Activity Overview

Students read a report from a volcano observatory to note changes that take place prior to a volcanic eruption. Students then consider these clues or signals to design an instrument that can be used to monitor and detect changes in a volcano prior to an eruption.

Preparation and Materials Needed

Your preparation for this activity depends upon the importance you place on having students construct models of their volcano-monitoring instruments. If you do have students construct instruments, you will have to decide whether you or they will supply the physical materials. Students can construct their models of monitoring instruments from materials readily available at home.

Being asked to design, and perhaps build, a working instrument to monitor a volcano will be a challenge for the students. Here are just a few ideas for your consideration. You might want to use them to give hints or ideas to students who have little experience with the wide range of materials available for use, or whose level of imagination or creativity is below what is needed to complete this activity without frustration.

Volcanologists use devices called tiltmeters to measure extremely small changes in the slope of the land surface caused by magma movements in the subsurface. They also use modern surveying techniques, using sophisticated surveying equipment, to detect changes in land–surface elevation at points far apart. Students cannot be expected to attain the needed level of sensitivity of professional instrumentation (unless a student with genius invents an entirely new instrument!), but they should be able to think of devices that could measure coarser changes in slope or elevation. Following are examples of three devices that are within most students' abilities to imagine or appreciate:

(1) Set a large square of plate glass on lumps of modeling clay at the four corners of the plate. Plate glass would be better than ordinary window glass, because it is more nearly perfectly planar, and it is much more difficult to break. Place a marble or, better, a large steel ball bearing in the center. It will roll off the glass. Adjust the horizontality of the glass by pressing at the corners above the modeling clay until the plate is so nearly horizontal that the ball will not roll off. If the slope of the land changes sufficiently, the ball will roll off in the direction of tilt. This is a sensitive, but only nonquantitative device for detecting tilt.

(2) Connect three or four long lengths of garden hose together, and attach one-meter lengths of clear plastic tubing to each end, using duct tape (wrap it tightly to prevent leaks) or hose clamps. Tie each end to a piece of 2 x 4 lumber set vertically in the ground like a fence post. Fill the hose to the point where you can

see the water level in the clear tubing. Tape a meter stick securely behind the clear tubing at each end, so that you can sight horizontally through the tubing to read the elevation of the water surface. Record the water level at each end. If the ground surface tilts, the reading will increase in one end and decrease in the other as the water seeks to re-level itself. With just a bit of trigonometry, you could then compute the change in slope angle of the ground. The accuracy of the device increases with the length of the hose.

(3) Buy, rent, or borrow a hand-held laser level, now in common use by contractors and do-it-yourselfers. Mount it rigidly on a platform that is attached firmly to the ground. Adjust the platform so that the beam is level. (Such levels are usually self-adjusting, within certain limits.) Aim the laser beam at a meter stick stuck vertically in the ground as far away as the beam is still well-defined. Note the point on the meter stick where the beam strikes. If the ground tilts, the reading on the meter stick will change.

Volcanologists also use seismometers to detect earthquakes (usually minor ones) caused by movement of magma as it rises toward the surface. Students should be able to design a crude seismometer for this purpose. Construction and use of such a seismometer is included in one of the activities in **Chapter 3** of this module, on earthquakes. You might look ahead to that material to help the students imagine a design for a seismometer at this point. The basic principle of a seismometer is simple. Attach a large mass (a rigid lump of dense material) to springs or flexible cords within a rigid frame. When the ground moves during an earthquake or an explosion, or even the passage of a motor vehicle, the frame, because it is attached to the ground, moves as well. The large mass, on the other hand, tends to stay in one place, by Newton's first law of motion, because the spring or cord is so easily stretched. All that is needed is a way to detect the very small motion of the (almost motionless) mass relative to the (moving) frame, by somehow magnifying the motion so that a deflection can be read on a scale.

Think about It

Student Conceptions

The question "How would you be able to tell that a volcano was about to erupt?" should reveal your students' ideas about the signals that volcanoes give off prior to an eruption. Students might be expected to suggest that earthquakes precede an eruption (because of magma activity and fracturing of bedrock beneath the breaking of rock within the volcano), or that there is a change (increase) in the release of smoke and gases. Entertain students' ideas in a brief discussion. Ask students to provide reasons for their ideas. Record the ideas on a chart or overhead for students to consider. It is very likely that amongst the class you will receive answers that pertain very directly to what students will explore in this activity.

Answer for the Teacher Only

The phenomena that might be expected prior to a volcanic eruption are covered in the **Background Information** at the beginning of this activity. Here is a summary of the major effects:

- Changes in land–surface topography caused by updoming as magma pushes its way toward the land surface.
- Increase in the frequency of minor to medium-size earthquakes as magma exerts forces on surrounding and overlying rocks, causing them to fracture and shift.
- Increased frequency of failure of steep slopes in the form of rockfalls or other mass movements, as Earth movements cause fracturing and loosening of already unstable near–surface materials on steep slopes.
- Changes in the composition or rate of emission of volcanic gases from fissures. Typically, the volume of gases released increases as the magma approaches the surface.
- Increase in the temperature of hot-spring waters, if there are hot springs in the vicinity.

Assessment Tool

Think about It Evaluation Sheet

Refer students to their copy of this evaluation sheet to help them to understand and internalize basic expectations for the warm-up activity. Ask them to write down all that they know about volcanoes and the changes that volcanoes might undergo prior to an eruption, and to describe their ideas and beliefs clearly. If students draw a diagram to indicate the changes, check that it is a clear diagram that is fully labeled so that the reader understands what the diagram is intended to show.

Investigate

Evidence in the Montserrat report in the student text that signals an impending eruption is shown in boldface type below:

Montserrat Volcano Observatory Daily Report 3/25/99 to 3/26/99
A slight change in the nature and level of **seismicity** was observed during the period under review. There were nineteen (19) **earthquakes**, nineteen (19) **rockfalls** and three (3) **regional events**. An increase in small earthquakes that are thought to be associated with **rock fracturing** due to **dome growth** was noted. About one hundred and thirty-four (134) of these small events were recorded on the Gages and Chances Peak Seismographs. The southern and eastern EDM [electronic distance measurement] triangles were measured today. The very small **changes in the elevation of the land** measured were consistent with the recent trends. Visual observations were made early this morning from the helicopter in excellent viewing conditions and subsequently from Chances Peak. The dome continues to **steam** and **vent gas** from various locations. The focus of activity has shifted from the two previously active areas (near Farrell's and to the north of Castle Peak) to two new areas located on the eastern and western sectors of the dome. Rockfalls may continue to occur in the area north of Castle Peak. The rockfalls in this area have been the source of the recent **ash clouds**.

It is important to note that any one such report does not provide a comprehensive list of changes that signal an impending eruption. Also, an eruption does not always occur every time there is a change in some aspect of the volcano: the magma beneath the volcano might subside or drain back downward again, or merely remain in place without further uprise, without causing an eruption at that particular time. The report selected for students to read was, however, made on the day before an eruption at Montserrat.

Assessment Tool

Investigate Notebook Entry-Evaluation Sheet
The **Investigate Notebook Entry-Evaluation Sheet** is designed to help students get a sense of the expectations for *EarthComm* notebook entries. You might wish to review the criteria and discuss with students how the criteria relate to what they are being asked to do in the investigation.

Because technological design (in this case, the design of a monitoring instrument) is an important element of the National Science Education Standards for Science and Technology, you might consider developing a specific rubric for evaluating student work through a class discussion.

Encourage the sharing of designs during the investigation and also during a class discussion at the end of the investigation. Students in the audience who listen to presentations should be encouraged to question and seek clarification about designs and usefulness of the instrument.

Reflecting on the Activity and the Challenge

The text in this section summarizes the benefits of volcano-monitoring programs and methods.

Check Your Understanding

1. Monitoring equipment cannot be used to prevent an eruption. Monitoring instruments work by providing scientists with information that can be used to make decisions. If the information is available and interpreted properly, monitoring instruments can prevent or reduce loss of life by enabling timely evacuation of residents.

2. Monitoring a volcano requires instrumentation for detecting changes in and around the volcano and personnel to gather and interpret the information.

3. Active feeding of magma into a volcano results in swelling or updoming of the land surface, steepening of the slopes of the volcano, and fracturing of bedrock beneath the volcano due to upward forces exerted by the rising magma rock layers that stretch beyond the breaking point.

4. Tiltmeters are highly sensitive instruments. They can detect changes in surface slope elevation of a few parts per million — 1 in 10^6 (for example, a local change in slope equivalent to one millimeter in elevation difference over a distance of one kilometer, which translates to a difference in local slope angle of $5.7 \times 10^{-5°}$).

Understanding and Applying What You Have Learned

Have your group's spokesperson report to the class about your experiences designing, devising written plans, understanding the plans of other groups, and using monitoring instruments. In your notebook, record your responses to the following questions:

1. a) Answers will vary.
   b) Answers will vary.
   c) Answers will vary. Monitoring instruments, even those simple in design, might provide residents with information to make decisions prior to an eruption.
   d) The elevation of the surface of the volcano increases prior to an eruption. The slope of the land increases. Usually, the elevation of the surface of the volcano, and the slope of the land on the flanks of the volcano increases prior to an eruption.
   e) You would measure the elevation of the land over time by methods of land surveying, and look for changes.
   f) The emission of volcanic gases usually increases prior to an eruption.

g) Seismic activity almost always increases prior to an eruption.

h) Answers will vary.

i) Answers will vary.

2. Answers will vary.

a) Answers will vary.

b) Monitoring volcanic gases, which require one's presence on the volcano, especially within the caldera, is likely to be the most dangerous.

c) Answers will vary.

d) All aspects of volcano monitoring are challenging, for both geologists and communities, because all give uncertain indications on which to base predictions. Perhaps the most challenging, physically and emotionally, are those requiring one's presence near a volcano that might erupt at any time!

3. Weather is a day-to-day phenomenon that affects everyone. Severe weather has done much more damage and caused far more injuries and deaths in recent times than volcanoes. If the rare gigantic volcanic eruptions eventually occur in America's future, then much more elaborate and systematic monitoring would probably ensue.

Preparing for the Chapter Challenge

Students should have produced a design that they can include in their **Chapter Report**, as well as learned about other students' designs, which they can summarize in a brief essay with sketches. Ask students to explain how they will incorporate their volcano-monitoring instruments into their story or screenplay about a volcanic eruption. Remind students about the importance of scientific accuracy within the criteria used to evaluate their **Chapter Challenge**.

Inquiring Further

1. Volcanic hazards of Mt. Rainier

The video *Perilous Beauty: The Hidden Dangers of Mount Rainier* shows footage of an explosive eruption. It can be used to help students to better understand the need for volcano monitoring in the United States.