Lesson Two

Rock Types – Illustrated with Crayons

Summary
Rocks are the key to understanding the history of Earth. Learning to read them will help you discover a story that covers billions of years. Rocks also play an important role in our everyday lives. We eat rocks and minerals, such as salt on our french fries. We live in or visit buildings with slate blackboards, brick walls, and/or cement floors. We read in the news about conflicts over natural resources derived from rock, including coal, natural gas, and oil. In understanding the world of rocks, students will develop a better understanding of the world around them.

Another way to think about the effect of geology is to consider land forms and processes. For example, rock outcrops might influence where roads go. Get students to think about the topography of their town and how it has influenced where people live. If students live in a river valley, they might think about how sediments accumulate in a flood plain; this is one way that sedimentary rocks form. Or why is there town located where it is? Does it have to do with geology (e.g., located to take advantage of water or good transportation site)?

This activity introduces the three main types of rocks and the processes that form them. Wax crayons are eroded into sediment, compacted into sedimentary rock, partially melted and pressed into metamorphic rock, and finally melted and cooled into igneous rock. This understanding is the basis of the rock cycle. In the "Going Further" section, there is a recipe for making your own sandstone, siltstone and conglomerate using sediments and a sodium silicate solution. In addition, this activity dovetails well with the FOSS Earth Materials' modules. (http://www.fossweb.com/modules3-6/EarthMaterials/index.html)

This activity is adapted and modified from one created for MyScienceBox by Irene Salter (http://www.mysciencebox.org)

Objectives
Students will be able to:

1. describe the 3 major types of rock (sedimentary, metamorphic, and igneous) and discuss the relationships between them
2. diagram the rock cycle
3. describe the geologic processes that form sedimentary, metamorphic and igneous rocks
4. list several examples of how rocks and minerals are part of their everyday lives.

Estimated teaching time
One class session

Groups
Individual

Materials
For each student:
From the Box:

- A copy of the 'Rock Cycle Template'

Teachers will need to provide from their own supplies:

- 2 wax crayons (Crayola brand crayons work well)
- 1 pencil sharpener
- 6 inch square of aluminum foil
- Styrofoam or other cup to hold hot water
- Source of hot water (I use a hot pot style electric water heater)

For the whole class:
From the Box:

- Samples of sedimentary, metamorphic, and igneous rock, sorted into boxes of the same rock type
- Roll of Tums™
- Projectile point

Teachers will need to provide from their own supplies:

- 3-6 large containers or water pitchers for water that has cooled down in the students' cups

Teacher background
See document labeled **ROCKS AND MINERALS BACKGROUND INFORMATION for ACTIVITIES**

The rock cycle is perhaps the most basic, fundamental principle of geology. We might think of rocks as static and permanent, but on the scale of geologic time, all rocks are in transition, slowly changing and transforming from one kind into another. In its simplest form, the rock cycle describes the relationships between the three types of rock:

1. Igneous Rocks - Formed from the cooling of molten rock (magma or lava).
2. Sedimentary Rocks - Formed from layers of sediment particles (pieces of pre-existing rock or once-living organisms) as the pressure of overlying layers compacts them into rock. Sometimes a cementing agent, like dissolved minerals such as silica or carbonates, helps bind the sediment particles together.
3. Metamorphic Rocks - Formed from other rock types that, under intense heat and pressure, change their physical and/or chemical form.

Molten rock solidifies either rapidly, at the Earth's surface (lava), or slowly, under the Earth's surface (magma), into igneous rock (this is modeled by the whole crayon we start with). As these rocks are exposed to erosion and weathering, they are broken down into sediment (a pile of crayon shavings). The grains of sediment may be transported long distances by water, wind or gravity, and eventually deposited in

History Note

The rock cycle is attributed to James Hutton (1726-1797), the "father of geology" who meticulously explored and documented the landscape of the British Isles. Hutton proposed the principle of uniformitarianism, the idea that the processes that shape the world today also operated in the past. His idea brought about the revolutionary notion that given how long it takes for geologic processes to occur today, the Earth must be very, very old for all the existing landforms to have been created, not merely the 6,000 years allowed by tracing Biblical genealogy. One of his most famous quotes states that with respect to the Earth there is "no vestige of a beginning, and no prospect of an end".

layers. As more and more sediment layers build up on top of each other, the sediments are compacted and sometimes cemented together into sedimentary rock (squishing the crayon shavings together) in a process called lithification ('lithi' means rock). With heat and pressure (partial melting in hot water), the rock will undergo a physical and/or chemical change into metamorphic rock. If the rock is melted completely and cooled, you once again have igneous rock.

With greater scientific sophistication and the plate tectonics revolution, many geologists now suggest that the basic rock cycle described in this lesson is too simple. The basic rock cycle is cyclical, with no apparent direction or trend. Instead, if plate tectonics is taken into account, there may indeed be a trend towards greater and greater diversity of rock types over time. For more information, see the Tectonic Rock Cycle at
http://csmres.jmu.edu/geollab/fichter/Wilson/PTRC.html

Student background
It helps the discussion of sedimentary rocks if students are familiar with identifying different sediments (gravel, sand, silt, clay) by size. We have enclosed a small card that contains a drawing illustrating the difference in variously-sized particles. It also helps to know the difference between rocks and minerals.

Set up
The activity can take place in a classroom.

1. Rip sheets of aluminum foil into 6 inch squares
2. Set out remaining materials – crayons, knives, cups, and hot water source
3. Copy Rock Cycle Template handout
4. Sort the rock samples into the 3 rocks types, if they aren't already sorted

Introducing the activity

1. Begin by asking students what they know about rocks. (If you have already done Lesson Plan One you may want to skip to question 2, or you could use this as a review or ask students to think of other ways that rocks/geology affects their lives.)
   Sample questions might include.
   - ⇒ Do you eat rocks? (They may not eat rocks but certainly eat minerals, such as salt. Show them the package of Tums™ and read the ingredients, the second item of which is calcium carbonate (or calcite), a mineral.)
   - ⇒ Have you heard about geology in the news? (Oil and gas, volcanoes, earthquakes, tsunamis)
   - ⇒ Are there any rocks in this building? (Building stone, brick, slate, marble are all possibilities)
   - ⇒ Can you think of a tool made from a rock that people have used for thousands of years? (Arrowheads, knives, and axe blades.)
   - ⇒ Can they name a movie based on rocks? (*Volcano*, *Journey to the Center of the Earth*, *Jurassic Park*, etc.)

2. After showing students that rock is part of their daily lives, ask students what they know about rocks.

- ⇒ Can they name the three broad categories: sedimentary, metamorphic, and igneous?
- ⇒ Can they tell them apart?
- ⇒ Do any of them collect them?
- ⇒ Can any of them tell you where the nearest rock outcrop (rock at the surface) is located?
- ⇒ Why do we study rocks?

3. Pass around samples of sedimentary rock. Ask students to observe the rocks and describe some of the similarities between them. (Ask students to think about where a sedimentary rock forms? Sand accumulating on a beach or sand dune. Silts and muds accumulating in a flood plain during a flood. Sediments building up in a lake.) As students offer their ideas, write them on the board in one column.

   Sample attributes might include: can see grains, grains can be of different sizes, has layers or streaks, grains come off if you rub it.

Sedimentary Rock	Metamorphic Rock	Igneous Rock

Note: If you don't want to write the actual name of the sample, you can use Sample 1, Sample 2 and Sample 3 for the headings and then have the students try to figure out which is which once they know a little bit more about the three types of rocks below.

4. Collect the sedimentary rocks then pass around samples of metamorphic rocks. Ask students to observe the rocks and describe how these rocks are different from the sedimentary rocks. Again, write their ideas in a column on the board. Sample attributes might include: no grains, has crystals, many colors, very hard, swirly patterns.

5. Collect the metamorphic rocks then pass around samples of igneous rocks. Ask students to observe the rocks and describe how these rocks are different than the other two types of rocks. Again, write their ideas in a column on the board. Sample attributes might include: no grains, some have crystals, some have lots of holes, uniform texture and pattern throughout the rock, no layers or swirls.

6. Tell the students that they have been observing and categorizing the three rock types: sedimentary, metamorphic, and igneous rocks. Explain that today, they will be using crayons to model the processes that create each of these three types of rock.

7. Pass out the **Rock Cycle** handout, crayons, foil, and pencil sharpener.

To Make a Sedimentary Rock

8. Tell students that they have been given a sample of a crayon rock. Looking at the three descriptions on the board. Which one is this sample most similar to? It doesn't have grains, layers or streaks. Thus it is an igneous crayon rock! On their handout, in the box at the top of the circle, have students write "igneous rock".

9. The first step is to create sediment. Have students unwrap their crayons then create a pile of crayon shavings on their piece of aluminum foil by using their pencil sharpener. They may trade crayons among themselves to acquire a mixture of colors. Give them around 5 minutes to build up a decent sized pile. (It's okay of they have chunks, as well as shavings.)

10. On the diagram, the arrow from "igneous rock" can be labeled "erosion". The next box can be labeled "sediment".

11. Now fold over the foil to wrap up the sediment pile. Press down on the pile as hard as you can. Gently unwrap it. The sedimentary crayon rock will be fragile but should hold together in a packed layer.

12. Discuss the similarities between the sedimentary crayon rock and the real sedimentary rocks the students observed earlier. (Both types could have different sized grains (shavings), different colors, and layers. Differences might be that the sedimentary rock has grains organized by size (when sediments settle in water, for example, heavier grains settle more quickly followed by light grains, which often leads to a layered effect); the source of sediments in a sedimentary rock would come from different sources and not just one; and there would be some sort of cement mixed into the rock to hold it all together.

13. On the diagram, the arrow from "sediment" can be labeled "lithification – compacting and cementing sediments together". The next box can be labeled "sedimentary rock". Discuss this process as it occurs in the real world with layers being squeezed under other layers.

To Make a Metamorphic Rock

14. Now get a helper to pass out the cups and go around yourself to fill each cup with hot water. Have another helper place containers for cooled water near each table or cluster of desks.

15. Each student should create a little boat out of their piece of aluminum foil for their sedimentary crayon rock and float his or her boat on the hot water. Watch as the heat from the water melts the crayon. Remove the foil when the wax is soft to the touch and

the colors have swirled together but not so much that the colors are indistinguishable. Let the metamorphic crayon rock cool.

16. Discuss the similarities between the metamorphic crayon rock and the real metamorphic rocks the students observed earlier. The real metamorphic rock will have aligned grains, meaning that the axis of each mineral faces the same direction. This can result in layers, as in a slate or a gneiss, or all minerals having aligned faces, as in a schist. (One way to think of this is to compare a metamorphic rock to a deck of cards. Before metamorphism the minerals are unaligned, like a pile of cards, and after the minerals are aligned, like in a deck of cards.) Another difference is that usually some sort of change occurs in the chemistry of the rock, as it is heated and squeezed during metamophism.

17. On the diagram, the arrow from "sedimentary rock" can be labeled "metamorphism – heat and pressure transforms the rock". The next box can be labeled "metamorphic rock". Discuss this process as it occurs in the real world with rocks being subjected to intense heat and pressure beneath the surface of the Earth.

To Make an Igneous Rock

18. At this point, the temperature of the water the cups may have cooled. Ask students to dump their water into the containers. Go around and refill each cup with hot water.

19. Each student should put their metamorphic crayon rock back in the foil boat and float it on the hot water. This time, allow the wax to melt until a smooth pool of liquid wax forms and the colors blend together uniformly. Carefully remove the foil and let the igneous crayon rock cool.

20. Discuss the similarities between the igneous crayon rock and the real igneous rocks the students observed earlier.

21. On the diagram, the final arrow from "metamorphic rock" can be labeled "melting into magma then cooling". Discuss this process as it occurs in the real world with rocks being melted deep within the Earth then extruded again as volcanoes or bubbles of magma that do not reach the surface.

Questions for Students

22. Ask the students:
    a. Do they think this igneous rock could be turned into sedimentary rock? How? (If the rock formed underground, somehow it would have to be uplifted to the surface, which occurs via plate tectonic action. Once at the surface, wind, water, and ice could attack, weaken, and break down the rock into smaller bits. A good example is the Cascade Mountains, which over time have been steadily eroded, producing sediments that have washed into the sea and are becoming new sedimentary rocks.)

b. Could it be turned directly into metamorphic rock? How? (The igneous rock coud be buried by sediments so deeply that the heat and pressure rise enough to convert it to a metamorphic rock.)
c. Could a sedimentary rock be turned directly into metamorphic rock? How? (If enough sediments pile atop a sedimentary rock, you can get metamorphism or a sedimentary rock could be metamophosed if two continents run into each other and one slides over the other and buries the sediments deeply. This is how the famous marble of Carrara, Italy that was used by Michelangelo was formed.)

23. Add additional arrows across the middle of the rock cycle to illustrate that any type of rock can turn into any other type of rock. For example, metamorphic rock can be eroded into sediment then compacted and cemented into sedimentary rock.

24. If there is time, students can experiment with turning their igneous crayon rock into a new sedimentary, metamorphic, or igneous crayon rock.

Wrap Up Questions

25. Ask students some of the same questions from the beginning of the lesson, having them explain the differences between the rock types and how the rocks form. Ask students about a geologic world events or geologic topic in the news and see if they can name the type of rock. For example, any volcanic eruption (http://www.volcano.si.edu/reports/usgs/) involved igneous rocks; any mention of fossils most likely involved sedimentary rocks; and any mention of any famous sculpture most likely involved a metamorphic rock, marble. (This last one might be harder to have a recent item but could refer to a piece of art such as a marble or granite sculpture.)

26. Clean up! Students can keep their crayon rocks.

Assessment

1. 9th grade teacher Marcie Krech, has a list of great extension activities related to the rock cycle (http://www.scienceteachingideas.com/rocks.htm). They include a vocabulary cut & paste, a lab, a whole class puzzle, a game and a comic strip activity. In fact, Marcie has put her whole Earth Science curriculum online for others to learn from. Thank you!
2. Give students rocks to classify as sedimentary, igneous, or metamorphic.

Going further

1. Ask students to think about the local landscape and whether they know the types of rocks they have seen. If not, or even if so, ask them to see if they can bring into the classroom an example of each rock type, which they found. (They may not always be able to do this as all three rock types don't occur everywhere, but perhaps they could try and find the three rock types in different stones used in building. All three are common usually in construction.)
2. Make sedimentary rocks! Any sediment (powdered clay, silt, playground sand, or a sand and gravel mixture) can be turned into a sedimentary rock with the addition of a dilute

sodium silicate solution. See the Sources section for where to purchase sodium silicate. The recipe:

- 15 ml dilute sodium silicate, dilute full strength sodium silicate with water in a 1 to 1 ratio (a 20 ml syringe is a great measuring tool and dispenser for this viscous solution)
- 6 tablespoons of sediment (playground sand works great although kids like to mix and match sediments for their own special rock type)

Mix the sediment and sodium silicate in a clear plastic 9 oz cup with a disposable stirrer like a popsicle stick. Be careful not to get sodium silicate on your hands or in your eyes. Smooth out the surface of the mixture with the stirrer. Set aside for 2 days. Once the mixture is completely dry, it can be popped out of the cup and examined up close. If you plan on doing the "Layers Upon Layers" lesson, consider adding layers of a different sedimentary rock on top of the first before removing the rock from the cups. You are, in effect, creating a permanent version of the depositional cups formed in the "Layers Upon Layers" lesson.

3. Try the History of Rock lesson (http://mysciencebox.org/rockhistory) where students research a rock and discover the story of its formation.
4. The National Parks Service has a great collection of teacher lesson plans related to rocks and the rock cycle called Geodetectives (http://www.nps.gov/brca/Geodetect/Rocks%20&%20Minerals/RM%20unitpage.htm). There are individual activities for each of the three main rock types, a candy rock cycle activity, and a brilliant idea for comparing rocks to identify which rocks are best used for what purposes – building a house, tools, jewelry, etc.

References

The best write up for the crayon rock cycle activity is available from Eric Muller of the Exploratorium's Teacher Institute. Go to The Crayon Rock Cycle at http://www.exo.net/~emuller/activities/ Eric has developed many other fantastic activities, particularly for Earth Science.

For additional information about the rock cycle, go to:

- Rocksandminerals.com (http://www.rocksandminerals.com/rockcycle.htm)
- The Department of Geology at James Madison University (http://csmres.jmu.edu/geollab/fichter/Wilson/PTRC.html)
- Wikipedia (http://en.wikipedia.org/wiki/Rock_cycle)

Sodium silicate solution (also called water glass) can be purchased from most science supply companies such as Flinn Scientific (http://www.flinnsci.com) and Science Kit & Boreal Labs (http://sciencekit.com). 500 ml costs $5-6. Sometimes it can be found at marine supply stores in quart sized containers for sealing the outside of boats.

Teaching standards

Science Content Standard 4. Students, through the inquiry process, demonstrate knowledge of the composition, structures, processes and interactions of Earth's systems and other objects in space.

Benchmark Grade 8, Number 2 - Differentiate between rocks types and minerals types and classify both by how they are formed and the utilization by humans

A. Differentiate between igneous, sedimentary, and metamorphic rocks.
B. Identify that rock is composed of different kinds of minerals
C. Define minerals as the building blocks of rocks.
D. Compare and contrast the differences between rocks and minerals.

Benchmark Grade 5, Number 2 -Describe and measure the physical properties of earth's basic materials (including soil, rocks, water and gases) and the resources they provide

A. Describe the formation of the three rock types.
B. Compare and contrast the characteristics of the three basic types of rocks: sedimentary, metamorphic and igneous
C. Identify specific samples of sedimentary, metamorphic and igneous rocks
D. Identify everyday uses of rocks
E. Classify rock samples by rock type

Glossary

- Cement – Chemically precipitated mineral that occurs in spaces among sediments and that binds those grains together.
- Erosion – The process in which particles are detached from rock and carried away by agents such as wind, water, and ice.
- Igneous rock - Formed from the cooling and crystallization of magma.
- Lithification – The conversion of sediments into rock.
- Magma - Molten (melted) rock beneath the Earth's surface
- Metamorphic rock - A rock that has undergone chemical or structural changes due to heat and/or pressure.
- Rock cycle – Sequence of events involving the formation, alteration, break down, and formation of rocks due to natural processes, including metamophism, erosion, deposition, and magmatism.
- Sediment – Solid fragments of material, either physically transported and deposited; chemically precipitated; or organically secreted.
- Sedimentary rock - A rock formed from the accumulation and consolidation of sediment, usually in layered deposits.

Rock Cycle