P.D.V.P.College Tasgaon
Dept. of Geography
(PG)

GCT-412
Geohydrology & Oceanography

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GCT-412: Geohydrology & Oceanography

Unit-3: Geological Oceanography

3.1. Origin and evolution of ocean basins: theory of plate tectonics and seafloor spreading

3.2. Topography of the ocean floor: continental shelf, slope, rise, submarine channels, hills, ridges, trenches and abyssal plains

3.4. Bottom relief of Pacific, Atlantic and Indian Ocean

3.5. Origin and evolution of island arcs; Estuarine & coastal processes and landforms.

Unit-4: Physical, Chemical and Biological Oceanography

4.1 Air-sea interaction and ocean circulation: currents, waves and tides; Currents of Pacific, Atlantic, & Indian Ocean

4.2 Properties of oceanic water: chemical composition, salinity, temperature, and density

4.3 Origin and growth of coral reefs; Ocean deposits: origin, type and distribution;

4.4 Ocean and global environment: El Nino and Sea level changes; Oceanic regions & Marine resources; Marine pollution

Origin and evolution of ocean basins

THEORY OF PLATE TECTONICS AND SEAFLOOR SPREADING

- Ocean basins are considered as **relief feature of the first order**
- There are different views regarding origin of ocean basin

- But universally following statement is considered for origin of ocean basins

- **Ocean basins** form initially by the **stretching** and **splitting** (rifting) of continental crust and by the rise of **mantle material and magma** into the crack to form new **oceanic** lithosphere.

- The above statement more precisely explained and described in plate tectonic theory

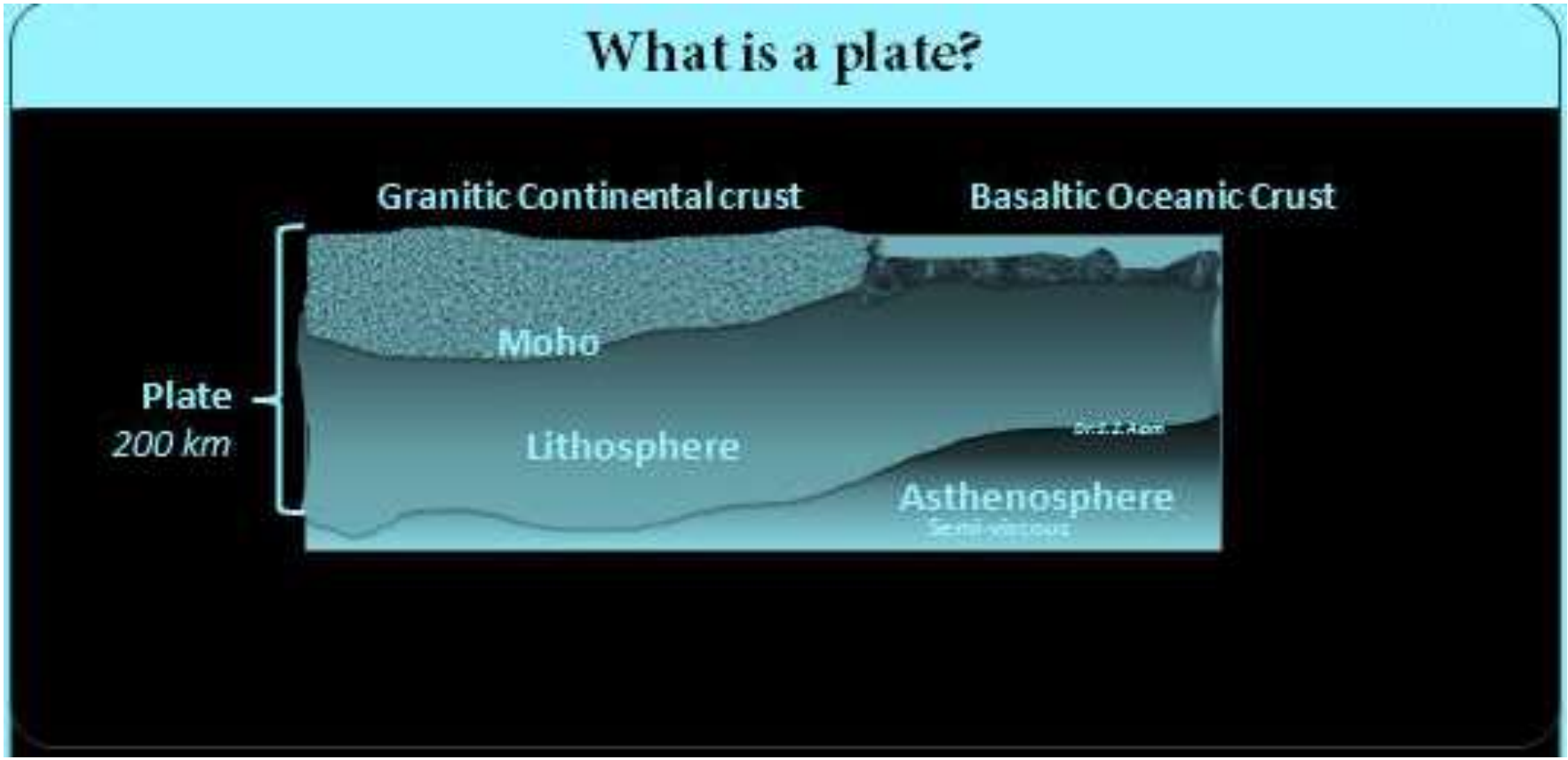
The rigid lithospheric slabs or rigid and solid crustal layer are technically called ‘plates’

The term plate was first used by Canadian geophysicist
J. T. Wilson in 1965

‘The whole mechanism of the evolution, nature and motion of plates and resultant reaction is called as plate tectonics’

(Plate Motion is referred to as Plate Tectonics)

What is a plate?

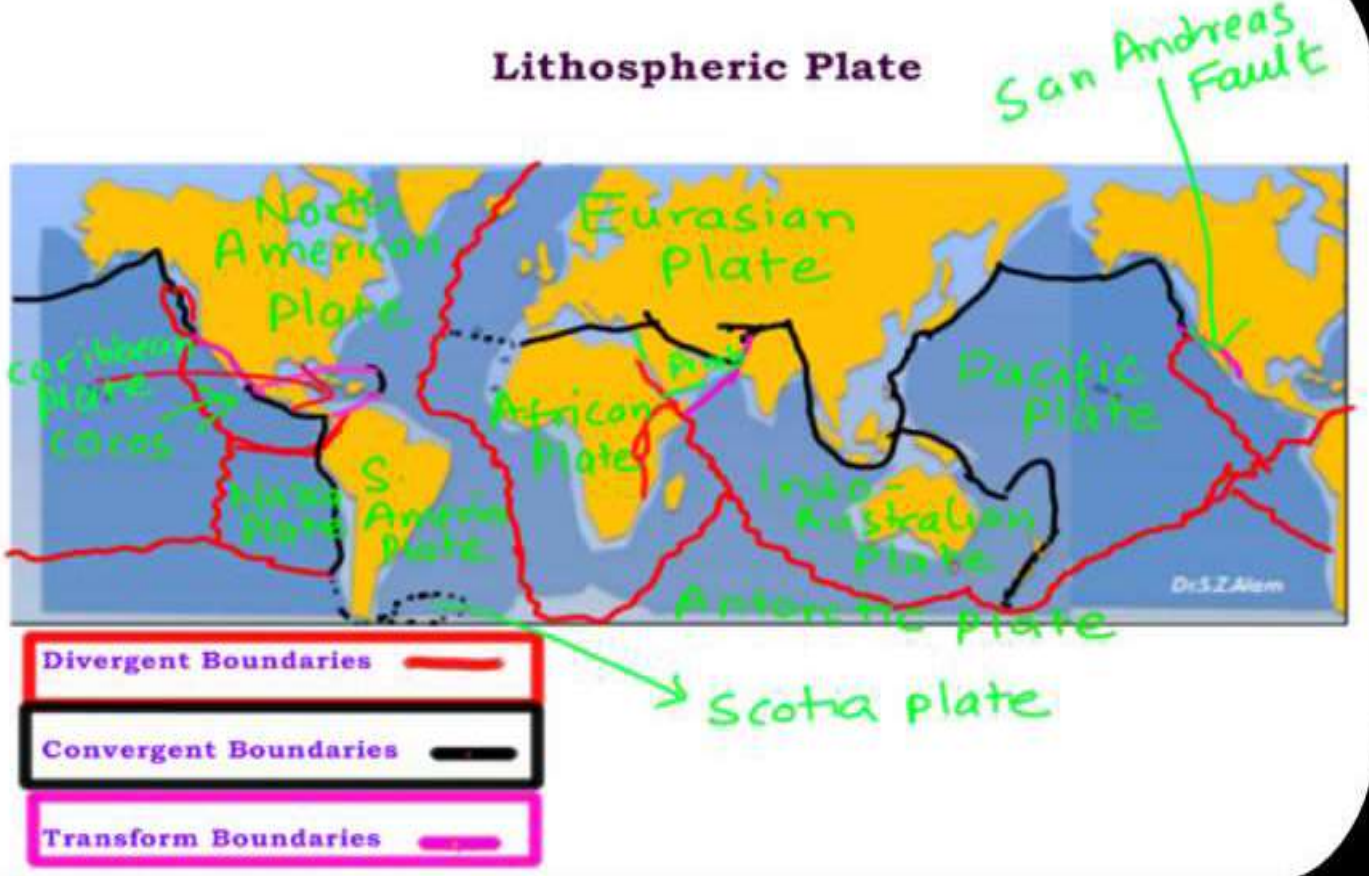


- There are six major plates

  Eurasian plate, Indian – Australian plate, American plate, Pacific Plate, African Plate and Antarctic Plate

  and 20 minor plates have been identified.

Major and Minor Plates



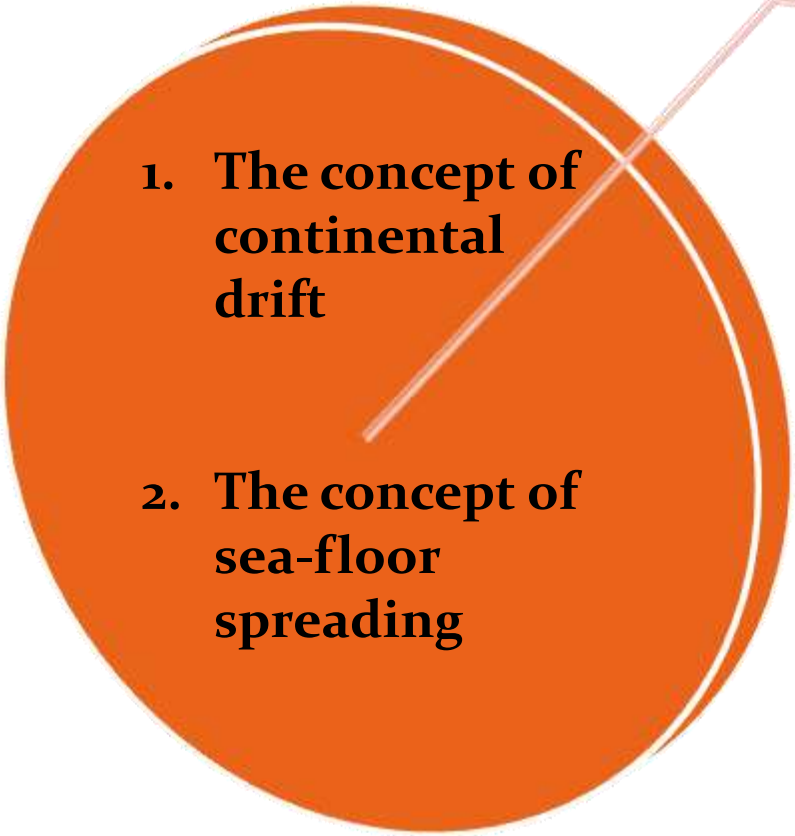


PLATE TECTONIC THEORY, A GREAT SCIENTIFIC ACHIEVEMENT IN THE DECADE OF 1960S IS BASED ON TWO MAJOR SCIENTIFIC CONCEPTS

Assumptions of the Theory

1. While the new Ocean crust is being generated, old crust must either be destroyed or reduced at the same rate. Therefore, the **total area of the crust remains unchanged or** constant.

2 . The **“Sea Floor Spreading” occurs.**

3. The outermost layer of the Earth, known as the lithosphere, behaves as a strong, rigid substance resting on a weaker region in the mantle known as the asthenosphere (KentC.Condie).The plates are continuously in motion.

Evidences

- The Shapes Match: Jig-Saw-Fit
- The identical fossils of Plants and Animals
- Comparative Stratigraphy: A Similar Sequence of Rocks at Numerous Locations

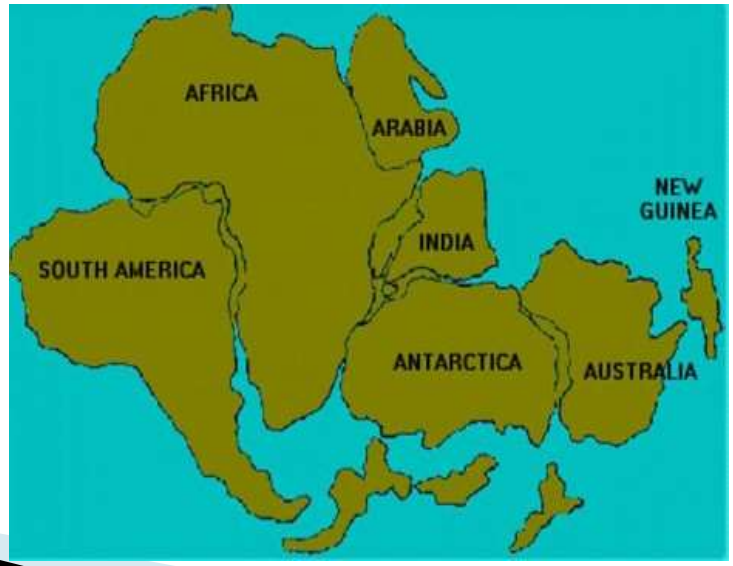


Plate margins or boundaries are most important because all tectonic activities occur along the plate margin.

Constructive plate margin

Plate margin are generally divided in two groups,

Destructive Plate margin

Conservative Plate margin

Types of Plate boundaries

- **Divergent or extensional boundary or constructive margin:**

  linear feature that exists between two tectonic plates that are moving away from each other. For example, Mid-Atlantic Ridge separates the North and South American Plates from the Eurasian and African Plates. This pulling apart causes "sea-floor spreading" as new material is added to the oceanic plates.

- **Convergent plate boundary:**

  Here crust is destroyed and recycled back into the interior of the Earth as one plate having higher density dives under another. It is also known as destructive plate boundary. It is noteworthy mountains and volcanoes are often found where plates converge. In general there are 3 types of convergent boundaries: (i) Oceanic-Continental Convergence; (ii)Oceanic-Oceanic Convergence and (iii) between two continental plates

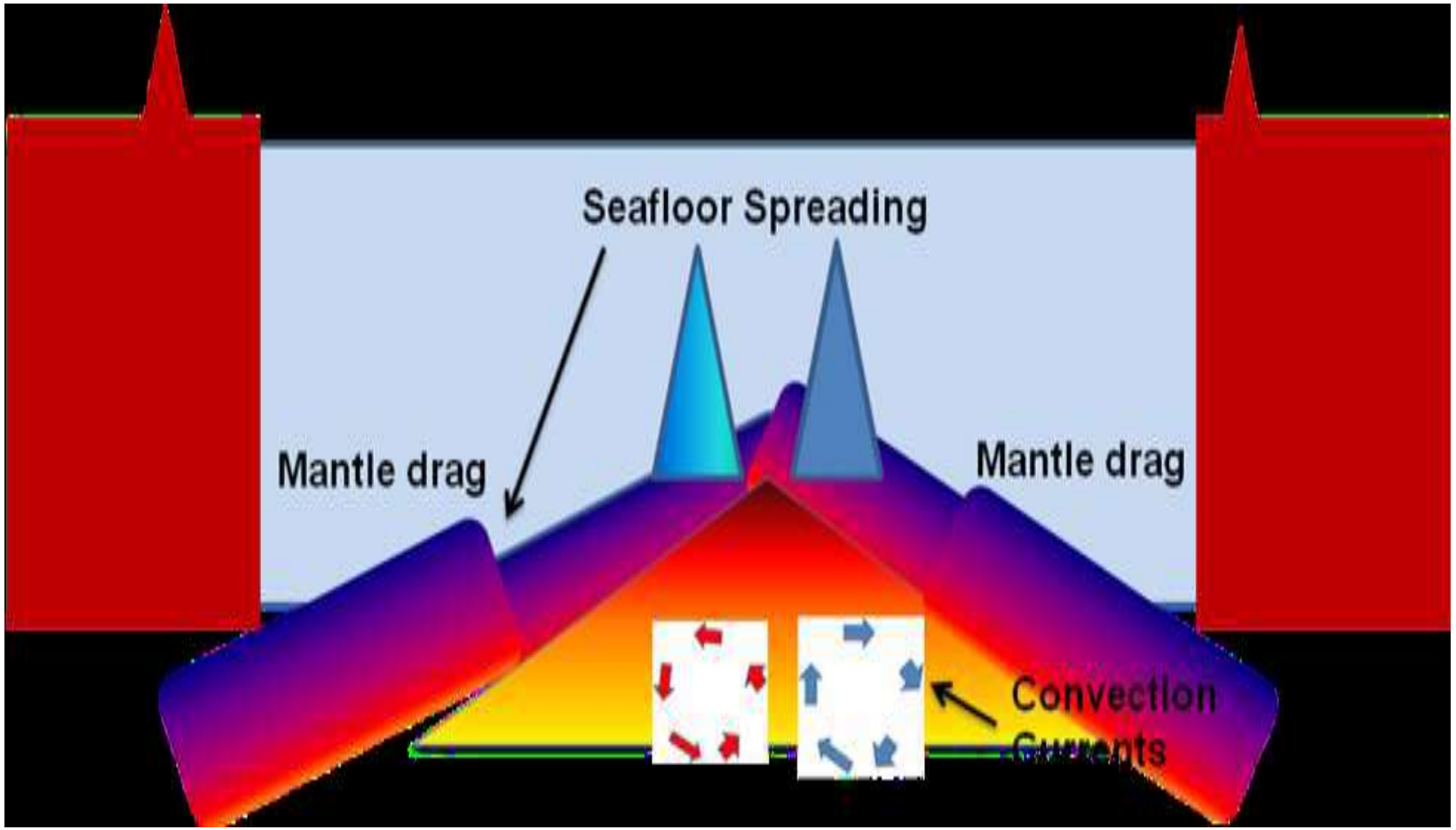
- **Parallel or Transform Boundaries or strike-slip boundary:**

  Is said to occur when tectonic plates slide and grind against each other along a horizontal transform fault.

SEA-FLOOR SPREADING

The concept of sea floor spreading was first propounded by Hary Hess in 1960.

Hess propounded that the mid oceanic ridges were situated on rising convectional currents coming up from mantle.


Seafloor Spreading
Mantle drag
Mantle drag
Convection
Currents

Paleomagnetism

The additional evidence in support of plate tectonic theory came from Paleomagnetism ***which is helpful to decode the magnetic reversals*** of rocks on both the sides of oceanic ridges. British geophysicists **Frederick Vine and Dummond Mathews in the year 1963 found that same patterns of magnetized rocks exists on** both the sides of mid oceanic ridges belonging to same period

They together discovered “normal” and “reverse” polarity on the ocean floor i.e., either side of oceanic ridges. It indicates that both sides of a ridge were created during the same time period.

In other words, when molten lava are upwelled along the mid oceanic ridges, these divided the basaltic layer into two equal halves and these basaltic layer slides horizontally on either side of mid oceanic ridge

The rate of sea floor spreding is calculated on two basis

1. Age of isochrons (line which join the points of equal dates of magnetic strips)
2. Distance between two isochrons

On the basis of above principles

Atlantic ocean expanding 2 cm per year

Pacific ocean expanding 6 cm per year

Indian ocean expanding 1.5 to 3 cm per year.

Thank You

Topography of the ocean floor

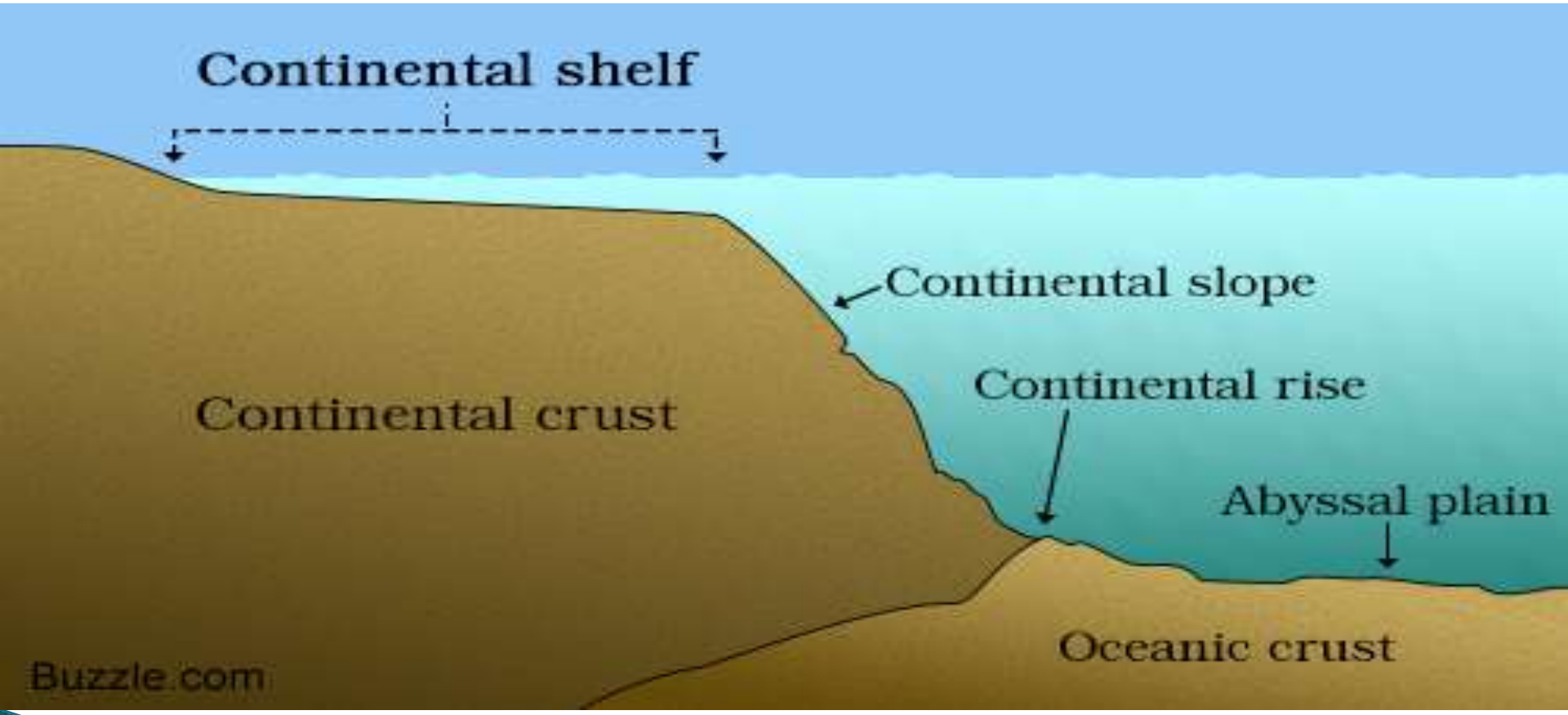
After this lesson, we would be able to understand the profile of the continents and oceans, details of continental shelf, slope and the deep ocean basins. In addition, we would be acquiring the details of submarine canyons, continental rises, abyssal hills, abyssal plains, mid oceanic ridges, island arcs, seamounts, sand deep sea trenches

The surface beneath the oceanic waters is characterized by a lot of morphological features. The structure, configuration and relief features of these oceans also vary from one ocean to the other.

Continental shelf

Continental shelf is the first morphologic unit of the oceans located adjacent to the coastline. It is an extension of the land beneath the ocean surface.

The width of the shelf zone ranges from 60 to more than 1500 km. The average width of the continental shelf goes to about 75 kilometers. It begins from the shoreline and gently s lopes down to a depth of about 150 meters. In some places, it is almost not existing.


Continental shelf
Continental slope
Continental rise
Continental crust
Abyssal plain
Oceanic crust
Buzzle.com

Distribution of the Shelf zone:

The Continental Shelf is very wide in the Northwest coast of the Europe.

Around Africa, the area of Continental Shelf is very narrow. The Pacific Coast of North America has a narrow continental shelf.

The Atlantic has a wide shelf. At present, the continental shelf comprises 6% of Earth's total area of the world.

The maximum width is seen at the Siberian shelf in the Arctic Ocean

Continental Slope

Continental slopes are the longest and highest slopes on the earth. The Origin of continental slope is varied. They are formed due to erosional processes, tectonic activities. In this steep topographic gradient, there may be no marine deposits. Most of the sediments will be directly moving down into the deep ocean basins.

- The slope may be straight or curved.
- region next to the continental shelf
- The width may extend upto 150 km ins ide the sea
- water depth may range from 200m to 2000m

- slope may range from 5°to more than 60°.
- occupies 8.5 % of the total area of ocean basins
- Within Atlantic ocean it is about 12.4%
- Pacific ocean - about 7.0%
- Indian Ocean, it is about 6.5%

Continental Rise

- At the base of continental slope, the topographic gradient decreases to 1° (or) less and the ocean enters into the abyssal plains or hills
- This portion of the sea floor is known as continenta l rise
- **Characteristics of Rise:**
- These underwater hills are composed of tons of accumulated sediments.
- The general s lope of the continental rise is between 0.5 degrees and 1.0 degrees.

Submarine channels

- Submarine channels are river driven canyons inside the seas. They are often found to be extending from the mouths of major rivers of continents.
- They develop in transverse direction to the continental s helves are the steep sided and '**V**' shaped valleys with tributaries

hills, ridges, trenches

Abyssal Plains

Bottom relief of Pacific, Atlantic and Indian Ocean