Earth's Interior

Imagine watching an island grow! That's exactly what you can do on the island of Hawaii. On the south side of the island, molten material pours out of cracks in Mount Kilauea and flows into the ocean. As this lava flows over the land, it cools and hardens into rock.

The most recent eruptions of Mount Kilauea began in 1983, when an area of cracks 7 kilometers long opened in Earth's surface. Through the cracks spurted "curtains of fire" -- fountains of hot liquid rock from deep inside Earth. Since that time, the lava has covered more than 100 square kilometers of land with a layer of rock. When the lava reaches the sea, it extends the borders of the island into the Pacific Ocean.

Exploring Inside Earth

Earth's surface is constantly changing. Throughout our planet's long history, its surface has been lifted up, pushed down, bent, and broken. Thus Earth looks different today from the way it did millions of years ago.

Volcanic eruptions like those at Mount Kilauea make people wonder, What's inside Earth? Yet this question is very difficult to answer. Much as geologists would like to, they cannot dig a hole to the center of Earth. The extreme conditions in Earth's interior prevent exploration far below the surface.

The deepest mine in the world, a gold mine in South Africa, reaches a depth of 3.8 kilometers. But that mine only scratches the surface. You would have to travel more than 1,600 times that distance -- over 6,000 kilometers -- to reach Earth's center. Geologists have used two main types of evidence to learn about Earth's interior: direct evidence from rock samples and indirect evidence from seismic waves.

Evidence From Rock Samples

Rocks from inside Earth give geologists clues about Earth's structure. Geologists have drilled holes as much as 12 kilometers into Earth. The drills bring up samples of rock. From these samples, geologists can make inferences about conditions deep inside Earth, where these rocks formed. In addition, forces inside Earth sometimes blast rock to the surface from depths of more than 100 kilometers. These rocks provide more information about the interior.

Evidence From Seismic Waves

Geologists cannot look inside Earth. Instead, they must rely on indirect methods of observation. Have you ever hung a heavy picture on a wall? If you have, you know that you can knock on the wall to locate the wooden beam underneath the plaster that will support the picture. When you knock on the wall, you listen carefully for a change in the sound.

To study Earth's interior, geologists also use an indirect method. But instead of knocking on walls, they use seismic waves. When earthquakes occur, they produce **seismic waves**. Geologists record the seismic waves and study how they travel through Earth. The speed of seismic waves and the paths they take reveal the structure of the planet.

Using data from seismic waves, geologists have learned that Earth's interior is made up of several layers. Each layer surrounds the layers beneath it, much like the layers of an onion.

A Journey to the Center of Earth

The three main layers of Earth are the crust, the mantle, and the core. These layers vary greatly in size, composition, temperature and pressure. If you could travel through these layers to the center of Earth, what would your trip be like? To begin, you will need a vehicle that can travel through solid rock. The vehicle will carry scientific instruments to record changes in temperature and pressure as you descend.

Temperature As you start to tunnel beneath the surface, the surrounding rock is cool. Then at about 20 meters down, your instruments report that the surrounding rock is getting warmer. For every 40 meters that you descend from that point, the temperature rises 1 Celsius degree. This rapid rise in temperature continues for several tens of kilometers. After that, the temperature increases more slowly, but steadily. The high temperatures inside Earth are the result of heat left over from the formation of the planet. In addition, radioactive substances inside Earth release energy, which further heats the interior.

Pressure During your journey to the center of Earth, your instruments record an increase in pressure in the surrounding rock. **Pressure** results from a force pressing on an area. Because of the weight of the rock above, pressure inside Earth increases as you go deeper. The deeper you go, the greater the pressure.

The Crust

Your journey to the center of Earth begins in the crust. The **crust** is the layer of rock that forms Earth's outer skin. **The crust is a layer of solid rock that includes both dry land and the ocean floor.** On the crust you find rocks and mountains. The crust also includes the soil and water that cover large parts of Earth's surface.

This outer rind of rock is much thinner than the layer that lies beneath it. In fact, you can think of Earth's crust as being similar to the paper-thin skin of an onion. The crust is thickest under high mountains and thinnest beneath the ocean. In most places, the crust is between 5 and 40 kilometers thick. But it can be up to 70 kilometers thick beneath mountains.

The crust beneath the ocean is called oceanic crust. Oceanic crust consists mostly of rocks such as basalt. **Basalt** is dark rock with a fine texture. Continental crust, the crust that forms the continents, consists mainly of rocks such as granite. **Granite** is a rock that usually is a lighter color and has a coarse texture.

The Mantle

Your journey downward continues. About 40 kilometers beneath the surface, you cross a boundary. Below the boundary is the solid material of the **mantle**, a layer of hot rock. **Earths mantle is made up of rock that is very hot, but solid. Scientists divide the mantle into layers based on the physical characteristics of those layers.** Overall, the mantle is nearly 3,000 kilometers thick.

The Lithosphere

The uppermost part of the mantle is very similar to the crust. The uppermost part of the mantle and the crust together form a rigid layer called the **lithosphere**. In Greek, lithos means “stone.” The lithosphere averages about 100 kilometers thick

The Asthenosphere

Below the lithosphere, your vehicle encounters material that is hotter and under increasing pressure. As a result, the part of the mantle just beneath the lithosphere is less rigid than the rock above. Like road tar softened by the heat of the sun, this part of the mantle is somewhat soft -- it can bend like plastic. This soft layer is called the **asthenosphere**. In Greek, asthenes means “weak.” Although the asthenosphere is softer than the rest of the mantle, it is still solid. If you kicked it, you would stub your toe.

The Lower Mantle

Beneath the asthenosphere, the mantle is solid. This solid material extends all the way to Earth’s core.

The Core

After traveling through the mantle, you reach Earth’s core. **The core is made mostly of the metals iron and nickel. It consists of two parts -- a liquid outer core and a solid inner core.** Together, the inner and outer core are about 3,480 kilometers thick.

Outer Core and Inner Core

The **outer core** is a layer of molten metal that surrounds the inner core. Despite enormous pressure, the outer core behaves like a liquid. The **inner core** is a dense ball of solid metal. In the inner core, extreme pressure squeezes the atoms of iron and nickel so much that they cannot spread out and become liquid.

Most of the current evidence suggests that both parts of the core are made of iron and nickel. But scientists have found data suggesting that the core also contains substances such as oxygen, sulfur, and silicon. Scientists must seek more data before they decide which of these other substances is most important

The Core and Earth's Magnetic Field

Scientists think that movements in the liquid outer core create Earth's magnetic field. Because Earth has a magnetic field, the planet acts like a giant bar magnet. Magnetic field affects the whole Earth

Consider an ordinary bar magnet. If you place it on a piece of paper and sprinkle iron filings on the paper, the iron filings line up with the bar's magnetic field. If you could cover the entire planet with iron filings, they would form a similar pattern. When you use a compass, the compass needle aligns with the lines of force in Earth's magnetic field.

Convection and the Mantle

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. Think about it - the ice cube MELTS because of the heat transfer from your hand.

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. 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.

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, transferring 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 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 spreads out and cools, becoming denser. Then gravity pulls this cooler, denser soup back down to the bottom of the pot, where it is heated up 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 fluids 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.**

Convection currents in Earth

In Earth's mantle, large amounts of heat are transferred by convection currents. **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 4 billion years!

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

Study Guide

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Drifting Continents

*Wegener's hypothesis was that all the continents had once been joined together in a single landmass and have since drifted apart

*Wegener gathered evidence from different scientific fields to support his ideas about continental drift. He studies land features, fossils and evidence of climate change

*Wegener could not provide a satisfactory explanation for the force that pushes or pulls the continents

Sea-Floor spreading

*In sea-floor spreading, the sea floor spreads apart along both sides of a mid-ocean ridge as new crust is added. As a result, the ocean floors move like conveyor belts, carrying the continents along with them

*Several types of evidence supported Hess's theory of sea-floor spreading; eruptions of molten material, magnetic stripes in the rock of the ocean floor and the ages of the rocks

*In a process taking tens of millions of years, part of the ocean floor sinks back into the mantle through deep-ocean trenches

The Theory of Plate Tectonics

*The theory of plate tectonics explains the formation, movement and subduction of Earth's plates

*There are three kinds of plate boundaries: divergent boundaries, convergent boundaries, and transform boundaries. A different type of plate movement occurs along each