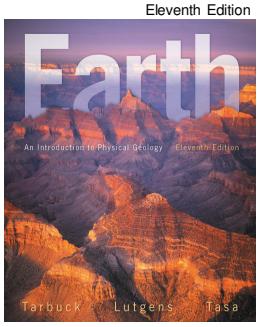
Chapter 1 Lecture

An Introduction to Geology

Earth: An Introduction to Physical Geology

Eleventh Edition



Tarbuck and Lutgens

The Science of Geology

- Geology is the science that pursues an understanding of planet Earth
  - Physical geology examines Earth materials and seeks to understand the many processes that operate on our planet
  - Historical geology seeks an understanding of the origin of Earth and its development through time

The Science of Geology, Continued

- Geology, people, and the environment
  - More people now live in cities than in rural areas
  - Populations are affected by geologic hazards and rely on natural resources
    - Geologic hazards are natural processes that adversely affect people
    - Natural resources addressed by geology include:
      - Water, soil, metallic and nonmetallic minerals, and energy

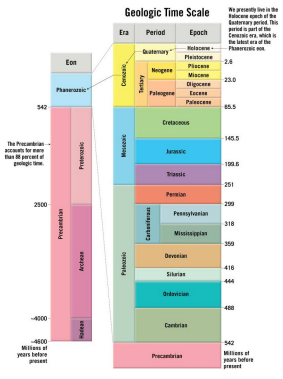
The Development of Geology

- The nature of Earth has been a focus of study for centuries
  - Catastrophism – Earth's landscapes were shaped primarily by catastrophes
  - Uniformitarianism – the physical, chemical, and biologic laws that operate today have operated throughout the geologic past

The Development of Geology

- The magnitude of geologic time involves millions and billions of years
- Earth is 4.6 billion years old
- An appreciation for the magnitude of geologic time is important because many processes are very gradual

The Geologic Time Scale



The Nature of Scientific Inquiry

- Science assumes the natural world is consistent and predictable
- The goal of science is to discover patterns in nature and use the knowledge to make predictions
- Scientists collect data through observation and measurements

The Nature of Scientific Inquiry, Continued

- How or why things happen are explained using:
- Hypothesis – a tentative (or untested) explanation
- Theory – a well-tested and widely accepted view that the scientific community agrees best explains certain observable facts

The Nature of Scientific Inquiry, Continued

- There is no fixed path that scientists follow that leads to scientific knowledge
- However, many scientific investigations involve:
  - A question is raised about the natural world
  - Scientific data are collected
  - One or more hypotheses are developed
  - Experiments are developed to test the hypotheses
  - Hypotheses are accepted, modified, or rejected
  - Data and results are shared with the scientific community

A View of Earth

- Earth is a small, self-contained planet
- Earth's four spheres are:
  - Hydrosphere – the water portion
  - Atmosphere – the gaseous envelope
  - Geosphere – the solid Earth
  - Biosphere – all plant and animal life

A View of Earth

This image taken from *Apollo 17* in December 1972 is perhaps the first to be called "The Blue Marble". The dark blue ocean and swirling cloud patterns remind us of the importance of the oceans and atmosphere.

Earth as a System

- Earth is a dynamic planet with many interacting parts or spheres
- A system is a group of interacting parts that form a complex whole
- Earth system science:
  - Aims to study Earth as a system composed of numerous interacting parts
  - Employs an interdisciplinary approach to solve global environmental problems

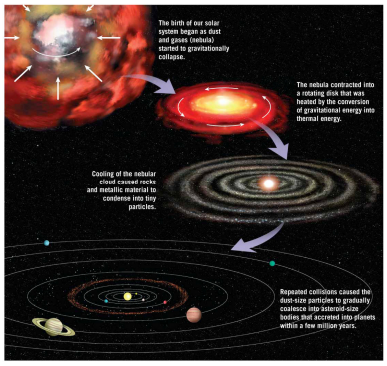
Early Evolution of Earth

- The universe began with the Big Bang
- Earth and the other planets formed at essentially the same time out of the same material as the Sun
- The Nebular Theory proposes that the bodies of our solar system evolved from an enormous rotating cloud called the solar nebula

Early Evolution of Earth, Continued

- Nebular Theory
  - The solar nebula consisted of hydrogen and helium, in addition to microscopic dust grains
  - A disturbance caused the solar nebula to slowly contract and rotate
  - The solar nebula assumed a flat, disk shape with the protosun (pre-Sun) at the center
  - Inner planets began to form from metallic and rocky substances
  - Larger outer planets began forming from fragments of ices (H_2O, CO_2, and others)

The Nebular Theory



Early Evolution of Earth

- Formation of Earth's layered structure
  - Metals sank to the center
  - Molten rock rose to produce a primitive crust
- Chemical segregation established the three basic divisions of Earth's interior
- A primitive atmosphere evolved from volcanic gases
- The earliest primitive crust was lost to erosion and geologic processes

Earth's Internal Structure

- Earth is divided into three major layers by composition:
  - Crust – Earth's thin, rocky outer skin, divided into the continental and oceanic crust
    - Oceanic crust is approximately 7 kilometers thick and composed of basalt
    - Continental crust is 35 – 70 kilometers and composed primarily of granodiorite
  - Mantle – is approximately 2900 kilometers thick and composed of peridotite
  - Core – is composed of an iron-nickel alloy

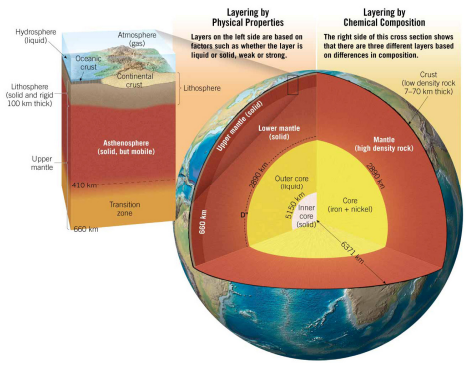
Earth's Internal Structure

- Additionally, Earth is divided into different zones based on physical properties:
- Lithosphere – the rigid outer layer of Earth that consists of the crust and the upper mantle
- Asthenosphere – the soft, weak layer below the lithosphere
- Transition zone – a zone marked by a sharp increase in density below the asthenosphere

Earth's Internal Structure

- Additionally, Earth is divided into different zones based on physical properties:
- Lower Mantle – a zone of strong, very hot rocks subjected to gradual flow below the transition zone
- Outer core – liquid outer layer of the core
- Inner core – solid inner layer of the core

Earth's Internal Structure



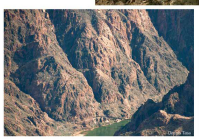
Rocks and the Rock Cycle

- Rocks are divided into three major groups:
  - Igneous rocks
    - Cooling and solidification of magma (molten rock)
  - Sedimentary rocks
    - Sediments are derived from weathering of preexisting rocks
    - Sediments will lithify into sedimentary rocks
    - Accumulate in layers at Earth's surface

The Three Rock Groups

Igneous rocks form when molten rock solidifies at the surface (extrusive) or beneath the surface (intrusive). The lava flow in the foreground is the fine-grained rock basalt and came from SP Crater in northern Arizona.

Sedimentary rocks consist of particles derived from the weathering of other rocks. This layer consists of durable sand-size grains of the glossy mineral quartz that are cemented into a solid rock. The grains were once a part of extensive dunes. This rock layer, called the Navajo Sandstone, is prominent in southern Utah.

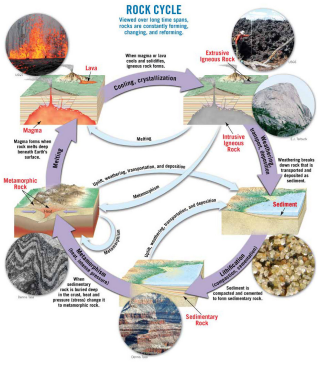


The metamorphic rock pictured here, known as the Vishnu Schist, is exposed in the inner gorge of the Grand Canyon. Its formation is associated with environments deep below Earth's surface where temperatures and pressures are high and with the forces associated with ancient mountain-building processes that occurred in Precambrian time.

Rocks and the Rock Cycle

- Rocks are divided into three major groups:
  - Metamorphic rocks
    - Formed by "changing" preexisting igneous, sedimentary, or other metamorphic rocks
    - Driving forces are heat and pressure
- The rock cycle allows us to visualize the interrelationships among different parts of the Earth system

The Rock Cycle



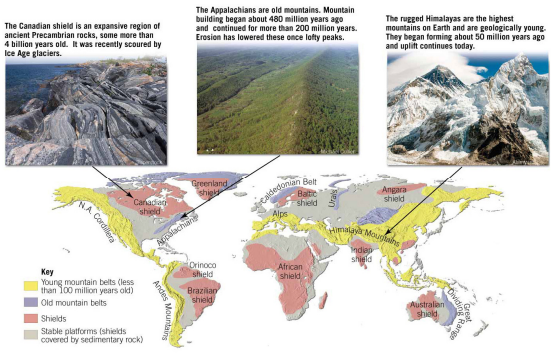
The Face of Earth

- Earth's surface is divided into continents and ocean basins. The difference between these two areas is relative levels
  - The elevation difference is a result of differences between density and thickness
- Continents are relatively flat plateaus approximately 0.8 kilometers above sea level composed of granitic rocks
- The average depth of ocean basins, composed of basaltic rocks, is 3.8 kilometers below sea level

The Face of Earth

- Features of continents include mountain belts, cratons, shields, and stable platforms
  - Mountain belts are the most prominent features of continents
  - Cratons are the stable interior of the continents
  - Shields are expansive, flat regions of deformed crystalline rocks in the cratons
  - Stable platforms are the flat portions of cratons covered with a thin veneer of sedimentary rocks

The Continents



The Face of Earth

- Features of the ocean floor include continental margins, deep-ocean basins, and oceanic ridges
  - Continental margins are the portion of the sea-floor adjacent to major landmasses
    - The continental shelf is a gently sloping region of continental crust extending from the shore
    - The continental slope is a relatively steep dropoff that extends from the continental shelf to the deep ocean floor
    - The continental rise consists of a thick wedge of sediment that moved downward from the continental shelf and slope to accumulate on the sea-floor

The Face of Earth

- Features of the ocean floor include continental margins, deep-ocean basins, and oceanic ridges
  - Deep ocean basins are the portions of the sea-floor between the continental margins and the oceanic ridges
    - The abyssal plain is a flat feature of the deep ocean basin
    - Deep-ocean trenches are deep and relatively narrow depressions that make up only a small portion of the ocean floor
    - Seamounts are small volcanic structures that dot the ocean floor

The Face of Earth

- Features of the ocean floor include continental margins, deep-ocean basins, and oceanic ridges
  - Oceanic ridges are the most prominent feature on the ocean floor and are composed of igneous rock that has been fractured and uplifted

End of Chapter 1