I Earth's Interior

- A How we know what's inside
  - i) Astronomy - Physics
    - (1) Calculating Earth's Density
    - (2) Gravitational influence, mass
    - (3) Volume, Shape, Diameter
    - (4) calc. Density of Earth 5.5 g/cm^3
    - (5) Surface 2.8 g/cm^3
  - ii) Drilling through the crust – deepest is 12 km (≈ 7.4 miles)
  - iii) Earth's delivery service
    - (1) Kimberlite Pipes and Xenoliths
    - (2) Volcanoes
    - (3) Seismic data – (will discuss later)
  - iv) Vibration energy waves
  - v) Earthquake data
- B Interior Structure
  - i) Chemical Composition
    - (1) Crust
      - (a) 5 to 75 km thick
      - (b) Solid
      - (c) Silicon (Si) and Oxygen (O)
      - (d) Continental
        - (i) 5 to 8 km thick
        - (ii) Old (billions of years in age)
        - (iii) Deformed
        - (iv) Density 2.7 g/cm^3 - Granite
      - (e) Oceanic
        - (i) 5 to 8 km thick
        - (ii) Relatively young (less than 200 million years)
        - (iii) Undeformed
        - (iv) Density 3.0 g/cm^3 - Basalt
    - (2) Mantle
      - (a) Approximately 2900 km thick
      - (b) 82% of Earth's Volume
      - (c) 68% of Earth's Mass
      - (d) Density increases with depth through the mantle
      - (e) 3.2 g/cm^3 in upper portion
      - (f) 5 g/cm^3 in lower portion
      - (g) Silicon (Si) and Oxygen (O) with some iron (Fe) and magnesium (Mg)
    - (3) Core
      - (a) Total diameter – 7000 km
      - (b) 16% of Earth's Volume
      - (c) 32% of Earth's Mass – Density 10.8 g/cm^3
      - (d) Iron (Fe) Rich
- C Interior Components - Physical Properties
  - i) Lithosphere

- (1) Solid, strong, and rigid outer layer
- (2) Includes all of crust and the upper mantle
- (3) 10 to 300 km thick

ii) Asthenosphere
- (1) High Temperature
- (2) Moderate Pressure
- (3) Soft-plastic zone (Rock can flow)
- (4) Upper Mantle
- (5) 100 to 500 km thick

iii) Mesosphere
- (1) High Temperature Zone
- (2) High Pressure Zone
- (3) Rock is stronger and more rigid than in the overlying Asthenosphere
- (4) Remainder of Mantle

iv) A Two Component Core
- (1) Inner Core
  - (a) ≈1200 km thick
  - (b) Solid
- (2) Outer Core
  - (a) ≈2300 km thick
  - (b) Liquid – Molten
  - (c) May have Nickel (Ni) present

II Plate Tectonics

A Plates and Plate Boundaries
- 1 Plates
  - a Can be oceanic crust
  - b Can be continental crust
  - c Can be a combination of both
- 2 Divergent
- 3 Convergent
- 4 Transform

B Divergent Boundaries – Mid-Ocean Ridges (MOR)
- 1 Separates 2 tectonic plates
- 2 Tectonic plates move apart
- 3 New Oceanic Crust is generated
- 4 Average crustal generation – 5 cm/yr; varies between 2-20 cm/yr
- 5 Rifting
  - a Upwelling below continent
  - b Crust extends, thins, & weakens
  - c Extension causes faulting and volcanism
  - d Forms rift valley
  - e Spreading continues
  - f Rift becomes deeper and wider – creates a linear sea
  - g Further spreading creates an ocean basin
- 6 Ophiolite Complex
  - a Oceanic Crust

- b Marine Sediment
- c Pillow Basalts
- d Sheeted Dikes
- e Gabbro

7 Earthquakes and Divergent Boundaries
- a Earthquakes are shallow, less than 10 km in depth
- b Small magnitude (low energy)
- c Narrow pattern along MOR

C Convergent Boundaries

1 Plates come together
- a Ocean-Ocean Convergence
- b Ocean-Continent Convergence
- c Continent-Continent Convergence

2 Subduction Zones
- a Ocean-ocean collision or ocean-continent collision
- b Density differences in crust forces one plate to descend under the other plate
- c More dense plate descends at an angle between 15o to 75o with an average of ≈ 45^{o}
- d Subduction of plate creates a deep-ocean trench
  - i Range in depth between 8 – 12 km
  - ii 100’s km wide and 1000’s km long

3 Ocean-Continent Collision
- a Ocean crust is more dense (3.0 g/cm3) than continental crust (2.8 g/cm3)
- b Ocean Crust subducts
- c Within the mantle, plate begins to melt
- d Melt has basaltic to intermediate composition
- e Hot melt (magma) is less dense (more buoyant) than surrounding material and rises
- f Ascending magma incorporates continental crust – composition becomes intermediate to felsic
- g Creates linear zone of igneous activity (volcanoes or intrusions-plutons) called a Continental Arc

4 Ocean-Ocean Convergent Zone - Ocean-Ocean Collision
- a Similar to Ocean-Continent Convergent Zone except no influence of Continental Crust
- b Magmas are basaltic to intermediate in composition
- c Ascending magma creates linear Volcanic Island Arc

5 Continent-Continent Convergent Zone (Collision)
- a Is preceded by Ocean-Continent Convergence
- b Density between plates is similar – neither will subduct
- c Crust buckles, fractures, shortens, thickens due to compressional stress
- d Creates large mountains of folded and faulted rocks.

6 Earthquakes & Convergent Boundaries
- a Earthquake depth ranges from shallow (< 10 km) to deep (> 300 km)

        b High magnitude (high energy) – 95% of all earthquake energy is released from convergent zone earthquakes
        c Wide zone, but with a pattern

D Transform Boundary
    1 Transform Faults
        a Plates slide past one another
        b Crust is neither produced nor destroyed
        c Facilitate plate movement
        d Connect segments of MOR
        e Found in both ocean crust and continental crust
        f Can create compressional structures (folds) and extensional structures (basins)
    2 Earthquakes and Transform Boundaries
        a Earthquakes are shallow, less than 10 km in depth
        b Small magnitude (low energy)
        c Common
        d Narrow pattern along MOR

E Hot Spots

F Plate Tectonics – Driving Mechanisms
    1 Driven by the release of internal energy in the form of heat
    2 Proposed mechanisms
        a Convection cells
        b Differences in density and forces generated by plates
        c Forces Active on Plates
        d Slab-pull – sinking of dense ocean crust pulls the plate
        e Ridge-push – gravity pulls plate off of the MOR
        f Basal drag – resistance of plate from underlying asthenosphere
        g Mantel resistance – subducting plate is resisted in the asthenosphere and mesosphere
            (a) Friction – resistance along transform faults and between converging plates