Convection and the Mantle

Reading Preview

Key Concepts

- How is heat transferred?
- What causes convection currents?
- What causes convection currents in Earth's mantle?

Key Terms

- radiation
- conduction
- convection
- density
- convection current

Target Reading Skill

Outlining An outline shows the relationship between major ideas and supporting ideas. As you read, make an outline about heat transfer. Use the red headings for the main topics and the blue headings for the subtopics.

Convection and the Mantle

I. Types of Heat Transfer
  A. Radiation
  B.
  C.
II. Convection Currents

Lab zone Discover Activity

How Can Heat Cause Motion in a Liquid?

1. Carefully pour some hot water into a small, shallow pan. Fill a clear, plastic cup about half full with cold water. Place the cup in the pan.
2. Allow the water to stand for two minutes until all motion stops.
3. Fill a plastic dropper with some food coloring. Then, holding the dropper under the water's surface and slightly away from the edge of the cup, gently squeeze a small droplet of the food coloring into the water.
4. Observe the water for one minute.
5. Add another droplet at the water's surface in the middle of the cup and observe again.

Think It Over

Inferring How do you explain what happened to the droplets of food coloring? Why do you think the second droplet moved in a way that was different from the way the first droplet moved?

Earth's molten outer core is nearly as hot as the surface of the sun. What makes an object hot? Whether the object is Earth's core or a cooking pot, the cause is the same. When an object is heated, the particles that make up the object move faster. The faster-moving particles have more energy.

If you have ever touched a hot pot accidentally, you have discovered for yourself (in a painful way) that heat moves. In this case, it moved from the hot pot to your hand. The movement of energy from a warmer object to a cooler object is called heat transfer. To explain how heat moves from Earth's core through the mantle, you need to know how heat is transferred.

Types of Heat Transfer

Heat always moves from a warmer substance to a cooler substance. For example, holding an ice cube will make your hand begin to feel cold in a few seconds. But is the coldness in the ice cube moving to your hand? No! Since cold is the absence of heat, it's the heat in your hand that moves to the ice cube. This is one of the ways that heat is transferred. **There are three types of heat transfer: radiation, conduction, and convection.**

Radiation The transfer of energy through space is called **radiation.** Heat transfer by radiation takes place with no direct contact between a heat source and an object. Sunlight is radiation that warms Earth's surface. Other familiar forms of radiation include the heat you feel around a flame or open fire.

Conduction Heat transfer within a material or between materials that are touching is called **conduction.** For example, a spoon in a pot of soup heats up by conduction, as shown in Figure 8. Heat moves from the hot soup and the pot to the particles that make up the spoon. The particles near the bottom of the spoon vibrate faster as they are heated, so they bump into other particles and heat them, too. Gradually the entire spoon heats up. When your hand touches the spoon, conduction transfers heat from the spoon directly to your skin. Then you feel the heat. Conduction is responsible for some of the heat transfer inside Earth.

Reading Checkpoint **What is conduction?**

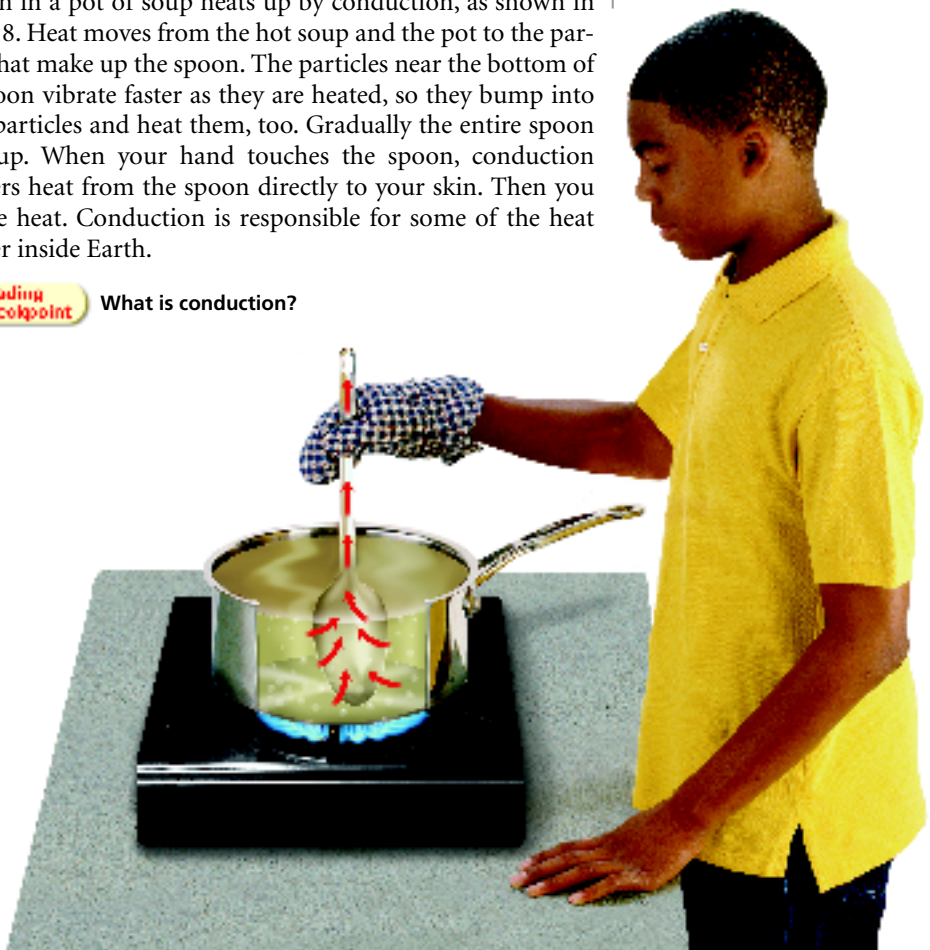

FIGURE 8
Conduction
In conduction, the heated particles of a substance transfer heat through contact with other particles in the substance. Conduction heats the spoon and the pot itself. That's why you need a mitt to protect your hand from the hot handle.

Go Online
PHSchool.com

For: More on convection currents in the mantle
Visit: PHSchool.com
Web Code: cfd-1012

Convection Heat can also be transferred by the movement of fluids—liquids and gases. **Convection** is heat transfer by the movement of currents within a fluid. During convection, heated particles of fluid begin to flow. This flow transfers heat from one part of the fluid to another.

Heat transfer by convection is caused by differences of temperature and density within a fluid. **Density** is a measure of how much mass there is in a volume of a substance. For example, rock is more dense than water because a given volume of rock has more mass than the same volume of water.

When a liquid or gas is heated, the particles move faster and spread apart. As a result, the particles of the heated fluid occupy more space. The fluid's density decreases. But when a fluid cools, its particles move more slowly and settle together more closely. As the fluid becomes cooler, its density increases.

Convection Currents

When you heat soup on a stove, convection occurs in the soup, as shown in Figure 9. As the soup at the bottom of the pot gets hot, it expands and therefore becomes less dense. The warm, less dense soup moves upward and floats over the cooler, denser soup. At the surface, the warm soup cools, becoming denser. Then gravity pulls this cooler, denser soup back down to the bottom of the pot, where it is heated again.

A constant flow begins as the cooler, denser soup sinks to the bottom of the pot and the warmer, less dense soup rises. A **convection current** is the flow that transfers heat within a fluid. **Heating and cooling of the fluid, changes in the fluid's density, and the force of gravity combine to set convection currents in motion.** Convection currents continue as long as heat is added. Without heat, convection currents eventually stop.

Reading Checkpoint **What is the role of gravity in creating convection currents?**

FIGURE 9
Convection Currents
Differences in temperature and density cause convection currents. In the pot, convection currents arise because the soup close to the heat source is hotter and less dense than the soup near the surface.

Convection Currents in Earth

In Earth's mantle, large amounts of heat are transferred by convection currents, as shown in Figure 10. **Heat from the core and the mantle itself causes convection currents in the mantle.**

How is it possible for mantle rock to flow? Over millions of years, the great heat and pressure in the mantle cause solid mantle rock to flow very slowly. Many geologists think that plumes of mantle rock rise slowly from the bottom of the mantle toward the top. The hot rock eventually cools and sinks back through the mantle. Over and over, the cycle of rising and sinking takes place. Convection currents like these have been moving inside Earth for more than four billion years!

There are also convection currents in the outer core. These convection currents cause Earth's magnetic field.

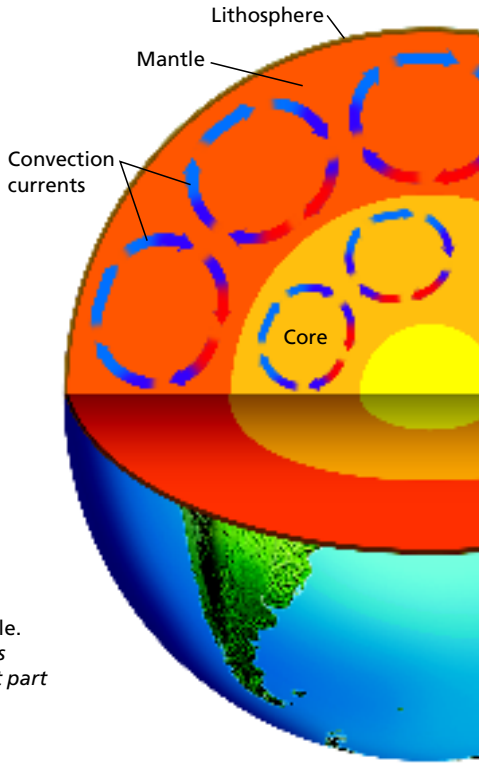

FIGURE 10
Mantle Convection
Most geologists think that convection currents rise and sink through the mantle. **Applying Concepts** *What part of Earth's interior is like the soup in the pot? What part is like the burner on the stove?*

Section 2 Assessment

Target Reading Skill **Outlining** Use the information in your outline about heat transfer to help you answer the questions below.

Reviewing Key Concepts

1. **a.** **Listing** What are the three types of heat transfer?
   b. **Explaining** How is heat transferred through space?
2. **a.** **Defining** What is a convection current?
   b. **Relating Cause and Effect** In general, what happens to the density of a fluid as it becomes hotter?
   c. **Summarizing** Describe how convection currents form.
3. **a.** **Identifying** Name two layers of Earth in which convection currents take place.
   b. Relating Cause and Effect What causes convection currents in the mantle?
   c. **Predicting** What will happen to the convection currents in the mantle if Earth's interior eventually cools down? Explain.

Lab zone At-Home Activity

Tracing Heat Flow Convection currents may keep the air inside your home at a comfortable temperature. Air is made up of gases, so it is a fluid. Regardless of the type of home heating system, heated air circulates through a room by convection. You may have tried to adjust the flow of air in a stuffy room by opening a window. When you did so, you were making use of convection currents. With an adult family member, study how your home is heated. Look for evidence of convection currents.