Ocean 201 week 2 Lecture 3: Physiography of the Seafloor (M.J. Mottl)

Text from slides

Ocean Depth versus Continental Height
Why do we have dry land?

- Solid surface of Earth is dominated by two levels:
  - **Land** with a mean elevation of +840 m (29% of Earth surface area).
  - **Ocean floor** with mean depth of -3800 m (71% of Earth surface area).

If Earth were smooth, depth of oceans would be 2450 m over the entire globe!

Hypsometric curve of Earth shows ***two modes***.
Hypsometric curve of Venus shows only one!
Why?

Origin of Continents and Oceans

- ***Crust*** is formed by differentiation from mantle.
- A small fraction of mantle melts.
- Melt has a different composition from mantle.
- Melt rises to form crust, of two types:
  1) Oceanic 2) Continental

Two Types of Crust on Earth

- ***Oceanic Crust***
  - About 6 km thick
  - Density is 2.9 g/cm3
  - Bulk composition: ***basalt***

  (Hawaiian islands are made of basalt.)
- ***Continental Crust***
  - About 35 km thick
  - Density is 2.7 g/cm3
  - Bulk composition: ***andesite***

Concept of Isostasy: I

- Derived from Greek:
  - Iso ➔ equal
  - Stasia ➔ standing
- Density and thickness of a body determine how high it will float (and how deep it will sink).
- Crust is in gravitational equilibrium:
  - Buoyancy mechanism
  - Compensation occurs in asthenosphere.

Concept of Isostasy: III

- Continental mountains can be viewed as blocks of wood of lower density and greater thickness that float higher and sink deeper than oceanic crust.

- Oceanic crust is more dense but thinner so it floats/sinks to a lesser extent than does continental crust.

Hypsometric curve of Earth shows ***two modes***.
Hypsometric curve of Venus shows only one!
Why? Venus has only one type of crust!

Position of Shoreline
- 25% of continental crust currently below sea level
- Continents are high and dry relative to most of geologic past…
- Past range of sea level is about +300 m to -150 m

Sea Level During the Paleozoic
Throughout most of the Paleozoic (600-225 Ma) sea level was high, widely flooding continents as shown in the maps above. Note the orientation of North America wrt the equator of the time. Land is dark, shallow seas are lightly shaded. Present coasts are shown for reference but are not geographically correct for the time.

Causes of Sea Level Change
1. Change in the volume of the ocean basins
2. Change in the mass of ice on the continents
   If ice sheets/glaciers were to melt, sea level would rise by 70 m.
- Local vertical tectonic motion

Physiography of the Ocean Floor
- Area of Earth: 510 Mkm2
- Area of Oceans: 361Mkm2
- Deepest part of ocean: Mariana Trench 11.04 km
- Highest point on land: Mt. Everest 8.85 km

Continental Margins
- 20% of ocean area
  - Continental shelf, 1/1000 slope, up to 400 km wide, extends to shelf break at ~130 m depth.
  - Continental shelf was exposed 20Ky bp during the last glaciation (lower sealevel).
  - Continental slope, 1/40 slope (4o), <200 km wide
  - Continental rise, 1/400 slope, 100-1000km wide, formed of sediment

Types of Continental Margins
Atlantic (shelf, slope, rise): passive, aseismic
Pacific (shelf, slope, trench): active, seismic
  - Chilean type: Shelf, slope, then trench
  - Mariana (or island arc) type: Shelf, slope, marginal basin, volcanic island arc, trench

Mid-Ocean Ridges (axis and flanks)

- 60,000 km long (including back-arc basins)
- Occupy 1/3 of ocean basin area.
- Axis depth ~2500 m
- Parallel ridge and valley structure, with or without axial valley

Continental and Oceanic Cross Sections

Fracture Zones

- Troughs generally perpendicular to mid ocean ridge segments, which they offset.
- 10-100 km wide, up to 3500 km long
- Up to a few km relief

Other Sea Floor Features

1. Abyssal Plains: Slope <1/1000, 3000-6000 m deep, 200-2000 km wide
2. Abyssal Hills: < 1000 m high, transition to MOR
3. Seamounts: off ridge volcanoes, > 1000 m high
4. Trenches: along continental margins or *island arcs*
5. Marginal (back arc) Basins: separated from deep ocean by island arcs and/or trenches

Trench Cross Section…
7-11 km deep: 2-4 km deeper than surrounding seafloor
40-120 km wide

Characteristics of Pacific Ocean

- 50% of ocean area, 53% of volume
- Largest and deepest (3940m)
- Surrounded by mountain belts, trenches, & island arcs
- Narrow continental shelves
- Isolated from terrigenous sediment input by marginal basins and trenches
- Numerous volcanic seamounts and islands

Characteristics of Atlantic Ocean

- 26% of ocean area, 25% of volume
- Narrow with longest N-S link
- Split nearly symmetrically by Mid-Atlantic Ridge
- Shallowest (3575 m) because of wide continental margins
- Highest input of fresh water and terrigenous sediment from rivers (Congo + Amazon ➔25% of global water discharge)

Characteristics of Indian Ocean

- 21% of ocean area, 21% of volume
- Average depth (3840 m)
- Small area (9%) of conti-nental shelves
- Mainly in S. hemisphere

- Few islands, but numerous submarine plateaus and rises
- River and sediment input in northern part of basin