Essentials of Geology, 11e

An Introduction to Geology

Chapter 1

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Geology 101

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The Science of Geology

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

The Science of Geology

- Geology, people, and the environment
  - There are many important relationships between people and the natural environment
  - Some of the problems and issues addressed by geology involve natural hazards, resources, world population growth, and environmental issues

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On January 13, 2001, a magnitude 7.6 earthquake caused considerable damage in El Salvador.

Caption: The damage pictured here was caused by a landslide that was triggered by the earthquake. As many as 1000 people were buried under 8 meters (26 feet) of landslide debris. Geologists seek to understand the processes that create such events. *(Photo by Reuters/STR/Getty Images Inc.-Hulton Archive Photos)*

The Science of Geology

- Some historical notes about geology
  - The nature of Earth has been a focus of study for centuries
  - Catastrophism
  - Uniformitarianism and the birth of modern geology
    - "The present is the key to the past."

Geologic Time

- Geologists are now able to assign fairly accurate dates to events in Earth history
- Relative dating and the geologic time scale
  - Relative dating means that dates are placed in their proper sequence or order without knowing their age in years

Geologic Time

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

The Geologic Time Scale

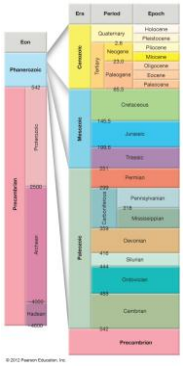

Figure 1.8

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 *facts* through observation and measurements

The Nature of Scientific Inquiry

- How or why things happen are explained using a:
  - **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

- Scientific method
  - Scientific method involves gathering facts through observations and formulation of hypotheses and theories
- There is no fixed path that scientists follow that leads to scientific knowledge

A View of Earth

- Earth is a planet that is small and self-contained
- Earth's four spheres
  - **Hydrosphere**
  - **Atmosphere**
  - **Biosphere**
  - **Solid Earth**

A.

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A View of Earth from the Moon

Figure 1.12 A

Earth as a System

- Earth is a dynamic planet with many interacting parts or spheres
- Parts of the Earth system are linked
- Positive versus negative feedback
- It is characterized by processes that
  - Vary on spatial scales from fractions of a millimeter to thousands of kilometers
  - Have time scales that range from milliseconds to billions of years

The atmosphere, hydrosphere, and the geosphere

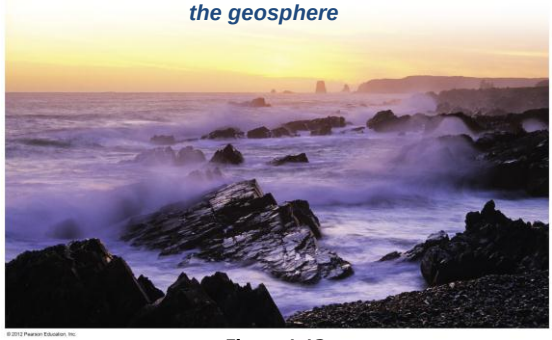

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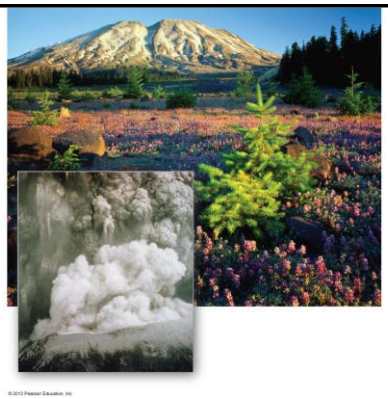
Figure 1.13



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Earth as a System

- The Earth system is powered by the Sun, which drives external processes
  - In the atmosphere
  - In the hydrosphere
  - At Earth's surface

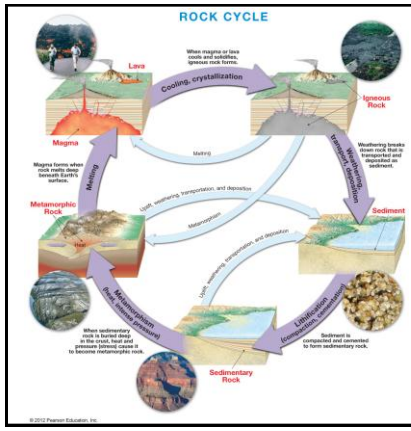
Earth as a System

- The Earth system is also powered from Earth's interior
  - Heat remaining from the Earth's formation and heat that is continuously generated by radioactive decay powers the internal processes that produce volcanoes, earthquakes, and mountains

The Rock Cycle

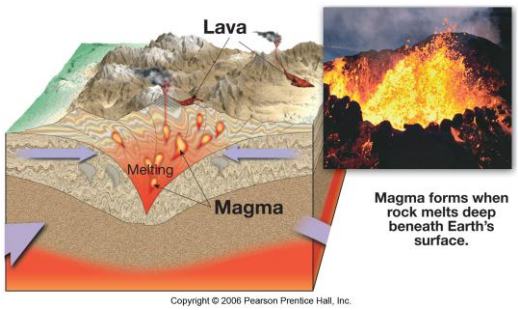
Part of the Earth system

- **The loop that involves the processes by which one rock changes to another**
- **Illustrates the various processes and paths as Earth's materials change both on the surface and inside Earth**



The Rock Cycle

Figure 1.22



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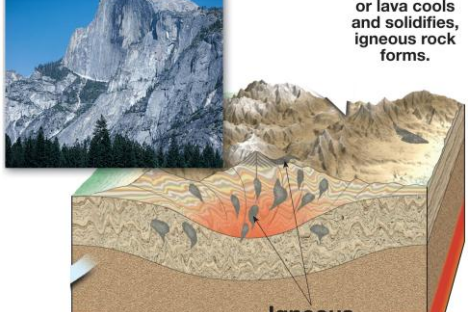

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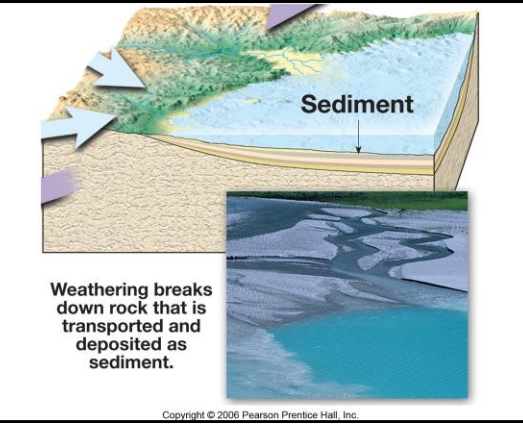

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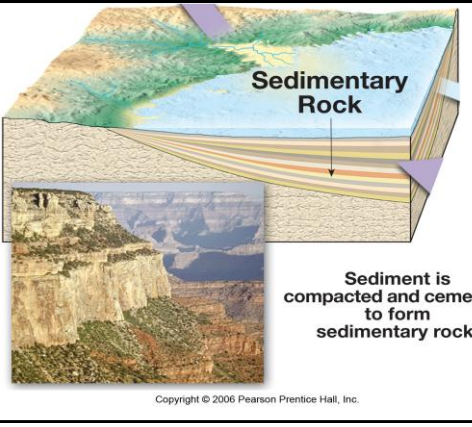

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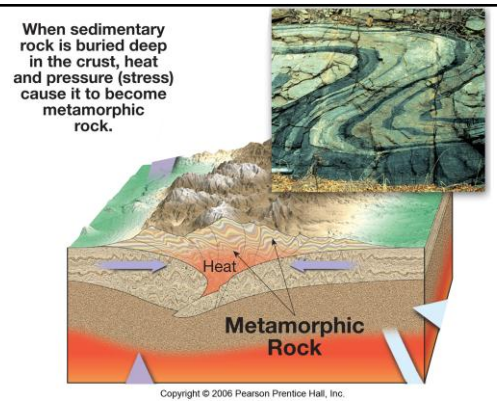
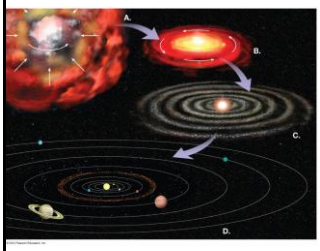


Early Evolution of Earth ~4.5 byo



Same time & material as the Sun.

Nebular theory.

Earth's layered structure:

- Temperature increase
- Gaseous materials escaped

Figure 1.23

Earth's Internal Structure

- **Earth's internal layers defined by:**
  - **Chemical composition**
  - **Physical properties**
- **Layers defined by composition**
  - **Crust**
  - **Mantle**
  - **Core**

Earth's Internal Structure

- **Four main layers of Earth are based on physical properties and hence mechanical strength**
  - **Lithosphere**
  - **Asthenosphere**
  - **Mesosphere**
  - **Core**
    - **Outer**
    - **Inner**

Earth's Internal Structure

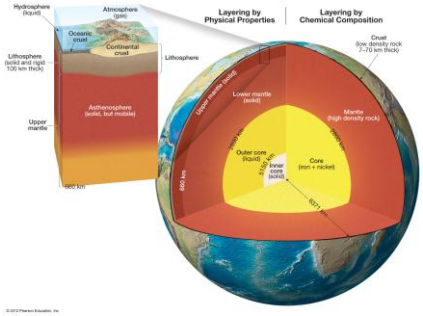


Figure 1.26

The Face of Earth

- **Earth's surface**
  - **Continents**
  - **Oceans**
- **Continents**
  - **Mountain belts**
    - **Most prominent feature of continents**
  - **The stable interior**
    - **Shields and stable platforms**

Major Surface Features

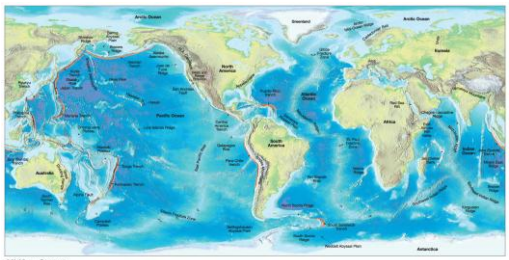


Figure 1.27

Earth's Mountain Belts, Stable Platforms, and Shields

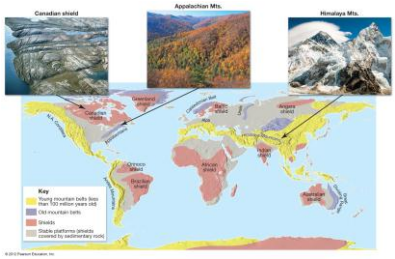


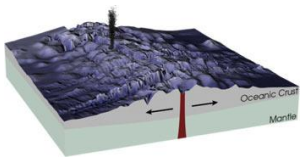
Figure 1.28

The Face of Earth

- Ocean basins
  - Continental margins
    - Includes the continental shelf, continental slope, and the continental rise
  - Deep-ocean basins
    - Abyssal plains
    - Oceanic trenches
    - Seamounts

The Face of Earth

- Ocean basins
  - Oceanic ridge system
    - Most prominent topographic feature on Earth
    - Composed of igneous rock that has been fractured and uplifted



Dynamic Earth

- The theory of plate tectonics
  - Involves understanding the workings of our dynamic planet
  - Began in the early part of the twentieth century with a proposal called continental drift – the idea that continents moved about the face of the planet

Dynamic Earth

- The theory of plate tectonics
  - A theory, called plate tectonics, has now emerged that provides geologists with the first comprehensive model of Earth's internal workings
- Plate boundaries
  - All major interactions among individual plates occur along their boundaries

Earth's Lithospheric Plates

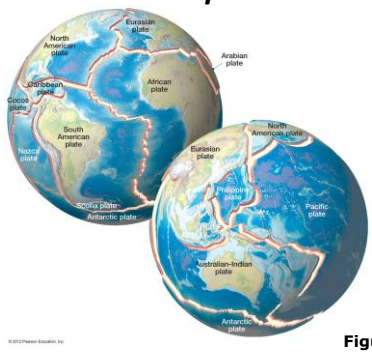


Figure 1.29

Dynamic Earth

- Plate boundaries
  - Divergent boundary – two plates move apart, resulting in upwelling of material from the mantle to create new seafloor
  - Convergent boundary – two plates move together with subduction of oceanic plates or collision of two continental plates

Convergent and Divergent Plate Boundaries

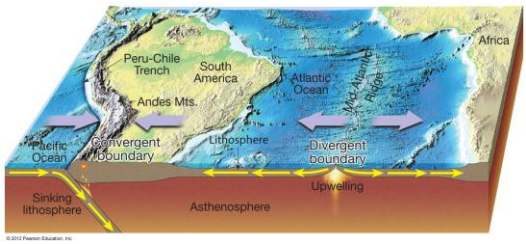


Figure 1.31

Dynamic Earth

- Plate boundaries
  - Transform boundaries – located where plates grind past each other without either generating new lithosphere or consuming old lithosphere
  - Changing boundaries – new plate boundaries are created in response to changes in the forces acting on the lithosphere

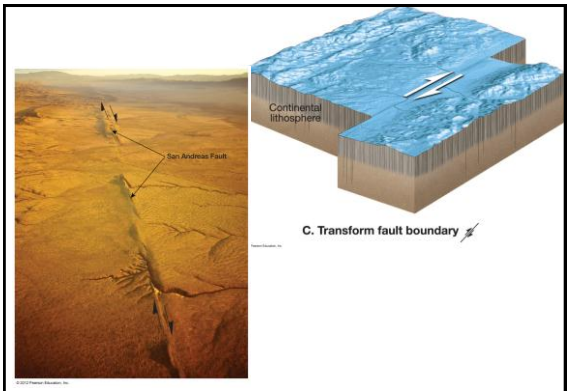


Figure 1.30c & 1.34

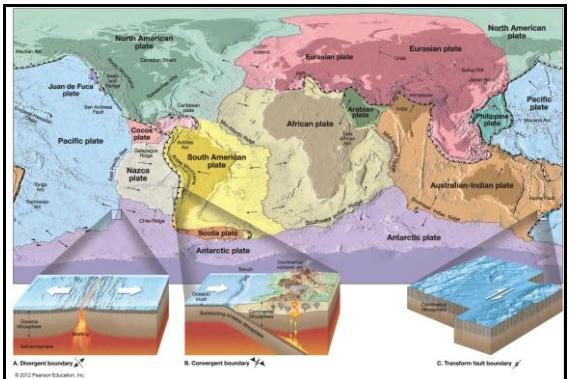
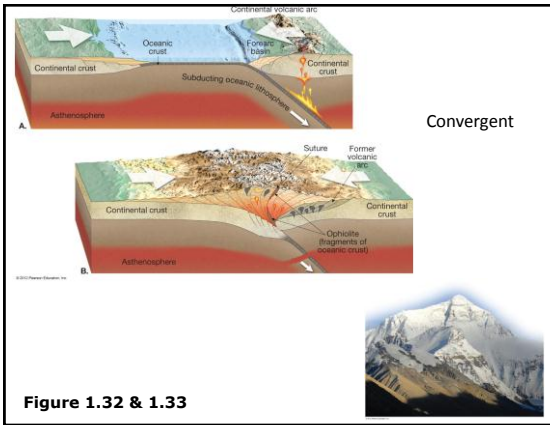


Figure 1.30



Convergent

Figure 1.32 & 1.33

End of Chapter 1