READING FOR PREDICTING EARTHQUAKES AND VOLCANOES
HOLT PAGES 205-207 AND PAGES 234-235

Section 3

Earthquakes and Society

Terms to Learn

gap hypothesis
seismic gap

What You'll Do

- Explain earthquake hazard.
- Compare methods of earthquake forecasting.
- List ways to safeguard buildings against earthquakes.
- Outline earthquake safety procedures.

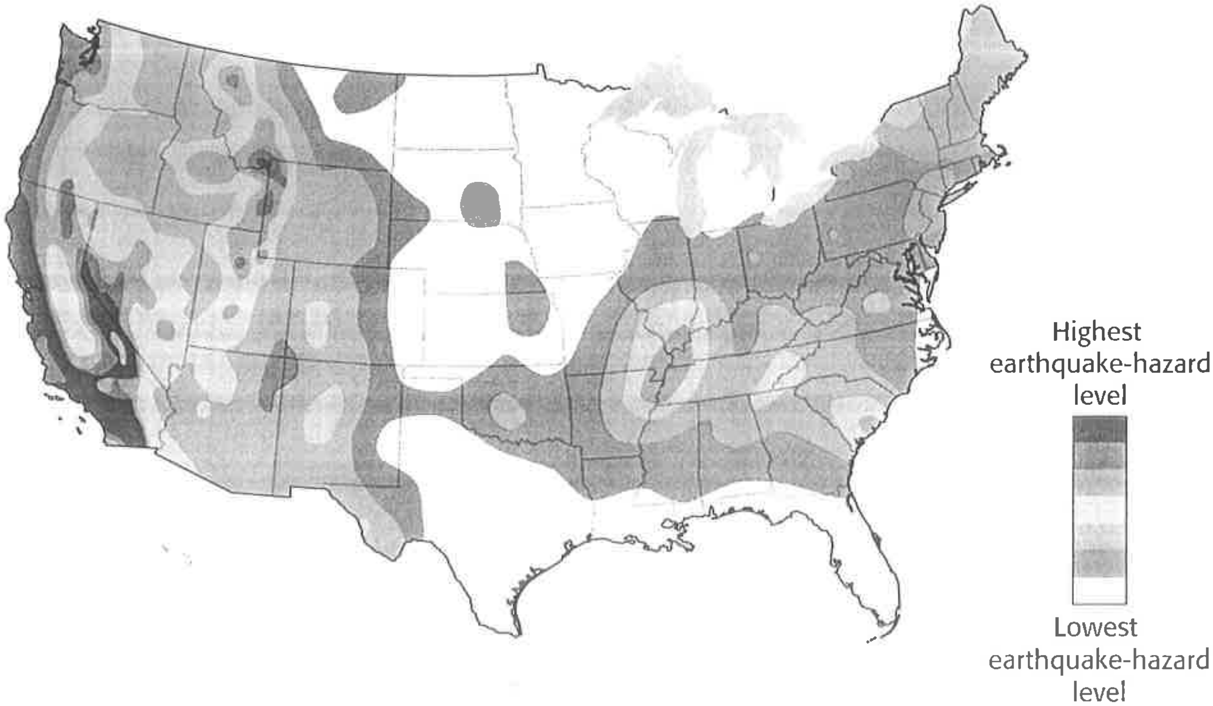
Earthquakes are a fascinating part of Earth science, but they are very dangerous. Seismologists have had some success in predicting earthquakes, but simply being aware of earthquakes is not enough. It is important for people in earthquake-prone areas to be prepared.

Earthquake Hazard

Earthquake hazard measures how prone an area is to experiencing earthquakes in the future. An area's earthquake-hazard level is determined by past and present seismic activity. Look carefully at the map in **Figure 10.** As you can see, some areas of the United States have a higher earthquake-hazard level than others. This is because some areas have more seismic activity than others. The West Coast, for example, has a very high earthquake-hazard level because it has a lot of seismic activity. Areas such as the Gulf Coast or the Midwest have much lower earthquake-hazard levels because they do not have as much seismic activity.

Can you find the area where you live on the map? What level or levels of earthquake hazard are shown for your area? Look at the hazard levels in nearby areas. How do their hazard levels compare with your area's hazard level? What could explain the earthquake-hazard levels in your area and nearby areas?

Figure 10 *This is an earthquake-hazard map of the continental United States. It shows various levels of earthquake hazard for different areas of the country.*



Self-Check

According to the chart below, about how many earthquakes with a magnitude between 6.0 and 6.9 occur annually?

(See page 726 to check your answer.)

Earthquake Forecasting

Predicting when and where earthquakes will occur and how strong they will be is a difficult task. However, by closely monitoring active faults and other areas of seismic activity, seismologists have discovered some patterns in earthquakes that allow them to make some broad predictions.

Strength and Frequency As you learned earlier, earthquakes vary in strength. And you can probably guess that earthquakes don't occur on a set schedule. But what you may not know is that the strength of earthquakes is related to how often they occur. The chart in **Figure 11** provides more detail on this relationship.

Figure 11 *Generally, with each step down in earthquake magnitude, the number of earthquakes per year is about 10 times greater.*

Worldwide Earthquake Frequency (Based on Observations Since 1900)

Descriptor	Magnitude	Average occurring annually
Great	8.0 and higher	1
Major	7.0–7.9	18
Strong	6.0–6.9	120
Moderate	5.0–5.9	800
Light	4.0–4.9	about 6,200
Minor	3.0–3.9	about 49,000
Very minor	2.0–2.9	about 365,000

This relationship between earthquake strength and frequency is also observed on a local scale. For example, each year approximately 10 earthquakes occur in the Puget Sound area of Washington with a magnitude of 4 on the Richter scale. Over this same time period, approximately 10 times as many earthquakes with a magnitude of 3 occur in this area. Scientists use these statistics to make predictions about the strength, location, and frequency of future earthquakes.

Can animals predict earthquakes? To decide for yourself, turn to page 218 to read about links between animal behavior and earthquakes.

The Gap Hypothesis Another method of predicting an earthquake's strength, location, and frequency is based on the gap hypothesis. The **gap hypothesis** states that sections of active faults that have had relatively few earthquakes are likely to be the sites of strong earthquakes in the future. The areas along a fault where relatively few earthquakes have occurred are called **seismic gaps. Figure 12** below shows an example of a seismic gap.

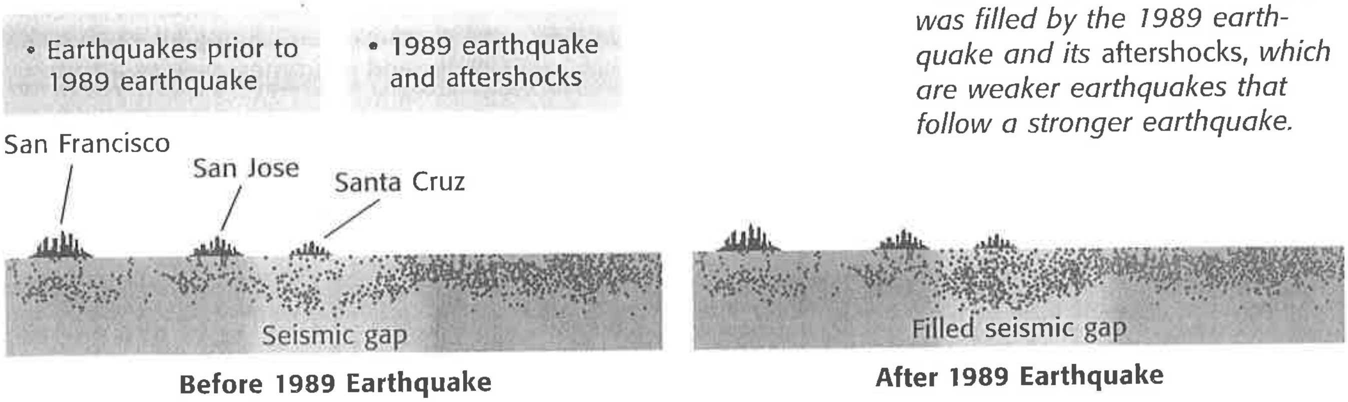


Figure 12 *This diagram shows a cross section of the San Andreas Fault. Note how the seismic gap was filled by the 1989 earthquake and its* aftershocks, *which are weaker earthquakes that follow a stronger earthquake.*

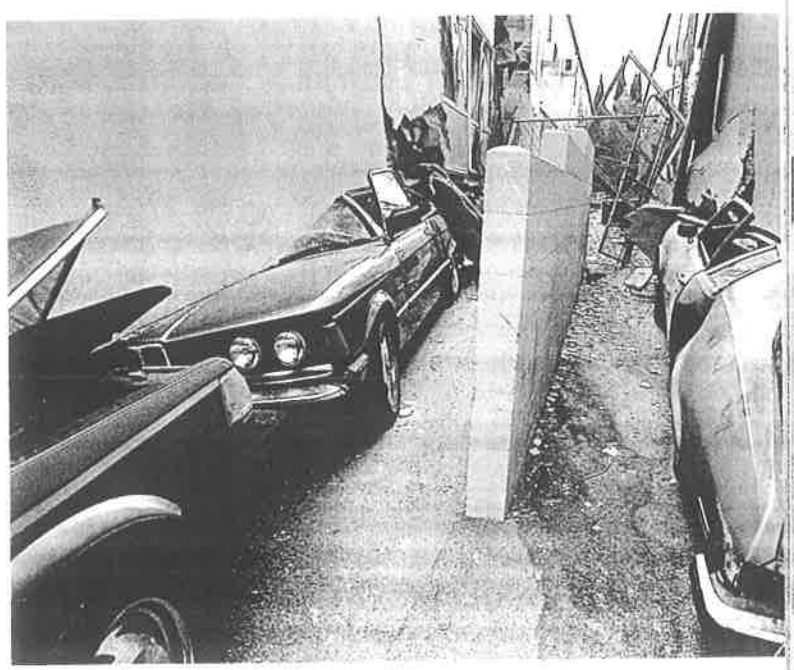
The gap hypothesis helped seismologists forecast the approximate time, strength, and location of the 1989 Loma Prieta earthquake in the San Francisco Bay area. The seismic gap that they identified is illustrated in Figure 12. In 1988, seismologists predicted that over the next 30 years there was a 30 percent chance that an earthquake with a magnitude of at least 6.5 would fill this seismic gap. Were they correct? The Loma Prieta earthquake, which filled in the seismic gap in 1989, measured 7.1 on the Richter scale. That's very close, considering how complicated the forecasting of earthquakes is.

Earthquakes and Buildings

Much like a judo master knocks the feet out from under his or her opponent, earthquakes shake the ground out from under buildings and bridges. Once the center of gravity of a structure has been displaced far enough off the structure's supporting base, most structures simply collapse.

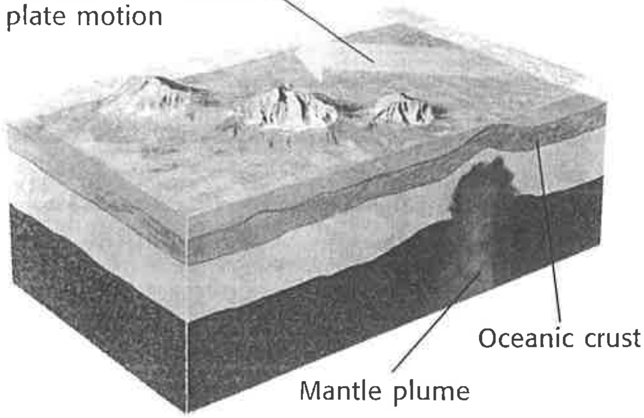
Figure 13 shows what can happen to buildings during an earthquake. These buildings were not designed or constructed to withstand the forces of an earthquake.

Figure 13 *An earthquake shook the ground floor out from under the second story of this apartment building, which then collapsed.*

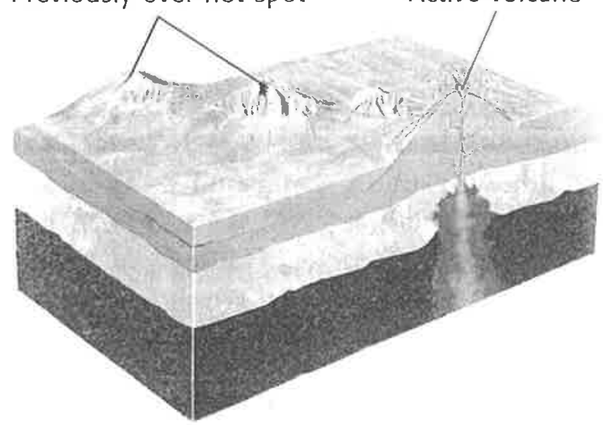


A hot spot often produces a long chain of volcanoes. This is because the mantle plume stays in the same spot, while the tectonic plate above moves over it. The Hawaiian Islands, for example, are riding on the Pacific plate, which is moving slowly to the northwest. **Figure 12** shows how a hot spot can form a chain of volcanic islands.

Figure 12 How a Hot Spot Forms Volcanoes



1 *A plume of hot mantle rock flows slowly upward through the mantle.*



2 *As the tectonic plate moves slowly over the mantle plume, a chain of volcanic islands forms.*

Predicting Volcanic Eruptions

To help predict volcanic eruptions, scientists classify volcanoes based on their eruption histories and on how likely it is that they will erupt again. *Extinct* volcanoes are those that have not erupted in recorded history and probably never will again. *Dormant* volcanoes are those that are not currently erupting but have erupted at some time in recorded history. *Active* volcanoes are those that are in the process of erupting or that show signs of erupting in the very near future.

Measuring Small Quakes Most active volcanoes produce small earthquakes as the magma within them moves upward and causes the surrounding rock to shift. Just before an eruption, the number and intensity of the small earthquakes increase, and the occurrence of quakes may be continuous. These earthquakes are measured with a *seismograph,* as shown in **Figure 13.**

Figure 13 *Seismographs help scientists determine when magma is moving beneath a volcano.*

Measuring Slope Measurements of a volcano's slope also give scientists clues with which to predict eruptions. For example, bulges in the volcano's slope may form as magma pushes against the inside of the volcano. By attaching an instrument called a *tiltmeter* to the surface of the volcano, scientists can detect small changes in the angle of the slope.

Measuring Volcanic Gases The outflow of volcanic gases from a volcano can also help scientists predict eruptions. Some scientists think that the ratio of certain gases, especially that of sulfur dioxide (SO_2) to carbon dioxide (CO_2), is important in predicting eruptions. They know that when this ratio changes, it is an indication that things are changing in the magma chamber down below! As you can see in **Figure 14**, collecting this type of data is often dangerous.

Figure 14 *As if getting this close to an active volcano is not dangerous enough, the gases that are being collected here are extremely poisonous.*

Measuring Temperature from Orbit Some of the newest methods scientists are using to predict volcanic eruptions rely on satellite images. Many of these images record infrared radiation, which allows scientists to measure changes in temperature over time. They are taken from satellites orbiting more than 700 km above the Earth. By analyzing images taken at different times, scientists can determine if the site is getting hotter as magma pushes closer to the surface.

REVIEW

1. How does pressure determine whether the mantle is solid or liquid?
2. Describe a technology scientists use to predict volcanic eruptions.
3. **Interpreting Illustrations** Figure 9, shown earlier in this chapter, shows the locations of active volcanoes on land. Describe where on the map you would plot the location of underwater volcanoes and why. (Do not write in this book.)

internet**connect**

sciLINKS NSTA

TOPIC: What Causes Volcanoes?
GO TO: www.scilinks.org
***sci*LINKS NUMBER:** HSTE215

APPLY

Calling an Evacuation?

Although scientists have learned a lot about volcanoes, they cannot predict eruptions with total accuracy. Sometimes there are warning signs before an eruption, but often there are none. Imagine that you are the mayor of a town near a large volcano, and a geologist warns you that an eruption is probable. You realize that ordering an evacuation of your town could be an expensive embarrassment if the volcano doesn't erupt. But if you decide to keep quiet, people could be in serious danger if the volcano does erupt. Considering the social and economic consequences of your decision, your job is perhaps even more difficult. What would you do?