ES 106 Sea Floor Sediments, Sea Floor Tectonics,

I. Water planet
   A. 71% covered by sea
   B. All 'oceans' are interconnected
   C. Less land exposed in southern hemisphere

II. Ocean basins—four main basins
   A. Pacific
      1. ½ of all ocean surface
      2. greater than area extent of all continents
      3. average depth 3940 m
      4. has deepest ocean trench in western portion—Mariana Trench
   B. Atlantic
      1. ½ size of Pacific
      2. Narrow—bounded by continents with similar shoreline shape
      3. less average depth than Pacific
   C. Indian
      1. depth nearly same as Atlantic
      2. slightly smaller than Atlantic
      3. bounded by land on north—mostly in southern hemisphere
   D. Arctic
      1. small—7% of Pacific
      2. shallow— ¼ average depth of other oceans
   E. Average elevation—Continents vs. Oceans
      1. continents—840 m above sea level
      2. oceans—3730 m below sea level: 4+ times elevation above sea level

III. Ocean Floor
   A. Mapping
      1. Challenger—127,500 km voyage in 1870s
         a. Depth—by weighted line
         b. Salinity, temperature, clarity
      2. Modern depth measurements by SONAR
         a. SOund Navigation And Ranging
         b. Ping emitted is received
         c. Distance calculated by travel time of ping
         d. Sidescan instruments show details, not depth
      3. Seismic Reflection Profiles
         a. Explosions produce sediment-penetrating sound waves
         b. Shows information about character of sea-floor
      4. Satellilte Radar Altimiters
         a. Measure height of sea surface
         b. Gravity causes irregularities
            1) Higher surface over undersea mountains
            2) Lower surface over deep sea floor
         c. Ability to detect small scale differences

B. Provinces of the sea floor
    1. continental margin
        a. continental shelf
            1) part of continental crust flooded by ocean
            2) narrow, gently sloping zones to about 130 m depth
        b. drops off at continental slope
            1) very narrow
            2) markedly steeper than shelf
        c. submarine canyons
            1) cut outer shelf and slope
            2) deliver sediment to ocean basin floor
    2. ocean basin floor
        a. most is abyssal plains—flat, featureless surface
        b. deep ocean trenches—small portion at lithosphere plate convergence
        c. seamounts—volcanic peaks
        d. plateaus—volcanic plains
    3. oceanic ridge
        a. tectonic feature of divergent lithospheric plates
        b. 1000 to 4000 km wide, 2000 to 3000 m high—not topographic marvel in appearance

IV. Two types of crust: continental and oceanic
    A. Continental
        1. enriched in silica, ~75%
        2. less dense than oceanic crust
            a. not subducted in tectonic processes
            b. older, thicker because it remains at surface
    B. oceanic
        1. about 50% silica, about 50% iron, magnesium
        2. greater density than continental crust
            a. plate convergence results in subduction
            b. none over 180 million years old
    C. shoreline NOT the division between them: some ocean water has flooded edges of continental crust
        1. amount of water in ocean basin is variable: presently 3% water is ice
        2. volume of ocean basin is variable

V. Continental margins
    A. Two types, depending on position with respect to edge of lithospheric plate
        1. active—edge of lithospheric plate: usually convergent plate boundary
        2. passive—not on edge of lithospheric plate
    B. Active continental margins
        1. convergent lithospheric plates
        2. subduction zone
        3. narrow continental shelf/margin
        4. trench catches sediment before it reaches deep sea floor
        5. accretionary wedge, or not—depending on rate, age

C. Passive Continental Margins
1. Continental Shelf
    a. Gently sloping from shoreline to ocean basin floor
        1) Slopes 1/10 of one degree—2 m / km
        2) Would look flat to observer—some exceptions
            a) Glacial deposits from time of lowered sea level
            b) Submarine canyons—also formed in lowered sea level
    b. Part of continental crust—flooded by ocean
    c. Various widths worldwide—up to 1500 km in places
        1) Average width 80 km
        2) Average depth of outer edge 130 m
            a) Shallow enough for exploitation
            b) Petroleum, sand and gravel, fishing
    d. 7.5% of world ocean
    e. Gradual subsidence of shelf results in thick sediment deposits
2. continental slope: seaward edge of continental shelf
    a. boundary of continental to oceanic crust
    b. narrow and steep
        1) 20 km wide
        2) Average slope 5^{o}, to + 25^{o} in places
3. continental rise—only forms where shelf is not terminated by trench
    a. wedge of sediment beyond continental slope on deep sea floor
    b. slightly more slope than shelf surface
    c. 100s of km wide
    d. Composed of coalescence of deep sea fans deposited by flows from submarine canyons
4. submarine canyons
    a. extensions of shelf valleys cut into continental margin from shelf to deep sea floor
    b. river valleys extended onto shelf during glacial ages
        1) additional runoff during melting enhanced erosion
        2) sediment-laden water could be dense enough to flow below sea water
    c. undersea erosion continues with sediment-laden sea water
        1) deposition of sediment on canyon slopes, continental shelf
        2) episodic downslope movements of unstable deposit
            a) overcomes oversteepened slope
            b) massive underwater landslide
            c) may have trigger such as earthquake
        3) flow capable of scouring canyon further
            a) ‘Turbidity current’ creates ‘turbidite deposit’
                i. High density due to sediment load
                ii. Flows down the submarine canyon to deep sea floor
                iii. Spreads and slows on exit from canyon mouth
                    a. Deposits its coarse load first
                    b. Gradually drops finer and finer material
                    c. Single bed with coarse-to-fine grain character—‘graded bedding’
            b) May erode canyon head closer to shore, create distinctive scour marks in surface it flows over

VI. Ocean Basin Floor
  A. Deep sea trenches—Atlantic has only two
    1. At convergent lithospheric plates
      a. Subduction zone takes oceanic plate into mantle
        1) Earthquakes deeper toward trench
        2) Volcanic activity above subducted plate
          a) Water lowers melting temperature of hot rock
          b) Magma → volcanic arc: continental or oceanic island
      b. Accretionary wedge may be massive or absent
    2. Mariana Trench in western Pacific
      a. is 11,022 m deep—
      b. explored in 1960
        1) by Picard and Walsh in *Trieste*
        2) reached 10,912 m
        3) saw flatfish, jellyfish, shrimp
  B. Abyssal plains
    1. surface is flat—deposits of abyssal clay
    2. subsurface often more rugged
    3. more abyssal plains where there are no deep-ocean trenches along continental margin
  C. Seamounts, guyots, oceanic plateaus
    1. volcanic features of deep-ocean floor
    2. Seamounts, Guyots
      a. Hotspot or oceanic ridge volcanism—
        1) may emerge from sea surface leads to formation of Guyot
          a) subject to wave erosion
          b) eventual subsidence below sea surface
      b. seamount keeps conical shape, due to lack of wave erosion
    3. oceanic plateaus
      a. topographically high ocean floor composed of volcanic rock
      b. mantle plume or deep-sea rifts discharge massive amounts of basaltic lava
VII. Oceanic Ridge—divergent plate boundary
  A. Description
    1. 70,000 km interconnected
    2. 20% of Earth's surface
      a. 1000 to 4000 km wide
      b. 2 to 3 km (2000 to 3000 m) high
  B. Features
    1. Earthquake activity common, shallow
    2. high heat flow
    3. volcanic activity—basaltic, pillow lava
    4. rift valleys parallel to ridge axis
  C. new oceanic crust created at ridge, older is drawn away from ridge