

Deforming the Earth's Crust

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What happens when rock is placed under stress?
- What are three kinds of faults?
- How do mountains form?

National Science
Education Standards
ES 1b, 2a

What Is Deformation?

In the left-hand figure below, the girl is bending the spaghetti slowly and gently. The spaghetti bends, but it doesn't break. In the right-hand figure, the girl is bending the spaghetti quickly and with a lot of force. Some of the pieces of spaghetti have broken.



How can the same material bend in one situation but break in another? The answer is that the stress on the material is different in each case. *Stress* is the amount of force per unit area that is placed on an object. ✓

DEFORMATION

Like the spaghetti, rocks can bend or break under stress. When a rock is placed under stress, it *deforms*, or changes shape. When a small amount of stress is put on a rock slowly, the rock can bend. However, if the stress is very large or is applied quickly, the rock can break.



Learn New Words As you read, underline words that you don't understand. When you learn what they mean, write the words and their definitions in your notebook.

TAKE A LOOK

1. Describe Circle the picture in which the girl is putting the most force on the spaghetti.



2. Define What is stress?

SECTION 4 Deforming the Earth's Crust *continued*

What Happens When Rock Layers Bend?

Folding happens when rock layers bend under stress. Folding causes rock layers to look bent or buckled. The bends are called *folds*.

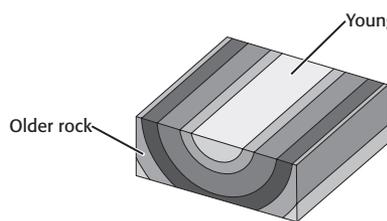
Most rock layers start out as horizontal layers. Therefore, when scientists see a fold, they know that deformation has happened. ✓

READING CHECK

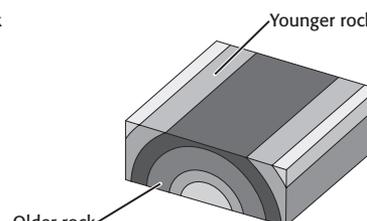
3. Explain How do folds indicate that deformation has happened?

TYPES OF FOLDS

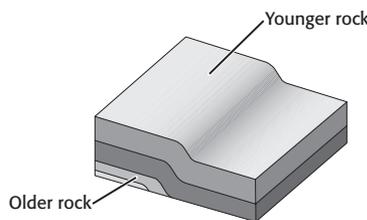
Three of the most common types of folds are synclines, anticlines, and monoclines. In a *syncline*, the oldest rocks are found on the outside of the fold. Most synclines are U-shaped. In an *anticline*, the youngest rocks are found on the outside of the fold. Most anticlines are \cap -shaped. In a *monocline*, rock layers are folded so that both ends of the fold are horizontal. The figure below shows these kinds of folds.



In a **syncline**, the youngest rocks are on the inside of the fold.



In an **anticline**, the oldest rocks are on the inside of the fold.



In a **monocline**, both sides of the fold are horizontal.

TAKE A LOOK

4. Identify Color the oldest rock layers in the figure blue. Color the youngest rock layers red.

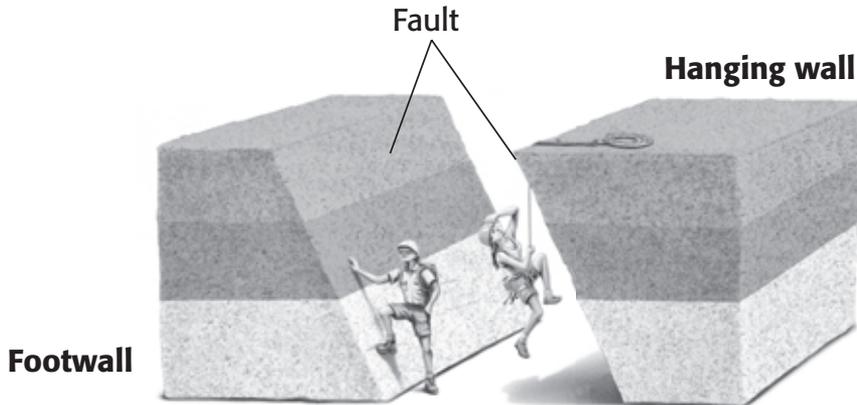
What Happens When Rock Layers Break?

When rock is put under so much stress that it can no longer bend, it may break. The crack that forms when rocks break and move past each other is called a **fault**. The blocks of rock that are on either side of the fault are called *fault blocks*. When fault blocks move suddenly, they can cause earthquakes.

SECTION 4 Deforming the Earth's Crust *continued*

HANGING WALL AND FOOTWALL

When a fault forms at an angle, one fault block is called the *hanging wall* and the other is called the *footwall*. The figure below shows the difference between the hanging wall and the footwall.



The footwall is the fault block that is below the fault. The hanging wall is the fault block that is above the fault.

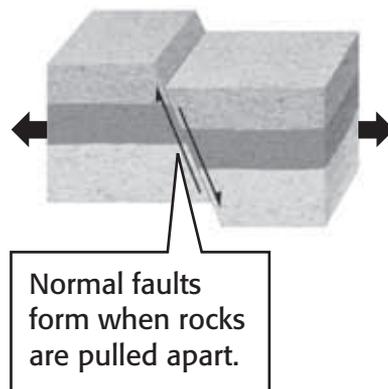
TAKE A LOOK

5. Compare How is the hanging wall different from the footwall?

Scientists classify faults by how the fault blocks have moved along the fault. There are three main kinds of faults: normal faults, reverse faults, and strike-slip faults.

NORMAL FAULTS

In a *normal fault*, the hanging wall moves down, or the footwall moves up, or both. Normal faults form when rock is under tension. **Tension** is stress that pulls rock apart. Therefore, normal faults are common along divergent boundaries, where Earth's crust stretches. ✓



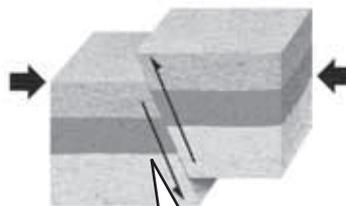
READING CHECK

6. Explain Why are normal faults common along divergent boundaries?

SECTION 4 Deforming the Earth's Crust *continued*

REVERSE FAULTS

In a *reverse fault*, the hanging wall moves up, or the footwall moves down, or both. Reverse faults form when rock is under compression. **Compression** is stress that pushes rock together. Therefore, reverse faults are common at convergent boundaries, where plates collide.



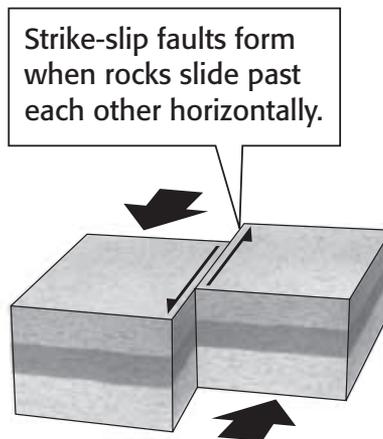
Reverse faults form when rocks are pushed together.

TAKE A LOOK

7. Identify Label the hanging walls and the footwalls on the normal and reverse faults.

STRIKE-SLIP FAULTS

In a *strike-slip fault*, the fault blocks move past each other horizontally. Strike-slip faults form when rock is under shear stress. *Shear stress* is stress that pushes different parts of the rock in different directions. Therefore, strike-slip faults are common along transform boundaries, where tectonic plates slide past each other.



Strike-slip faults form when rocks slide past each other horizontally.

TAKE A LOOK

8. Describe How do strike-slip faults form?

It can be easy to tell the difference between faults in a diagram. However, faults in real rocks can be harder to tell apart. The figure on the top of the next page shows an example of a fault. You can probably see where the fault is. How can you figure out what kind of fault it is? One way is to look at the rock layers around the fault. The dark rock layer in the hanging wall is lower than the same layer in the footwall. Therefore, this is a normal fault.

SECTION 4 Deforming the Earth's Crust *continued*



In these rocks, the hanging wall has moved down compared to the footwall. Therefore, this is a normal fault.

TAKE A LOOK

9. Explain How can you tell that this is a normal fault?

How Do Mountains Form?

As tectonic plates move over Earth's surface, the edges of the plates grind against each other. This produces a lot of stress in Earth's lithosphere. Over very long periods of time, the movements of the plates can form mountains. Mountains can form in three main ways: through folding, faulting, or volcanism.

Critical Thinking

10. Apply Concepts Why does it take a very long time for most mountains to form?

FOLDED MOUNTAINS

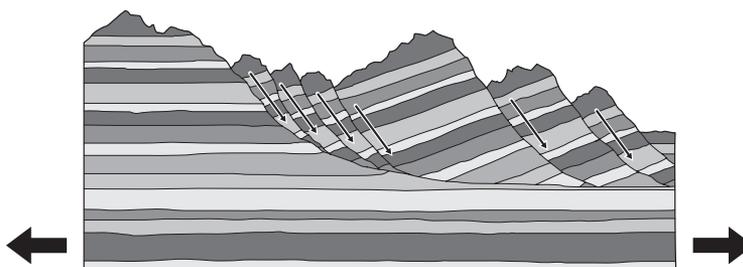
Folded mountains form when rock layers are squeezed together and pushed upward. Folded mountains usually form at convergent boundaries, where continents collide. For example, the Appalachian Mountains formed hundreds of millions of years ago when North America collided with Europe and Africa.

FAULT-BLOCK MOUNTAINS

Fault-block mountains form when tension makes the lithosphere break into many normal faults. Along these faults, pieces of the lithosphere drop down compared with other pieces. This produces fault-block mountains. ✓

READING CHECK

11. Identify What kind of stress forms fault-block mountains?



Fault-block mountains form when tension causes the crust to break into normal faults.

SECTION 4 Deforming the Earth's Crust *continued*

 **Say It**

Investigate Find out more about a volcanic mountain chain, such as the Andes, the Hawaiian islands, or Japan. Share what you learn with a small group.

TAKE A LOOK

12. Identify What kind of convergent boundary have the Andes mountains formed on?

VOLCANIC MOUNTAINS

Volcanic mountains form when melted rock erupts onto Earth's surface. Most major volcanic mountains are found at convergent boundaries.



The Andes mountains are examples of volcanic mountains. The Andes have formed where the Nazca plate is subducting beneath the South American plate.

Volcanic mountains can form on land or on the ocean floor. Volcanoes on the ocean floor can grow so tall that they rise above the surface of the ocean. These volcanoes form islands, such as the Hawaiian Islands.

Most of Earth's active volcanoes are concentrated around the edge of the Pacific Ocean. This area is known as the *Ring of Fire*.

TAKE A LOOK

13. Describe Fill in the table with the features of each kind of mountain. Include where the mountains form and what they are made of.

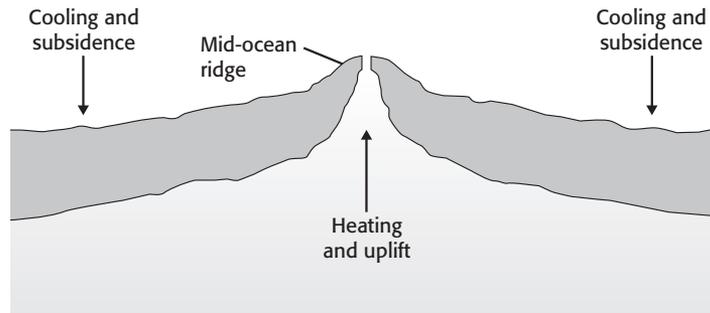
Type of Mountain	Description
Folded	
Fault-block	
Volcanic	

How Can Rocks Move Vertically?

There are two types of vertical movements in the crust: uplift and subsidence. **Uplift** happens when parts of Earth's crust rise to higher elevations. Rocks that are uplifted may or may not be deformed. **Subsidence** happens when parts of the crust sink to lower elevations. Unlike some uplifted rocks, rocks that subside do not deform.

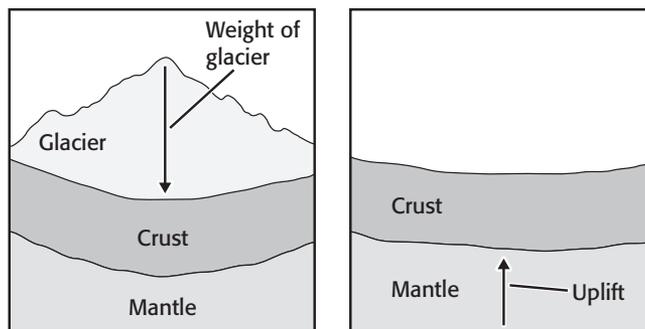
SECTION 4 Deforming the Earth's Crust *continued***CAUSES OF SUBSIDENCE AND UPLIFT**

Temperature changes can cause uplift and subsidence. Hot rocks are less dense than cold rocks with the same composition. Therefore, as hot rocks cool, they may sink. If cold rocks are heated, they may rise. For example, the crust at mid-ocean ridges is hot. As it moves away from the ridge, it cools and subsides. Old, cold crust far from a ridge has a lower elevation than young, hot crust at the ridge.

**TAKE A LOOK**

14. Explain Why does ocean crust far from a mid-ocean ridge subside?

Changes in the weight on the crust can also cause uplift or subsidence. For example, glaciers are huge, heavy bodies of ice. When they form on the crust, they can push the crust down and cause subsidence. If the glaciers melt, the weight on the crust decreases. The crust slowly rises back to its original elevation in a process called *rebound*.

**TAKE A LOOK**

15. Identify What force caused the crust to subside in the left-hand figure?

Fault-block mountains are an example of a third way subsidence can happen. When the crust is under tension, rocks are stretched. They can break and form normal faults. The crust can sink along these faults, causing subsidence. This kind of subsidence is common in rift zones. A *rift zone* is a set of deep cracks that forms at a divergent boundary.

Section 4 Review

NSES ES 1b, 2a

SECTION VOCABULARY

<p>compression stress that occurs when forces act to squeeze an object</p> <p>fault a break in a body of rock along which one block slides relative to another</p> <p>folding the bending of rock layers due to stress</p>	<p>subsidence the sinking of regions of the Earth's crust to lower elevations</p> <p>tension stress that occurs when forces act to stretch an object</p> <p>uplift the rising of regions of the Earth's crust to higher elevations</p>
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1. Compare How are folding and faulting similar? How are they different?

2. Describe Fill in the spaces in the table to describe the three main kinds of faults.

Kind of fault	Description	Kind of stress that produces it
Normal		
	Hanging wall moves up; footwall moves down.	
		shear stress

3. Explain Why are strike-slip faults common at transform boundaries?

4. Infer Why are fault-block mountains probably uncommon at transform boundaries?

5. Define What is the Ring of Fire?
