Layers of the Earth

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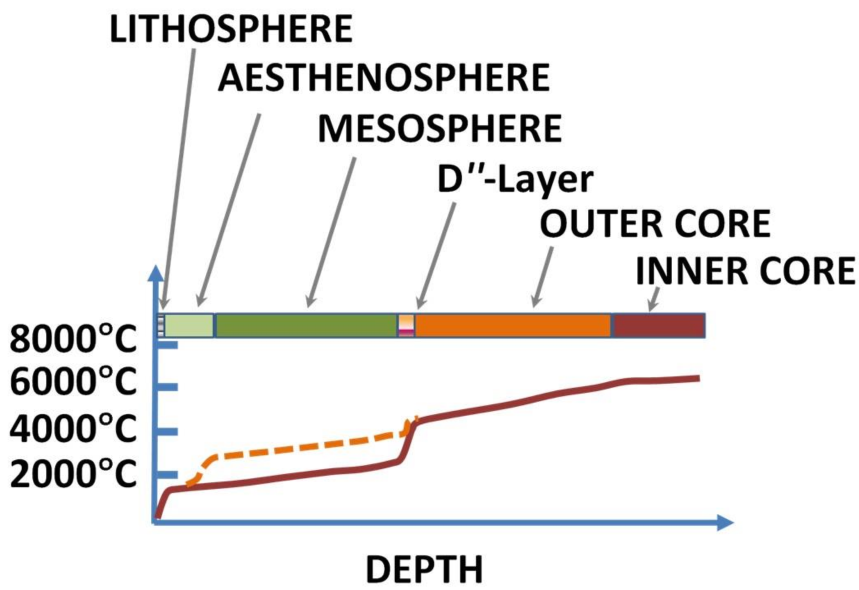
Chapter 1: Temperature and Composition

Temperature

Temperatures deep inside the earth can range from 4,000-6,000°C. That is as hot as the sun! Because of such immense pressure, rocks remain solids and liquids, instead of turning to gasses. Only 50km (30 mi) beneath the surface, it is already almost 1000°F! It also has a pressure of 200,000psi (pressure per square inch), bike tires are about 35psi.

The temperatures increase as you go deeper into the earth, with the **Lithosphere**, compromised of the **Crust** and upper mantle, being the coolest averaging about 300-500°C. The **Asthenosphere** is the next layer, averaging about 1,300°C, making it slightly more fluid than the lithosphere above it. It transitions into the place called the "Moho," or **Mohorovicic discontinuity**, or the point between the crust and the mantle below. The **Upper Mantle** is much stronger than the asthenosphere at about 500-900°C, and the **Lower Mantle** is denser and hotter, reaching temperatures over 4,000°C. Finally, the **Core** is the hottest at about 5,000°C, being the most "gooey" of the layers.



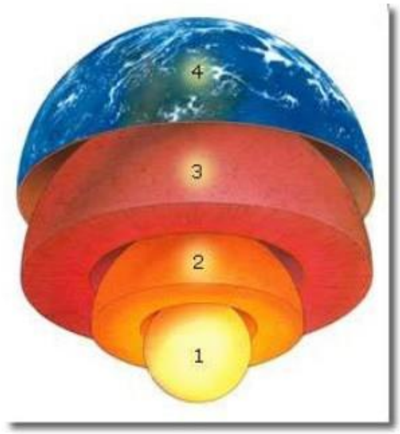
Layer Boundary (After Daly, 1940)	Hypothetical Depth (km)	Computed Temperature
Surface …	0	+10° C
Top of vitreous, oceanic sub-layer	60	1,405
Top of asthenosphere	80	1,590
Top of asthenosphere	100	1,650
Base of asthenosphere and top of mesosphere	200	1,950
Base of asthenosphere and top of mesosphere (Jeffreys discontinuity)	480	2,790

Composition

Each layer has a distinct set of rocks and minerals that make it unique, however they all contain some of the same things, such as iron. Despite their similarities, the differences in composition are what define the layers, causing them to be distinct.

Earth's crust is much like a "skin" consisting of two types, **oceanic** and **continental**. Oceanic crust is mainly basalt with limestone, serpentine, and clay. Continental crust consists of mostly granite and some quartz. The upper mantle is thought to contain rocks such as olivine, peridotite, and garnet. These shift at the Moho because of high pressure and are replaced by more stable minerals such as perovskite. The rest of the mantle consists of other iron-rich rocks.

The core is divided into the outer and inner core because of the distinctions between the state of iron at the depths. The outer core is liquid iron, flowing plastically. The inner core, however is solid because of such extreme pressure.



4. **The 6-35 km (4-21 miles) thick lithosphere. Earth's crust.**

3. **The 2900 km (1.800 miles) thick Mantle layer formed from rapidly flowing magma.**

2. **The 2000 km (1,250 miles) thick outer core containing such molten heavy metals as nickel and iron.**

1. **The 1370 km (851 miles) thick inner core, which is in a crystalline state because of the influence of heat and high pressure.**

This diagram shows the different layers of the Earth as well as how thick they are. It also tells how the elements and minerals behave at those conditions

Stop and Think!

1. How do the layers temperatures affect the materials as you move deeper through the layers? (ex: The Lithosphere is very rigid, does that change as you move into the Asthenosphere?)

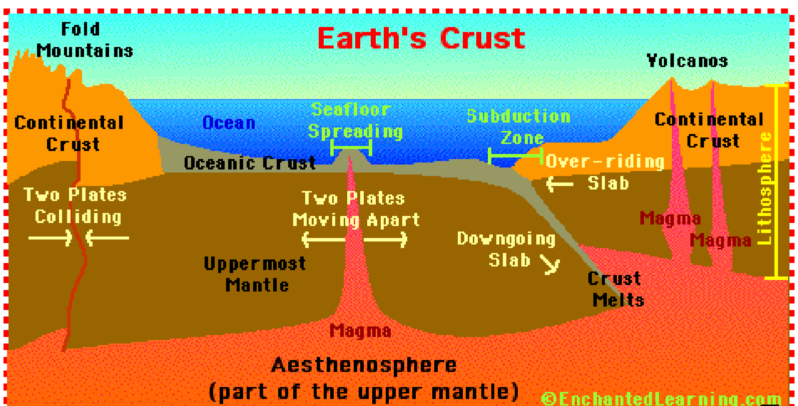
Chapter 2: The Layers

Lithosphere

The lithosphere consists of the crust and the upper mantle. As we read before, crust can be divided into two different types, continental and oceanic crust. Both types "float" on the denser mantle.

Continental crust is about 25-90 km (15-55 mi) thick and divided into tectonic plates. These plates move slowly (just a few centimeters) each year over the more fluid mantle. The tectonic plates make up distinct regions of the earth's surface such as continents.

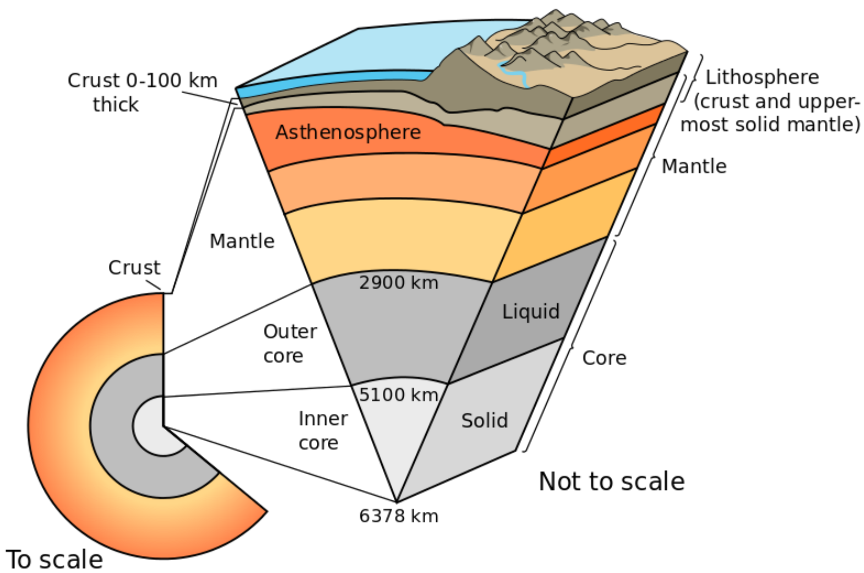
Oceanic crust, which is much thinner than continental crust at only 6-11km (3-6 mi) thick, is where new crust is formed. This can happen by two plates moving apart and magma from the asthenosphere coming up and cooling to form new seafloor.



Asthenosphere

The Asthenosphere is more fluid than the rigid Lithosphere above it, with a plastic-like texture. This is due to the increased temperature and pressure that rocks experience as they descend into the Asthenosphere from the Lithosphere, making them **molten**.

The molten nature of the Asthenosphere makes it possible for **plate tectonics** to happen. If the plates were not able to shift on the semi-liquid region, then new mountains would not form, and the theory of **Pangaea**, the supercontinent of 300mil years ago, would not exist. Mountains are formed when two plates **converge**, or flow towards each other, and possibly even cause asthenospheric material to flow up through causing a volcano. Asthenosphereic material can also escape to the surface when plates move away from each other, or **diverge**. The Asthenosphere is the supplier of new material for the Lithosphere and replaces the lithospheric material as it is cycled through, as shown in the diagram on page 7.

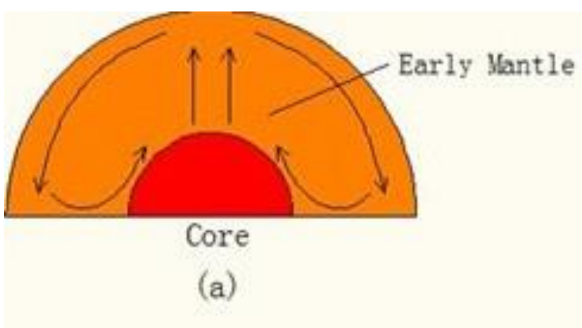


See how the Asthenosphere tends to be thicker under the oceanic crust, where new Lithosphere is forming.

Mantle

We move from the Asthenosphere into the Upper Mantle through the Mohorovicic discontinuity, or **Moho**. The Moho is characterized by a drastic increase in seismic rate, discovered by Andrija Mohorovicic in 1909. The Upper Mantle is fairly plastic, relative to the layers above it. Not much is known about the **seismic activity** of the Lower Mantle, but scientists assume that it is relatively consistent.

Since the mantle is molten, flowing freely, it has **convections** similar to those that occur when boiling water on a stove. The magma heats as it gets closer to the Core and rises closer to the Asthenosphere, cooling as it gets closer and falling again to be heated and rising again, continuously cycling.



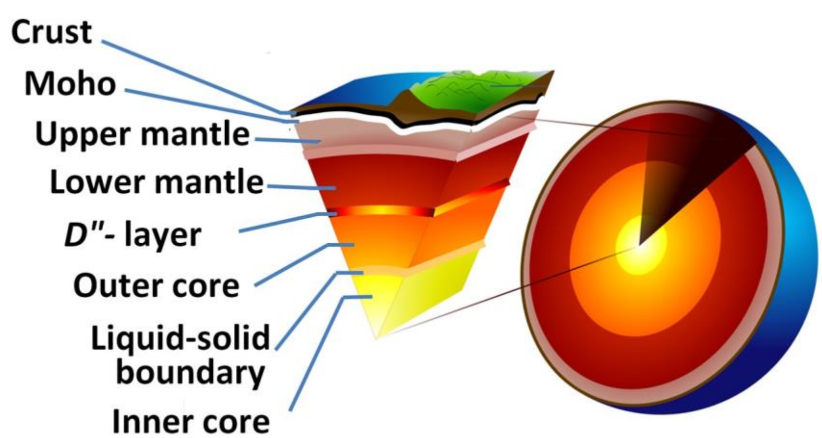
Core

The Core is something that scientists can only make hypothesis about because it is so deep in the earth that no instrument could make it that far down, even if it was long enough. The temperatures and pressure are so extreme that anything would be destroyed before any data was **accumulated**.

What we do know is that there are two parts, an Outer Core and an Inner Core. The Outer Core is liquid iron **alloy**, at extremely high temperatures flowing molten. The Inner Core is thought to be solid iron, and has been thought to be pure iron for many years until recently. Scientists have been studying the core's density and testing it to see if a lighter element may be present in addition to iron.

Stop and Think!

1. Why might there be such a difference in the thickness between Oceanic and Continental Crust?
2. How does the Asthenosphere make plate tectonics possible?
3. What is the Mohorovicic discontinuity, or Moho?
4. What is the difference between the Outer and Inner Core?

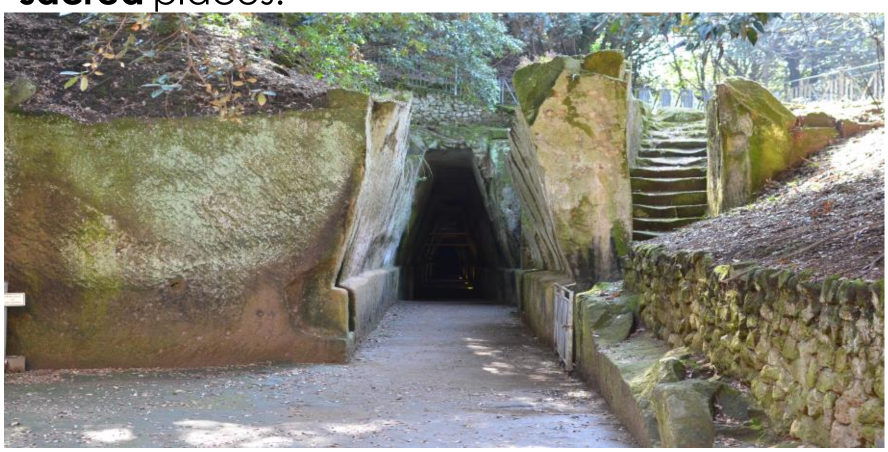


Chapter 3: Folklore, Hollow Earth

Origins

The legend of the earth having a hollow center stems back to a wide variety of peoples. The most common belief is that the center of the earth is a place for afterlife. Ancient Greeks called it the underworld, it has been referred to as the Christian hell, and the Jewish Sheol to name a few. Others believed it was the source of life, such as the Angami Naga tribe in India and the Mandan Native Americans.

What connects all these communities is the belief that the entrance or exit to the middle of the earth is through tunnels. They believed that caves or tunnels would extend all the way down through the layers of the earth. These were incredibly important and sometimes **sacred** places.



The Theory through the Centuries

In the 19th Century, 1692, Edmond Halley suggested a hollow shell of 500 miles thick with two shells within one another separated by their own **atmospheres**. This theory suggested that people could inhabit the shells, due to the atmospheres. However, it was not until later that the concept was thought about more seriously.

John Cleves Symmes Jr suggested hollow shells about 810 miles with openings at both poles with four inner shells in 1818. This is the most famous Hollow Earth theory and he became well known. Symmes proposed an expedition to the North Pole hole to try and prove his theory, asking president John Quincy Adams. Adams said he would approve the journey but left office before he could do so. The next president, Andrew Jackson, said he would not support the mission.

The 20th Century brought many theories such as that of Atlantis by Walburga, Lady Paget. She claimed that cities existed under a desert and would be discovered once the 21st Century came. Another theory came from Dr. Raymond Bernard who claimed that UFOs came from inside the earth in his book *The Hollow Earth* in 1964 as well as hollow worlds. He even theorized that the people of Atlantis were the first to pilot flying saucers.

Disproving Hollow Earth Theory

The theory of Hollow Earth was further researched in the late 20th Century through a variety of methods. One of the most **credible** ways was through seismic studies. These showed that the time it would take for the seismic waves to travel through solid rock, liquid alloy, and solid nickel iron (such as in a earth that has all the layers) matched the gathered data much more accurately, and that a hollow earth was almost impossible.

Another method of disproval was through the analysis of gravity. It is known that enormous objects have a tendency to pull together, forming a non-hollow sphere that also has a gravitational pull of its own; displayed by stars and planets. If, however, the earth *did* defy this and was hollow, someone could not stand on the inner surface because there would be such a strong pull outwards. This is because of the **centrifugal force** of the earth's rotation.

The last way that scientists have disproved the theory of Hollow Earth is through direct observation. Have you ever thought that maybe you could "dig to the other side of the world?" Well, the deepest hole ever was the Z-44 Chayvo Oil Well, offshore of Russia, which was 12,376m (40,604ft) deep. Because of this, scientists believe that there is no way that a Hollow Earth could exist.

The Chayvo Yastreb land rig is the research center and testing site for the Z-44 Chayvo Oil Well, the deepest hole ever drilled into the earth.

Stop and Think!

1. What is similar about all of the beliefs about the Hollow Earth theory held by early cultures?
2. How are the theories proposed by the scientists of the 19th and 20th centuries similar and how are they different?
3. What do you think is the most convincing evidence against the Hollow Earth theory?

Glossary

Accumulated: To gather or collect, often in gradual degrees.

Alloy: A substance composed of two or more metals, or of a metal or metals with a nonmetal.

Asthenosphere: The region below the lithosphere, where the rock is less rigid than that above it and below it.

Atmosphere: Layers of gases surrounding a planet that make it possible for life to survive.

Centrifugal Force: Effect that seems to cause an object moving in a curve to move away from the curve's center.

Continental Crust: Thick layer of Earth that sits beneath continents.

Convection: movement of a fluid from a cool area to a warm area.

Converge: area where two or more tectonic plates bump into each other.

Core: The extremely hot center of Earth, made up of mostly iron.

Credible: Worthy of belief or confidence.

Crust: The rocky outermost layer of Earth.

Diverge: Area where two or more tectonic plates are moving away from each other.

Lithosphere: Outer, solid portion of the Earth consisting of the crust and Upper Mantle.

Lower Mantle: Bottom layer in Earth's mantle, closest to the core.

Moho: Point between Earth's crust and the mantle below. Also called the Mohorovicic discontinuity.

Mohorovicic Discontinuity: Point between Earth's crust and the mantle below. Also called the Moho.

Molten: Solid material turned to liquid by heat.

Oceanic Crust: Thin layer of the Earth that sits beneath ocean basins.

Pangaea: The theory of a landmass that existed when all the continents were joined from about 300 to 200 million years ago.

Plate Tectonics: Movement and interaction of the Earth's plates.

Sacred: Religious respect because of a connection to divinity; holy.

Seismic Activity: Shock wave of force or pressure that travels through the Earth.

Upper Mantle: Layer in Earth's mantle between the Asthenosphere and the Lower Mantle

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Common Core State Standards

CCSS.ELA-LITERACY.RI.5.2
Determine two or more main ideas of a text and explain how they are supported by key details; summarize the text.

CCSS.ELA-LITERACY.RI.5.4
Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a *grade 5 topic or subject area*.

CCSS.ELA-LITERACY.W.5.7
Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

CCSS.ELA-LITERACY.W.5.6
With some guidance and support from adults, use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of two pages in a single sitting.

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