Five-Es Rocks Unit Overview

Topic:

The Rock Cycle: dynamic processes producing Earth's wide variety of rock types.

Indiana State Standards:

7.3.7 – Give examples of some changes in the Earth's surface that are abrupt, such as earthquakes and volcanic eruptions, and some changes that happen very slowly, such as uplift and wearing down of mountains, and the action of glaciers.

7.3.8 – Describe how sediments of sand and smaller particles, sometimes containing the remains of organisms, are gradually buried and are cemented together by dissolved minerals to form rock again.

7.3.8 – Explain that sedimentary rock, when buried deep enough, may be reformed by pressure and heat, perhaps melting and recrystallizing into different kinds of rock. Describe that these reformed rock layers may be forced up again to become land surface and even mountains, and subsequently erode.

Objectives:

- Students will be able to define igneous, sedimentary and metamorphic rocks with regard to the rock cycle
- Students will be able to explain the movement of earth materials through the rock cycle.

- Students will be able to explain that subjecting earth materials to heat and pressure is a process called metamorphism.
- Students will be able to explain that the melting and recrystallization of earth materials produces igneous rocks.
- Students will be able to explain weathering and erosion of earth materials produces sediment.
- Students will be able to explain that the compaction and cementation of sediment produces sedimentary rocks.

Activities:

This unit includes the following activities:

- Igneous Rock Identification
- Sedimentary Rock Identification
- Metamorphic Rock Identification
- Rock Cycle-opoly activity
- Rock Cycle with Crayons

Suggested Schedule:

	Activity	Time
Day 1	Igneous Rock Identification	1.5 hours
Day 2	Sedimentary Rock Identification	1.5 hours
Day 3	Metamorphic Rock Identification	1 hour
Day 4	Rock Cycle-opoly	1 hours
Day 5	Rock Cycle with Crayons (The Crayola Cycle Demonstration)	1.5 hours
Day 6	Summative assessment	

Background:

Rocks here on planet Earth are not static. Dynamic processes are continuously modifying the rocks of planet Earth. Geologists, use a framework known as the rock cycle to describe the relationship between these processes and the products. These products are the three different rock types, Igneous, Sedimentary, and Metamorphic. This process→ product distinction is quite important to the geological sciences and is key in understanding the rock cycle. For the purposes of this activity, each process and product will be described separately. However, it should be stressed that each of these exists within the context of the remaining processes and products.

Table 1
Geologic Processes and Products

Processes	Products
Weathering and Erosion	Igneous Rocks
Lithification	Sedimentary Rocks
Crystallization	Metamorphic Rocks
Metamorphism	Magma / Lava
Melting	

Magma and Igneous Rocks:

Igneous rocks are defined as those, which are formed by the process of crystallization from Magma. Magma, defined as molten material beneath the surface of the Earth, crystallizes as it cools. It is often a useful analogy to describe the phase change between water (liquid) and ice (solid).

Igneous rocks can be classified by two methods. First, they can be classified chemically, based upon their mineral content.

Second, Igneous rocks can be classified based upon their method of origination. Magma, from within the Earth, can follow two tracks. First, it can rise to the surface and erupt. While the molten material is on the surface, we refer to it as Lava. Once on the surface this rock cools rapidly. The result of this rapid cooling is small crystals, which

are not visible to the naked eye. These rocks are referred to as Extrusive or Volcanic Igneous rocks. Alternately, if the Magma does not reach the surface, it cools slowly over many thousands of years. The result is much larger crystals, which are easily seen with the naked eye. These are referred to as Intrusive or Plutonic Igneous Rocks.

Because igneous rocks are classified by both composition and origin, rocks that are of the same composition can have different names. For example, Gabbro and Basalt both have the same composition; however, Gabbro cooled slowly within the Earth's crust, while Basalt cooled rapidly on the Earth's surface.

Igneous Rock Classification				
	Felsic	Intermediate	Mafic	Ultra-Mafic
Course Grained	Granite	Diorite	Gabbro	Peridotite
Fine Grained	Rhyolite	Andesite	Basalt	
Remaining extrusive igneous rocks • Tuff • Pumice • Scoria • Obsidian				

Weathering, Erosion, and Sediment

Rocks at the Earth's surface are constantly bombarded by a number of environmental factors. These include, water, wind, ice, changing temperatures, vegetation, and more. These environmental factors act as destructive processes that are referred two as weathering. Simply put, the process of weathering is the process of breaking rocks into smaller pieces. This can occur by two different tracks. First, physical weathering is a mechanical process of breaking rocks into smaller pieces. An

excellent analogy is the act of swinging a sledgehammer against a rock. The resulting product is smaller pieces of rock. In nature, this occurs in a number of places. One example is liquid water trapped in fractures. If temperatures fluctuate below freezing nightly, the resulting expansion from the formation of ice results in the widening of the fracture. Over time, this process has a tremendous effect. Chemical weathering, the second possible process, occurs when minerals within the rock are changed due to exposure to water and atmospheric gases. A common example is the dissolution of CaCo3 from the rock Limestone.

Erosion is the second part of the process. After a rock has been weathered, wind, water, or ice picks up (erodes) the piece. This process of being picked up is referred to as erosion. Once picked up, the process doesn't stop. Geologists refer to the movement of the piece as transportation. Excellent examples of transportation include rivers, wind (sand dunes), and glaciers.

Often, these pieces of rock are seen sitting around. In the case of a sand dune, often the wind is not strong enough to move the particles every day. Thus, the particles sit around waiting for a windy day to be transported. At this time, these pieces are referred to as sediment.

Lithification and Sedimentary Rocks

As is obvious from the similarities between the words, Sediment and Sedimentary rocks are related. Indeed, Sedimentary rocks are produced from Sediment by the process of lithification.

Metamorphism and Metamorphic Rocks

Metamorphic rocks began at some point as a different rock type. At some point, the process of metamorphism altered them. Metamorphism occurs by three different, and often coincident agents. These agents are Heat, Pressure, and Chemically active fluids.

5E's Igneous Rock Lesson

Topic:

Igneous Rocks

Indiana State Standards:

7.3.9 Explain that sedimentary rock, when buried deep enough, may be reformed by pressure and heat[1], perhaps melting and recrystallizing[2] into different kinds of rock. Describe that these reformed rock layers may be forced up again to become land surface and even mountains, and subsequently erode.

1 Metamorphic rock
2 Igneous rock

Note: Footnotes added for clarification purposes. They do not exist in the Indiana State Standards.

Materials:

Set of rock samples sufficient for the level and time allotted. It is best to label each rock with an identifying number or letter.

Suggested Igneous Rock Samples

Granite	Diorite
Gabbro	Rhyolite
Andesite	Basalt
Obsidian	Pegmatite
Pumice	Porhyritic sample
Peridotite	Tuff

Lesson:

Evaluate:

Basically, what we want to do here is assess the students' understanding of some fundamental concepts. We want to talk about physical properties. For example, how do we decide how hard something is? What about color? Density? Are there other indicators we can use to describe these rocks?

Engage:

Define the problem. How do we organize our observations?

How do scientists organize their observations?

We want to talk about how scientists organize their observations. For example, scientists use tables, flow-charts, dichotomous keys, databases, indexes… etc. to organize their observations. Examples from several areas of science could be shown here.

Explore:

Students get directly involved. Creating a method to identify each rock.

Give the rock samples to each student/group. Explain to the students that their task is to create a key to identify each rock sample. The key must be based upon observable physical properties. Part of their grade will be based upon how well their peers can identify each rock correctly using the key. Students should be encouraged to look at a variety of samples of each rock type, as their peers will likely be using a different set of rocks.

Make copies of each group's key and distribute one to each group. Have each group rate each key. It often works best if the samples are renumbered/relabeled at this point.

Explain:

How useable where the identification methods?

This is the time to discuss each group's findings. Were errors found? What could be done to improve each key? Was each key usable on every set of rocks? Can one perfect key be produced? Are different keys suitable for different purposes?

At the beginning no effort was made to identify the properties commonly used by geologist for rock identification. At this point we want to give names to the properties that the students have certainly already "discovered".

Elaborate:

Many teachers choose to place rocks within a framework of the "big ideas" in the earth sciences. If this is the case, this is the time to talk about the rock cycle, plate tectonics, or human uses of earth materials.

The Rock Cycle:

The rock cycle is a framework used by geologists to explain the movement and continuous alteration of earth materials. An extensive description is given in the unit overview.

Evaluate:

At this stage in the unit a summative assessment is not recommended. Instead a formation assessment is the tool of choice to determine if students have attained an understanding. The suggested method for this unit is the production of a portfolio.

5E's Sedimentary Rock Lesson

Topic:

Sedimentary Rocks

Indiana State Standards:

7.3.9 Describe how sediments of sand and smaller particles, sometimes containing the remains of organisms, are gradually buried and are cemented together by dissolved minerals to form rock again.

7.3.9 Explain that sedimentary rock, when buried deep enough, may be reformed by pressure and heat[1], perhaps melting and recrystallizing[2] into different kinds of rock. Describe that these reformed rock layers may be forced up again to become land surface and even mountains, and subsequently erode.

3 Metamorphic rock
4 Igneous rock
Note: Footnotes added for clarification purposes. They do not exist in the Indiana State Standards.

Materials:

Set of rock samples sufficient for the level and time allotted. It is best to label each rock with an identifying number or letter.

Suggested Sedimentary Rock Samples

Sandstone	Shale
Limestone	Siltstone
Mudstone	Coquina
Coal	Chert
Conglomerate	Breccia

Lesson:

Evaluate:

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Engage:

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5E's Metamorphic Rock Lesson

Topic:

Metamorphic Rocks

Indiana State Standards:

7.3.9 Explain that sedimentary rock, when buried deep enough, may be reformed by pressure and heat[1], perhaps melting and recrystallizing[2] into different kinds of rock. Describe that these reformed rock layers may be forced up again to become land surface and even mountains, and subsequently erode.

5 Metamorphic rock
6 Igneous rock
Note: Footnotes added for clarification purposes. They do not exist in the Indiana State Standards.

Materials:

Set of rock samples sufficient for the level and time allotted. It is best to label each rock with an identifying number or letter.

Suggested Metamorphic Rock Samples

Slate	Phylite
Schist	Gneiss
Marble	Quartzite

Lesson:

Evaluate:

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Engage:

Define the problem. How do scientists organize their observations?

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The Rock Cycle:

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Evaluate:

Rock Cycle Activity

Topic:

The rock cycle

Indiana State Standards:

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Objectives:

- Students will be able to define igneous, sedimentary and metamorphic rocks with regard to the rock cycle
- Students will be able to explain the movement of earth materials through the rock cycle.
- Students will be able to explain that subjecting earth materials to heat and pressure is a process called metamorphism.
- Students will be able to explain that the melting and recrystallization of earth materials produces igneous rocks.
- Students will be able to explain weathering and erosion of earth materials produces sediment.
- Students will be able to explain that the compaction and cementation of sediment produces sedimentary rocks.

Materials:

Quantity (per student/group)	Item
1	Rock Cycle Sheet
1	Instruction Sheet
1	Dice
1	End of activity questions

Lesson background:

The continuous process where rocks change from one of three types to another is known as the rock cycle. The changes from one type to another can take many different paths.

Procedure:

1. Divide the students into appropriate groups
2. This activity assumes that students have had a brief introduction to the rock cycle. If not, the following sequence might be helpful.
    a. Ask students if they think rocks can change. Hand out a copy of the rock cycle.
    b. Explain to students the rock cycle is the framework upon which geologists understand how rocks slowly change from one type to another.
    c. Show students examples of sediment and igneous, sedimentary, and metamorphic rocks. Ask if they can think of any ways to transform one of the samples to another.
        i. Note: It helps if you use a sedimentary rock with larger clasts. Using sediment of the same size is also quite helpful.
        ii. It is also sometimes helpful to break a rock into smaller pieces; thus, introducing weathering.
3. Explain to students that they are going to play a game where they will simulate the movement around the rock cycle.
4. Explain the directions to the students. Using a board game analogy is quite useful here. All students start on Magma and progress around the board (rock cycle). Make sure that students are recording their "route" and know to repeat the activity three times.
5. Observe students during the exercise. Answer questions as needed.
6. Have students begin the questions as they finish.

Closure:

1. Have students complete the question sheet.
2. Discuss with students why some parts of the rock cycle cannot be observed.

Directions:

You are a piece of earth material traveling through the rock cycle. Starting from magma, roll the dice to determine your next step. Record your progress in a table for 20 steps. Repeat this again two more times.

Location	Dice	Go to:
Magma	Even	Cooling and solidification
	Odd	Magma (stay where you are)
Cooling and solidification	Even	Igneous Rock
	Odd	Cooling and Solidification (stay where you are)
Igneous	1 or 5	Weathering
	2 or 6	Metamorphism
	3 or 4	Melting
Weathering	Even	Sediment
	Odd	Weathering (stay where you are)
Sediment	Even	Lithification
	Odd	Sediment (stay where you are)
Lithification	Even	Sedimentary Rock
	Odd	Lithification (stay where you are)
Sedimentary Rock	1 or 5	Metamorphism
	2 or 6	Weathering
	3 or 4	Melting
Metamorphism	Even	Metamorphic Rock
	Odd	Metamorphism (stay where you are)
Metamorphic Rock	1 or 5	Melting
	2 or 6	Weathering
	3 or 4	Metamorphism
Melting	Even	Magma
	Odd	Melting (stay where you are)

Questions:

1. Where did you spend most of your time?

2. Why is the rock cycle called a cycle?

3. What are the possible directions a sedimentary rock can take in this cycle?

4. Did all of your classmates follow the same path?

5. Does every rock follow the same path in nature?

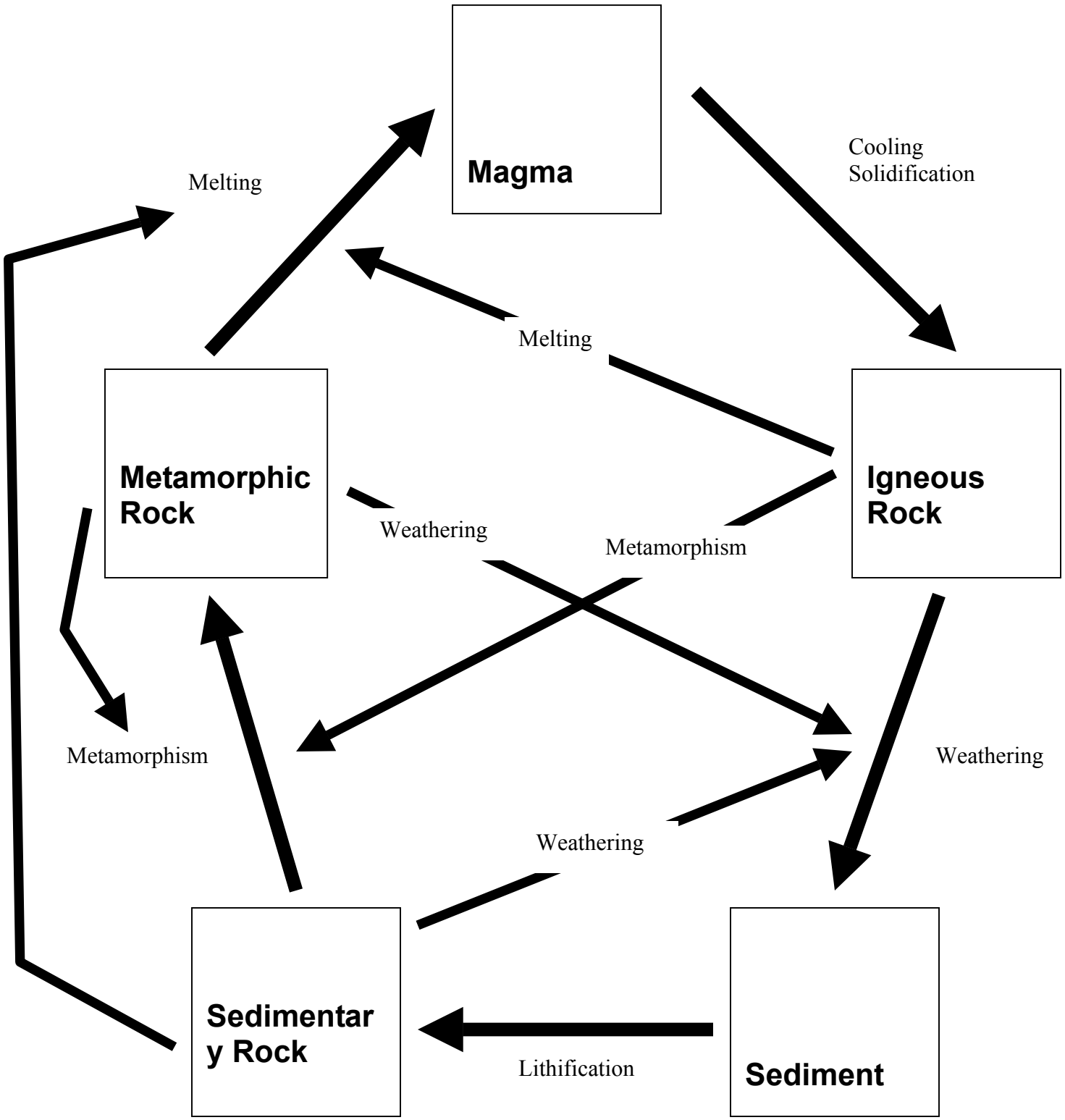
6. How much of the rock cycle can be observed? How much is inferred? List specific steps in your answer.

7. How might the movement of material through the rock cycle affect people?

8. Assuming that each roll required 200,000 years, determine the average time it took for each of the following steps to occur.
   Cooling to sediment:_____

   Weathering to Igneous rock:_____

   Metamorphic rock to weathering:_____



The Rock Cycle

The Crayola Cycle

Topic:

Metamorphic Rocks

Indiana State Standards:

7.3.9 Explain that sedimentary rock, when buried deep enough, may be reformed by pressure and heat[1], perhaps melting and recrystallizing[2] into different kinds of rock. Describe that these reformed rock layers may be forced up again to become land surface and even mountains, and subsequently erode.

7 Metamorphic rock

8 Igneous rock

Note: Footnotes added for clarification purposes. They do not exist in the Indiana State Standards.

Materials:

4-6 Crayons per student	Knife or Pocket pencil Sharpener	Aluminum foil
Hot Plate	Wax paper	Newspaper
Tongs	Plywood 18" x 18"	Goggles
Hot plate	Aluminum pan	Aprons

Background:

Lesson:

Weathering

Weathering is the process of breaking down rocks. It occurs at or near the Earth's surface. There are two types of weathering, Physical and Chemical.

1. Have students cover their work area with newspaper
2. Using a knife or pencil sharpener, have students shave four or six crayons into shavings. Pile the fragments by color on separate pieces of wax paper. It is often

easiest to have each group shave down a different color. Make sure that the students know they are "weathering" rock material.

3. Wrap the fragments by color in wax paper.
4. Depending on class level and remaining time, discuss the questions (attached as an appendix) or assign questions as homework.

Erosion

Weathering produces loose material that is subject to erosion. Erosion is often defined as the movement of weathered material. The material is transported by wind, water, or ice. Often, it accumulates in layers of loose material known as sediment. This is known as deposition. In addition, stratification can occur when different types of sediment cover one another.

1. Have each group of students place a sheet of Aluminum foil (approx. 10x18) on their work area.
2. In the center of the foil each student should drop his or her "rock fragments." This should be done sequentially i.e. student A then student B etc. When every student has "deposited" their fragments, have the students examine the pile carefully.
3. Carefully fold the foil over the fragments.
4. Depending on class level and remaining time, discuss the questions (attached as an appendix) or assign questions as homework.

Lithification and Sedimentary Rocks

Sedimentary rocks are comprised of sediment, which has been lithified. The process of lithification consists of two parts. First, compaction reduces the size and

number of spaces between fragments. Second cementation "glues" the fragments together.

1. Have students place the foil package between the two pieces of plywood.
2. Have the lightest student in class briefly step onto the board.
3. After removing the package from between the boards, have the students carefully open the foil and examine the "sedimentary rock."
4. Have students remove a small piece from the sedimentary rock. The remainder should be left in the foil package.
5. Depending on class level and remaining time, discuss the questions (attached as an appendix) or assign questions as homework.

Metamorphism and Metamorphic Rocks

Metamorphic rocks result when preexisting rocks are subjected to heat and pressure. However, melting does not occur. Often, metamorphic rocks appear to have flowed as a plastic material.

1. Have students place the foil package between two pieces of plywood.
2. Have a heavier student briefly stand atop the board.
3. Briefly place the foil package on a hot plate at low temperature.
4. Repeat steps one through three for an additional three times. Make sure to use the tongs after the package has been on the hot plate.
    a. Note: the temperature of the hot plate is sometimes difficult to identify. Ideally the temperature should be hot enough to allow the crayon to flow; however, it shouldn't be hot enough to completely melt the crayon. Every

brand of crayon tends to be different. Thus, some experimentation is required to find the correct temperature.

5. Place the package on the counter and allow it to cool.
6. While the package is cooling, discuss the questions. Have the students predict the answers for each question
7. Once the package is cool enough to handle, have students open and examine the newly formed "metamorphic rock."
8. Place part of the metamorphic rock in an aluminum tray. Store the remaining metamorphic rock and the previously saved sedimentary rock in a safe place.
9. Depending on class level and remaining time, discuss the questions (attached as an appendix) or assign questions as homework.

Igneous rock

Igneous rocks are formed from the cooling and solidification of molten rock (magma).

1. Place the aluminum tray atop the hot plate.
2. Carefully adjust the hot plate's temperature until the "rock" has melted. Be careful that the wax does not splatter. Goggles and Aprons are suggested for this part.
3. Turn off the hot plate and allow the "rock" to cool. Use the tongs to move the tray if necessary. The tray can be placed atop several layers of newspaper if needed.
4. While the tray is cooling, discuss the questions.

5. Once cooled, have the students compare the previously saved sedimentary and metamorphic rocks.

Assessment

A summative assessment has been included as part of the larger rock cycle unit.

Student Questions

Weathering

1. Are all weathered rock fragments in your pile the same size? Why or why not?
2. What have you observed about rock fragments in nature?
3. Where do rock fragments tend to collect?
4. How do rocks get smaller in size?
5. How might ice be an agent of weathering? How about a tree root?
6. Does mechanical weathering differ from chemical weathering? Which type of process does this activity represent?

Erosion and Deposition

1. Explain you action as an agent of erosion
2. Explain the process of erosion
3. What are deposition and stratification? What are some conditions that might control deposition?
4. Why are similar-sized rock fragments often found together?
5. Where could you find rock debris fragments in loose layers?

Lithification of Sediment

1. Describe the thickness now compared to when it was initially deposited on the foil
2. What happened to the spaces between the rock fragments?
3. Explain the difference between compaction and cementation
4. Does the activity done here represent compaction of cementation?

Metamorphism and Metamorphic Rocks

1. Describe the color-layer thickness, comparing metamorphic rock with sedimentary rock.
2. Describe the change in fragment shape.
3. Why did this change happen?

Igneous Rocks

1. What happened to the “rock” fragments when they were heated on the hot plate?
2. How does the igneous rock differ from the previously saved sedimentary and metamorphic rocks? Which type is easiest to break apart? Most difficult?