Topic: 7. Submarine Relief:

1. General idea of ocean relief.
2. 2. Relief of Atlantic, Pacific and Indian oceans.

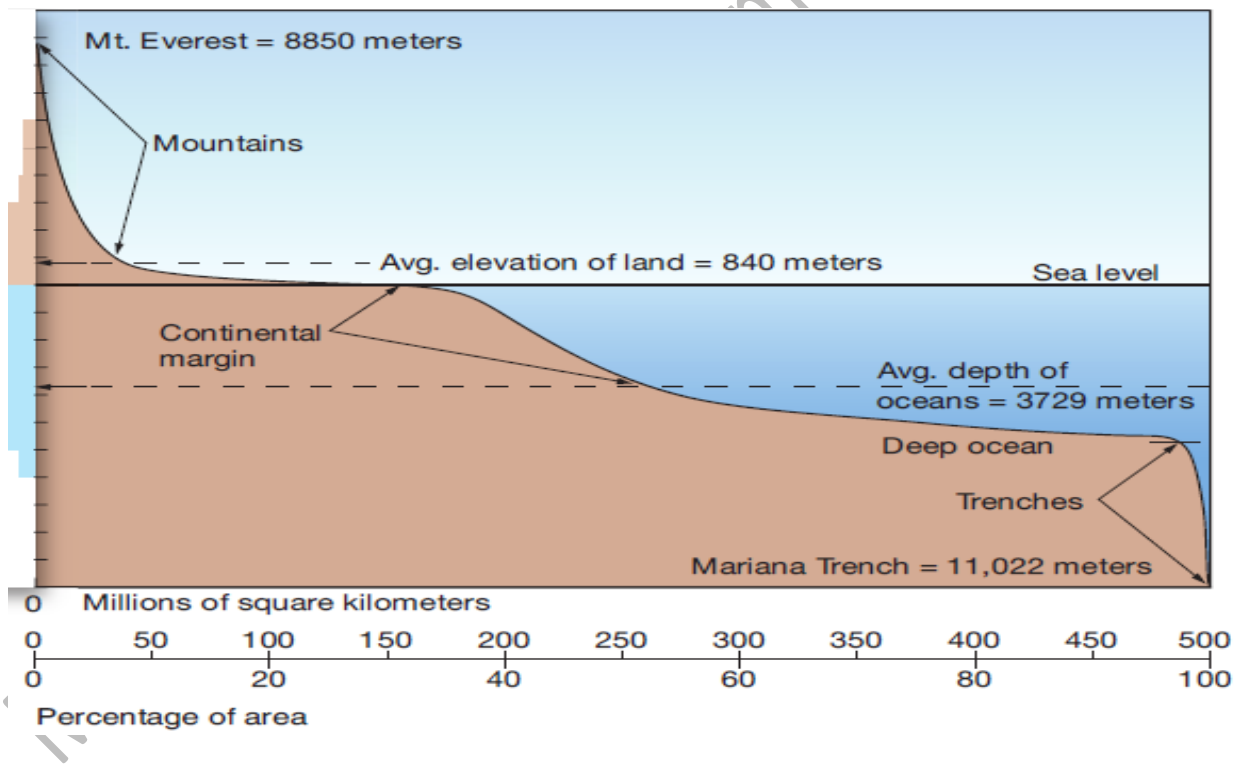
1. General idea of ocean relief.

Introduction:

Bathymetry (*bathos* depth, *metry* measurement) is the measurement of ocean depths and the charting of the shape, or *topography* (*topos* place, *graphy* description of) of the ocean floor. Determining bathymetry involves measuring the vertical distance from the ocean surface down to the mountains, valleys, and plains of the sea floor. The first recorded attempt to measure the ocean s depth was conducted in the Mediterranean Sea in about 85 B.C. by a Greek named Posidonius. Posidonius s crew made a **sounding**. The standard unit of ocean depth is the **fathom** (*fathme* * outstretched arms2), which is equal to 1.8 meters (6 feet).

Earth s hypsographic curve:

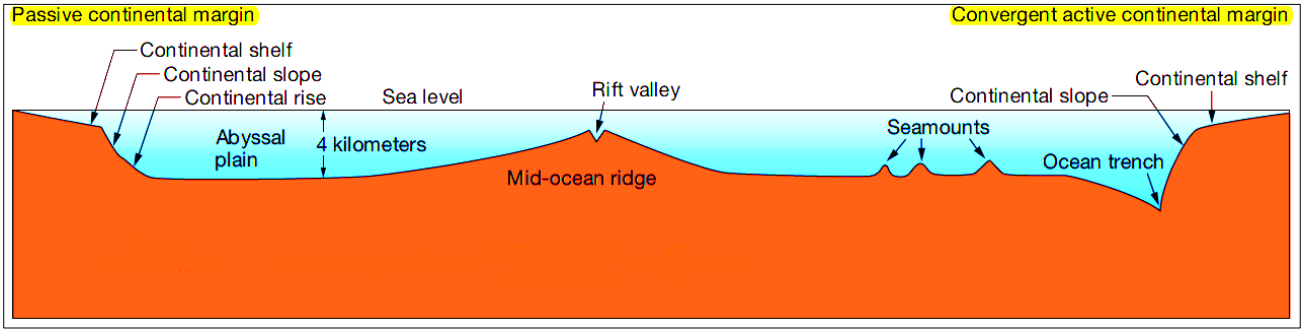
Earth s **hypsographic** (*hypos* * height, *graphic* * drawn) **curve**, which shows the relationship between the height of the land and the depth of the oceans. The bar graph (Figure 3.5, *left side*) gives the percentage of Earth's surface area at various ranges of elevation and depth.



General idea of ocean relief:

The ocean floor (**relief)** can be divided into three major provinces

(1) **Continental margins**,.. which are shallow-water areas close to continents,
(2) D**eep-ocean basins**,.. which are deep-water areas farther from land, and
(3) **Mid-ocean ridge**,.. which is composed of shallower areas near the middle of an ocean.



Passive versus Active Continental Margins

Continental margins can be classified as either passive or active, depending on their proximity to plate boundaries.

1. **Passive margins:** passive margins usually lack major tectonic activity (such as large earthquakes, eruptive volcanoes, and mountain building).The East Coast of the United States.
2. **Active margins:** a high degree of tectonic activity.

- Two types of active margins exist.
  - **Convergent active margins** are associated with oceanic continental convergent plate boundaries.
  - **Transform active margins** are less common and are associated with transform plate boundaries.

Divisions of the Ocean Floors

Major Ocean Relief Features

The ocean floors can be divided into five major divisions:

1. **The Continental Shelf;**
2. **The Continental Slope;**
3. **The continental rise**
4. **The Deep Sea Plain (Abyssal Plain.)**
5. **The Oceanic Deeps.**

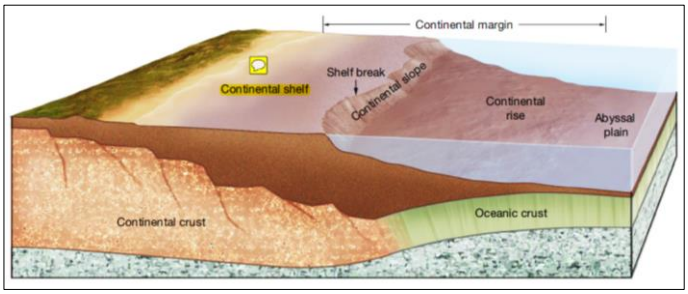
Besides, these divisions there are also major and minor relief features in the ocean floors like…. ridges, hills, Sea mounts,guyots, trenches, canyons, etc.

Minor Ocean Relief Features:

Ridges, Hills, Seamounts, Guyots, Trenches, Canyons, Sleeps, Fracture zones, Island arcs, Atolls, Coral reefs, Submerged volcanoes and Sea-scarps

Continental Shelf

- The **continental shelf** is defined as a generally flat zone extending from the shore beneath the ocean surface to a point at which a marked increase in slope angle occurs, called the **shelf break**.
- It is usually flat and relatively featureless because of marine sediment deposits but can contain coastal islands, reefs, and raised banks. The



- The average width of the continental shelf is about 70 kms,
- But it varies from a few tens of meters to 1500 kms.

- The broadest shelves occur off the northern coasts of Siberia and North America in the Arctic Ocean.
- The average depth at which the shelf break occurs is about 135 meters
- Examples: Continental Shelf of South-East Asia, Great Banks around Newfoundland, Submerged region between Australia and New Guinea

The shelf is formed mainly due to

- submergence of a part of a continent
- relative rise in sea level
- Sedimentary deposits brought down by rivers

Various types of shelves based on different sediments of terrestrial origin —

- glaciated shelf: (Surrounding Greenland),
- coral reef shelf : (Queensland, Australia),
- shelf of a large river: (Around Nile Delta),
- shelf with dendritic valleys: (At the Mouth of Hudson River)
- shelf along young mountain ranges: (Shelves between Hawaiian Islands).

Importance of continent shelves

Importance of continent shelves

1. Marine food comes almost entirely from continental shelves;
2. They provide the richest fishing grounds;
3. They are potential sites for economic minerals

❖ 20% of the world production of petroleum and gas comes from shelves.

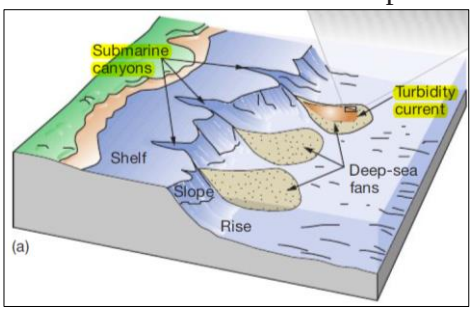
❖ Polymetallic nodules (manganese nodules; concentric layers of iron and manganese hydroxides) etc. are good sources of various mineral ores like manganese, iron copper, gold etc..]

Continental Slope

- The **continental slope**, which lies beyond the shelf break, is where the deep-ocean basins begin.
- Total relief in this region is similar to that found in mountain ranges on the continents.
- The break at the top of the slope may be from 1 to 5 kms.
- Worldwide, the slope of the continental slopes averages about 4 degrees but varies from 1 to 25 degrees.
- the Pacific Ocean, the continental slopes average more than 5 degrees

Submarine Canyons and Turbidity Currents

- **Submarine canyons**, which are narrow but deep submarine valleys that are V-shaped in profile view and have branches or tributaries with steep to overhanging walls.



Continental Rise

- The **continental rise** is a transition zone between the continental margin and the deep-ocean floor comprised of a huge submerged pile of debris.
- The material transported by these currents is responsible for the creation of continental rises.
- **deep-sea fans**, or **submarine fans**. One of the largest deep-sea fans in the world is the Indus Fan, a passive margin fan that extends 1800 kilometers (1100 miles) south of Pakistan.

Deep-Ocean Basins:

- The deep-ocean floor lies beyond the continental margin province (the shelf, slope, and the rise).
- Deep sea plains are gently sloping areas of the ocean basins.
- These are the flattest and smoothest regions of the world.
- The depths vary between 3,000 and 6,000m. These plains are covered with fine-grained sediments like clay and silt.

Oceanic Deeps or Trenches

- These areas are the deepest parts of the oceans.
- The trenches are relatively steep sided, narrow basins.
- They are some 3-5 km deeper than the surrounding ocean floor.
- They occur at the bases of continental slopes and along island arcs and are associated with active volcanoes and strong earthquakes.
- That is why they are very significant in the study of plate movements.
- As many as 57 deeps have been explored so far; of which 32 are in the Pacific Ocean; 19 in the Atlantic Ocean and 6 in the Indian Ocean.
- Deepest Point on the Earth in Pacific Ocean: **Mariana Trench (- 11022m)**

Abyssal Plains

- These **abyssal** (*a* * without, *byssus* * bottom) **plains** average between 4500 meters and 6000 meters deep.
- They are not literally bottomless, but they are some of the deepest (and flattest) regions on Earth.
- Abyssal plains are formed by fine particles of sediment slowly drifting onto the deep-ocean floor.
- Over millions of years, a thick blanket of sediment is produced by **suspension settling** as fine particles (analogous to marine dust) accumulate on the ocean floor.
- The type of continental margin determines the distribution of abyssal plains.
- For instance, few abyssal plains are located in the Pacific Ocean; instead, most occur in the Atlantic and Indian Oceans

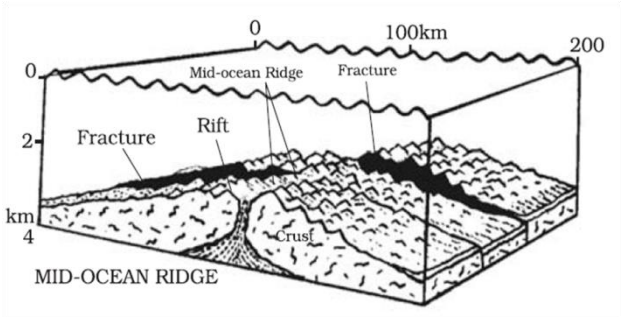
Minor Relief Features

Apart from the above mentioned major relief features of the ocean floor, some minor but significant features...

- **Mid-Oceanic Ridges**

A mid-oceanic ridge is composed of two chains of mountains separated by a large depression.

The mountain ranges can have peaks as high as 2,500 m and some even reach above the ocean's surface. Iceland, a part of the mid- Atlantic Ridge, is an example.



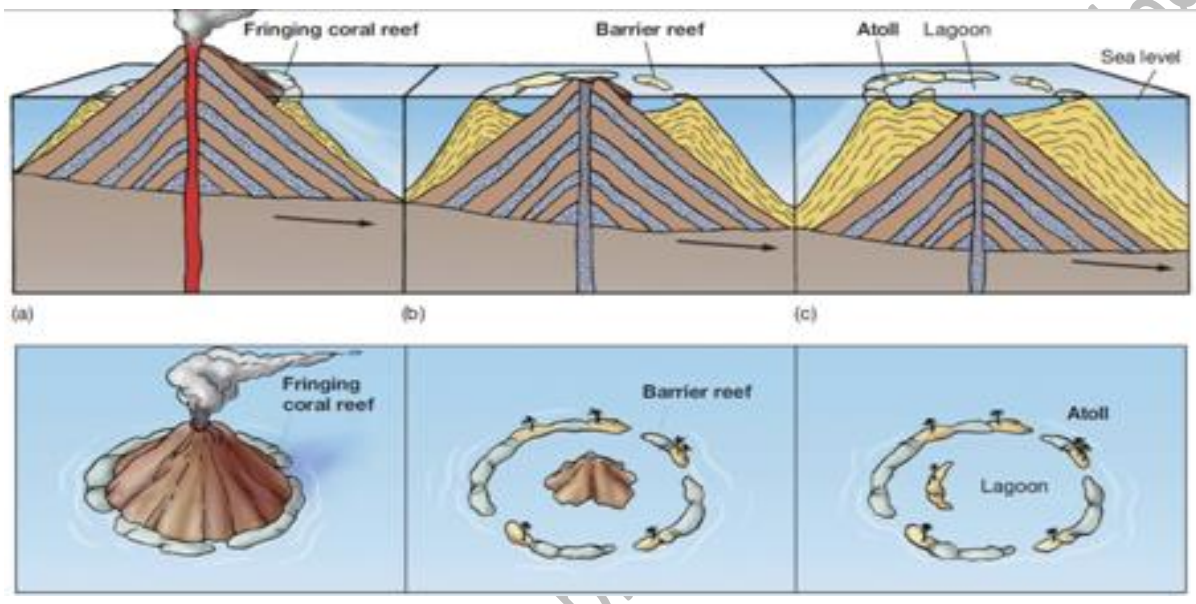
- **Seamount**
  - It is a mountain with pointed summits, rising from the seafloor that does not reach the surface of the ocean.
  - Seamounts are volcanic in origin.
  - These can be 3,000-4,500 m tall.
  - The Emperor seamount, an extension of the Hawaiian Islands in the Pacific Ocean, is a good example.
- **Submarine Canyons**
  - These are deep valleys, some comparable to the Grand Canyon of the Colorado river.
  - The Hudson Canyon is the best known canyon in the world.

Guyots

- It is a flat topped seamount.
- They show evidences of gradual subsidence through stages to become flat topped submerged mountains.
- It is estimated that more than 10,000 seamounts and guyots exist in the Pacific Ocean alone.

Atoll

- These are low islands found in the tropical oceans consisting of coral reefs surrounding a central depression.
- It may be a part of the sea (lagoon), or sometimes form enclosing a body of fresh, brackish, or highly saline water.



Relief of Atlantic, Pacific and Indian oceans

The Pacific Ocean

- This ocean is the largest of all the water bodies.
- Together with its associated seas, it covers about one-third of the earth's surface and exceeds the total land area of the world in size.
- Its shape is roughly triangular with its apex in the north at the Bering Strait.
- The Pacific is the deepest of all oceans.
- The major portion of the basin has an average depth of about 7,300 metres.
- This vast ocean is dotted with more than 20,000 islands, highest number of Islands.
- Main Island Group are Malenesia, Micronesia, Polynesia.
- The islands situated close to the continent are continental islands. The islands appearing in the mid-ocean are coral and volcanic in origin.
- Submarine Canyons are more abundantly found along the straight coast than highly indented.
- It is 14,880 km from North to south between Bering strait to north to Cape Adre (Antarctica) in South.
- The Northern Pacific is the deepest part of

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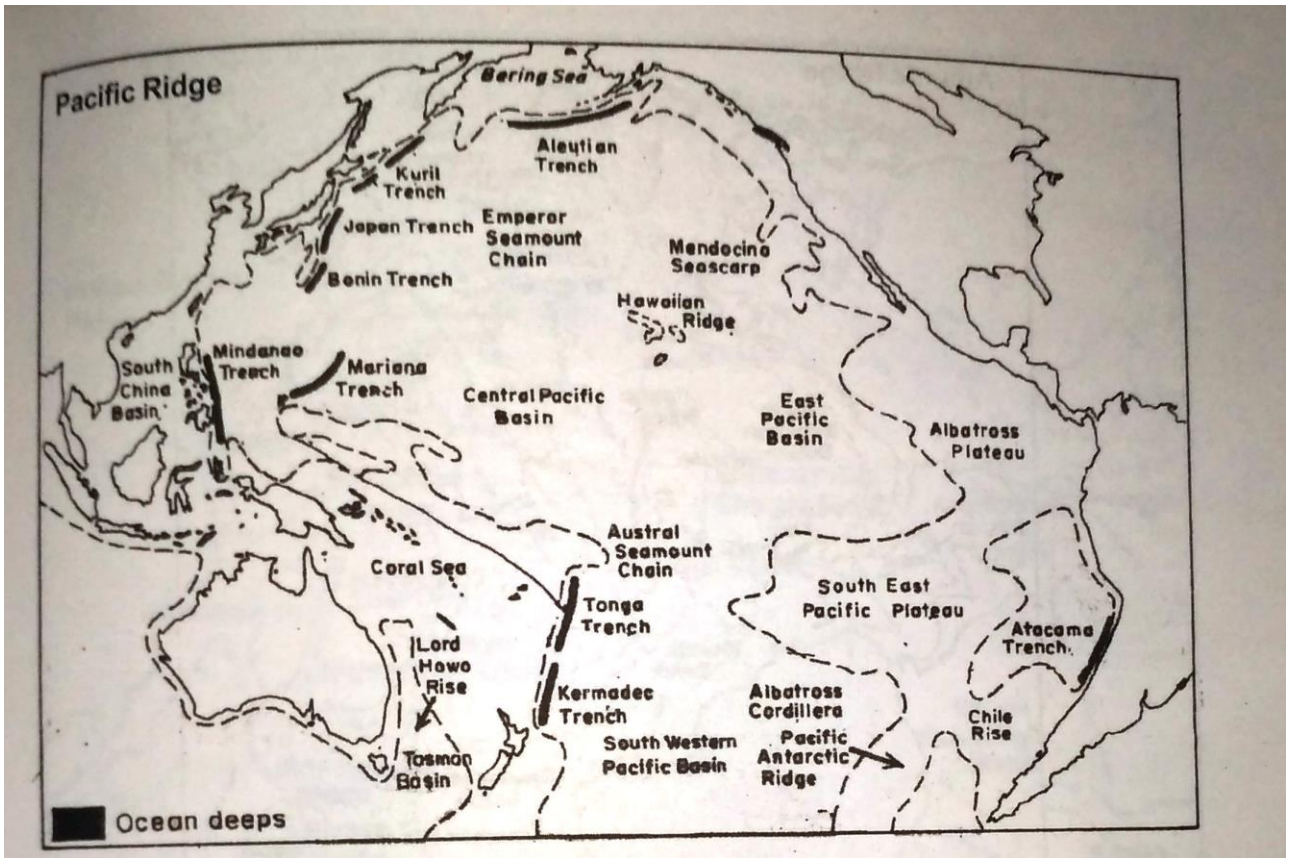


the ocean. The average depth of this part ranges between 5,000-6,000 metres.

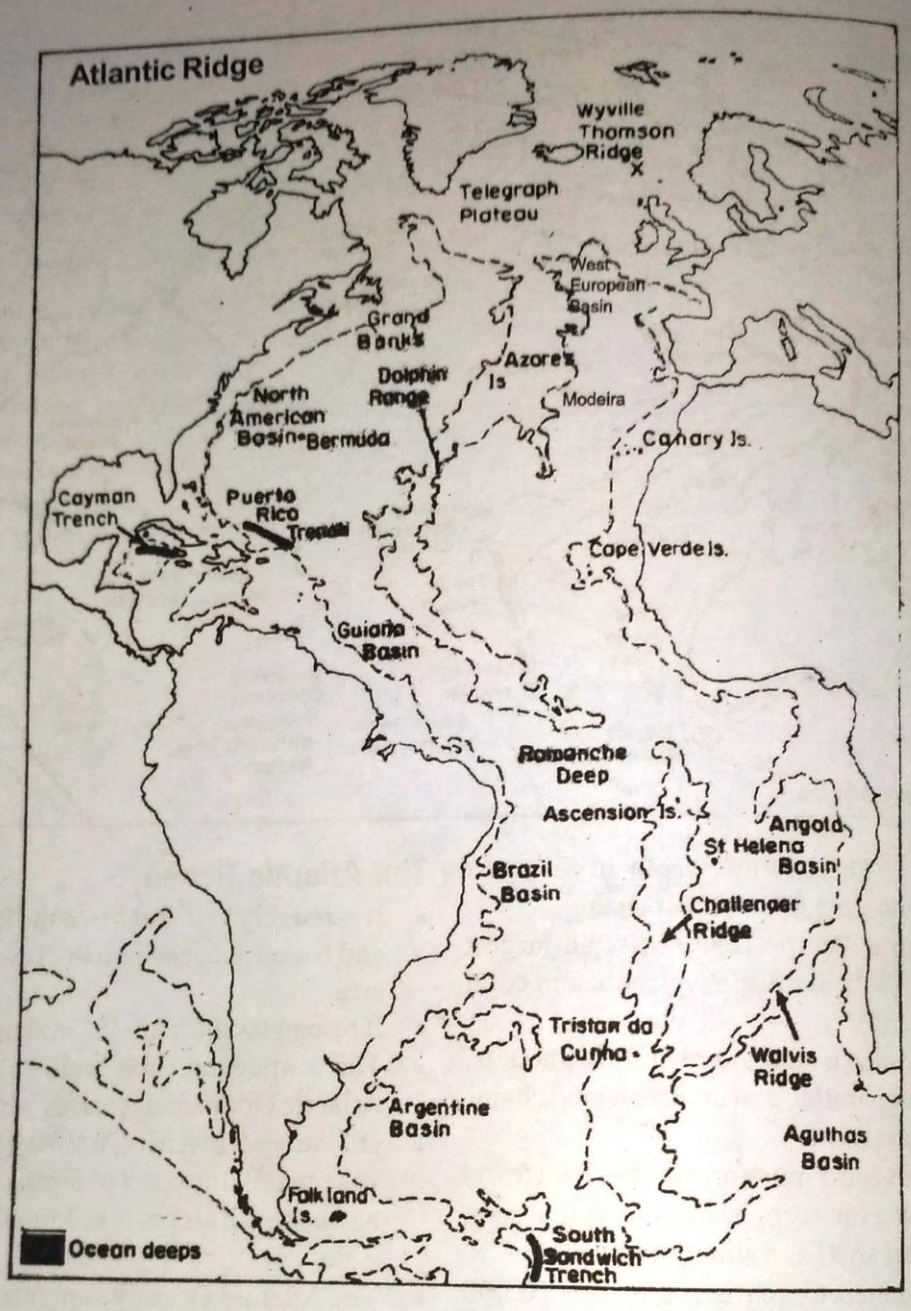
- The Central Pacific represents the largest number of Island must of volcanic and coral origin.
- There are also a large number of seamounts, guyots and parallel, and arcuate island chains in the central part.
- The south-west portion of the Pacific is marked by a variety of islands, marginal seas, continental shelf and submarine trenches.
- The Mindanao trench is more than 10,000 metres deep.
- The average depth of this part is about 4,000 metres.
- The south-east Pacific has broad submarine ridges and plateaus.
- This part of the Pacific is conspicuous by the absence of marginal seas.

Major trench of Pacific Ocean

a.	Mariana	11,002
b.	Tonga	10,882
c.	Kuril	10,498
d.	Philippine	10,475
e.	Japan	10,375

The Atlantic Ocean

- It is roughly half the size of the Pacific Ocean and covers about one-sixth of the earth's total area.
- It resembles the letter 'S' in shape.
- The continental shelf occurs all around the Atlantic Ocean, but it varies in width.
- Off the coast of Africa, it is 80-160 kilometres wide but off the coast of north-east America, north-west Europe, it is 250-400 kilometres wide.
- The Atlantic Ocean has numerous marginal seas on both sides, especially in its northern part.
- Most of the marginal seas are located on the shelves.
- The Hudson Bay, the Baltic Sea, and the North Sea are located on the shelves.
- The most striking feature of the Atlantic Ocean is the presence of the mid-Atlantic Ridge.
- It extends from the north to the south paralleling the 'S' shape of the ocean itself.
- The ridge is about 14,000 km long and the 4,000 metres high.
- The ridge though under the sea level has many peaks projected out of the deep water



above the surface of the ocean.

- These peaks are the islands of the Mid-Atlantic.
- Examples include Pico Island of Azores, Cape Verde Island.
- In addition, there are some coral islands such as Bermunda and Volcanic Islands like. Ascension, Tristan da Cunha, St Helena, Gough and others.
- The Atlantic Ocean lacks in troughs and trenches which are more of a characterstic of the Pacific Ocean.
- North Cayman and Puerto Rico are the two troughs and Romanche and South Sandwich are the two trenches in the Atlantic Ocean.

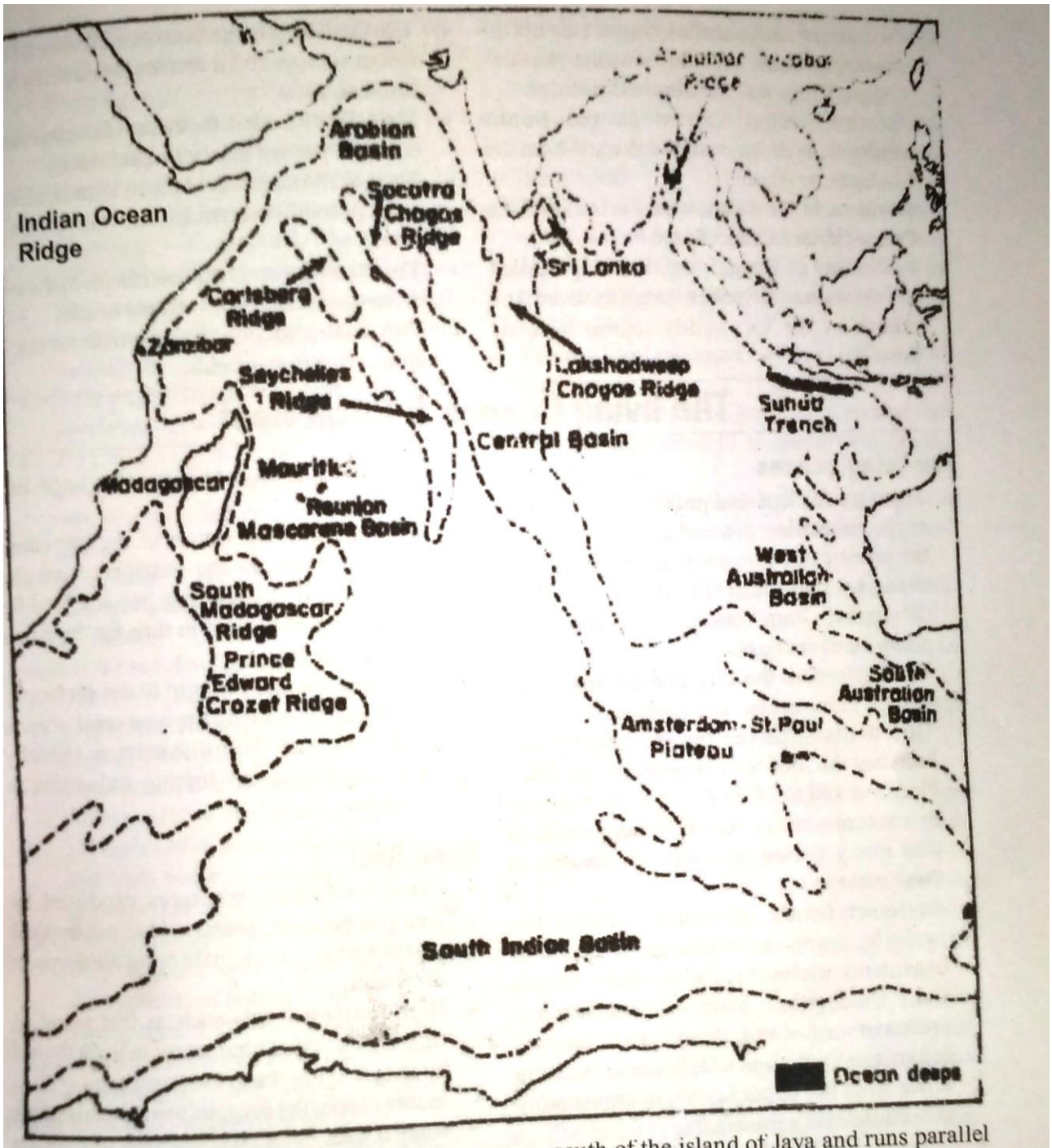
Average depth	
Pacific ocean	4572m
Indian Ocean	4000m

The Indian Ocean

- The Indian Ocean is smaller than the Atlantic Ocean.
- It can be considered only half an ocean.
- The average depth of the Indian Ocean is 4,000 metres which is comparatively lesser than that of other oceans.
- The marginal sea are less in number than the Pacific and the Atlantic Oceans.

The Indian Ocean has three zones:

1. Western Zone - Large numberof Islands



2. Eastern Zone - Deepest part
3. Central Zone - Mid-oceanic ridge and many tiny islands.

- The floor of the Indian Ocean has fewer irregularities in comparison to the other two oceans.
- Important trenches and deeps of Indian Ocean:
  a. Java or Sunda Trench (7,450 m)
  b. Ob trench (6,875 m)
  c. Mauritius, Amirante trench
- Linear deeps are almost absent. The only exception is the Sunda Trench, which lies south of the island of Java and runs parallel to it.
- There are a number of broad submarine ridges on the floor of the Indian Ocean.
- Like the Atlantic Ocean, a prominent submarine ridge runs from Kanya Kumari continuously southward to Antarctica.
- Unlike the Atlantic Ridge, it is wider and does not extend so near the surface.
- It is called the Lakshdweep–Chagos Ridge in the north, the St Paul Ridge in the middle and the Amstredam St Paul Plateau in the south.

- Two minor and parallel ridges run north-westward. These are known as the Socotra-Chagos Ridge and the Seychelles Ridge.
- Another ridge, known as the South Madagascar Ridge, runs southward from the Madagascar island.
- It widens in the south, where it is called the Prince Edward Crozet Ridge.
- In the Bay of Bengal, another ridge called the Andaman-Nicobar extends from the mouth of the Irrawaddy to the Nicobar Islands.
- The Carlsberg Ridge has been discovered by recent surveys and it divides the Arabian Sea into two parts.
- Most of the islands in the Indian Ocean represent detached parts of the continental blocks.
- The Lakshdweep and Maldive Islands, off the coast of south-western India, represent coral islands.
- The Mauritius and Reunion islands to the east of Madagascar are of volcanic origin.
- The eastern section of the Indian Ocean is almost free from islands.