How do we respond to challenges caused by Earth’s forces?

The forces that create landforms can also pose great dangers to people. Two such forces are volcanoes and earthquakes.

**The Dangers of Earthquakes**

Most large earthquakes happen where plates are moving past or under each other. For example, where the edges of the Pacific plate meet the Eurasian, Australian, and American plates, they create the Ring of Fire. It is the earthquake zone and the string of volcanoes that surround the Pacific Ocean (Figure 1.18). Where plates meet, pressure builds and grows.

**FIGURE 1.18** This map shows the Ring of Fire region, around the Pacific Ocean. Within it, the map shows the largest earthquakes since 1900, volcanic eruptions, and urban areas with more than 10 million people as of 2013.
When the energy is released, shock waves shake the land. The **epicentre** is the place on Earth’s surface directly above where the main shock occurs. After the first shock wave, there can be a series of smaller shock waves called aftershocks.

During an earthquake, Earth’s surface may shift by as much as several metres. In open areas, shock waves from earthquakes rarely injure anyone, but the force can destroy buildings (Figure 1.19). The falling debris often injures or kills people who are inside or nearby.

As well, the shaking of Earth’s surface may create many damaging natural events, such as tsunami waves. The 2004 earthquake in the Indian Ocean that you read about on page 14 is an example of this. Tsunamis can move at speeds of up to 800 km/h, which is about as fast as a passenger jet flies. They can travel for thousands of kilometres across open water. Depending on where and when they reach land, tsunamis can cause huge amounts of destruction, injury, and death.

**THE DANGERS OF VOLCANOES**

The flows of lava that escape during a volcanic eruption can be very harmful to people. However, because lava moves slowly, people usually have enough time to escape. The biggest risks to people from volcanoes are the very hot gases, ash, and rocks that are shot into the air during eruptions. These eruptions release toxic gases. These gases can make it hard to breathe, and they can damage people’s lungs.

The lava can cause fires, however, and the ash that is released can also destroy property. This can create huge challenges to local economies. It can even have worldwide effects.

![This photo shows the scene after an earthquake in Beichuan County, in Sichuan, China, in 2008.](image-url)
When you are researching a geographic topic, such as how mountains are formed or what effect a landslide might have on a local community, you need to ask good research questions. These questions help you narrow your focus as well as locate, gather, and organize your information.

A good inquiry question
• will lead to answers you don’t already know
• uses words whose meanings are clear
• is open-ended and will lead to many possible answers
• helps give you answers that will focus your research
• can be answered by gathering evidence
• might lead you to think about what you assumed when you asked the question
• might lead you to ask more questions

A factual question, on the other hand, asks for accurate details about a problem or topic; for example, “What continent has the world’s tallest mountain?” It is not a good inquiry question.

WHAT ARE GOOD INQUIRY QUESTIONS?
When we study geography, key questions include the following: What is where? Why there? Why care? Look at the chart in Figure 1.20 for other good examples.

TRY IT
Try out your understanding of research questions.
1. Think about a geographic topic that you might want to research. For example, you might want to learn more about a recent natural disaster.
2. Decide what you want to learn about that topic. Remember to think about the geographic focus: What is where? Why there? Why care? For example, perhaps you will decide to learn the causes of the natural disaster, what could have been done to prevent it, and whether everyone acted properly to try to prevent it.
3. Write three possible research questions to help you find out what you want to know. Ask one or two classmates to review the questions and offer suggestions for improvement. Revise your questions, if necessary, based on their ideas.

<table>
<thead>
<tr>
<th>Question Type</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>definitional</td>
<td>asks to make the meanings of terms clear</td>
<td>What exactly is a mountain?</td>
</tr>
<tr>
<td>comparative</td>
<td>asks for differences between, or similarities in, aspects of a problem or topic</td>
<td>How are the Rocky Mountains similar to the Alps?</td>
</tr>
<tr>
<td>cause and effect</td>
<td>seeks reasons for the cause of a problem and an understanding of its effects</td>
<td>Why are some mountains active volcanoes?</td>
</tr>
<tr>
<td>decision-making</td>
<td>asks for decisions about actions that could help solve a problem</td>
<td>What could be done to help protect people from volcanic eruptions?</td>
</tr>
<tr>
<td>speculative</td>
<td>suggests what conclusion might come from an action</td>
<td>How many lives would be saved if people were ordered to move away from volcanic mountains?</td>
</tr>
<tr>
<td>ethical</td>
<td>examines the rights and wrongs of a problem or topic</td>
<td>Should governments control how close people live to active volcanoes?</td>
</tr>
</tbody>
</table>

FIGURE 1.20 This chart explains several types of questions.
TOOLS FOR MEASURING DAMAGE

The seismograph is an important tool that measures and records the size and magnitude of movements of the ground, especially of an earthquake. Magnitude is determined by the strongest seismic waves that are recorded for an earthquake. As an example, the earthquake that caused the 2004 tsunami was a magnitude of 9.1. It was the third-largest earthquake ever recorded on a seismograph. Volcanic eruptions can also be measured on a seismograph. Before Mount Redoubt, Alaska, erupted in 2009 (Figure 1.21) scientists were able to issue warnings based on the data they recorded.

Scientists use a Richter scale to classify earthquakes. The difference between one whole number of magnitude and the next is a 10-times increase in energy. So, an earthquake of 6.0 releases 10 times more energy than an earthquake of 5.0 magnitude.

The damage to human-made structures, such as houses and roads (Figure 1.22), increases as the movements of the ground increase in size. For example, an earthquake that measures 4.0 to 4.9 on the Richter scale is considered small. In an earthquake of that size, windows might break and small objects fall from shelves. An earthquake that measures 7.0 to 7.9 is a major earthquake. This size earthquake causes buildings to be knocked off foundations and underground pipes to break.

FIGURE 1.21 A scientist installs a seismic station near Mount Redoubt Volcano.

I wonder what kind of courses geologists take at school to have a career studying earthquakes?

FIGURE 1.22 People carrying their belongings across a destroyed road in central Philippines after a 6.8 magnitude earthquake in February 2012.

I wonder whether there has ever been an earthquake in the Philippines before?
On January 12, 2010, a 7.0 magnitude earthquake shook the Caribbean nation of Haiti. The quake’s epicentre was just 25 km from the capital city of Port-au-Prince. The city was destroyed. Officials estimated that 316,000 people died and 300,000 were injured. About 285,000 homes were demolished or badly damaged.

Even before the earthquake, life was difficult in Haiti. It was the poorest country in the Americas. Half of the population did not have access to a toilet. Only about one-third had safe drinking water. For years, Haiti struggled to keep a stable government and a working economy.

Unlike the state of California in the United States, which experiences similar events, Haiti had few resources to prepare for earthquakes or other natural disasters. Nor did they have the resources to deal with the devastation earthquakes can create.

HELP FOR HAITI
Following the earthquake, international aid agencies such as the Red Cross raced to set up operations in Port-au-Prince. Individuals hurried to help as well. Among them was 13-year-old Bilaal Rajan from Toronto, Ontario (Figure 1.23).

It wasn’t the first time Rajan had taken action for Haiti. In 2004, a hurricane hit the island. Rajan, then eight, spearheaded a cookie-selling fundraiser at his school. He and his team of 12 raised more than $6000 for UNICEF to help the people of Haiti.

Over the years, Rajan continued to speak out for those suffering from natural disasters and poverty. For example, as you read about on page 14, in 2004, a huge tsunami in the Indian Ocean caused great devastation, as well as many injuries and deaths. Rajan helped raise funds to help the survivors through his Canada Kids Earthquake Challenge. In 2005, he became UNICEF Canada’s child ambassador. In 2010, at the age of 13, he challenged every Canadian child to raise $100 for UNICEF Canada’s Haiti Emergency Fund by fundraising in their schools or communities.

“The challenges of the Haitian people won’t go away overnight, but young Canadians can make an enormous difference,” said Rajan.

Why did Rajan feel he needed to get involved in this crisis? “I know it’s hard to put ourselves in other people’s shoes,” he said, “but we have to. It’s our duty to help other kids because, as Canadians, we have so much and others don’t.”

FIGURE 1.23 Bilaal Rajan

A CALL TO ACTION
1. List several reasons why you think people get involved in helping relief organizations. Share your list with a classmate and see if you can add more reasons to your list. Decide which of the reasons would most encourage you to help a relief organization.

2. How will you contribute to an issue you care about? What can be done in your school community to fund raise for this cause?
PROTECTING OURSELVES
Disaster response organizations have some advice to offer. In case of volcanic eruption, people should leave the area immediately. The organizations also recommend having breathing protection, such as masks, and emergency supplies of food and water on hand. In case of an earthquake, people indoors should seek shelter, for example, behind a large piece of furniture or against an interior wall. People outdoors should stay in the open away from large trees, buildings, and power lines. They should not move away until the possibility of aftershocks has passed.

IMPROVED TECHNOLOGIES AND STRUCTURES
Improved technologies, such as seismographs, are helping scientists predict earthquakes and volcanoes. There are about 4000 seismographs around the world, constantly recording the time and size of each quake.

When a seismograph records a series of small shocks in an area, scientists know that a plate boundary may be undergoing pressure at a particular location, which could mean that a large quake is coming.

As well, before a volcanic eruption occurs, magma moves into an area below the volcano. Sometimes, seismographs can alert scientists to these movements of magma. They may be able to predict a volcanic eruption.

No one has been able to design a structure that could survive a direct hit from a massive earthquake. But in places where earthquakes are common, laws require buildings to be more resistant to earthquake damage.

As a result, engineers are improving structures. They have developed new building materials that bend, instead of break, when shaken by shock waves. They have designed walls that contain braces to help them resist shaking and prevent collapse. Whole buildings have been designed with flexible bases to absorb shock waves. They remain still even when the ground is moving. Figure 1.24 shows an example of this kind of building.

CHECK-IN
1. **GEOGRAPHIC PERSPECTIVE** Should people be forced to move away from areas where there are earthquakes and volcanoes? Consider the impacts this policy would have. Create a t-chart that lists pros and cons of such a policy. Express your conclusion in a paragraph or by creating a poster.

2. **PATTERNS AND TRENDS** Why do you think some places have earthquakes, tsunamis, and volcanoes while other places do not? Discuss this question with a classmate. Choose a way to summarize your discussion.