Journey to the Centre of the Earth

Geophysics is the study of the physics of the Earth (e.g., the motions of seismic waves through the different layers of the Earth). The seismological data yielded in geophysics has allowed scientists to determine that the Earth's interior is made up of different layers, each of which has distinct physical and chemical properties.

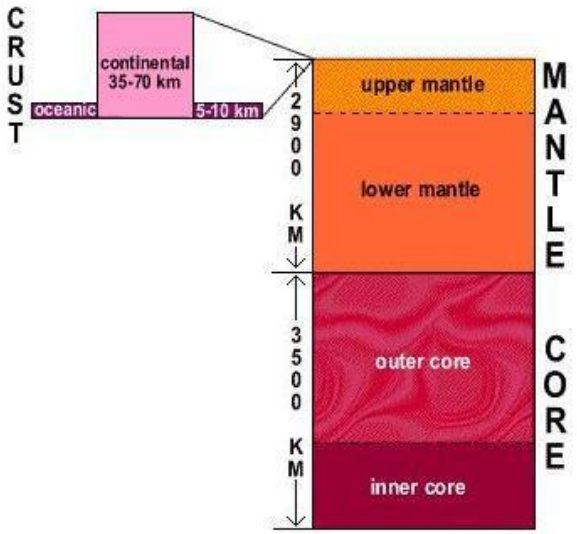
Layers cannot form in a solid state and in the early formation of the Earth, when the Earth was in a molten state, the layering of the Earth occurred. The heavier, denser elements sank to the centre and the lighter elements and compounds settled out into the layers above. There are two ways of classifying the layers: by the chemical properties and by the physical properties.

1. **Chemical Layers:**

The **crust** is the outermost layer of the Earth and is where the continents and oceans are situated. The crust varies in thickness from 35 - 70 km in the continents (it is thicker under mountains) and 5 - 10 km in the ocean basins. It is composed of mostly "light" alumino-silicates (rocks composed of silicon-oxygen and aluminium), which are less dense than the mantle.

The **mantle** is the next layer down and is composed of ferro-magnesium silicates (rocks with silicon-oxygen, iron, and magnesium). It is 2900 km thick and is divided into two layers, the upper and lower mantle. Most of the internal heat of the Earth is located in the mantle, and the large convection cells in the mantle drive the plate tectonic processes.

The **core** is divided into two layers; the outer liquid core is composed of a liquid nickel-iron alloy and is 2300 km thick, and the inner solid core at 1200 km thickness is composed almost entirely of iron. It is believed that the motion of the liquid outer core creates the Earth's magnetic field.



2. Physical Layers:

The Earth is also separated into layers based on the physical properties.

The **lithosphere** is the solid outer layer of the Earth that is composed of the crust and the solid portion of the upper mantle. The lithosphere is divided into the plates that move due to tectonic forces.

The **asthenosphere** is the "plastic" layer in which the lithosphere floats on; it is part solid and part liquid.

The **mesosphere** is mostly solid, very hot, and it flows slowly.

The **outer core** is a liquid because there is less pressure than the inner core and the high temperature keeps the rock in a molten state.

The **inner core** is solid due to the high pressures from the rest of the Earth surrounding it. The temperatures in the inner core could reach 9000°C.

The Flexible Crust:

What happens when you sit on a soccer ball? Your weight creates a depression in the ball, and when you get up the surface of the ball returns to its normal shape. Geologists observe the same phenomenon when a large mass (glacier, seamount) is on the crust; isostasy is the bending of the crust due to a large mass on top. During the last ice age part of the continental crust was bent down from the mass of the glaciers. Since the retreat of the glaciers, the crust has been rising slowly in a process called isostatic rebound, returning to its normal shape.

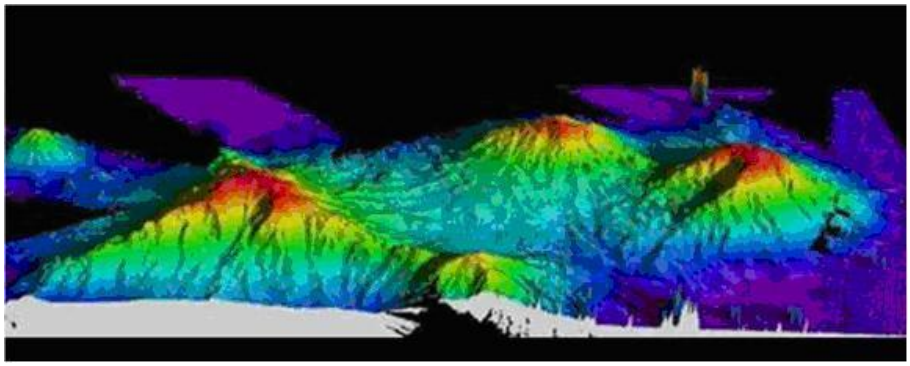
Studying the Earth's Layers

Seismology

Seismic waves have played a major role in our understanding of the layers in the Earth. The waves travel at different speeds in different mediums therefore the type of material they travelled through can be inferred from seismic data recorded from major earthquakes at stations around the world. In the assignment for this activity, you will investigate how seismology is used to determine layers of the Earth, as well as how the approximate depth of the layers can be calculated.

Sonar (Sound navigation and ranging)

Bouncing a sonar signal off of the ocean floor and measuring the length of time for the signal to return is how mapping of the ocean floor is accomplished. The length of time for the signal to return is used to calculate the distance (depth).



Example of a sonar image off the coast of New England.

LITHOPROBE

LITHOPROBE is an international scientific project investigating the evolution and nature of the lithosphere beneath the Canadian landmass and surrounding oceans. The region is divided into different transects, each of which is focussed on specific geological features that represent global tectonic processes. Seismic reflection (rebounding of seismic waves off of a change in rock layer) is the main technique used as it produces excellent images of the boundaries between rock layers and the structures. Other methods being used are stratigraphy, electromagnetic studies, paleomagnetism, and sedimentology.

Ocean Drilling Program

The Ocean Drilling program is an international operation to explore the structure and composition of the ocean basins. The project began in 1985 as the drill ship "Joides Resolution" was sent on over 100 trips taking 2000 deep sea cores. Some of the core analysis has revealed past climate changes, extinction events, and evidence of changes in paleomagnetism.