Introduction

Geology

Geology is the study of the Earth. The field of geology encompasses the composition, structure, physical properties, and history of Earth's components, and the processes by which they are shaped. Geologists typically study rock, sediment, soil, rivers, and natural resources.

Branches of Geology

Engineering geology

Engineering Geology is the application of the geologic sciences to engineering practice for the purpose of assuring that the geologic factors affecting the location, design, construction, operation and maintenance of engineering works are recognized and adequately provided for. Engineering geologists investigate and provide geologic and geotechnical recommendations, analysis, and design associated with human development. The realm of the engineering geologist is essentially in the area of earth-structure interactions, or investigation of how the earth or earth processes impact human made structures and human activities.

Hydrogeology

Hydrogeology is the area of geology that deals with the distribution and movement of ground water in the soil and rocks of the Earth's crust, (commonly in aquifers). The term geohydrology is often used interchangeably.

Economic geology

Economic geology is concerned with earth materials that can be used for economic and/or industrial purposes. These materials include precious and base metals, nonmetallic minerals, construction-grade stone, petroleum minerals, coal, and water. The term commonly refers to metallic mineral deposits and mineral resources.

Environmental geology

Environmental geology involve the study of the interaction of humans with the geologic environment including the biosphere, the lithosphere, the hydrosphere, and to some extent the atmosphere. It includes:

- Managing geological and hydrogeological resources such as fossil fuels, minerals, water (surface and ground water), and land use.
- Defining and mitigating exposure of natural hazards on humans
- Managing industrial and domestic waste disposal and minimizing or eliminating effects of pollution, and
- Performing associated activities, often involving litigation.

Petrology

Petrology is a branch of geology that deals with the origin and composition of rocks. Petrologists analyze the physical and chemical conditions involved in the formation of the three major types of rocks: igneous, metamorphic, and sedimentary. Such analysis helps provide clues to the origin and development of the earth.

Structural geology

Structural geology is the study of the three-dimensional distribution of rock units with respect to their deformational histories. It is concerned with the physical and mechanical properties of natural rocks. Structural fabrics and defects such as faults, folds, foliations and joints are internal weaknesses of rocks which may affect the stability of human engineered structures such as dams, road cuts, open pit mines and underground mines or road tunnels.

Stratigraphy

Stratigraphy studies rock layers and layering (stratification). It is primarily used in the study of sedimentary and layered volcanic rocks.

Sedimentology

Sedimentology encompasses the study of modern sediments such as sand, mud (silt), and clay, and the processes that result in their deposition.

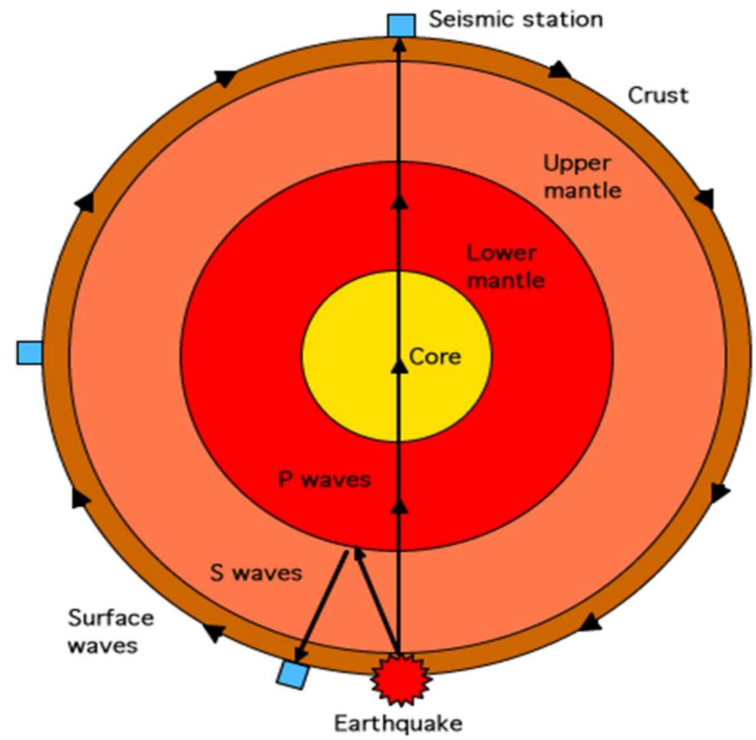
Paleontology

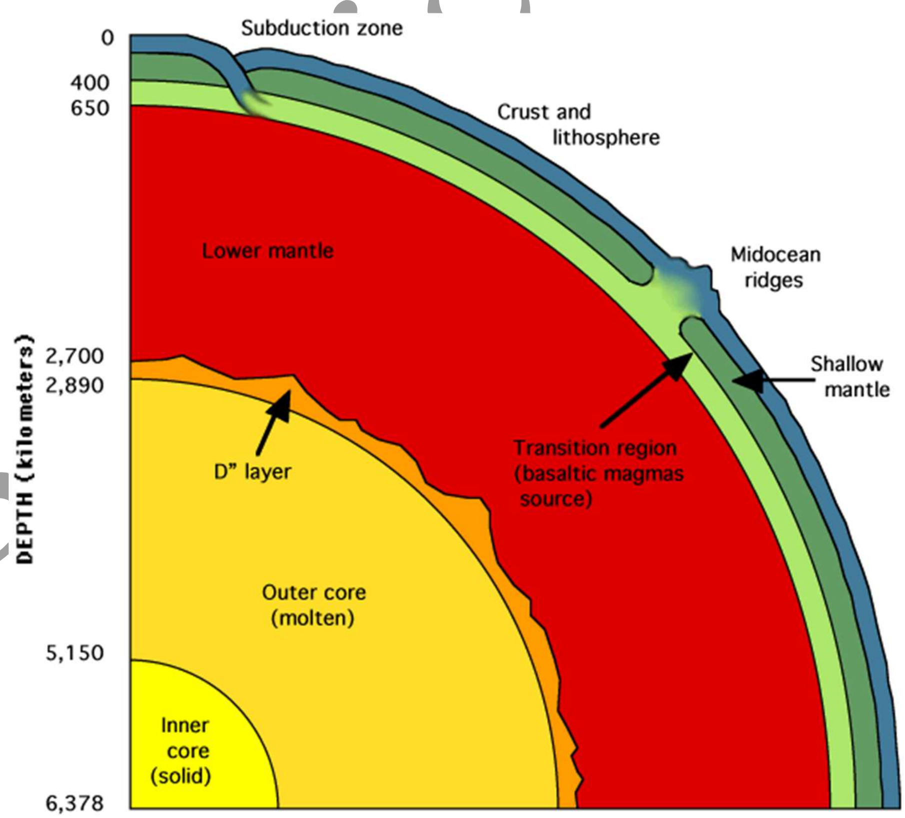
Paleontology is the study of prehistoric life, including organisms' evolution and interactions with each other and their environments.

The Earth's Interior

Seismic discontinuities aid in distinguishing divisions of the Earth into inner core, outer core, D", lower mantle, transition region, upper mantle, and crust (oceanic and continental). Lateral discontinuities also have been distinguished and mapped through seismic tomography but shall not be discussed here.

- **Inner core:** 1.7% of the Earth's mass; depth of 5,150-6,370 kilometers (3,219 - 3,981 miles). The inner core is solid and unattached to the mantle, suspended in the molten outer core. It is believed to have solidified as a result of pressure-freezing which occurs to most liquids when temperature decreases or pressure increases.
- **Outer core:** 30.8% of Earth's mass; depth of 2,890-5,150 kilometers (1,806 - 3,219 miles). The outer core is a hot, electrically conducting liquid within which convective motion occurs. This conductive layer combines with Earth's rotation to create a dynamo effect that maintains a system of electrical currents known as the Earth's magnetic field. It is also responsible for the subtle jerking of Earth's rotation. This layer is not as dense as pure molten iron, which indicates the presence of lighter elements. Scientists suspect that about 10% of the layer is composed of sulfur and/or oxygen because these elements are abundant in the cosmos and dissolve readily in molten iron.
- **D":** 3% of Earth's mass; depth of 2,700-2,890 kilometers (1,688 - 1,806 miles). This layer is 200 to 300 kilometers (125 to 188 miles) thick and represents about 4% of the mantle-crust mass. Although it is often identified as part of the lower mantle, seismic discontinuities suggest the D" layer might differ chemically from the lower mantle lying above it. Scientists theorize that the material either dissolved in the core, or was able to sink through the mantle but not into the core because of its density.





- **Lower mantle:** 49.2% of Earth's mass; depth of 650-2,890 kilometers (406 -1,806 miles) The lower mantle contains 72.9% of the mantle-crust mass and is probably composed mainly of silicon, magnesium, and oxygen. It probably also contains some iron, calcium, and aluminum. Scientists make these deductions by assuming the Earth has a similar abundance and proportion of cosmic elements as found in the Sun and primitive meteorites.

- **Transition region:** 7.5% of Earth's mass; depth of 400-650 kilometers (250-406 miles) The transition region or mesosphere (for middle mantle), sometimes called the fertile layer, contains 11.1% of the mantle-crust mass and is the source of basaltic magmas. It also contains calcium, aluminum, and garnet, which is a complex aluminum-bearing silicate mineral. This layer is dense when cold because of the garnet. It is buoyant when hot because these minerals melt easily to form basalt which can then rise through the upper layers as magma.
- **Upper mantle:** 10.3% of Earth's mass; depth of 10-400 kilometers (6 - 250 miles) The upper mantle contains 15.3% of the mantle-crust mass. Fragments have been excavated for our observation by eroded mountain belts and volcanic eruptions. Olivine $(Mg,Fe)_2SiO_4$ and pyroxene $(Mg,Fe)SiO_3$ have been the primary minerals found in this way. These and other minerals are refractory and crystalline at high temperatures; therefore, most settle out of rising magma, either forming new crustal material or never leaving the mantle. Part of the upper mantle called the asthenosphere might be partially molten.
- **Oceanic crust:** 0.099% of Earth's mass; depth of 0-10 kilometers (0 - 6 miles) The oceanic crust contains 0.147% of the mantle-crust mass. The majority of the Earth's crust was made through volcanic activity. The oceanic ridge system, a 40,000-kilometer (25,000 mile) network of volcanoes, generates new oceanic crust at the rate of 17 km^3 per year, covering the ocean floor with basalt. Hawaii and Iceland are two examples of the accumulation of basalt piles.
- **Continental crust:** 0.374% of Earth's mass; depth of 0-50 kilometers (0 - 31 miles). The continental crust contains 0.554% of the mantle-crust mass. This is the outer part of the Earth composed essentially of crystalline rocks. These are low-density buoyant minerals dominated mostly by quartz (SiO_2) and feldspars (metal-poor silicates). The crust (both oceanic and continental) is the surface of the Earth; as such, it is the coldest part of our planet. Because cold rocks deform slowly, we refer to this rigid outer shell as the lithosphere (the rocky or strong layer).
- **The Mohorovičić:** discontinuity referred to as the Moho, is the boundary between the Earth's crust and the mantle. The Mohorovičić discontinuity was first identified in 1909 by Mohorovičić, when he observed that seismograms from shallow-focus earthquakes had two sets of P-waves and S-waves, one that followed a direct path near the Earth's surface and the other refracted by a high velocity medium. The Mohorovičić discontinuity is 5 to 10 kilometers (3–6 mi) below the ocean floor, and 20 to 90 kilometers (10–60 mi), with an average of 35 kilometers (22 mi), beneath typical continents.
- **The Lehmann discontinuity** refers to an abrupt increase of P-wave and S-wave velocities in the vicinity of 220±30 km depth, discovered by seismologist Inge Lehmann. It appears beneath continents, but not usually beneath oceans, and does not readily appear in globally averaged studies