topic IX

How Is the Earth's Crust Affected by Its Environment?

Time Emphasis: 6 days

	INVESTIGATION	A-1a	A-1b	A-1c	B-1a	B-2a	LTI #16	LTI #17	LTI #18	LTI #19	FE - #1	FE - #2	FE - #3	FE - #4	FE - #5			
	Estimated Time (Periods)	1	1	2	1½	2												
TOPIC OUTLINE																		
A. Weathering																		
A-1 Evidence of Weathering	*What Is Some Evidence That Earth Materials Weather?*																	
A-1.1 Weathering processes	A-1.11			■							■	■	■	■	■			
	A-1.12	■			■						■	■	■	■	■			
	A-1.13										■			■				
A-1.2 Weathering rates	A-1.21		■	■														
	A-1.22	■			■							■						
A-1.3 Soil formation	A-1.31	■										■						
	A-1.32																	
A-1.4 Soil solution	A-1.41		■															
B. Erosion																		
B-1 Evidence of erosion	*What Evidence Suggests That Rock Materials Are Transported?*																	
B-1.1 Displaced sediment	B-1.11						■					■	■		■			
	B-1.12																	
B-1.2 Properties of transported materials	B-1.21				■								■					
B-2 Factors affecting transportation	*How Does the Transportation of Rock Materials Take Place?*																	
B-2.1 Gravity	B-2.11																	
	B-2.12																	
B-2.2 Water erosion	B-2.21							■					■					
	B-2.22					■							■					
	B-2.23					■							■					
	B-2.24												■					
	B-2.25								■	■			■					
B-2.3 Wind and ice erosion	B-2.31						■											
	B-2.32																	
B-2.4 Effect of erosional agents	B-2.41																	
B-2.5 Effect of man	B-2.51																	
B-2.6 Predominant agent	B-2.61											■			■			
PROCESS OF INQUIRY OBJECTIVES																		
Mathematical Skill	PIO-1		■	■		■							■					
Measurement Skill	PIO-2	■	■	■	■	■					■		■					
Creating Models	PIO-3			■		■												
Analysis of Error	PIO-4		■	■		■							■					
Data Analysis	PIO-5		■	■	■	■							■					
TITLES		Soil Formation	Reaction Rate and Particle Size	Rock Abrasion	Nature of Sand	Stream Flow	Soil Erosion	River	Stream BH	Stream Sediment	School Building and Grounds	Pit	Stream	Cemetery	Beach			

Multimedia: Check Multimedia Section of Supplement for reference to this topic.

IX-A-1a: SOIL FORMATION

QUESTION:

What is some evidence that earth materials weather?

MATERIALS:

Two soil samples, one top soil the other subsoil. If possible, both should be derived from igneous rock. (This usually can be picked up easily in any gravel bank within a 50 mile radius of the Adirondacks and in isolated areas in the rest of the state.) Other necessary materials are: a magnifier, teasing needle, coarse-grained granite, crushed granite (10 ml.), small containers. If available, stereo microscopes work very nicely for viewing the soil samples.

SUGGESTED APPROACH:

1. Give students the materials listed above, and ask them to follow the instructions listed in the student section of this investigation.

2. You may wish to put a list on the chalkboard of the similarities and differences found by the students. This listing often forms the basis for a lively postlaboratory discussion.

PRECAUTIONS:

1. Some of the materials used in this investigation may be discolored due to oxidation. Most students, however, will be able to distinguish between the fragments of quartz and the dark colored ferromagnesium minerals such as mica and hornblende.

2. Washing the samples to enable observation of the larger particles is a good idea, but will increase the laboratory time beyond the normal period.

TYPICAL RESULTS:

1. The students should be able to generalize the relationship between depth of soil and effects of weathering on the parent rock.

MODIFICATIONS:

Use any residual soil and its parent rock. The problem here is that New York State contains very little residual soil. Students should be made aware that New York's soil is predominantly transported.

REFERENCES:

Investigating the Earth, pp. 274-275, Teacher's Guide, pp. 334.

IX-A-1a: SOIL FORMATION

QUESTION:

What is some evidence that earth materials weather?

INTRODUCTION:

The weathering of granite results in a number of byproducts such as small chunks of quartz and mica, colloids, and ions. The common minerals of granite weather at different rates in the same environment. Those that weather most slowly remain as fragments; those that weather more rapidly form colloids and ions and are eventually transported away by infiltrating ground water and surface running water. In this particular investigation, you will study the products of granite that accumulate when weathering occurs.

OBJECTIVES:

When you have finished this investigation, you should be able to explain the relationship between soil, weathered rock, and the parent rock.

METHOD:

1. Examine the granite and soil samples given to you in whatever detail you wish. One of the questions you may wish to ask is: "What happens when you place a small quantity of each material in a separate test tube of water, shake the test tube, and let it settle?"

2. As you progress through your examination of the various samples, make a list of the similarities and differences between them.

QUESTIONS:

(A-1.12) 1. How are the granite and the two soil samples similar to each other and how are they different?

(A-1.12) (A-1.22) 2. Can you identify any of the minerals that are present in the granite as well as in the soil samples? What are they? What are the properties which allowed you to identify them?

(A-1.31) 3. What arrangement can you make of the materials as they would be found from the surface of the ground downward?

Easy (1)

IX-A-1b: REACTION RATE AND PARTICLE SIZE

QUESTION:

What is some evidence that earth materials weather?

MATERIALS:

Four different size quantities of marble chips, dilute hydrochloric acid, balances, 250 ml. beakers, timer, lab aprons, graduated cylinders, safety glasses, sieve kit.

SUGGESTED APPROACH:

1. Preparation of Materials:

   a) Marble chips may be obtained at very reasonable cost from local nurseries. Approximately 5 gm. will be needed for each student group.

PRECAUTIONS:

1. The students should wear the lab aprons and safety glasses at all times during this investigation.
2. Particles larger than 4 mm. may take more than one class period to dissolve.
3. Do not substitute test tubes for beakers.
4. The teacher may want to experiment to find the best acid concentration to complete the reaction in the time desired. A 1 to 3 ratio by volume may be satisfactory.

MODIFICATIONS:

Use Alka Seltzer if rock material isn't available.

IX-A-1b: REACTION RATE AND PARTICLE SIZE

QUESTION:

What is some evidence that earth materials weather?

INTRODUCTION:

In this exercise, you are going to investigate the relationship between the particle size of a particular rock and the rate of reaction of an acid on it.

OBJECTIVES:

When you have finished this investigation, you should be able to:

1. state the relationship between reaction rate and particle size.
2. relate reaction rate versus particle size to weathering in the natural environment.

METHOD:

1. Crush the marble chips until the largest particles are less than 1/2 cm. in diameter.
2. With a sieve kit or homemade wire screens, separate the rock into four different size fractions. The fractions should range from about 4 to 5 mm. down to a coarse dust.
3. Mass 5 gram portions of each of the four sized fractions of rock.
4. Place 100 milliliters of the dilute hydrochloric acid in each of the four 250 milliliter beakers.
5. Add the rock to the acid (GENTLY) and measure the time needed for the rock to be completely dissolved (when no more bubbles are given off).
6. Prepare a graph of your observations (particle size versus length of reaction time).

QUESTIONS:

(A-1.21) 1. What interpretation can be drawn from your graphs?

(A-1.21) 2. What controls in this investigation allow you to interpret the relationship between particle size and reaction rate?

3. What experimental errors might be present in this investigation that were not taken into account?

(A-1.21) (A-1.41) 4. How is this investigation related to naturally occurring geological processes?

Challenging (2)

IX-A-1c: ROCK ABRASION

QUESTION:

What is some evidence that earth materials weather?

MATERIALS:

Bottle or covered cans, balance, soaked rock, (soft limestone or shale), screen, clock, graph paper, large bottle (for rock debris).

SUGGESTED APPROACH:

1. Angular, freshly broken chips of limestone or shale, soft enough to abrade, provide the best material for this investigation. The chips should be soaked at least one hour prior to the period they are to be used. This soaking enables the material to absorb water and reduce experimental error.

2. Discuss the factors that might affect the rate at which rocks wear.

3. A brief discussion of how one might go about studying the specific factor of time should be undertaken. This discussion should include controls, experimental error, suggested time intervals, measurement, and graphing of the data.

4. After each group has completed their shaking time, have them dispose of the water in a common container.

5. Following completion of the investigation, a chart of all the student data should be made so that the students can prepare graphs on the complete set of data.

PRECAUTIONS:

1. Presoaking is essential to accurate student measurements.

2. Chips should not be used more than once, since the rounded fragments do not erode as easily and the results in the succeeding investigation will be quite poor and difficult to interpret.

3. The rate and manner of shaking of the different groups should be as similar as possible.

4. In order to get standardized results, it will be necessary to express the abrasion as a percent of weight lost rather than an amount.

TYPICAL RESULTS:

If the procedures are standardized, the results of the students should be quite similar. The data, although scattered, should illustrate an increase in the mass lost per unit time. A leveling off of the weathering rate may become evident if the times become extended. This leveling is due to the particles becoming sufficiently rounded to reduce the rate of weathering significantly.

MODIFICATIONS:

1. Use other variables such as different types of rocks, rhythms for shaking, or amounts of water.

REFERENCES

Investigating the Earth, pp. 17-19, Teacher's Guide, pp. 42-44

IX-A-1c: ROCK ABRASION

QUESTION:

What is some evidence that earth materials weather?

INTRODUCTION:

The materials of the earth are undergoing continual change, both chemical and physical. As the result of these changes, the materials can be changed in size, shape, and composition. This investigation is concerned with the physical changes that rocks undergo as they are carred in a stream as a result of contact with the streambed, as well as other materials in the stream.

OBJECTIVES:

When you finish this investigation,you should be able to:

1. state the relationship between time and the effect of mechanical abrasion on rock fragments.

METHOD:

1. Take two spoonfuls of soaked rock. Using the balance, determine the mass and record it. Place the rock in the jar provided, add 500 ml. of water and shake the jar for the assigned number of minutes with the motion agreed upon by the class.

2. Pour the liquid contents of the jar through a screen into another bottle. Place the material which did not pass through the screen on a paper towel.

3. Determine the mass of the materials on the paper towel and record it.

4. Compare the materials on your paper towel with those of groups having different shaking times and describe any differences which are evident.

5. Stir the contents of your discard bottle and measure out 100 ml. Mass a piece of wet filter paper, record the mass, and place it in a funnel. Pour the 100 ml. of discard liquid through the filter paper and record the mass. Calculate the mass of suspended materials per 100 ml. of waste water.

6. Place 25 ml. of the filtrate from Step 5 in a massed evaporating dish and evaporate to dryness. Mass the dish and its contents and calculate the mass of dissolved material per 100 ml of water.

7. Determine the percent of change in mass for the particular time you shook the contents of the container. Place your data with that of the other groups on the summary data chart provided on the board.

$$\text{percent change} = \frac{\text{initial mass} - \text{final mass}}{\text{initial mass}} \times 100$$

8. Using the data collected by the entire class, draw a graph consisting of shaking time versus percent of mass lost.

QUESTIONS:

(A-1.11) 1. Why were the rock fragments presoaked before you used them?

(A-1.21) 2. What generalization can you make after comparing the observations of your remaining rock chips with those of the other groups who had different shaking times?

(A-1.21) 3. What interpretation can you give of your graph of the data compiled by the class?

(A-1.21) 4. How can you account for the leveling off of the curve as it approaches the longer shaking periods?

5. How many grams of rock per 100 ml. went into suspension? into solution?

(A-1.11) 6. What comparisons can you draw between this investigation and the natural environment?

Easy (1.5)

IX-B-1a: NATURE OF SAND

QUESTION:

What evidence suggests that rock materials are transported?

MATERIALS:

Sand from a local beach, stream bed, and sand pit; sandstone (different varieties), crushed granite, dropping bottles of diluted hydrochloric acid, test tubes, magnets, balance, small cans, magnifiers (10X), optional: Stereo microscopes.

SUGGESTED APPROACH:

1. This investigation is quite open in nature. The student should be allowed to investigate a wide number of properties of the sand.

PRECAUTIONS:

1. Label the specimens of sandstone. The sandstone will become spotted with acid; so have different specimens for each class.

IX-B-1a: NATURE OF SAND

QUESTION:

What evidence suggests that rock materials are transported?

INTRODUCTION:

Sand is the result of many earth processes. In this investigation, you will make a large number of observations concerning the "nature of sand" and gain an insight into its source area, transportation media, and area of deposition.

OBJECTIVES:

When you have finished this investigation, you should be able to:

1. detect differences in sand samples.

2. make inferences as to the origin of sand, and weathering agents responsible for its condition.

METHOD:

1. Examine the sands available. Use both the unaided eye and your magnifier. Note the size and shape of grains, their color and transparency.

2. Using any of the materials provided, determine the properties of the dominant material in the sand. Record the properties of any other materials that you think are present. NOTE: Diamonds and gold are found in sands in some parts of the world.

3. Fill two small cans of equal size with different sands. Compare their mass. Examine the samples with the magnifier and test them with a magnet. Record your observations.

4. Take the crushed fragments provided and examine the particles. Compare these to the samples of sand. Record your observations.

5. Place some of the crushed particles in a test tube half filled with water, shake them and allow them to settle. Record any sorting that might take place.

6. Examine the specimens of the various kinds of sandstone. Try to rub some of the grains off. Note what happens with each specimen.

7. Put a drop of hydrochloric acid on each sandstone specimen and record what happens.

QUESTIONS:

(B-1.21) 1. In what ways were the sands that you observed different from each other?

(B-1.21) 2. In what ways were the sands that you observed similar to each other?

(B-1.21) 3. What characteristics did the dominant material in the sand have? Did you observe any other materials with differing characteristics in the sand? If so, what were their characteristics? What characteristics do all the materials in the sand have in common?

4. What were the similarities and differences you observed in the light and dark-colored sands?

(A-1.22) 5. What were the similarities and differences you observed between the crushed particles of rock and the particles of sand you observed? Based on the similarities of the crushed material and the sand, what possible relationship between the two could be drawn?

6. What inferences would you like to make about where the sand originated? How was it transported? How was it deposited? If given more time and the necessary equipment, do you think you could investigate these materials longer and come up with additional observations? What would you do?

(A-1.12)
(A-1.22) 7. What observations did you make when you compared the various kinds of sandstone in regards to their:

a) ability to rub off grains

b) reaction to acid

c) color changes after application of the acid

Easy (2)

IX-B-2a: STREAM FLOW

QUESTION:

How does the transportation of rock materials take place?

MATERIALS:

Trough (3' to 6' in length), thin-walled hose with adjustable clamps, support for trough buckets for dispensing and collecting water, stop watch, coarse sand, protractor, fine silt, small bits of paper folded like butterfly wings.

SUGGESTED APPROACH:

1. The apparatus should be set up as indicated in student directions.

2. When investigating the effects of slope, the volume must be kept constant. When the effect of a change in volume is investigated, the slope must be kept constant.

3. When investigating variations due to grain size, slope and volume must remain constant.

4. Follow the investigation with Field Experience #3 ("Stream") so that the investigation may continue.

PRECAUTIONS:

1. Emphasis should be made that the investigation concerns a MODEL of an actual stream, and, as such, it does not represent the conditions in a stream exactly.

2. Do not overemphasize the importance of slope since most rivers have a very low slope. Rivers in general probably vary more in volume than in slope. The same river may vary in volume a number of times during the year.

3. The water should be run into the trough and not on the gravel to best approximate the conditions of an actual stream.

TYPICAL RESULTS:

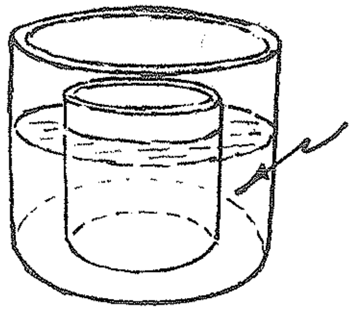
Quantitative results will not be too accurate. However, the students should be able to see the direct relationship between rate of erosion and the slope and volume of a stream.

MODIFICATIONS:

1. MATERIALS: Large, round, straight-sided glass jars (preferably battery jars); smaller round straight-sided glass jars that nest inside the larger ones, clean sand and gravel, dowel sticks or other thin sticks for stirring, heavy white or black paper, graph paper.

SUGGESTED APPROACH:

a) Set up apparatus as shown in the diagram below:



b) Line the inner jar with white or black paper and weigh it down with a heavy object so that it will not move easily.

c) Center the inner jar and place some clean sand and small pebbles in the space between the inner and the outer jar. Then add water to the sand and pebbles to within one inch of the top of the shortest jar.

d) Demonstrate to the students how a stirring stick may be moved around and around in the water to produce a steady flow of water in the space between the jars, causing the sand and pebbles to move. Point out that this is really, in a sense, a "circular creek."

e) Let the students determine the relation of the diameter of the particles moved to the velocity of the water, and then graph their findings. Students may be allowed to work out their own procedures. Bits of paper towel in the water can aid in determining its velocity.

2. To form a large circular creek, cut or saw through the middle of the tread of a badly worn automobile tire to form two halves. Apply white paint to the inside of one of the halves. Partially fill it with sand, pebbles, and water.

REFERENCES:

Investigating the Earth, pp. 279-282, Teacher's Guide, pp. 339-340.

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IX-B-2a: STREAM FLOW

QUESTION:

How does the transportation of rock materials take place?

INTRODUCTION:

Streams and rivers vary in their ability to erode earth materials. Two factors that are most vital are the stream's slope and volume. In this exercise you will be investigating the relationship of these two quantities to the ability of a stream to erode the land.

OBJECTIVES:

When you have finished this investigation, you should be able to:

1. graph and state the relationship between the variables of slope and volume of stream flow to: the rate of erosion and the particle size capable of being transported.

METHOD:

1. Place the trough on your desk so that the end overhangs about 6 inches. Lift the other end up and support it with books at about a 15 degree angle. Position a bucket full of water so that you can siphon water by means of 2 hoses into the upper part of the trough. Place another bucket on the floor to catch the water after it leaves the trough.

2. Using one siphon, with the clamp opened no more than half way, determine the water velocity (by placing small bits of folded paper in the water and measuring the time for them to go a measured distance down the trough) at two different slopes between 15 degrees and 0 degrees. Record your observations and graph the results.

3. Now position the trough at about 10 degrees slope. This time measure the velocity with the one siphon open and again with two siphons open.

4. Position the trough at 10 degrees slope with one siphon open. Now pour 10 ml. of coarse sand into the trough, record how long it takes for all the sand to be transported away. Next open both siphons and repeat.

5. Position the trough at 15 degrees slope and open only one siphon. Pour in 10 ml. of coarse sand and measure the time for it to be transported. Lower the trough to 5 degrees and repeat. Record the time in both instances.

6. Repeat sections 4 and 5 using 10 ml. of fine silt. Record your observations.

7. Graph your results for steps 2 and 3.

QUESTIONS:

(B-2.22) 1. From your observations, what do you think the relationship is between stream slope and the ability of a stream to erode?

(B-2.23) 2. From your observations, what do you think is the relationship between stream volume and its ability to erode?

(B-2.22) (B-2.23) 3. What do you hypothesize is the relationship between particle size in a stream and the slope and volume of that stream?

4. What could happen in nature in order to produce these same changes in slope and volume that you did in your model of a stream?