SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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National Science Teachers Association

SCOPE, SEQUENCE, and COORDINATION

National Science Education Standard—Earth and Space

Energy in the Earth System

The outward transfer of Earth's internal heat drives convection circulation in the mantle that propels the crustal plates comprising Earth's surface across the face of the globe.

Heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents.

Teacher Materials

Learning Sequence Item:

940

Density of Rocks

March 1996
Adapted by: Brett Pyle

Convection in Earth's Mantle, Atmosphere, and Oceans: their Sources and Effects. Experiments dealing with heat capacity of water would be helpful to demonstrate the heat reservoir nature of the ocean. *(Earth and Space Sciences, A Framework for High School Science Education, p. 138.)*

Contents

This micro-unit was adapted by **Brett Pyle** (Grady Middle School, Houston)

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Learning Sequence

Convection in Earth's Mantle, Atmosphere, and Oceans: their Sources and Effects. Experiments dealing with heat capacity of water would be helpful to demonstrate the heat reservoir nature of the ocean. *(Earth and Space Sciences, A Framework for High School Science Education, p. 138.)*

Science as Inquiry	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
This Rock Is So Dense **Activity 1** Continental Blocks **Activity 2** Getting into Hot Water **Activity 3** Down by the Sea **Activity 4** Cooling **Assessment 3** The Dynamic Earth **Reading 2** The Midas Volcano **Reading 3** Volcanic Double Whammies **Reading 4**	The Problem of Land Subsidence **Reading 1**	Climate Factor **Assessments 1, 2** Cooling **Assessment 3**	

Suggested Sequence of Events

Event #1

Lab Activity

1. This Rock Is So Dense (one hour)

Alternative or Additional Experiments

2. Continental Blocks (45 minutes)

Event #2

Lab Activity

3. Getting into Hot Water (one hour)

Alternative or Additional Experiments

4. Down by the Sea (one hour)

Event #3

Readings from Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives, and History and Nature of Science

Students select two or three from the following:

Reading 1 The Problem of Land Subsidence
Reading 2 The Dynamic Earth
Reading 3 The Midas Volcano
Reading 4 Down by the Sea

Readings can be found in the student version of this publication.

Assessment items are at the back of this volume.

Assessment Recommendations

This teacher materials packet contains a few items suggested for classroom assessment. Often, three types of items are included. Some have been tested and reviewed, but not all.

1. Multiple choice questions accompanied by short essays, called justification, that allow teachers to find out if students really understand their selections on the multiple choice.

2. Open-ended questions asking for essay reponses.

3. Suggestions for performance tasks, usually including laboratory work, questions to be answered, data to be graphed and processed, and inferences to be made. Some tasks include proposals for student design of such tasks. These may sometimes closely resemble a good laboratory task, since the best types of laboratories are assessing student skills and performance at all times. Special assessment tasks will not be needed if measures such as questions, tabulations, graphs, calculations, etc., are incorporated into regular lab activities.

Teachers are encouraged to make changes in these items to suit their own classroom situations and to develop further items of their own, hopefully finding inspiration in the models we have provided. We hope you may consider adding your best items to our pool. We also will be very pleased to hear of proposed revisions to our items when you think they are needed.

Teacher Sheet

Science as Inquiry

This Rock Is So Dense!

Relate the densities of representative rock types for the core, mantle, and crust to the layered structure of the earth.

Materials:

Per lab group:

overflow container
graduated cylinder
pan balance
samples of peridotite, basalt, granite, and iron
water
kite string

Procedure:

Give each lab group the samples of granite, peridotite, basalt, and iron. Students will determine the density of each of the samples. They should determine the mass of each sample first, while samples are still dry. They will then use water displacement to determine the volume. If they have not used this method before, have them refer to the technique sheet. After the students have completed the density measurements and calculations they will use the chart on the student sheet and their data to complete the questions.

Background:

The samples used are representative of the various layers within the earth. Students should be encouraged to be as accurate as possible in their density measurements. Some densities are fairly close (particularly oceanic and continental crust), so experimental error must be minimized.

The average densities for the various layers in the earth are as follows:

continental crust	2.7 gm/cm^3
oceanic crust	3.0 gm/cm^3
mantle	4.5 gm/cm^3
core	10–13 gm/cm^3

The densities of the granite, basalt, and peridotite should correlate quite well with the densities of the first three layers respectively in the chart above. Iron, however, has a density of 7.8 gm/cm^3, which is significantly less than the core density. The difference is due to the much greater pressures at the core, which significantly increase the density.

Further Variations:

After students have completed the lab work, you may wish to show them a column of liquids of various densities that shows layering. This may help them visualize the separation of substances based on density.

Adapted from:

Abramson, Donald D. *Mastering Basic Skills in Science*. New York: AMSCO School Publications, 1989.

Kirkland, B., Kocurek, G., and Mosher, S. *Earth, Wind and Fire*. Dubuque, Iowa: Kendall/Hunt Publishing Co., 1995.

Science as Inquiry

Continental Blocks

Examine the reasons behind the varying thickness of continental crust.

Materials:

Per lab group:
five wood blocks approximately 1” × 4” × 8”
tub or pan for water (clear if possible)
pan balance
ruler

Procedure:

Have students determine the density of one of the wood blocks. Based on the density, they should be able to explain why the wood will float in the water. Explain to them that the wooden blocks and the water will be used to simulate continental crust and mantle. They could be asked which will represent each rock type and why. It should be stressed to students that the mantle is not liquid (like the water we are using to simulate it) but rather a plastic solid. Silly Putty™ can be used as a good analogy of a solid-like material that will flow over time.

Once students have determined the density of the wood they should place three blocks into a pan of water (Figure 1). The wood represents a piece of continental crust with the water underneath representing the mantle. Have students “build” a mountain range by first adding one block and then a second block on top of the middle block (Figure 2). They should record drawings and observations of what happens at each stage on their data sheet. Have them pay particular attention to the amount of wood that is above and below the waterline.

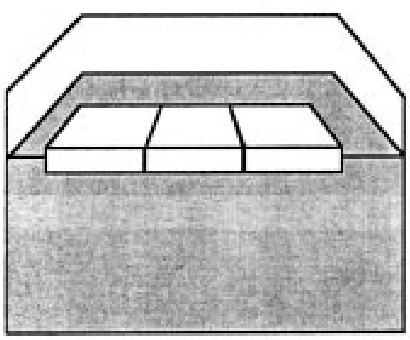


Figure 1. Blocks floating in water representing continental crust.

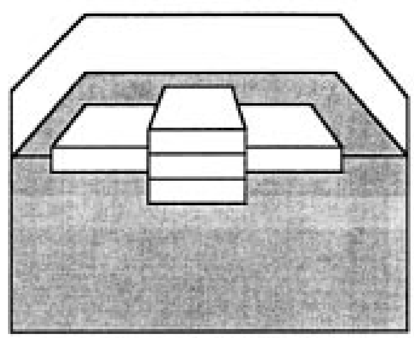


Figure 2. Addition of two wood blocks to simulate a mountain range.

Students should recognize that the density of the wood and the density of the water will determine how much of the wood is above the waterline. If the wood has a density of 0.70, then 70% of the block will be below the surface of the water and 30 % will be above the water. This ratio will remain constant no matter how many blocks are stacked on top of each other. Students can then be led to the conclusion that the continental crust will be thickest in places where the crust sticks up most above the mantle-crust boundary, i.e., under mountain ranges.

Next ask the students why mountain ranges are still standing after millions of years of erosional activity. Have them then remove the top block off of their “mountain range.” Are the “mountains” still rising above the level of the surrounding “plains” of the continent? Have students make observations of what they see occurring.

Background:

The blocks of wood used in this experiment can be of any wood as long as you use the same wood for all blocks (and as long as it floats!). Common white pine will work and is inexpensive. Two pieces of 1” × 8” × 8’ wood will provide 48 blocks after it is cut.

The reason that the wood maintains the same ratio of wood above water vs. below water has to do with the buoyancy of the wood. As blocks are removed from the top, the remaining blocks rise up and readjust so that the balance is maintained. In geological terms this is known as isostatic adjustment. This is not one of the primary focuses of this lab but can be addressed if time allows. This also explains how mountain ranges remain standing after millions of years of erosion. Although the tops of the mountains will eventually become rounded (the Appalachians for example) they do not completely level off because the crust is rising as erosion removes material from the top.

Further Variations:

If you address isostasy in this lab you can also discuss some of the results of the continental plates shifting or rising as rock is eroded from their surface. It has been theorized that this type of readjustment is responsible for some earthquakes that occur far away from plate boundaries. This has been one of the reasons proposed for the New Madrid earthquake, whose epicenter was in Missouri.

Adapted from NAGT Crustal Evolution Education Project, *Continents and Ocean Basins: Floaters and Sinkers.* Rochester, N.Y.: Ward’s Natural Science Establishment, Inc., 1979.

Science as Inquiry

Getting into Hot Water

Compare the heating and cooling rates of water vs. sand to examine the heat reservoir nature of large bodies of water.

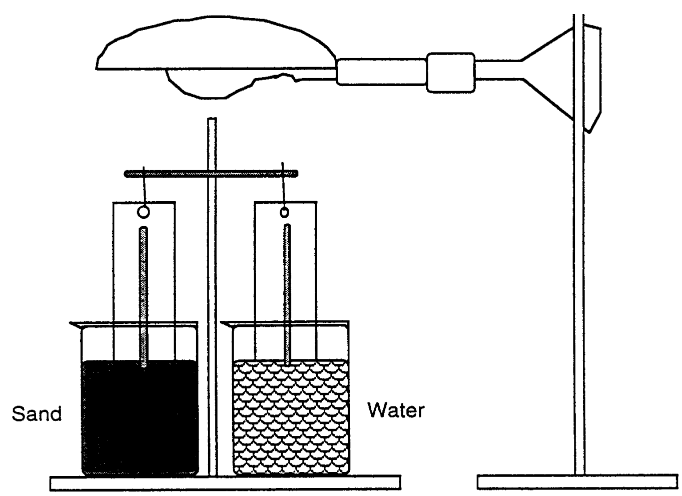
Materials:

Per lab group:

two Styrofoam™ cups
two thermometers
two ring stands
one ring clamp
one portable lamp socket with 200-watt bulb
pan balance
graduated cylinder
sand
water
string

Procedure:

Have students measure 200 grams of sand and place it in a Styrofoam cup. Have them then measure 200 grams (= 200 mL) of water and place it in the second Styrofoam cup. Using string attached to the ring on a ring stand, they should suspend the two thermometers so that the bulb of each thermometer is just below the surface of the contents of each cup. They should then place the lamp directly above the cups (see figure).



Once the setup is completed, students should record the starting temperature of the sand and the water. The starting temperatures should be the same. If you are using water right out of the tap it may be cooler than room temperature. You will need to allow this water to come to room temperature before starting. To avoid this problem, have some water in a bucket or aquarium for students to use that has been sitting at room temperature for some time. Next students should turn on the lamp and record the temperature of the water and the sand each minute for 15 minutes. The lamps are then turned off and students record the temperature of the sand and the water each minute for 15 more minutes. Have them plot this information on a graph.

Background:

Make sure that the sand used is completely dry. If there is moisture in the sand it can affect the results. It is also important that the cups have equal masses of material. The sand should be measured on a pan balance and not simply fill the beaker to the 200 mL line. The concept of specific heat is defined as the energy required to raise 1 gram of a substance 1 ºC.

This lab deals with the concept of specific heat and how the specific heat of water is different from that of sand (and by extension land). Water has a high specific heat so it heats up slowly and cools down slowly. The implications of these differences will be explored further in the next activity.

Further Variations:

This experiment can be extended to larger amounts of water. The ideal situation would involve a pond or outdoor pool where temperatures could be taken at regular intervals during the day and compared with temperatures of the surrounding ground. On a smaller scale this extension could be done with buckets of sand and water placed outside the classroom. Another option would be to compare the average monthly seawater temperatures to average land temperatures of a coastal city over the course of a year.

Adapted from Ford, B.A. and P. Smith, P.S. *Project Earth Science: Physical Oceanography.* Arlington, Va.: National Science Teachers Association, 1995.

Teacher Sheet

Science as Inquiry

Down by the Sea

Observe the effects of oceans on climate and temperature.

Materials:

Per student:
graph paper
ruler
map of United States

Procedure:

Students graph the variations in average monthly temperatures of locations around the globe. They then examine the temperature variations of the different locations and determine what effects large bodies of water have on climate, specifically temperature and rainfall.

Have students use the data contained in the table on the student sheet to construct a line graph of average monthly temperatures for each city. They should also use the map and list other pertinent information about the city, such as latitude, proximity to large bodies of water, elevation, average yearly rainfall, etc.

Background:

There are many factors that can affect the climate of a particular city. In this exercise you want to focus primarily on the monthly temperatures compared to proximity to the ocean. Students should notice that the overall range of temperature is less in coastal cities. Recalling the information from Activity 3, water takes longer to heat up and longer to cool down than land as the surrounding air temperature changes. In this way the oceans, as well as large lakes, act as temperature buffers for the surrounding land. Inland areas experience more temperature variation between summer and winter.

Further Variations:

You may wish to have students look up their own temperature information. You can provide them with maps and almanacs and have them choose two cities to compare. They should pick one coastal city and one inland city. You may wish to discuss beforehand why it is important to choose cities at approximately the same latitude. Information on monthly temperatures of U.S. and Canadian cities can be found in most world almanacs. For cities around the world, travel guides may be a good source of information.

Adapted from *The World Almanac & Book of Facts* (H.U. Lane, Ed.). New York: Newspaper Enterprise Association, Inc., 1985.

Science in Personal and
Social Perspectives

Climate Factor

Item:
If you were to choose to live in an area where the temperature changes the least from morning to evening and from season to season, where would you choose to live?

A. in an inland area as far as possible away from the oceans
B. in an area near a small lake
C. on the coast near the ocean
D. in high mountains

Justification:
Explain why the area you chose would have a more even temperature year-round.

Answer:
C. The ocean heats up more slowly in hot weather, and cools more slowly in cold weather, thus evening out the temperature on the land nearby. The other areas do not have such a moderating influence nearby.

Science in Personal and
Social Perspectives

Climate Factor

Item:
In some experimental homes built in desert regions in the Southwest of the U.S., the homeowner wishes to store heat so as to keep the house warm on cold nights, or in the winter time. The heat is captured from solar radiation during the day, and in the summertime. Which of the following would you recommend for heat storage around the sides of the house?

A. Large rocks, as dark a color as possible.
B. Large rocks, as white a color as possible.
C. Water placed in barrels which are painted white.
D. Water placed in barrels which are painted black.

Justification:
Explain why your choice is better for solar heat storage than the other three choices.

Answer:
D. Water has a higher heat capacity than rock, so that more energy is stored for a given temperature rise. Painting the barrels black will absorb solar radiation more efficiently when the sun is out, and radiate heat back to the house more, during the cool nights or winter months.

Science as Inquiry/
Science in Personal and
Social Perspectives

Cooling

Item:
When you are in the park on a hot summer day, you may prefer to stand under a tree because it is cooler there. It is cool because the tree leaves are shadowing you from the sun's rays. But they also provide a cooling effect in other ways. What might be other ways that trees cool their environment?

Answer:
Water can evaporate from tree surfaces causing evaporative cooling.