

Environmental Science

Systems and Solutions


FOURTH EDITION

Michael I. McKinney
Robert M. Schoch
Logan Yonavjak



Chapter 5

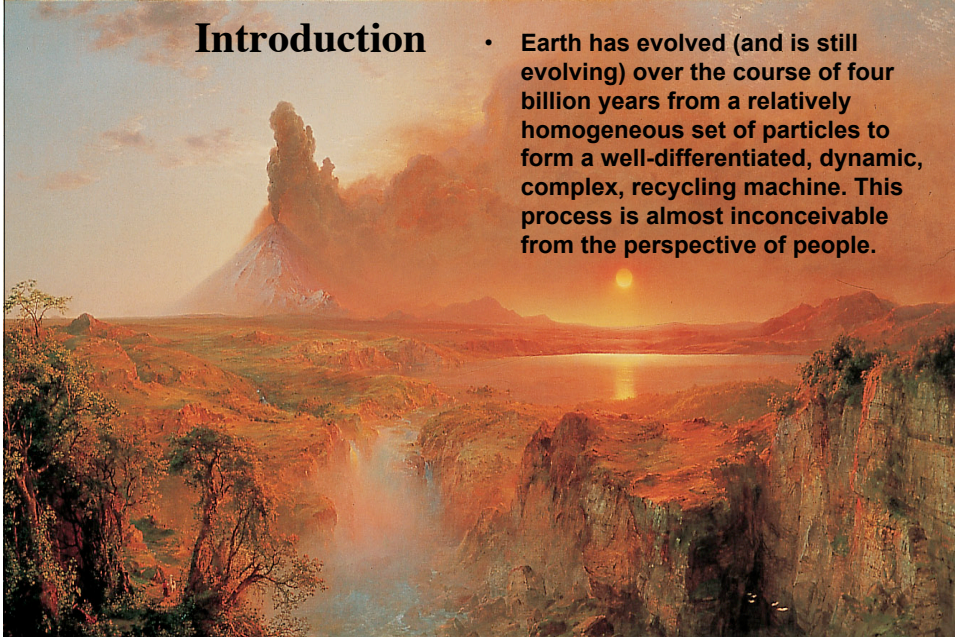
THE DYNAMIC EARTH AND NATURAL HAZARDS

Modified by  Jones and Bartlett Publishers


Environmental Science *Systems and Solutions* FOURTH EDITION

Introduction

- Earth has evolved (and is still evolving) over the course of four billion years from a relatively homogeneous set of particles to form a well-differentiated, dynamic, complex, recycling machine. This process is almost inconceivable from the perspective of people.



Cotopaxi, 1862. Frederic Edwin Church. Founders Society Purchase, Robert H. Tannahill Foundation Fund, Gibbs-Williams Fund, Dexter M. Ferry, Jr. Fund, Merrill Fund, Beatrice W. Rogers Fund, and Richard A. Monoghan Fund. Photograph copyright 1985 The Detroit Institute of Arts

Modified by  Jones and Bartlett Publishers

Workings of Planet Earth Today

- Earth is the third planet out from the center of the solar system, but very different from the other planets. Water can exist in liquid form, making life possible.
- The gases and liquids around the Earth are constantly moving, causing degradation, erosion, and destruction of mountains.



Courtesy of NASA
Modified by [kg](#) and Bartlett Publishers

Workings of Planet Earth Today

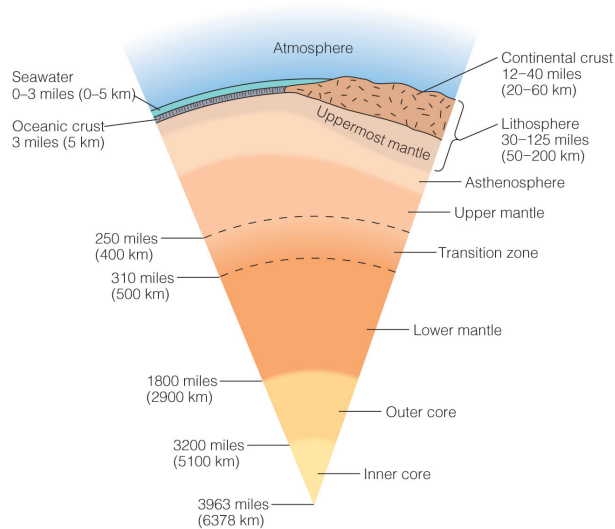
- The Earth's interior is very hot and constantly seething and churning.
- This heat causes plate tectonic activity and constant rejuvenation of surface rocks.



Courtesy of U.S. Department of Interior/USGS

Modified by [kg](#) and Bartlett Publishers

Figure 5-2 Schematic Section through the Earth



Modified by Jones and Bartlett Publishers

Plate Tectonics

- **Plate tectonics forms the unifying theory that explains most geological structures observed on the surface of Earth**
- **Virtually all earth scientists accept it.**
- **The theory of plate tectonics explains:**
 - Continental movement
 - Mountain building
 - Sea floor creation and destruction
 - Volcanic eruption
 - Earthquakes

Modified by Jones and Bartlett Publishers

Earth's Tectonic Plates

- Today, the Earth's lithosphere is divided into about eight major tectonic plates and numerous smaller ones.

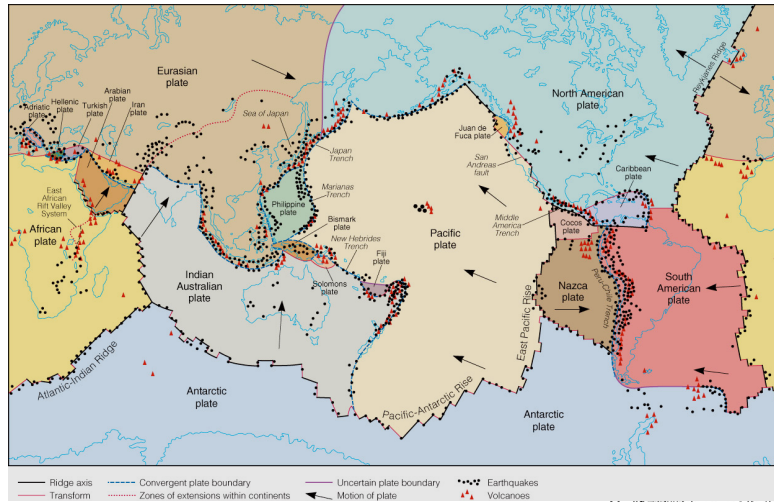


Figure 5-3

Modified by Jones and Bartlett Publishers

Plate Movements

- The plates move slowly, 0.8 to 12 inches (8 to 30 cm) a year.
- This movement has caused major changes in the position of the continents over the last few hundred million years.
- Pacific plate moves at about 7 cm/year (about 3 inches/year) about speed fingernails grow!

Modified by Jones and Bartlett Publishers

Continental Movements



Earth about 240 mya



Earth about 70 mya



The modern Earth

Figure 5-4

Modified by kg
© 2011 Sinauer Associates, Inc. and Bartlett Publishers

Question

- ◆ Which is false? Oxygen in the atmosphere
 - A. Is “pollution” caused by plant life
 - B. Is in danger of being used up
 - C. Is essential for animals, but not plants
 - D. A green house gas causing global warming
 - E. A uncommon compared to many other elements

Modified by kg

Question

- ◆ Do you “believe” in evolution? (i.e. think it is likely human beings evolved from other mammals over the past millions of years)

- A. Yes
- B. No
- C. Don't know at this time
- D. It is not such a simple question

Modified by kg

Plate Movements

- **Most scientists believe that convection currents in Earth's molten mantle cause plate movement.**

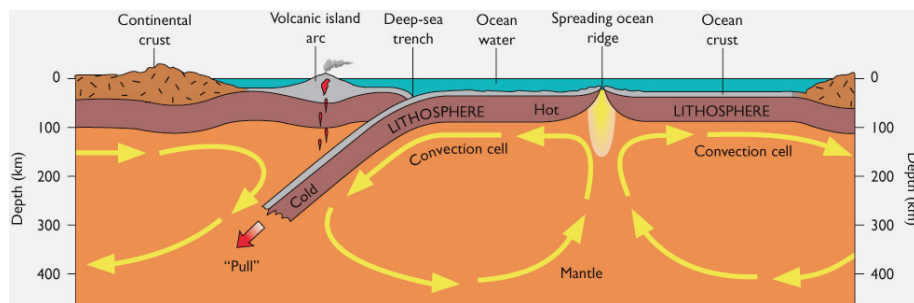
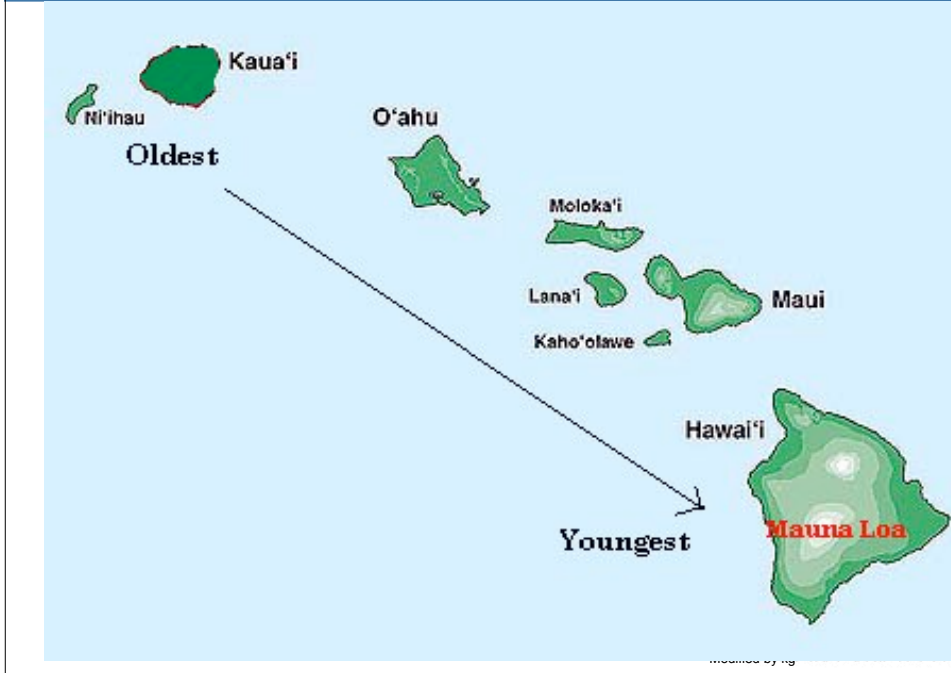


Figure 5-5

Modified by kg, McGraw-Hill Education and Bartlett Publishers



Types of Plate Boundaries

- There are convergent, divergent, and strike-slip types of plate interactions

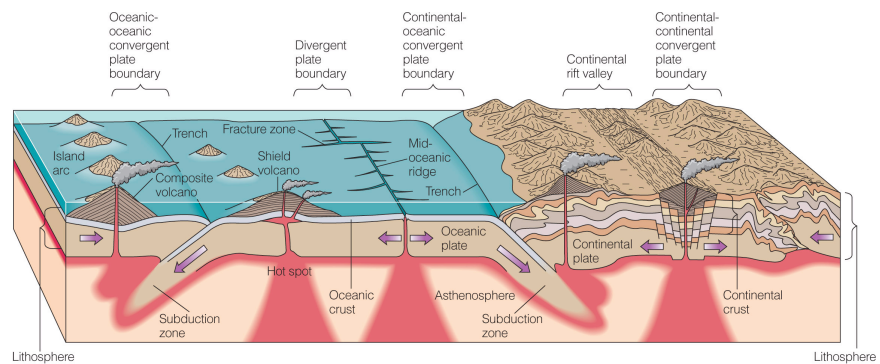


Figure 5-6

Modified by kg
© 2011 Sinauer Associates, Inc. and Bartlett Publishers

Rocks: Their Origin and the Rock Cycle

- There are three main types of rocks; igneous, sedimentary, and metamorphic with characteristic features
- The rock cycle allows the movement of these three types of rock, all beginning with igneous rock that comes from the Earth's core in the form of magma. The rock cycle is slow, taking in the order of millions to hundreds of millions of years to complete.



Figure 5-9 The Grand Canyon exposes many different types of sedimentary rocks.

© GeoM/Shutterstock, Inc.

Modified by  Jones and Bartlett Publishers

The Rock Cycle

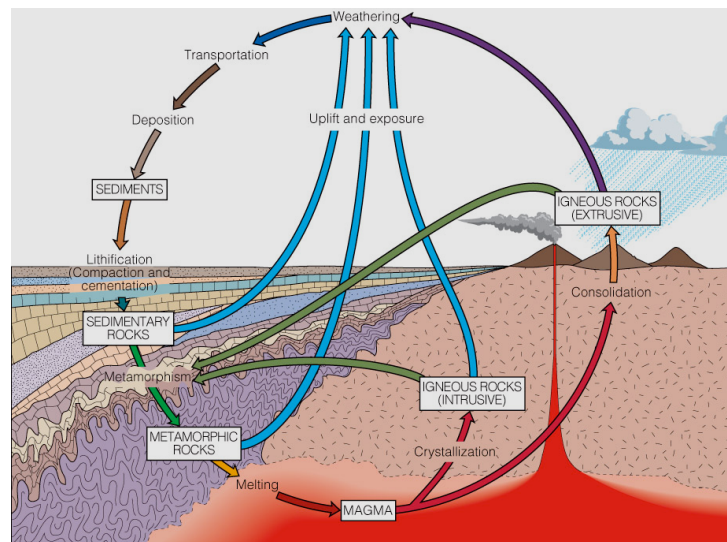


Figure 5-11

Modified by  Jones and Bartlett Publishers

Climate and Weather

- **The movement of gases and water, driven by solar energy, creates weather over short time periods.**
- **Climate patterns are the average of weather over longer time periods.**

Modified by Jones and Bartlett Publishers

Atmospheric Cycles

- **The atmosphere's circulation is controlled by a complex variety of forces.**
- **Energy from the sun creates belts of convective circulation cells that stretch around the Earth:**
 - Hadley Cell
 - Ferrell Cell
 - Polar fronts and flows

Modified by Jones and Bartlett Publishers

Atmospheric Circulation Patterns

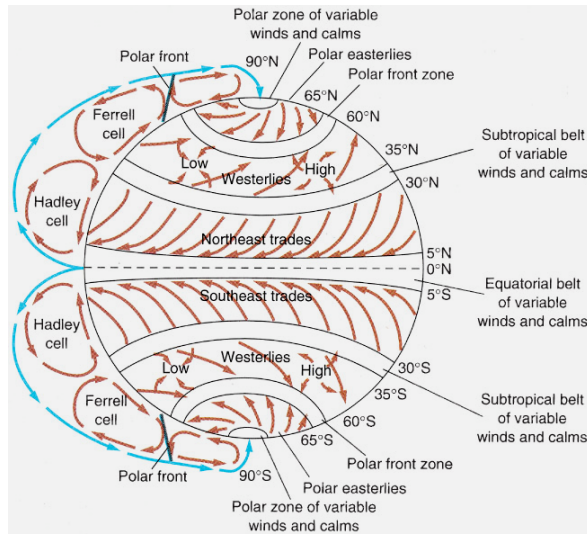


Figure 5-12

Modified by Jones and Bartlett Publishers

Atmospheric Cycles

- **Two factors add complexity to these patterns:**
 - The Coriolis effect produced by the Earth's rotation on its axis
 - The Earth's topography

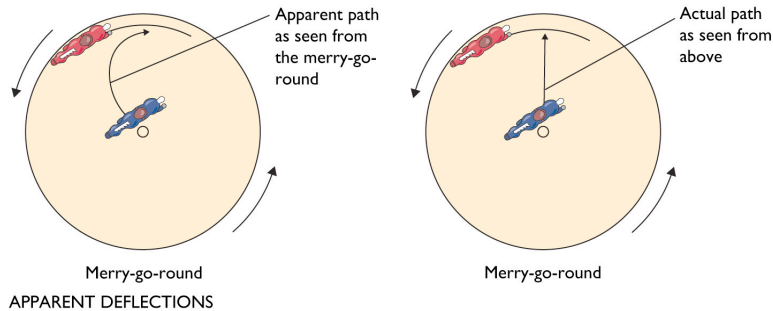
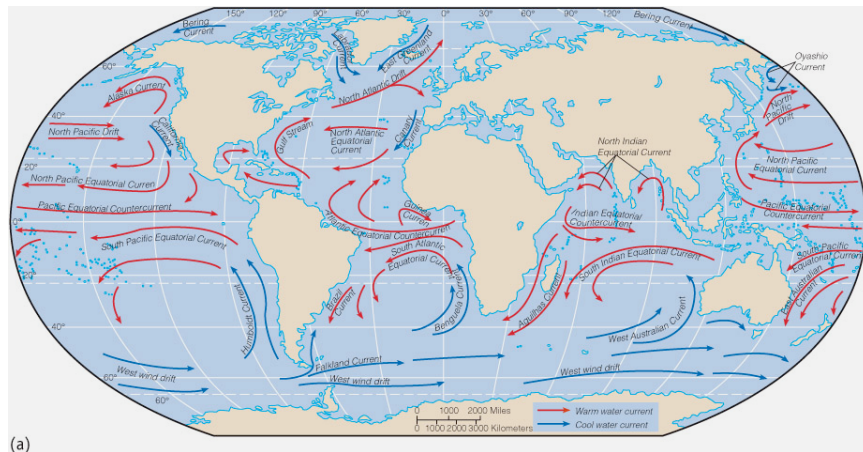


Figure 5-13 A simplified demonstration of the Coriolis effect.

Modified by Jones and Bartlett Publishers

Ocean Circulation

- Moving air masses create ocean currents.



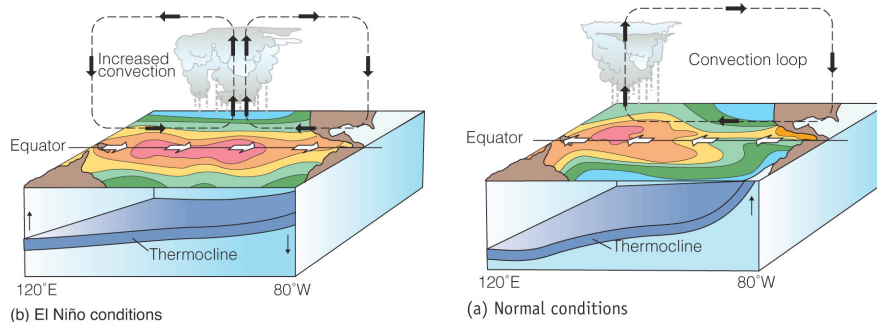
(a)

Figure 5-14

Modified by Jones and Bartlett Publishers

El Niño Southern Oscillation (ENSO)

- Periodic weather phenomenon that occurs approximately every 3 to 7 years.



(b) El Niño conditions

(a) Normal conditions

Figure 5.CS1_01 (a) Normal conditions (non-El Niño) in the Pacific. (b) El Niño conditions in the Pacific.

Modified by Jones and Bartlett Publishers

Rotation, Orbits, and Seasons

- The Earth is tilted $23\frac{1}{2}$ degrees on its axis relative to its plane of rotation around the sun.
- At the equinoxes (March and September), the sun shines directly on the equator.
- At the solstices, the sun shines most directly on the northern (June) or southern (December) hemispheres.

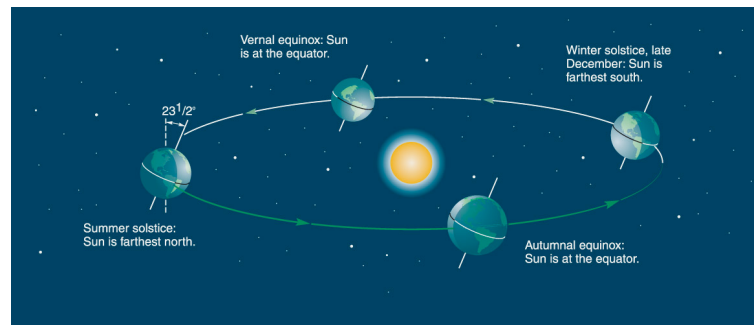


Figure 5-16

Origin and Physical Development of Earth

- The Earth is not a stagnant, unchanging planet.
- We need a historic perspective if we are to evaluate the modern environment in a holistic context.
- Our sun and solar system originated about 5 billion years ago when a gas and dust cloud collapsed and coalesced in this part of the galaxy.

Origin and Physical Development of Earth

- **The oceans and atmosphere developed between 3.5 and 4 billion years ago.**
- **Since that time, the oxygen in the atmosphere has increased considerably as a result of two processes:**
 - The breakdown of water by ultraviolet radiation
 - Plant photosynthesis

Modified by Jones and Bartlett Publishers

Natural Hazards

- **People have always had to cope with “unpredictable” natural hazards.**
- **Although most acts of nature cannot be controlled, we have learned to better predict their occurrences and mitigate their effects.**
- **As the human population increases, the magnitude of “disasters” caused by these hazards will probably be exacerbated.**

Modified by Jones and Bartlett Publishers

Geological Hazards: Earthquakes

- Earthquakes are shock waves that result when large masses of rock in the Earth's crust move relative to each other.
- Earthquakes are a constant threat to human life and causes extensive damage to human settlements

Figure 5-17
Islamabad, Pakistan,
7.6 earthquake in
October, 2005.



Modified by Jones and Bartlett Publishers

Measuring Earthquakes

- The intensity, magnitude, or strength of an earthquake is commonly measured either on the Richter scale or the Mercalli scale.
- The Richter scale is based on the amplitude of the seismic waves.
 - The Richter scale is a logarithmic scale
- The Mercalli scale is based on observations close to an earthquake's origin.

Modified by Jones and Bartlett Publishers

Volcanoes

- **Volcanoes are spots in the Earth's crust where hot, molten rock (magma) wells up to the surface. They are hard to predict. Volcanoes are found at:**
 - Convergent tectonic plate margins
 - Divergent tectonic plate margins
- **“Hot spots” over a hot mantle plume**
- **Volcanoes can have an effect on global climate change by adding a tremendous amount of gas, ashes, and dust into the atmosphere**



Figure 5.18: The 1980 eruption of Mount St. Helens, Washington.

Modified by kg Jones and Bartlett Publishers

Land Instability

- **Land instability includes:**
 - Landslides
 - Rockfalls
 - Avalanches
 - Mechanical soil failure
 - Cliffs in san diego being eroded in the



Landslide and Debris Flow, La Conchita, California

Modified by kg Jones and Bartlett Publishers

Weather Hazards

- **Tropical cyclones (hurricanes and typhoons) are intense storms that develop over warm tropical seas.**
- **Tornadoes are rapidly rotating vortices of air that form funnels. When they touch the ground surface, they are among the most intense and destructive phenomena found in nature.**



Courtesy of NOAA Photo Library, NOAA Central Library, OAR/ERL /National Severe Storms Laboratory (NSSL)

Modified by kgmes and Bartlett Publishers

Floods

- **Natural floods are a normal part of the environment, but they often seem “unusual” from a human perspective. Cumulatively, floods are among the most destructive of natural hazards.**
- **Other weather-related or induced hazards include:**
 - Droughts
 - Fires
 - Coastal storm surges



Courtesy of Petty, Officer 2nd Class Kyle Niemi/U.S. Coast Guard. Photo courtesy of U.S. Army

Modified by kgmes and Bartlett Publishers

Question

◆ Which are you most afraid of?

- A. Earthquake
- B. Hurricane or tornado
- C. Fire
- D. Lightening strike
- E. Car accident

Modified by kg