EXERCISE 4

Volcanoes and Volcanic Hazards

INTRODUCTION

The objective of this exercise is to investigate the different types of volcanoes, volcanic products, and volcanic hazards that exist in the United States. Even though you may not live in an area with active volcanoes, given appropriate wind directions and large enough eruptions, all citizens of the United States live downwind from volcanoes (Wright and Pierson, 1991).

There are two major types of volcanoes that typically present hazards in the United States: basaltic *shield volcanoes,* as found in Hawaii; and *composite volcanoes* (also known as stratovolcanoes), as found in the Cascade Mountains of Washington, Oregon, and California, and in Alaska. It is unusual for there to be more than a few years without an eruption from a Hawaiian volcano (Tilling, Heliker, and Wright, 1987), and the eruption of Pu'u O'o has had more than 50 eruptive episodes over nearly a quarter century. In the Cascade Range, Lassen Peak erupted in 1914–15, and Mount St. Helens had a major eruption in 1980, which was followed by smaller eruptions into 1986. After nearly a 20-year pause, Mount St. Helens rejuvenated in 2004 with an ongoing series of dome-building eruptions. Mount St. Helens is explored in more detail in the next exercise.

Shield volcanoes are relatively flat and composite volcanoes are often conical. The shapes are related to the viscosity of the magma and the eruptive process. Viscosity is a measure of how easily a substance flows; it depends on chemical composition, temperature, and gas content of the magma. A low-viscosity substance will be very fluid, like water, while a high-viscosity substance will be very thick, like molasses or honey.

Most magmas are composed primarily of silica, with lesser amounts of other elements. Basaltic magma has comparatively low silica (approximately 50 percent SiO_2), andesitic magma has an intermediate silica content (approximately 60 percent SiO_2), dacitic magma has a slightly higher silica content (approximately 65 percent SiO_2), and rhyolitic (also know as silicic) magma has silica concentrations that range up to about 75 percent SiO_2. The relationships among magma composition, magma viscosity, volcano form, and typical eruption products are given in Table 4.1.

In addition to shield and composite volcanoes, there are several other types of volcanoes that erupt less frequently and have potential impacts that range from minor to catastrophic. These include both relatively small volcanic domes and large calderas (volcanoes that collapse as a result of an eruption). Pyroclastic flow eruptions take place typically in volcanoes with dacitic or rhyolitic magma, and can occur from the collapse of small domes or erupt from large calderas, and are composed of volcanic ash (tephra) fragments that are transported in a hot, gas-rich cloud. Pyroclastic flows are the most devastating type of volcanic eruption, as they can travel at speeds of over 100 km per hour with temperatures above 500°C. Exceptionally large but fortunately rare eruptions known as "supervolcanoes" can have worldwide impacts.

Dormant volcanoes can also be hazardous. Landslides and debris flows can be triggered on steep slopes by earthquakes or rocks that have been weakened by chemical actions of hot water and steam can suddenly slide without warning. Weakened ground can suddenly collapse, and volcanoes, even when not erupting, can give off gases.

Figure 4.1 is a simplified sketch of a composite volcano and its associated hazardous phenomena. Table 4.2 describes volcanic products and their hazards in greater detail.

The first part of this exercise explores types of volcanoes using data presented in Tables 4.1 and 4.2, Figure 4.1, and this introduction. Then we look at volcanic activity associated with Yellowstone National Park, which is a large rhyolitic volcanic center; Mount Rainier, which is typical of volcanoes of the andesitic volcanic centers of the Cascade Range; and the active volcanoes of Hawaii, which have basaltic composition.

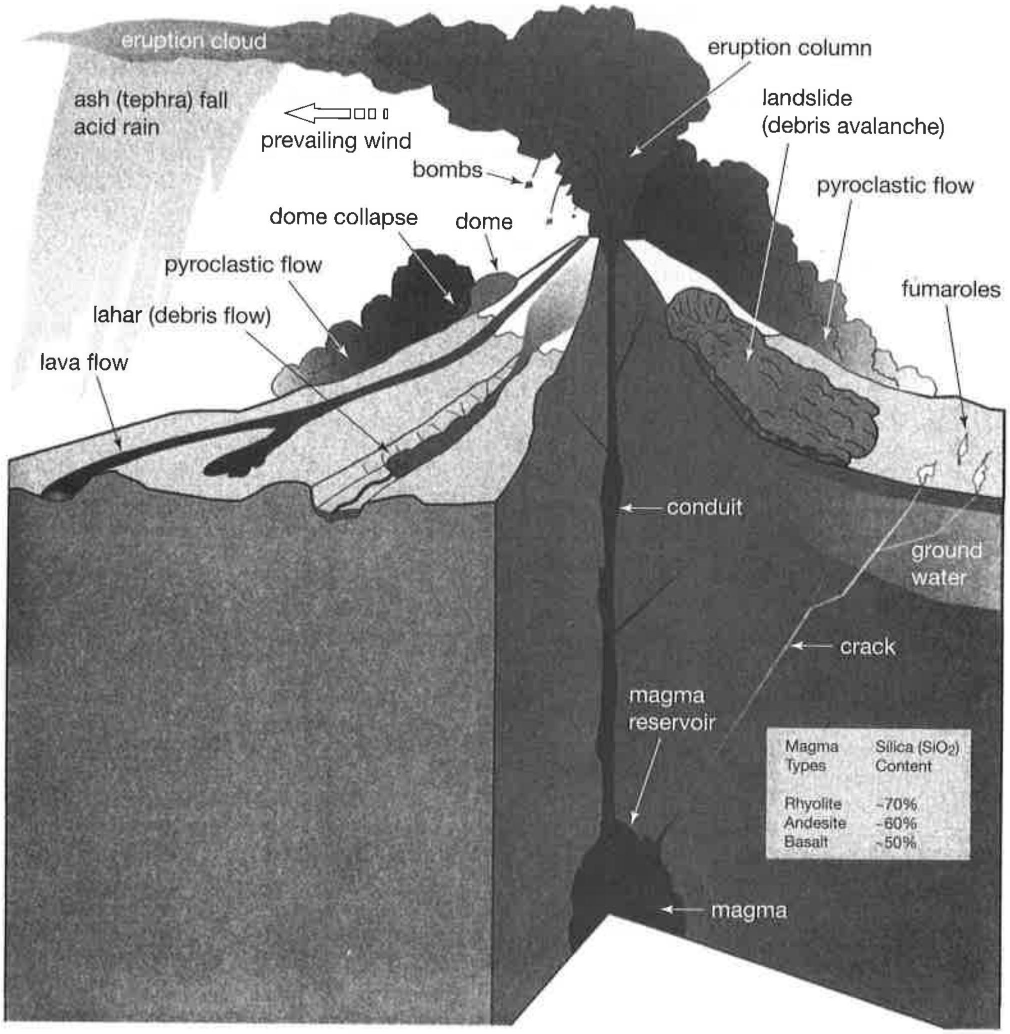


FIGURE 4.1 Diagram of a typical composite volcano, illustrating the locations and extent of selected volcanic hazards. Courtesy of Bobbie Meyers, U.S. Geological Survey

TABLE 4.1 Relationships among Magmatic Composition, Viscosity, Volcano Form, and Typical Volcanic Eruption Products for Different Types of Volcanoes

Magma Composition	Relative Viscosity	Volcano Form	Typical Eruption Products
Rhyolitic (approximately 70–75% silica)	High (sticky) for lavas; gas-charged pyroclastic flows (hot ash clouds) can be very mobile	Smaller domes, local flows, or large calderas from explosive eruptions	Pyroclastic flows, lava flows, lateral blasts, tephra, lava domes, gases, lahars (especially if caldera-filling lakes are suddenly drained)
Dacitic (approximately 65% silica)	Intermediate to high	Composite volcanoes, domes	Intermediate between rhyolitic and andesitic: pyroclastic flows, lava flows, lateral blasts, tephra, lava domes, lahars, gases
Andesitic (approximately 60% silica)	Intermediate	Conical composite volcanoes	Lava flows, tephra, pyroclastic flows, landslides, lahars, gases
Basaltic (approximately 50% silica)	Low (fluid)	Shields and rifts; cones where formed of tephra	Lava flows, tephra, gases

Note that all volcanoes can erupt from central vents or from fracture zones on the flanks of the volcano. Calderas (volcanic collapse areas) can form in all types of volcanoes, with their size controlled by the amount of new magma erupted.

TABLE 4.2 Volcanic Products and Their Hazards (modified from Miller, 1989)

Volcanic Products	Processes that Create Volcanic Products and Characteristics of Volcanic Hazards	Physical Locations of Volcanic Hazards
Volcanic landslides (debris avalanches)	Small rock falls to large failures of volcanic slopes. May be triggered without eruption from steep slopes composed of weak or thermally altered rock. Move at high speed on steep slopes and slow when they flatten out.	Partly topographically controlled[1] on flanks of volcanoes. Large debris avalanches can cover broad areas of low-angle slopes up to 50 km or more from volcanoes and may extend further down valleys.
Pyroclastic flows	Eruption of fragments of hot rock or explosion or collapse of a lava flow or lava dome. Ash fragments transported in gas-rich cloud move away from volcano at tens to >100 km/hr.	Mostly topographically controlled. Effects may extend 40 km downslope and 65 km or more down valleys. Adjacent areas may be affected for many km by hot ash clouds.
Lateral blasts	Explosive ejection of rock fragments from the side of the volcano. Sudden; debris moves at speeds up to hundreds of km/hr.	Distribution of blast controlled by direction of blast. Blasts may impact a 180° sector up to tens of km away from vent.
Lava flows	Eruption of molten lava, which flows downslope slowly. Fronts of flows on low-gradient slopes may move slower than a person can walk.	Most flows follow topographic lows and reach <10 km from the vent. Can pond and fill valleys if enough lava erupts.
Lava domes	Result from nonexplosive, high-viscosity (sticky) lava, which is erupted slowly and accumulates above the vent.	Domes typically limited to above and within a few km of a vent, usually in areas of rhyolitic or dacitic volcanism. May also collapse or explode, creating pyroclastic flows.
Lahars (debris flows)	From eruption onto snow and ice or into rivers; also from eruptive displacement of crater lakes or from heavy rain falling on loose pyroclastic debris. Sudden; move at tens of km/hr.	Primarily follow rivers from volcano flanks downstream. Impacts may extend many tens of km from source area. Can occur years after an eruption, if loose ash persists. Can dam side streams and create secondary floods.
Floods	Origin similar to lahars (debris flows), which may transition downstream into floods. Commonly move at < 20 km/hr. Jokulhlaup (glacier burst) floods release water from breakage of ice-dammed lakes, which may be subglacial and therefore unknown from surface observation.	Confined primarily to river valleys. May extend for hundreds of km. Can also back up waters in side streams and create secondary floods.
Ash (tephra)	Produced by vertical columns of fragments of magma propelled in part by expanding hot gas. Fine-grained ash can be carried great distances by wind. Eruption is sudden; explosive dispersal at tens of km/hr.	Can blanket all areas near and downwind from volcano; impacts may extend hundreds of km, depending on eruption volume, height, wind speed, and direction; climate change may occur globally. Many large tephra eruptions occur at rhyolitic or dacitic volcanoes.
Gases	Produced by eruptions or magma outgassing. Gases may be hot or cold and commonly contain sulphur, carbon dioxide, and other harmful compounds. Can pool locally if denser than air, or can move away from volcano through eruption or atmospheric dispersion. Carried at speeds of up to tens of km/hr.	Distribution controlled by wind speed and direction. Greatest impacts on air quality near volcano; odor, haze, and mild impacts may extend a few hundred km. If large volumes of gases are released during an eruption, climate impacts may occur globally, e.g., sulfate aerosols may cause cooling and CO_2 and other greenhouse gases (GHG) can cause warming of the atmosphere.
Phreatic and hydrothermal explosions	Usually driven by sudden burst of hot, high-pressure water changing to steam; can occur without direct eruption of magma. Rock fragments blasted out in explosion.	Typically smaller, locally confined eruptions on or near volcano; water must be at boiling temperature underground. If water comes in contact with magma, locally violent eruptions can be created.

1. Topographic control means that areas impacted by a particular product are usually limited to the bottoms and lower sides of valleys, although they may spread out over areas of low topography such as broad slopes or valley bottoms.

QUESTIONS 4, INTRODUCTION

1. Sketch representative topographic cross sections of volcanoes with high-viscosity, intermediate-viscosity, and low-viscosity lavas. Which type of magma is most explosive? Least explosive? Which type of magma has the highest silica content? The lowest?

2. Refer to Figure 4.1 and Table 4.2, and describe briefly the volcanic products and hazards for both people and property that are likely to exist in the following locations.

a. If people or property are on a ridge top, close to a composite volcano?

b. If people or property are on a valley bottom close to a composite volcano?

c. If people or property are on a valley bottom 25 km from a composite volcano?

d. If people or property are on a ridge top 10 km from a rhyolitic volcano?

3. Do basaltic lava flows present a greater hazard to people or to property? Why?

4. Refer to Figure 4.2. If you live to be 100 years old:

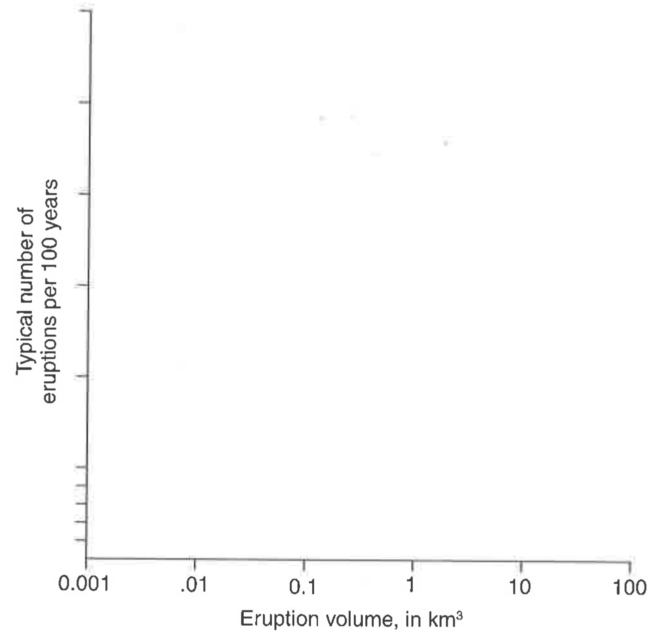
a. how many eruptions the size of Kilauea or Unzen are likely in your lifetime?

b. how many eruptions the size of Etna are likely to occur in your lifetime?

c. how many eruptions the size of Mount St. Helens are likely to occur in your lifetime?

d. how many eruptions the size of Pinatubo or Katmai are likely to occur in your lifetime?

5. Use the graph below, and build a histogram to illustrate the data you calculated in answering question 4 above. Determine your own vertical scale.



6. From the data on your graph (question number 5), describe the relationship between eruption size and eruption frequency (the typical number of eruptions per 100 years).

PART A. RHYOLITIC VOLCANOES

Rhyolitic volcanoes present many different kinds of volcanic hazards (Table 4.1). Since no major eruptions have occurred recently in the United States, the interpretation of possible hazards from rhyolitic volcanoes in the United States must be based on other data, including eruptions from elsewhere around the world and U.S. eruptions in the geologic past.

Two of the major rhyolitic volcanic centers in the United States are the Long Valley Caldera in California and the Yellowstone Caldera in Wyoming. These sites are shown in Figure 4.3, which is a map that also shows the distribution of volcanic ash from these volcanic centers.

Rhyolitic volcanoes may have different scales of eruptions. They may erupt small plugs and domes of rhyolite, or they may erupt as "supervolcanoes" that can have global impacts. Both Long Valley and Yellowstone have had these different scales of eruptions. Geophysical evidence suggests that there is active magma in the subsurface at both volcanoes.

A1. Supervolcano Eruptions

Table 4.3 presents data from Long Valley and Yellowstone eruptions. We focus on one aspect of these eruptions, their tephra distribution. It is important to note,

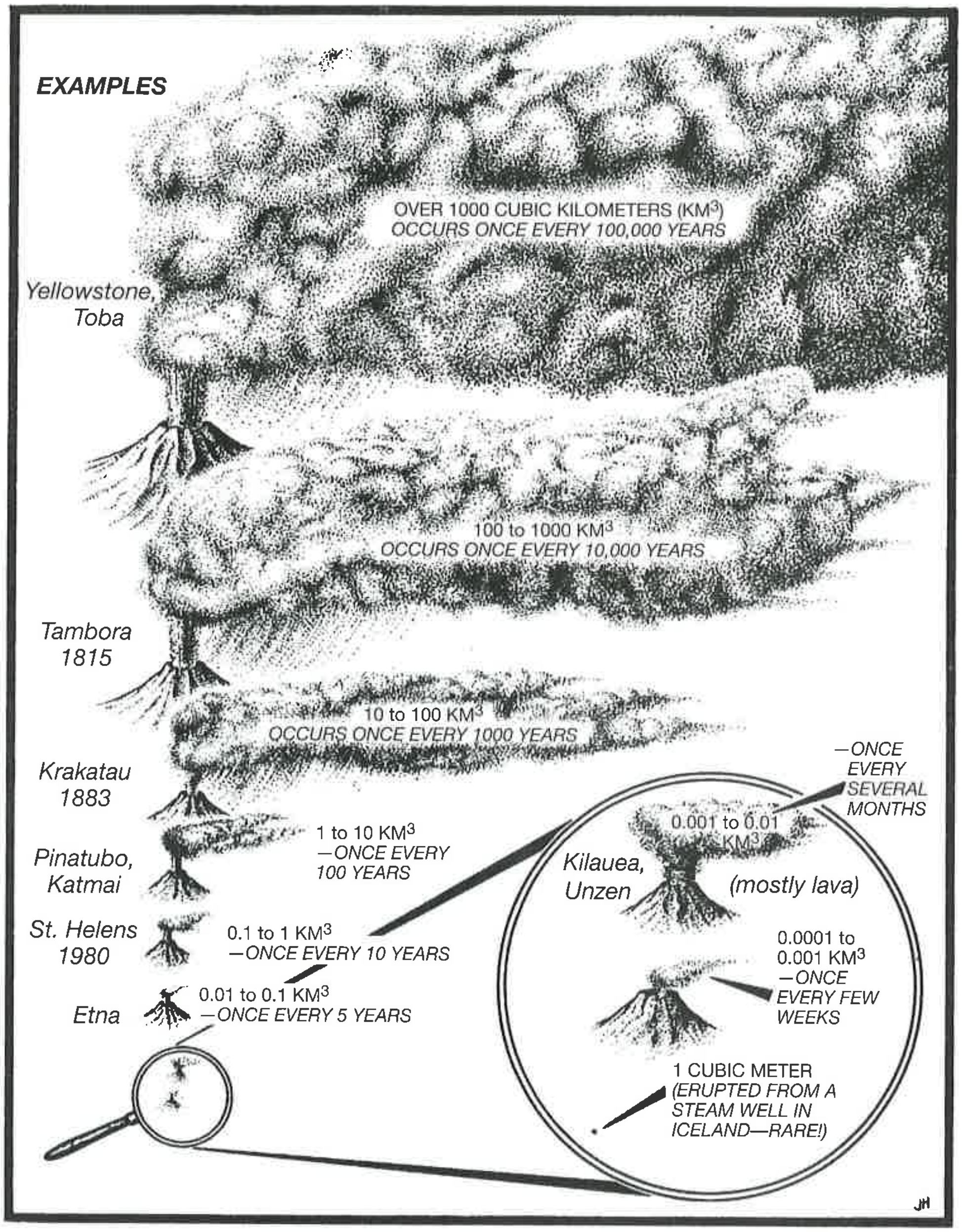


FIGURE 4.2 Magma volumes from several different volcanic eruptions (from Fischer, Heiken, and Hulen, 1997).

however, that each of these eruptions produced major pyroclastic flows that traveled far from their respective volcanoes. All eruptions created major calderas.

QUESTIONS 4, PART A1

1. How do the sizes of the larger Yellowstone and Long Valley eruptions (Table 4.3) compare with eruptions shown in Figure 4.2?

2. Use the data on Figure 4.2 to help determine the approximate "Long-Term Recurrence Interval" and record your result in Table 4.3.

3. Refer to Figure 4.3. Do you live in an area that has been impacted in the past by tephra (ash) from either volcano?

4. From the ash distribution data, were the wind directions the same for each eruption?

5. Figure 4.3 shows where tephra from Long Valley and Yellowstone are found now. Do you think that the current distribution of tephra is an accurate map of the original distribution? Explain.

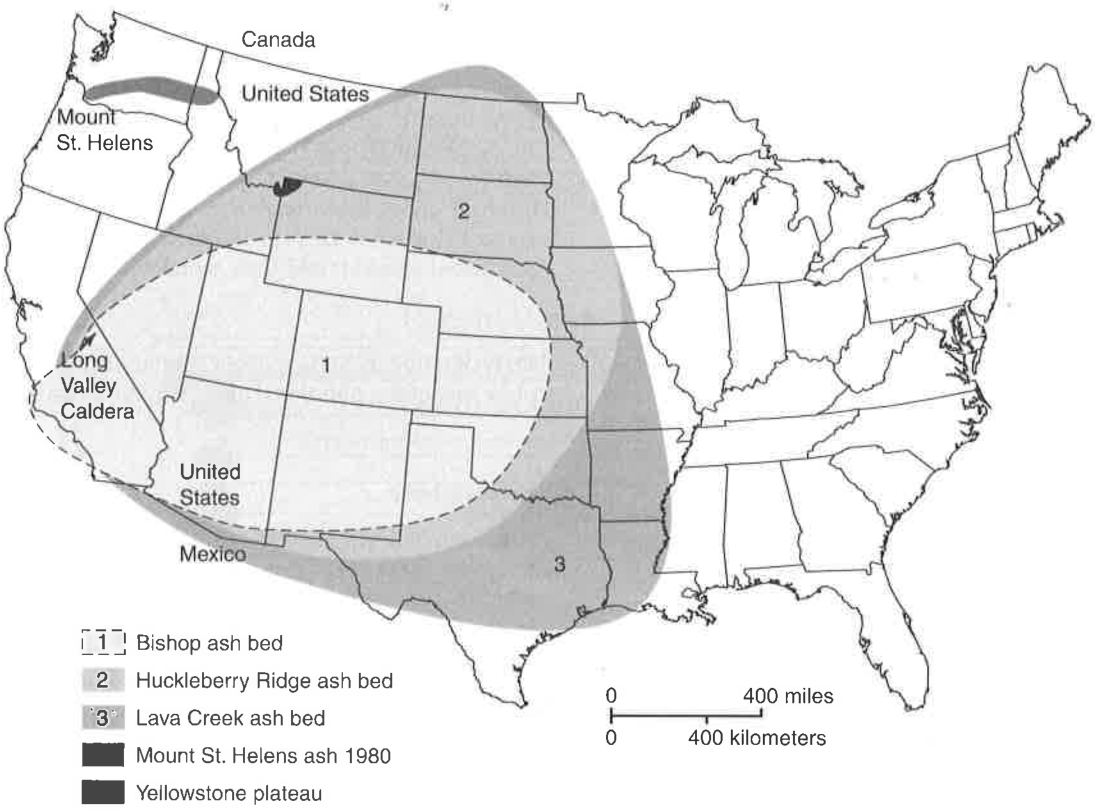


FIGURE 4.3 The distribution of the Huckleberry Ridge and Lava Creek ash beds from Yellowstone, the Bishop ash bed from Long Valley caldera, and Mount St.Helens ash of 1980 (modified from Lowenstern and others, 2005).

TABLE 4.3 Supervolcano Eruptions at Yellowstone and Long Valley

Supervolcano	Age of Eruption	Approximate Size of Eruption	Long-Term Recurrence Interval
Yellowstone	2.1 million years ago	2450 cubic km	
Yellowstone	640,000 years ago	1000 cubic km	
Long Valley	760,000 years ago	625 cubic km	

6. What geologic processes might have changed the distribution of ash since the time of eruption?

7. Given their recurrence interval, do you think it is appropriate to worry about the eruption of a supervolcano? Why or why not?

8. Figure 4.2 shows that the eruption of Tambora in 1815 produced between 100 and 1000 km^3 new material (it has been estimated at about 150 km^3 of new material). This eruption led to "the year without a summer" in some parts of the United States.

a. The eruption of Yellowstone about 640,000 years ago was how many times larger than the eruption of Tambora?

b. If Tambora had moderate global climatic impacts, what impacts would a Yellowstone-size eruption have today?

A2. Smaller-Scale Rhyolitic Eruptions and Ongoing Geologic Hazards: Long Valley and Yellowstone

After the cataclysmic eruptions described above, both Long Valley and Yellowstone have had rhyolitic eruptions that have filled the calderas created by the big eruptions. At Long Valley, the youngest eruptions may have been only about 250 years ago. There were larger eruptions about 600 years ago. Volcanism at Yellowstone is much older, with the youngest eruptions having occurred about 70,000 years ago. (Christiansen and others, 2007).

Several data sets, when combined, suggest the interpretation that there is active magma beneath both calderas. Long Valley and Yellowstone both have broad doming occurring that could be related to magmatic movement. Both volcanoes also have seismic patterns that suggest magma. Both also have hot springs (but only Yellowstone has numerous geysers; it also is important to note that many hot springs around the world are not located in areas with active volcanoes).

QUESTIONS 4, PART A2

Long Valley

Figure 4.4 shows the location and timing of recent volcanic activity in the Long Valley area. The named sites on this map have all been active in the last 5,000 years. The population of Lee Vining is approximately 500, the population of June Lake is somewhat lower, and the population of Mammoth Lakes is approximately 7,500. There are seasonal variations in population, however, due to tourism and skiing.

1. How many volcanic eruptions (not including steam blasts) occurred in the past 5,000 years?

2. What is the average recurrence interval between eruptions for the past 5,000 years?

3. How many volcanic eruptions occurred in the past 1,000 years?

4. What is the average recurrence interval between eruptions for the past 1,000 years?

5. According to the U.S. Geological Survey (Hill and others, 1998), it has been about 250 years since there was an eruption at Paoha Island in Mono Lake. Is this area due for an eruption or not? Explain your reasoning.

6. How many steam blasts occurred in the past 5,000 years?

7. a. What is the geographic relation of steam blasts to the 760,000-year-old caldera?

b. What does this relationship imply about the origin of steam blasts?

8. What geologic factors might contribute to there not being any steam blasts identified that are more than 1,000 years old?

9. Is there a trend in the spatial distribution (northern, southern, central region, etc.) of volcanic eruptions over the past 5,000 years that can help predict where the next eruption might take place? Explain.

10. Approximately 600 years ago eruptions from the South Deadman Creek dome included both pyroclastic flows that traveled about 5 km from the vent, and ash that traveled about 15 km from the vent. If this dome erupts again, are any populated areas at risk? If so, which one(s)?

11. If other vents were to have similar eruptions, could they place any of the populated areas at risk? Explain.

Yellowstone

Although Yellowstone has not had a magmatic eruption for the past 70,000 years, it is still geologically very active. With plentiful hot water and substantial heat, Yellowstone is subject to hydrothermal explosions. With active magma at depth, Yellowstone also has the potential for renewed, small-scale volcanic activity. Figure 4.5 is a simplified geologic map of the park.

12. Post-caldera viscous rhyolite flows have flowed up to approximately 10 miles from their vent areas. Refer to Figure 4.6. If a rhyolitic lava eruption were to occur from a vent area at the bottom of the canyon, would it likely present a hazard to developed areas on the canyon rim? Explain.

13. How would the hazards be different at Canyon if the eruption were a pyroclastic flow? Basaltic eruption? Explain.

14. Mammoth (near the north edge of the map) is located in an area of precaldera rocks. There is a series of mapped volcanic vents south of Mammoth. Based on the topography of the area (Figure 4.5), is Mammoth likely to be at risk if one of these vent areas erupts a rhyolite flow? A pyroclastic flow? A basalt flow? Explain.

15. What if there were new volcanic eruptions in the Old Faithful area? What kind of eruption(s) could threaten other developed areas?

16. If a small hydrothermal explosion like Porkchop (Figure 4.7) were to occur, is the damage likely to be widespread?

17. What impacts could a 2-mile-diameter hydrothermal explosion have if it occurred in a populated area?

18. Yellowstone Lake is the large lake on the eastern part of the caldera (Figure 4.5). What impacts might be expected if a 2-mile-diameter hydrothermal explosion occurred under the lake?

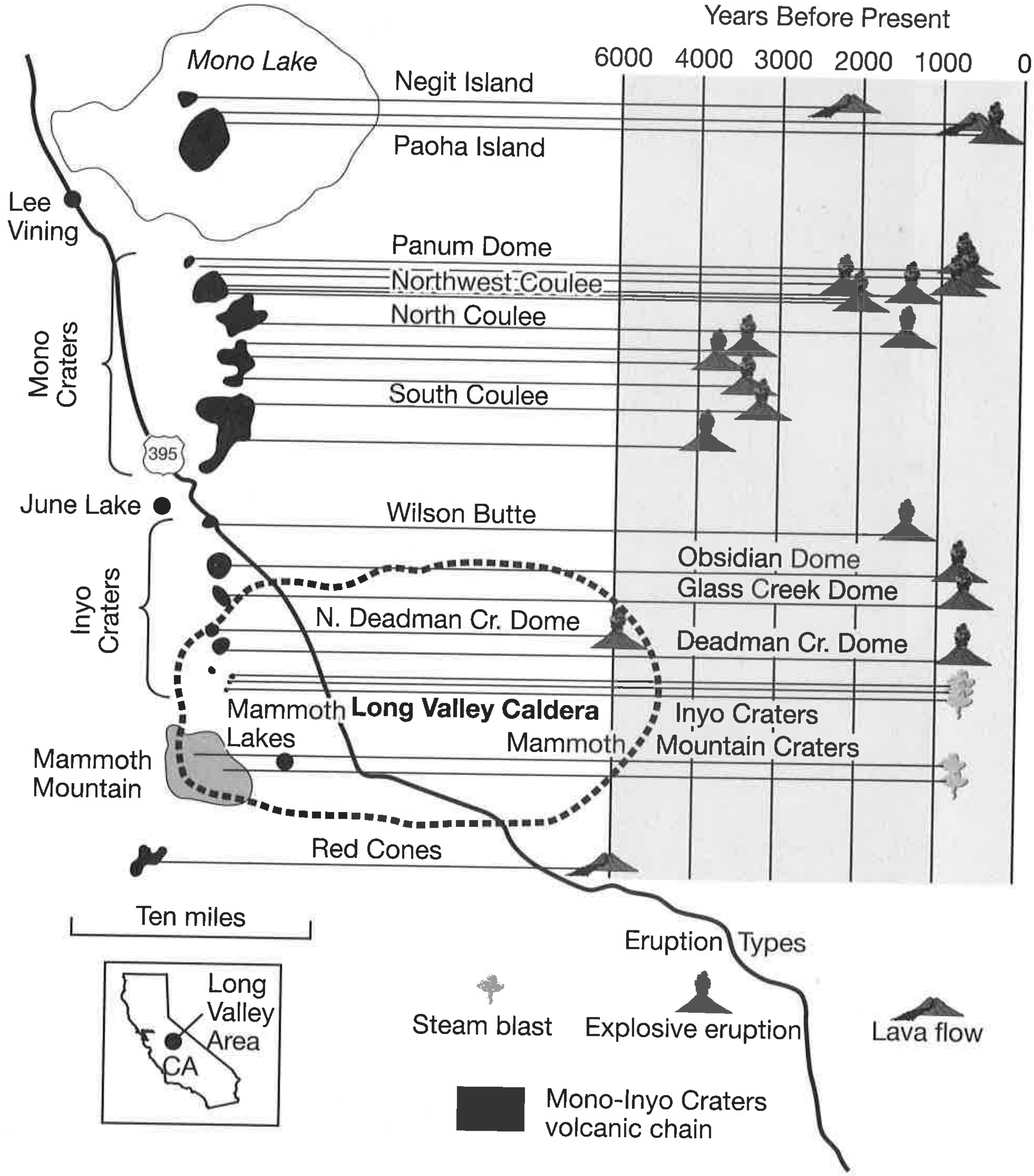


FIGURE 4.4 This map shows the location, time, and type of volcanic eruptions in the Long Valley area over the past 5,000 years. Steam blasts are also known as phreatic (pronounced "free-attic") eruptions, and are created when hot waters explode to steam. They do not involve the eruption of new magma. Explosive eruptions include both relatively small pyroclastic eruptions that extend about 5 miles from their vents, and tephra eruptions. (US Geological Survey, Long Valley Observatory)

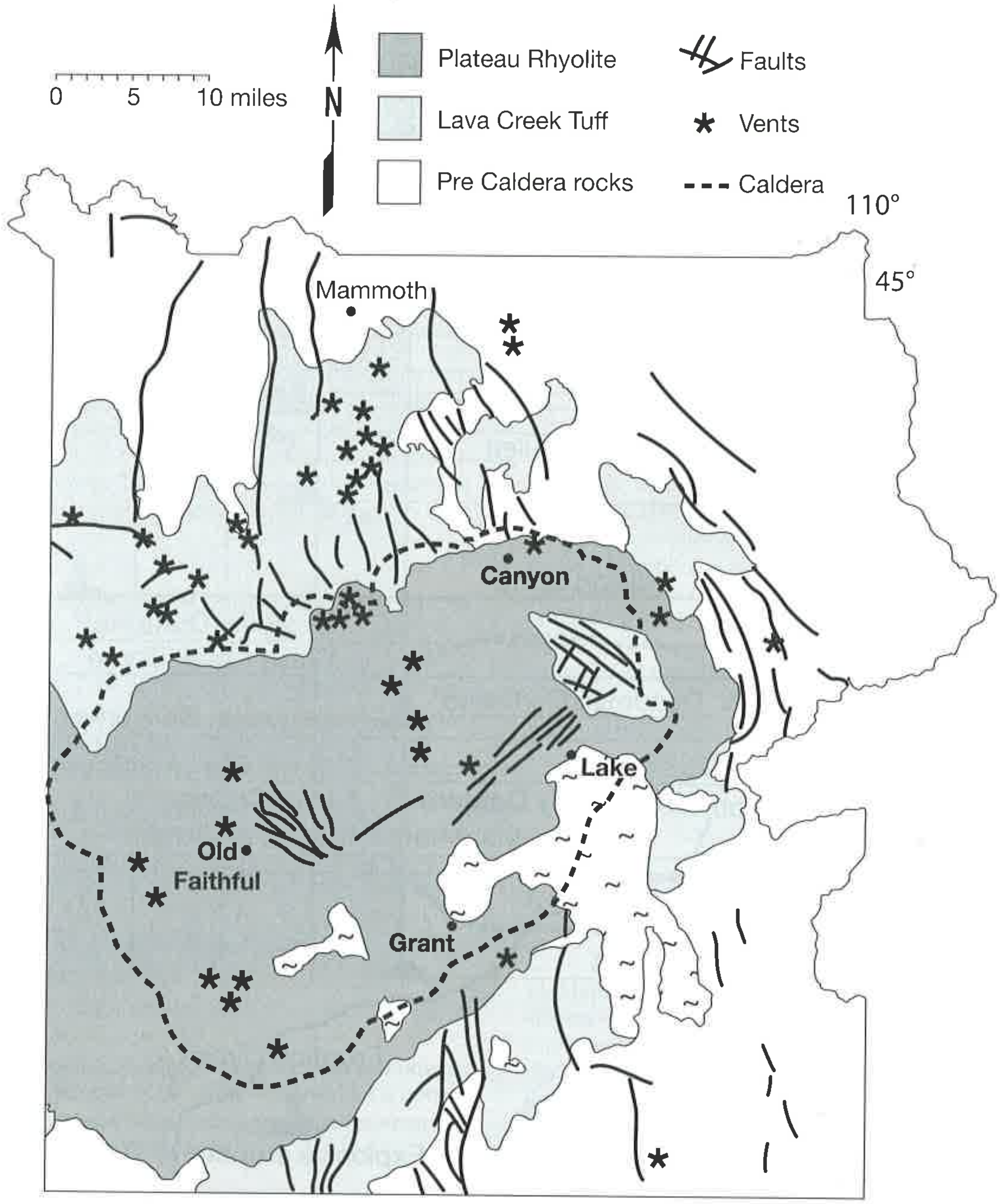


FIGURE 4.5 Simplified geologic map of Yellowstone National Park. The rock units are combined into three major categories. Pre-caldera rocks are those that were deposited before the major eruption 640,000 years ago, and include sedimentary, igneous, and metamorphic rock units. The Lava Creek Tuff is the pyroclastic flow unit that was deposited when the caldera erupted 640,000 years ago. Postcaldera rhyolite flows now fill and extend beyond the hole made by the caldera collapse. Star symbols indicate volcanic vent areas.

(Modified from Christiansen, 2001, Kciffer, 1971, and Lowenstern and others, 2005)

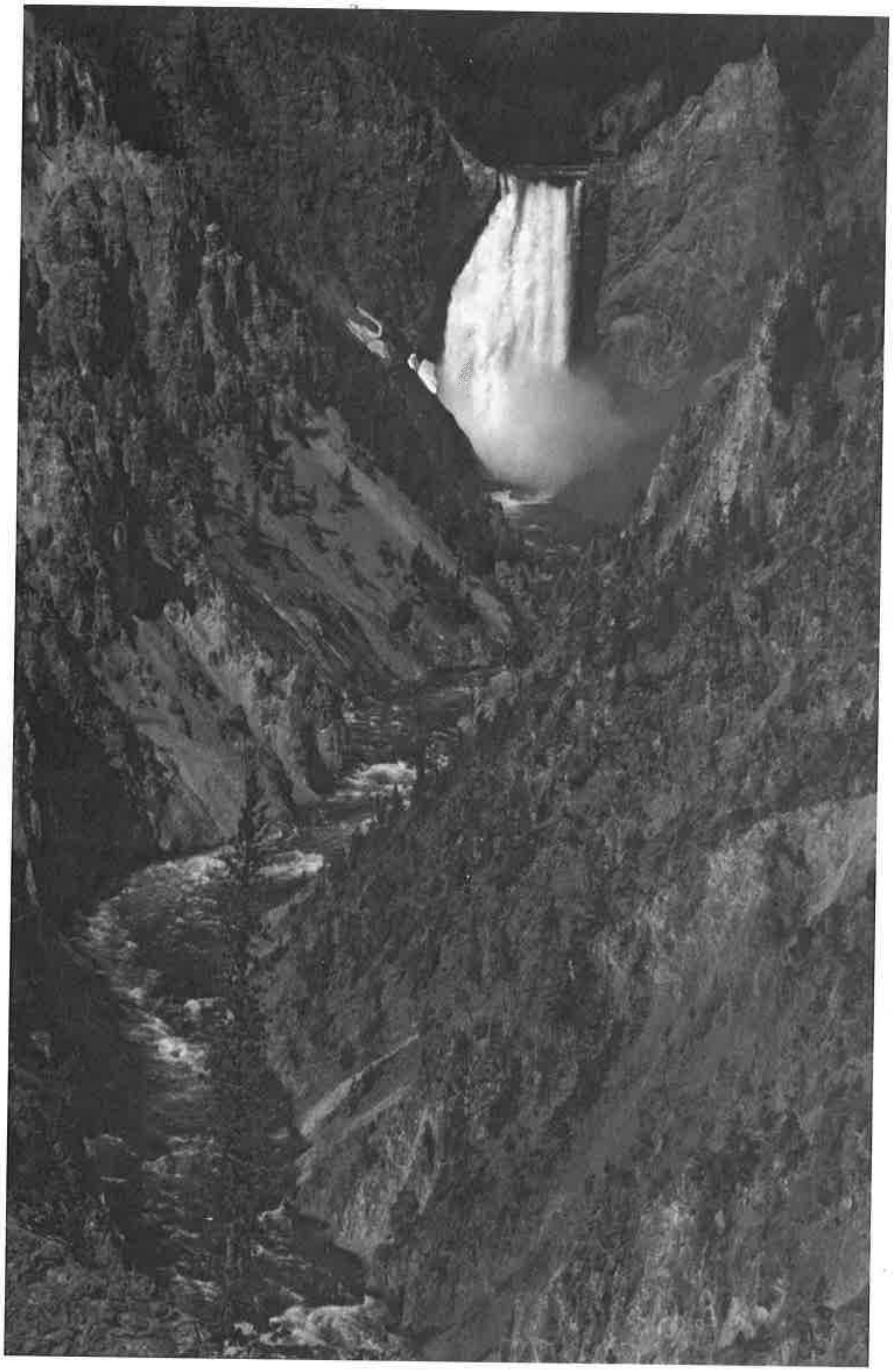


FIGURE 4.6 Aerial photograph of the Canyon of the Yellowstone River. For scale, the waterfall is slightly more than 300 feet (90 m) high. (Photograph © 2008 Duncan Foley, reprinted with permission)

FIGURE 4.7 Porkchop Geyser erupted in a small hydrothermal explosion in 1989. The blocks that surround the pool were thrown out of the ground during the explosion. This is one of the smaller such explosions that have occurred. Other hydrothermal explosions have been documented that are up to 2 miles in diameter. (Photograph © 2008 Duncan Foley, reprinted with permission)

PART B. COMPOSITE VOLCANOES

Mount Rainier, Washington

Mount Rainier (Figure 4.8) is located in western Washington, near the Puget Sound lowlands that include the cities of Tacoma and Seattle (Figure 4.9, in the color map section at the back of the book, is a shaded topographic map of Mount Rainier). The proximity of this active volcano to major population areas has led the U.S. Geological Survey to designate Mount Rainier as potentially one of the most hazardous volcanoes in the world (U.S. Geodynamics Committee, 1994).

Potential geologic hazards from Mount Rainier are particularly great, due to the combination of the height of the volcano (4393 m; 14,410 feet), its active nature, steep upper slopes, and heavy cover of the mountain by glaciers. Hazards at Mount Rainier exist both during and between magma eruptions (Hoblitt and others, 1995; U.S. Geological Survey, 1996).

People who live near a volcano need to know the types of volcanic events that create risks to people and/or property, the probable size of those events, how far the events are likely to extend beyond the volcano and, ideally, when the events will occur. If it cannot be determined when an event is going to occur (i.e., a forecast or prediction cannot be made), it is helpful to know when the last episode of a particular event occurred and how often similar events have occurred in the geologic past. In this section of this exercise we look at past geologic events at Mt. Rainier that have created hazards, and evaluate the risks that exist for people living in nearby towns.

QUESTIONS 4, PART B

1. Table 4.4 lists some hazards (adapted from U. S. Geodynamics Committee, 1994) that have been identified as existing at Mount Rainier. Fill in the blanks in the table, using "H" for high risk, "M" for moderate risk, and "L" for low risk. Refer to Tables 4.1 and 4.2 and Figure 4.1 to help you fill in the blanks in the table. You may also wish to refer to your textbook.

2. A major concern for people living below the slopes of Mount Rainier is the possibility of large landslides and lahars. These could occur without warning during dormant periods of the volcano, if the rocks become too weakened by heat and fluids

FIGURE 4.8 Oblique aerial photograph of the upper cone of Mount Rainier from the northwest, showing the Puyallup Glacier and the steep upper slopes. Note also the crater at the top of the volcano, which has been filled in with younger eruptive products. Photo courtesy of U.S. Geological Survey Austin Post photograph collection.

that alter them, or if the rocks are shaken during a regional (not volcano-related) earthquake. Use the topographic maps in this exercise and at the back of the book to analyze areas that may be at risk from landslides and lahars. Sketch on the topographic map (Figure 4.9 in the back of the book) areas that may be at risk from landslides and lahars from Mount Rainier. Explain your choice of areas, and your decision of how far to extend the areas from the peak of the mountain.

3. What volcanic hazards do the citizens of Orting need to be aware of?

4. How are the hazards in Orting likely to be different from hazards in Seattle or Tacoma? Refer to Figure 4.9, the color plate in the back of the book.

5. Review the aerial photograph (Figure 4.10) and topography of Orting as shown on Figure 4.9.

a. If you were in charge of planning an evacuation because of an imminent volcanic hazard, what geological, economic, and social factors should you include in developing your plan?

TABLE 4.4 Volcanic Hazards and Their Relative Risks at Mt. Rainier, During Eruptions and in Dormant Periods

Hazard	Risk Close to Mt. Rainier	Risk Away from Mt. Rainier	Risk During an Eruption	Risk in Dormant Periods
Lava flow				
Phreatic (steam-or gas-driven) eruptions				
Volcanic bombs				
Tephra				
Pyroclastic flows				
Lahars				
Jokulhlaups (glacier-burst floods)				
Collapse of part of upper cone				
Debris avalanche				
Volcanic earthquakes				
Gases				

b. Assume that there are about 30 minutes from the time a lahar starts on the upper slopes of Mt. Rainier until it reaches Orting. Where do you suggest citizens of Orting go? Explain your choice.

c. In 1990, the population of Orting was about 2,100 people. In 2005 it was approximately 4,500 people. What additional risks are created by population growth in Orting?

PART C. SHIELD VOLCANOES

Shield volcanoes are characterized by the eruption of basaltic magmas, which have low viscosity and therefore cannot develop steep sides to their edifices. Basaltic eruptions, despite their drama, are the least explosive types of eruptions. In Hawaii, shield volcanoes typically erupt either from central vent areas or from rift zones that extend laterally from the central vents for many kilometers.

Hawaii

Figure 4.11a is a map of the Island of Hawaii, and shows general zones of volcanic hazards. It also identifies the five major volcanoes that compose the island. Table 4.5 describes how the U.S. Geological Survey has identified nine different levels of hazards on the island. Figure 4.11b is a more detailed map of lava flow hazards from Kilauea volcano.

QUESTIONS 4, PART C

1. Use the data in Table 4.5 and Figures 4.11a and b. Is the hazard from lava flows greater in the northern or southern part of the island of Hawaii?

2. Is anywhere on the island completely safe from volcanic hazards? Explain.

3. Use topographic data on Figure 4.11a and sketch on lined or graph paper a topographic profile from the City of Hilo through the summit of Mauna Loa to the ocean on the west. (See Exercise 2 for information about drawing topographic profiles.)

FIGURE 4.10 An aerial photograph of Orting. The river along the north side of town is the Carbon River, and the river along the south side of town is the Puyallup River. Both these rivers have their origins high on the slopes of Mt. Rainier. The rivers flow toward the top of the image.

a. From its profile, is Hawaii most like a basaltic shield volcano, an andesitic composite cone, or a rhyolitic volcano?

b. What is the vertical exaggeration of your profile? What would the profile look like with no exaggeration?

c. Does the amount of vertical exaggeration that you drew influence your interpretation of the kind of magma in Hawaii? _____ Explain.

4. Look at Figure 4.11b. Analyze it to answer the following questions.

a. Where are the zones of highest hazard from Kilauea and Mauna Loa?

b. Where are the zones of lowest hazard?

c. What geologic factors might be different between zones of higher hazard and zones of lower hazard?

d. Using the information on these two maps, which town(s) would likely be subject to hazards from the eruption of Pu'u O'o on the east rift zone of Kilauea? (Note that lava flows downhill.)

5. Review hazards listed on Tables 4.1 and 4.2. Lava is not the only hazard on Hawaii. What other hazards could be expected in Hilo from an eruption of:

TABLE 4.5 Hazard zones from lava flows on the Island of Hawaii are based chiefly on the location and frequency of historic and prehistoric eruptions and the topography of the volcanoes. Scientists have prepared a map that divides the five volcanoes of the Island of Hawaii into zones that are ranked from 1 through 9 based on the relative likelihood of coverage by lava flows. Caption and table from U.S. Geological Survey (http://hvo.wr.usgs.gov/hazards/LavaZonesTable.html, downloaded August 4, 2007)

Hazard Zones for Lava Flows on the Island of Hawaii			
Zone	**Percentage of area covered by lava since 1800**	**Percentage of area covered by lava in last 750 years**	**Explanation**
1	Greater than 25	Greater than 65	Includes the summits and rift zones of Kilauea and Mauna Loa where vents have been repeatedly active in historic time.
2	15–25	25–75	Areas adjacent to and downslope of active rift zones.
3	1–5	15–75	Areas gradationally less hazardous than Zone 2 because of greater distance from recently active vents and/or because the topography makes it less likely that flows will cover these areas.
4	About 5	Less than 15	Includes all of Hualalai, where the frequency of eruptions is lower than on Kilauea and Mauna Loa. Flows typically cover large areas.
5	None	About 50	Areas currently protected from lava flows by the topography of the volcano.
6	None	Very little	Same as Zone 5.
7	None	None	20 percent of this area covered by lava in the last 10,000 yrs.
8	None	None	Only a few percent of this area covered in the past 10,000 yrs.
9	None	None	No eruption in this area for the past 60,000 yrs.

Source: Wright and others, 1992

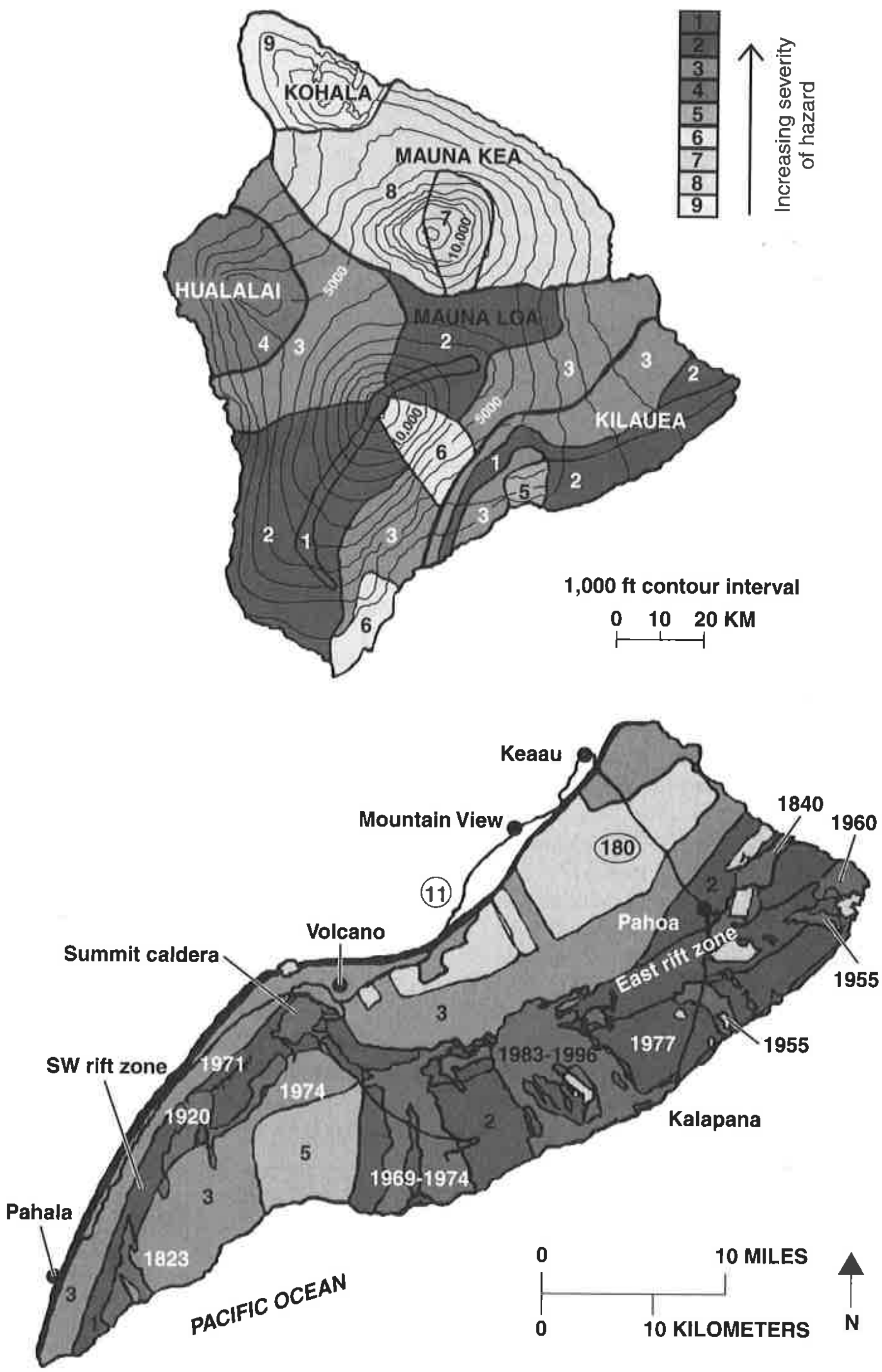


FIGURE 4.11 Volcanic hazard zones on the Island of Hawaii, with detail for the Kilauea area.

a. Mauna Loa?

b. Kilauea?

6. If Mauna Loa is showing early signs of an eruption, such as increased seismic activity and swelling of the volcano from rising magma, what actions should the residents of Hilo take?

7. What data are needed to determine the areas on the island that are at risk from tephra? Gases?

8. Are these areas likely to be large or small? What is your evidence?

9. If you plan to vacation at or move to the Island of Hawaii, what are some data that would be helpful to know before your trip?

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