Volcano Fan Club

Grade Level: 6–9

Learner Objectives:

Students will:

- Recognize how wind influences the dispersion pattern of tephra.
- Understand the energy transformations that occur during tephra fall.
- Recognize how volcano researchers assess the area of tephra fall

Setting: classroom (or an easy to clean area)

Timeframe: 50 minutes

Volcano Fan Club—50 minutes

Materials:

Blowing in the Wind

- Copies of *"Volcano Fan Club"* student page
- Copies of *"Volcano Fan Club"* experiment instructions
- 3 fans with 3-speed settings

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USGS
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NATIONAL PARK SERVICE

Living with a Volcano in Your Backyard-An Educator's Guide with Emphasis on Mount Rainier

Prepared in collaboration with the National Park Service

U.S. Department of the Interior
U.S. Geological Survey

General Information Product 19

Overview

Students simulate tephra transport by placing ingredients in front of a running fan, and mapping the resultant layers.

Teacher Background

What is tephra?

The term ***tephra*** refers to fragments of volcanic rock and lava of all sizes that are blasted into the atmosphere by explosions or carried upward in ***eruption columns*** or ***lava fountains***. Large pieces of tephra fall to the ground first. Smaller pieces stay aloft for longer periods of time which allows the wind to blow tiny particles to a great distance from the volcano.

Volcanic ash refers to the tiniest pieces of tephra, smaller than 2 millimeter (0.1 inch) in diameter, which is a bit larger than the size of a pinhead. It is formed during explosive eruptions by the shattering of magma. Volcanic ash is not a product of combustion, such as ash formed by the burning of paper or wood. It is hard and very abrasive, mildly corrosive, and is electrically conductive, especially when wet.

Building tephra deposits

Once ejected into the air, the wind carries tephra particles. How far a tephra particle travels depends upon wind speed and size of the eruption. Coarse and heavy particles fall on or near the volcano; fine-grained, light-weight particles travel farther. The resulting tephra layer on the ground is progressively thinner and finer-grained with increasing

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- 3 checkerboard plastic table cloths or butcher paper or computer plotter paper similar in size to standard picnic table cloths
- 3 rolls of masking tape
- 3 sets of washable markers
- 3 spoons
- 1 cup cocoa powder
- 1 cup oatmeal
- 1 cup rice grains
- 1 cup cornmeal
- brush or broom or vacuum cleaner
- measuring stick

Vocabulary: Eruption column, lava, lava fountains, Law of Superposition, tephra, volcanic ash

Skills: Observing, predicting, analyzing, graphing, cooperating, interpreting

Benchmarks:

See benchmarks in Introduction.

distance downwind from the volcano. Viewed on a map, the plume trace and tephra layers are generally in the shape of an elongated oval. At high wind speeds the tephra layer is long and narrow. At lower wind speeds the tephra layer is shorter and wider. When there is no wind, the tephra deposit may be circular around the vent.

During successive eruptions tephra might fall in a similar pattern, overlapping or covering completely the older layer. Geologists establish the relative ages of layers by looking at the order in which the layers were deposited. As stated by the ***Law of Superposition***, layers that are younger will be deposited on top of layers that are older.

Meteorological records show that at Cascade Range volcanoes, the wind blows most often from west to east. This trend in wind direction during ancient eruptions is revealed in multiple tephra layers that are thickest on the east side of the Cascade Range.

The extensions in this activity provide opportunities for students to determine the path of volcanic ash after its eruption from a Cascade Range volcano.

Four clues to reading a tephra deposit

Geologists rely on four principal lines of evidence when they interpret tephra layers and identify their volcano of origin:

1. Tephra layers are thickest near and on the source volcano.
2. Coarse tephra falls to the ground before finer-grained tephra.
3. Younger layers overlie older layers.
4. A unique chemical signature exists at many volcanoes that allows researchers to match tephra with its source volcano. This fourth clue holds great importance to geologists, though it is not addressed in this activity.

Once your students understand these concepts and conduct the activity, they can be part of the volcano fan club!

Teacher Tips

- *Conduct the activity* Volcanic Processes *or, for older and mature classes, show the video* Understanding Volcanic Hazards, *which displays magnificient footage of tephra. This prepares your class for the activity*
- *See the* Soda Bottle Volcano *activity for an understanding of how tephra is produced*
- *See the* Tephra Popcorn *activity for a description of the different types of tephra*
- *See the* Tephra Explorer *activity to learn more about tephra layers at Mount Rainier*

Procedure

What to do Before Class Begins:

Blowing in the Wind:

- Decide whether to conduct this activity with student groups or as a teacher demonstration, and whether you wish to do multiple runs.
- Select an area that is easy to clean and has enough space for all three experiment stations, 6 millimeters x 1.5 meters (20 feet x 5 feet).
- For each experiment station, prepare 1 cup of each tephra sample (cocoa cornmeal, oatmeal, and rice)—more if you plan to conduct multiple runs with varying conditions.

Activity Procedure:

Blowing in the Wind:

Simulate an eruption of tephra and analyze the resulting layers.

1. Tell students that once they complete this activity, they can become part of the volcano fan club!

2. Explain to students that they will make a series of tephra layers with household ingredients. They will collect, analyze and graph data before presenting results to the class.

3. If conducting this activity with student participation, divide students into three groups and assign each group a station. Each group will simulate a different wind speed.

4. Distribute the "***Blowing in the Wind***" student page. Review the experiment instructions on the student page.

5. Instruct students to record their data on the student page. Keep in mind that each square on the table cloth represents one square kilometer (or mile).

6. When students finish the experiments, and before cleanup, instruct each group to observe the other groups' "tephra" layers.

7. Instruct students to graph the distribution of the "tephra" layers, and to answer the questions on the student page.

8. Reassemble the class. Each group should present their results and graph to the reminder of the class. Discuss the similarities and differences in each group's results.

9. Lead a discussion. In what ways, does this experiment illustrate the four clues? How did wind speed affect the results? How does wind direction play a role in tephra distribution? How well does this activity illustrate the process of tephra dispersal from an erupting volcano? Why might tephra on the slopes of one volcano be found on the slopes of another? How might one eruption produce multiple tephra layers oriented in different directions? Hypothesize about what happens to tephra when it falls through rain.

Adaptations

- Instruct students to show results of their experiment in stylized illustrations or to diagram their results on a whiteboard.
- Instruct students to use a computer spreadsheet program to construct their data table and graph.
- Ask students to make their own tephra by crushing colorful pieces of cereal to make different sizes of tephra.
- Instead of a large fan, try using a hair dryer or hand-held mini-fan in the experiment.
- Change the wind direction by setting the fan at an angle to the paper.
- Add topography to the experiment. Instruct students to make hills and valleys by stuffing material under the table cloth or paper. Repeat the experiment and observe how topography affects tephra distribution.
- Illustrate the concept by showing layers of various types of candy in a candy jar.

Extensions

- ***Simulate effects of ash fall on a map landscape.***
  Simulate effects of ashfall on the region around a volcano. Obtain a large paper map that shows a volcano and surrounding landscape, including towns and cities, roads, airports and other features. Place children's toy plastic animals, cars, trucks, airplane, school buses and emergency vehicles on the map surface. Set up a fan on the volcano to create wind. Simulate volcanic ash, either with the use of real volcanic ash, or fine silt or clay, cocoa powder, or flour. Students use a spoon to ladle the "ash" in front of wind created by the fan. Students observe and discuss which areas are ash covered, and effects on animals, transportation, and communities. See Internet Resources for Web sites that describe effects of volcanic ash.

- ***Determine the path of volcanic ash using data at the American Meteorological Society's data pages.***
  This extension requires students to possess some understanding about meteorological maps and of atmospheric pressure and its control over wind direction and speed. Students estimate the travel direction and speed of an ash plume at a Cascade Range volcano. Instruct students to visit the American Meteorological Society's DataStreme Web pages (See Internet Resources Page for address). At the Web site, students observe the wind speed and direction in the upper air above a Cascade Range volcano of their choice. They note the pressure levels for 850 millibars, 700 millibars and 500 millibars, then assume that an eruption hurls volcanic ash to an altitude of 6 kilometers (approximately 20,000 feet). Students make predictions about the where the ash will travel to in 9 hours.

Assessment

For assessment, instruct students to show results of their experiment in an illustration, or to diagram or graph the class results on a whiteboard. Review the student page results and look for evidence of student recognition that coarse materials fall first, followed by fine-grained material. Students should demonstrate ability to measure the area of the concentrated tephra; graph the data and interpret it. Instruct students to draw stylized diagrams of any tephra deposit formed by far-traveled winds, and by an eruption with no winds. Assess application to real-world situations by assigning interpretation of an additional ready-to-interpret data set of your choosing, and by asking questions about how this pattern of distribution might affect all regions of your state.

References

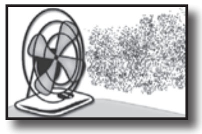
Frances, P., Oppenheimer, C., 2004, Volcanoes: New York, N.Y., Oxford University Press, 521 p.

Kenedi, C.A., Brantley, S.R., Hendley, J.W., II, and Stauffer, P.H., 2000, volcanic ash fall—A hard rain of abrasive particles: U.S. Geological Survey Fact Sheet 027–00, 2 p.

Myers, B., Brantley, S.R., Stauffer, P.H., and Hendley, J.W., II, 1997, What are volcano hazards? (revised March, 2008): U.S. Geological Survey Fact Sheet 002–97, 2 p.

Refer to **Internet Resources Page** for a list of resources available as a supplement to this activity.

Name ______________________________

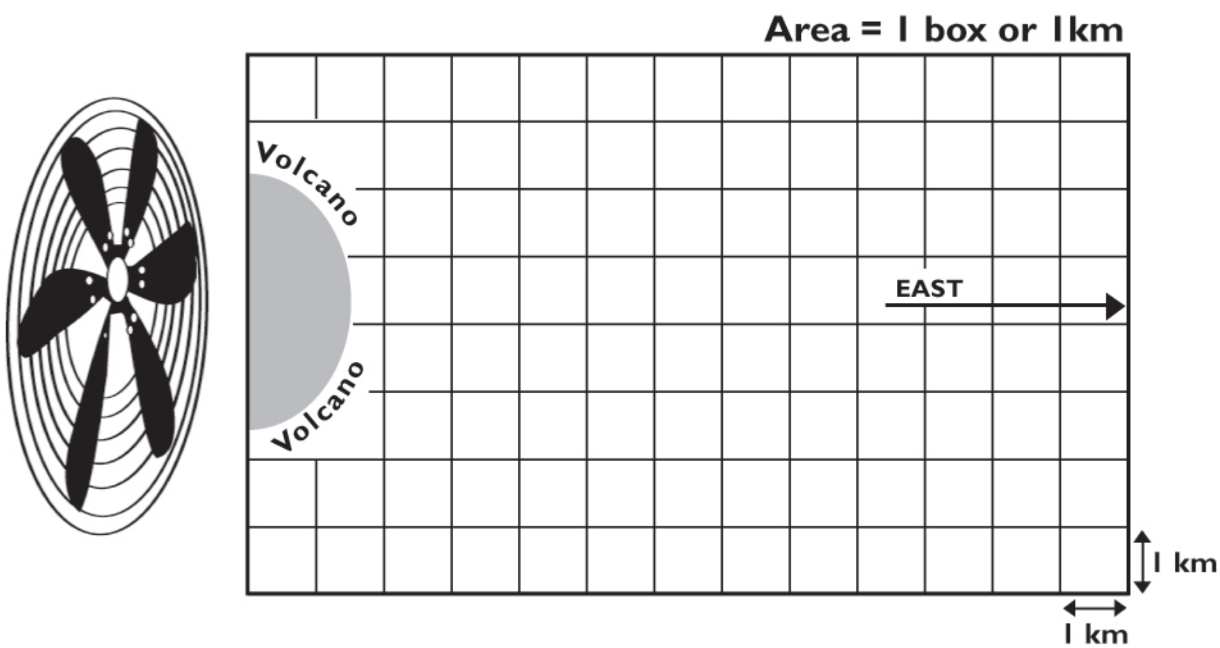


Volcano Fan Club

Instructions:

The Setup:

1. Collect materials: student page, table cloth, fan, masking tape, washable marker, measuring stick, and tephra samples: cocoa powder, cornmeal, rice, and oatmeal.
2. Lay table cloth or paper flat across your work area. Tape the corners down, if necessary.
3. Place the fan at one end of the table cloth (see diagram).
4. Use the washable marker to draw a semicircle with a 15 centimeters, (6 inches) radius in front of the fan to represent the slopes of the volcano. Label the semicircle “Volcano.”



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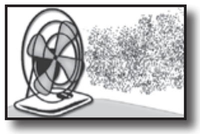
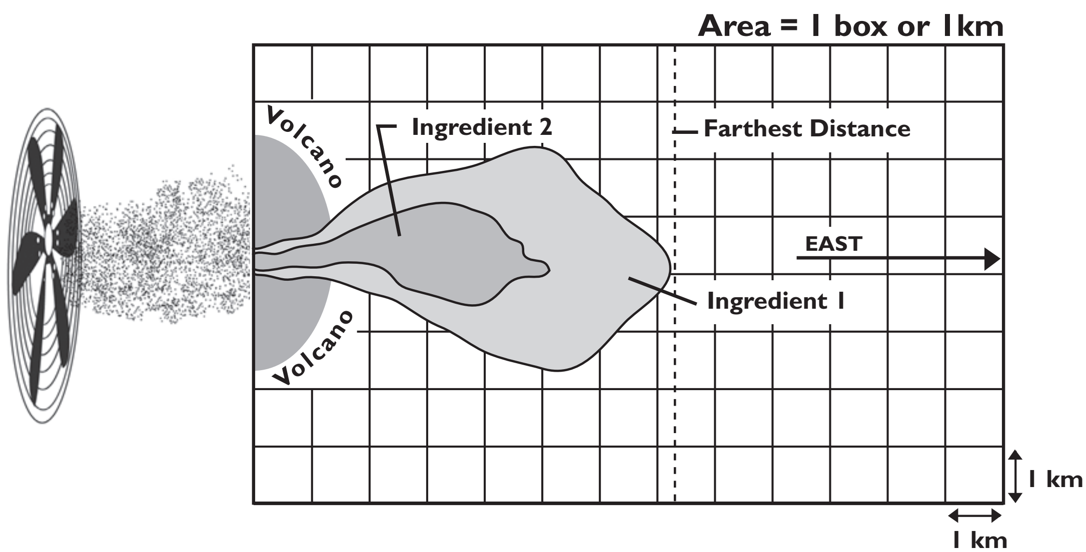


Volcano Fan Club-continued

Instructions:



The Experiment—Depositing Tephra

1. Read through all of the directions before beginning the experiment.
2. Make a prediction and hypothesis on your "***Volcano Fan Club***" (page 10).
3. Turn on the fan to the proper setting as assigned to your group. Use a spoon to gently sprinkle one ingredient at a time in front of the fan, as if releasing it into the wind. Place your hand to the same position relative to the fan each time.
4. Turn off the fan between releases of each ingredient.
5. Use a washable marker to outline the concentrated area of the deposit where the majority of the ingredients fell. This will require using your best judgment (the job is no easier for geologists who do similar mapping of tephra after volcanic eruptions!)
6. Measure the farthest distance traveled by each ingredient. Recall that the side of each square equals 1 kilometer. Record the results on the student page.
7. Count the total number of squares that are covered by each ingredient. Record the results in the space provided on the student page.
8. Repeat until all tephra samples have been used.
9. Complete the data sheet by calculating the area covered by each type of tephra. Record the results in square kilometers.
10. Prepare the results of your experiment as a bar graph to be shared with your class.

Name ______________________

Volcano Fan Club-continued

Ingredients	Farthest Distance Traveled (km)	Area of Ash Cover (1 square= 1km2)	Other Observations

Instructions:

1. Make predictions about which ingredients will travel farthest, and which will cover the largest area.

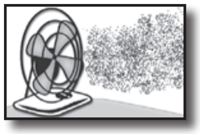
2. Write a hypothesis based about your predictions.

3. Conduct your experiment using “Volcano Fan Club” Instructions on page 9. Record your data on the table above.

4. On the next page, graph results, and address the instructions below.

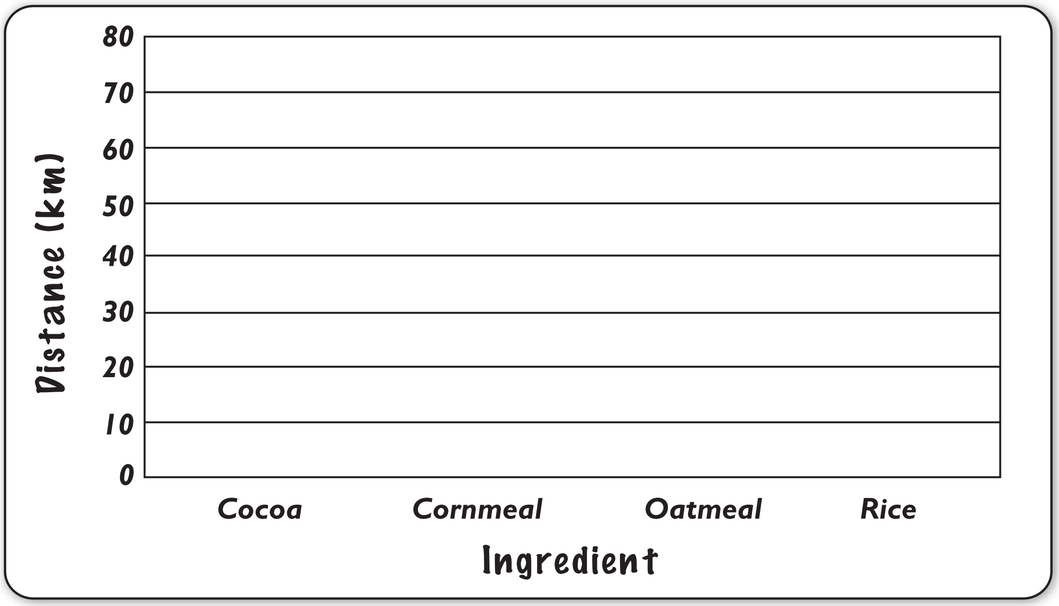
Experimental Wind Speed: ______________________ (high, medium or low)

Name ______________________________

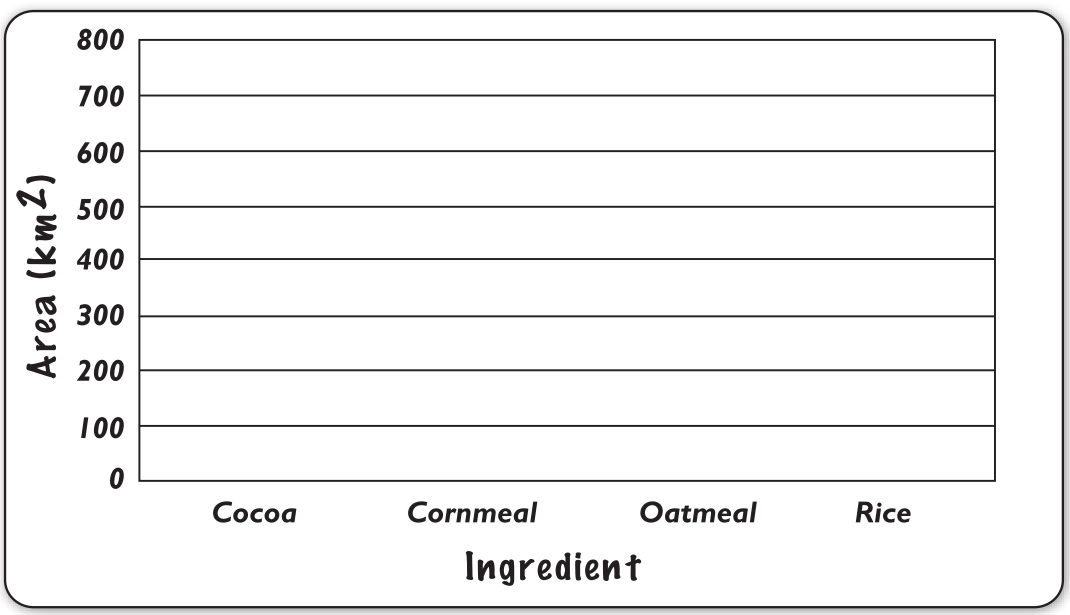


Volcano Fan Club-continued

Maximum Distance Traveled for Each Ingredient

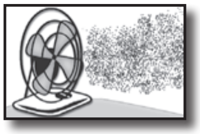


Area Covered for Each Ingredient



Student Page

Team Names ______________________________



Volcano Fan Club Results

Analyzing your results from the graphs:

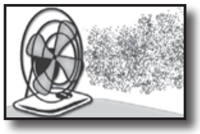
1. Describe the relationship between tephra size and distance traveled. Explain these observations.

2. Describe the relationship between tephra size and area covered. What factors influence this relationship?

3. Write a conclusion and cite data as evidence.

4. Use your knowledge of tephra distribution to describe the atmospheric conditions that brought tephra from Mount St. Helens and ancient Mount Mazama (Crater Lake, Oregon) to the slopes of Mount Rainier. Describe at least one likely characteristic of this tephra.

5. Describe the energy transformations that occur when tephra erupts from a volcano, travels downwind, and falls to the ground.



Volcano Fan Club Results—Answers

Instructions:

1. Each group's predictions will vary, based on the fan speed assigned to them.

2. Students might predict correctly that the smaller and lighter materials travel farther and spread more broadly in area than larger, heavier materials. Some students might note correctly that the aerodynamics of some ingredients might influence results.

Graph Results:

Graph results should indicate greater transport distance and area covered by the finer-grained materials, such as cocoa and cornmeal.

Analyzing your results from the graphs:

1. Describe the relationship between tephra size and distance traveled. Explain these observations.

Graph results should indicate greater transport distance and area covered by the finer-grained materials, such as cocoa and cornmeal. This results from the greater capacity of rapidly moving air to transport particles before they settle, than slowly moving air.

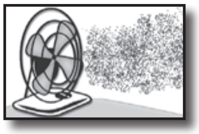
Note: Remember to discuss the similarities and differences in each group's results.

2. Describe the relationship between tephra size and area covered. What factors influence this relationship?

Graph results should indicate greater area covered by fine-grained materials, caused by the easier transport of fine particles.

3. Write a conclusion and cite data as evidence.

Fine-grained material can remain airborne even after coarse material falls to the ground. The area covered and distance of travel depends in part upon wind speed. Wind direction determines the ash plume direction of travel. Cite evidence from students' graphs.



Volcano Fan Club Results—Answers -continued

4. Use your knowledge of tephra distribution to describe the atmospheric conditions that brought tephra from Mount St. Helens and ancient Mount Mazama (Crater Lake, Oregon) to the slopes of Mount Rainier. Describe at least one likely characteristic of this tephra.

Winds blowing from southwest to northeast were of sufficient velocity to transport tephra to the slopes of Mount Rainier. The tephra found on the slopes of Mount Rainier is medium to fine-grained material.

Note: Encourage discussion about what additional atmospheric conditions (rain, jet stream, etc.) and eruption variables (amount of tephra erupted, height of the eruption cloud, etc.), might influence the path of an ash cloud.

5. Describe the energy transformations that occur when tephra erupts from a volcano, travels downwind, and falls to the ground.

Tephra ejected from the volcano rises due to thermal energy, and gains potential energy with altitude. Once thermal energy is expended, tephra particles begin to fall. Kinetic energy is expended as the tephra particles fall towards the ground.