ELSEE
Environmental Laboratory for
Sustainability and Ecological Education

Lesson 2: Rocks and Geology

California Education Standards:

Kindergarten, Physical Sciences

1. Properties of materials can be observed, measured, and predicted. As a basis for understanding this concept:

a. *Students know* objects can be described in terms of the materials they are made of (e.g., clay, cloth, paper) and their physical properties (e.g., color, size, shape, weight, texture, flexibility, attraction to magnets, floating, sinking)

Grade 2, Earth sciences

3. Earth is made of materials that have distinct properties and provide resources for human activities. As a basis for understanding this concept:

a. *Students know* how to compare the physical properties of different kinds of rocks and know that rock is composed of different combinations of minerals.

b. *Students know* smaller rocks come from the breakage and weathering of larger rocks.

Grade 4, Earth sciences

4. The properties of rocks and minerals reflect the processes that formed them. As a basis for understanding this concept:

a. *Students know* how to differentiate among igneous, sedimentary, and metamorphic rocks by referring to their properties and methods of formation (the rock cycle).

5. Waves, wind, water, and ice shape and reshape Earth's land surface. As a basis for understanding this concept:

a. *Students know* some changes in the earth are due to slow processes, such as erosion, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.

b. *Students know* natural processes, including freezing and thawing and the growth of roots, cause rocks to break down into smaller pieces.

c. *Students know* moving water erodes landforms, reshaping the land by taking it away from some places and depositing it as pebbles, sand, silt, and mud in other places (weathering, transport, and deposition).

Grade 6, Earth sciences

1. Plate tectonics accounts for important features of Earth's surface and major geologic events. As a basis for understanding this concept:

d. *Students know* that earthquakes are sudden motions along breaks in the crust called faults and that volcanoes and fissures are locations where magma reaches the surface.

e. *Students know* major geologic events, such as earthquakes, volcanic eruptions, and mountain building, result from plate motions.

f. *Students know* how to explain major features of California geology (including mountains, faults, volcanoes) in terms of plate tectonics.

2. Topography is reshaped by the weathering of rock and soil and by the transportation and deposition of sediment. As a basis for understanding this concept:

a. *Students know* water running downhill is the dominant process in shaping the landscape, including California's landscape.

b. *Students know* rivers and streams are dynamic systems that erode, transport sediment, change course, and flood their banks in natural and recurring patterns.

Grade 7, Earth Sciences

4. Evidence from rocks allows us to understand the evolution of life on Earth. As a basis for understanding this concept:

a. *Students know* Earth processes today are similar to those that occurred in the past and slow geologic processes have large cumulative effects over long periods of time.

c. *Students know* that the rock cycle includes the formation of new sediment and rocks and that rocks are often found in layers, with the oldest generally on the bottom.

Objective:

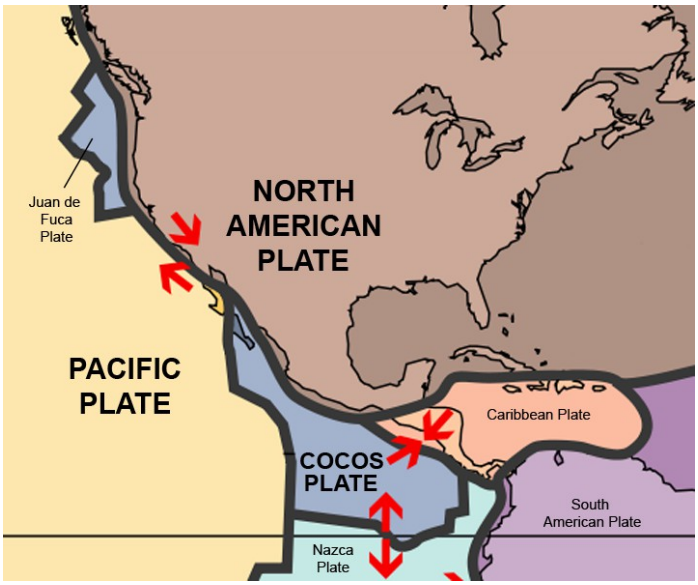
Explain and show how parts of California were formed from the collision of tectonic plates, the Pacific sliding below the Continental, causing earthquakes and volcanoes and, in the process, unusual soils by forcing up rarer elements from deep below the surface. We learn about how the weathering wind, rain, sun and ice help convert this land to a new substance called "soil," a substance teeming with life.

Vocabulary:

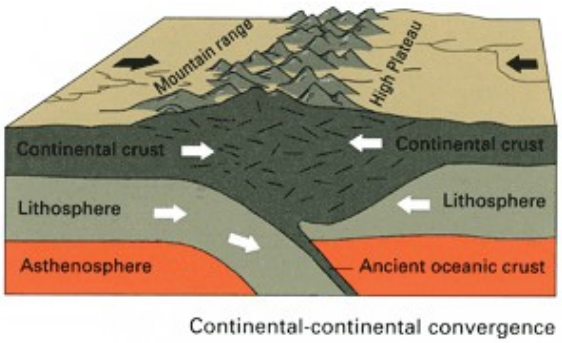
Magma - hot molten rock below the earth's crust
Plate Boundaries - where the edge of one plate meets another
Convergent Boundary - where two plates are colliding
Uplift - when two colliding plates form mountains
Subduction - when one plate slides under another converging plate
Rift - place where the earth's crust is being pulled apart
Fault - breaks in the earth's crust formed by earthquakes
Weathering - process by which big rocks are broken down into many small rocks, and eventually soil
Erosion - process by which pieces of rock and soil are removed from one place by water or wind and transported and deposited to another place
Sediment - little pieces of rock and other particles that are carried and deposited by rivers
Rock Cycle - the transitions that happen between the three major rock groups over long periods of time

Lesson:

In the previous lesson, we briefly mentioned plate tectonics. Now we will learn more about what they are and how they work. The planet earth is made of rock and metal, but it is covered with a crust that forms the whole outer layer of the earth. The crust is all the continents, oceans, and land that we live on. Think of the earth like an egg, and the egg's shell is like the earth's crust. However, the earth is not like a perfect eggshell; imagine the egg being cracked - the shell is still on it but it is divided into lots of pieces. Just as that shell is divided into many pieces, the earth's crust is divided into lots of huge plates that are continuously moving very slowly because of hot molten rock beneath the earth's crust, called **magma,** moving around underneath them. These plates move much too slowly for us to even see (about 10 cm per year), but it has made a big difference over the billions of years that the earth has been around. Remember that the shifting of tectonic plates is what changed Pangea, the huge continental landmass, to the current continents that we have today.



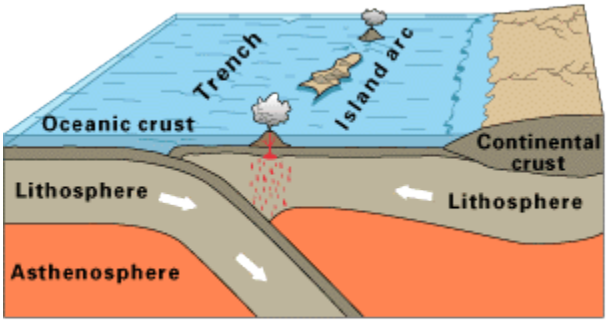
As these plates move, they often glide smoothly, but sometimes they rub against each other, bump into each other, and separate from each other. These kind of movement are the cause of many geological features such as mountains, volcanoes, and valleys at the borders of the plates. These lines between plates are called **plate boundaries**. There are three different types of tectonics boundaries -- convergent, divergent, and transform -- and the type of boundary determines how the land is shaped and formed.



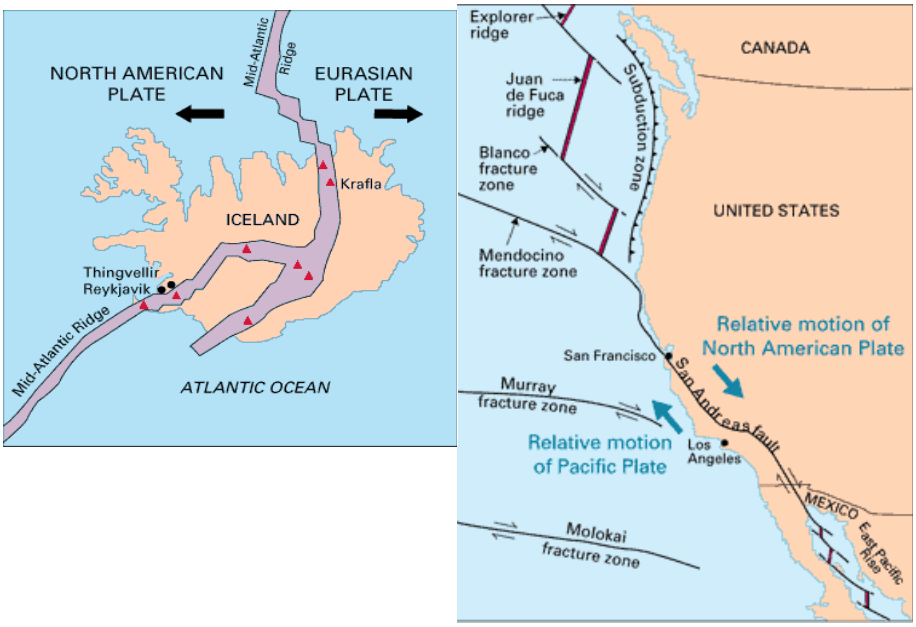
Continental-continental convergence

Convergent boundaries are where two plates are moving towards each other and collide. There are several possible outcomes of this head-on collision, which depend on the type of plates that are involved. Plates are either continental (have landmasses on them), or oceanic (covered by ocean). When a continental plate runs into another continental plate, the land masses crumple and form mountains in a process called **uplift**. Many huge mountain ranges, including the Himalayas (home to Mount Everest, the tallest mountain in the world), have been created by this process. Another type of convergent boundary is formed when an oceanic plate and a continental plate collide. Because the ocean plate is heavier, it slides under the continental landmass in a process called **subduction**. As this is happening, the continental plate is lifted up, and forms

mountain ranges. An example of a mountain range formed this way is the Andes. As the oceanic plate is diving under the continental plate, and the rock sinks slowly closer to the center of the earth, it gets very hot and melts. This **magma** often bursts back up through the crust, creating volcanos. Some of the mountains in the Andes Range are volcanos. The third type of convergent boundary is formed when two oceanic plates collide. One plate **subducts** under the other, and this forms deep ocean trenches, such as the Mariana Trench in the Pacific ocean, which is the deepest spot on earth. This type of collision also creates underwater volcanoes, like the ones that formed Japan.



Oceanic-oceanic convergence



Divergent boundaries occur where two plates are moving apart from each other in opposite directions. When this happens between oceanic plates, magma from deep in the earth comes up through the gap, forming underwater mountain ranges and volcanoes that may become high

enough to form islands. In fact, the world's longest mountain range, the Mid-Atlantic Ridge, was formed this way and is completely under water. When this type of movement happens between two continental plates, **rifts** (places where the earth's crust is being pulled apart) are created, which turn into rift valleys if the plates keep separating. An example is the great rift valley in Africa, which is still growing today, and may eventually result in Africa splitting into two continents.

Transform boundaries are where two plates are sliding against each other in opposite directions. As they move against each other, they grind against each other and create a break in the earth's crust called a **fault**. The San Andreas fault in California is the result of a transform boundary. As the plates grind against one another, they sometimes create earthquakes.

Once these big geological features, such as mountains, volcanoes, and faults are formed by plate tectonics, other processes continue to reshape the landscape. All the rocks and soil that we see on our planet today had to come from a much larger rock, such as a mountain or volcano lava. The process by which these big rocks are broken down into many small rocks, and eventually soil, is called **weathering**. Then these little pieces are more easily moved to new places, which is called **erosion**. Wind and water, such as rain, rivers, waves, and ice, are the two main forces that shape our landscape through weathering.

Ice is a big force in weathering rocks because it cracks them during the process of freezing and melting. Streams and rivers are the main forces that reshape the landscape. They start at the top of mountains, and as they flow they slowly wear down the mountains (weathering) and carry little pieces of the mountains, called **sediment**, with them, depositing these pieces downstream (erosion.) The soil around rivers is usually very fertile, or good for growing plants, because the river has so many little particles of rock and other debris that it has eroded, and it deposits this nutritious sediment all along its banks. A great example of the extreme power of rivers to reform

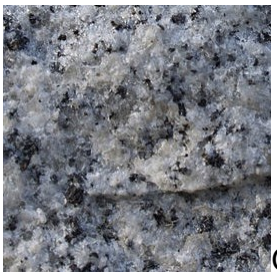
the landscape is the Grand Canyon. It was formed by the Colorado River flowing through it and slowing eroding it to make it deeper and deeper.

The ocean is also a very powerful weathering force. Every little piece of sand once came from a much larger rock or shell, and the waves of the ocean have slowly broken them down. Wind also causes weathering and erosion. Wind can pick up dirt particles and deposit them elsewhere. The forces we have discussed so far are slow processes, and they make a huge difference over a long time. Other faster processes such as landslide and rock falls can reshape topography dramatically.

Now that we know generally how rocks are formed, we will learn about the different kinds of rocks. There are three major types of rocks – igneous, sedimentary, and metamorphic – and the differences are a result of how they were formed and from where they came.

Igneous rocks form when magma cools and hardens. Sometimes magma can cool within the earth and this happens very slowly, forming big crystals. When this happens, the rocks are called intrusive igneous rocks. Examples of this type of rock are pumice and granite Look, you can see the granite crystals! The other way an igneous rock can form is when magma comes up through the earth and burst through the earth's crust in a volcano (the magma is called lava after it breaks the surface) and then cools. The lava cools quickly when exposed to the air, so there is no time for big crystals to form. These rocks are called igneous extrusive. Sometimes they appear smooth and glassy, such as obsidian, and sometimes they have air bubble from gas being trapped, such as pumice. Igneous rocks are usually black, white, grey, or combinations of these colors.


Pumice


Granite


Obsidian

Sedimentary rocks are formed by the accumulation of sediment (little pieces of sand, rock, dirt, shells, etc.) Very slowly, layers of sediment are deposited on top of each other, and all these layers slowly harden to form rocks. You can often see little particles of sand or pebbles in this type of rock. Sedimentary rocks are usually the only type that contain fossils, because the fossils become trapped in the rocks while new layers of sediment accumulate over them and then harden. Sedimentary rocks are relatively soft and can crumble fairly easily. Some examples are limestone, sandstone, shale, and conglomerate.


Sandstone Cliff


Conglomerate

Metamorphic rocks are formed when other rocks are changed by intense heat and pressure (squeezing), usually under the earth's surface, and over a very long period of time. These rocks eventually resurface as metamorphic rocks. These rocks often have a layered appearance and shiny crystals that formed very slowly. Some examples of metamorphic rocks are gneiss, which started as granite; marble, which started as limestone; slate, which started as shale; and quartzite, which started as sandstone.


Gneiss

Rocks are constantly being formed from new lava, broken down and made into new sedimentary rocks, and incorporated back into the earth to slowly become metamorphic rocks. This is called the **rock cycle**. Eventually rocks become small enough to form soil, the basis for life. Without soil, we could not grow plants, and without plants, humans and other animals could not exist! We eat plants, which take nutrients from the soil, which was formed from rocks. This means that all the nutrients in our bodies originally came from rocks!

Materials:
paper
pen/pencils
clipboards
magnifying lens

Activities:
Divide students into teams of 5 students and go into the garden. See which team can find the most types of rocks. Have the students look for as many different types of rocks as they can find. Each time they find a rock, the docent can give them hints such as how the rock was formed and have students decide which type of rock it is (igneous, metamorphic, or sedimentary).

For younger children, it would be wise to characterize the rocks according to color and physical attributes and have them make the distinction by writing it down or verbally stating it to the leader.

After this activity it's important to conduct a discussion. Why did they pick certain rocks for their certain categories? Have the groups explain exactly what they found. Have them record their observations. Ask each student to imagine how this rock was formed and how many years it took to form.

Sources and Links:
http://www.youtube.com/watch?v=f7qONcTRid8 **(Video)**
http://pubs.usgs.gov/gip/dynamic/tectonic.html

http://science.nationalgeographic.com/science/earth/the-dynamic-earth/plate-tectonics-article/ great explanation of different types of plate boundaries and the tectonic activity that occurs at each
http://www.kidsgeo.com/geology-for-kids/0060-weathering.php
http://www.learner.org/interactives/rockcycle/types.html great interactive resource!
http://pubs.usgs.gov/gip/dynamic/understanding.html