Earth Processes

Objectives:

- Students will learn about the rock cycle in more depth. They will come to understand the cyclical nature of the process and see that the crust is not static, but constantly changing.
- Students will understand the igneous rocks are formed from cooling liquid rock, and that crystalization is usually a part of that process.
- Students will explore the processes of weathering, erosion, deposition and lithification as they relate to the rock cycle and sedimentary rocks
- Students will gain an understanding of the forces needed to form metamorphic rocks from parent rock material, and where in the crust those forces are found.
- Students will make simple hypotheses about the origins of some landforms based on observing rock samples and maps.

I. Rock Cycle Redux

Materials: Whatever materials were used in the short introduction.

1. Divide the students in groups. Have them write or illustrate in some way their understanding of the rock cycle.

2. Students present their understandings to the class. Discuss the presentations, and address any problematic naive theories that may have developed.

II. Formed from Fire: Igneous Rock

Materials:

A large selection of intrusive and extrusive igneous rocks.
Hot plates
Good volcano video clip if not already used in plate tectonics section
Chart paper
Markers
Tape
Crystal making supplies as listed below

For Alum Crystals

3 cups water
1 cup granulated alum (two 1.9 oz. containers found in the spice section at the grocery store will suffice)
1 clear jar with lid
1 nail
hammer
cotton string
tape
weight such as a nail or paper clip

For Sugar Crystal

Saturated Sugar Solution
1 large clear jar or heat resistant cup
cotton string tied to paper clip (this works best if string is dipped into sugar water and rolled in sugar grains at least 24 hours beforehand)
pencil

For Charcoal Garden:

1/2 cup water
4 Tablespoons liquid bluing
4 Tablespoons ammonia
4 Tablespoons salt (this makes enough solution for 2 student groups to use in their cups
masking tape label
Aluminum Pie Plate
Charcoal Briquets
food coloring (optional)

For Epsom Salt Crystals

Epsom salt
masking tape to label
water
plastic spoons
small cups or beakers for mixing
small pie pans
food coloring

3. Ask students what they recall about igneous rocks. Discuss the origin of these rocks. Emphasize that every igneous rock started out as molten rock, lava or magma, then cooled.

4. If not already done in plate tectonics, show a good clip of lava so the students have a strong picture of molten rock in their minds.

5. Show the students igneous samples, discussing such characteristics as cooling rate and crystal size. Be sure to include samples of extremely fast cooling rocks such as obsidian and pumice. Explain what is meant by intrusive and extrusive rock

6. Explain to the students that they are going to make crystals. Choose one or more of the kinds of crystals from below. Either all the students can make the same kind, or two kinds, or you may set up stations around the room and they rotate. All the kinds are included, so that the teacher may choose from among them and organize the room as best suits the students' needs.

Crystal Growing Instructions

Alum Crystals
Procedure:

1. Punch a hole in the lid of a jar with a hammer and nail. Thread the string through hole in the lid, so the string reaches the bottom of the jar. Keep the string attached to lid by tying it to a nail or paper clip. On the opposite end of the string, tie another nail or paper clip as a weight.

2. Boil 3 cups of water. Pour 1 cup of alum into the jar and add the boiling water. Stir until dissolved.

3. Place the lid on the jar making sure the string hangs free. Tape the hole in the top of the lid completely closed. Shake jar well. Repeat twice more with 15 minute intervals. Wait one hour and shake again.

4. Let the jar rest undisturbed. In about 12 hours, crystals will have formed on the string and/or bottom of the jar.

5. If you wish the crystals on the string to continue to growing, take string out of solution and redissolve crystals that formed on the bottom of the jar. You can do this by heating the jar in a microwave on high for 8 minutes, then stir until solution is clear or pour the remaining solution and crystals out of the jar and into a pan to heat and stir until the solution is clear.

6. Let solution cool in the jar until it is warm, but not hot. Place the string of crystals back into the jar and close the lid tightly. Shake the jar and then let it rest over night. More alum from the solution will grow on the string of crystals.

Sugar Crystals
Procedure:

1. Pour sugar into boiling water. Stir until sugar is completely dissolved. Heat to 242 F (120 C)

2. Pour the solution into a jar to cool. Lower the paper clip end of the cotton string into the solution- about 1 inch from the bottom of the jar. Tie the string to a pencil and let the pencil rest on top of the jar. Let the jar rest undisturbed. Do not put the lid on the jar. If a crust forms on top of the solution, break it open. A thin stick can be used instead of string

Charcoal Garden
Procedure:

1. The teacher prepares the solution.

2. Students label their pie tins with masking tape. Place a few pieces of charcoal in the pie tin. Pour the solution into the pie tin, leaving about 1/2 " of solution on the bottom.

3. Set aside the pie tins so they will not be disturbed.

*You can prolong crystal growth by adding two more tablespoons of water and two more tablespoons of ammonia.

Epsom Salt Crystals
Procedure:

1. Pour 1 Tablespoon hot water into each cup.

2. Students add 1 teaspoon of Epsom salts and stir with spoon until crystals dissolve.

3. Keep adding more Epsom salt (1-2 more teaspoons) until the solution is saturated. Add food coloring if desired

4. Pour the Epsom salt solution into a small pie tin and set aside

5. Students make daily observations of their crystals until the crystals stop growing. Discuss the results

6. Brainstorm a list of questions about crystals that students feel they could answer with an experiment. (what happens if the solution isn't saturated, does the temperature of the solution

matter, does string or a stick work better in the solution, etc.). Write down questions on the chart paper.

7. Working singly or in pairs or groups, students choose a question and design an experiment to answer that question. After the experiment has been checked for safety by the teacher, the students then carry out the experiment.

III. From Here to There and Back Again: Sediments and Sedimentary Rock

A. Weathering

Materials:

1 rock with a crack in it
21 jagged stones
3 coffee cans with lids
Tape
Markers
Water
3 beakers
Paper towels
Vinegar or lemon juice
Chalk
4 Petri dishes
Soapless steel wool
Salt

1. Very briefly review sedimentary rocks with students. Reinforce that they are made from pieces of preexisting rock. Then explain that they are going to do several short demonstration labs that model how such a process might happen. Tell them that the first part of that process is called weathering, and it is the breaking up of rocks into smaller pieces, and that it can be mechanical or physical.

2. Mechanical Weathering

   Break Rocks with Water: Find a rock with a crack that can be filled with water. Put the rock with the water-filled crack into the freezer. After it has frozen completely, repeat the experiment until the rock eventually splits. When water freezes, it expands and this will crack the rock into pieces. This occurs mainly in areas that are warm during the day and freezing at night.

   Stream and Wave Tumbling: Get 21 rough, jagged stones that are all about the same size. Divide them into 3 piles, labeled 1, 2, and 3. Put each pile in a coffee can, also labeled 1, 2, and 3. Fill the cans half full with water, put the tops on and leave overnight. The next day, shake can 1 100 times, can 2 1,000 times and can 3 no times. Carefully pour the water from each can into a beaker labeled 1, 2, or 3, and put the stones on paper towels labeled 1, 2, and 3. Compare the water and stones. The stones will be more rounded the more they were shaken, and there will be more sediment in the the shaken cans, the most probably in can 2. This simulates the actions of stones being carried in a stream or by waves.

3. Chemical Weathering

   Acid Attack: Pour vinegar or lemon juice over a piece of chalk in a petri dish and watch it disappear slowly. Acid rain is formed when carbon dioxide and other gases from car and factory exhausts combine with rain. Acids can also be formed by decaying plant matter. Both of these weather or break down rocks as shown with the chalk.

Rust Away: Put a piece of steel wool (no soap) in each of three petri dishes. Pour equal amounts of water on two of them, leaving the third dry. Generously salt one of the two wet ones. Observe and compare for at least a week. When iron gets wet, oxidation speeds up, yielding more rust (iron oxide), a weaker material than the original steel. The salt speeds up the reaction even more.

4. Challenge the students to come up with a simulation for another aspect of mechanical or chemical weathering, carry it out, and demonstrate the results to the class.

B. Erosion and Deposition

Materials:

Stream table materials
Chart paper
Markers
File cards
Local USGS or other topographic maps

1. Explain briefly to students that erosion is moving weathered rock and soil particles from one place to another. Ask them to brainstorm ways that might happen. They will probably come up with various forms of water, such as streams and waves, may think of wind, but often forget gravity. A few may have heard of glaciers. List them all, explain very briefly as needed, and post the list.

2. Ask them if particles keep moving forever. Of course, they don't, and when they stop moving, they settle somewhere. Explain to the students that process of settling is called deposition, and that erosion and deposition go together in nature. Challenge the students to think of some examples of erosion and deposition and present their examples to the class.

3. To model erosion and deposition by streams and rivers, simple stream tables can be made very inexpensively. There are many many write ups of this both on line and in books, so they will not be repeated here. It is a very fruitful area of inquiry.

4. For many parts of the country, including here, past ice ages, have brought periods of glaciation. Divide the students in groups, and challenge them to research how glaciers have affected the landscape where they live. They will present their findings to the class. Discuss glacial features as a class, using topographic maps, which the students have learned to use earlier in the year.

5. Describe and explain erosion and deposition by gravity, ice, water and wind. Using visualizations and field study, identify examples of each.

6. Using visualizations and field study, identify a variety of land forms. Explain how each was formed. Predict what will happen to each as the cycle of weathering and erosion continues into the future.

7. In groups, students construct models of the earth's surface to show erosional and depositional features. Students present their models, explaining how their land forms came to be. They also predict what the area represented by their model might look like in the future, as weathering, erosion and deposition continue. In addition, students identify areas of possible human impact on their models.

8. In groups, give students a selection of sediments, such as mud, sand, pebbles, clay, and shells. Have students observe the sediments with the aid of hand lenses and microscopes. Record observations, and hypothesize what environment the sediments may have formed in. Then, give students rock samples of sedimentary rocks that were formed from similar sediments. Students observe the rocks, and match the sediments to the rocks that were formed from that type of

sediment. Challenge the students to hypothesize what kinds of environments may have existed for those rocks to form.

9. Take a weathering, erosion and depostion walk around the school. Give each pair of students several file cards to write down locations and what was happening at each location. Have students share findings with each other. Interested students can write a guided tour to the neighborhood.

C. Lithification

Discuss with the class the relationship between all the sediments explored in the last few activities and sedimentary rocks. Use a video clip or some other interesting way to briefly explain lithification and what part it plays in the rock cycle.

IV. Changes, changes: Metamorphic Rock

1. Have several paired samples of metamorphic rocks and parent rocks. Some good examples might be granite and a matching gneiss, limestone and marble, conglomerate and metaconglomerate, and shale, slate and schist. Challenge the students to find similarities and differences between the pairs.

2. Remind the students that metamorphic means changed. Again challenge them: this time to think of where in the crust there might be enough heat and or pressure to change the form of one rock to another without completely melting it.

3. Show them a rock with some contact metamorphism and ask them to explain what they think happened.

V. Putting It All Together: Reading the Landscape

4. Discuss with students: now that we know rocks and minerals and how they are formed. How can we use that information to “read” or “reconstruct” the history of the Earth’s crust?

5. The first step is to see under the surface. Elicit from students when we can actually do that – roadcuts, canyons, natural cliffs and bluffs, etc.

   Explain to them that when geologists cannot find such natural occurrences, they take “core samples.”

   Do the classic core sample lab. Directions are readily available online or in many geology/earth science textbooks.

   Things to note about this activity: Use a straw as a core sample, and a dowel or pencil to push the core sample out of the straw. Also, whatever you use (cake, jell-o, playdough) must be in uneven layers and must be in some sort of opaque container. Put something on the surface, such as frosting, cookie crumbs, sugar, etc.

   Here are the general instructions:

   a. Students predict by making a drawing what they think the interior of their sample looks like.
   b. Take the core samples. Mark in journal/lab notebook where you took your core samples from and number them.
   c. Draw each of the numbered core samples. Carefully label top and bottom.

d. Make a second prediction, based on the core samples.
e. Cut open the sample and draw what it actually looks like. Again, label top and bottom.
f. Discuss results as a class.

6. Simple lithographic symbols and how to use them.

   Take out final diagram from previous activity. Real world geologists use cross-sections like this using standard lithographic symbols.

   Give students the handout with the key for the rock types. Explain the different rock types, and show samples if you have them.

   Give students the landform puzzle sheet and challenge them to figure out what each represents. For each example, have them "write the story" of what happened. Discuss as a class. After a class discussion, hand them the challenge puzzle, and have them write the story.

7. Field trips

   There are many good field trips in most areas where you can show great real life examples of the geology ideas the students have been studying. Below is a short list of places in the Boston area where you might want to take your students. There are, of course, many other trips you might want to research. Among those are: The Blue Hills, Nahant, Middlesex Fells, Worlds' End in Nantasket, Boston Harbor Islands.

   a. Around your school! Consider terrain, landforms, choice of building materials, weathering, erosion and deposition. The nice thing about observing geology at the school is kids can see how immediately accessible these ideas arre.
   b. Intersection of Beacon St. and Bishopsgate Road in Newton (just past Hammond Pond Parkway, going outbound). A beautiful outcrop of Cambridge mudstone showing layering and some deformation, capped with Roxbury Conglomerate.
   c. Hammond Reservation/ Webster Conservation Area Ledges– about 200 yards south of Beacon Street on the right. (Park on the shoulder - being careful of poison ivy!) Enter at trail marked with a white sign; follow trail around the back of the ledges. When trail forks, go right. You'll see the exposed outcrop about 30 yards in front of you. In the summer the area can be very overgrown, so continue to watch for poison ivy! (Bring bugspray, too!)

      At this site you'll see loads of Roxbury conglomerate interlayered with sandstone; the sandstone is full of feldspar and quartz. You can see cross bedding and rippling from ancient river flow.
   d. Bloomingdale's parking lot in Chestnut Hill Mall
      i. Upper parking lot, opposite the Crate and Barrel entrance. A nice outcrop showing layered argillite (a slightly metamorphosed mudstone). In the area you can see contact between the argillite and the Roxbury Conglomerate.
      ii. Glacial scarring on smoothed conglomerate criss-crossed with construction scoring (Although it may be hard to tell without close inspection that this is actually conglomerate as it's been smoothed). The rock can be found just over the guardrail, just around the corner behind the bus stop next to Bloomingdale's. It's fun to try to figure out which scars came from the glaciers and which came from the construction equipment.
      iii. Huge outcrop of Roxbury Conglomerate (Chestnut Hill Mall lower parking lot; just east of the pond). This outcrop was clearly blasted away, and shows about 50' of exposed rock. Lots of nice fracturing and different pebble size to observe.
   e. Dane Park in south Brookline (Hammond Stree, opposite Beaver Country Day School). This is a nice spot to see volcanic tuff and altered basalt (part of the "Brighton

Volcanics”). There are volcanic “bombs” embedded in some of the deposits. There is a nice little geology trail you can follow.

f. Arnold Arboretum (Bussey Street, about 100 yards south of Walter Street, on the right heading south. Walk along the upper edge of an old quarry – now used to store piles of wood chips – and you can follow a dirt road into the quarry itself). You’ll see Squantum “Tillite” – consolidated glacial till. Further back in the quarry you’ll see foliation from metamorphism.

VI. Finalize Pet Rock Biography

Suggested outline for the Pet Rock Biography:

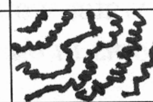
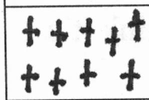
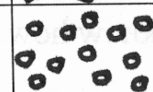
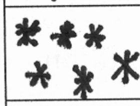
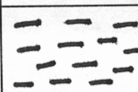
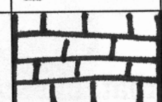
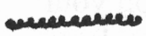
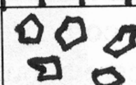
1. As you proceed through activities around the basic geologic processes, periodically come back to the "pet rock". What general rock type is it? (Metamorphic, Igneous, Sedimentary or some combination) What mineral(s) might be present?

2. Identification of the rock – go through a process of having the students identify the specific rock type. They may very well have a great deal of trouble (as may you!), but the point is to go back to evidence, make it clear what's an educated guess as opposed to a more certain identification. This is an important time to bring out whatever rock identification books and keys you can find. There are many online guides as well (be careful to check the sources!). It may be that the student has to go with a "best guess" as opposed to a definitive identification.

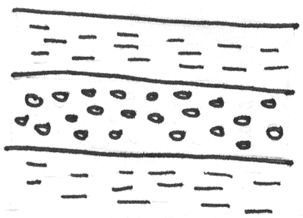
3. Going with their identification, what might be the origin of their rock? Do they know if the rock is local? What geologic process might explain *where* and *when* this rock was formed? It's important that students understand that there is no real "right" answer here – there are better answers based on evidence, but given the limited information we're not asking them to produce the actual true history of this rock. Again, we're training them to use evidence to justify a hypothesis.

4. Have students choose their format to write up the biography (we've left the details out here since classes vary widely) and proceed to have them complete the assignment.

Key to Rock Types

Symbol	Rock Type	Symbol	Rock Type
	Intrusive Igneous		Schist and/or Gneiss
	Intrusive Igneous		Conglomerate
	Intrusive Igneous		Sandstone
	Intrusive Igneous		Shale
	Lava Flow		Limestone
	Baked Rock, partially or fully metamorphosed		Breccia

Landform Puzzles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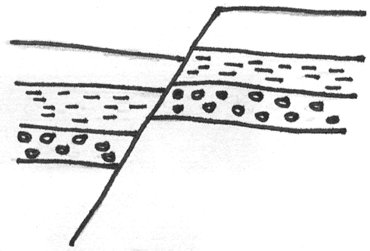
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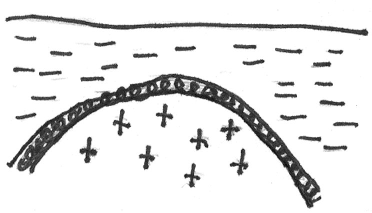
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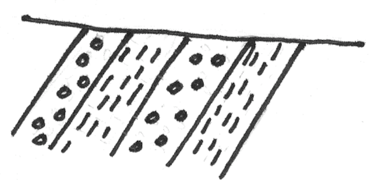
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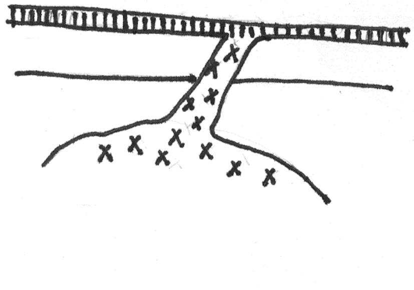
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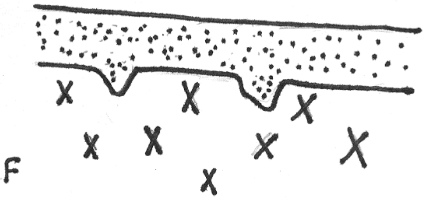
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Challenge Puzzle!