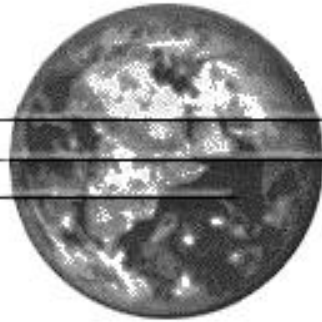


Geoscience 101

The Solid Earth



Lecture 10

M-W November 20, 22
T November 21

Interior of the Earth **CHAPTER 19**

This is only an outline of the lecture. You will need to go to class to fill in the outline, although much of the relevant information is also in the text.

EARTH'S INTERNAL STRUCTURE

USE OF SEISMIC WAVES TO EXPLORE THE INTERIOR

Read pages 435-442 on use of seismic waves. Pages 442-449 are also recommended.

We are able to drill most of the way through the crust, but have not yet reached the mantle.

We have to use instruments to explore the mantle and core.

One of the methods of exploration is the behavior and velocity of seismic waves in the Earth.

To explore the crust, it is possible to set off small explosions to send seismic waves through the region we want to explore.

To explore the mantle and core, we use the waves set off by earthquakes.

REFLECTION AND REFRACTION

Seismic waves are sound waves, and are reflected and refracted by changes in the rock in the Earth just as light or sound waves are reflected and refracted by changes such as entering water from the air, or passing through window glass.

The velocity of seismic (and sound) waves depends on the elasticity of the material through which they are passing.

Solids are more elastic than water; water is more elastic than air.

Metamorphic rock is more elastic than sedimentary rock, which is more elastic than soft sediment.

Sound and seismic waves have higher velocity in the more elastic material. Velocity changes cause reflection & refraction.

At each boundary between types of material, the waves are refracted (bent) and partially reflected (bounced back).

The wave follows the path that takes the shortest time.

As we know from our own lives, sometimes a circuitous route takes a shorter time.

Starting with knowledge of the time and location of an earthquake, and the length of time required for the P and S waves to reach each seismograph (in a network), it has been possible to determine the velocity of P and S waves in different layers of the earth.

Knowledge of the velocity tells us the elasticity, and that gives us a pretty good idea what it must be made of.

We have learned that Earth consists of a crust, a mantle, and a core with a liquid outer layer and a solid inner layer. We have learned some details about each of these layers.

P waves behave differently than S waves, and this tells us more about the interior of the Earth.

THE CRUST - MANTLE BOUNDARY: THE MOHO

Seismic waves are reflected and refracted at the base of the crust. This boundary is called the Mohorovicic Discontinuity (Moho).

Seismologists have discovered that the Moho is much deeper under continents than under the ocean basins.

This tells them that continental crust is much thicker than ocean crust.

Continental crust varies in thickness from 20 to 60 km.

Ocean crust varies in thickness from 5 to 10 km.

Seismic waves are faster in ocean crust than in continental crust, because it is made of mafic igneous rock. (They have also been able to check this by drilling most of the way through it.)

Continental crust is more intermediate or felsic in composition, and consists of igneous, metamorphic and sedimentary rock.

THE MANTLE

At the base of the crust, seismic waves encounter the mantle lithosphere -- the uppermost layer of the mantle. This layer is about 100 km thick.

The mantle, including the mantle lithosphere, seems to be made almost entirely of ultramafic rock, which is more elastic than crustal rock.

Because of the greater elasticity, seismic waves speed up when they enter the lithosphere.

At the base of the lithosphere, however, seismic waves slow down! This zone below the lithosphere is called the Low Velocity Zone.

They slow down because, although the composition evidently doesn't change, the Low Velocity Zone contains a few percent of magma, spread through a thickness of several hundred kilometers.

This magma greatly reduces the elasticity.
The Low Velocity Zone is also called the asthenosphere.

The plates that make up the lithosphere slide over the asthenosphere like bread sliding over jelly in a sandwich.

Below the Low Velocity Zone, the mantle is more solid. This is because pressure gradually increases with increasing depth.

Hot material is moved away from the deep mantle by convection, so the temperature does not increase very fast with increasing depth.

As pressure increases faster than temperature, the rock becomes more solid.

The rock also becomes more elastic, and seismic waves gradually speed up as they go deeper in the mantle.

The core-mantle boundary is about 2900 km deep.

THE CORE

The core extends from 2900 km deep to the middle of the earth, 6400 km below the surface.

At the base of the mantle, P waves suddenly slow down.

Not only that, but S waves don't go through the boundary! No S waves arrive on the side of the earth opposite an Earthquake (fig. 19-2).

These facts can be explained by realizing that the outer core must be liquid!

S waves (shear waves) don't go through liquids.

P waves slow down because of the suddenly much lower elasticity. Liquids aren't very elastic.

Then, part way through the core, P waves speed up. This is because the inner core is solid.

Geophysicists are able to discover these behaviors by studying waves travelling in different directions from an earthquake.