

## CHAPTER 5

# VOLCANOES

### Important Concepts

1. Most *magmas* originate in the upper mantle, at depths between 50 and 250 kilometers, and are typically generated (1) at divergent plate boundaries, (2) over subduction zones, and (3) at hot spots.
2. Most *volcanoes* are located over subduction zones, although a few volcanoes are associated with mantle hot spots. *Fissure eruption*, rather than eruption from a single pipe or vent, accounts for the immense volume of volcanic rocks formed at the divergent boundaries (spreading centers). The very extensive basaltic rocks of the Columbia Plateau in the western United States and of the Deccan Plateau in western India were formed by fissure eruption on continents.
3. The chemical composition of a magma influences its physical properties. Silica-poor, iron- and magnesium-rich magmas (*mafic* magmas) are low in viscosity and flow easily. Silica-rich magmas (*felsic* magmas) are viscous and flow sluggishly. Felsic magmas tend to trap dissolved gases, which may lead to explosive eruptions. Explosive eruptions are potentially more hazardous than nonexplosive (passive) eruptions.
4. The two main products of volcanic eruptions are *lavas* and *pyroclastics* (fragmental volcanic material). Landforms produced by volcanic eruptions reflect the kind of material erupted:
  - (a) A *shield volcano* is a low, flat, gently sloping volcano built from many flows of fluid, low-viscosity lava. The Hawaiian Islands are composed of shield volcanoes.
  - (b) A *volcanic dome* is a compact, steep-sided structure built of very viscous, rhyolitic and andesitic lavas emitted from a central pipe or vent. A volcanic dome has formed in the crater of Mount St. Helens left by its 1980 explosive eruption (although the Mount St. Helens volcano as a whole is a composite volcano).
  - (c) A *cinder cone* is a symmetric, cone-shaped volcano formed from the accumulation of pyroclastics close to the volcanic vent.
  - (d) A *composite volcano* (or *stratovolcano*) is built of interlayered lava flows and pyroclastics. They tend to have viscous, gas-charged lavas and can erupt explosively. Most of the volcanoes in the Cascade Range of the western United States are of this type.
5. The primary source of hazards related to volcanic eruptions are the products of eruptions: lava flows, pyroclastic flows, *lahars* (volcanic mudflows), ash falls, toxic gases (mainly SO<sub>2</sub>), and phreatic eruptions.
6. A volcanic eruption can have a global impact on climate and atmospheric chemistry through the production of volcanic dust and/or sulfur-rich gases.
7. In terms of their activity, volcanoes can be classified as active, dormant, or extinct.
8. The likely regions of future volcanic activity can be predicted from the present-day plate tectonic map, but not the precise location or time of eruption. Selected volcanoes are routinely monitored for advance warning of volcanic activity. The volcanic precursors geologists look for are seismic activity, bulging, uplifting, or tilting of a volcano's surface, thermal changes, and changes in the mix of released gases.

9. Areas in the United States vulnerable to present and future volcanic hazards include the Aleutian Islands of Alaska, Hawaii, the Cascade Range, the Mammoth Lakes/Long Valley area of California, and the Yellowstone National Park.

## Key Terms

active volcano	lahar
andesite	lava
ash	mafic
basalt	phreatic eruption
cinder cone	pyroclastic flow
composite volcano	pyroclastics
dormant volcano	rhyolite
extinct volcano	shield volcano
felsic	stratovolcano
fissure eruption	ultramafic
hot spots	volcanic dome

## Multiple Choice

1. Most magmas originate in the
  - a. upper mantle.
  - b. lower mantle.
  - c. outer core.
  - d. inner core.
2. Mafic (silica-poor) lavas
  - a. are low in viscosity and flow easily.
  - b. tend to trap dissolved gases, leading to explosive eruptions.
  - c. are viscous and flow sluggishly.
  - d. are associated with subduction-zone volcanoes.
3. Most volcanic activity on land areas occurs
  - a. along the equator.
  - b. in association with subduction zones.
  - c. at hot spots.
  - d. in continental interiors.
4. A well-known volcano associated with a rift zone is
  - a. Mauna Loa.
  - b. Kilimanjaro.
  - c. Mount Katmai.
  - d. Mont Pelée.

5. Most volcanic rock is created at
  - a. hot spots.
  - b. subduction zones.
  - c. seafloor-spreading ridges.
  - d. fault zones.
6. The Columbia Plateau is an example of a
  - a. shield volcano.
  - b. volcanic dome.
  - c. fissure eruption.
  - d. lahar.
7. The Hawaiian peak called Mauna Loa is an example of a
  - a. volcanic dome.
  - b. cinder cone.
  - c. composite volcano.
  - d. shield volcano.
8. Which of the following is not a type of pyroclastic material?
  - a. volcanic bombs
  - b. volcanic cinders
  - c. volcanic ash
  - d. flowing lava
9. Volcanoes composed of pyroclastics are called
  - a. shield volcanoes.
  - b. stratovolcanoes.
  - c. cinder cones.
  - d. volcanic domes.
10. Volcanoes of the Cascade Range are
  - a. stratovolcanoes.
  - b. shield volcanoes.
  - c. volcanic domes.
  - d. cinder cones.
11. The residents of the Icelandic island of Heimaey stopped a lava flow by
  - a. bombing it.
  - b. cooling the lava with water.
  - c. building a dike.
  - d. channeling the lava into a ditch.
12. A pyroclastic outburst of a denser-than-air mixture of hot gases and fine ash is known as a
  - a. lahar.
  - b. phreatic eruption.
  - c. steam explosion.
  - d. pyroclastic flow.

13. The catastrophe at Lake Nyos, Cameroon, Africa, in 1986 was caused by
- a steam explosion.
  - the release of carbon dioxide.
  - a lahar.
  - a pyroclastic flow.
14. Volcanic eruptions may, at least temporarily,
- contribute to the formation of acid rain.
  - decrease average global temperature.
  - increase the rate of ozone depletion.
  - All of the answers are correct.
15. All of the following are possible volcanic precursors except
- seismic activity.
  - deformation of a volcano's surface.
  - changes in barometric pressure.
  - changes in the mix of gases emitted by the volcano.
16. Volcanologists
- can readily predict the volume of lava to expect from an eruption.
  - can anticipate the likelihood of an explosive eruption.
  - can readily predict the timing of a volcanic eruption months or years in advance.
  - can readily predict the volume of pyroclastics to expect from an eruption.
17. Concerning responses to eruption predictions, the safest course is to
- remain in the area until volcanic activity confirms the prediction.
  - undertake precautionary evacuations.
  - ignore the prediction since volcanologists rarely make accurate predictions.
  - remain in the area but stock up on water, food, and other supplies in case there is an eruption.
18. Subduction is the underlying cause of the
- volcanoes of the Hawaiian Islands.
  - volcanoes of the Cascade Range of the Pacific Northwest.
  - geothermal features of Yellowstone National Park.
  - volcanoes of the East African Rift system.

### Fill In the Blanks

- \_\_\_\_\_ is the volcanic, fine-grained compositional equivalent of granite.
- The collection of volcanoes rimming the Pacific Ocean is known as the \_\_\_\_\_.
- A \_\_\_\_\_ has formed in the crater of Mount St. Helens.
- Bits of violently erupted volcanic material are collectively called \_\_\_\_\_.
- Stratovolcanoes are also called \_\_\_\_\_ volcanoes.
- A mudflow of meltwater and volcanic ash produced by a volcanic eruption is called a \_\_\_\_\_.

7. The town of St. Pierre, on the Caribbean island of Martinique, was destroyed by a \_\_\_\_\_ that occurred during the eruption of Mont Pelée in 1902.
8. During the A.D. 79 eruption of Mount Vesuvius, many people were killed by the release of \_\_\_\_\_.
9. A volcano considered to be \_\_\_\_\_ is very unlikely to erupt again.
10. A \_\_\_\_\_ is an enlarged volcanic summit crater formed by either an explosion or the collapse of a volcano.

### True or False

Indicate whether the following statements are true or false. If false, correct the statement to make it true.

- \_\_\_\_\_ 1. The eruption of Mount St. Helens in 1980 made many Americans realize for the first time that they lived in areas threatened by volcanoes.
- \_\_\_\_\_ 2. Silica-rich magmas are less viscous, thinner, and flow more easily than silica-poor magmas.
- \_\_\_\_\_ 3. Most volcanoes are located over subduction zones.
- \_\_\_\_\_ 4. The most energetic pyroclastic eruptions are more typical of volcanoes with viscous lavas ,because thicker lavas tend to trap more gases.
- \_\_\_\_\_ 5. Lava flows are among the most hazardous of volcanic activities because they are the least predictable of volcanic hazards.
- \_\_\_\_\_ 6. The violent eruption of the Indonesian island of Krakatoa in 1883 was an example of a phreatic eruption.
- \_\_\_\_\_ 7. Volcanic eruptions that spew sulfur-rich gases into the atmosphere may enhance the effects of acid rain.
- \_\_\_\_\_ 8. There are an estimated 3000 to 5000 active volcanoes in the world.
- \_\_\_\_\_ 9. It is possible that animals might “foresee” volcanic events and that studying their behavior might provide volcanologists with clues to impending eruptions.
- \_\_\_\_\_ 10. The major eruption of Mount Pinatubo in 1991 came as a complete surprise to volcanologists and local residents.

## **Review Questions**

1. List the different products (direct or indirect) of volcanic eruptions and the hazards they may cause. What, if anything, can be done to minimize or eliminate these hazards?
2. Discuss the distinctions among active, dormant, and extinct volcanoes. Comment on the limitations of this classification scheme.
3. What are the precursor phenomena that can be used to predict a volcanic eruption in an area being monitored for such indications? How successful were the geologists in predicting the Mount St. Helens eruption of 1980?
4. Why is there a general coincidence between the distribution of documented earthquake epicenters and young volcanoes? Discuss the exceptions to this general distribution pattern.
5. Name three areas of active volcanism in the United States (including Alaska and Hawaii), and discuss the plate tectonic setting of each.
6. Do you expect the Yellowstone National Park region to be a potential candidate for future volcanic activity? Justify your answer.
7. What is a fissure eruption? Give examples of active volcanism and ancient volcanism through fissure eruption.

## **Surfing the Net**

Excellent compilation of information on the Cascade volcanoes and links to other U.S. volcanoes (U.S Geological Survey):

<<http://vulcan.wr.usgs.gov/home.html>>

About the U.S.G.S's Volcano Disaster Assistance Program, which involves the world's only volcano crisis response team (U.S. Geological Survey):

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

Useful online U.S. Geological Survey publications:

“Volcanoes”	< <a href="http://pubs.usgs.gov/gip/volc/">http://pubs.usgs.gov/gip/volc/</a> >
“Volcanoes of the U.S.”	< <a href="http://pubs.usgs.gov/gip/volcus/">http://pubs.usgs.gov/gip/volcus/</a> >

An excellent source of information about terrestrial volcanoes and those on other planets (NASA-supported):

<<http://volcano.und.nodak.edu/vw.html>>

A virtual field trip to Hawaii's volcanoes:

<<http://www.satlab.hawaii.edu/space/hawaii/virtual.field.trips.html>>

## CHAPTER 5 ANSWER KEY

### Multiple Choice

- |      |       |       |       |
|------|-------|-------|-------|
| 1. a | 6. c  | 11. b | 16. b |
| 2. a | 7. d  | 12. d | 17. b |
| 3. b | 8. d  | 13. b | 18. b |
| 4. b | 9. c  | 14. d |       |
| 5. c | 10. a | 15. c |       |

### Fill in the Blanks

- |                  |   |
|------------------|---|
| 1. Rhyolite      | 6. lahar                                |
| 2. ring of fire  | 7. pyroclastic flow (or nuées ardentes) |
| 3. volcanic dome | 8. toxic (or volcanic) gases            |
| 4. pyroclastics  | 9. extinct                              |
| 5. composite     | 10. caldera                             |

### True or False

1. True
2. False. Silica-rich magmas are more viscous, thicker, and flow more sluggishly than silica-poor magmas.
3. True
4. True
5. False. Lava flows can be hazardous; however, they are at least predictable, since their flow paths can be anticipated.
6. True
7. True
8. False. There are an estimated 300 to 500 active volcanoes in the world.
9. True
10. False. Mount Pinatubo exhibited several volcanic precursors prior to its main eruption on 15 June 1991; these included increased seismic activity, a bulge on the volcano's summit, emissions of ash, and a sudden drop in gas output.