

Volcanoes: How Safe Are They?

Teachers: This lesson contains three classroom activities with discussion questions related to the AFG video clips volcanoes and volcanic hazards. These may be used individually or together, depending on the needs of your class.

Note: You can access and view the video clips used in this lesson in the Teacher Resources section of the AFG Web site (www.pbs.org/americanfieldguide/teachers).

Grade Level: 9-12

Background Information

Volcanoes have been an influence on Earth since its formation. They have shaped our planet and our atmosphere. Before scientific theories were developed to explain them, humans documented the power of volcanoes and, at times, their destructive power. As dramatically demonstrated by the catastrophic eruption of Mount St. Helens in May 1980 and of Pinatubo in June 1991, volcanoes can wreak havoc and devastation in the short term. However, it should be emphasized that the short-term hazards posed by volcanoes are balanced by benefits of volcanism and related processes over geologic time. Volcanic materials ultimately break down to form some of the most fertile soils on Earth, cultivation of which fostered and sustained civilizations. People use volcanically produced materials, as abrasive and cleaning agents, and for many chemical and industrial uses. The internal heat associated with some young volcanic systems has been harnessed to produce geothermal energy. Yet, today, half a billion people live close enough to Earth's 1,500 active terrestrial volcanoes to be threatened by them. In this series of lessons, we will investigate the location of volcanoes around the globe and the dangers they present to the populations that live in close proximity to them.

Related National Standards

This lesson addresses the following National Content Standards found at:
<http://books.nap.edu/html/nses>

Content Standard D: As a result of their activities in grades 9-12, all students should develop an understanding of:

- Energy in the Earth System
 - The outward transfer of earth's internal heat drives convection circulation in the mantle that propels the plates comprising earth's surface across the face of the globe.
- Origin and evolution of the Earth System
 - Interactions among the solid earth, the oceans, the atmosphere, and organisms have resulted in the ongoing evolution of the earth system. We can observe some changes such as earthquakes and volcanic eruptions on a human time scale, but many processes such as mountain building and plate movements take place over hundreds of millions of years.

Content Standard F: As a result of their activities in grades 9-12, all students should develop an understanding of:

- Natural and human-induced hazards
 - Normal adjustments of earth may be hazardous for humans. Humans live at the interface between the atmosphere driven by solar energy and the upper mantle where convection creates changes in the earth's solid crust. As societies have grown, become stable, and come to value aspects of the environment, vulnerability to natural processes of change have increased.
 - Natural and human-induced hazards present the need for humans to assess potential danger and risk... Students should understand the costs and trade-offs of various hazards – ranging from those with minor risk to a few people to major catastrophes with major risk to many people.

Extension Web sites from PBS

- **Deadly Shadow of Vesuvius**
<http://www.pbs.org/wgbh/nova/vesuvius/>
This site contains detailed information about deadly volcanic eruptions. It contains a number of useful teacher tools as well as information for students.
- **Hawaii – Born of Fire**
<http://www.pbs.org/wgbh/nova/hawaii/>
Learn about igneous rocks and lava sampling by scientists. The site also contains information for the teachers about the formation of the Hawaiian volcanoes and useful tools for the classroom.
- **SCIENCE ITALIAN STYLE: Eruption!**
http://www.pbs.org/safarchive/4_class/45_pguides/pguide_503/4553_eruption.html
This site is a resource for teachers where students may study the viscosity of lava flow.
- **Savage Earth: Out of the Inferno – Volcanoes**
<http://www.pbs.org/wnet/savageearth/volcanoes/index.html>
An extensive site with a wealth of resources about volcanoes. It contains several useful demonstrations that can be used in a classroom setting.

Activity 1: Where are the Volcanoes?**Time Allotted:**

45-minute period

Materials:

- World map
- Push pins labeled with a number
- Access to the Internet
- Blank paper
- Crayons, markers, colored pencils
- Volcano List (attached)

Objectives:

- Students will locate volcanoes throughout the world.
- Students will identify and record general information about the volcano.
- Students will organize information about the volcano into a fact sheet display.

Pre-Teaching Activity

Ask students to write in their journal for 5 minutes about the question "How do volcanoes affect people?" Save these entries to be used at the end of the activity set. Students will compare this pre-activity journal entries to an entry completed after activities and discussions about volcanic hazards.

Classroom Activity

1. Divide students into pairs. Each pair will become an expert on a volcano from the Volcano List (attached).
2. Students will research the following information about their volcano and organize this information into a fact sheet, which will be posted in the classroom. Most of the information listed below can be found using the web links found on the Volcano List.
 - Name of the volcano
 - Location – longitude and latitude, country
 - Cities within a 50-mile radius of the volcano (include populations of those cities). Use the Internet or maps as available.
 - Size of the volcano, including area and elevation
 - A sketch of the volcano
 - The eruptive history of the volcano including dates and brief descriptions of each eruption

- New vocabulary or words they are unsure of
 - Any other interesting facts
3. Students will then locate their volcano on the large world map and place the corresponding numbered pushpin at that location. The fact sheets will be displayed as a border around the world map.
 4. New vocabulary words will be added to a class list of vocabulary that is new to students or needs to be reviewed. This list will include new vocabulary from all groups.



Watch the AFG Video Segment: "Mount Edgecumbe, Alaska"

Note: You can access and view the video clips used in this lesson in the Teacher Resources section of the AFG Web site (www.pbs.org/americanfieldguide/teachers).

Discussion Questions for Video Segment

- What do geologists propose as the origin of Mount Edgecumbe?
- What dangers might Mount Edgecumbe pose to the residents of Sitka if it were still active?
- What evidence from the past is there of these dangers?



Watch the AFG Video Segment: "Mount St. Helens Blast Zone"

Stop segment when they turn around to look at the volcano

Discussion Questions for Video Segment

- How did the Cascade volcanoes form?
- Why are they lined up in nearly a straight line from North to South?

Post-Activity Discussion

This is an opportunity for the teacher to work through some of the new vocabulary words or assign students vocabulary words to define. A discussion of the activity may include the following questions:

- Where do we generally find volcanoes throughout the world?
- Are the researched volcanoes near major cities?
- Is there a potential for danger given the eruptive histories of these volcanoes?

Related Web Site

- **Index to Cascade Volcano Observatory's Volcanoes of the World**

<http://vulcan.wr.usgs.gov/Volcanoes/framework.html>

This website is an index of links to most of the major volcanoes in the world. It is a valuable tool for both teachers and students.

Activity 2: What is a Volcanic Hazard?**Time Allotted:**

Two 45 minute periods, one for research and one for presentations

Materials:

- Materials needed for demonstrations (will differ by group, students must be responsible for obtaining necessary materials or informing the teacher of what they need one day in advance)
- Blank paper
- Colored pencils, markers, crayons
- Access to the Internet
- Teacher scoring guide for group presentations
- Student note taking sheet

Objectives:

- Students will define volcanic hazards.
- Students will build models or demonstrations of volcanic hazards.
- Students will demonstrate their research on volcanic hazards in the form of a group presentation to the class.

Pre-Teaching Activity:

Use a wrap up discussion or writing from Activity 1 to generate ideas for volcanic hazards based on general research of the eruptive history of volcanoes. What do you know about volcanic hazards? What would you like to know? Encourage students to develop a list of some hazards they have heard of or are familiar with.

**Watch the AFG Video Segment: "Mount St. Helens Blast Zone"**

Note: You can access and view the video clips used in this lesson in the Teacher Resources section of the AFG Web site (www.pbs.org/americanfieldguide/teachers).

Discussion Question for Video Segment:

- What types of volcanic hazards were present before the eruption of Mount St. Helens?
- What types of destruction resulted from eruptive blast?

Classroom Activity:

1. Divide students into groups of 3-4
2. Using the Volcanic Hazard List (attached), groups will organize a class presentation. This class presentation must include all of the following components:
 - A definition of the hazard. What materials are involved and what conditions frequently exist for this hazard to occur.
 - A visual aid. This can be a demonstration and/or a drawing, photograph, video clip, computer movie, map or diagram.
 - A history and occurrence of this type of hazard.

American Field Guide Teacher Resources: Volcanoes

Access this lesson plan online at: www.pbs.org/americanfieldguide/teachers

- Examples of where this hazard has happened and the damage it has caused. Attempt to limit your search for examples in the United States.
 - The potential hazards for city populations located close to active volcanoes.
3. After researching this information, students will present a 3-4 minute informative presentation to the class about their hazard of interest. Other students will take notes on the presentations using the note-taking sheet. It is essential for students to take detailed and complete notes during the presentation to participate in the third activity.
 4. The teacher will assess each group presentation using the included Volcanic Hazard Presentation Scoring Guide.



Watch the AFG Video Segment: "Newberry Crater Submerged Campsite"

Discussion Question for Video Segment

- Describe the volcanic hazards faced by the ancient cultures living near the Newberry Caldera.

Related Web Sites

The following sites are useful for both teachers and students for finding information on volcanic hazards:

- **USGS: Types of Volcanic Hazards**
<http://volcanoes.usgs.gov/Hazards/What/hazards.html>
- **USGS: Volcano and Hydrologic Hazards, Features, and Terminology**
<http://vulcan.wr.usgs.gov/Glossary/framework.html>
- **Volcanic Hazards**
<http://www.dartmouth.edu/~volcano/EvI.html>
- **USGS: Volcanic Fact Sheets**
<http://volcanoes.usgs.gov/Products/sproducts.html#fs>
- **USGS: Glaciers and Ice Sheets and Volcanic Eruptions**
http://vulcan.wr.usgs.gov/Glossary/Glaciers/description_glaciers_hazards.html

These are useful for students looking for demonstrations, activities or visual aids to include as a part of their presentation:

- **Volcano Hazard Activity**
<http://volcano.und.nodak.edu/vwdocs/Online/haz.html>
- **USGS Volcanoes Teachers Guide**
<http://mac.usgs.gov/mac/isb/pubs/teachers-packets/volcanoes/>
- **Volcano World Search Engine**
http://volcano.und.edu/big_search.html

Further information on humans and volcanoes:

- **USGS: Cascades Volcano Observatory - Living With Volcanoes**
<http://vulcan.wr.usgs.gov/LivingWith/framework.html>

Activity 3: How do Volcanoes Affect People?**Time Allotted:**

Two to three 45-minute class periods plus some time as homework

Materials:

- Scenarios for volcanic eruptions (attached)
- Completed notes from Activity 2 or background information on volcanic hazards
- Access to the Internet

Objectives:

- Students will apply their knowledge of volcanoes and volcanic hazards to a specific situation.
- Students will analyze possible scenarios and compile their research in small groups.
- Students will create a volcanic risk assessment.

Classroom Activity

1. To set the scene for the activity, tell the class that each student will be working as a volcanic hazard expert for the U.S. Geological Survey. Their task will be to research the potential risks posed by one of the currently active volcanoes on the Scenario Sheet (attached) and create an assessment report to be used by the local communities surrounding the volcano.
2. As hazard experts, students will work together in groups to compile a volcanic risk assessment of their designated active volcano. Volcanic risk assessments are detailed, written documents that describe:
 - The location and size of the volcano
 - The eruptive history of the volcano
 - Its potential for eruption
 - The most likely hazards posed by the volcano
 - A plan for monitoring the volcano
 - Proposed actions for informing people in metropolitan areas near the volcano.
3. The final product should include the above information. Each group will determine the specifics of the information to be included. This assessment should be 3-5 pages in length and **must include** a bibliography or works cited page. This assessment should be graded using a scoring guide similar to the scoring guide for the Volcanic Hazard presentations. These assessments can be extended to include presentations to the class.

Volcanic Hazard Presentation Scoring Guide

Teachers: Use this scoring guide for grading the student presentations on Volcanic Hazards.

Hazard: _____

Student Names:

Points	Required components: Hazard, definition, history, examples, potential for disaster	Group participation and involvement in presentation	Demonstration or visual aid	Knowledge or understanding of the hazard
	Includes all required components; content is clear and focused	All members contribute and participate in presentation	Visual tools help explain and describe the action and risk of the hazard	Clear main ideas, carefully selected details, complex connections and insights
	Missing one or two required components, content is less organized	Some members do not contribute	Visual aid is present but lacks focus or is not connected to presentation	Main idea is present; limited supported details; limited understanding
	Includes only part of necessary components; presentation is unclear and unorganized	One group member dominates presentation; other members make no effort to contribute	Visual aid is missing or unrelated to hazard	Unclear main idea; few or no details; presentation is a list of facts with no understanding of hazard.

Volcano List

Volcanoes around the World:

Use the following list of volcanoes and Internet links to learn more about these volcanoes.

- **Mount Pinatubo**
http://volcano.und.edu/vwdocs/volc_images/southeast_asia/philippines/pinatubo.html
- **Bezymianmy**
http://volcano.und.edu/vwdocs/current_volcs/bezymianny/bezymianny.html
- **Nevado del Ruiz**
http://volcano.und.edu/vwdocs/volc_images/img_ruiz.html
- **Erebus**
http://volcano.und.edu/vwdocs/current_volcs/erebus/erebus.html
- **Katmai**
http://volcano.und.edu/vwdocs/volc_images/north_america/alaska/katami.html
- **Kilauea**
http://volcano.und.edu/vwdocs/volc_images/north_america/hawaii/kilauea.html
- **Krakatau**
http://volcano.und.edu/vwdocs/volc_images/southeast_asia/indonesia/krakatau.html
- **La Palma**
http://volcano.und.edu/vwdocs/volc_images/africa/lapalma.html
- **Kelut**
http://volcano.und.edu/vwdocs/volc_images/southeast_asia/indonesia/kelut.html
- **Mt. Etna**
http://volcano.und.edu/vwdocs/volc_images/img_etna.html
- **Mt. Fuji**
http://volcano.und.edu/vwdocs/volc_images/img_fuji.html
- **Mt. Pelée**
http://volcano.und.edu/vwdocs/volc_images/img_mt_pelee.html
- **Mt. Rainier**
http://volcano.und.edu/vwdocs/volc_images/img_rainier.html
- **Mount St. Helens**
http://volcano.und.edu/vwdocs/volc_images/img_st_helens.html
- **Montserrat**
http://volcano.und.edu/vwdocs/current_volcs/montserrat/montserrat.html
- **Popocatepetl**
http://volcano.und.edu/vwdocs/volc_images/north_america/mexico/popocatepetl.html
- **Mount Vesuvius**
http://volcano.und.edu/vwdocs/volc_images/img_vesuvius.html

Volcanic Hazards List

Working in your groups, prepare a presentation on one of the following volcanic hazards:

- Volcanic gases
- Lahars
- Landslides
- Lava flows
- Pyroclastic flows
- Tephra or ashfall
- Jokulhlaups or glacial hazards
- Volcanic floods
- Tsunami

Web Resources

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<http://volcanoes.usgs.gov/Hazards/What/hazards.html>
- **USGS: Volcano and Hydrologic Hazards, Features, and Terminology**
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- **Volcano World Search Engine**
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Further information on humans and volcanoes:

- **USGS: Cascades Volcano Observatory - Living With Volcanoes**
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Volcanic Hazard Note Sheet

Use this sheet to take notes during your classmates' volcanic hazards presentations. Be sure to take detailed and accurate notes. You will need this information in the next activity.

Names of presenters	Hazard and definition	History and occurrence of this hazard	Examples of where this hazard has occurred	Potential for this hazard affecting cities near volcanoes

Scenarios for Activity Three: Volcanic Eruptions

Mount Rainier, Washington

Mount Rainier, at 4,393 meters (14,410 feet) is the highest peak in the Cascade Range. It is a volcano covered by more glaciers than any other mountain in the conterminous United States. This tremendous mass of rock and ice, in combination with great topographic relief, poses a variety of geologic hazards, both during inevitable future eruptions and during the intervening non-eruptive periods. Built upon the flanks of Mount Rainier are the metropolitan centers of Seattle, Tacoma and Olympia. These cities and the many smaller towns are at substantial risk from this volcano.

Mammoth Lakes, California

Long Valley Caldera a 15- by 30-km oval-shaped depression located 20 km south of Mono Lake along the east side of the Sierra Nevada in east-central California. This area of eastern California has produced numerous volcanic eruptions over the past 3 million years, including the massive caldera-forming eruption 760,000 years ago. The most recent eruption occurred just 250 years ago in Mono Lake at the north end of Mono-Inyo Craters volcanic chain. On May 25-27, 1980, the Long Valley caldera was rocked by four $M = 6$ earthquakes. This seismicity heralded the onset of a wave of activity within the caldera that has continued through the present time. Unrest has taken the form of seismic swarms, uplift of the resurgent dome, and areas of vegetation killed by increased CO₂ emissions, all interpreted as resulting from magma injected to different levels beneath the caldera. Continuing economic development in the Mammoth Lakes area has swelled the local population, increasing the risk to people and property if an eruption were to occur.

Three Sisters, Oregon

Three Sisters is one of three potentially active volcanic centers that lie close to rapidly growing communities and resort areas in Central Oregon. Two types of volcanoes exist in the Three Sisters region and each poses distinct hazards to people and property. South Sister, Middle Sister, and Broken Top, major composite volcanoes clustered near the center of the region, have erupted repeatedly over tens of thousands of years and may erupt explosively in the future. In contrast, other volcanoes, which range from small cinder cones to large shield volcanoes like North Sister and Belknap Crater, are typically short-lived (weeks to centuries) and erupt less explosively than do composite volcanoes. Hundreds of these less-eruptive volcanoes scattered through the Three Sisters region are part of a much longer zone along the High Cascades of Oregon in which birth of new volcanoes is possible.

Hawaii

Ever since lava first erupted above sea level over 500,000 years ago to begin building the Island of Hawaii, countless eruptions from its five volcanoes have built the "Big Island" to a towering height of more than 4,000 m (13,000 ft). Its two most active volcanoes -- Mauna Loa and Kilauea -- erupt lava frequently enough to pose a serious hazard to property on many parts of the island. About 40 percent of Mauna Loa has been covered by lava in the past 1,000 years and over 90 percent of Kilauea's surface is covered by lava less than 1,100 years old. As land development expands toward areas of relatively high hazard, the threat to life and property on Hawaii will increase accordingly.