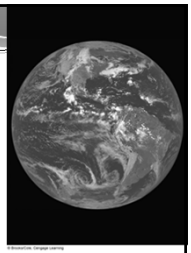
Chapter 1



Understanding Earth

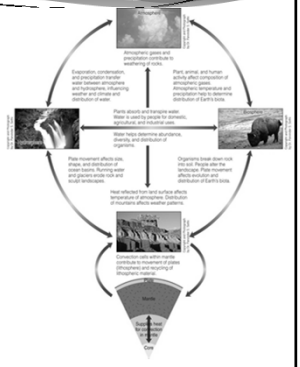
A Dynamic and Evolving Planet

Introduction

Geology is more than just looking at rocks.

The Earth is a complex, integrated system of related parts, components, or sub-systems.

Geologist attempt to understand the Earth system and how each part affects each other part.



Why Earth is a Dynamic and Evolving Planet

Earth has continuously changed during its 4.6 billion year existence as a result of interactions between its various subsystems and cycles.

What is Geology?

- Geology is the study of the Earth.
  - Physical geology
  - Historical geology

What is geology?

Geologists are employed in diverse occupations.

- Principle occupations include:
  - Mineral and energy resource exploration
  - Solving environmental problems
  - Predicting natural disasters

Geology and the Formulation of Theories

- What is a theory?

- A theory is usually arrived at through the scientific method
- A scientific theory is a testable explanation for some natural phenomenon, that is supported by a large body of evidence.
- Simple rule: No test – No Theory!

How Does Geology Relate to the Human Experience?

- Geology pervades our everyday lives and is a part of many aspects of human experience, including the arts and literature.

- Environmental & Society
- Natural Events
- Economics and Politics
- Our Role as Decision Makers
- Consumers and Citizens
- Sustainable Development

Assignment #1: Find an article about a geologically-related issue and turn it in next class period.

Figure 1.2, p. 6

Global Geologic and Environmental Issues Facing Humankind

- Most scientists would argue that overpopulation is the greatest problem facing the world today.

Associated problems include:

- Increased risks from earthquakes, tsunami, floods and volcanoes
- More pollution
- Wildlife threatened
- Shortages of resources
- Poverty

Origin of the Universe

- Did it begin with a Big Bang?

- In the Big Bang theory, the universe began approximately 14 billion years ago.
- An extremely dense, hot body of matter expanded and cooled

Origin of the Universe

- How do we know? Evidence for the Big Bang:

The Spiral Galaxy M66 (NGC 3627)
VLT MELIPAL/YEPUN + FORS1/FORS2

- the universe is expanding from a central point (confirmed by Doppler Effect)
- The entire universe has a pervasive and constant background radiation, thought to be the faint afterglow of the Big Bang.
- The abundance of H and He vs. heavier elements

Our Solar System

- Its Origin and Evolution

- The Solar System formed from a rotating cloud of interstellar matter about 4.6 billion years ago.
- This cloud, upon condensing, collapsed under the influence of gravity and flattened into a rotating disk.
- The sun, planets, and moons formed within this disk.

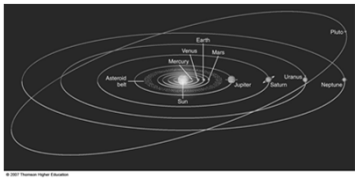


Figure 1.7, p. 16

Our Solar System

- Evidence for the Solar Nebula Theory

- All the major planets occupy a flat plane within the solar system.
- All the planets and their moons revolve in the same direction around the sun.
- The composition of the planets and our Sun.
- Evidence of other solar systems in our Galaxy.

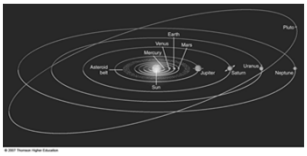


Figure 1.7, p. 16

Earth

- Its Place in Our Solar System
  - Earth formed from a swirling eddy of nebular material 4.6 billion years ago, accreting as a solid body and soon thereafter differentiated into a layered planet during a period of internal heating.

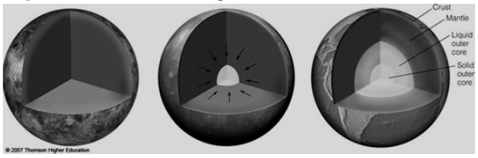


Fig. 1.9, p. 17

Why Earth is a Dynamic and Evolving Planet

- As the earth differentiated, 3 concentric layers formed.
  - Core
  - Mantle
  - Crust.

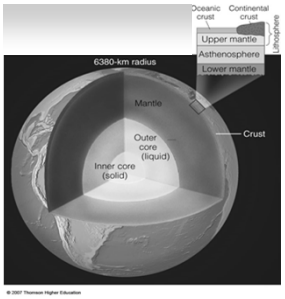


Fig. 1.10, p. 18

Why Earth is a Dynamic and Evolving Planet

- The Core

The core consists of

- a small, solid inner region
- a larger, liquid, outer portion

composed of iron and a small amount of nickel.

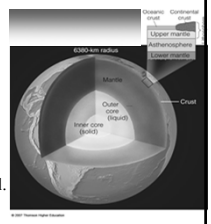


Fig. 1.10, p. 18

Why Earth is a Dynamic and Evolving Planet

- The Mantle

The mantle surrounds the core and is divided into:

- a solid lower mantle
- an asthenosphere that behaves plastically and flows slowly
- a solid upper mantle.

Composed primarily of dense, silicate materials with iron and magnesium.

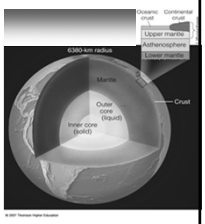


Fig. 1-10, p. 18

Why Earth is a Dynamic and Evolving Planet

- The Asthenosphere

- Surrounds the lower mantle
- Behaves plastically and slowly flows
- Partial melting in the asthenosphere generates magma (molten rock) that rises to the earth's surface.

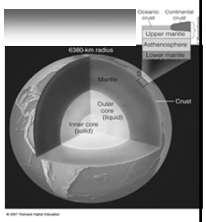


Fig. 1.10, p. 18

Why Earth is a Dynamic and Evolving Planet

- The Crust

The outermost layer, the crust, is divided into:

- thick continental crust
- thin oceanic crust

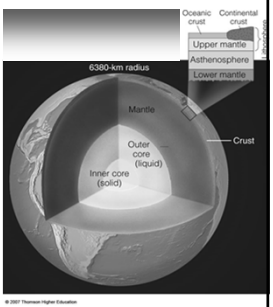


Fig. 1.10, p. 18

Why Earth is a Dynamic and Evolving Planet

- The Lithosphere
- The crust and upper mantle make up the lithosphere which forms the solid outer layers of the Earth.

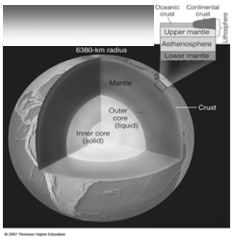


Fig. 1.10, p. 18

Why Earth is a Dynamic and Evolving Planet

- Plate Tectonic Theory
- The lithosphere is composed of rigid plates that diverge, converge, or slide sideways past one another as they move over the asthenosphere

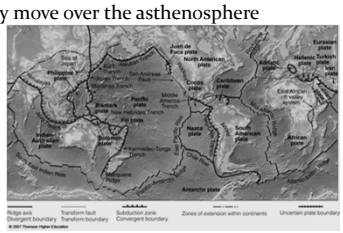
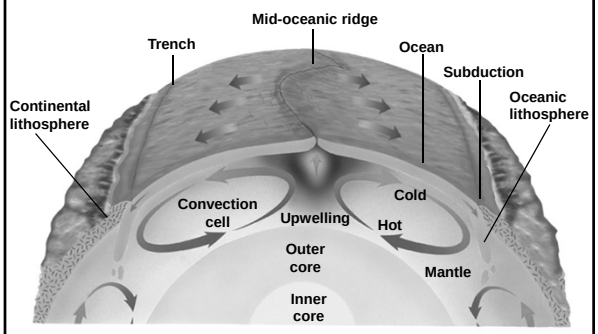


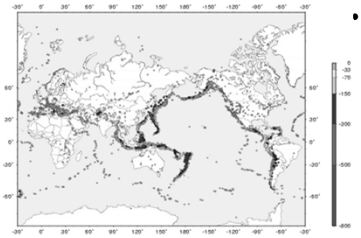
Fig. 1.12, p. 19

Stepped Art
Fig. 1-12, p. 17



Why Earth is a Dynamic and Evolving Planet

- Plate Tectonic Theory

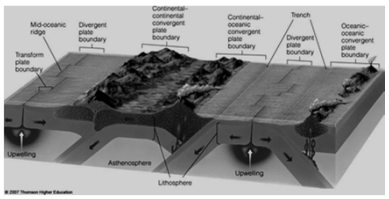


- Volcanoes and earthquakes occur at the boundaries between the plates.

Fig. 1.13, p. 19

Why Earth is a Dynamic and Evolving Planet

- Plate Tectonics and Earth Systems
- Plate tectonic theory is a unifying explanation for many geologic features and events, helping us understand the composition and internal processes of Earth on a global scale.



The Rock Cycle

- A rock is a solid aggregate of one or more minerals, as well as non-crystalline matter such as natural glass or organic material like coal.
- There are three major groups of rocks
  - Igneous
  - Sedimentary
  - Metamorphic

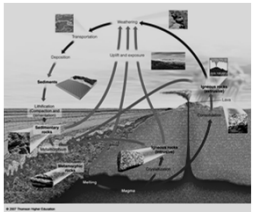


Fig. 1.14, p. 21

The Rock Cycle

- Igneous Rocks form from the crystallization of magma as it cools or the consolidation of volcanic ejecta.

Granite
Intrusive Igneous Rock

- Intrusive igneous rock

Basalt
Extrusive Igneous Rock

- Extrusive igneous rock

Fig. 1.15 a-b, p. 22

The Rock Cycle

- Sedimentary Rocks are typically deposited in layers formed from:
  - rock/mineral fragments
  - precipitation of minerals from solution
  - the compaction of plant and animal remains.

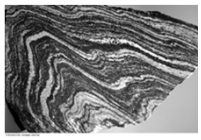
Conglomerate
Forms from river gravels

Limestone
Precipitation from seawater

Fig. 1.15 c-d, p. 22

The Rock Cycle

- Metamorphic Rocks form from alteration of other rocks, usually by:
- Heat
- Pressure
- Chemically active fluids

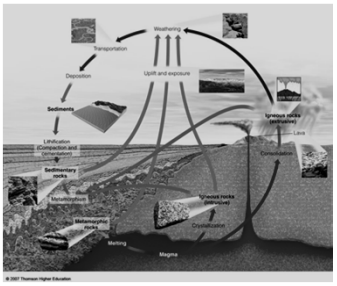


Gneiss

Quartzite

Fig. 1.15 e-f, p. 22

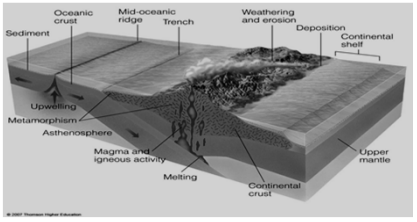
The Rock Cycle



The Rock Cycle

Fig. 1.17, p. 21

- How are the rock cycle and plate tectonics related?

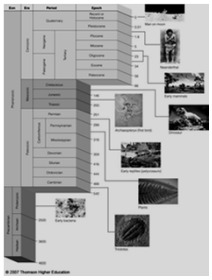


Organic Evolution and the History of Life

- The theory of organic evolution states:
  - that all living things are related and
  - have descended with modification from organisms living in the past.
- Charles Darwin proposed that the mechanism of natural selection results in survival reproductive age of those organisms best suited to their environment.
- Fossils, the remains of once-living organisms provide the evidence for evolution and a history of life before humans.

Geologic Time

- An appreciation of the immensity of geologic time is central to understanding the evolution of the Earth and its' life.



- Geologic time differs from the human perspective of time
- Earth goes through cycles of much longer duration than the human perspective of time
- The immense span of time encompassed by the Earth's existence and geological processes sets geology apart
- The geologic time scale is the calendar that geologists use to date past events in Earth's history.

Fig. 1.17, p. 24

Geologic Time and Uniformitarianism

- Uniformitarianism forms a cornerstone of geology. It is a fundamental tenet of geology.
  - This principle states that the laws of nature have remained unchanged through time and thus, that the processes observed today have also operated in the past, though possibly at different rates.
  - Therefore, to understand and interpret geologic events from evidence preserved in rocks, geologists must first understand present-day processes in rocks.