2 ***Introduction to Geology***

Chapter 1

3 ***Chapter 1 – Intro to Geology***

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5

- Geology is the science that pursues an understanding of planet Earth
  - Physical geology examines materials composing Earth and seeks to understand the many processes that operate beneath and on the surface of our planet.

  - Historical geology seeks an understanding of the origin of Earth and its development through time.

6

- Geology, People, and the Environment
  - *Natural hazards* are part of living on Earth
    - Geologists study volcanoes, floods, tsunamis, earthquakes, and landslides.
    - These are natural processes but become *hazards* when they occur where people live.

7 ***"Environmental" Geology***

December 26, 2004
Sumatran Earthquake /
Tsunami

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  - More people now live in cities than in rural areas
    - Creates *mega-populations* more vulnerable to hazards
  - *Resources* are another important part of geology
    - Include water, soil, metallic and nonmetallic minerals, and energy

10 ***"Environmental" Geology***

January 12, 2010: Haiti Earthquake

11 ***"Environmental" Geology***

April 4, 2010: "Mexicali" Quake

12 ***"Environmental"***
Geology

La Conchita, 1995

People were warned, evacuated, none killed

January 10, 2005

Not so lucky…

13 ***Figure 1.3***

14 ***Closer to home…***

15 ***October 2007:***
(photos are one hour apart)

16

- The nature of Earth has been a focus of study for centuries
  - Mid 1600s – James Ussher

- Catastrophism
- Earth's landscapes shaped primarily by catastrophes

– 1795 – James Hutton
- Uniformitarianism
- The physical, chemical, and biologic laws that operate today have operated throughout the geologic past
- *The present is the key to the past*

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18 ***Grand Canyon from South Kaibab Trail***

19 ***Knightia, from Wyoming***
(Eocene fish fossil)

20 ***fossil fern***

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- Geology Today
  – Uniformitarianism still valid
    - Some geologic processes are not directly observable but have well-established evidence to suggest they occur.
  – Earth processes vary in intensity but still take a very long time to create or destroy major landscape features.
    - The magnitude of geologic time involves millions and billions of years
    - Earth is 4.6 billion years old

22 **The Geologic Time Scale**

23 ***Relative dating –***

The Geologic Time Scale

24 ***More Detail:***

25 ***Relative dating***

26

- Science is a process of producing knowledge
  – Based on making observations and developing explanations
  – Assumes the natural world behaves consistently and predictably
- The goal of science is to discover patterns in nature and use that knowledge to make predictions.
- Data are essential to science and the development of scientific theories.

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- How or why things happen are explained using:
  – Hypothesis - a tentative (or untested) explanation
    - A hypothesis must *fit observations* and be *testable*
  – 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.

29 ***Field Studies***

30 ***Field Studies***

31 ***Remote Sensing***

32 ***Remote Sensing***

33 ***Actual Scientific Method (joke!)***

34

- Earth is a dynamic body with many separate, but interacting, parts:
  – Hydrosphere - global ocean and fresh water
  – Atmosphere - gaseous envelope

  - Geosphere - the solid Earth
  - Biosphere - all plant and animal life

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- 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
- Processes that characterize the Earth system vary on spatial and temporal scales and are powered by energy from the Sun and heat from the Earth's interior.

39 ***Earth as a System:***

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

40 ***Sources of Energy:***

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

41

- Origin of our Solar System
  - The universe began with the *Big Bang.*
  - The components of the solar system formed at essentially the same time out of the same material.
  - 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, helium, and 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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44 ***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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- As material accumulated forming early Earth, temperature was high enough for iron and nickel to melt.
- Formation of Earth's layered structure
  - Metals sank to the center
- Chemical differentiation
  - Molten rock rose to produce a primitive crust
  - Established the three basic divisions of Earth's interior: core, mantle, and crust
- A primitive atmosphere evolved from volcanic gases

46

- 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 thick and composed primarily of *granodiorite*
  - Mantle - approximately 2900 kilometers thick and composed of peridotite
  - Core - composed of an iron-nickel alloy

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- Earth's interior 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
  - 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

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- Rocks are divided into three major groups:
  - Igneous, sedimentary, and metamorphic
- The rock cycle
  - Allows us to visualize the interrelationships among different parts of the Earth system.
  - Helps us understand the origin of igneous, sedimentary, and metamorphic rocks and see that each type is linked to the others by Earth processes

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- Igneous rocks
  - Cooling and solidification of 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
- Metamorphic rocks
  - Formed by "changing" preexisting igneous, sedimentary, or other metamorphic rocks
  - Driving forces are heat and pressure

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- Rocks are divided into three major groups:
  - Igneous rocks
    - Cooling and solidification of magma (molten rock)

55 ***Vulcan's Throne, Grand Canyon***

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59 ***granite boulders in ABDSP***

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- Rocks are divided into three major groups:
  - Sedimentary rocks
    - Sediments are derived from weathering of preexisting rocks
    - Sediments will lithify into sedimentary rocks
    - Accumulate in layers at Earth's surface

61 ***lichens on granite***
(biological & chemical weathering)

- 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
-

A “nice” metamorphic rock…

Interactions:

- Earth’s surface is divided into ocean basins and continents.
  - Their elevation difference is a result of differences in their relative density and thickness.
- Ocean basins
  - Average depth is 3.8 km below sea level
  - Composed of approximately 7 km thick basaltic rocks
- Continents
  - Relatively flat plateaus average 0.8 km above sea level
  - Composed of granitic rocks, average 35 km thick

- 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 sea-floor.

- 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.
- Oceanic ridges are the most prominent feature on the ocean floor and are composed of igneous rock that has been fractured and uplifted.

The Pacific Ocean Basin
Atlantic & Indian Ocean Basins

- Features of continents include mountain belts, cratons, shields, and stable platforms.
  - Mountain belts are the most prominent features of continents.
  - Stable interiors of continents, called cratons
  - Shields are expansive, flat regions of deformed crystalline rocks within cratons.
  - Stable platforms are the flat portions of cratons covered with a thin veneer of sedimentary

rocks.

End of Introduction to Geology