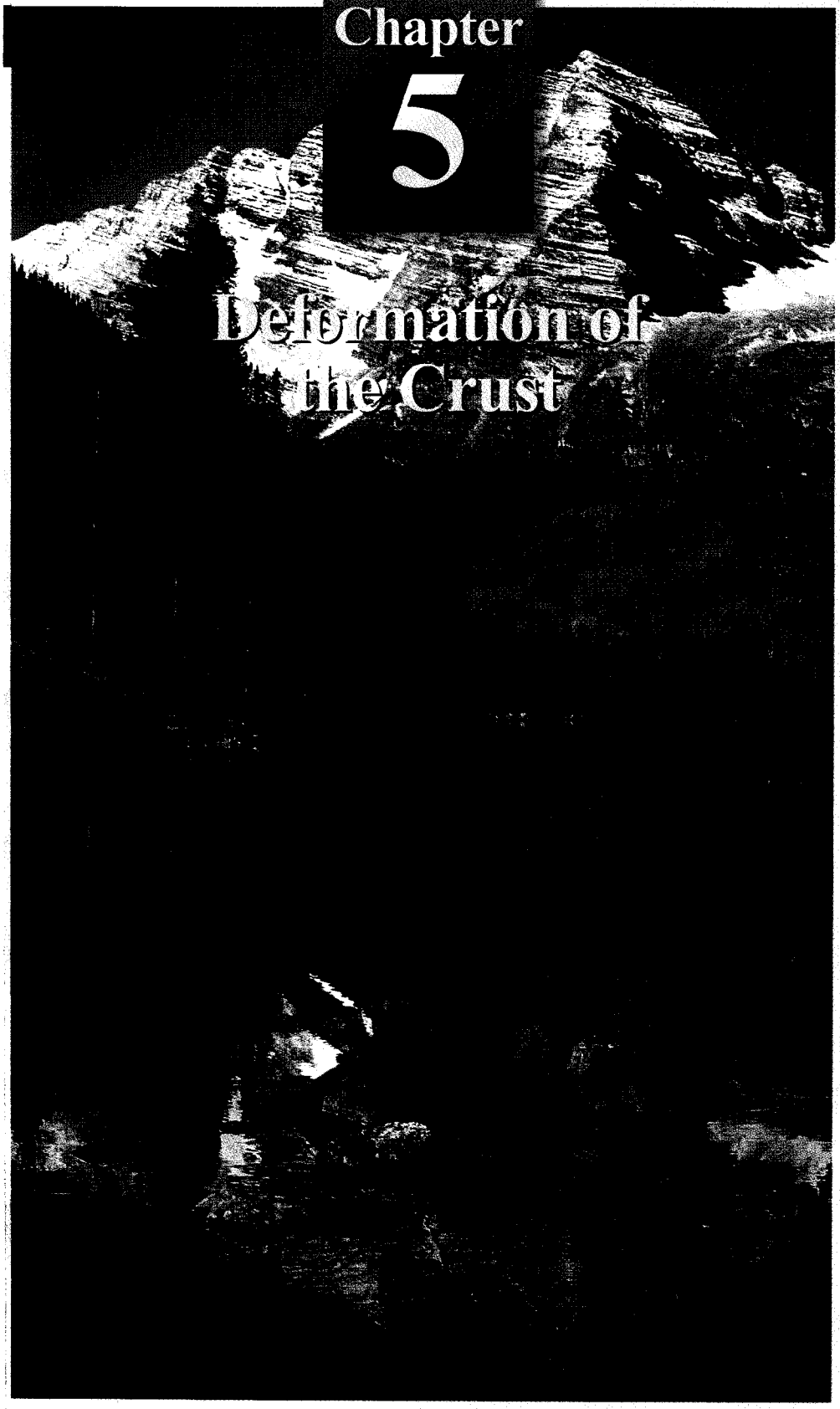
Chapter 5

Deformation of the Crust



If you were to look carefully among the rocks on the peaks of some mountains, you might be surprised to find fossils of animals that lived in the sea. A closer inspection might also reveal waves of folded, twisted, or fractured rock. The forces that deform the earth's crust and make mountains out of the flat ocean bottom are mainly the result of plate tectonics, the movement and collision of lithospheric plates. In this chapter, you will learn how plate movement builds and alters the topographic features of the earth.

Chapter Outline

The action of moving plates raised the Colorado Rockies.

5.1 How the Crust Is Deformed

Section Objectives

- **Predict isostatic adjustments that will result from changes in the thickness of the earth's crust.**
- **Identify sources of stress in crustal rock.**

The Himalayas, the Rockies, the Andes—these are the names of some of the earth's most majestic mountain ranges. These imposing landforms are visible reminders that the shape of the earth's surface is always changing. Such changes result from **deformation,** the bending, tilting, and breaking of the earth's crust. Plate tectonics, the movement of the earth's lithospheric plates, is the major cause of crustal deformation. However, plate movement is not the only force that shapes the earth's crust.

Isostatic Adjustment

Some changes in the earth's crust occur because of changes in the weight of some part of the crust. The crust rides on top of the mantle. When parts of the crust become thicker and heavier, they will sink more deeply into the mantle. If the crust becomes thinner and lighter, it will rise higher on the mantle.

These movements can be compared to the behavior of a block of wood floating on water, as illustrated in Figure 5–1. When a metal weight is placed on the block, the weight forces the block to float more deeply in the water. What will happen to the block of wood when the weight is lifted?

The up-and-down movements of the crust occur because of two opposing forces. The crust presses down on the mantle. The mantle presses up on the crust. When these two forces are balanced, the crust moves neither up nor down. However, when weight is added to the crust, it sinks until a balance of the forces is again reached. The balancing of these two forces is called **isostasy.** The up-and-down movements of the crust to reach isostasy are called **isostatic adjustments.** As these isostatic adjustments occur, areas of the crust are bent up and down. Pressure created by this bending causes the rocks in that area of the crust to deform.

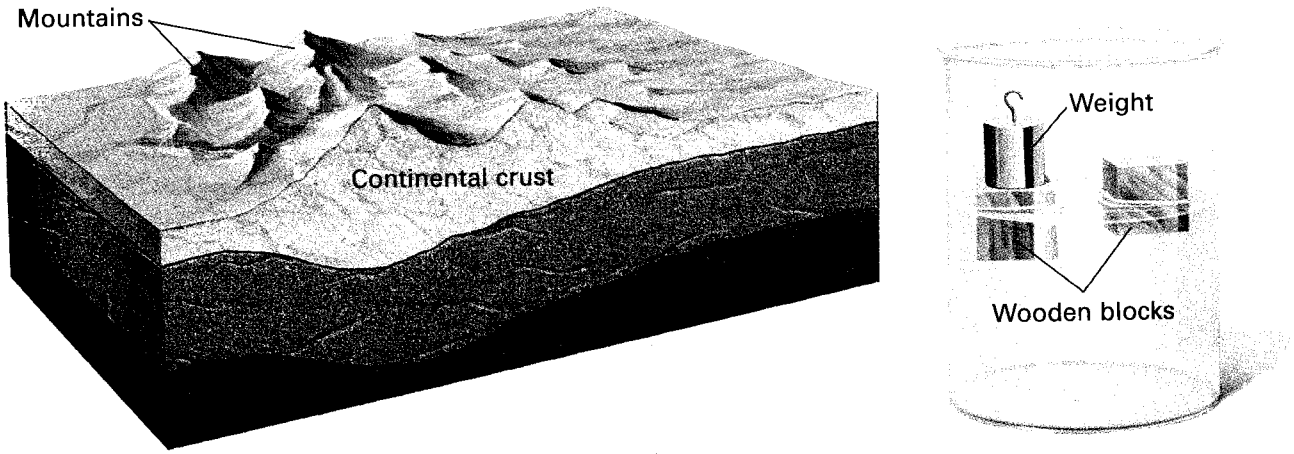
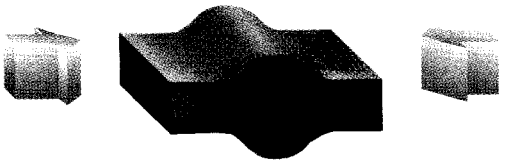
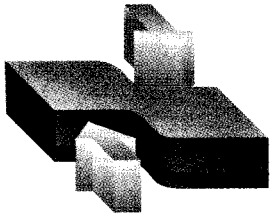


Figure 5–1. The thicker, heavier parts of the crust sink more deeply into the asthenosphere than the thinner, lighter parts (left). The illustration to the right shows isostatic adjustment. Adding weight to the wooden block on the left forces it to float more deeply in the water.



Compression

Tension



Shearing

Figure 5–2. The forces that deform rock are compression, tension, and shearing.

Isostatic adjustments are constantly occurring in areas of the crust with mountain ranges. Over millions of years, the wearing away of rocks can significantly reduce the overall height and weight of a mountain range, such as the Appalachians of the eastern United States. As the crust becomes lighter, the region may rise.

Another example of isostatic adjustment can be found in areas where rivers flow into large bodies of water carrying large amounts of mud, sand, and gravel. When a river flows into the ocean, this material is deposited on the nearby ocean floor. The added weight of the material causes the floor to sink, allowing more material to be deposited. A very thick accumulation of these deposits has formed in the Gulf of Mexico at the mouth of the Mississippi River.

Isostatic adjustments can also be found in areas where glaciers once covered the land. The weight of the ice caused the crust underneath it to sink. Much of the glacial ice has now retreated. The land that earlier was covered with ice is slowly rising again in response to its reduced weight. Thus, recently glaciated regions in Canada and northern Europe are now undergoing another isostatic adjustment.

Stress

Isostatic adjustment and plate movement cause **stress** in the rocks that make up the earth's crust. Stress is a force that causes pressure in the rocks of the crust. For example, when the weight of an ice sheet causes part of the crust to sink, stress increases on the rocks of the sinking crust. As the ice sheet disappears, a resulting rise in the crust also causes stress. Similarly, crustal stress occurs when lithospheric plates collide, separate, or rub together. This stress causes **strain** in crustal rocks. Strain is a change in the shape or volume of rocks that results from the stress of being squeezed, twisted, or pulled apart.

There are three main types of stress, as illustrated in Figure 5–2. **Compression** occurs when crustal rocks are squeezed together. Compression reduces the volume of rocks. It also tends to push the rocks higher up or deeper down into the crust.

Another type of stress is **tension.** Tension is the force that pulls rocks apart. When rocks are pulled apart by tension, they tend to become thinner.

A third type of stress is called **shearing.** Shearing pushes rocks in opposite horizontal directions. Sheared rocks bend, twist, or break apart as they slide past each other.

Section 5.1 Review

1. Explain the principle of isostatic adjustment.
2. Define *stress* and *strain*.
3. Name and describe the three main types of stress.
4. Contrast the isostatic adjustment that might result from the melting of glacial ice with the isostatic adjustment that a large river emptying into the ocean might cause.