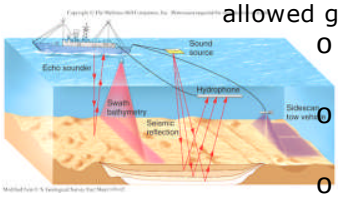
Chapter Outlines

NOTE: This is intended to help students 'organize' their understanding of each topic. It is <u>not</u> a comprehensive study guide for quizzes or midterms, i.e. <u>study your text!</u>

Sea Floor

It is estimated that the world's first oceans formed about four billion years ago as a result of the cooling of the primitive earth. Volcanic eruptions discharged huge amounts of hot water vapor and other gases that cooled to form liquid water on the rugged surface. The volume of the oceans grew as volcanoes continued to emit gases from the molten rocks below. The chemical composition of the ocean water became salty as sodium, calcium, and magnesium were freed by chemical weathering and swept into the ocean by erosional processes.

- Oceans cover about **70 percent** of Earth's surface. The geology of the sea floor was largely unknown until the last half of the twentieth century when the rapid advance of new technologies allowed geologists to study the sea floor in great detail.



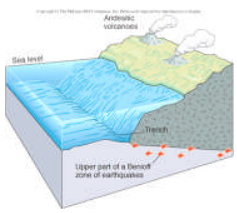
Measuring/mapping the sea floor

  - **Echo sounder** *(many variations exist)* – determines depth by measuring time for a sound wave to travel from a ship, to the ocean floor, and back to the ship.
  - **Seismic profiler** - similar to echo sounder, but uses frequencies that penetrate the ocean floor and provide information on underlying structures.
  - **Rock dredge** – collects rock and mud samples from the ocean floor.
  - **Corer** – drills and retrieves a 'column' of seafloor sediment.
  - **Deep sea drilling** – also drills and retrieves columns of sediment, but can drill into the ocean floor rock to great depths.
  - **Submersibles** – allows scientists to travel to the ocean floor to make observations *(deepest was to the bottom of the Mariana trench in 1960).*
  - **Satellites** – can map ocean floors by using the variations in the ocean surface *(less accurate).*

Drilling the sea floor

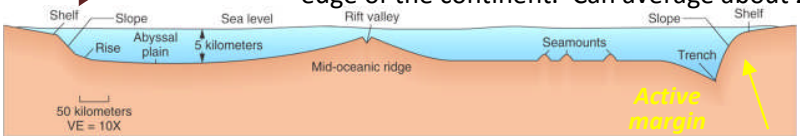
- <u>Continental Margins</u>

Active continental margin



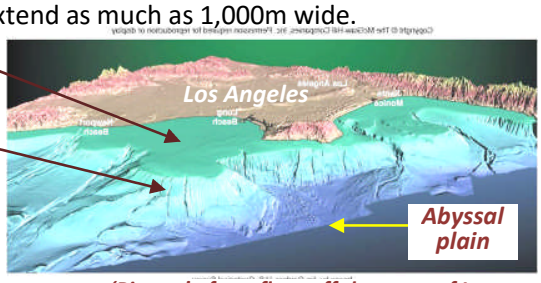
  - **Active margin** – much tectonic activity, continental slope ends in an **oceanic trench**
  - **Passive margin** – little tectonic activity, consists of continental shelf, slope, rise, then abyssal plain
  - **Continental shelf** – shallow, almost flat platform that extends seaward from the edge of the continent. Can average about 200m deep and extend as much as 1,000m wide.

Passive continental margin

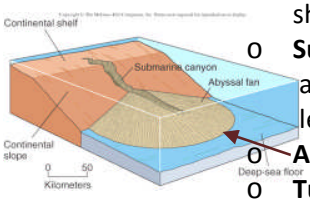


Continental shelf

Continental slope



'Picture' of sea floor off the coast of Los Angeles (made from echo soundings)

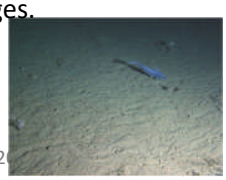


  - **Continental slope** – extends from the continental shelf into the deep ocean at an average of 4 to 5 degrees.
  - **Submarine canyons** – features cut into continental shelves and slopes, either by streams during times of very low sea levels *(ice ages),* or by turbidity currents
  - **Abyssal fans** – often found at the mouths of submarine canyons
  - **Turbidity currents** – large volumes of dense, sediment-laden water that become dislodged by some disturbance and travel very rapidly down continental slopes to the abyssal plain.

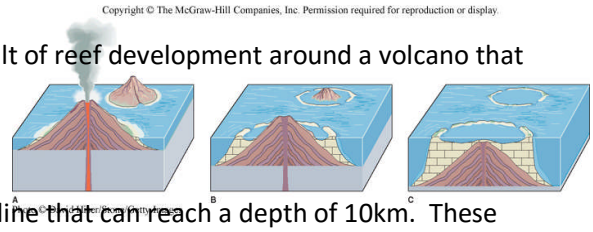
- <u>Ocean floor sediments</u>
  - **Terrigenous sediment** – derived from land, found their way to the sea floor. They can be found on the continental rise and abyssal plains largely due to turbidity currents and similar processes.
  - **Pelagic sediment** – windblown clay particles and microskeletons of marine organisms that settle slowly far from shore into the deep ocean. These are nearly absent at mid-ocean ridges.
  - **Hydrogenous sediment** – mineral-rich sediments that precipitated from seawater.

Microscopic skeletons (pelagic sediment)

Deep sea floor…likely pelagic sediment

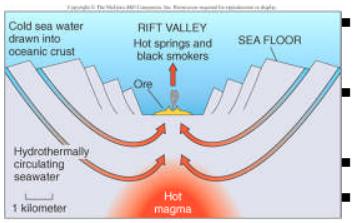


- Reefs – as used in this chapter, reefs are accumulations of organism that form in warm shallow water... typically consisting of coral.
  - **Fringing reefs** – flat expanses of reef that grow in the shallow water near the shore.
  - **Barrier reefs** – are elongated features that develop offshore parallel to the coastline and are separated by deep lagoons.
  - **Atoll** – circular reefs found in deeper water, the result of reef development around a volcano that has since subsided.

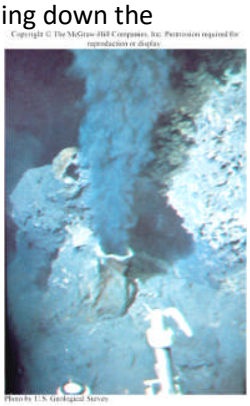


Typical reef-building sequence

- Seafloor features
  - **Oceanic trench** – a narrow trough parallel to a coastline that can reach a depth of 10km. These are the deepest places on Earth's surface.
    - They form at converging boundaries, and are associated with Benioff earthquake zones dipping landward under the continents or island arcs.
    - Volcanoes found above the upper part of Benioff zones are arranged in long belts parallel to trenches and are often andesitic.
    - Trenches are marked by very low heat flow and large negative gravity anomalies.
  - **Midoceanic Ridges** – encircles the globe like the seams on a baseball, typically running down the center of oceans.
    - They form at diverging plates and typically have a tensional rift valley at the crest.
    - They are associated with basaltic volcanism *(submarine)* hydrothermal activity and shallow earthquakes.
    - A rift valley usually runs down the crest of the ridge.
    - Extremely high heat flow, often marked by line of hot springs supporting unique biological communities.
    - They are often offset along transform fault zones.

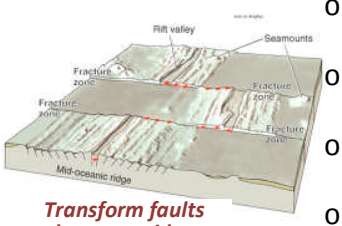


Midocean ridge & rift valley



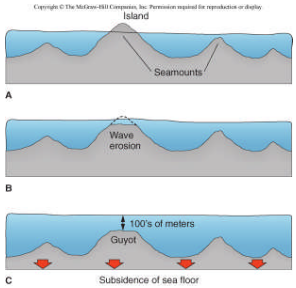
Hydrothermal vent at a midocean ridge

  - **Transform faults** – are that portion of fractures between two offset portions of a midoceanic ridge.



Transform faults between ridge sections

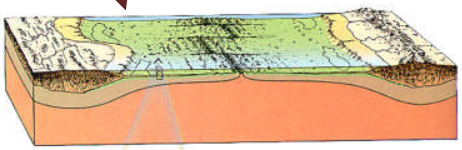
  - **Seamounts** – submerged conical basaltic volcanic peaks that rise ≥1000m above the seafloor along mid-ocean ridges and out in abyssal plains. Chains of seamounts form aseismic ridges.
  - **Guyots** – submerged, flat-topped seamounts that were apparently cut by wave action, and commonly capped with coral reefs.
  - **Aseismic ridges** – chains of seamounts and guyots that are not associated with earthquakes.
  - **Abyssal plains** – extremely flat regions beyond the base of the continental rise. These are the flattest features on Earth with slopes of <0.01° due to accumulation of sediments.

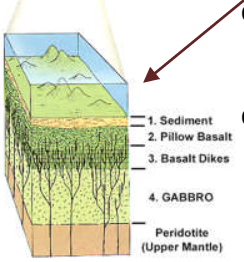


Seamounts, & formation of a guyot

Section view of continental and oceanic crust across a 'spreading center'

- Oceanic crust
  - **Oceanic crust** *(mafic)* is thinner *(7-10 km)* and denser *(3.3 g/cc)* than continental crust *(felsic)*
    - Layer 1: marine sediments of various composition and thickness
    - Layer 2: pillow basalts overlying basaltic dikes
    - Layer 3: sill-like gabbro intrusions *(not directly sampled)*





Oceanic crust 'layers'

  - **Ophiolites** in continental mountain ranges are thought to be sequences *(large blocks)* of oceanic crust that were brought to Earth's surface by tectonic forces. With that assumption, they are thought to include examples of upper mantle rock *(peridotite).*
  - All rocks and sediments of the sea floor are younger than 200 million years *(in contrast, much older rock is commonly found on continents).* Seafloor is continually being made anew at midoceanic ridges and destroyed *(subducted)* at deep ocean trenches.