

PHYSICAL GEOLOGY G202: INTRODUCTION TO THE EARTH

I. Introduction

- A. INTRODUCTORY STATEMENT: The Earth is our home and habitat, without its abundant resources (air, water, heat) we would not be in existence today!
- B. The Earth is ~5.5 billion years old
 - 1. Vastness of Earth history: the Earth is 5.6 billion years old, to count to 5.6 billion, 1 digit recited at every second, would take approximately 160 years, 2 lifetimes to count that high.
 - 2. Human Species- Homo Sapiens - Evolved in last 1-2 million years
 - a. Dominant Species - Advanced Cerebral Development
 - 3. "Industrial Age" - last ~ 125 yrs
 - a. Significant Anthropogenic Impact on the Planet!!!
 - (1) Atmospheric Impacts
 - (2) Landscape Impacts
 - (3) Hydrologic Impacts
 - (4) Biologic Impacts
- C. Geology Defined
 - 1. Geology = "study of the earth"
 - 2. Physical Geology = study of the physical composition and processes of the Earth
 - a. rocks and minerals
 - b. internal processes
 - (1) volcanism
 - (2) earth quakes
 - (3) plate tectonics
 - c. surface processes
 - (1) e.g. rivers, glaciers, deserts, oceans
 - 3. Historical Geology = study of Earth history including past life (fossils), past processes, and physical conditions

II. Earth Environmental Spheres

Earth can be subdivided into "spheres" of composition represented by the complex interface of four principal components of the environment:

- A. Geosphere
 - 1. comprised of the solid, inorganic portion of the Earth's framework
 - a. Atoms, Elements, Mineral Compounds = Rocky Framework
 - 2. Earth Parts: Crust, Mantle, Core
 - a. Lithosphere - Rigid plates of crust and upper mantle

- b. Asthenosphere - deformable, "hot and mushy" mantle upon which lithospheric plates "ride"
- 3. Rocks - generally silicate-based compounds
 - a. Average Crustal Composition: 8 Elements constitute 98% of the earth's crustal minerals

Oxygen	46.6%
Silicon	27.7%
Aluminum	8.1%
Iron	5.0%
Calcium	3.6%
Sodium	2.8%
Potassium	2.5%
Magnesium	2.1%
Others	1.5%
Total	100%

B. Atmosphere: the gaseous envelope of air that surrounds the Earth

- 1. Bounded by Earth's Gravity
- 2. Average composition of elemental gases in dry air
 - a. Nitrogen (N₂)= 78%
 - b. Oxygen (O₂)= 21%
 - c. Argon (inert) = 0.93%
 - d. Carbon Dioxide (CO₂) = 0.035%
 - e. all others - trace
- 3. Ability to absorb heat in atmosphere from energy radiated from earth's surface, helps keep the planet warm
 - a. "Greenhouse Gases"
 - (1) water vapor
 - (2) carbon dioxide
 - (3) methane

C. Hydrosphere: the waters of the Earth

- 1. "Blue Planet" = unique in solar system
 - a. Free Standing Surface Water
 - (1) Liquid State at Average Surface Temperatures
 - (2) > 70% of Earth Surface Covered by Oceans
- 2. Global Water Budget
 - a. Surface Water
 - (1) Rivers, Streams, Lakes, Ocean
 - b. Ground Water (beneath the surface)
 - (1) Aquifers = porous / permeable Earth Materials
 - (a) Rock, Sediment

- c. Biologic Water
 - (1) Plants, Animals
 - (a) Human Body: > 60% Water
- d. "Stored" and Frozen Water ("Cryosphere")
 - (1) Glacial Ice
 - (a) Continental Glaciers (Polar Ice Sheets)
 - i) e.g. Greenland, Antarctica
 - (b) Alpine Glaciers
 - i) e.g. Mt. Hood / Cascades
 - (2) Sea Ice
 - (a) Arctic / Antarctic Oceans
 - i) e.g. Ross Ice Shelf in Antarctica

- D. Biosphere: all living matter and cellular tissue on the Earth
 - 1. Microscopic and Macroscopic Life Forms
 - 2. Flora and Fauna (Plants and Animals)
 - 3. Life Concentrated Near Earth Surface
 - a. the vast majority of all Earthly life inhabits a zone less than 3 miles thick, and the total vertical extent of the life zone is less than 20 miles.

These 4 Environmental Spheres are not discrete and separated but are interdependent and interwoven with one another. E.g. soil- composed of mineral matter (geosphere), contains life forms (biosphere), soil moisture (hydrosphere), and soil gas (atmosphere) in pore spaces.

III. Earth in Relation to Universe and Solar System

A. "Home Base"

- 1. The is our home and seemingly infinite in its size and abundance relative to our personal lives, our Earth however is merely an infinitesimal speck floating in the vastness of space, the buffer of life between us as individuals and the hostile vacuum of space.

B. The Big Picture: Earth in the Universe

- 1. Basic Earth Visualization:
 - a. spherical in form ("oblate spheroid")
 - (1) Polar diameter = 7900 miles
 - (2) Equatorial diameter = 7927 miles
 - b. Rotation on North-South axis
 - (1) 1 revolution / 24 hrs
 - (2) rotation from west, towards east
 - (a) right-hand curl, with thumb pointing up!
 - c. Orbiting about Sun: 1 / 365 days
 - d. Earth Axis Tilted 23.5 degrees from vertical relative to plane of ecliptic
 - (1) Ecliptic = plane of planetary orbital paths

2. Earth Facts

Radius ~ 4000 miles

Diameter ~ 8000 miles

Circumference = 24,900 miles

Distance to Moon = 230,000 miles

Distance to Sun = 93,000,000 miles

Distance to Next Nearest Star = 2.5×10^{13} mi.

Highest Elevation = 30,000 ft AMSL

Lowest Elevation = 36,000 ft BMSL

3. Solar System (Our Sun = Star = "Sol")

a. Composition and Structure

(1) 9 planets, at least

(2) >40 moons or planetary satellites

(a) Moons or planetoid bodies of rock and/or frozen gas orbiting around planets under the influence of gravity (satellites)

(b) moon light: result of reflection of sun's electromagnetic radiation

(3) hundreds of comets,

(4) thousands of asteroids, and

(5) millions of meteors (from dust to boulder size).

b. Sun = Star: accumulation of hydrogen and helium, spontaneously undergoing fusion, emitting electromagnetic radiation of varying wavelength.

(1) Sun's radiant energy responsible for warming planet, driving climate system, allowing life to exist on planet.

(2) Earth's Sun: one of > 100 billion stars in the Galaxy Milky Way

(a) Galaxy: Accumulation of stars organized about a nucleus, bound by common larger scale gravitational point

(b) Milky Way Galaxy one of hundreds of billions of galaxies in the universe

(3) 99% of solar system mass contained in Sun

(a) primarily in form of hydrogen

c. Planets in Solar System

(1) Inner Planets = "Terrestrial" = made of rocky material

(a) Characterized by mineral composition, smaller diameters, slower rotations, greater density.

i) Mercury

ii) Venus

iii) Earth

iv) Mars

- (2) Outer Planets = "Jovian" = made of frozen gases
 - (a) Characterized by large diameters, large masses, less density, rapid rotations, and composed entirely of frozen gases (hydrogen mainly)
 - i) Jupiter
 - ii) Saturn
 - iii) Uranus
 - iv) Neptune
 - v) Pluto

- 4. Cosmology (Origin) of Universe and Solar System (Models and Hypotheses):
 - a. Big Bang Theory- all matter of the universe was compressed through gravitational attraction into a concentrated mass in space. Gravitational forces became so intense that a "big bang" occurred in which all of cosmic material began dispersing throughout the universe at enormous speeds.
 - (1) Hot Plasma Cooling through Time
 - (a) Formation of atoms, elements, matter
 - (2) Gravity = the organizing force in universe
 - (a) Gravity drives formation of rotating disks, spheres, and circular motion
 - (3) Age of Universe: Estimates ~15-20 Billion Years Old
 - b. Our solar system- originated when a nebula (or a cold diffuse molecular cloud of gas and dust, 1 light year in diameter) began to contract inward forming a hot, dense protosun. The hot center was surrounded by a revolving disk of cold cosmic material that formed the planets.
 - (1) Planets Formed ~ 5 b.y. ago
 - (2) moons represent failed planets captured by planet gravity
 - (3) Sun's gravity dominates solar system

IV. Driving Forces of Geologic Processes: **Climate, Gravity, Internal Heat/Tectonics**

- A. **Climate** (Exogenic Force: from without)- average weather conditions at any place over a long period of time.
 - 1. Climate and the sun: Climate driven by solar energy of sun, i.e heat
 - 2. Climate largely driven by heat transfer of sun's energy about atmosphere and ocean waters
- B. **Gravity as a controlling factor**
 - 1. Force of attraction between the earth's center of mass and surface materials (sediment, soil, water) drives landscape evolution
 - a. $F = G [(m_1 m_2) / r^2]$; where F = force of gravity, G = gravitational constant, m = mass of 2 objects in space, r = distance separating the two objects in space. Given all other variables constant, F > with < r, and F < with > r. Each body exerts an equal force of attraction

- (1) g = acceleration of a falling object (e.g. sediment) due to gravitational force F , assumed to be constant at 980 cm/sec^2
- (2) Gravity obviously influences surface water flow, mass wasting/hillslope movement processes, serving as a driving force

C. **Internal Heat of the Earth (i.e. Tectonics)**

1. Internal Heat of Earth: supplied primarily by:
 - a. radioactive decay with exothermic heat loss
 - b. frictional heat by earth tides and internal rock deformation
 - (1) Based on seismic analysis: earth's outer core is thought to be of high enough temperature to be molten
2. Internal Heat Transfer
 - a. Mantle convection: physical movement of rock material as a heat transporting medium
 - (1) hot, deeper mantle rises as it is of $<$ density
 - (2) cooler, shallower mantle sinks as it is of $>$ density
 - b. Internal heat transfer of the earth thought to be the driving mechanism of plate tectonics and plate motion

Summary of Ultimate Driving Forces in Geology

Gravity = fundamental force in the universe

Climate = result of external heat exchange on the Earth's Surface

Internal Heat = result of intern heat exchange inside the Earth

Class Question: How do the three driving forces influence the following geologic phenomena?

Volcanism

Glaciers

Rivers

Landslides in Western Oregon