by hot, rising magma, push plates around.

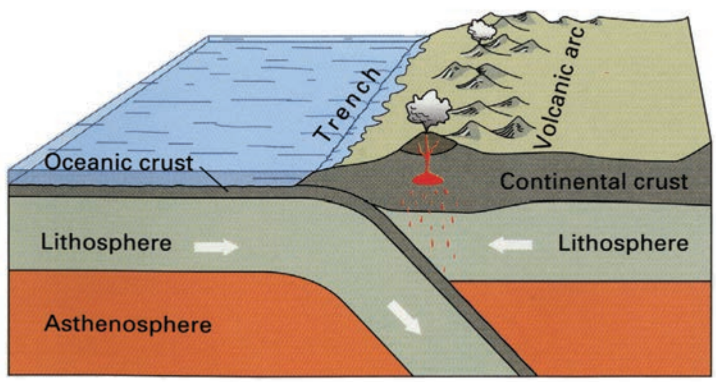
So what makes the plates move around? Geologists think that magma close to the core heats and rises toward the surface. Cooler magma descends to take the place of the heated magma.

This circular movement in the magma, called **convection,** is what pushes the plates around. Scientists call these forces that affect the crust of Earth tectonic forces. Tectonic forces drive some plates away from each other, some plates toward each other, and some plates past each other. The San Andreas Fault on the west coast of the United States marks where the North American Plate and the Pacific Plate are scraping past one another.

The plates don't move very fast by most standards—maybe 1 cm per year. But, as you know, geologists rarely think in time units less than a million years, so in a million years a continent can move 10 km, and in 100 million years 1000 km. Now that's getting somewhere!

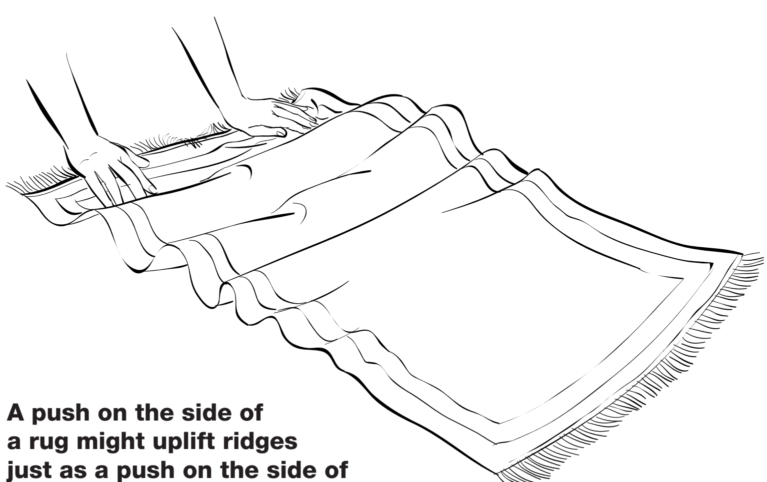
Constructive and Destructive Processes

Now back to the Grand Canyon and those mountains that weathered into the sediments that became the Colorado Plateau. When two plates are driven toward one another and they crash, something has to give. Sometimes one plate slides under another. The part of the plate driven down into the magma melts. This melted material might push up through the crust and onto the surface. When that happens we see a volcano or a lava flow. Places with lots of volcanoes, like the west coast of Mexico and South America, and Washington, Oregon, and California, usually indicate that two plates are colliding. The Cascade Range from Canada to the middle of California is all created by volcanic activity.



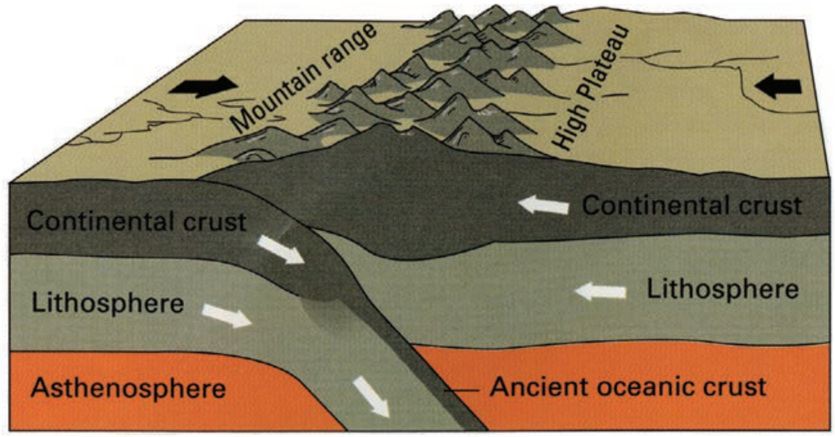
An oceanic plate sliding under a continental plate melts rock that might come up in the form of volcanoes.

Sometimes when two plates collide, the plates get rumpled and folded. The same thing happens when you push on one end of a small rug. The rug has to go someplace, so it forms a bunch of hills and valleys. The same thing can happen when plates collide. We see this happening in Asia today where India is colliding with the Eurasian Plate, rumpling up the landscape to create the Himalayan mountains, which rise higher each year.



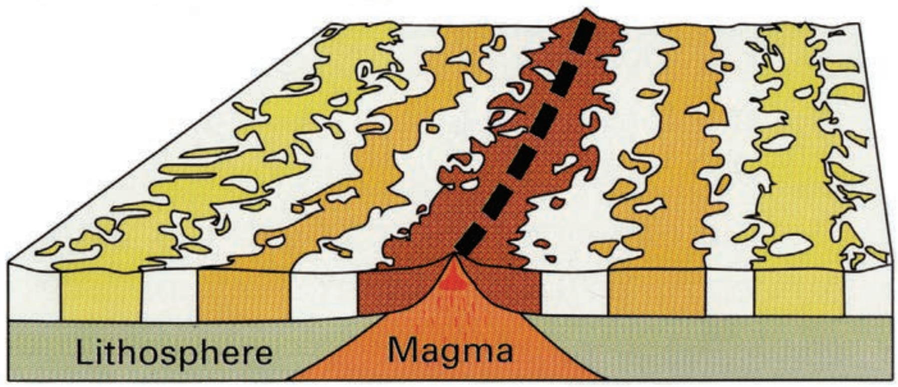
A push on the side of a rug might uplift ridges just as a push on the side of a continent might uplift mountains.

It's possible that millions of years ago something like this happened near what is now the Grand Canyon. A mountain range resulted from a tectonic collision. After that the forces of wind and water broke the mountains down to dust and carried them into the basin to form the sedimentary rocks of the Grand Canyon.



When two continental plates collide, the result might be the uplift of a mountain range.

Earth is constantly recreating its surface and reconstructing its landforms as a result of several processes. The **constructive processes** are mountain building (a result of plate collisions—uplifting and volcanism); new crust formation (where two plates are pulling apart); and sedimentation (resulting from deposition). The **destructive processes** are weathering by gravity, wind, and water (which break rocks apart); erosion (which carries rock away); and tectonic activities (plates sliding under other plates to be consumed by the magma).



New crust is added where magma flows up between two diverging plates.

The Kaibab Mystery


Fossils in the Kaibab Limestone *Marco Molinaro photo*

Now that we have stepped back and taken in the big picture of the constructive and destructive Earth-shaping processes, let's come back down to Earth. Here we are, standing on the Grand Canyon's Kaibab Formation. Right under our feet are fossils—sponges, brachiopods, and crinoids. These fossils are the unmistakable remains of animals that once lived in a tropical sea. How could that be? This Kaibab Formation is more than 8100 feet above sea level!

Two possibilities spring to mind. Either the sea was once 9000 feet deeper than it is today, so that the area where we are standing was under water. Or perhaps millions of years ago the sediments we are standing on were deposited 8100 feet lower in elevation, down below sea level. Let's reason through these two possibilities.

The idea that the seas may have been 9000 feet deeper a few hundred million years ago is too far out of bounds for serious consideration. There is no evidence anywhere else on Earth suggesting that there was ever an incredibly vast additional quantity of water. That leaves the idea that the Kaibab Formation was deposited at or below sea level before being lifted to such a height. Let's see how this idea plays out.

Geologists studied index fossils and other evidence to figure out that the Kaibab Formation was deposited near the end of the Paleozoic era, around 245 million years ago (mya). Furthermore, geologists have found clues that suggest that around the end of the Mesozoic era, about 70 mya, a major geological event caused faulting, folding, and uplifting. What kind of global event might produce these kinds of massive changes in the landforms? Maybe a collision between plates or possibly some extreme magma activity under the North American Plate. The Rocky Mountains started rising at this time, and the area that would become the Colorado Plateau began its "elevator ride" upward.

A **fault** is a place where Earth's crust is broken and the rocks on the two sides of the fault move past one another. The Bright Angel Trail goes down a canyon formed by erosion along the Bright Angel Fault. Geologists know that faults result when extreme force is applied to the crust. When rocks actually break under the strain and slip and slide past one another along a fault, the result is often an earthquake. Today people at Grand Canyon Village on the South Rim occasionally feel small earthquakes that are caused by movements along either the Bright Angel Fault or other faults in the area.

Bright Angel Fault *Marco Molinaro photo*

Folds are another structural feature of the Colorado Plateau that suggest movement of Earth's crust. The Colorado Plateau is well known for its **monoclines**—large sections of rock layers that slope down on one side. At the Grand Canyon, the East Kaibab monocline marks the eastern boundary of the Kaibab Plateau. The existence of this monocline and others suggests a time when portions of the land were compressed and folded during the elevation of the plateau.

The rocks on this monocline are deformed so they slope down to the right side of this picture.

Piecing together the history of the Colorado Plateau is a tough job. Part of the story is still a mystery. Geologists are sure the Kaibab Formation was deposited about 9000 feet lower in elevation than where it stands today. And the faulting and folding throughout the plateau suggest massive uplifting forces. But what primary event or events provided the driving force to lift the Colorado Plateau? It was one of the constructive processes, but just how it happened is still one of those lingering mysteries of the Grand Canyon. That's part of the fun of geology—there's always another mystery to solve.

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Student Questions

1. What distinguishes the geosphere from the other three major systems described on page 100?

2. In the text, the lithosphere is described as a region of the geosphere. What is the lithosphere made up of?

3. Using the text and the diagram on page 100, list the layers from innermost layer to the outermost layer of the geosphere. Identify whether the layers are liquid or solid.

4. How does the example of the hard-boiled egg accurately model the Earth's lithosphere as described on page 101, and what are the limitations of the model?

5. After reading pages 101-102, describe the purpose of the red arrows in the diagram on the bottom of page 101. Identify and describe the concept the author was trying to clarify.

6. The author described the lithosphere as, "the most interesting part of the geosphere." Give three examples from the text section, "Constructive and Destructive Processes," that support the author's claim.

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Sample Answers

1. **What distinguishes the geosphere from the other three major systems described on page 100?**
The geosphere is the solid rocky surface and the interior of the planet. The hydrosphere is Earth's water, the atmosphere is the air that surrounds the Earth, and the biosphere is all the living things on Earth.

2. **In the text, the lithosphere is described as a region of the geosphere. What is the lithosphere made up of?**
The lithosphere is made up of the crust and uppermost mantle.

3. **Using the text and the diagram on page 100, list the layers from innermost layer to the outermost layer of the geosphere. Identify whether the layers are liquid or solid.**
The first layer is the inner core, it is a solid metallic layer made of solid. The second layer is the outer core, a liquid metallic layer. The third layer is the mantle, which is fluid molten rock. The fourth layer is the crust, which is a solid rock layer.

4. **How does the example of the hard-boiled egg accurately model the Earth's lithosphere as described on page 101, and what are the limitations of the model?**
A broken eggshell correctly models the solid plates of rock. The biggest difference is that on an eggshell the plates or pieces do not move around, but on the Earth the pieces of the crust do.

5. **After reading pages 101-102, describe the purpose of the red arrows in the diagram on the bottom of page 101. Identify and describe the concept was the author trying to clarify.**
The red arrows represent the convection currents in the magma. Magma close to the core gets heated and rises to the surface and then cooler magma moves downward.

6. **The author described the lithosphere as, "the most interesting part of the geosphere." Give three examples from the text section, "Constructive and Destructive Processes," that support the author's claim.**
First, it is interesting because the lithosphere is where the tectonic plates are moving causing volcanoes to form. Second, when two plates collide they can form hills and valleys. Third, there are destructive processes like erosion breaking landforms down.