Introduction to Geology

Chapter 1

Intro to Geology: summary in haiku form

Here's geology.
It's the study of the Earth -
complete entity.

- 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

- 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

"Environmental" Geology

December 26, 2004
Sumatran Earthquake /
Tsunami

"Environmental" Geology

January 12, 2010: Haiti Earthquake

"Environmental" Geology

April 4, 2010: "Mexicali" Quake

"Environmental"
Geology

La Conchita, 1995

People were warned, evacuated, none killed

January 10, 2005

Not so lucky...

Figure 1.3

Closer to home...

October 2007:
(photos are one hour apart)

- 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
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- 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

Knightia, from Wyoming

fossil fern

Grand Canyon from South Kaibab Trail

Relative dating –

The Geologic Time Scale

More Detail:

Relative dating

- 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

- 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
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- 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

Field Studies

Field Studies

Remote Sensing

Remote Sensing

Actual Scientific Method (joke!)

- 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
    -

- 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
    -

Earth as a System:

- System –
  Group of interacting, or interdependent, parts that form a complex whole

33 ***Sources of Energy:***

- Heat from the earth's interior –
  Powers the internal processes that produce volcanoes, earthquakes, and mountains

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- 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

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- 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)

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37 ***Nebular Hypothesis of Solar System Formation***

38 ***Nebular Hypothesis***

- Inner planets – high temp's, weak gravitational fields, unable to grab lighter elements
- Outer planets – colder, huge amounts of lighter elements

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- 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
  -

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- 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

-
  -

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- 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

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- 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

- 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

- 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

Vulcan's Throne,
Grand Canyon

granite boulders in ABDSP
lichens on granite
12 seconds at the rim (not!)

A "nice" metamorphic rock...

The Rock Cycle:

Interactions:

- 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

- 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

- Features of the ocean floor include continental margins, deep-ocean basins, and oceanic ridges
  - Continental margins are the portion of the seafloor 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 seafloor

- Features of the ocean floor include continental margins, deep-ocean basins, and oceanic ridges
  - Deep ocean basins are the portions of the seafloor 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

- 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

Continents and Ocean Basins

The Pacific Ocean Basin

Atlantic & Indian Ocean Basins

Shields & Mountains

Continental Features

Medicine Bow Mountains, Wyoming

Edge of the Canadian Shield (North Dakota)

Oceanic Features

End of Introduction to Geology