

Lecture 9: The Earth and What's Inside

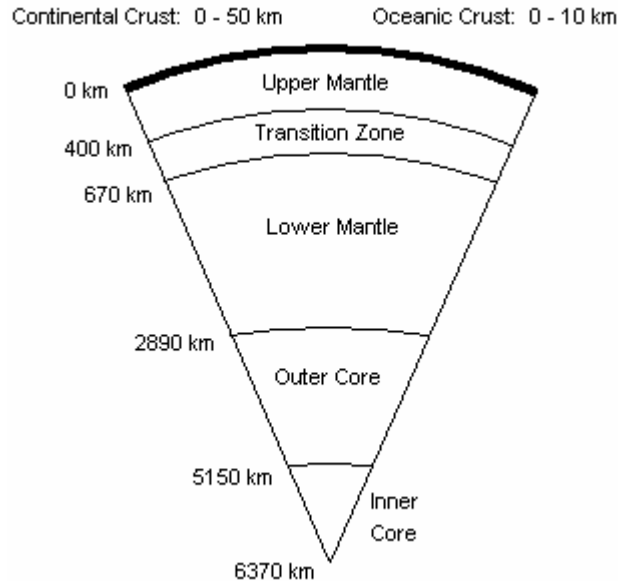
This lecture discusses the bulk composition of the Earth, its structure, and a few important minerals in the core and crust.

Earth's Bulk Composition

Scientists estimate the bulk composition of the Earth from meteorites. They assume that certain meteorites called chondrites have compositions similar to the Earth because both were formed from the same space dust, and use the chemical makeup of the meteorites to approximate the composition of the Earth. Their work has shown that the Earth is mostly iron, oxygen, silicon, magnesium, and nickel. They subtract low-T volatile elements in meteorites from the chemical inventory, though, because Earth's proximity to the Sun and its high temperatures during formation have driven these off.

Earth's Structure

Geophysical data show that the Earth is divided into a number of sections, as shown in the following diagram.



The following table shows what percent of the Earth each part makes up, its mass, and the number of minerals it contains.

Part of Earth	% of Bulk Earth	Mass (g)	# of Minerals (phases)
Ocean		1×10^{21}	
Continental Crust	0.4	2×10^{25}	> 3000
Oceanic Crust	0.1	6×10^{24}	> 3000
Upper Mantle	10.3	6×10^{26}	5
Transition Zone	7.5	4.5×10^{26}	2
Lower Mantle	49.2	2.9×10^{27}	2
Outer Core	30.8	1.8×10^{27}	1
Inner Core	1.7	1×10^{26}	1

The Core

The core represents 32.5% of the Earth's mass. Scientists believe it is mostly iron-nickel alloy, although they do not know very much about the properties of these metals at the pressures in the core (140 GPa – 350 GPa). At these pressures, for example, some scientists think that iron melts at 2000 K, and others think it melts at 4000 K.

In addition to iron and nickel, studies indicate that there is a light element in the core, presumably in the molten part. The identity of the light element is unknown, but oxygen and sulfur are likely candidates. Sulfur is Professor Groves's favorite candidate.

Before Moving to the Mantle: Digression into Sulfur and Sulfides

Sulfides are a class of minerals in which one or two metals are bonded to sulfur. The bonding can be ionic, covalent, or metallic, and as a result sulfides often exhibit a metallic luster even though they are brittle. Sulfides are economically important because a lot of precious metals are tied up in them, including silver, platinum, and palladium. Below is a list of common sulfides.

Common Sulfides

Sphalerite	ZnS
Pyrite	FeS ₂
Galena	PbS
Chalcopyrite	CuFeS ₂
Arsenopyrite	FeAsS
Molybdenite	MoS ₂
Pentlandite	(Fe, Ni) ₉ S ₈
Stibnite	Sb ₂ S ₃

Sulfides are mostly found in ore deposits in the Earth's crust. These deposits form when hydrothermal fluids leach elements that do not fit into the crystal structures of common silicate minerals and deposit them in cracks or fractures called veins. Veins can vary in thickness from a fraction of an inch to several hundred feet.

Veins are usually stratified. At the top of a vein, surface fluids dissolve some of the primary (hypogene) ore minerals and oxidize them, creating a leached zone composed of gossan. Gossan consists of hydrated iron oxides like limonite and goethite and is the smoking gun prospectors use to find sulfide ore deposits. The soluble elements leached from the surface are redeposited below and form a secondary enrichment zone of supergene minerals. This zone is important in mining because metals like copper, gold, and silver precipitate there.