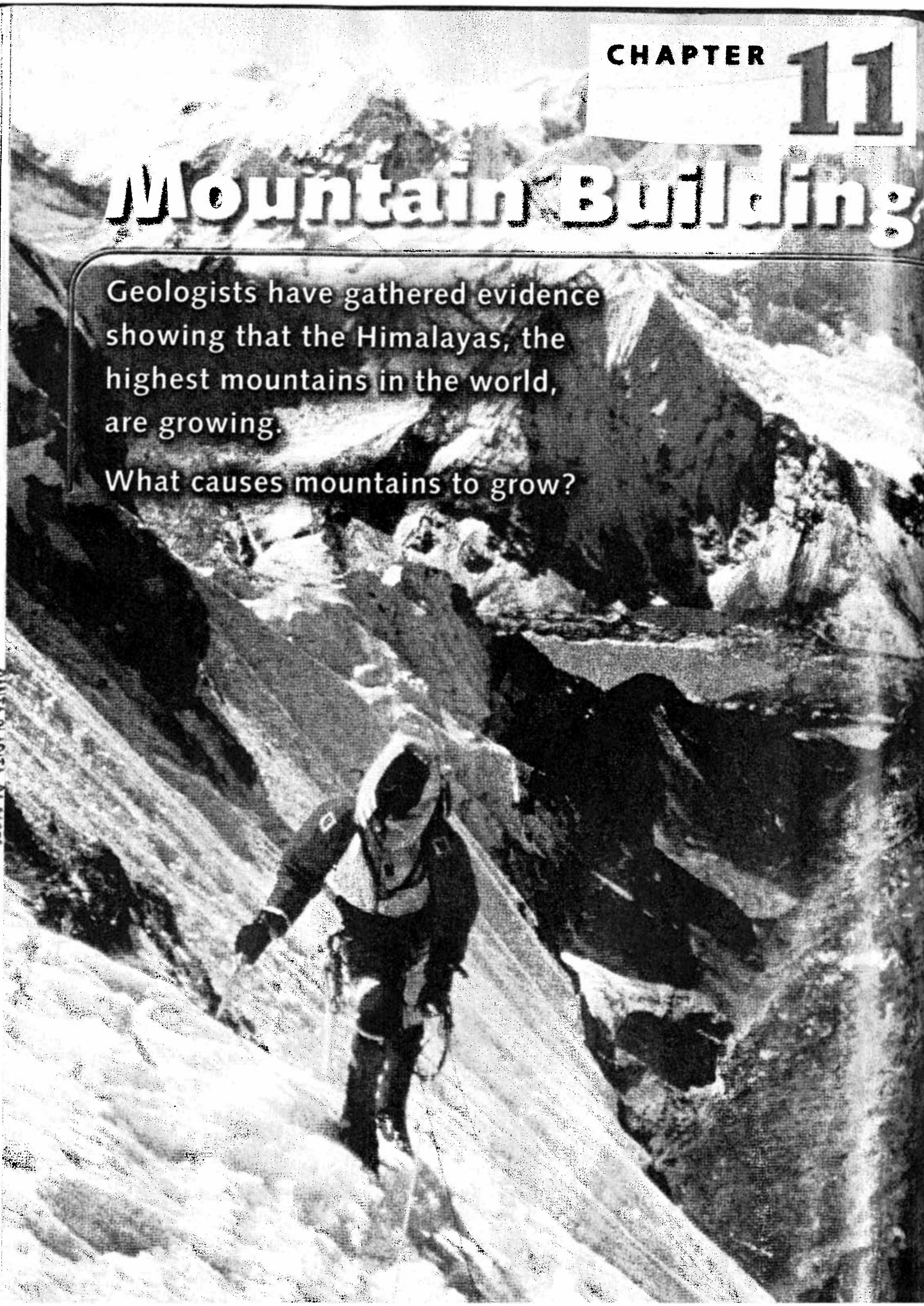
CHAPTER 11

Mountain Building

Geologists have gathered evidence showing that the Himalayas, the highest mountains in the world, are growing.

What causes mountains to grow?



CHAPTER 11

PREVIEW

▶ FOCUS QUESTIONS **In this chapter you will study mountains and learn more about the key questions below.**

Section 1 Where do mountains form?

Section 2 How do mountains form?

Section 3 How can mountains be classified?

▶ REVIEW TOPICS **As you investigate mountain building, you will need to use information from earlier chapters.**

- pluton **(p. 125)**
- collision boundary **(p. 178)**
- fault **(p. 214)**
- volcano **(p. 194)**

▶ READING STRATEGY

QUESTION

Before reading the chapter, skim its contents and develop questions you would like to explore. Write your questions in your science notebook. As you read, record information.

INTERNET RESOURCES
CLASSZONE.COM

At our Web site, you will find the following Internet support for this chapter.

DATA CENTER

EARTH NEWS

VISUALIZATIONS
- Fault Motion
- Formation of the Himalayas

LOCAL RESOURCES

INVESTIGATIONS
- How Are Mountains Related to Plate Tectonics?
- How Do Rocks Respond to Stress?
- What Forces Created These Geologic Features?

11.1

Where Mountains Form

KEY IDEA

Events at plate boundaries and at continental margins result in the formation of mountains.

KEY VOCABULARY

- mountain
- continental margin

A **mountain** is a large mass of rock that rises a great distance above its base. Most mountains result from forces associated with processes that occur at convergent plate boundaries.

Mountain Belts

Most of the world's mountains occur in long belts that tend to follow convergent plate boundaries. These mountain belts are regions where mountains are forming or have formed in the past. The North American Cordillera is a mountain belt that runs down the western side of North America from Alaska to Mexico. This mountain belt is made up of smaller groups of mountains called mountain ranges. For example, the Cascade Range is part of the North American Cordillera.

Some mountains, such as the Himalayas, lie along current plate boundaries. Other mountains, such as the Appalachians, do not. By analyzing how the rocks in the Appalachians are arrayed and by studying the ages of the rocks and the materials in them, geologists have concluded that the Appalachians formed at a plate boundary that existed millions of years ago.

Continental Margins

In order to understand how processes at convergent plate boundaries contribute to mountain building, geologists study what happens along Earth's continental margins. A **continental margin** is a boundary between continental crust and oceanic crust.

There are two types of continental margins. Active continental margins occur along plate boundaries. Passive continental margins do not occur at plate boundaries. For example, there is an underwater continental margin along the east coast of North America that marks the boundary between the North American continent and the oceanic crust. Both the continental crust and the oceanic crust along this continental margin are part of the North American Plate.

Mountain building takes place near active continental margins. One place where an active continental margin exists is along the west coast of South America. Here, the Nazca [NAHZ-kuh] Plate, which is carrying

INVESTIGATIONS
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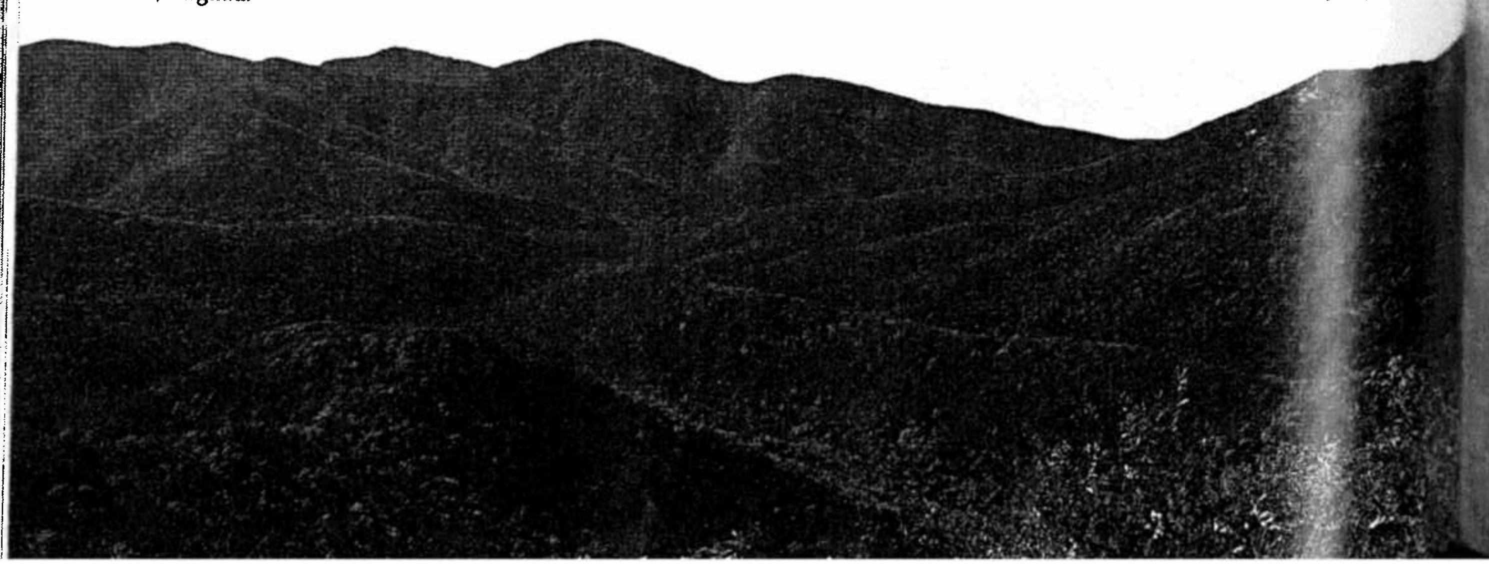
How Are Mountains Related to Plate Tectonics? Examine the locations and ages of mountain belts to determine their relationship to plate boundaries. *Keycode:* ES1101



THE APPALACHIANS The Blue Ridge mountains are a mountain range in the Appalachians. This view is from an overlook in Shenandoah National Park, Virginia.

oceanic crust, is subducting beneath the South American Plate, which is carrying continental crust. The west coast of South America is very mountainous and prone to earthquakes and volcanic activity. The slow process of mountain building is taking place today in this region.

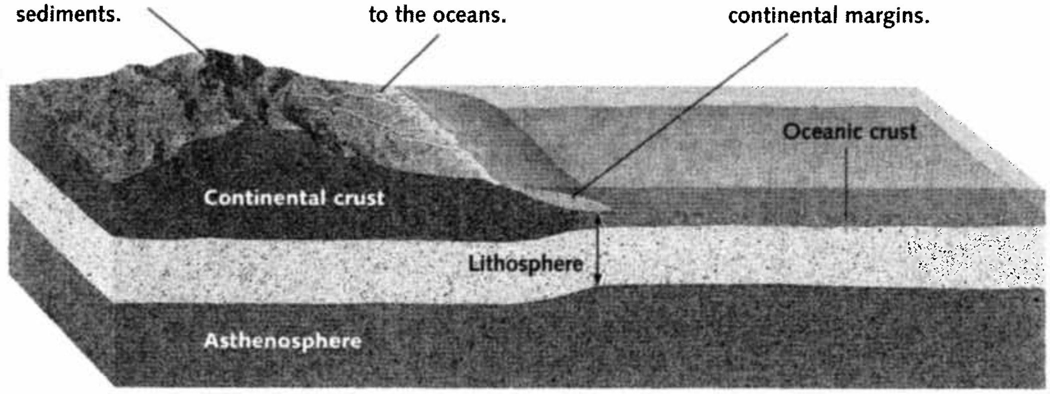
Passive continental margins are stable areas because they do not occur at plate boundaries. These areas accumulate large amounts of sediment. Some of the sediment comes from skeletons and shells of marine organisms. But much of it consists of sediments that have been weathered away from the continent and transported to the continental margin by rivers. One example of a passive continental margin lies off the east coast of North America. A wedge of sediment 250 kilometers wide and as much as 10 kilometers thick has accumulated there. Eroded rock materials from the Appalachians now lie along this passive continental margin.

Sediment Buildup at a Passive Continental Margin

1 Over time, mountains wear away, creating sediments.

2 Rivers and other agents of erosion carry sediments to the oceans.

3 These and other sediments are deposited along passive continental margins.



How are passive continental margins related to mountain formation? These passive continental margins provide the materials that form mountains. The mountains of today were passive continental margins in the past. The active continental margin on the west coast of South America was a passive continental margin until about 200 million years ago. The Andes Mountains contain the sediments that were deposited on that passive continental margin.

11.1 *Section Review*

1. **Where do most of the world's mountains form?**
2. **CRITICAL THINKING Compare and contrast passive and active continental margins.**
3. **GEOGRAPHY Look at the plate boundary map on pages 712–713. Identify at least two active continental margins and two passive continental margins. What mountain ranges appear to be associated with the active continental margins you identified?**

11.2

KEY IDEA

Rocks at converging plate boundaries are under stress, and this stress may lead to deformation.

KEY VOCABULARY

- anticline
- syncline
- normal fault
- reverse fault
- thrust fault
- strike-slip fault
- joint

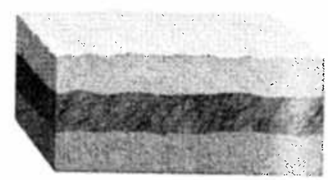
How Mountains Form

A sculptor uses a hammer to hit a chisel, and the point of the chisel hits a rock. The rock breaks because the sculptor has concentrated the force of the hammer blow onto the relatively small area where the chisel meets the rock. The sculptor has increased the amount of stress being applied to the rock. *Stress* is a measure of the amount of force applied over a given area.

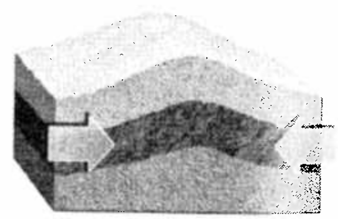
Stress is applied to rocks at converging plate boundaries. Rocks at Earth's surface are rigid, and usually respond to stress by fracturing. Deeper in Earth, high pressures and temperatures make rocks less rigid than those at the surface. For this reason, stress applied to rocks deep within the lithosphere may cause the rocks to fold or stretch without fracturing. Mountain belts are made of rocks that have been permanently deformed under stress.

Types of Stress

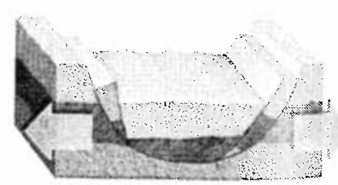
The illustration at the right models a series of rock layers. The bottom rock layers are under stress from the weight of layers above. Overall, however, the rock layers are relatively stable. The illustrations below show three different types of stress that might affect the rock layers.



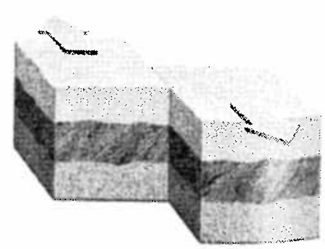
COMPRESSION The rock layers are being squeezed inward. Stress that involves squeezing is called compression. Compression tends to make rock layers thicker and shorter.



TENSION The rock layers are being stretched. Stress that involves pulling and stretching is called tension. Tension tends to make rocks thinner and longer. In this illustration, some of the rock layers have fractured.



SHEAR STRESS The rock layers are being pushed in two different, opposite directions. Stress that involves forces moving in opposite directions is called shear stress. Shear stress tends to distort the shape of the rocks, especially along the plane between the opposing forces.



INVESTIGATIONS
CLASSZONE.COM

How Do Rocks Respond to Stress?
Apply a force to model rocks under different conditions and view the results.
Keycode: ES1102

Compression, tension, and shear stress all contribute to the process of mountain building at plate boundaries. These three types of stress usually occur together. Different types of rocks may respond differently to the same stress. For example, a layer of sandstone may respond to stress by folding. A thin layer of shale lying next to the sandstone may fracture rather than fold.

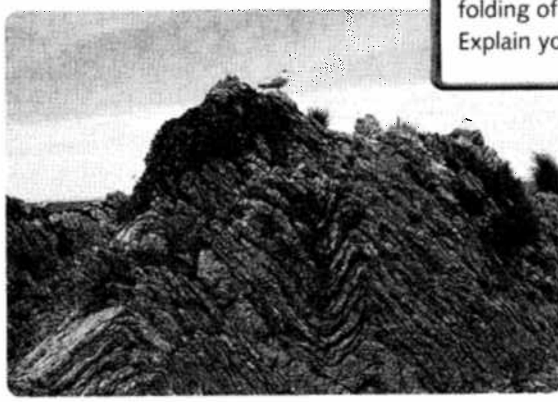
Scientific Thinking

INTERPRET

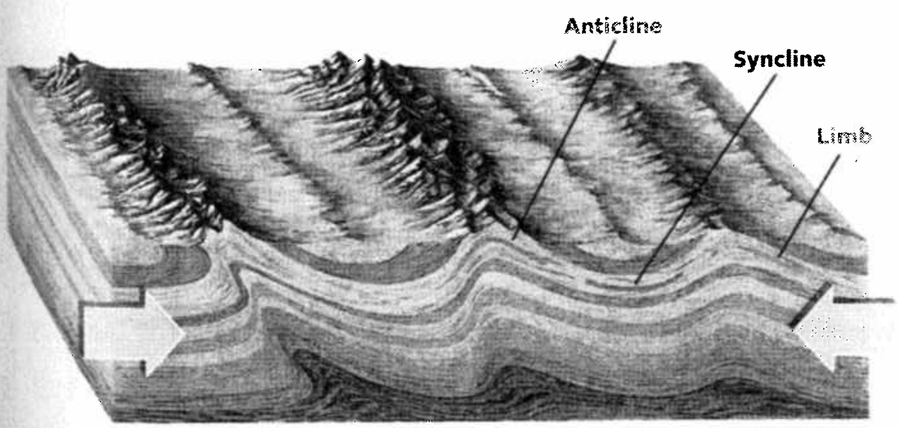
The photograph to the left shows folded rock layers in New Zealand. Identify the types of stress that may have caused the folding of these rock layers. Explain your thinking.

Folds

During plate collisions, stress can cause rock layers along continental margins to crumple into folds. Although this folding occurs deep beneath Earth's surface, folded rock layers may be exposed after long periods of time by uplift, weathering, and erosion.



Geologists use a number of terms to describe folds in rocks. As shown in the diagram below, an **anticline** is an upfold in the rock layers. A **syncline** is a downfold. The two sides of a fold are called limbs. The steepness, or dip, of the limbs reflects the intensity of folding. Limbs may be gently dipping, steeply dipping, straight up and down, or even overturned. The compass direction of the fold or of the rock layers exposed at the surface along the fold is called the strike. Sometimes folding can cause extreme deformation. In other cases, rock layers have been pushed into gentle anticlines and synclines.



FOLDED ROCK LAYERS

A well-known example of folded mountains is the Valley and Ridge Province of the Appalachian Mountains. In this region, which extends from New York State to Alabama, the rock layers have not been badly crumpled. Instead, the stress of collision has formed the layers into long, straight folds. Interestingly, the valleys between the mountains do not correspond to fold synclines nor the ridges to fold anticlines, as one might expect. Instead, the locations of the valleys and ridges are controlled primarily by the weathering rates of the rocks in different areas of the folds.

20 Minutes

Mini LAB

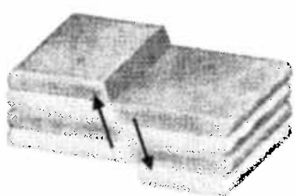
Modeling a Fault

Materials

- Two fist-sized pieces of different-colored clay
- wire

Procedure

1. Flatten each piece of clay until it is about 1 cm thick. Cut each piece into two congruent rectangles.
2. Stack all four rectangles, forming a block with layers of alternating colors.
3. Using the wire, cut through the block diagonally, as shown.
4. Move one side of the block up and the other down. Move the sides in the opposite directions.



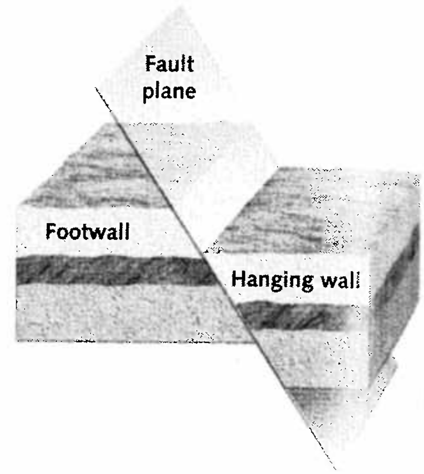
Analysis

What types of faults have you modeled? For each fault, what type of stress did you exert? What would you change to model other types of faults?

Faults

As you learned in Chapter 10, a fault is a break in the lithosphere along which movement has occurred. Not only are movements along fault planes the primary cause of earthquakes, they are also an important part of the process of mountain formation.

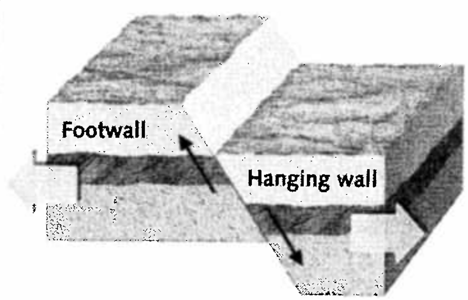
The illustration at the right shows a fault plane, which is the surface between the two pieces of moving crust at a fault. The part of the fault above the fault plane is called the hanging wall. The part of the fault below the fault plane is the footwall.



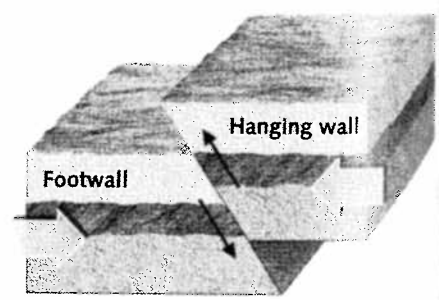
Geologists classify faults by the way in which the rocks on either side of the fault plane move with respect to each other. In each of the fault illustrations below, the large arrows indicate stress being applied to the rocks. The small black arrows show movement along the fault plane.

A **normal fault** occurs when the hanging wall moves down with respect to the footwall. Normal faults occur in areas where tension is pulling the crust apart.

A **reverse fault** occurs when the hanging wall moves up with respect to the foot wall. Reverse faults are caused by compression. Such compression may occur, for example, when two plates collide. The compression at a reverse fault thickens and shortens rocks.

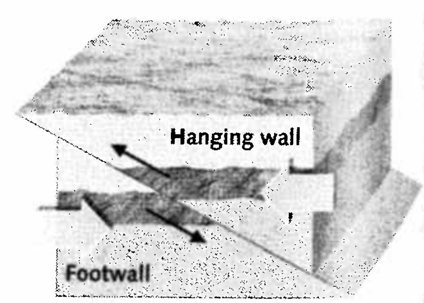


NORMAL FAULT



REVERSE FAULT

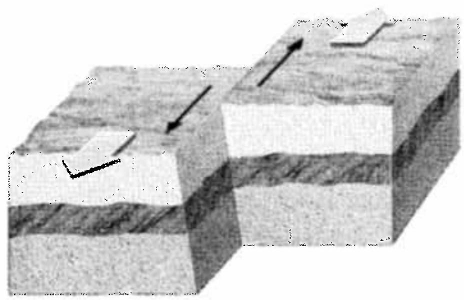
A **thrust fault** is a reverse fault in which the fault plane dips 45° or less from the horizontal. Thrust faults are common in many mountain belts, including the Appalachians. From studies of thrust faults, geologists have seen that compressive stresses can move sheets of rock over great distances.



THRUST FAULT

At a **strike-slip fault,** the rocks on opposite sides of the fault plane move horizontally past each other. The San Andreas Fault is a well-known example.

Extremely long strike-slip faults are found in the Himalayas. These faults result as the Indian Plate pushes rock materials aside on its drive into the Eurasian Plate. Some of the faults are thousands of kilometers from the plate boundary.



STRIKE-SLIP FAULT

VISUALIZATIONS
CLASSZONE.COM

Examine animations of fault motion.
Keycode: ES1103

Joints

Joints, like faults, are breaks in bedrock. Unlike faults, joints are breaks along which no apparent movement has occurred. Joints can be the result of the same stresses that lift, tilt, and fold rock layers into mountains. They are one of the most common rock structures.

The surface of a joint is usually a plane, although the surfaces of some joints are curved. The joint plane appears on the surface of a rock outcrop as a line. These lines can appear in parallel groups called joint sets. Sometimes one joint set is crossed at an angle by another joint set.

Joints provide channels through which fluids enter and move through bedrock. Hot fluids rising through the crust may fill a joint with quartz, calcite, or some other mineral to form a vein deposit. Caverns form when groundwater flows through and dissolves limestone along joint planes. In some areas, surface features are controlled by joint patterns. The spires at Bryce Canyon are the result of weathering along joints.

11.2 *Section Review*

1. Describe different ways that rocks can respond to stress.
2. Compare and contrast an anticline and a syncline.
3. Explain the difference between a normal fault and a reverse fault.
4. What is a thrust fault?
5. Describe the movement in a strike-slip fault.
6. **CRITICAL THINKING** What visual clues could a geologist use to decide whether a large crack in a rock cliff is a joint or a fault?
7. **MATHEMATICS** Geologists use a device called a clinometer to measure the dip of a limb in an anticline or syncline. The clinometer measures the angle that the limb makes with a horizontal line. Sketch and label an anticline with a limb whose dip is about 45°. Then sketch and label an anticline with a limb whose dip is about 30°.

SCIENCE & Technology

Measuring Mount Everest

How tall is the world's tallest mountain? And is it getting taller over time? These questions have not been easy to answer. First comes the challenge of climbing Mount Everest. Then comes the challenge of getting an accurate measurement.

How has technology helped scientists face these challenges?

THE GLOBAL POSITIONING SYSTEM includes hand-held receivers—such as this one—which pick up satellite signals.

In 1954, Everest's height was measured at 8848 meters (nearly 6 miles) tall. However, none of the surveying instruments were placed any closer than 48 kilometers from Everest's summit, a fact that increased the uncertainty of the measurement.

In the mid-1990s, new technology, the Global Positioning System (GPS), made it possible to get very accurate elevation measurements for any point on Earth. By processing signals from 24 satellites that orbit Earth, a GPS receiver can give information about the receiver's exact location. Scientists knew that GPS could be used to find Everest's elevation. The tricky part would be getting a receiver to Everest's frozen and forbidding summit.

In spring 1999, a climbing team began the trek to Everest's peak. The team carried lightweight GPS units with lithium batteries guaranteed to work at temperatures as cold as −40°C. Readings from the GPS receiver that the team placed at Everest's summit and readings from a second receiver placed at a lower elevation were used to determine the mountain's height. This new measurement, 8850 meters, was 2 meters higher than the 1954 measurement. Because GPS technology is unaffected by atmospheric or gravitational effects (which may have skewed the 1954 measurement), the new measurement is highly reliable. It is now accepted as Everest's official height.

By taking new GPS measurements year after year, scientists can track Mount Everest's height and position over time. As India continues to thrust under Nepal and China, Mount Everest apparently grows higher by about 4 millimeters each year. It also moves about 6 centimeters to the northeast each year.

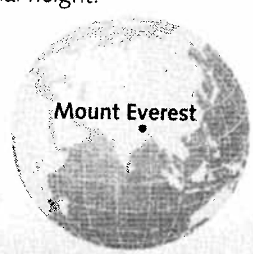
Extension

SCIENCE NOTEBOOK

Consider the advantages and disadvantages of monitoring mountain formation using GPS technology. What might a sudden change in the pattern of mountain building indicate?

DATA CENTER
CLASSZONE.COM

Learn more about the Global Positioning System (GPS).
Keycode: ES1104



MEASURING Scientists used surveying instruments that incorporated GPS technology to measure Mount Everest.

Types of Mountains

The forces involved in plate interactions produce features such as folds and faults. Mountains can be classified by these and other features.

11.3

KEY IDEA

Mountains can be classified by features that result from forces involved in plate interactions.

KEY VOCABULARY

- folded mountains
- dome mountain
- fault-block mountains

Folded Mountains

When two plates carrying continental crust collide, rocks can fold and crumple into **folded mountains.** The Appalachians, the Alps, the northern Rocky Mountains, the Urals, and the Himalayas are examples of folded mountains. Although geologists studying these mountains may also find faults and evidence of igneous activity, folded rocks are an especially prominent feature.

Before two continents can collide, the ocean basin between them must close. This change occurs as the oceanic crust subducts beneath one of the continents. Subduction stops, however, once the ocean is gone and the continents are in contact, because continental crust is not dense enough to subduct. Continued plate movements cause the rocks of the continental margins to crumple into mountains.

As shown by the diagram below, the formation of the Himalayas was preceded by the closing of an ocean between India and Tibet, a part of Eurasia. The oceanic crust disappeared into a subduction zone, although some of the crust was caught up in the collision, along with sediments that had accumulated on the edges of the colliding continents. Once the continents collided, subduction stopped. India continued to move north, pushing some rocks aside and crumpling others into the Himalayas. Mountain building is still going on today, as the Indian Plate continues to push into the Eurasian Plate.

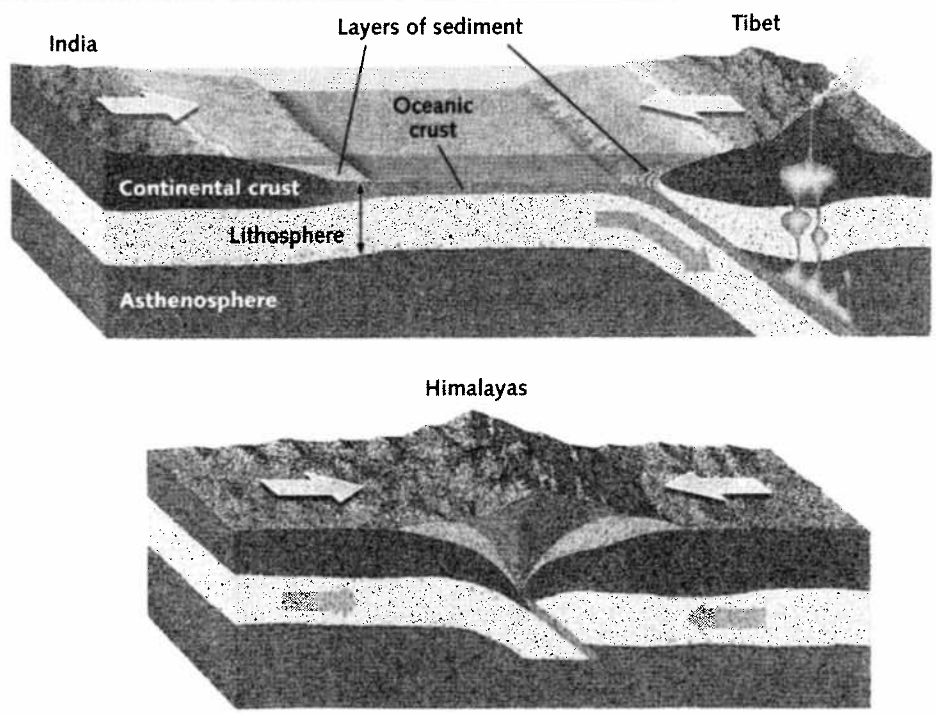
VISUALIZATIONS CLASSZONE.COM

Observe an animation of the Himalayas forming.
Keycode: ES1105

Formation of Himalayas

1. As India moved toward Tibet, the oceanic crust between the two continents subducted beneath the Eurasian Plate.

2. Once the ocean had closed, subduction stopped. India and Eurasia collided, crumpling and folding rocks into the Himalayas.



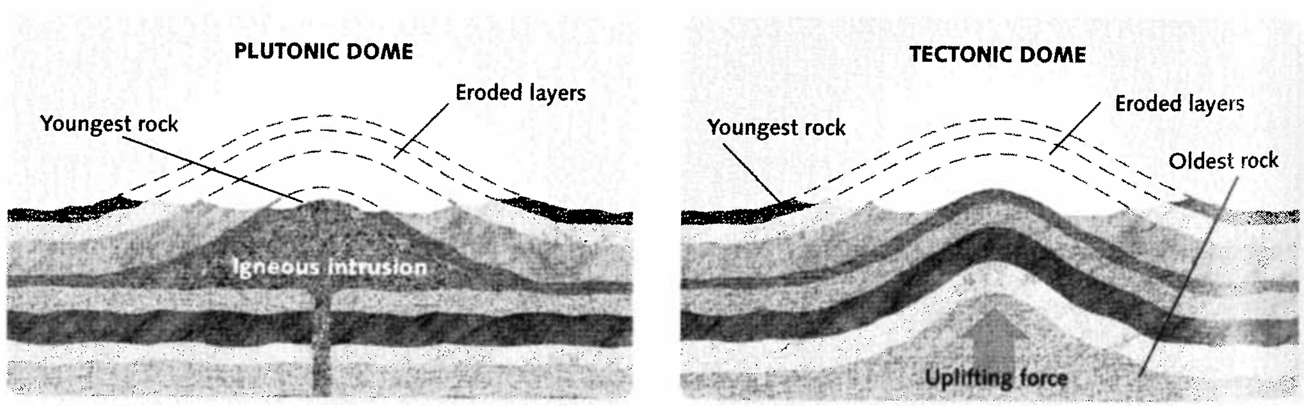
Dome Mountains

A **dome mountain** is a nearly circular folded mountain. Dome mountains are not found in mountain belts such as the Himalayas or the Appalachians. Instead, they are individual, isolated structures that tend to occur in areas of essentially flat-lying sedimentary rocks. These layers are bent upward in a dome shape as a result of uplifting forces. If the rocks above the dome mountain's center have eroded away, the layers of rock may stand out as sharp ridges around the edge of the mountain.

There are two basic types of dome mountains. One type is called a plutonic dome mountain. The other type is referred to as a tectonic dome mountain. Plutonic dome mountains form when overlying crustal rocks are pushed upward by an igneous intrusion, such as a laccolith. Because the intrusion occurs after the overlying crustal rocks have been formed, the igneous rock at the core of the mountain is younger than the sedimentary rocks around the core. Many examples of plutonic dome mountains are found on the border of the Colorado Plateau and the Rocky Mountains.

Tectonic dome mountains result from uplifting forces that arch rock layers upward. All the rocks in the dome were present before the uplift occurred. The rocks at the core extend under the rocks around the dome and, therefore, must be older. Two examples of tectonic dome mountains are the Adirondack Mountains of New York State and the Black Hills of South Dakota.

Formation of Dome Mountains



An igneous intrusion pushes up existing rock layers. When these rock layers wear away, the igneous rock is exposed at the center of the dome. The igneous rock is younger than all of the rock layers in the dome.

Uplifting forces arch rock layers into a dome. As the top layers wear away, older rock layers are exposed. The exposed layer at the center of the dome is older than the exposed layers around the edges of the dome.

Volcanic Mountains

Volcanic activity is a contributor to mountain formation. As you learned in Chapter 9, volcanic mountains such as the Cascades tend to form on continental crust near a subduction boundary.

Volcanic rocks are not common in the Himalayas, but some do occur on the northern edge of the range. These rocks may have formed when the

Indian Plate was still subducting under the Eurasian Plate. Once the plates collided, subduction stopped, and volcanic activity ceased.

Fault-Block Mountains

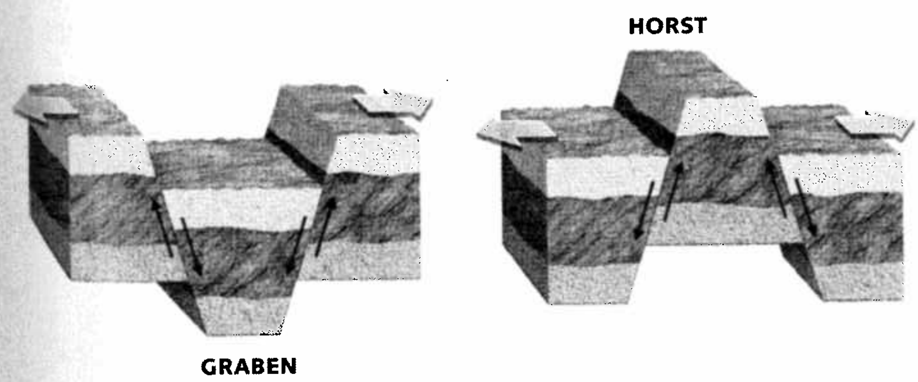
Although many mountain belts form as a result of compression, tension plays a large role in the formation of **fault-block mountains.** In some parts of the western United States, Earth's crust is slowly being uplifted. This uplift has caused the crust to stretch and crack, forming normal faults along the surface. As uplift continues, whole blocks of crust have been pushed up into fault-block mountains. Examples of such mountains are the Sierra Nevada of California, the Wasatch Range of Utah, and the Teton Range of Wyoming.

Horsts and Grabens

Tensional stress and normal faulting also result in features called horsts (hawrsts) and grabens (GRAH-buhns). Along the Great Rift Valley in East Africa, rising magma is forcing the crust upward. Tensional stress causes the crust to stretch. On either side of the wide rift valley, normal faults have formed. Between these normal faults, large blocks of crust have dropped. These blocks of crust are called grabens.

Sometimes a block of crust is thrust upward between two normal faults. This block of crust is called a horst. Horsts and grabens are found in the Basin and Range Province of Nevada.

GREAT RIFT VALLEY Tensional stress has resulted in normal faults along the sides of the Great Rift Valley in Africa.



11.3 *Section Review*

1. What type of mountains tend to form when two landmasses collide?
2. What is a dome mountain?
3. Where do volcanic mountains tend to form?
4. How do fault-block mountains form?
5. **CRITICAL THINKING** How is compression involved in forming folded mountains?
6. **PAIRED ACTIVITY** Work with a partner to develop a presentation that illustrates one of the processes by which mountains are formed.

CHAPTER 11

MAP Activity

Folded Mountain Range

SKILLS AND OBJECTIVES

- ***Observe*** the locations of the major mountain ranges of the world.
- ***Correlate*** mountain system locations with types of plate boundaries.
- ***Compare*** and ***contrast*** continental and oceanic mountain ranges.
- ***Interpret*** the structure and geology of an area from map and cross section data.
- ***Infer*** the relative resistance to weathering of various rock types.

MATERIALS

- **Appendix B** *Physical World Map*, pages 710–711
- **Appendix B** *Earth's Tectonic Plates Map*, pages 712–713
- **Appendix B** *Physical United States Map*, pages 708–709
- **Appendix B** *Topographic Map: Harrisburg, Pennsylvania*, page 718
- Tracing paper, 10 cm × 15 cm

Folded mountain ranges are the largest and most complex type of mountains found on continents. Most of these mountains consist of roughly parallel ridges of sedimentary rock. The energy needed to shape thousands of meters of sedimentary rock layers into folded mountains comes from the movements of Earth's lithospheric plates. The major mountain chains of today were formed, or are forming, at plate boundaries. The region around Harrisburg, Pennsylvania, displays some of the classic features of folded mountain ranges. The cross section on the next page shows the structure of the rock layers found in the Harrisburg area.

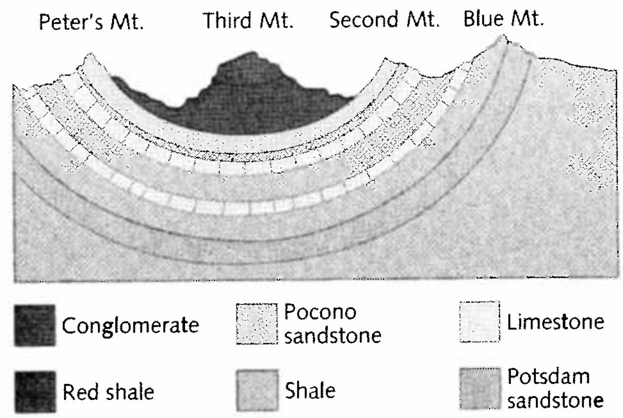
In this activity, you will explore the locations and features of folded mountains. In Part A, you will compare the locations of major mountain ranges with plate boundaries. In Part B, you will use the cross section on the next page and a topographic map of Harrisburg to study the physical features of folded mountains.

Procedure

Part A: Folded Mountains and Plate Boundaries

1. Use the Physical World Map on pages 710–711 to locate the Rocky, Appalachian, Andes, Atlas, Alps, and Himalayan mountains.
2. Use the Earth's Tectonic Plates Map on pages 712–713 to identify and list the plate (North American, Eurasian, African, etc.) on which each mountain range listed in Step 1 is located.
3. How many of the mountain ranges named in Step 1 are directly on or beside a plate boundary? Name the mountain range and identify the two plates that meet at that plate boundary.
4. Use the Physical World Map to locate the Mid-Atlantic Ridge, the East Pacific Rise, the Southeast Indian Ocean Ridge, and the Southwest Indian Ocean Ridge. Each of these mid-ocean ridges is an underwater mountain range.
5. Review the definitions of *divergent boundary* and *convergent boundary* on pages 176 and 177. Which term applies to the mountains identified in your answer to Step 3? Which term applies to mid-ocean ridge systems? In terms of plate motions, explain the basic difference between the formation of mountain chains on continents and the formation of mountain chains on the ocean floor.

Part B: Features of Folded Mountains



6. Using the Physical Map of the United States on pages 708–709, find the location of Harrisburg. In what mountain range is Harrisburg located?

7. Compare the topographic map of Harrisburg on page 718 with the geologic cross section shown at right. List the four mountains that occur on both the map and the cross section. In what general map or compass direction was the cross section drawn?

8. Two of the mountains shown on the cross section are from the same rock formation. Name these mountains and the rock formation.

9. Using Section 11.2 as a reference, what vocabulary term best describes the structure shown in the cross section above?

10. Compare the composition of the ridges with that of the valleys in the Harrisburg area. Which rock types form ridges? Which rock types form valleys?

11. Use tracing paper to outline the cross section above. Label Third Mountain. Locate Stone Glen on the topographic map. Where would it be located on the cross section? Label its location on your tracing paper. Repeat this procedure for Lucknow, the airway beacon, and the WHP TV tower. Which of these features is located on or formed by the oldest rocks? Which is located on or formed by the youngest rocks?

Analysis and Conclusions

1. The Andes Mountains are younger than the Appalachian Mountains. What evidence on the Physical World Map supports this statement?
2. Would you expect to find extensive mountain building taking place in Australia? Explain your answer.
3. Why is it impossible to determine if sedimentary rock layers have been overturned if you use only a topographic map?
4. Using the Physical Map of the United States, identify at least three eastern states (not including Pennsylvania) where folded rock layers would be expected to occur at Earth's surface. Why would folded rocks not be expected to occur in the Atlantic Coastal Plain?

CHAPTER 11 REVIEW

Summary of Key Ideas

11.1 In general, the world's mountains lie in belts that follow Earth's plate boundaries. Mountain building occurs along active continental margins. Large amounts of sediment accumulate in the relatively shallow water of passive continental margins.

11.2 Mountains are made of rocks that have been deformed under stress. Compression, tension, and shear stress are different types of stress. Stresses applied to rocks form folds, faults, and joints. A fault is a break in the lithosphere along which movement has occurred. Normal faults occur where tension pulls the crust apart. Reverse faults and thrust faults are caused by compression. Strike-slip faults are associated with shear stress. A joint is a break in the bedrock along which no apparent movement has occurred.

11.3 Mountains can be classified by features that result from forces associated with plate tectonics. Folded mountains can form when two plates carrying continents collide. Dome mountains are nearly circular folded mountains that result from uplifting. Fault-block mountains, horsts, and grabens are associated with normal faults.

KEY VOCABULARY

anticline (p. 239)	**mountain** (p. 236)
continental margin (p. 236)	**normal fault** (p. 240)
dome mountain (p. 244)	**reverse fault** (p. 240)
fault-block mountains (p. 245)	**strike-slip fault** (p. 241)
folded mountains (p. 243)	**syncline** (p. 239)
joint (p. 241)	**thrust fault** (p. 240)

Vocabulary Review

Write the vocabulary term or terms that best complete the sentence.

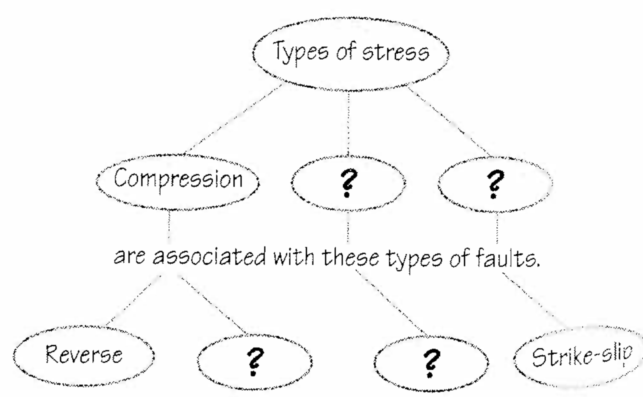
1. An upfold in rock layers is called a(n) __?__ , and a downfold in a rock layer is called a(n) __?__ .
2. Depending on how it formed, a(n) __?__ can be classified as plutonic or tectonic.
3. The boundary between continental crust and oceanic crust is called a(n) __?__ .

Explain the difference between the terms in each pair.

4. fault; joint
5. active continental margin; passive continental margin
6. normal fault; reverse fault

Concept Review

7. How are continental margins related to mountain building?
8. Sketch some folded rock layers and label the following features: anticline, syncline, limb.
9. Explain how a thrust fault is formed. How is a thrust fault related to a reverse fault?
10. What type of mountains are the Himalayas? How did the Himalayas form?
11. Would you expect to find some volcanic rock in the Himalayas? Why?
12. How are horsts and grabens similar? How are they different?
13. **Graphic Organizer** Complete the concept map below.



Critical Thinking

14. **Draw Conclusions** Use the Physical World Map on pages 710–711. Would you expect the west coast of Africa to be an active or a passive continental margin? Explain.

15. **Apply** A geologist standing on a low hill notes that rock layers stand out in sharp ridges all around the edge of the hill and dip gently away in all directions. The oldest rocks are at the center of the hill, and the rock layers away from the center are younger. What kind of structure could the geologist be standing on? Explain.

16. **Analyze** Plutonic and tectonic dome mountains can have an igneous rock core. How could contact metamorphism, which was discussed in Section 6.4, be used to determine whether a dome mountain is plutonic or tectonic?

Internet Extension

INVESTIGATIONS
CLASSZONE.COM

What Forces Created These Geologic Features?
Examine images of faults and folds. Annotate the images to show the forces and conditions that created them.

Keycode: ES1106

Writing About the Earth System

SCIENCE NOTEBOOK Explain how the volcanic mountains in the Cascade Range were formed. Identify the stages at which the hydrosphere, the geosphere, and the atmosphere were involved in the formation of volcanic mountains like those in the Cascade Range.

Interpreting Diagrams

The diagram below shows a cross section of the sedimentary rock layers in a folded area. The cross section was drawn from west to east along a line about 50 kilometers long. Points *A* through *F* are locations along the ground surface. The rock layers have not been overturned.

17. On which side of the anticline do the rock layers have the greater dip? On which side of the syncline do the rock layers have the greater dip?

18. How do the ages of the rocks change from point *B* to point *D*? From point *E* to point *D*?

19. On the basis of your answer to question 18, how does the age of rocks at the center of an anticline compare with the age of rocks at the center of a syncline?

20. If a normal fault occurs at line *XY*, what will be the effect on the distance between points *A* and *F*? What will be the effect on the distance if the fault is a reverse fault? Explain.