Concordia University
Engineering and Computer Science

CIVI-231 Geology for Civil Engineers

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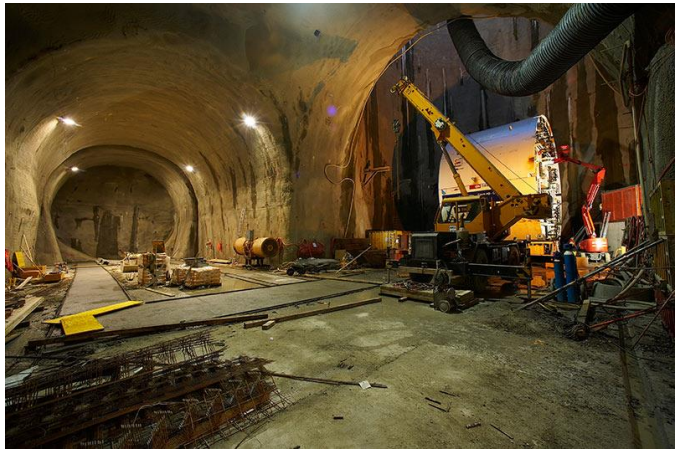
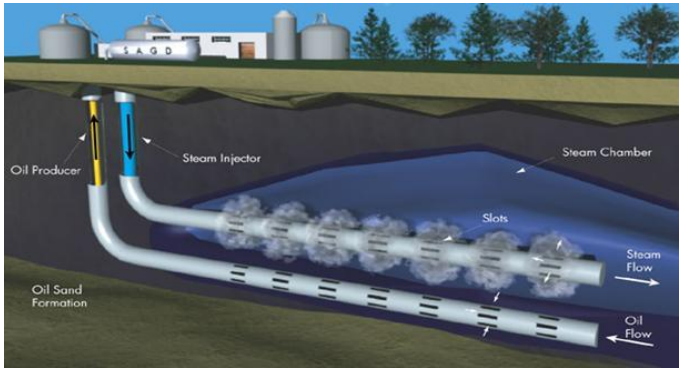
why civil engineers need Geology?

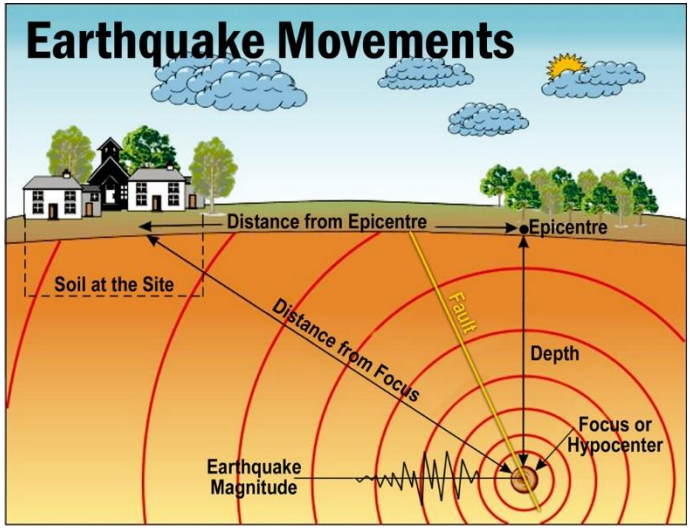
Tunnel



Oil production



Pipeline



OR

With solid background in Geology?

More opportunities in jobs!

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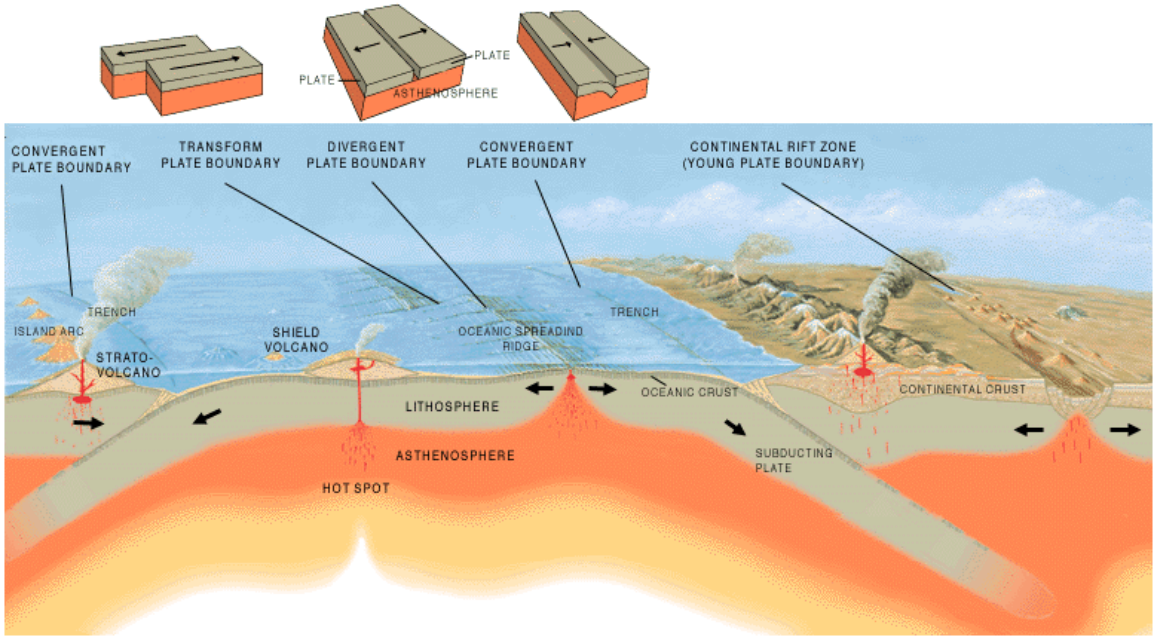
Course outline

Chapter 1: An Introduction to Geology and Plate Tectonics

Figure 1.1 These sharp peaks in the French Alps are being sculpted by alpine glaciers. Geologists study the processes that create and modify these mountains.



The Science of Geology

Geology (*geo* = earth; *logos* = discourse)

- **Physical geology** – studies Earth materials; seeks to understand processes that operate on and beneath its surface
- **Historical geology** – seeks to understand the origin of Earth and its development through time

The Science of Geology

Geology, people, and the environment

- Relationships between people and the natural environment include:
  - Natural hazards
  - Resources
  - World population growth
  - Environmental issues

The Science of Geology

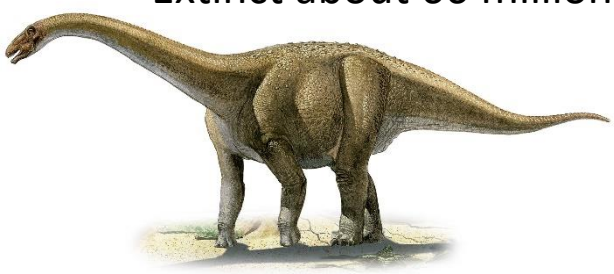
Some historical notes about geology

- **Catastrophism** – 17th century, Earth's landscapes were formed by sudden disasters
- **Uniformitarianism** - *"The present is the key to the past".* Proposed in the 18th century by James Hutton, and states that the processes we observe on our planet today have been shaping our planet throughout time.

Geologic Time

- Scientists such as James Hutton knew Earth must be very old.
- Before the discovery of radioactivity, it was difficult to determine the age of Earth.
- Our current age-dating techniques are constantly being refined.

Extinct about 66 million years ago



4.6 billion years

Geologic Time

Relative dating and the geologic time scale

- Relative dating – Events are placed in their proper sequence or order without knowing their age in years
- Law of Superposition – Younger rock layers are deposited over older rock layers.
- Principle of Fossil Succession – Fossil organisms success each other in a determinable order.

Geologic Time

The magnitude of geologic time

- Involves vast times – millions or billions of years
- The Earth is 4.6 billion years old!
- An appreciation for the magnitude of geologic time is important because many processes are very gradual

Geologic Time

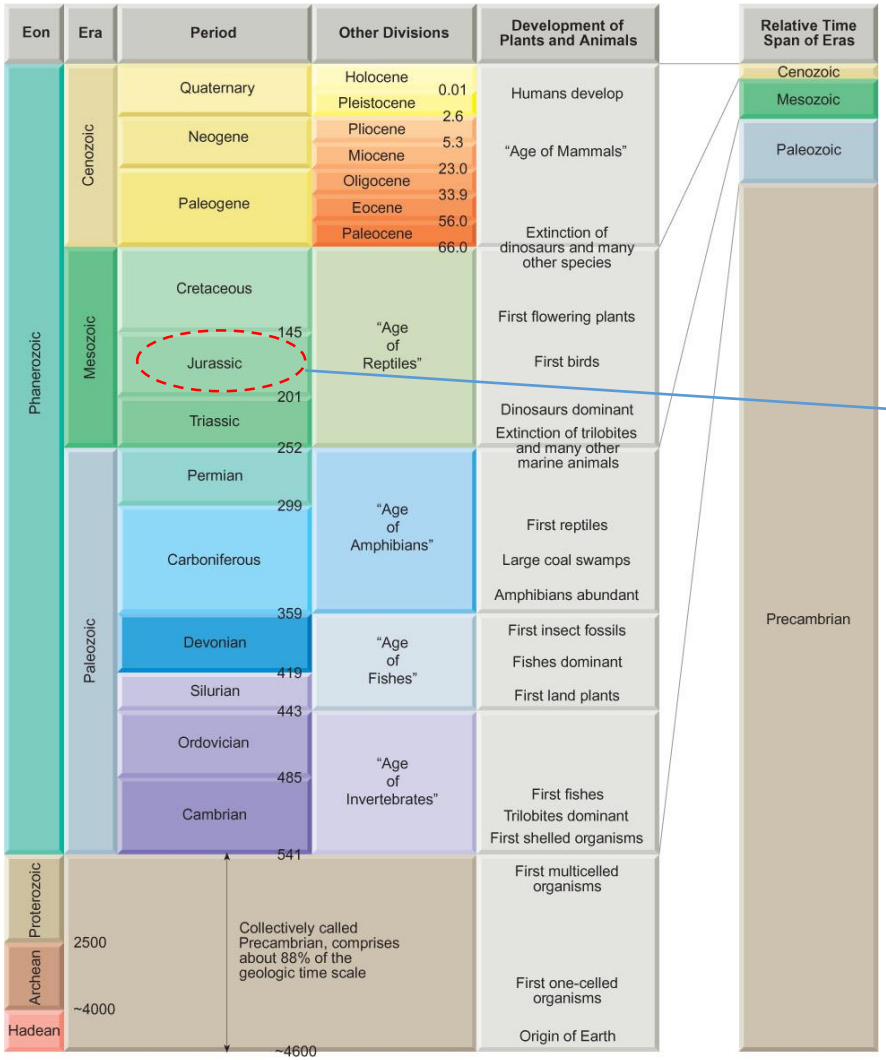


Figure 1.6 The geologic time scale. Numbers on the time scale represent time in millions of years before the present. These ages were added long after the time scale had been established by using relative dating techniques. The Precambrian accounts for more than 88 percent of geologic time.
(Adapted from the International Commission on Stratigraphy. Chart drafted by K. M. Cohen, S. Finney, and P. L. Gibbard.

Early Evolution of Earth

Origin of Planet Earth

- ***Big Bang* theory** – Large explosion sent all matter in the universe flying outward at incredible speeds
- **Nebular hypothesis** – Bodies in solar system evolved from a rotating cloud called a *solar nebula*
- ***Protosun* and *protoplanets*** - Formed from a contracting, slowly spiraling nebula

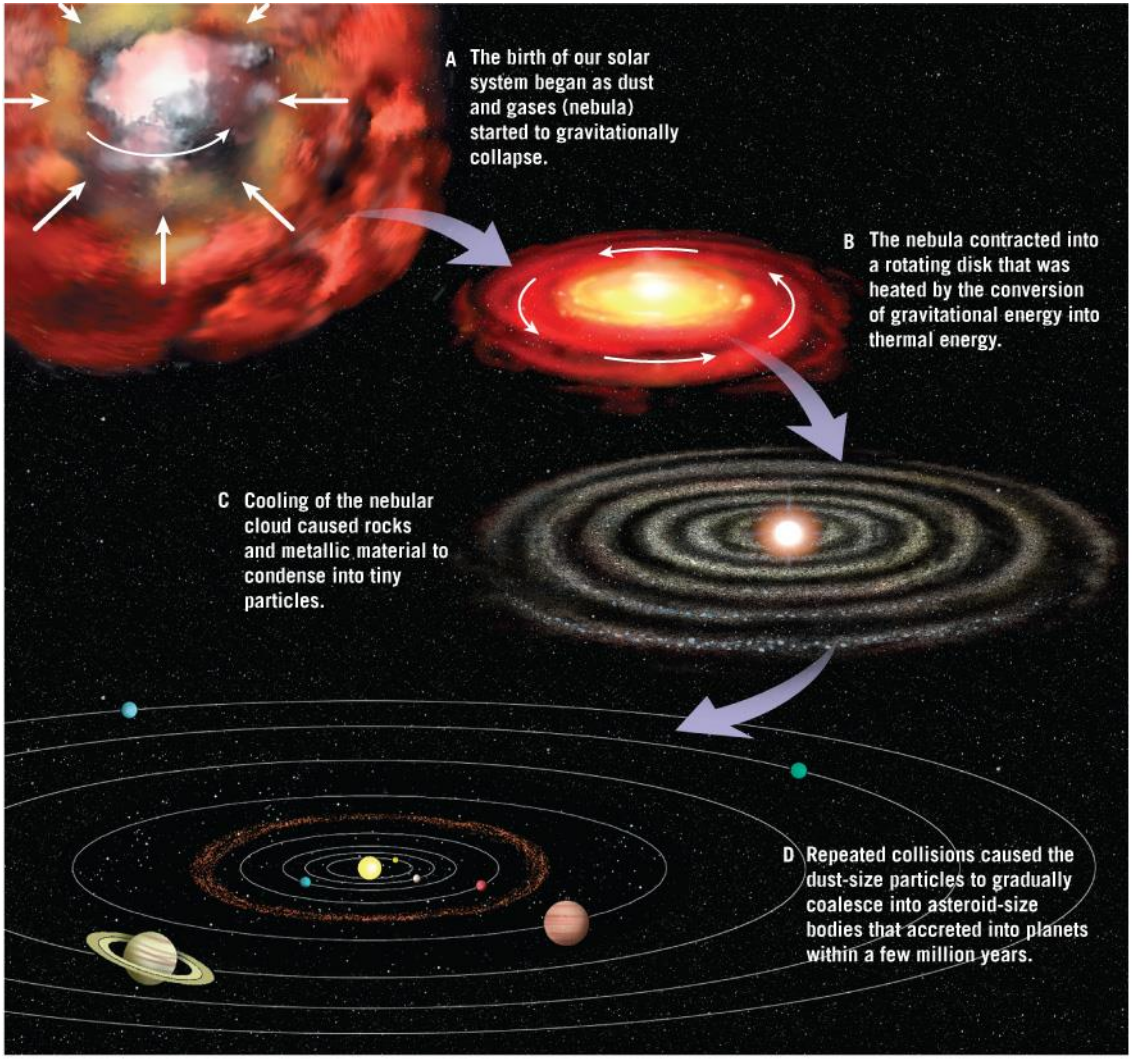


Figure 1.8 Nebular theory. **A.** A huge rotating cloud of dust and gases (nebula) begins to contract. **B.** Most of the material is gravitationally swept toward the centre, producing the Sun. However, owing to rotational motion, some dust and gases remain orbiting the central body as a flattened disk. **C.** The planets begin to accrete from the material that is orbiting within the flattened disk. **D.** In time most of the remaining debris collects into the planets and their moons.

SMARTFIGURE 1.8
Nebular theory
Formation of the solar system according to the nebular theory.

Video

Early Evolution of Earth

Formation of Earth's Layered Structure

- Chemical segregation early in the formation of Earth by gravity
- Core – Inner layer: dense, iron-rich
- Crust – Outer layer: solid, thin
- Mantle – Largest layer between core and crust composed of iron, magnesium and oxygen-seeking elements

Plate Tectonics: A Geologic Paradigm

- **Continental drift** – Alfred Wegener (1915) proposed continents moved about the face of the planet
- **Plate Tectonics** – current understanding of how continents move

Continental Drift: An Idea Before its Time

Evidence across the Atlantic Ocean:

- Fit of Continents – Fit together like a jigsaw puzzle.
- Fossil evidence – Same fossils found on separated continents.
- Rock type and Structural Similarities – Rocks on one continent match those on another continent.
- Paleo-climatic evidence – Evidence for ancient glacial ice explained by a super-continent.

Planet of Shifting Plates

Plate Tectonics:

- The lithosphere is broken-up into pieces called “plates”.
- There are seven major plates.
- Lithospheric plates move relative to one another at very slow rates.
- Movement driven by convection in mantle.
- Averages about 5 cm / year.

Planet of Shifting Plates

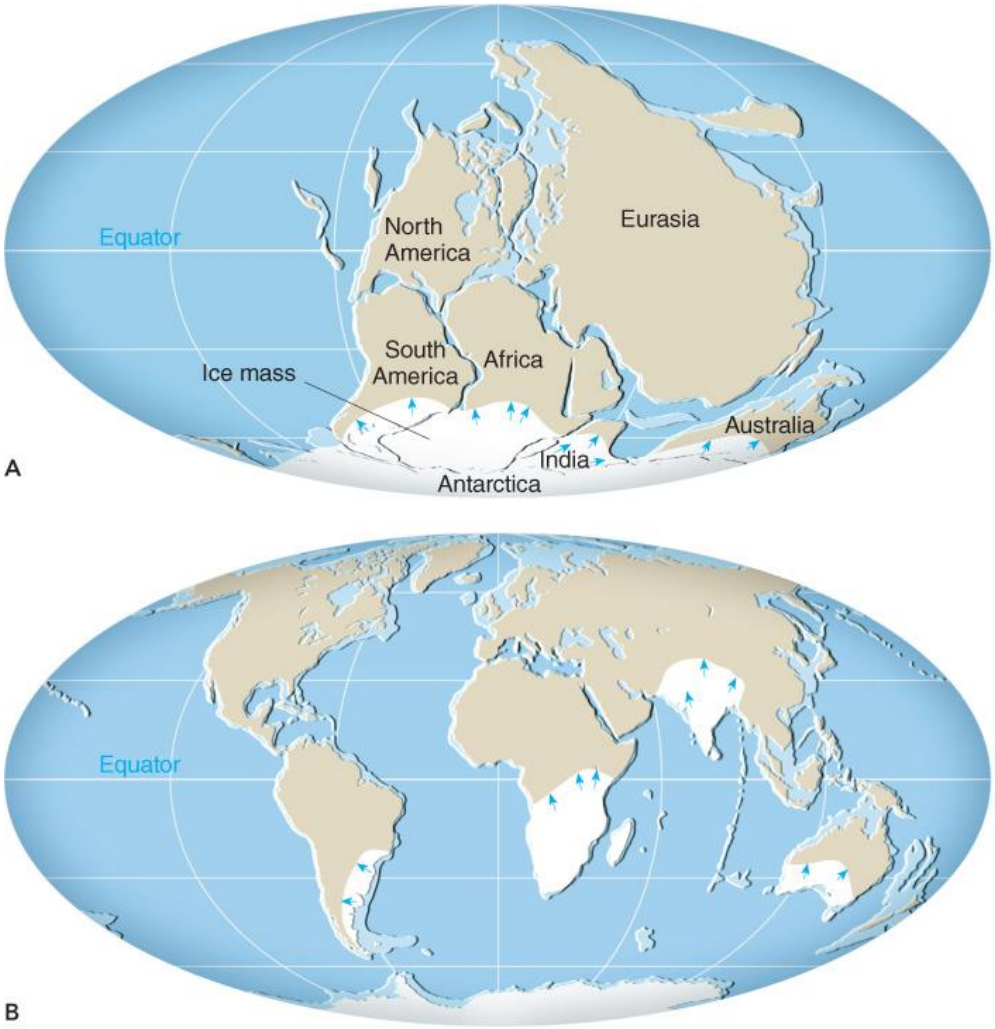


Figure 1.15 **A.** The supercontinent Pangaea, showing the area covered by glacial ice 300 million years ago. **B.** The continents as they are today. White areas contain evidence of the old ice sheet.

Planet of Shifting Plates

Plate boundaries

- Divergent boundary
  - Two plates move apart, resulting in upwelling of material from the mantle to create new seafloor.
  - Occurs mainly at mid-ocean ridges.
  - Can occur under continents at rift valleys.

Planet of Shifting Plates

Plate boundaries

- Convergent boundaries
  - Two plates move towards each other.
  - Continental settings: two continental plates collide.
  - Oceanic settings: oceanic crust descends into mantle. This margin of crust consumption into the mantle is called a “subduction zone”.

Planet of Shifting Plates

Plate boundaries

- Transform fault boundaries
  - Plates slide past each other without either generating new lithosphere or consuming old lithosphere.
  - These faults form in the same direction as plate movement.

Planet of Shifting Plates

Mosaic of rigid plates that constitute Earth's outer shell.

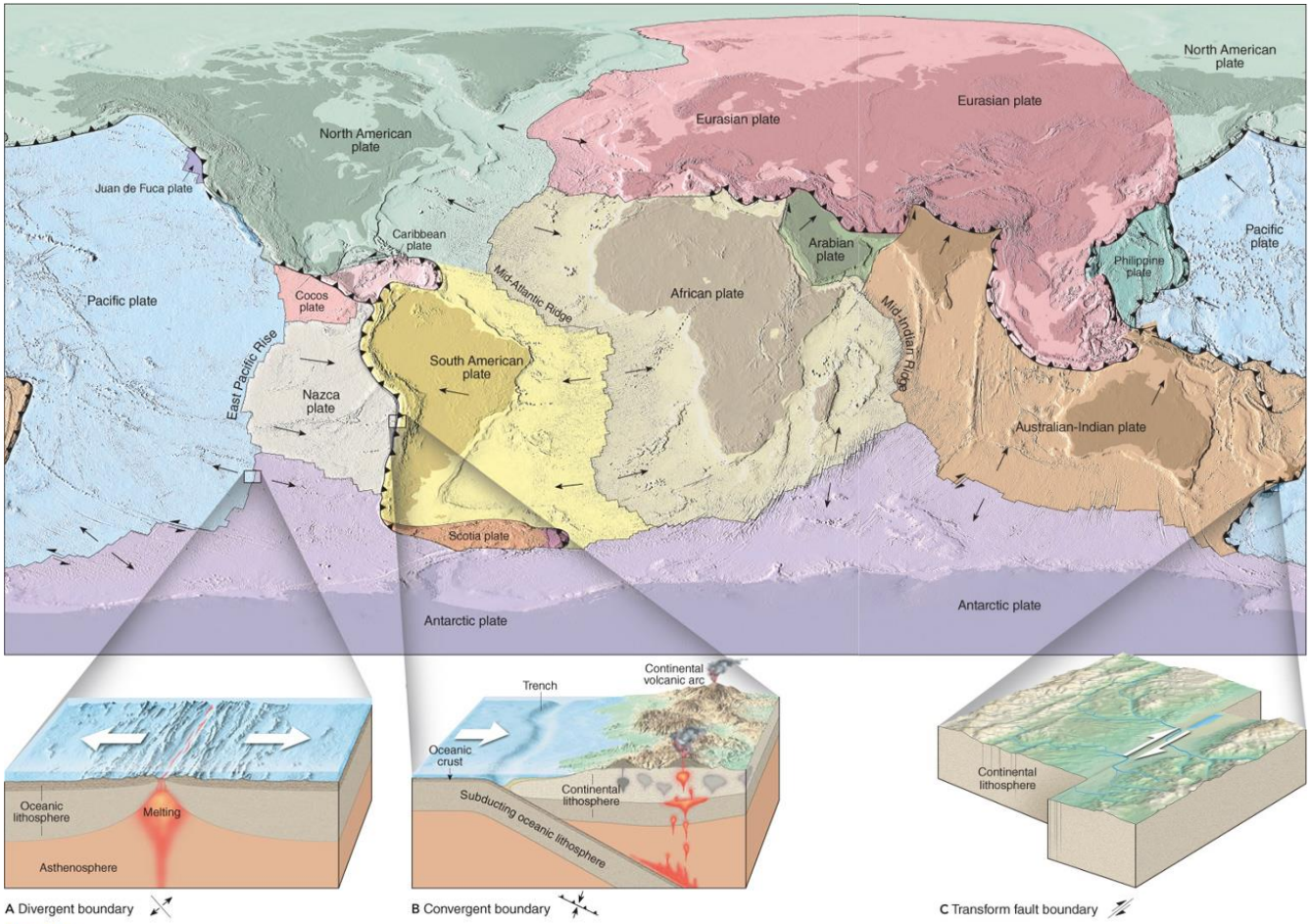


Figure 1.16 Mosaic of rigid lithospheric plates that constitute Earth's outer shell. (From W. B. Hamilton, U.S. Geological Survey)

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Earth's Internal Structure

Two Types of Defining Earth's Internal Structure:

Composition:

- Crust
- Mantle
- Core

Physical Properties:

- Lithosphere
- Asthenosphere
- Mesosphere
- Inner Core
- Outer Core

Earth's Internal Structure

View of Earth's layered structure

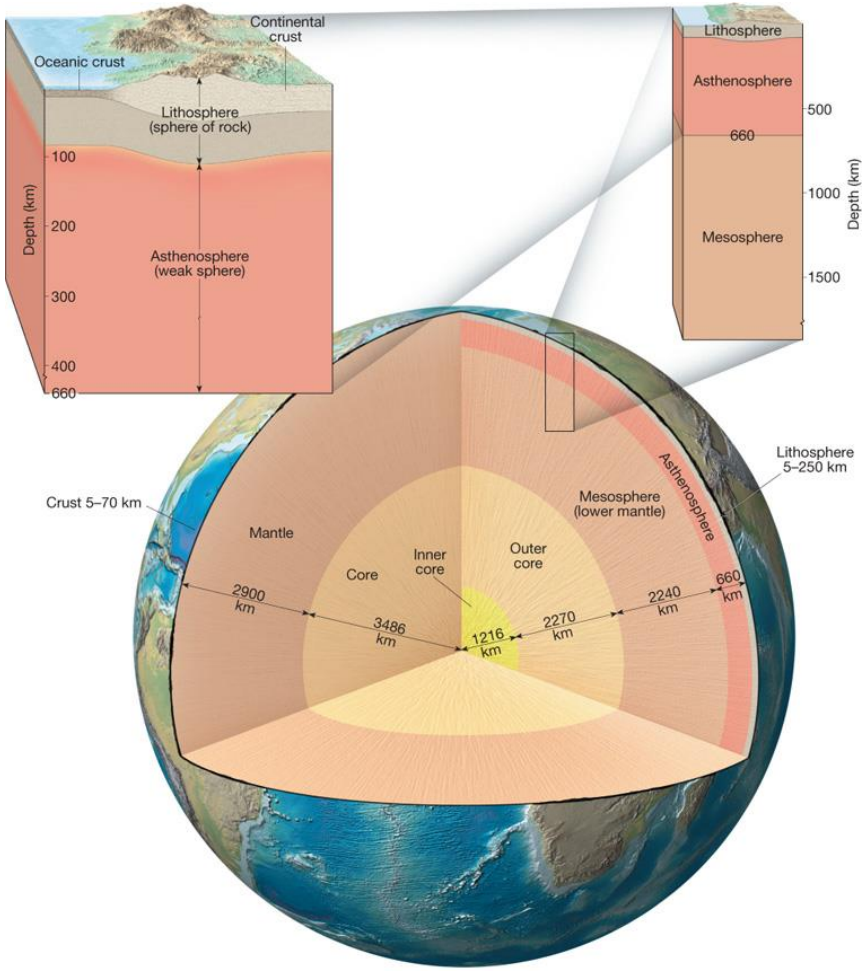

Figure 1.17 Views of Earth's layered structure. The left side of the large cross-section shows that Earth's interior is divided into three different layers based on compositional differences: the crust, mantle, and core. The right side of the large cross-section depicts the five main layers of Earth's interior, based on physical properties and hence mechanical strength: the lithosphere, asthenosphere, mesosphere, outer core, and inner core. The block diagram above the large cross-section shows an enlarged view of the upper portion of Earth's interior.

Video

Earth's Spheres

- Earth is a small, fragile and self-contained planet.
- Earth's four interacting spheres:
    - Hydrosphere
    - Atmosphere
    - Biosphere
    - Geosphere
- These four spheres are constantly interacting with each other.

Earth's Spheres

The breathtaking beauty of Earth as seen by the Apollo astronauts in the 1960s and 1970s.

A B

Figure 1.18 **A.** View that greeted the Apollo 8 astronauts as their spacecraft emerged from behind the Moon. **B.** Africa and Arabia are prominent in this image of Earth taken from Apollo 17. The tan cloud-free zones over the land coincide with major desert regions. The band of clouds across central Africa is associated with a much wetter climate that in places sustains tropical rainforests. The dark blue of the oceans and the swirling cloud patterns remind us of the importance of the oceans and the atmosphere. Antarctica, a continent covered by glacial ice, is visible over the South Pole.
(Photos by NASA)

Earth's Spheres

Hydrosphere

- Includes: Oceans, freshwater, glacial ice
- Oceans account for almost 71%

Atmosphere

- Thin layer producing weather, climate

Biosphere

- Includes all living things on Earth

Geosphere

- Includes rocks, landforms, Earth's Interior

The Face of Earth

Two principal divisions of Earth's surface:

1. Continents
   - Average elevation is 840 m above sea level
   - 40% of Earth's surface
2. Ocean basins
   - Average depth is 3800 m below sea level
   - 60% of Earth's surface

The Face of Earth

Continents

- Young mountain belts – most prominent
- Old mountain belts – more eroded
- Shields – very old, large, flat expanses of rock

Ocean basins

- Oceanic ridge system – the most prominent topographic feature on Earth
- Trenches – can exceed depths of 11,000 m

Earth as a System

- Earth's four spheres are linked as a system through their interactions.
- Earth's system is powered by energy from the sun and heat from Earth's interior.
- Humans are part of this system. Our actions produce often large-scale changes in all four spheres.

Earth as a System

The Rock Cycle: Part of the Earth system

- The process by which one rock changes to another rock: metamorphic, igneous, sedimentary.
- Each rock type is linked to the other.

Earth as a System

The Rock Cycle: Part of the Earth System

- Basic Cycle:
  - Molten *magma* becomes igneous rock
  - Weathering creates sediments
  - Sediments *lithify* into sedimentary rock
  - Burial and heat produce metamorphic rock
  - Metamorphic rock can be heated to produce magma, or eroded to form sediments.

Earth as a System

The Rock Cycle:
Rocks constantly form, change, and re-form over longs spans of time

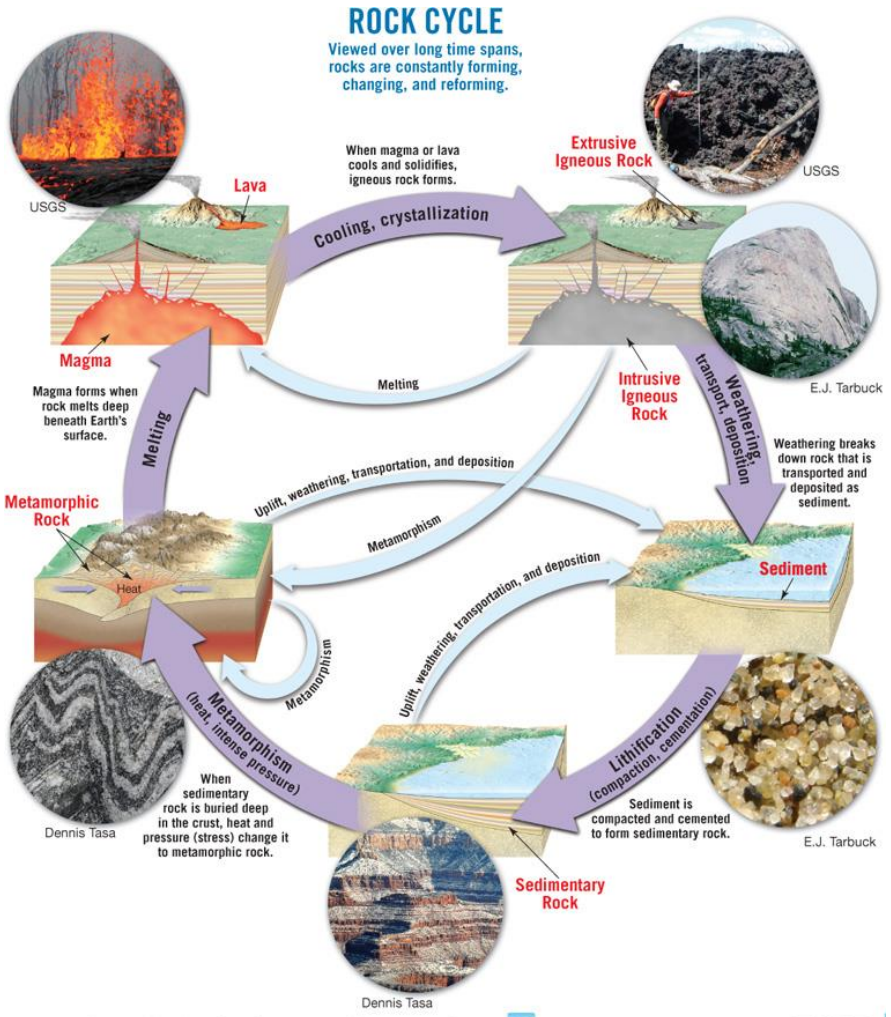

Figure 1.22 Viewed over long spans, rocks are constantly forming, changing, and re-forming. The rock cycle helps us understand the origin of the three basic rock groups. Arrows represent processes that link each group to the others.

SMARTFIGURE 1.22
The rock cycle

Video

Example questions for quiz

1. The _____ layer of the Earth is molten and metallic in composition.
a. inner core b. lithosphere c. mantle d. outer core

2. The famous San Andreas Fault in California is a _____ plate boundary.
a. convergent b. emergent c. divergent d. transform

Thanks for the attentions!