

INCORPORATED RESEARCH INSTITUTIONS FOR SEISMOLOGY

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**Timecodes:**

0:00 Intro

0:46 Seismic waves

0:57 Three layers ( like egg?)

1:56 Basic layers

2:01 Crust chemistry

2:53 Mantle chemistry

3:46 Core

4:47 crust vs. plate?

5:36 Earthquakes, volcano, magnetics

Much of our knowledge of Earth’s insides comes from monitoring the thousands of earthquakes that occur every year.  Five centuries ago, the world had mostly accepted that the Earth was not only a sphere, but was thought to be of uniform rock throughout. Two hundred years later, Sir Isaac Newton, studying our planetary system, calculated that the *interior* of the Earth must be made of far-denser material than the surface rock. Newton's estimate of the overall density of the Earth remains essentially unchanged today. In the early 1900’s scientists discovered they could use data from earthquakes as method for looking deep beneath the surface. By understanding the travel times of different seismic waves to worldwide stations scientists were able to calculate where boundaries occurred and what those boundaries represented. They thus determined that the Earth has three layers based on chemical composition: *crust, mantle,* and *core.* *As an analogy for relative scale, these layers can be compared to an egg, with the shell representing the outermost brittle layer, the white the mantle and the yoke the core.*

How did scientists figure out where these layers were? They used the arrival times of seismic waves to world-wide seismic stations

Seismic waves, leave the hypocenter of an earthquake and travel in all directions. If the earth had no changes with depth, seismic waves would travel straight paths. But the earth has composition, density and temperature changes that cause the seismic rays to reflect and refract along boundaries as velocity in the mantle *generally* increases with depth.Innovations in computer technology in concert with a steady beat of earthquakes helps scientists to continue to refine our understanding of Earth’s interior.

The basic layers of the earth are grouped by their *chemical* composition.

The crust is made of chiefly eight major elements shown here by their relative abundance. Oxygen, silicon, aluminum, iron, calcium, sodium, potassium and magnesium. At this scale the crust is too thin to show as more than a thin line without zooming in. It ranges from 5 to 10 km thick in the dense basaltic oceanic crust and up to 75 km in the thicker less-dense granitic rock of the continental crust. This difference in density and thickness of these two types of crust is the reason why the earth has oceans and continents.

The crust is often mistaken for the tectonic plates. However, The crust is just the *top* *part* *of the tectonic plate.* We will return to tectonics in a moment. But first back to the three layers.

Below the crust is the *mantle,* composed of the same elements but in different proportion, with increasing amounts of the heavier elements in the rock. The chemical composition of the 2,900 km-thick mantle varies little from top to bottom, but there are distinct physical variations due to temperature and pressure differences. The uppermost mantle is relatively cool and brittle and ranges from 50 to 120 km thick. Below this zone, the upper mantle becomes notably more plastic and malleable due to the right combination of heat and pressure. That ductile zone is known as the Asthenosphere, and varies up to 400 kilometers deep, depending mainly on temperature. The lower mantle comprises 55% of the planet by volume and is denser and hotter than the upper mantle.

At the center of the Earth is the *core,* which is nearly twice as dense as the mantle because it is a metallic iron alloy, rather than rock. Unlike the egg-yolk analogy, the Earth's core is made up of *two* distinct parts: The *liquid* outer core and a *solid* inner core. Although the inner core hotter, there is also *greater* pressure squeezing the atoms, changing the material from liquid to solid. The liquid outer core is convecting vigorously and generates Earth's magnetic field.

Back to plate tectonics. As you recall, the cooler uppermost part of the mantle is brittle. How can the top of the mantle be brittle, when the same material in the asthenosphere is ductile? A Big hunk candy bar can be used as an analogy. Like the uppermost cool mantle, when the Big Hunk is cold, it is brittle and breaks when bent. When you heat it up it becomes ductile, or plastic, and can bend and flow.

Earlier we mentioned that the crust is merely the top of the tectonic plate. This uppermost mantle behaves much like the overlying crust and together they form a rigid layer of rock called the *lithosphere* that moves in unison. The lithosphere ranges from as much as 100 km thick in the oceanic plate to 200 km thick in continental plates.

It is in this brittle zone that earthquakes occur due to compression, extension & shearing. Over billions of years, the cooled surface of the earth has been broken up into the moving plates that are called lithospheric plates, or more commonly, tectonic plates. Because they are mostly more buoyant than the asthenosphere, they float above it.

Convection currents driven by temperature, pressure and gravity provide the mechanism for the process we know as plate tectonics.

Earthquakes, volcanoes and the Earth’s magnetic field are *all* the consequence of the Earth trying to lose heat as it converts some of the thermal energy into mechanical energy in the process.

Without the earthquakes we may not have had a way to see so deep into the earth.

Without the tremendous heat being released from the interior of the earth, we would not have the mechanism to drive plate tectonics.