1. Details of Module and its structure

Module Detail	
Subject Name	Geography
Course Name	Geography 01 (Class XI, Semester - 1)
Module Name/Title	Hydrological Cycle and Relief of the Ocean Floors – Part 1
Module Id	kegy_11301
Pre-requisites	Geography has been a part of the teaching of Environmental Studies at the different level of studies. What students have gained in the primary level is the basis for further learning at upper-primary level, where they are introduced to Geography as a separate subject. In previous classes students have learned about ocean and their characteristics. They will broaden their learning about oceans and associated features.
Objectives	After reading this lesson, learners will be able to: **Hydrological Cycle** 1. Understand the process of the water cycle and create water cycle chart. 2. Describe the different ways in which water is used, and the quantities used for various purposes. 3. Recognise the factors that control precipitation, interception, evaporation, transpiration and how these vary globally. **Relief of the Ocean Floors** 1. They will understand the oceanic landforms. 2. They will understand the four major divisions in the ocean relief.
Keywords	Hydrological Cycle, Evaporation, Water Vapour, Continental Shelf, Continental Shelve, Abyssal Plain, Submarine Canyon, Seamount.

2. Development Team

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Hydrological Cycle (Water Cycle)

Introduction

Water is an essential component of all life forms that exist over the surface of the earth. The creatures on the earth are lucky that it is a water planet; otherwise we all would have no existence. Water is a rare commodity in our solar system. The earth, fortunately has an abundant supply of water on its surface. Hence, our planet is called the *'Blue Planet'.* The role of water resources in the environment is paramount. It is recognized that water is a scarce and precious natural resource to be planned, developed and conserved in an integrated and environmentally sound basis. In doing so, the preservation of the quality of environment and the ecological balance are also of prime consideration. The adverse impact, if any, on the environment is minimized and is off-set by adequate compensatory measures. Planning of water resources is major component of the environment in which man occupies the center-stage. Apart from the need for sustenance of life i.e. for drinking etc., water is also required for producing food and fibre, municipal needs industrial, power and recreation requirements etc. Looking at the prime importance of water it is necessary to understand the natural process of water cycle. In simple words water cycle, also known as the hydrological cycle or the hydrologic cycle, describes the continuous movement of water on, above and below the surface of the Earth.

Hydrological Cycle refers to the movement of water of oceans, atmosphere and lands in a series of continuous interchanges of both geographic position and physical state.

The Cycle

Water is a cyclic resource. It can be used and re-used. Water also undergoes a cycle from the ocean to land and land to ocean. The hydrological cycle describes the movement of water on, in, and above the earth. The water cycle has been working for billions of years and all the life on earth depends on it. The distribution of water on earth is quite uneven. Many locations have plenty of water while others have very limited quantity. The hydrological cycle, is the circulation of water within the earth's hydrosphere in different forms i.e. the liquid, solid and the gaseous phases. It also refers to the continuous exchange of water between the oceans, atmosphere, land surface and subsurface and the organisms.

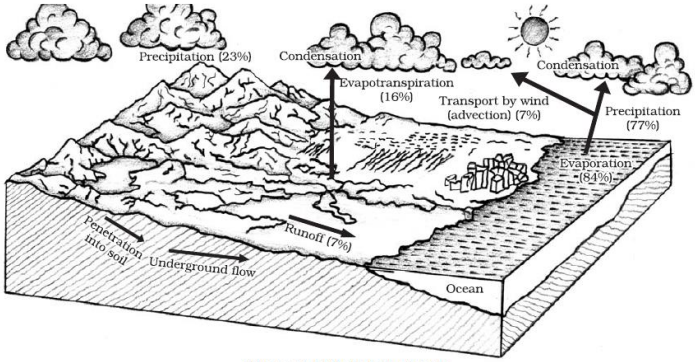

Figure 13.1 : Hydrological Cycle

Table 13.1 : Water on the Earth's surface

Reservoir	*Volume (Million Cubic km)*	*Percentage of the Total*
Oceans	1,370	97.25
Ice Caps and Glaciers	29	2.05
Groundwater	9.5	0.68
Lakes	0.125	0.01
Soil Moisture	0.065	0.005
Atmosphere	0.013	0.001
Streams and Rivers	0.0017	0.0001
Biosphere	0.0006	0.00004

Table 13.1 shows distribution of water on the surface of the earth. About 71 per cent of the planetary water is found in the oceans. The oceans with a mean depth of 3800 meters hold 97% of all earths' water reserves of 1.31 x 10^{24} $cm^{3.}$ The remaining is held as freshwater in glaciers and ice-caps, groundwater sources, lakes, soil moisture, atmosphere, streams and within life. Nearly 59 per cent of the water that falls on land returns to the atmosphere through evaporation from over the oceans as well as from other places. The remainder runs-off on the surface, infiltrates into the ground or a part of it becomes glacier (Figure 13.1).In the study of the water cycle, the focus is on transfer of water between these stores. Various stages involved in the cycle are evaporation, moisture transport, condensation, precipitation and runoff.

It is to be noted that the renewable water on the earth is constant while the demand is increasing tremendously. This leads to water crisis in different parts of the world — spatially and temporally. The pollution of river waters has further aggravated the crisis. How can you

intervene in improving the water quality and augmenting the available quantity of water?

Table 13.2 : Components and Processes of the Water Cycle

Components	*Processes*
Water storage in oceans	Evaporation Evapotranspiration Sublimation
Water in the atmosphere	Condensation Precipitation
Water storage in ice and snow	Snowmelt runoff to streams
Surface runoff	Stream flow freshwater storage infiltration
Groundwater storage	Groundwater discharge springs

Terms used in Hydrological Cycle

Evaporation	Process by which a liquid becomes a gas
Condensation	The process of changing from a gaseous to a liquid or state
Precipitation	The falling to earth of any form of water (rain or snow or hail or sleet or mist)
Transpiration	Loss of water from a plant through its leaves
Infiltration	Seepage of water into soil or rock
Percolation	The slow movement of water through pores in soil or permeable rock
Surface runoff	Water which runs along the surface into collection points (streams, rivers, ponds, lakes, etc)
Ground Water	Water found beneath Earth's surface
Water Table	The top of the saturated zone
Discharge	Waters that are emptying from one moving source (stream or river) into another moving or still source (river or lake)
Aquifer	A rock layer that stores and allows the flow of ground water
Evapotranspiration	Evaporation from plants
Permeability	A rock's ability to let water through it

Impermeable	A rock that tends to stop the flow of water
Water cycle	The continuous process by which water moves from Earth's surface to the atmosphere and back
Humidity	The amount of moisture in the air
Relative humidity	The percentage of water vapour in the air compared to the maximum amount the air could hold at a given temperature
Psychomotor	Instrument used to measure relative humidity that has two thermometers (wet bulb and dry bulb)
Precipitation	Any form of water that falls from clouds and reaches Earth's surface

Relief of the Ocean Floor

Oceans bottoms are not plain as believed earlier; they reveal many complex and varied features which rival the relief features on land. The oceans are confined to the great depressions of the earth's outer layer. The oceans, unlike the continents, merge so naturally into one another that it is hard to demarcate them. The geographers have divided the oceanic part of the earth into five oceans, namely the Pacific, the Atlantic, the Indian, Southern ocean and the Arctic. The various seas, bays, gulfs and other inlets are parts of these four large oceans.

A major portion of the ocean floor is found between 3-6 km below the sea level. The 'land' under the waters of the oceans, that is, the ocean floor exhibits complex and varied features as those observed over the land (Figure 13.2). The floors of the oceans are rugged with the world's largest mountain ranges, deepest trenches and the largest plains. These features are formed, like those of the continents, by the factors of tectonic, volcanic and depositional processes.

Divisions of the Ocean Floors

The ocean floors can be easily divided into four major divisions (Figure 13.3):

(i) the Continental Shelf;

(ii) the Continental Slope;

(iii) the Deep Sea Plain;

(iv) 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.

Major Ocean Relief Features	Minor Ocean Relief Features
Four major divisions • The continental shelf, • The continental slope, • The Deep Sea Plain or the abyssal plains, • The Oceanic deeps.	• 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 the extended margin of each continent occupied by relatively shallow seas and gulfs. It is the shallowest part of the ocean showing an average gradient of 1° or even less. The shelf typically ends at a very steep slope, called the shelf break.

The width of the continental shelves varies from one ocean to another. The average width of continental shelves is about 80 km. The shelves are almost absent or very narrow along some of the margins like the coasts of Chile, the west coast of Sumatra, etc. On the contrary,the Siberian shelf in the Arctic Ocean, the largest in the world, stretches to 1,500 km inwidth. The depth of the shelves also varies. It may be as shallow as 30 m in some areas while in some areas it is as deep as 600 m.

The continental shelves are covered with variable thicknesses of sediments brought down by rivers, glaciers, wind, from the land and distributed by waves and currents. Massive sedimentary deposits received over a long time by the continental shelves, become the source of fossil fuels.

The continental shelf is formed mainly due to submergence of a part of a continent, relative rise in sea level and sedimentary deposits brought down by rivers. Examples: Continental Shelf of South-East Asia, Great Banks around Newfoundland, Submerged region between

Australia and New Guinea. Massive sedimentary deposits received over a long time by the continental shelves, become the source of fossil fuels (Petroleum).

There are various types of shelve based on different sediments of terrestrial origin:

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

Do You Know

- The average width of continental shelves is between 70 – 80 km.
- Depth may be as shallow as 30 m in some areas while in some areas it is as deep as 600 m.
- Marine food comes almost entirely from continental shelves;
- They provide the richest fishing grounds;
- They are potential sites for economic minerals

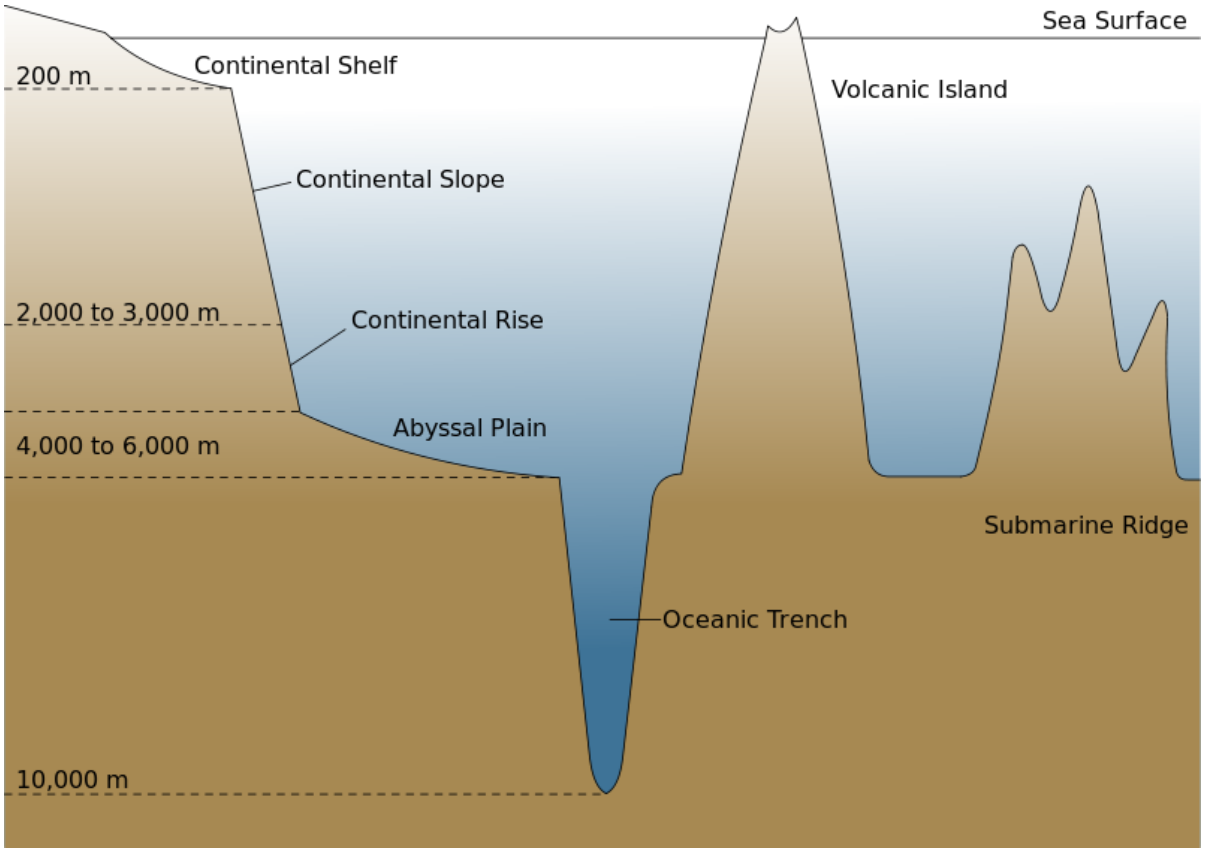

Figure 13.3. Ocean Bottom Relief

SLOPE	Active Margins	Passive Margins	All Margins

Continental Slope

The continental slope connects the continental shelf and the ocean basins. It begins where the bottom of the continental shelf sharply drops off into a steep slope. The gradient of the slope region varies between 2-5°. The depth of the slope region varies between 200 and 3,000 m. The slope boundary indicates the end of the continents. Canyons and trenches are observed in this region (Table 13.3).

On an average, the slope is a narrow band 41 km wide that encircles all continents and islands. The passive margin slopes of the South Atlantic Ocean are the widest on average (73 km), although the slope attains its greatest width of 368 km in the North Atlantic, where the slope protrudes south of Newfoundland. The most narrow, active margin, slopes are in the Mediterranean and Black Seas (25.8 km). The average width of active slopes (35.6 km) is somewhat less than the average width of passive margin slopes (45.7 km).

Ocean	Mean (km)	Maximum (km)	Mean (km)	Maximum (km)	Mean (km)	Maximum (km)
Arctic Ocean	0 ± 0	0.0	33 ± 0.5	287.3	33 ± 0.5	287.3
Indian Ocean	50.4 ± 0.9	205.3	52.4 ± 0.7	255.2	51.9 ± 0.6	255.2
Mediterranean and Black Seas	25.8 ± 0.5	118.0	47 ± 1.1	127.6	31 ± 0.5	127.6
North Atlantic Ocean	26.7 ± 0.5	144.2	63.6 ± 0.8	368.2	51.1 ± 0.6	368.2
North Pacific Ocean	39.7 ± 0.4	254.2	72.7 ± 4	217.2	40.8 ± 0.4	254.2
South Atlantic Ocean	73.2 ± 3.4	152.4	70.1 ± 1.3	279.4	70.2 ± 1.2	279.4
South Pacific Ocean	32.6 ± 0.4	122.4	34.3 ± 1	144.4	32.9 ± 0.4	144.4
Southern Ocean	32.5 ± 1.1	190.4	22.7 ± 0.4	181.8	24.3 ± 0.4	190.4
All Oceans	35.6 ± 0.2	254.2	46 ± 0.3	368.2	41.5 ± 0.2	368.2

Table 13.3 Statistics on the width of the geomorphic continental slope (after Harris et al., 2014), measured as the horizontal distance between the shelf break and foot of slope.

Deep Sea Plain or Abyssal plain

Deep sea plains are gently sloping areas of the ocean basins. These are the flattest and smoothest regions of the world. It is an underwater plain on the deep ocean floor, usually found at depths between 3,000 and 6,000m. These plains are covered with fine-grained

sediments like clay and silt. Lying generally between the foot of a continental rise and a mid-ocean ridge, abyssal plains cover more than 50% of the Earth's surface. They are among the flattest, smoothest and least explored regions on the Earth. Abyssal plains are key geologic elements of oceanic basins (the other elements being an elevated mid-ocean ridge and flanking abyssal hills). In addition to these elements, *active* oceanic basins (those that are associated with a moving plate tectonic boundary) also typically include an oceanic trench and a subduction zone. They are poorly preserved in the sedimentary record, because they tend to be consumed by the subduction process. The creation of the abyssal plain is the end result of spreading of the seafloor (plate tectonics) and melting of the lower oceanic crust. The remainder of the sediment is composed chiefly of pelagic sediments. Metallic nodules are common in some areas of the plains, with varying concentrations of metals, including manganese, iron, nickel, cobalt, and copper. These nodules may provide a significant resource for future mining ventures.

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 platemovements. As many as 57 deeps have been explored so far; of which 32 are in the Pacific; 19 in the Atlantic Ocean and 6 in the Indian Ocean. The **Mariana Trench off the Guam Islands** in the Pacific Ocean is the deepest trench with, a depth of more than **11 kilometres.** They are associated with **active volcanoes** and **strong earthquakes** (Deep Focus Earthquakes like in Japan). This makes them very significant in the study of plate movements.

Minor Relief Features

Apart from the above mentioned major relief features of the ocean floor, some minor but significant features predominate in different parts of the oceans.

Mid-Oceanic Ridges or Submarine 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. A mid-oceanic ridge is composed of two chains of mountains separated by a large depression. Running for a total length of **75,000 km**, these ridges form the **largest mountain systems on the earth.**

These ridges are either broad, like a plateau, gently sloping or in the form of steep-sided narrow mountains. These oceanic ridge systems are of **tectonic origin** and provide evidence in support of the theory of **Plate Tectonics.** Iceland, a part of the mid-Atlantic Ridge, is an example.

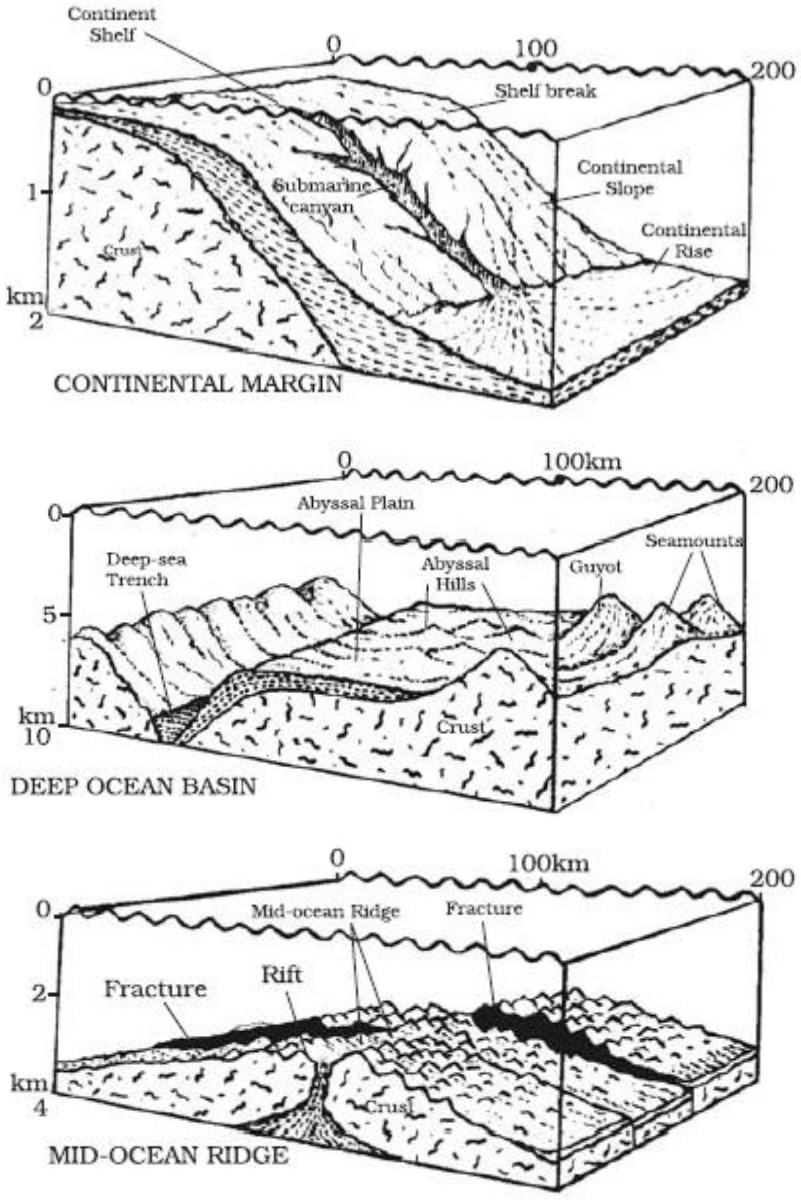

Figure 13.2 : Relief features of ocean floors

SONAR (Sound Navigation and Ranging)

A system for the detection of objects under water by emitting sound pulses and detecting or measuring their return after being reflected.

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.

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. 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.

The study of the morphology of the ocean is important because the relief controls the nature, character and the motion of the sea water. The oceanic movement in the form of currents, in turn, cause many variations which are important to the character of marine fauna and flora. The bottom relief of the oceans also influences navigation, fishing and other important activities of man.

Summary

- Continental Shelf is the gently sloping seaward extension of continental plate.
- These extended margins of each continent are occupied by relatively shallow seas and gulfs.
- The continental slope connects the continental shelf and the ocean basins.
- It begins where the bottom of the continental shelf sharply drops off into a steep slope.
- Deep sea plain covers nearly 40% of the ocean floor.
- The gradient of the slope region varies between 2-5°.
- The depth of the slope region varies between 200 and 3,000 m.
- They are some 3-5 km deeper than the surrounding ocean floor.
- The trenches lie **along the fringes of the deep-sea plain** at the bases of continental slopes and along island arcs.
- The trenches run **parallel to the bordering fold mountains** or the **island chains**.
- The trenches are very common in the Pacific Ocean and form an almost continuous ring along the western and eastern margins of the Pacific.
- The **Mariana Trench off the Guam Islands** in the Pacific Ocean is the deepest trench with, a depth of more than **11 kilometres.**
- Atolls 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.