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INTRODUCTION
Earthquakes and tornadoes often occur with little warning. Volcanic eruptions, by contrast, can often be forecast well before they happen. Many different signs from the earth tell scientists that a volcano may be about to erupt. Earthquakes, which normally occur before a volcanic eruption, mean that molten rock within the earth is rising, putting pressure on rock. Usually these earthquakes are weak and cannot be detected without the aid of seismographs. An increase in the number of earthquakes may indicate to scientists that a volcano is getting ready to erupt.

Other signs of possible eruption include the presence of steam and ash, which can emerge during small explosions from a volcanic vent. The amount of sulfur in the air over a volcano might also increase as gas is released from the rising molten rock. The top and sides of the volcano may begin to bulge as the molten rock

OBJECTIVES FOR THIS LESSON
Analyze the causes and effects of volcanic eruptions by watching a video.

Brainstorm what you know and want to learn about volcanoes.

Analyze scientists’ ability to forecast volcanic activity and explore the challenges they face in making such forecasts.

Identify other catastrophic events related to volcanoes.

Classify the effects of volcanic eruptions as either destructive (negative) or constructive (positive).
approaches the surface. Volcanologists use special tools to measure the changes that occur in a volcano. By monitoring these changes, scientists can attempt to forecast when the volcano might erupt. The right forecast can save lives and protect property.

What causes volcanoes? How are volcanoes destructive? Do volcanoes have any constructive, or good, effects? In this section of Catastrophic Events, you will investigate questions such as these and discuss the relationships among volcanoes and other catastrophic events.

**Getting Started**

**1.** Think about the investigation of mantle convection in Lesson 16. What evidence do we have that the earth’s interior is hot? Discuss the answers to this question with your class.

**2.** How would you define the word “volcano”? What do volcanoes tell us about the earth? Share your ideas with the class.

**MATERIALS FOR LESSON 18**

**For your group**
- Concept map
- 1 set of colored markers
Inquiry 18.1
Thinking About Volcanoes

PROCEDURE

1. Watch the video about the volcanic eruption of Mt. Pinatubo in the Philippines, called *In the Path of a Killer Volcano*. As you watch, identify the following things and record information about them in your notebook:

   A. Two or more instruments or procedures that scientists used to monitor the volcano’s activity
   
   B. Two or more signs that the volcano was about to erupt
   
   C. One or more possible causes of the volcano’s eruption
   
   D. Two or more effects of the volcano’s eruption

   Organize your ideas using a table, list, chart, or other method.

2. Collect your group concept map and a set of markers. Meet with your group to discuss what you recorded about volcanoes in Lesson 1. Add to your concept map any new information you learned by watching the video.

3. Share your group’s revised concept map with the class. Your teacher will use your ideas to make a class concept map.

REFLECTING ON WHAT YOU’VE DONE

1. Think about the work of the scientists in the video. Answer the following questions in a class discussion:

   A. *Did the scientists work in a group or alone when observing Mt. Pinatubo? Why do you think they did so?*

   B. *How did the scientists monitor the volcano? What were the signs that it would erupt?*

   C. *What were some of the risks posed by the volcano’s possible eruption?*

   D. *What could the scientists do to reduce or eliminate these risks?*

   E. *What did the scientists consider when deciding whether to issue an alert?*

   F. *In what way did the scientists communicate their ideas to others?*

   G. *What challenges did the scientists face in deciding whether to issue an alert?*
Think about the eruption of Mt. Pinatubo. Describe other catastrophic events that are associated with volcanoes.

Now you will watch a second video, entitled Geothermal Energy. How are the effects of volcanoes in this video different from those shown in the first video?

Did you gain any additional knowledge about volcanoes from the second video? Your teacher will add those ideas to the class concept map.

Work with your class to classify the effects of volcanoes as either constructive or destructive.

What questions do you have about volcanoes? Share them with your class. You may find answers to many of these questions in Lessons 19 through 24.

Read over Table 18.1: Comparing Catastrophic Events. You will play a game with this table in Lesson 22.
### Table 18.1 Comparing Catastrophic Events

<table>
<thead>
<tr>
<th>Event</th>
<th>Where It Occurs Nationally</th>
<th>How Large an Area It Covers</th>
<th>Why It Occurs</th>
<th>How Often It Occurs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flood</strong></td>
<td>River basins and floodplains—all states</td>
<td>Many counties to many states</td>
<td>Prolonged heavy rainfall, heavy snowmelt in spring</td>
<td>Seasonal, decade, century</td>
</tr>
<tr>
<td><strong>Hurricane</strong></td>
<td>Atlantic and Gulf coasts, Hawaii</td>
<td>Many states</td>
<td>Large tropical depression</td>
<td>Seasonal on coast, decade to century in any one spot</td>
</tr>
<tr>
<td><strong>Tornado</strong></td>
<td>Midwestern and southern states</td>
<td>Counties and city blocks</td>
<td>Supercell spawned by thunderstorms (low pressure)</td>
<td>Seasonal</td>
</tr>
<tr>
<td><strong>Landslide</strong></td>
<td>Steep slopes—all states</td>
<td>Neighborhoods</td>
<td>Steep slopes and unstable surface materials</td>
<td>Irregular</td>
</tr>
<tr>
<td><strong>Volcanic Activity</strong></td>
<td>Western states, Hawaii, Alaska</td>
<td>Many counties to many states</td>
<td>Upward movement of molten rock leading to eruption</td>
<td>Decades to centuries</td>
</tr>
<tr>
<td><strong>Earthquake</strong> (magnitude 5.5–7.0)</td>
<td>Western states, midcontinent, and East coast (infrequent), Hawaii, Alaska</td>
<td>Many counties</td>
<td>Underground stresses built up by moving plates or moving molten rock</td>
<td>Decades (magnitude &gt; 5.5) to centuries (magnitude &gt; 7.0)</td>
</tr>
<tr>
<td><strong>Tsunami</strong></td>
<td>West coast</td>
<td>Coastal zones</td>
<td>Underwater earthquake</td>
<td>Irregular, decades to centuries</td>
</tr>
<tr>
<td>How Long We Know Before It Will Occur</td>
<td>What To Do If It Occurs</td>
<td>Other Events Associated With It</td>
<td>How to Reduce Risks</td>
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<tr>
<td>Days</td>
<td>Move to higher ground</td>
<td>Mudslides, landslides, erosion</td>
<td>Build river dikes and/or river dams; build on high ground</td>
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<tr>
<td>Days</td>
<td>Move inland</td>
<td>Flooding, thunderstorms, seashore erosion</td>
<td>Construct windproof structures; build structures that water flows through along the coasts</td>
<td></td>
</tr>
<tr>
<td>Minutes</td>
<td>Go below ground</td>
<td>Thunderstorms</td>
<td>Build basements in all structures</td>
<td></td>
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<tr>
<td>Minutes to hours</td>
<td>Evacuate</td>
<td>Mudslides</td>
<td>Build elsewhere</td>
<td></td>
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<tr>
<td>Hours to months</td>
<td>Evacuate</td>
<td>Landslides, earthquakes, lightning, fire, whirlwinds, flooding caused by melted snow and glaciers, tsunamis</td>
<td>No preventive measures exist for ground structures; warn aircraft of ash clouds</td>
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<tr>
<td>Seconds</td>
<td>Go out of doors or under a stable object</td>
<td>Fire, tsunamis, landslides, disruption of vital services (water, electricity)</td>
<td>Build earthquake-resistant structures; use sensors that shut off utilities when seismic activity occurs</td>
<td></td>
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<tr>
<td>Minutes (local), hours (distant)</td>
<td>Move away from coast to higher ground</td>
<td>Flooding</td>
<td>Build away from the shore; build structures that water flows through</td>
<td></td>
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Minutes (local), hours (distant) | Move away from coast to higher ground | Flooding | Build away from the shore; build structures that water flows through | Build away from the shore; build structures that water flows through |

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Minutes (local), hours (distant) | Move away from coast to higher ground | Flooding | Build away from the shore; build structures that water flows through | Build away from the shore; build structures that water flows through |
For weeks, Mt. St. Helens spewed volcanic ash over the surrounding landscape and for hundreds of kilometers downwind to the east. Noticeable amounts of ash fell in 11 states. Altogether, Mt. St. Helens expelled enough ash to cover a football field to a depth of 240 kilometers.
Volcanic eruptions can range from violent to mild. All kinds of eruptions have effects that can be both harmful and beneficial to people and the environment.

**Volcanoes Can Be Destructive**

When volcanoes erupt, they often spew molten rock and fragments of rock over the ground and into the air. Fine fragments of rock, called ash, are usually ejected during very violent eruptions. Ash can affect people hundreds of kilometers away from an eruption. In 1980, in Spokane, Washington, it was dark at noon as a result of the ash cloud from the Mt. St. Helens’ eruption more than 300 kilometers away. Closer to the mountain, several people died from suffocation by the ash cloud from the initial blast. Volcanic ash can also contaminate water supplies, cause electrical storms, and collapse roofs.

Sometimes a volcano explodes sideways, shooting out ash and large pieces of rock that travel at very high speeds for several kilometers. These explosions can cause death by suffocation and knock down entire forests within seconds. Rivers of molten rock or hot fragments of rock from such eruptions can instantly ignite fires for great distances.

An erupting volcano can also be accompanied by earthquakes, flash floods, rockfalls, and mudflows. Floods occur when rivers are dammed by trees felled during an eruption or by molten rock moving across a river. Mudflows are powerful rivers of mud that form when debris from a volcanic eruption moves into a stream or river. Mudflows can move faster than people can run, and bridges in the path of these flows can be destroyed instantly. One kind of mudflow, called a lahar, happens when rain falls through clouds of ash or when rivers become choked with falling volcanic debris. During the eruption of Mt. St. Helens in 1980, lahars destroyed more than 200 homes, more than 300 kilometers of roads, and 220 kilometers of river channel.
A volcanic eruption can also cause a tsunami. A tsunami is a large sea wave usually brought on by underwater earthquakes, but volcanoes can cause tsunamis, too. The collapse of an island during a volcanic eruption or the dumping of heavy loads of volcanic debris into the ocean can create massive waves. The 1883 eruption of Krakatoa, a volcanic island in Indonesia between Sumatra and Java, unleashed a tsunami that swept the coasts of Sumatra and Java and drowned more than 36,000 people.

Severe weather-related events often accompany volcanic activity. These include lightning, thunderstorms, and whirlwinds (including tornadoes). In addition, the heat caused by a volcanic eruption can melt snow and glaciers, which can lead to flooding and landslides. Ash clouds from an erupting volcano can temporarily affect the weather in cities that are hundreds or even thousands of kilometers away. For example, the 1883 eruption of Krakatoa released 20 cubic kilometers of volcanic dust into the air. The dust rose so high that it reached the stratosphere. Within 13 days, it had encircled the globe and blocked sunlight from entering the atmosphere. For months, sunsets were strange-colored. Average daily temperatures around the world dropped an estimated 0.5 °C during 1884. It took 5 years for all of the volcanic dust to settle to the ground.

In 1815, another Indonesian volcano, Tambora, erupted even more powerfully. It blasted about 150 cubic kilometers of volcanic debris high into the atmosphere. The dust blocked so much sunlight that crops failed to grow around the world, and 1816 became known as “the year without a summer.” Again, it took several years before the effects of this eruption passed.

Volcanoes Can Be Constructive
Not all the materials that come out of volcanoes are harmful. Many volcanic areas have permanent hot
Volcanoes also create beautiful landscapes. Without volcanic activity, there would be none of the spectacular fissures that dot the Hawaiian landscape or the majestic peaks of the Cascade Range, such as Mt. Rainier.

Most people think of catastrophic events as violent natural hazards that create human and environmental risks. But as we have just seen, there is another side of the story. Catastrophic events can also be constructive forces on the earth. Volcanoes affect the composition of our oceans and atmosphere. Floods create sandy beaches along riverbanks. And earthquakes, as well as volcanoes, create and shape the mountains and islands that people enjoy.

Many hot springs that are beautiful to look at and provide recreation for residents and tourists. In addition, people can tap the geothermal energy of hot springs to heat their homes directly or to produce electricity. Icelanders, for example, use geothermal energy to heat their homes, buildings, and swimming pools. Iceland has a very short growing season. But greenhouses heated by geothermal energy provide Icelanders with vegetables, tropical fruit, and flowers year-round. Some people living in Arctic regions also heat their homes and greenhouses with water from hot springs. The hot water flows through pipes in their houses, warming the air. Geothermal steam is used to generate electricity in places such as Italy, New Zealand, the United States, Mexico, Japan, and Russia.

Volcanoes provide a wealth of natural products. Basalt, which forms from cooled lava and makes up much of the seafloor, is a raw material for cleaning agents, and it has many chemical and industrial uses. Volcanic ash enriches the soil with mineral nutrients. Minerals in molten rock are a major world source of nickel, chromium, platinum, and several other important elements. Obsidian, or “volcanic glass,” is an ideal material for fine stone work because it breaks with a typical curved fracture when struck with a sharp blow. Beautiful arrowheads of obsidian have been found in Ohio from the Hopewell culture, which flourished 1500 to 2300 years ago.

Most geysers are hot springs that erupt fountains of scalding water and steam.

This old engraving shows the 1866 eruption of Nea Kameni, Santorini, in Greece. A giant volcanic explosion and sudden sinking of the island’s center beneath the sea in 1650 B.C. caused a huge tsunami.