

CHAPTER 13

THE OCEAN FLOOR

A. Introduction:

Ocean basins have a great deal of features that matches those on the surface (i.e. continents) such as, volcanoes, deep canyons, rift valleys, and large submarine plateaus.

B. Mapping the Ocean Floor:

In 1920s *echo sounder* (*sonar*) was invented.

It is used to transmit sound waves toward the ocean bottom, and at the surface recording the echo reflected from the bottom. The travel time is recorded (2 way travel time).

Knowing the velocity of sound waves in water (1500 m/s), and knowing the time for the pulse to reach the ocean floor and return, depth can be calculated (*depth = velocity x time*).

Combining profiles from many adjacent measurements, a chart of the seafloor can be produced.

Modern echo sounders can be more complex. Multi beam sonar utilizes a configuration/array of sound sources and hydrophones.

It produces a profile of a narrow strip of seafloor, as opposed to single beam sounders, where they produce the depth of a single point every few seconds.

Oceanographers who study the topography of ocean floor established three major units:

1) *continental margins*

2) *deep-ocean basins*

3) *mid-ocean ridges*

C. Continental Margin:

It is the portion of the seafloor adjacent to the continents. It may include the continental shelf, continental slope, and continental rise. Two main types of continental margins: *passive* and *active*.

i. Passive continental margins:

Found along most of the coastal areas that surround the Atlantic Ocean, including the east coasts of N and S. America and west coasts of Africa and Europe.

Passive margins are *not* associated with plate boundaries. So, little volcanism and few earthquakes.

Passive continental margins comprise: continental shelf, continental slope, and continental rise

a. Continental Shelf:

It is a gently sloping submerged portion of the continental margin extending from the shoreline to the continental slope. It is actually the flooded extension of the continents.

It may extend 1500km (930 mi). Averages 80 km (50 mi) wide, and 130 m (430 ft) deep. Its slope is one-tenth of 1 degree.

It contains important mineral deposits, including large reservoirs of oil and gas, plus huge sand and gravel deposits. It is also important for fishing (as a source of food).

b. Continental Slope:

The steep gradient that leads to the deep-ocean floor and marks the seaward edge of the continental shelf.

It marks the boundary between the continental crust and oceanic crust. Its slope averages 5 degrees.

c. Continental Rise:

The gently sloping surface at the base of the continental slope. It may extend 100s of km into the deep-ocean basin.

It consists of a thick accumulation of sediment that moved downslope from the continental shelf to the deep-ocean floor.

Turbidity currents deliver these sediments to the base of the continental slope, and when these muddy currents emerge from the mouth of a canyon onto the flat ocean floor, they drop their load in a form of deep-sea fan.

ii. Active continental margins:

They occur where oceanic lithosphere is being subducted beneath the edge of a continent.

Such subduction results in a narrow margin consisting of highly deformed sediments that were removed from the descending lithospheric plate.

Active margins are common around the Pacific Rim in places where the leading edge of a continent is overrunning oceanic lithosphere.

The accumulation of deformed sediment and scraps of oceanic crust is called an accretionary wedge.

D. Deep-Ocean Basins:

The portion of sea floor that lies between the continental margin and the oceanic ridge system.

It contains *deep-ocean trenches*, *abyssal plains*, and broad volcanic peaks called *seamounts*.

i. Deep-Ocean Trenches:

Long, narrow features that form the deepest parts of the ocean. Most trenches are located in the Pacific Ocean.

They may reach 10,000 m deep (Mariana trench is 11,000 m below sea level).

They are the sites where lithospheric plates plunge back into the mantle, and usually associated with volcanic activity.

ii. Abyssal Plains:

The most level places on Earth. The abyssal plains may have less than 3 m of relief over a distance that may exceed 1300 km.

Scientists determined that abyssal plains low relief is due to the fact that thick accumulations of sediment, transported by turbidity currents, have buried rugged ocean floor.

Abyssal plains are more extensive in the Atlantic Ocean than in the Pacific. That is because the Atlantic Ocean has fewer trenches to trap sediments carried down the continental slope.

iii. Seamounts:

An isolated volcanic peak that rises at least 1000 m (3300 ft) above the deep-ocean floor.

They are more extensive in the Pacific, where subduction zones are common.

These undersea volcanoes form near oceanic ridges (regions of seafloor spreading). Some of these volcanoes may emerge as an island.

Erosion by running water and wave action may erode these features to sea level. Over a long time, the islands gradually sink.

E. Mid-Ocean Ridges:

A continuous mountainous ridge on the floor of all the major ocean basins and varying in width from 00-5000 km (300-3000 mi).

The rifts at the crests of these ridges represent divergent plate boundaries.

Ocean ridges are characterized by elevated position, extensive faulting, and numerous volcanic structures.

The interconnected ocean ridge system is the longest topographic feature on the surface of the earth. It exceeds 70,000 km (43,000 mi) in length. It may have a width of 3000-4000 km.

The ocean ridge runs through all major oceans (similar to the seam of a baseball).

Ocean ridges consist of layers upon layers of basaltic rocks that have been faulted and uplifted.

The Mid-Atlantic Ridge is a broad, submerged structures standing 2500 to 3000 m above the ocean basin floor. It lies 2500 m below sea level.

In Iceland, and some other places, this ridge has grown above sea level.

F. Seafloor Spreading:

In 1960, Harry Hess first put the idea of seafloor spreading. Later studies gave credibility to this idea, and geologist established such concept of seafloor spreading that occurs along narrow zones called ***rift zones*** (regions of Earth's crust along which divergence is taking place) that are located at the crests of ocean ridges.

As plates move apart, magma rises/wells up into the newly created fracture/crack/rift and generate new slabs of oceanic lithosphere.

Spreading Rates and Ridge Topography:

Active rift zones are characterized by frequent but weak earthquakes and a rate of heat flow that is greater than most other crustal segments.

East Pacific Rise has a relatively fast rate of spreading that averages 6 cm/y up to 10 cm/y.

The ***Mid-Atlantic Ridge*** has a slow rate of spreading that averages 2 cm/y.

In any case, and in all ridge systems new seafloor will be generated in a similar manner.

As seafloor spreading continues, older blocks are wedged/shifted away from the ridge axis and replaced by younger/recently formed blocks.

Generally, new material is always added during seafloor spreading, and in equal amounts to the two divergent plates.

Therefore, new ocean floor is expected to grow symmetrically on each side of a centrally located ridge crest (Atlantic and

Indian oceans are located near the middle of these water bodies, thus, called mid-ocean ridges).

East Pacific Rise is located far from the center of the Pacific Ocean. Much of its basin on the east has been overridden by the westward migration of the Atlantic plate.

G. Seafloor Sediments:

Some of these sediments were deposited by turbidity currents; others were slowly settled to the bottom from above.

Trenches act as traps for sediments originating on the continental margin; therefore, thick accumulations may exceed 9 km.

There are 3 types of seafloor sediments: Terrigenous, Biogenous, and Hydrogenous.

i. Terrigenous sediments:

They consist mainly of mineral grains that were weathered from continental rocks and transported to the ocean.

Sand-sized grains settle near shore. Very small particles may be carried for 1000s of km by ocean currents.

The rate at which sediment accumulates on the deep ocean floor is very slow. It may take 5000-50,000 yrs to form 1 cm layer.

However, the rate at which sediment accumulates on the continental margins near the mouths of rivers is rather rapid, and may form many km of thick sediments.

ii. Biogenous sediments:

Consists of shells and skeletons of marine animals and plants. Mainly microscopic organisms living in the sunlit waters near the ocean surface, and their remains fall down on the seafloor.

The most common Biogenous sediment is *calcareous (CaCO₃) oozes* (made of thick mud)

Another Biogenous sediment is *siliceous (SiO₂) oozes*.

iii. Hydrogenous sediments:

They consist of minerals that crystallize directly from seawater through chemical reactions (limestone is formed when CaCO₃ precipitates directly from the water).