1. Introduction to Physical Geology

Geology - study of the Earth.

Until 18th century, Earth was viewed as unchanging.

Age of the Earth assumed to be ~6,000 years based on the literal acceptance of the Old Testament - origin 4004 BC (James Ussher, Bishop of Armagh, 1581-1656)

Catastrophism – 17th - 18th century doctrine -
Earth's landscape shaped primarily by great catastrophes.

- Sudden and violent change.
- Fits rates of earth processes to young view of Earth's age.

James Hutton - late 18th century - rocks of his native Scotland were the result of processes presently going on at the earth's surface.
e.g. erosion, deposition, and volcanic activity.

Given enough time, the present rates of activity would be sufficient to produce all features of the rocks, and all of their observable relationships and configurations.

Uniformitarianism - physical, chemical, and biological laws that have operated today also operated in the geologic past.

- "The present is the key to the past".

Geologic processes occur over long periods of time. Small forces operating over great periods of time could produce major structures.

Charles Lyell - produced various versions of Principles of Geology (1830-1872) where he championed uniformitarianism.

- Implies a much older earth.

Geologic Time and the Geologic Time Scale

Radioactivity (breakdown of unstable atoms) at the turn of the 20th century allowed fairly accurate dates to be assigned to specific events in earth history.

- **Absolute dates**

Relative dating - events placed in proper sequence through the law of superposition

- each layer is older than the one above it

Fossils - the remains or traces of prehistoric life.

Principle of Faunal Succession - fossil organisms succeed each other in a definite and determinable order, and any period can be recognized by its fossil content.

Basis for establishing the time scale - changing character of life forms through time.

AGES OF THE UNIVERSE AND THE PLANETS

Most theories of the origin of our solar system are based on the premise that its planets formed almost simultaneously.

Meteorites are believed to represent the primitive material of the solar system.

Meteorites - 4.6 Ba (billion years old).
Oldest moon rocks - 4.6 Ba.
Oldest earth rocks - 3.6 - 4 Ba.

The universe believed to be 15 - 18 Ba.

Big Bang - origin of the universe.
matter was concentrated with infinite density at a single point, from which it exploded (~15-18 Ba)

- hypothetical release of all the energy, matter, and antimatter in existence.

Origin of the Earth

Nebular hypothesis -

1) the bodies of the solar system formed from an enormous cloud of gas of hydrogen (80%) and helium (15 %) and a small % of heavy elements (silicon, aluminum, iron, and calcium - substances of the common rocky materials).

2) About 5 Ba this huge cloud of minute rocky fragments and gases began to contract and rotate into a flat, rapidly rotating disk with matter at the center.

3) Greatest concentration of material pulled toward the center - protosun. Rings of material are left behind due to eddy-like contractions.

4) The material in the rings condenses into planets revolving in orbit around the sun.

5) The four inner or terrestrial planets - (Mercury, Venus, Earth and Mars) are closest to the sun and have a similar history. They grew where it was too hot for other light gases to be retained (hydrogen, helium, water, etc.). These materials were blown away, leaving heavier materials behind, such as iron, nickel, and other heavy compounds which form rocks. They became dense, rocky material.

Divisions of the Earth

Initially after its formation, the planet warmed to ~2000^{o}C due to:

1) collision of planetesimals with primitive Earth;

2) compression of planet under its own growing weight;

3) disintegration of radioactive elements.

- 2000^{o}C - temperature at which iron melts.

Because iron is heavier it sank to form an iron core at the center.

Lighter materials were separated, cooled, and formed a primitive crust.

Earth divided into distinct shells or spheres:

Inner Core - a solid iron rich zone.
- Single crystal of iron growing at the expense of the outer core. • rotating faster than the rest of the earth.

Outer Core - a molten metallic layer

Mantle - solid rocky layer.

Crust - lighter outer skin ranging from 5-40 km.

Lithosphere
- includes crust and uppermost mantle
- cool and rigid.
- Strong, solid, outermost shell
- 50-100 km thick.

Asthenosphere
- hot weak zone capable of gradual flow.
- at depths of 100-350 km (possibly to 700 km)

Two principal divisions of the earth's surface:
- **continents** - elevated regions of lower density crust.
- **ocean basins** - depressed areas of higher density crust.
  -contains mid-ocean ridge system continuous for 40,000 mi.

Continental crust similar to granite- density 2.7. Thicker-35 mi.
Oceanic crust is similar to basalt - density of 3.0. Thin; 3-5 mi.

Continental shelf - A gently sloping platform of continental material, extends seaward from the shore.
The boundary between the continents and the deep ocean basins is placed at the shelf break.

Continental slope, a steep drop-off, leads from the edge of the continental shelf into the deep ocean basin.

Continental slope grades into the abyssal plain, very level areas of the deep ocean floor. Overhead

Plate Tectonics

Earth's rigid outer shell (lithosphere) is broken into several individual pieces called **plates**. There are 7 huge slabs and ~20 smaller plates. Plates can either move apart, come together, or slide past one another.

Plates float on the weak, partially molten region of the upper mantle called the asthenosphere.

Divergent boundaries - where plates spread or move apart.
Occurs at mid-ocean ridges. As plate separates, gap is filled with molten rock from below. Material cools to form new piece of seafloor.

Convergent boundaries - where plates come together. Where lithosphere is destroyed. Subduction zone. Results in mountain building.

Transform boundaries - where plates slide past each other and crust is neither created or destroyed. Preserve geometry of spherical earth.

Rock Cycle

Igneous Rock - originates when molten material - **magma** cools and solidifies - **crystallization**.

- **intrusive** if cooled at depth
- **extrusive** if cooled at the surface.

When exposed at the surface, they undergo **weathering** - disintegration and decomposition.

Eventually transported as sediment; may be lithified into **sedimentary rock**.

If buried and subjected to heat and pressure, can be turned into **metamorphic rock**.