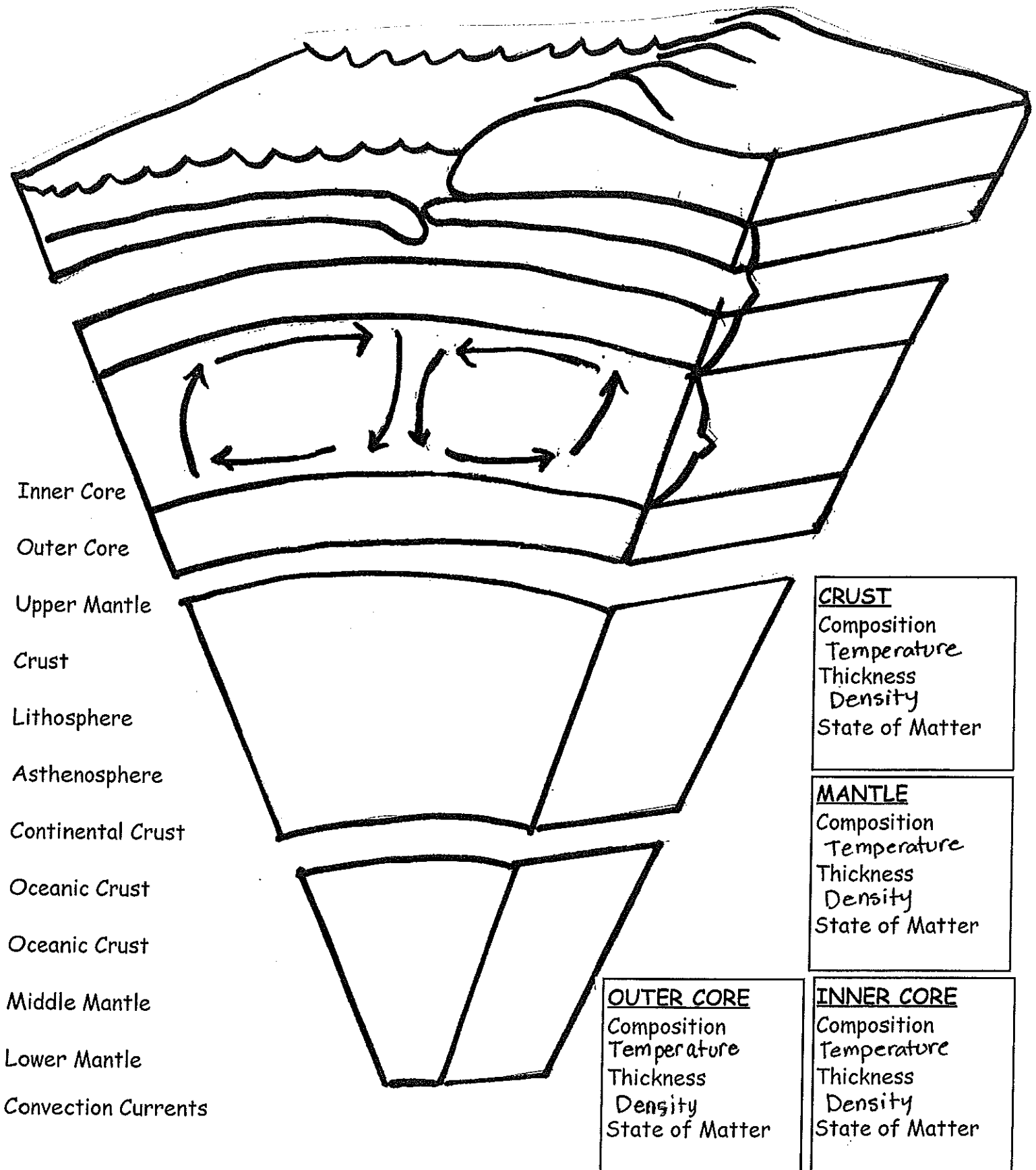
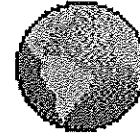


The Earth's Layers Foldable[®]

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The Earth's Layers

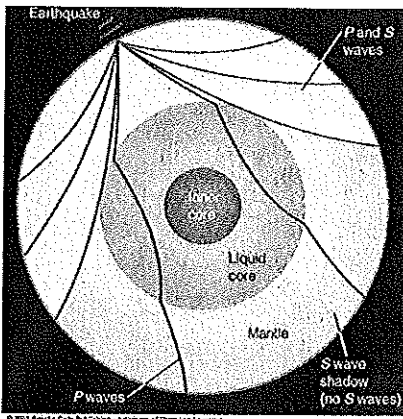


A Journey to the Center of the Earth

The deepest places on the earth are in South Africa. Mining companies trying to extract gold have mined into the earth about 3.5 km (about 6 miles). No one has gone deeper into the earth than the South African miners because of the heat and pressure at these depths prevents humans from going much deeper. So if we can't go very deep into the earth, how do we know what is below the surface when we cannot see it?

Isaac Newton (the scientist that discovered gravity) was one of the first scientists to develop theories about the structure of the earth. Based on his studies about gravity, Newton calculated the average density of the earth and found it to be more than twice the density of rocks on the surface. Newton realized that the inside of the earth had to be much denser than the surface.

Most of our knowledge about the structure of the earth comes from studying earthquakes. **Every earthquake sends out waves in all directions** like the way that dropping a rock into a lake sends out waves through the water. **These earthquake waves are called seismic waves.** Observing these seismic waves as they travel through the earth gives scientists an idea of the different materials that the waves move through.



There are two types of seismic waves, S-waves and P-waves. These waves behave differently when they pass through different types of materials. Just like a sound wave behaves different when it passes through water instead of air seismic waves behave differently when they pass through different phases of matter. Scientists know that P-waves will travel through all types of materials but S-waves will not travel through liquid. By calculating these seismic waves scientists have learned that there are four major layers that make up the earth. Three of these layers are solid, one of these layers is liquid, and one of these layers is gas.

The Atmosphere

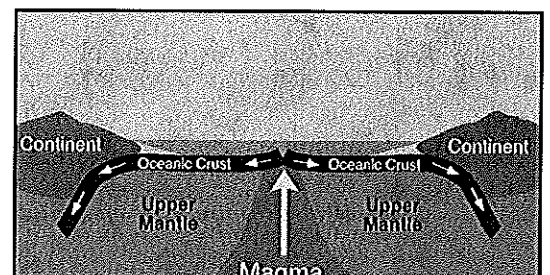
The earth is surrounded by all kinds of gases called the atmosphere. Without the atmosphere life on earth would not be possible. The atmosphere gives us air, water, and warmth. The atmosphere protects us from the harmful rays of the sun and from meteorites. This layer around the earth is a colorless, odorless, tasteless sea of gases. The atmosphere is made up of **gases such as nitrogen, oxygen, argon, and carbon dioxide.** It is **about 800 kilometers (500 miles) thick** and is less dense than the crust that it floats above. **The density of the atmosphere is (0.0013 g/cm³).** The atmosphere itself is made up of many different layers.

If you ever climb a high mountain yourself, you will notice that as you climb upward the air gets colder. The temperature of the air decreases as the altitude (height) increases because the air becomes less dense. That is, there are fewer and fewer molecules of air in a given amount of space. The thin, less dense air cannot hold as much heat. **The temperature of the atmosphere can range from -90°C – 2000 °C (-130 °F – 3632 °F)** depending on the layer of the atmosphere, how close it is to earth, how much ultraviolet radiation it absorbs and how dense the particles are in the layer.

The Crust

The crust lies above the mantle and is the earth's hard outer shell. The crust is the surface on which we are living. The crust is 0 – 32 KM (0 -19.8 miles). In relation to the other layers the crust is the thinnest and the least dense layer. It floats on the softer, denser mantle. The crust is made up of **solid rock** but these rocks are not the same all over the world.

There are two major types of crust: crust that makes up the ocean floors and crust that makes up the continents. **Oceanic crust is a thin layer found under the oceans.** Even though it is relatively thin it is



the densest type of crust (3.0 g/cm^3) and is made up of a metamorphic rock called basalt. Continental crust makes up the continents and rests on top of oceanic crust. Continental crust consists of less dense rock such as granite. Even though Continental crust is less dense (2.7 g/cm^3) it is much thicker than oceanic crust because it consists of the rocks that make up the continents.

Because the earth is very hot inside, a current of heat flows from the core to the crust. This is called convection current. This current cools as it rises closer to the surface of the earth. This convection current along the bottom of the crust causes the moving of the tectonic plates. **The constant, movement of the plates is called plate tectonics.** The movement of these plates is very slow but when they bump together it causes an earthquake. The combination of convection currents from the mantle and the effects of the atmosphere make the crust about $-17.7 - 870\text{C}$ ($0 - 1598 \text{ F}$) from the surface to the bottom of the crust. The crust and atmosphere are the coolest of earth's layers.

The Mantle

The layer beneath the crust and above the core is the mantle. It is **2,868 km kilometers (1,800 miles) thick** and makes up nearly 80 percent of the earth's total volume. The mantle has an average density of 4.5 g/cm^3 . The density increases with depth because the pressure increases. The mantle mainly consists of solid rocks made from silicon and magnesium. Deep into the mantle the rocks consist of magnesium and iron. Another reason that the mantle gets denser with depth is because the rocks at this level contain iron and iron is denser than the materials at the upper layers of the mantle. **The temperature of the mantle also increases with depth. It ranges from $870 - 2200 \text{ C}$ ($1,598 - 3992 \text{ F}$).**

In 1909, the Yugoslav scientist Andrija Mohorovicic (moh-hoh-ROH-vuh-chihch) observed a change in the speed of seismic waves as they moved through the earth. When the waves reached a depth of 32 to 64 kilometers below the earth's surface, their speed increased. The change in the speed of the waves at this depth indicated a difference in the density of the rock. **Mohorovicic discovered a boundary between the earth's outermost layer and the mantle.** In his honor, this boundary is now called the Moho.

The Core

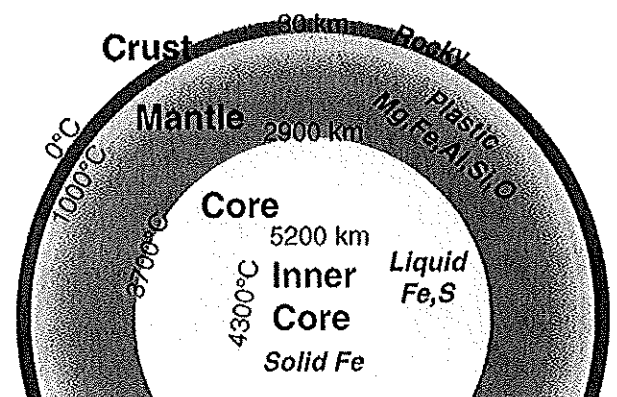
The inner part of the earth is the core. This part of earth is about 2,900 kilometers (1,800 miles) below the earth's surface. The core is a dense ball of the metals iron and nickel. After observing the speeds of P-waves and S-waves, scientists have concluded that the earth's center is divided into two layers, the outer core and the inner core.

The Outer Core

The outer core is so hot the iron and nickel metals are always molten. Molten means liquid metal so this layer liquid. The outer core begins about 2900 kilometers below the surface. **It is about 2300 kilometers (1429 miles) thick.** Because the earth rotates, the outer core spins around the inner core and that causes the earth's magnetism. Magnetism has been used by sailors to find their way on earth for thousands and thousands of years. Magnetism also influences particles outside the atmosphere of the earth up to more than 60,000 kilometers (37,000 miles) into space. **The outer core is about $2200 - 5000 \text{ }^\circ\text{C}$ ($3992 - 9032 \text{ }^\circ\text{F}$).** The density of the outer core is between 10 g/cm^3 and 12.3 g/cm^3 .

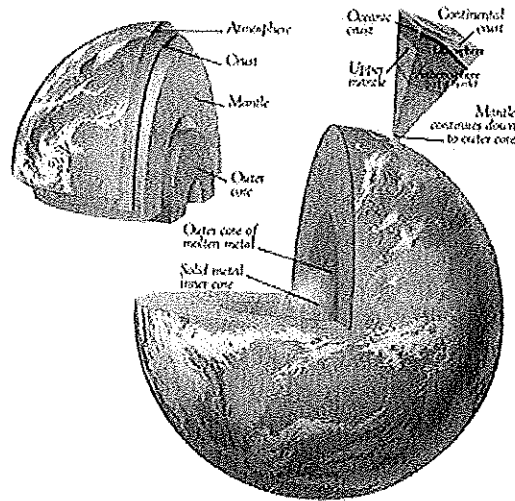
The Inner Core

The inner core is 5150 kilometers (3200 miles) below the earth's surface. One would still have to travel about 1300 kilometers (808 miles) more to reach the center. **The temperature in the inner core is about $5000 - 6000 \text{ }^\circ\text{C}$ ($9032 - 10832 \text{ }^\circ\text{F}$).** It is made from the same materials as the outer core but because of the high pressure the inner core is solid. This high pressure and the dense metals at the core make its density about 13 g/cm^3 .



Conclusion

Jules Verne's "Journey to the Center of the Earth" tells a story of scientists that find a volcanic vent and follow it to the center of the earth. Their journey is filled with adventures of strange weather patterns, giant mushrooms, extinct dinosaurs, and crystal caverns. Verne was not the only person to be fascinated with the inside of the earth. But scientists could not use probes such as those used in outer space to explore the interior of the earth. Earth's heat and pressure make this impossible. Volcanic vents occasionally bring up pieces of the earth from as deep as 150 kilometers, but these rocks are rare, and we have little hope of taking Jules Verne's journey. Instead much of our knowledge about the structure of the earth comes from observing earthquakes. Earthquakes can be tremendously destructive for humans but provide information about the inside of the earth. By observing the behavior of seismic waves we have learned that the mantle is the thickest of earth's layers, that the layers increase in temperature and density the deeper we go, and that the atmosphere protects us and allows life to exist on earth.



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Write one summary about the general ideas and patterns you have learned about density, temperature, and pressure of Earth's layers.