Building Mountains

One popular vacation that people enjoy is a trip to the mountains. Mountains tower over the surrounding land, often providing spectacular views from their summits or from surrounding areas. The highest mountain peak in the world is Mount Everest in the Himalaya in Tibet. Its elevation is more than 8,800 m above sea level. In the United States, the highest mountains reach an elevation of more than 6,000 m. There are four main types of mountains—fault-block, folded, upwarped, and volcanic. Each type forms in a different way and can produce mountains that vary greatly in size.

Age of a Mountain As you can see in Figure 11, mountains can be rugged with high, snowcapped peaks, or they can be rounded and forested with gentle valleys and babbling streams. The ruggedness of a mountain chain depends largely on whether or not it is still forming. Mountains like the Himalaya are currently forming at a rate of several centimeters per year, while much older mountains like the Ouachita Mountains in Arkansas stopped forming millions of years ago and are now being eroded by geological processes.

Figure 11 Mountains can be high and rugged like the mountains of the Himalaya shown on the left, or they can be large, gently rolling hills like the Ouachita Mountains in Arkansas, shown above.

Infer What determines how rugged and high a mountain chain is?
Fault-Block Mountains  The first mountains you’ll study are fault-block mountains. Some examples are the Sierra Nevada in California and the Teton Range in Wyoming. Recall that pulling, or tension, forces that occur at the boundaries of plates moving apart, work to create surface features such as rift valleys and faults. Fault-block mountains also form from pulling forces. Fault-block mountains are made of huge, tilted blocks of rock that are separated from surrounding rock by faults. When rock layers are pulled from opposite directions, large blocks slide downward, creating peaks and valleys, as shown in Figure 12.

Models of Mountain Building  If you hold a candy bar between your hands and then begin to pull it apart, cracks might form within the chocolate. Similarly, when rocks are pulled apart, faults form. Unlike rocks deep in Earth, rocks at Earth’s surface are hard and brittle. When they are pulled apart, large blocks of rock can move along the faults. The Teton Range of Wyoming formed when a block of crust was tilted as one side of the range was uplifted above the neighboring valley. As shown in Figure 13, if you travel to the Grand Teton National Park, you will see sharp, jagged peaks that are characteristic of fault-block mountains.

Now, hold a flat piece of clay between your hands and then push your hands together gently. What happens? As you push your hands together, the clay begins to bend and fold over on itself. A similar process causes rocks to fold and bend, causing folded mountains to form on Earth’s surface.

Figure 12  Before tension is applied, the layers of rock are even and fairly level. After tension is applied, huge blocks of rock separate and slip downward. This leaves large, tilted blocks that become mountains.

Figure 13  The Teton Range in the Grand Teton National Park has sharp, jagged peaks that are characteristic of fault-block mountains.
**Folded Mountains**  Traveling along a road that is cut into the side of the Appalachian Mountains, you can see that rock layers were folded just as the clay was when it was squeezed, or compressed. Tremendous pushing forces exerted by two of Earth’s plates moving together squeezed rock layers from opposite sides. This caused the rock layers to buckle and fold, forming folded mountains. **Folded mountains** are mountains formed by the folding of rock layers caused by compression forces.

*Reading Check* What type of force causes folded mountains to form?

The Appalachian Mountains are folded mountains that formed about 250 million to 300 million years ago. A small part of the folded Appalachians is shown in Figure 14. The compression occurred as the North American Plate and the African Plate moved together. The Appalachians are the oldest mountain range in North America, and also one of the longest. They extend from Alabama northward to Quebec, Canada. Erosion has been acting on these mountains since they were formed. As a result, the Appalachians are small compared to other mountain ranges. At one time, the Appalachian Mountains were higher than the Rocky Mountains are today.

**Upwarped Mountains**  The Adirondack Mountains in New York, the southern Rocky Mountains in Colorado and New Mexico, and the Black Hills in South Dakota are examples of upwarped mountains. **Upwarped mountains** form when forces inside Earth push up the crust. With time, sedimentary rock layers on top will erode, exposing the igneous or metamorphic rocks underneath. The igneous and metamorphic rocks can erode further to form sharp peaks and ridges.

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**Mini LAB**

**Modeling Mountains**

**Procedure**

1. Use layers of clay to build a model of each major type of mountain.
2. For fault-block mountains, cut the layers of clay with a plastic knife to show how one block moves upward and another moves downward.
3. For folded mountains, push on the layers of clay from directly opposite directions.
4. For upwarped mountains, push a large, round object, such as a ball, upward from below, forcing the layers of clay to warp.
5. For volcanic mountains, place layer upon layer of clay to form a cone-shaped feature.

**Analysis**

1. Do any of the mountains you have modeled look similar? Explain.
2. How could you recognize the different types of mountains?

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**Figure 14**  This roadcut in Maryland exposes folded rock layers that formed when the North American Plate and the African Plate collided.
Volcanic Mountains

Occasionally, magma from inside Earth reaches the surface. When this happens, the magma is called lava. When hot, molten lava flows onto Earth’s surface, volcanic mountains can form. Over time, layer upon layer of lava piles up until a cone-shaped feature called a **volcanic mountain** forms. Washington’s Mount St. Helens and Mexico’s Mount Popocatépetl, shown in **Figure 15**, are examples. Next, you will take a closer look at how volcanic mountains form.

Some volcanic mountains form when large plates of Earth’s lithosphere sink into Earth’s mantle at subduction zones. As the plates sink deeper into the mantle, they cause melting to occur. The magma produced is less dense than the surrounding rock, so it is forced slowly upward to Earth’s surface. If the magma reaches the surface, it can erupt as lava and ash. Layers of these materials can pile up over time to form volcanic mountains.

**Figure 15** Volcanic mountains form when lava and ash build up in one area over time.

- **Crater**: This bowl-shaped part of the volcano surrounds the vent. Lava often collects here before it flows down the slope.
- **Vent**: As magma flows up the pipe, it reaches the surface at an opening called the vent. Side vents often branch off of the main pipe.
- **Pipe**: Magma flows through this nearly vertical crack in the rock called the pipe.
- **Magma Chamber**: Magma that has been forced upward forms and fills a large pocket underneath the volcano. This pocket is called the magma chamber. In some cases, one magma chamber feeds several volcanoes.

**Topic: Volcanic Mountains**

Visit in7.msscience.com for Web links to information about volcanic mountains.

**Activity** Collect as many photographs of volcanic mountains as possible. Create a large map of the world with the photographs in their proper locations. Include some information about the volcanic mountains and the impact they have had on the environment around there.
Underwater Volcanic Mountains You know that volcanic mountains form on land, but did you know that these mountains also form on the ocean floor? Underwater eruptions can produce mountains beneath the sea. Eventually, if enough lava is erupted, these mountains grow above sea level. For example, Hawaii, shown above in Figure 16, is the peak of a huge volcanic mountain that extends above the surface of the water of the Pacific Ocean. Figure 16 also illustrates how the Hawaiian Islands formed.

Volcanic mountains like the Hawaiian Islands are different from the volcanic mountains that form where one plate subducts beneath another. The Hawaiian Islands formed from material that came from near the boundary between Earth’s core and mantle. Hot rock is forced upward through the mantle as a plume and melts to form a hot spot in Earth’s crust. As plates travel over the hot spot, a series of volcanoes, as seen in Hawaii, forms. Magma from subduction volcanoes forms much closer to Earth’s surface. Hot spot volcanoes also are much larger and have more gently sloping sides than subduction volcanoes.

What type of mountains make up the Hawaiian Islands?
Other Types of Uplift

You have learned about the origin of the pushing forces that bend crustal rocks during mountain-building processes. However, another force also works to keep mountains elevated above the surrounding land. If you place wooden blocks of various thicknesses in a container of water, you will notice that different blocks of wood float in the water at different heights. Also, the thicker blocks of wood float higher in the water than the thinner blocks do. The buoyant force of the water is balancing the force of gravity. A similar process called isostasy occurs in Earth. According to the principle of isostasy, Earth’s lithosphere floats on a plasticlike upper part of the mantle, the asthenosphere.

The effects of isostasy were first noticed near large mountain ranges. Earth’s crust is thicker under mountains than it is elsewhere. Also, if mountains continue to get uplifted, the crust under the mountains will become thicker and will extend farther down into the mantle. This is similar to the floating wooden blocks. If you pile another wooden block on a block that is already floating in the water, you will see that the new, larger block will sink down into the water farther than before. You also will see that the new block floats higher than it did before.

How can glaciers cause land to rise?

About 20,000 years ago, much of North America was covered by a large glacial ice sheet. How do you think an ice sheet can affect Earth’s crust? What do you think happens when the ice melts?

Identifying the Problem

More than 100 years ago, people living in areas that once had been covered by glaciers noticed that features such as old beaches had been tilted. The beaches had a higher elevation in some places and a lower elevation in others. How do you think old beaches could be tilted?

Solving the Problem

1. The weight of glaciers pushes down Earth’s crust. What do you think happens after the glacier melts?
2. How could rising crust cause beaches to be tilted? Do you think the crust would rise the same amount everywhere? Explain.
Adjusting to Gravity  Similar to the wooden blocks, if mountains continue to grow larger, they will sink even farther into the mantle. Once mountains stop forming, erosion lowers the mountains and the crust rises again because weight has been removed. If the process continues, the once-thick crust under the mountains will be reduced to the thickness of the crust where no mountains exist.

Icebergs behave in much the same way, as shown in Figure 17. The iceberg is largest when it first breaks off of a glacier. As the iceberg floats, it melts and starts to lose mass. This causes the iceberg to rise in the water. Eventually, the iceberg will be much smaller and will not extend as deeply into the water. How is this similar to what happens to mountains?

Figure 17  Isostasy makes Earth’s crust behave in a similar way to these icebergs. As an iceberg melts and becomes smaller, ice from below the water’s surface is forced up.