

## Marine Provinces

### Sverdrup Chapter 4 (with some of Chapter 2)

#### I. Bathymetry

- A. Definition: Bathymetry is the study of the ocean depth. Akin to topography in geography, it is driven largely by plate tectonics (large scale) and by biology, chemistry, and physics (small scale)
- B. Hypsographic Curve: a cumulative plot of area versus depth or elevation
  - There is a very uneven distribution of the planet Earth
  - The average (mean) depth of the oceans is 3800 m, of land, 840 m
  - 2 almost flat areas
  - 3 very steep areas
  - extreme features are caused by plate tectonics!
  - can use this fact to look for evidence of plate tectonics on other planets

#### II. Measurements

- A. Seismic Surveys
  - Set off an explosion (or use natural seismic events)
  - High frequency waves don't penetrate very far, bounce off solid objects very easily
  - Low frequency waves penetrate further
  - By measuring frequency and time to return, get both composition and depth
- B. Side-Scan Sonar
  - Provides a map of the ocean floor
  - Instead of explosions, it just bounces sound waves off the bottom
  - Maps can measure up to 60 km width, but lose resolution
- C. Satellites
  - Altimeters provide gravity maps of the ocean floor
  - GEOSAT satellite cannot measure the seafloor directly, but it can sense variations in elevations of the ocean surface to within 5 cm by bouncing radar waves off the ocean. Since we know where the satellite is, can measure the height of the ocean.
  - Sea Surface Height (SSH) is elevated over seamounts and ridges, and depressed over trenches and deep regions
  - PROBLEMS: can only detect regions about 10 km x 1 km (height) in size (seafloor objects), and bulges may be due to the density difference of the underlying rocks rather than just size, BUT it is very useful for regions where it is difficult to map, or to get multiple snapshots

- TOPEX/Poseidon improves resolution to about 2 cm SSH, can be used to watch things like Kelvin waves
- Ocean color satellites can also be used to estimate bathymetry by determining the color of the water, which corresponds to depth (mostly used for coral reefs)

#### D. LIDAR

- same idea as a SONAR, but uses a laser beam, and is flown in an airplane
- provides very high (mm) resolution, but only for shallow waters such as beaches

### III. Marine Provinces

#### A. Deep Ocean Basins vs. Continental Margins

- formation of ocean basins again dominated by plate tectonics
- Continental margins caused by an accumulation of weathered sediments overlying the basaltic crust

#### B. Continental Margins--2 general types:

##### 1) Atlantic-type Margins

- also called passive margins because not much seismic activity
- broad continental shelf, slope and rise; plate edges may extend well into the ocean, and the continental boundary is the former plate edge

##### 2) Pacific-type Margins

- Also called active margins, very seismically active
- Leading edge of margins created by the collision of oceanic and continental plates
- Characterized by deep, narrow trenches, and shallow shelf areas

### IV. Continental Margins (Atlantic Type):

#### A. Divided into continental shelf, continental slope, and continental rise

- Shelf is the shoreline to the shelf break, or to an increase in the average slope
- width varies from tens of meters to 1300 km, average about 70 km, 135 m deep
- Slope is similar to continental mountain ranges, avg. 4 degree angle (1-25 deg)
- >3 degrees, get submarine canyons
- resemble large river-cut canyons on continents, with V-shaped walls
- Turbidity Currents major mechanism of erosion in the canyons; may be started by earthquakes, other disturbances (river floods, etc.)
- They deposit sediments in a deep sea fan
- Continental Rise is due to the merging of many deep sea fans
- Amazon Cone is the biggest example, resembles the Mississippi Delta

- Western Boundary Undercurrent (WBUC) or slope current flows towards the equator along the base of the continental slope along western
- boundaries of most ocean basins (like the Gulf Stream)
- Forms a benthic nepheloid layer of suspended sediments

## V. **Deep-Ocean Marine Provinces**

- The depth of deep-ocean basins generally exceeds 4000 m, completely underlain by basaltic (oceanic) crust
- Much of this makes up the Abyssal Plains, a very flat section
- Abyssal Hills are common in the Pacific, but not Atlantic, because the Pacific is more tectonically active, younger, and further from the influence of continental processes
- Ocean ridges and rises are the longest and most continuous mountain belt on earth! They occupy about one third of the basins
- Hydrothermal Vents
  - o Seawater seeps through the cracks, circulates down and is heated by the magma (which may be within about 1 km of the surface)
  - o Warm Water Vents: 10-20 deg. C
  - o White Smokers: 30-300 deg. C Barium Sulfate makes them white
  - o Black Smokers >350 deg. C Black metal sulfides
  - o Hydrothermal circulation recycles the entire basin volume in 3 million years!
  - o Vents first discovered at the Galapagos Rift in 1977
  - o Fracture Zones
  - o extend beyond transform faults (such as the San Andreas, or Mendocino)
  - o Can extend for thousands of kilometers, may differ by 1500 m depth on either side due to unequal ages (and cooling/shrinking of older rock)
- Intra-Plate Features
  - o Seamounts and Table-mounts (guyots) are ancient volcanos that gradually sank (flat on top because of erosion)
  - o Coral reef development was proposed by Charles Darwin, and published in 1842, required seafloor sinking!
    - fringe reef, barrier reef, and atolls
  - o Hot Spots are also associated with the formation of seamounts
- Subduction Zones
  - o Trenches form in these areas
  - o Not much known about them (too deep)