Rocks Rock!

Rock cycle and igneous rock formation module

Authors: Tara Cornelisse (GK-12 Graduate Fellow), PhD Candidate, Environmental Studies Department, University of California Santa Cruz

Field-tested with: the 9th -grade students of Integrated Science 1, Watsonville High School, Watsonville, California, Fall 2011.

Concepts: Rock cycle, extrusive rocks, intrusive rocks, rock formation processes, igneous rock formation, crystal size, hypothesis development

Skills: Understanding a computer tutorial; Observation of rock characteristics; Hypothesis development based on observation; Experiment based on hypothesis; Explaining results.

Module Type: Computer activity, lab experiment, and discussion

Duration: 110-minute class session

Key materials:
- Computers (7-8)
- Rock samples
- Phenyl Salicylate
- Candles
- Spoons
- Wax paper
- Ice
- Hand warmers
- Worksheets and lab questions (included)

Science Education Standards:

National: Science As Inquiry; Earth and Space Science; Science and Technology

California: Earth Sciences; Investigation and Experimentation

Overview: In this 1-day module, students use Houghton-Mifflin's interactive online textbook, Exploring Earth, to learn about the rock cycle, the different types of rocks and how rocks are formed. They then look specifically at igneous rocks and learn how crystals develop and vary with temperature of cooling. Based on observations of cooling crystals, students develop a hypothesis, in groups, and carry out experiments to test their hypotheses. Students then compare real samples of different igneous rocks, using their results to interpret how the rock samples were cooled, answering questions about intrusive and extrusive rock formation processes.

This project is an opportunity for students to:
- Develop computer skills by following a tutorial in order to answer questions
- Observe rock characteristics and create a hypothesis about processes of formation
- Carry out experimental rock formation to test their hypotheses
- Analyze their results based on known rock formation processes
- Compare experimental results to real world rock samples

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For more information, see: http://scwibles.ucsc.edu

Background for Teachers

Rock Formation: effects of temperature

The rock cycle consists of metamorphic, igneous, and sedimentary rocks. Pressure and temperature are important in the formation of each type of rock. Igneous rock in particular can be formed **intrusively** (underground at higher temperatures) or **extrusively** (above ground at lower temperatures). Intrusive rocks cool more slowly, giving crystals more time to grow large. Extrusive rocks cool quickly, creating smaller crystals within the igneous rock (Allison 2009). In this module, students create their own igneous rocks and, by varying temperature, are able to view the variation in crystal formation first hand.

Science Education Standards Addressed: This module focuses on the rock cycle and igneous rock formation and addresses NSES standards A. Science As Inquiry (p.175-176); D. Earth and Space Science (p. 187-190); E. Science and Technology (p.192-193), as well as the following SCSCPS content standards:

Earth Sciences, 3. Plate tectonics operating over geologic time has changed the patterns of land, sea, and mountains on Earth's surface. As the basis for understanding this concept:

c. *Students know* how to explain the properties of rocks based on the physical and chemical conditions in which they formed, including plate tectonic processes.

Investigation and Experimentation, 1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing content in the other four strands, students should develop their own questions and perform investigations. Students will:

a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.

c. Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.

d. Formulate explanations by using logic and evidence.

i. Analyze the locations, sequences, or time intervals that are characteristic of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).

NSES (http://www.nap.edu/catalog/4962.html)
SCSCPS (http://www.cde.ca.gov/be/st/ss/documents/sciencestnd.pdf);

The Rock Cycle and Igneous Rock Formation

The rock cycle consists of the formation and erosion of the three types of rocks: metamorphic, igneous, and sedimentary. One version of the cycle starts out with a volcanic eruption causing magma to flow out onto the Earth's surface. This magma (called lava when on the Earth's surface) cools to form **igneous rock**. This igneous rock is washed down stream with rain and water, where it piles up. Over time, pressure cements the rock together to form **sedimentary rock**. With plate tectonic activities such as subduction, sedimentary rock is dragged down towards the Earth's core and exposed to high temperature and pressure that condenses the rock into **metamorphic rock**. Metamorphic rock is then exposed to such high temperatures that it melts to form magma, starting the rock cycle all over again. This version forms the basis for the online computer tutorial, The Rock Cycle. This is a chapter from an online textbook, Exploring Earth, designed to accompany Earth Science, the textbook by Spaulding and Namowitz (both published by McDougal Littel/Houghton Mifflin).

Igneous rocks, specifically, can form intrusively or extrusively, as described above in the first "Background for teachers" section, **Rock Formation: effects of temperature**. The size of crystals in igneous rocks vary with temperature of cooling and this cooling and crystal formation process is visible with the naked eye using a chemical called phenyl salicylate, or salol. Salol comes in powder form but when heated with a candle becomes a liquid. When this liquid is allowed to cool, a rock like structure forms slowly; the size of the crystals that form varies depending on the temperature at which it is cooled. These properties allow students to watch the rock formation process happen before their eyes and create and test hypotheses about how temperature affects crystal formation.

Once students form the "igneous" rocks and observe crystal formation at different cooling temperatures [cold (fast cooling, small crystals), room temperature (medium crystals), and warm (slow cooling, large crystals)] they will be able to compare the crystal sizes in real igneous rock samples and determine if the samples are intrusive (large crystals, i.e. Granite and Gabbro) or extrusive (small crystals, i.e. Basalt and Rhyolite).

Common Student Misconceptions and Risks:

Students will immediately want to keep their "rocks" formed using the salol. This is not possible, unfortunately, because while minimally toxic, salol can be toxic if consumed. Teachers can keep the crystals on display in the classroom, however. Also, make sure when getting ready to pour the "magma" (i.e., melted salol), the students first create a bowl-like shape out of their wax paper to cradle the cooling salol, otherwise it will spill along the sides. Be sure to remind students to examine the crystal formation process and compare it with crystals formed at room temperature (this is done as a demo).

Project Description

Materials:

- Computers (7-8, one per group of 3-4 students), either in the classroom or in a computer lab.
- Rock samples sets (7-8, one set per group of 3-4 students) containing 4 igneous rocks: Granite, Basalt, Rhyolite, and Gabbro; plus 3 sedimentary rocks (optional): Mudstone, Limestone, and Conglomerate. These can be obtained from a local university geology department OR purchased from Ward's Natural Science website (http://wardsci.com/search.asp?t=ss&ss=rocks&x=0&y=0)
- Phenyl Salicylate, 250g- can order from Ward's Natural Science (http://wardsci.com/product.asp?pn=IG0015440)
- Tea light Candles, 1 per student group
- Lighter (teacher uses only)
- Spoons, 1 per student group
- Wax paper, 1 roll
- Ice cubes, 1 per group
- Hand warmers, such as Grabber Hand Warmers from www.rei.com, 1 per group
- Computer tutorial worksheets, 1 per student (see below)
- Lab worksheet with pre and post-lab questions, 1 per student (see below)

Preparation:

- The day before the lab put a tray of ice cubes into the freezer.
- Print and make copies of both the computer tutorial worksheet and lab worksheets for each student.
- Because of time constraints, before students enter the classroom or computer lab, start all computers and open each to the rock cycle tutorial website: The Rock Cycle.
- Create 7-8 stations (one for each group of 4 students) with the rock samples on a labeled piece of paper (see below) at each station.
- Set out the lab materials: hand warmers, phenyl salicylate, spoons, candles, and wax paper, but keep ice cubes in the freezer until ready to use.
- Under a document camera or overhead projector, put a piece of wax paper, candle, and spoon with some phenyl salicylate, and lighter for the teaching demo.
- At the start of the class, break the students up into groups of 3-4.

Timeline:

5 minutes	Introduce the plan for the day
5 minutes	Introduce the computer tutorial, handout the worksheet, and demo how to start the computer tutorial
5 minutes	Break students up into groups of 3-4

30 minutes	Computer tutorial
3 minutes	Collect Computer tutorial worksheets and instruct students to go with their groups to an open station (at desks) with a set of rock samples.
10 minutes	Demo igneous rock creation and discuss crystal formation process using rock samples.
5 minutes	Allow groups to brainstorm hypothesis and experiment
2 minutes	Introduce lab materials and potential procedures
30 minutes	Conduct lab and help students with crystal observation/ lab questions
5 minutes	Clean up
10 minutes	Post-lab discussion

Procedure:

Introduce the plan for the day by telling the students that today we are going to learn about the rock cycle by completing an online computer tutorial, which is a little like a computer game. Then we are actually going to create our own igneous rocks and learn about how temperature affects crystal formation.

Pass out the computer tutorial worksheet (see below). Then, introduce the computer tutorial by demonstrating how to proceed through the tutorial. Ideally, show the students how to complete it by answering the first question or two with the whole class. Break students up into groups of 3-4 and assign them to a computer. Once all groups are at a computer, instruct the students to begin the tutorial, allowing 30 minutes for completion. Walk around from group to group to help answer any questions.

When the 30 minutes are up, collect the completed Computer tutorial worksheets and instruct students to go with their groups to an open station (at the desks) with a set of rock samples. Before beginning the lab, ask the whole class, "what are the three types of rocks" (sedimentary, metamorphic, and igneous). Then ask them how igneous rocks are formed (by cooling lava or magma) and tell them that they are going to create igneous rocks by cooling magma.

Demonstrate how to create "igneous" rocks from the phenyl salicylate using an overhead projector or document camera so the students can see what you are doing. This is done by taking a spoonful of phenyl salicylate and then melting it over a lit candle until it is all liquid, or "magma". Once the phenyl salicylate is melted, pour it over the wax paper boat and allow it to cool. While it is cooling discuss the crystal formation process with the class.

Ask the students "what is happening to the magma?" They will answer, "cooling", which is correct. Also ask them "what is forming?" Depending on where you are in the Earth Science unit, they may be able to answer "crystals" but if not will answering something to that effect that you can then use to expand upon. Ask them what they think will happen if you sped up the cooling? Or slowed down the cooling? Discuss how crystals are bigger the more time they have to form. If the magma cools at a faster rate (at a colder temperature), the crystals don't have much time to grow, so they are smaller. If the magma cools at a slower rate (at a higher temperature), the crystals have more time to grow and so are larger. Discuss the difference between intrusive and extrusive rocks and have them identify which is an example of each from their igneous rock samples. Have students answer the first four questions on the lab worksheet (see below). Once students have answered the first four questions on the lab worksheet, tell them about the materials they have available to cool the magma quickly (ice cubes) or slowly (hand warmers). Next, give the groups five minutes to brainstorm a hypothesis about crystal formation and temperature as well as how to test that hypothesis.

Once all groups have a hypothesis and potential experimental procedure, if so desired, demonstrate how to create a boat-like structure out of the wax paper over both an ice cube and hand warmer and remind the students that if they don't do that, the magma will spill over. Check that each group has an experimental plan and then allow students to get lab materials. Go around to each group with the container of phenyl salicylate and a lighter to get the started with melting their magma.

Allow the students 30 minutes to conduct the lab (the crystal will take about 10 or 30 minutes to cool completely when using the ice and warmers, respectively). While they are observing the crystal formation, encourage them to answer questions 1-4 on the second page of the lab. Also, remind them to compare their crystal with the demo you did at room temperature or other student groups who are cooling their rocks at different temperatures. Some student groups will have enough time and organization to conduct the rock formation using both the ice cube and hand warmer; others will only have time for one method of crystal formation. After the lab is complete, instruct students to clean up their stations and return all lab materials (except the rock samples and their newly formed igneous rocks).

Pick a particularly good example of crystals created by fast cooling (small crystals) and one created by slow cooling (large crystals) and put those examples under the document camera next to the crystal created at room temperature (medium-sized crystals) and label them "ice", "warmer", "room", respectively. By comparing the three crystals side by side, the effect of temperature on crystal formation is clearly visible and sets you up for a post-lab discussion. Conclude the lab and activity with a discussion directed by the post-lab discussion questions. Be sure to use the rock samples and their lab observations to discuss intrusive and extrusive rock formation.

Starting Point For Inquiry:

In this lab, the starting point for inquiry is the discussion that follows the demonstration of turning phenyl salicylate into "magma" and cooling it into an "igneous" rock. While the demonstration rock is cooling, students will immediately begin to see crystallization. This visual gets students interested and with the visual hook, the teacher can begin to discuss how the crystallization would be different if the magma was cooled differently. By using the real igneous rock samples in front of the students, they can begin to see how real rocks are affected by cooling at different temperatures. With that introduction and interest, students are then instructed to create their own hypothesis about crystal formation and temperature as well as their own experimental procedure to test their hypothesis. This inquiry based thinking is followed through when the students conduct experiments to test their hypotheses.

Assessment Methods:

Teachers should use the computer tutorial worksheet as well as lab questions to assess the students. Teachers should also keep track of participation in the hypothesis formation and lab, as well as in the post-lab discussion.

Appendices

Computer lab tutorial: If the above "Rock Cycle" link does not work to bring up the tutorial, go to www.classzone.com. On the home page, under subject select "high school" as the column and "science" as the row. Select California as the state and then press "go" under "find your book". At the next screen click on the "Earth Science" book. Then click on "Go to the Exploring Earth Website". Once there, click the top left-hand button that says "Investigations". Scroll down to "Chapter 6." The tutorial is the first link under Chapter 6: How Do Rocks Undergo Change? Keycode: ES0602. The tutorial will begin. There are three main pages in the tutorial—to advance through it, click the arrow buttons at the top or bottom corners of the page. But notice that the first page is a series of interactive animations, which are advanced by clicking on different parts of the illustration, and then closing the pop-up window.

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Worksheets and Answer Keys (see attached)

Computer Tutorial Worksheet: "Rock Cycle!"
Computer Tutorial Answer Key
Igneous Rock Formation Lab Worksheet: "Formation of Igneous Rocks!"
Igneous Lab Answer Key

Reference List

Allison, Mead A. (2009) Earth Science Holt McDougal, Houghton Mifflin Harcourt Publishing Company, Riverside. www.classzone.com

Gaboardi, Mabry (2004). Igneous Rocks. Florida State University GK-12 Fellowship Program: http://gk12.bio.fsu.edu/earth.html