EARTH'S LAYERS AND ISOSTASY – Tutorial Script

To understand the principles of Plate Tectonics, the dynamic surface-altering process that is the source of all the world's volcanoes, major earthquakes, and major mountains, we have to look more closely at the layers of the Earth, first discussed in the lecture on Earth Formation.

Let's review the basics. First, due to density separation, the core, mantle, and crust – the primary compositional layers – were formed. Let's look closer at the core. It's made mostly of iron and is separated into two physically distinct layers. They are compositionally quite similar – mostly made of iron. However, physically, we have a small solid inner core at the very center of the earth, where, though temperatures are higher than anywhere else inside our planet, pressures are so high that liquid iron can't exist. Surrounding the inner core is a much larger, liquid iron outer core. Because pressures are less here, iron can be stable as a liquid. For comparison, the outer core is almost twice as thick as the inner core. Combined, however, these two layers represent about ½ the radius of Earth.

Now let's go out to the crust, which is so thin that it would be impossible to see it in any whole-earth drawing shown to scale. So in all cases, we have to exaggerate it. The earth has a radius of about 6400 km. The crust is at most 50 km thick at most $1/128^{th}$ the radius of the earth. The rest of the earth, most of it in fact, is mantle!

Let's look more closely at the crust. It is composed of two kinds – denser **oceanic crust**, which is thin and mostly made of a rock called **basalt**. Its density makes it sink low, which is why it is the crust that underlies the lowest basins on the planet – the oceans. **Continental crust** is much thicker and less dense than oceanic crust. It is made out of many kinds of rocks, but its average composition is similar to that of a rock found on the continents – called **granite**. The buoyancy and thickness of continental crust makes it float high above the oceans, creating the continents.

To understand how crust floats, we need to look more closely at the top of the mantle and how it interacts with the crust. Because of the water content of the mantle and the temperatures and pressures encountered in the zone between about 100 and 300 km depth, the region there, called the Asthenosphere, behaves like a plastic solid – and is capable of flow over long periods of time. Thus it convects. Hotter, less dense material rises, displacing colder denser material, which sinks. The rest of the upper mantle plus all of the crust are fused together. We call that combination of crust + upper mantle that sits above the asthenosphere, the lithosphere. The lithosphere is broken up into pieces that we call plates. Some of the pieces contain continental crust, some oceanic crust – and some contain both side by side.

Pause now.

The plasticity of the underlying asthenosphere allows the overlying lithosphere to sink into it, much like icebergs or wood floating in the water. The denser lithosphere portions that contain oceanic crust will sink lower and be thinner. The less-dense lithosphere that contain continental crust will be much thicker and ride higher as well as extend deeper (again, like an iceberg). We call this process of lithosphere sinking into asthenosphere, **isostasy**. How do we know?

Scientists take images of the earth (like x-rays), by using seismic waves that travel through the earth and reflect and refract off major boundaries and return to the surface. The first major boundary that is encountered during this process, off which waves reflect, is called the **Moho**, after a Yugoslavian scientist who first discovered it, whose last name was Mohorovicic. (Moho is a shorter, easier-to-remember label!). Since the moho marks the boundary between the crust and the mantle, what layer does it sit within? The moho sits in the middle of the lithosphere, because the lithosphere contains all of the crust plus the upper-most mantle. Does the moho have anything to do with the asthenosphere? No.

And what do we notice when we study the Moho across the planet? It appears very close to the surface, at depths as low as 3-5 kilometers, beneath the oceans. It appears as deep as 50 kilometers below the highest mountains. As material is added to or removed from the crust, it will adjust isostatically, again, much like icebergs or ships in the ocean. When cargo is added to a cargo ship, what happens? It sinks lower into the water. When the cargo is removed? The ship rises. So what happens when the tops of mountains are eroded? Material is removed, so the crust rises upward. And what happens when the eroded sediment is carried to the coast and dumped on the edges of the continental shelf? The land there will sink under the weight. So earth's surface is continually rising and sinking isostatically as weight is removed or added by erosion, deposition, volcanic eruptions, mountain building processes, and other processes related to plate tectonics.

Pause now.

For more information and more detail, continue on to the next video in the series.

<u>Plate Tectonics Video Series:</u>
Part I: Earth's Layers and Isostasy
Part II: Plate Tectonics Basics
Part III: Plate Tectonics Global Impacts
Part IV: Plate Tectonics and Calif. Geology
Part V: Hotspots
Part VI: Paleomagnetism
Part VII: Hydrothermal Vents

Earth's Layers and Isostasy
Produced by Katryn Wiese
City College of San Francisco

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