Activity Overview

Students investigate the connections between volcanoes and the Earth system by considering the widespread distribution of volcanic material that enters the atmosphere. In particular, students explore the connections between winds and volcanic ash transport. This relationship is important for solving the **Chapter Challenge**, since the ability of volcanoes to affect regions of the United States depends upon the transport of airborne material. Students draw upon their knowledge of the relationship between magma composition and properties of the magma developed in **Activity 2** to better understand why some volcanoes erupt explosively with widespread, sometimes global effects, whereas others erupt quietly and locally. Students also explore some of the most famous recent examples of volcanic eruptions.

Scale is a very important concept in understanding the Earth system. This investigation gives students the chance to explore the scales and categories of volcanic eruptions. It also gives students the chance to make inferences from data (maps and data tables). Specifically, they should make inferences about the importance of knowing wind direction when thinking about what parts of the country might be affected by a volcanic eruption. They should also be aware that the pattern of ash dispersal could be complicated by variations in wind direction and speed with height in the atmosphere. A full appreciation of this would require a good understanding of the circulation of the atmosphere.

Preparation and Materials Needed

The investigation requires no special preparation.

Materials

- Graph paper

Think about It

Student Conceptions

The question explores students' conceptions of how far volcanic ash can travel. To this point in the chapter, students have examined flows. The largest lava flows in recorded history are small in scale compared to the area affected by volcanic ash. They may not be willing to admit that volcanic ash could ever reach their community, particularly if they live east of the Mississippi River.

Some students will consider what they learned in **Activity 1** and factor this into their thinking. For example, if they found a volcano within a certain distance of their community, they may note that ash and dust might reach their community. If they live in a volcanic region, they might point out particular types of flows that can reach their community. Some students believe that volcanic ash can travel around the globe. Few high school students will think of the gases and water vapor that emerge from a volcano as "material," and such materials are certain to eventually reach their community.

Answer for the Teacher Only

Refer to the last paragraph of the **Background Information**. If the students live anywhere in the western United States, they are likely to realize that they are within reach of an ash fallout from an explosive eruption in the Pacific Northwest, although the upper-level winds would have to be in the right direction. If they live in the eastern United States, much farther from the likely location of the eruption, there might still be fallout of very fine ash, but unless the eruption is of a size comparable to or greater than such uncommon eruptions as Tambora or Krakatoa, the ash would be very small in volume and would be detectable only by careful observation. The probability of an explosive volcanic eruption in the United States elsewhere than in the Pacific Northwest is with just a few exceptions (e.g., Yellowstone) extremely small, because the geologic setting is one of stable continental crust rather than a subduction plate boundary. If upper-level winds are moving in the right direction, they can transport ash from eruptions of volcanoes in Mexico to portions of the United States.

Assessment Tool

Think about It Evaluation Sheet

Refer students to the **Think about It Evaluation Sheet** to help them to understand and internalize basic expectations for the warm-up activity. This might be a good time to collect papers as a spot check of their engagement. Again, if you assign a value to this assessment, focus on the presentation of evidence and the clarity of expression, not the correctness of their preconceptions. The goal is to use the assessment to motivate them to engage in the activity.

Investigate

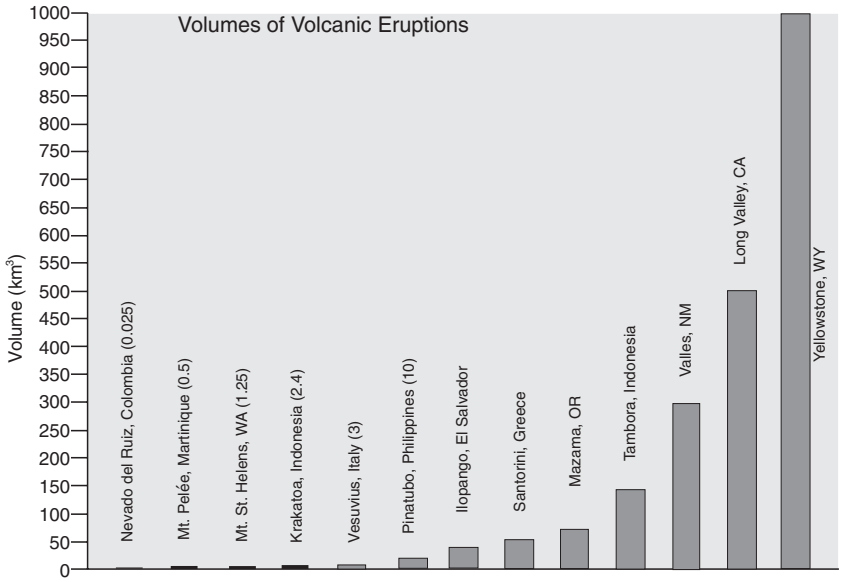
1. **a)** Twelve to thirteen states (thirteen if you count the northwestern part of Arkansas).

b) The ash moved to the east and southeast (and also to the northeast, which would be apparent if the map extended north into Canada).

c) Almost certainly so, but the map does not show Canada. It looks as though the ash would cover an area with oval shape, but the map cut off the northern part of the oval.

d) Answers will vary, but most students will consider this a large eruption because it put ash into a large part of the United States. Examine and discuss students' reasons.

2. The table shows the volume of 13 volcanic eruptions. Make a bar graph of the data.



Teaching Tip

Check student work to ensure that graphs are clearly labeled and properly scaled. Note: eruption volumes range from 0.025 to 1000 km^3.

Remind students to read parts (a) and (b) of **Question 2** before making their graphs, otherwise they will plot the names of volcanoes on the horizontal axis (part (a) without first putting them in order from least to greatest volumes (part (b)). Also, because some of the volcanic eruptions have long names, you might suggest that students number the eruptions on the graph and make a key on the side of the graph to relate the numbers to the names. Students can color-code their graphs to reveal the categories of sizes.

3. **a)** Students should make several groups of eruption sizes and denote the groups with a bracket or label. The idea is for them to explore the concept of relative scales and decide on categories.

   b) Answers will vary, but students will put Mt. St. Helens into a group outside of the large-scale volcanic eruptions.

   c) In addition to the volume, other important factors that need to be considered are: the height to which the ash plume rises in the atmosphere; the proportion of the ash that is of very fine sizes; and the speed and direction of the upper-level winds.

Teaching Note

Step 4: Only four of the five eruptions shown on the map are found in the data table (Huckleberry Ridge, Yellowstone is not in the data table). Thickness of ash mapped here is greater than what is shown on the figure on page 34. Therefore, area covered by Mt. St. Helens does not correspond to what is shown on page 34.

The word "relationships" in **Question 4(b)** can stump some high school students. As you circulate among student groups, check to see that they understand the intent of the question. An example of a relationship between two sources of data (in this case, the graph and map) is that "as the volume of the eruption increases, the area covered by the eruption increases."

4. **a)** The order from smallest to largest area is Mt. St. Helens; Mazuma, Oregon; Long Valley, California; Lava Creek, Yellowstone.

   b) The area covered by an eruption increases with the volume of material erupted, but the relationship is not linear. For example, the Yellowstone volcano erupted about 1000 times as much material as Mt. St. Helens, but the material erupted did not cover 1000 times the area. The relationship is not even strictly regular, in the sense that two eruptions of the same volume should not be expected to cover the same area, because of the factors mentioned in the answer to **3 c)** above.

   c) The volcano is not in the center of the area covered by the ash. In three cases, it is very much to one side. This suggests that wind carried the material away from the volcano.

Assessment Tool

Investigate Notebook Entry-Evaluation Checklist
Point out criteria within the **Investigate Notebook Entry-Evaluation Checklist** that are relevant to this particular investigation.

Reflecting on the Activity and the Challenge

This might be a good point to take stock of where your students stand in terms of whether or not they think that a volcano could affect their community, and what parts of the United States might be affected by volcanic eruptions.

Digging Deeper

Assign the reading for homework. The questions in **Check Your Understanding** (page 38) can be provided as a homework assignment.

Check Your Understanding

1. A lahar is a mixture of fine and coarse volcanic material and water that flows down the slope of a volcano. A pyroclastic flow is a dense mixture of hot gases, ash, and rock fragments. A caldera is a hole or depression where a volcanic vent has collapsed.

2. Tephra is the general term for particles of volcanic rock and lava erupted into the air. Tephra is divided into various sizes: volcanic blocks and bombs (the largest particles), lapilli (medium-sized particles), and ash (the finest particles).

3. The height of the ash plume, and the speed of the wind. See answer to **3 c)** in the **Investigate** section.

4. The higher the silica content of a magma, the more viscous the magma is. In more viscous magma, gas that comes out of solution, in the form of bubbles, cannot escape as easily from the magma, thus allowing gas pressure to build up, which leads to explosive eruptions.

5. a) The VEI is a scale or measure of the potential for explosive eruption. It is based on the volume of erupted material and the height the plume of erupted material reaches. The students are not given the algorithm used to convert these effects into a value of the index.

b) It is not a perfect indicator, because other factors, not built into the index, like the wind field near the eruption, the possible occurrence of pyroclastic flows, or the possible later occurrence of lahars, are either not built into the index or are included only indirectly.

Assessment Opportunity

Use (or rephrase) the questions in **Check Your Understanding** for a brief quiz to check comprehension of key ideas and skills. Use the quiz (or a class discussion about the questions in the textbook) to assess your students' understanding of the main ideas in the reading and the activity.

Teaching Tip

You may wish to provide a copy of the unlabeled diagram from page 36 to help your students answer **Check Your Understanding, Question 2**. See **Blackline Master Volcanoes 4.2.**

Understanding and Applying What You Have Learned

1. Ash fallouts affect by far the largest areas because the wind carries material great distances from the volcano. Lava flows can affect large areas over a series of volcanic eruptions, but individual lava flows are not as large. Pyroclastic flows are likely to extend beyond any single lava flow, and the largest cover areas much larger than single lava flows.

2. Not necessarily. There have been eruptions that have put ash as far east as Nebraska. Volcanoes in Mexico and the Caribbean (**Activity 1**) could affect the eastern United States if the wind direction is to the north or northeast, although the general arrangement of global wind belts (northeast trade winds at low latitudes in the Northern Hemisphere, and westerlies at mid-latitudes) effectively rules this out, because the ash would be traveling a very circuitous route to reach the eastern United States.

3. The Hawaiian eruptions are not nearly as explosive due to the low silica content of the magma. Eruptions at Mt. St. Helens are more explosive due to viscous lavas of high silica content, which allows gas pressures to build and lead to explosions.

4. **a)** In most cases the model will show ash moving eastward with the westerly winds at high altitudes.
   b) The maps indicate that high-altitude winds travel from west to east over most of the United States.
   c) Answers will vary.

Preparing for the Chapter Challenge

Students are asked to consider how the ideas they developed in **Activity 1** about places most likely to be affected by volcanic eruptions may have changed as a result of this activity. Students are left to devise their own ways to share what they have learned with their relatives. For example, they can include any simulations run at the NOAA web site and other maps and data tables used in this activity to describe their ideas.

Inquiring Further

1. Make a model of tephra transport

This inquiry activity involves design, creativity, and ingenuity, and can be used to conduct a variety of simulations of the transport and deposition of volcanic material. If the simulations are run in the classroom, use large plastic drop cloths (inexpensive ones available at paint stores) and some framing materials to minimize the transport of materials throughout the classroom. If students do this as an at-home assignment, they can photograph or videotape their investigative results for classroom viewing.

Remind students to wear protective eyewear during this activity, even if they are doing the activity at home.

NOTES

Teaching Tip

If your students do not have ready access to the Internet you may wish to provide them with a copy of the sample provided.

You can also run your own simulation on the volcano closest to your community (see student work from **Activity 1**) and photocopy the results of your simulation for students. Encourage students to manipulate variables within the simulation, such as the height of the ash cloud (it can be taken to 100,000 feet), and to explain any patterns and relationships that they observe when comparing the results of different trials.

Also, note that the sample simulation shown on the opposite page for an eruption in Washington shows ash being transported southeastward. Ask students to compare this with the pattern and direction of ash shown on the map on student page 34.