INTRODUCTION
When magma forcefully erupts from a volcano, it can shatter into billions of fragments. These pieces can be as small as dust particles or as large as trucks. The fragmented materials include rocks, minerals, and broken pieces of volcanic glass. When the broken pieces are fine grained, the material is called volcanic ash. Ash can flow over the ground like a river at a speed of 400 kilometers per hour, covering everything in its path. Or it can erupt into the atmosphere, making daylight turn to darkness. When the ash settles out of the air and lands on water or land, it affects people, plants, machines, and any other living or nonliving thing it comes in contact with.

What does ash look like? What do the properties of ash tell us about its impact on people, property, and the environment? In this lesson, you will find out.

OBJECTIVES FOR THIS LESSON

Observe the properties of two igneous rock samples and their fragments.

Brainstorm ideas about volcanic ash and how it forms.

Analyze the properties of a volcanic ash sample and discuss how these properties reveal its composition and its potential effects on people, property, and the environment.

Develop a working definition for the word “ash.”

Observe two rock samples formed from ash and other fragments of volcanic material.
Getting Started

1. Collect your materials. Remove the rocks labeled #6 and #7, three hand lenses, the loupe, a penny, a dropper bottle of vinegar, a flashlight, a magnet, and one sheet each of white and black paper. Answer these questions as you observe the rocks with the observation tools.

   A. How are the rocks alike and different?

   B. What are the basic properties of each rock?

   C. Describe how you think the rocks formed. What type of rock is each sample?

   D. Can you identify the rocks by name? Explain.

2. Mark your dust mask with your initials and put it on. Wear safety goggles as well. Working with one rock at a time over black paper, scratch the penny against the rock, as shown in Figure 23.1 (page 254). Use the loupe and hand lenses to look closely at the rock fragments. Do this with both rocks #6 and #7. Now try white paper. Then answer these questions:

MATERIALS FOR LESSON 23

For you
1. pair of safety goggles
1. dust mask

For your group
1. tote tray
1. set of rocks, numbered #6 through #9
3. hand lenses
1. double-eye loupe
1. sheet of black construction paper
1. sheet of loose-leaf paper (or white construction paper)
1. beaker of water
1. dropper bottle of vinegar
1. flashlight
1. penny
1. ring magnet
1. Ash Tube™
1. container of dry volcanic ash, with lid
1. coffee stirrer
1. metric ruler
Paper towels
A. What are the properties of each rock’s fragments?

B. How are the fragments of each rock alike or different?

C. What do you think causes rocks to break into fine pieces?

3. Collect one beaker of water for your group. Test the buoyancy of each rock sample. Think about how this property might affect waterways. Dry the rocks with a paper towel when you are finished.

4. Discuss your observations with the class.

5. Now listen as your teacher models and talks about how the rocks you have observed form.

6. The fine-grained rock fragments on your paper are some of the fragments that make up volcanic ash. Brainstorm what you know and want to know about volcanic ash, including how it forms and how it affects people and the environment.

### Inquiry 23.1
Investigating the Properties of Volcanic Ash

#### PROCEDURE

1. Your teacher will review the tests you will conduct on the properties of ash. Follow along using Procedure Steps 4 through 12.

2. How will you record your observations? Discuss your ideas with your teacher.

3. Before you begin the inquiry, review the Safety Tips.

4. Begin your tests using the materials in your tote tray. Some groups may need to complete Procedure Step 10 before doing the other steps.

5. Observe the appearance of the ash. Do these steps:
   
   A. Use the coffee stirrer to place a very small sample of ash on the black paper.

### SAFETY TIPS

- Wear your safety goggles and dust mask while working with volcanic ash.
- Do not touch your fingertips to your eyes at any time during this lab.
- Wash your hands thoroughly when you have finished this inquiry.

![Figure 23.1](image-url)  
*Scrape the penny against each rock. What do you observe?*
B. Put another small sample on the white paper.

C. Use a hand lens, and then the loupe, to observe the color of the dry ash. Record your observations.

D. Shine a flashlight on the ash particles and continue your observations under magnification. What kind of particles do you think make up the ash? Are any particles particularly shiny? If so, what might they be? Discuss and record your observations.

6. Test the texture of the ash. Do these steps:

A. Touch the dry ash with your fingertip.

B. Describe its texture (smooth or rough, clumping particles or easily separated particles).

C. Describe the size of the particles. Are they all the same size or do the particle sizes vary? Use your ruler under the loupe. Try to measure one of the particles. Is the ash coarse (large pieces) or fine? Record your observations.

7. Determine the relative hardness of the ash particles. Do these steps:

A. Place a small amount of ash on the penny.

B. Rub the ash against the penny using your thumbnail, as shown in Figure 23.2.

C. Inspect both your nail and the penny for scratches. Knowing that a harder object will scratch a softer object, how would you describe the hardness of the ash?

D. If scratches are visible, what material in the ash do you think might cause scratches? (Think back to “Getting Started.”)

E. Record your observations in your notebook.

8. Observe the settling rate of the ash particles. Do these steps:

A. Remove the Ash Tube™ from your tote tray. It is the clear tube containing water and ash. (See Figure 23.3.)

B. Shake the Ash Tube. Watch the ash in the water.

C. Draw a picture of the Ash Tube in your observation table. Label your drawing.

![Figure 23.2](image-url)
**LESSON 23 VOLCANIC ASH**

**D.** On the basis of your observations of the Ash Tube, what substances do you think make up the ash sample?

**9.** Observe the magnetic properties of the ash sample. Do these steps:

**A.** Shake the Ash Tube. Quickly place the Ash Tube inside the magnet ring, as shown in Figure 23.3.

**B.** Shake the Ash Tube again. Move the magnet up and down along the sides of the tube. What do you observe?

**C.** Next, place a small amount of dry ash on a white sheet of paper. Observing the ash under magnification, move the magnet next to the ash. Record your observations.

**Figure 23.3 Place the Ash Tube inside the ring magnet. Move the magnet up and down along the tube.**

**10.** With your group, go to the balance to find out more about the density of ash. Do the following:

**A.** Use the balance to measure the mass of 100 mL of ash.

**B.** Calculate the density of the ash. (Remember to account for the mass of the empty flask and rubber stopper in your calculations. Density is mass per unit volume, so you will need to divide.)

**C.** Use the balance to calculate the density of an equal volume (100 mL) of water.

**D.** How does the density of ash compare with that of an equal volume of water?

**E.** Discuss with your group how this property of ash might affect houses and other structures on the earth.

**11.** Remove rocks #8 and #9 from your tray. Use your tools to observe them. How do you think these rocks are related to ash? Place one drop of vinegar (a weak acid) on each rock. Do this under magnification. Repeat this step with a very small sample of the dry sample of ash. Record your observations.

**12.** Clean up. Do the following:

**A.** Return all the dry ash particles back to the small container. Place the lid on the container.

**B.** Wipe up ash from all surfaces.

**C.** Return all items to your tote tray.

**D.** Wash your hands.

**E.** Make certain your dust mask has your initials on it. You will reuse it in Lesson 24.
REFLECTING ON WHAT YOU’VE DONE

1. Share your results with your class.

2. Think about each of the properties of your ash sample. Answer these questions.

   A. On the basis of its hardness, how might volcanic ash harm people or property?

   B. On the basis of the settling test, how might ash affect waterways (for example, rivers, lakes, and ponds)?

   C. What does the density of the ash tell you about how it might affect property? What does it tell you about how it might affect the environment?

   D. What could you do to protect your health if you lived near erupting ash?

3. Use your observations to develop a working definition for the word “ash.”

4. Consider your observations of rocks #8 and #9. Answer the following:

   A. What are rocks #8 and #9 made of?

   B. How do you think these two rocks formed?

   C. Looking at rocks #8 and #9, do you think there are any constructive effects (benefits) of ash erupting from a volcano? What might they be?

5. Look ahead to Lesson 24, in which you will investigate the effects of volcanic ash fall.

Months before the eruption, scientists had observed many signs that the mountain was about to blow. A large bulge on the north face of the mountain kept growing, which was a sign that magma was rising. On March 20, 1980, an earthquake shook the area. It measured 4.1 on the Richter scale. One week later, a series of explosions began that sent fragmented older volcanic rock and steam into the air. These earthquakes, together with periodic venting of rock and steam, continued for weeks. Sulfuric acid levels rose in local ponds and streams, and hydrogen sulfide odors increased dramatically.

On May 18, 1980, an earthquake that registered 5.0 on the Richter scale triggered the collapse of the bulging north side of the mountain, causing a volcanic landslide. The decrease in pressure on the magma chamber caused a violent release of steam and lava. As bubbling lava rose in the air, it solidified instantly. A fine ash cloud rose 19 kilometers above the volcano, as shown in the photo on the next page.

Ash fell several meters deep in areas close to Mt. St. Helens, while prevailing winds drove the cloud to the east-northeast. Communities as far away as 800 kilometers were blanketed by ash. In Yakima, Washington, 130 kilometers to the east, the ash fall caused almost total darkness at midday. Nearly 1 billion tons of ash were deposited over a huge area. Acid droplets from the eruption remained suspended in the atmosphere for as long as 2 years.

Flows of hot gases and volcanic ash more dense than air raced down the north side of the mountain. This heavy ash flow destroyed everything in its path. It caused steam explosions when it encountered bodies of water or moist ground. These explosions continued for weeks; one even occurred a year later.

Heat from the eruption melted snow and glaciers, which mixed with ash on the upper slopes of the mountain and formed a thick volcanic mudflow. Like an avalanche, the mudflow displaced water in lakes and streams and caused flooding downstream.
When Mt. St. Helens erupted, an ash cloud rose 19 kilometers above the volcano.
Top: During the May 1980 eruption of Mt. St. Helens, at least 17 separate ash flows moved down the mountain like raging rivers. They traveled at speeds of over 100 kilometers per hour and reached temperatures of over 400 °C.

Bottom: Nearly 220 kilometers of river channels surrounding the volcano were affected by mudflows. A mud line on the trees shows the depth of the mud.
The volcano’s warning signs had allowed scientists to warn government agencies, which closed much of the area to tourists and restricted the activity of residents. Sadly, however, 63 people died as a result of the eruption, most of them because they ignored the evacuation advice.

The eruption of Mt. St. Helens left a large crater. Five more explosive eruptions occurred during 1980, and the volcano continued to erupt through 1986. These successive eruptions created a lava dome on the floor of the crater. Today, the eruptions appear to be over. But Mt. St. Helens is the most frequently active volcano in the Cascade Range, and scientists anticipate the volcano will erupt violently again.

**Monitoring the Volcano’s Warning Signs**

Scientists at the U.S. Geological Survey monitor Mt. St. Helens in order to predict future eruptions. In the top photo on page 00, geologists use a steel tape to measure the distance across a crack in the volcano’s crater floor. Widening cracks indicate that magma is rising, deforming the area, and leading to an eruption. These cracks usually extend outward from the lava dome, like the spokes of a wheel.

Geologists also use a tiltmeter to electronically measure changes in the slope of the crater floor, which are caused by moving magma. Tiltmeters allow 24-hour monitoring. The information collected from these instruments is relayed to the volcano observatory.

Scientists also place seismographs at stations near the lava dome to monitor earthquake activity. An increase in the number of earthquake vibrations is often the first sign that a major eruption is approaching. Scientists also collect gas samples from the volcano. They place gas sensors around vents near the lava dome and crater floor. Specially equipped airplanes measure sulfur dioxide emissions.
Top: Scientists use a steel tape to measure changes in the cracks on the crater floor.
Bottom: Geologists collect gas samples around the dome of the volcano.
gas, which usually increases 5- to 10-fold during an eruption.

**Signs of Renewal**

Plant and animal life returned to Mt. St. Helens. As early as the summer of 1980, new vegetation began to appear. Many small trees and plants, which had been protected during the eruption by packed snow, re-emerged after snowmelt. Seeds carried by the wind or by animals landed in the area and sprouted on the lava-covered ground. By 1985, new growth covered all the ridges surrounding the volcano. During the May 1980 eruption, many small animals—such as gophers, mice, frogs, fish, and insects—were protected from the blast because they were below ground or underwater. Many large animals, such as bear, elk, deer, and coyotes, were killed in the eruption, but with the return of a food supply, they have repopulated the region.

**Future Eruptions?**

Several other mountains in the Cascade Range (see map) pose a threat to populated areas. Eruptions of Mt. Shasta in northern California would cause damage and perhaps fatalities to several nearby communities. Mt. Hood, in Oregon, lies less than 65 kilometers away from the densely populated city of Portland. Probably the most dangerous eruption would be from Mt. Rainier, in Washington. During the past 10,000 years, there have been at least 60 mudflows from Mt. Rainier, one of which completely covered an area that is now populated by 120,000 people. No one can predict when another mudflow might take place from Mt. Rainier or when any of these Cascade mountain volcanoes might “wake up.” With continued monitoring and emergency evacuation plans in place, scientists and public officials hope everyone will be ready when the next volcano blows its top. 