Earth's Layers

Earth's Interior

Read to Learn

Clues to Earth's Interior

You cannot see very far inside Earth. The deepest mines and wells do not go much deeper than Earth's surface. How do scientists learn about Earth's interior? They use many methods to discover what is under the surface.

What's below Earth's surface?

Scientists use deep mines and wells to get clues about what is below Earth's surface. The deepest mine ever made is more than 3 km deep. People can use this mine to explore the geosphere.

The deepest well is more than 12 km deep. People cannot go down into this well. Instead, they bring samples to the surface. They also send tools down to make observations.

Temperature and Pressure Increase with Depth

It is hot in deep mines and wells. This is a clue that it is hot inside Earth. It gets hotter as you go deeper. The temperature is about 53°C (127°F) near the bottom of the deepest mine and about 190°C (374°F) near the bottom of the deepest well. There is no way to measure the temperature of Earth's center. Scientists estimate that it is about 6,000°C.

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Pressure Just as temperature increases, pressure increases toward the center of Earth. The weight of the rocks on the surface pushes on the rocks below. This pressure makes the rocks below more dense than the rocks on the surface.

Deep Wells The high temperatures and pressures inside Earth make it impossible to dig deep wells. Therefore, scientists have sampled only a small part of the geosphere. How can scientists learn about what is below the deepest wells?

Using Earthquake Waves

Scientists use indirect methods to learn about what is inside Earth. Most of their data comes from studying earthquake waves. How can scientists learn about what is inside Earth by using earthquakes?

Earthquakes release energy in the form of three types of waves. The waves move through Earth. They move in different ways through the different materials. They speed up in more-dense materials and slow down in less-dense materials. Some waves change direction when they reach certain materials. Others cannot travel through some materials. By studying how the waves move, scientists can learn about the density and structure of materials in Earth.

Earth's Layers

As you learned, differences in density resulted in the materials within Earth forming layers. Each layer of Earth is made of different materials. The densest materials are at Earth's center.

Crust

Earth's **crust** *is its brittle, rocky outer layer*. The crust is much thinner than the other layers of the geosphere. You might think of the crust as the shell on a hard-cooked egg. The crust is not only the thinnest layer, but it is also the least-dense layer of the geosphere. The crust is made mostly of elements of low mass, such as silicon and oxygen.

Rocks of the crust are under oceans and on land. The crust under oceans is called oceanic crust. It is formed of dense rocks that contain iron and magnesium. The crust on land is called continental crust. Continental crust is about four times thicker than oceanic crust. Continental crust is thickest under tall mountains. Continental crust is less dense than oceanic crust.

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Mantle

Earth's mantle is the layer just below the crust. *The* **mantle** *is the thick middle layer in the solid part of Earth*. The mantle contains more iron and magnesium than the oceanic crust does. This makes the mantle more dense than either the continental crust or the oceanic crust. The mantle is made of rock, just like the crust.

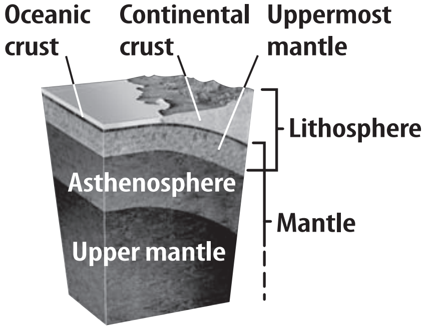
Scientists group the mantle into four layers. In each layer, the rocks react differently when forces push or pull on them.

Uppermost Mantle The uppermost layer of the mantle is made of hard rocks. These brittle, rigid rocks are similar to the rocks in the crust. For this reason, *scientists group together the crust and the uppermost mantle into a rigid, or hard, layer called the* **lithosphere** (LIH thuh sfihr).

Asthenosphere The rocks below the lithosphere are so hot that tiny bits melt. When this happens, the rocks are no longer brittle. They begin to flow. When a material, such as rock, flows, scientists use the word *plastic*. *The plastic layer within the mantle is called the* **asthenosphere** (as THEN uh sfihr).

The material in the asthenosphere is not like the plastics you use every day. The term *plastic* means the material is soft enough to flow. The asthenosphere flows slowly. Even if you could visit the mantle, you would not be able to see the rock flow because it moves too slowly. Rocks in the asthenosphere move about as slowly as your fingernails grow.

Upper Mantle and Lower Mantle The rock below the asthenosphere, shown below, is solid, even though it is hotter than the rock in the asthenosphere. How can it be solid when the cooler rock in the asthenosphere is plastic? The pressure below the asthenosphere is so high that melting does not occur. High pressure squeezes the hot rock into a solid. This solid rock of the upper mantle and lower mantle forms the largest layer of Earth.



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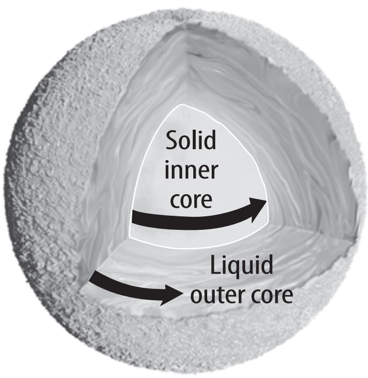
Core

The dense metallic center of Earth is the **core**. Imagine again that Earth is a hard-cooked egg. The yolk of the egg would be Earth's core. Earth's crust and mantle are made of rock. Why do you think the core is made of metal? Remember that early Earth was much hotter than it is now. Earth's materials flowed, just like they do in the asthenosphere today. As you learned earlier in the chapter, early Earth was soft enough for gravity to pull the densest material to the center. That dense material is metal. The core is mostly iron with small amounts of nickel and other elements. It has a liquid outer core and a solid inner core.

Outer Core You learned that pressure in the lower mantle is great enough to keep the rock in a solid state even though it is very hot. How, then, could the outer core—where the pressure is even higher—be liquid? The answer is that the mantle and the core are made of different materials. These materials melt at different temperatures. Just as in the asthenosphere, the effects of temperature outweigh the effects of pressure in the outer core. Scientists learned that the outer core is liquid by studying what happens to earthquake waves when they enter the outer core.

Inner Core Earth's inner core, shown in the figure below, is a dense ball of solid iron crystals. The temperature at the center of Earth is about 6,000°C. Because the pressure is so high, the iron is in a solid state.

The liquid outer core is not tightly attached to the solid inner core. Therefore, the two layers of the core can spin at different speeds. The inner core spins a little faster than the rest of Earth does.



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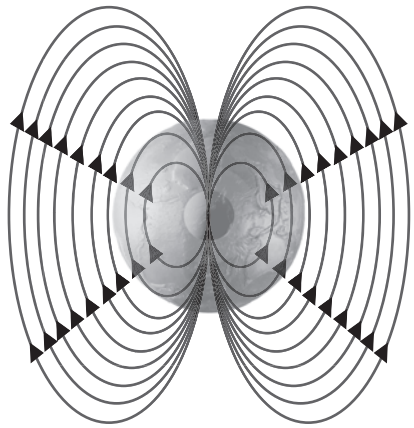
Earth's Core and Geomagnetism

Have you ever used a compass? The needle on a compass points north. The metallic compass needle lines up with a force field around Earth. This force field, which is shown below, is caused by Earth's core.



Earth's Magnetic Field

As you learned, Earth's inner core spins faster than the outer core does. This produces streams of flowing, molten iron in the outer core. The movement of these molten materials produces Earth's magnetic field.

Think of Earth's magnetic field as a bar magnet. It has opposite poles, as shown above.

For centuries, people have used compasses and Earth's magnetic field to navigate. But the magnetic field does not stay the same. Over geologic time, the magnetic field's strength and direction change. The poles have even reversed direction several times in Earth's history.

Magnetosphere

Earth's magnetic field protects Earth from charged particles that flow from the Sun. The magnetic field pushes away some charged particles and traps others. *The outer part of the magnetic field that affects the charged particles is called the* **magnetosphere** (mag NEE tuh sfihr). The flow of these charged particles produces the shape of the magnetosphere.

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