BLOCK - IV

EXTERNAL PROCESSES - II

The Geological processes of glaciers, lakes, seas and wind are exhibiting a variety of geological landscape on the earth surface. The geological actions of glaciers, lakes, seas, wind are discussed in the block.

The units included in the block are :

UNIT -10 GLACIERS

Contents

10.0 OBJECTIVES

After studying this unit, you should be able to

- explain glacier formation and classification
- describe geological work of glaciers
- explain the existing glaciers
- describe the causes of glaciations

10.1 INTRODUCTION

Snow fall is common in places and regions of high altitudes especially during the colder seasons. In such regions where the mean annual temperature is near the freezing point of water, much of the snow remains unmelted from one year to the next and consequently accumulates to great depths forming the snow fields. The elevation or the level of lower limit of such perennial accumulation of snow is called snow line. It rises from almost see level in the polar regions to altitudes of as much as 6000 mts. in tropical mountains.

The snow is commonly flaky and dry but as it accumulates in the snow fields, it is compact, partially melted and in refreezing it acquires a granular texture, then it is called **Neve** or **firn.** As the snow crystals are buried in compact, the air between them is expelled out and the water from the melting snow seeps in and freezes and thus the deep layers are transformed into compact but still porous ice.

With successive snowfalls over a long period a snow field grows in size and depth until the pressure on the ice which is formed in depth is sufficient to start its outward flowage as a glacier, ice is a weak solid and if a body of ice is as much as 60 to 90 mts. thick, its own weight is enough to overcome its slight rigidity and it begins to be deformed, flowing outward and downward in a manner as a shift fluid flows but nevertheless remaining as solid. As soon as a body of ice becomes thick enough to flow in this way, it becomes a glacier.

A **glacier** may be defined as a body of ice consisting mainly of recrystallized snow, flowing on the land surface in a manner similar to that of a river.

Glaciers originating in valley heads creep slowly downwards as tongue like streams of ice, flowage being maintained by the yearly replenishment of the neve fields. Ultimately glaciers dwindle away by melting, their front movements of ice is just balanced by the wastage. The glaciers vary in size from short but wide tongues of ice or snow on the narrow beaches of a cliff to tongues of ice extending down the valleys from the mountains like those of Alps, Himalayas etc. Glaciers are very viscous and therefore move extremely slowly. The size of glacier is to be enormously greater than that of a corresponding river. When the glaciers overflow the land and terminate in sea water sufficiently deep to allow the ice to float huge masses break away from the front and become ice bergs.

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of this unit:

1. Define the term glacier.

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10.2 CLASSIFICATION OF GLACIERS

On the basis of their form, we can distinguish four kinds of glaciers (i) Cirque glacier (ii) Valley glacier (iii) Piedmont glacier (iv) Ice Sheet.

Cirque glacier: It is a small glacier occupying a cirque or resting against the head wall of a cirque.

Valley glacier: It is a glacier that flow downward through a valley. In many respects they behave like a stream of water. It is otherwise known as Alpine glacier because of their typical development in the region of Alps Mountains.

Piedmont glacier: It is a glacier on a low land at the base of the mountain fed by one or more valley glacier. Example Malaspin glacier in Alaska.

Ice Sheet or Continental glaciers: It is a broad glacier of irregular shape generally blanketing a large land surface. Example - Antarctica and Green land is covered by ice sheets.

10.3 GLACIAL MOVEMENT

The average rate of movement of glaciers is far less than that of a river. It is not more than a few feet per day. Alpine glaciers move a meter or less per day. However a few ice tongues in

Greenland have been recorded with a rate of even 3 meters or a fraction. The movement of the glacial ice is called a flow. The movement of a glacier resembles that of a river in many ways. The centre move more rapidly than the margins where it meets resistance along the walls of the valley. The surface moves more rapidly than the deeper portions of the ice. At curves in its course the convex portion moves more rapidly than the concave. Since some parts of the ice moves faster than other parts, the movement of a glacier is called as differential movement.

The way ice flows is complex but is believed to be of two basic types. One mechanism involves internal movement within the ice. Ice behaves as a little solid until the load upon it is equivalent to the weight of about 50 to 60 meters of ice. Once the load is surpassed, the ice will behave as a plastic material and flow continuously. Another mechanism of glacial movement consists of the whole ice mass slipping along the ground. The lower portions of most glaciers are thought to move by the sliding process. Glaciers move down slope under the influence of gravity. The main causes of glacial motion lie within the ice of the glacier itself as it reacts to the changing conditions under which it exists. Melting of ice at the points of great compression stress and its refreezing after a forward movement is an important factor. As glacial ice moves it recrystallize to that of schist. When it refreezes it expands and the surrounding ice mass is subjected to the thrust of its expansive force. As the temperature rises it expands giving a forward thrust to the glacier. The sum of all these factors perhaps may be the cause of glacier motion.

Glaciers are constantly gaining and loosing ice. As we learned earlier, snow accumulation and ice formation occur above the snowline. Here the additions of snow thicken the glacier and promotes movement. Below the snowline, snow from the previous winter as well as some of the glacier ice melts into the sea. Whether the margin of a glacier is advancing, retreating or remaining stationary depends upon the economy of the glacier that is it depends upon the balance or lack of balance between accumulation on one hand and the wastage on the other. If ice accumulation exceeds wastage the glacier front advances until the two factors balance. At this point the terminus of the glacier is stationary. At a later time when wastage exceeds accumulation the ice front will retreat until a balance again is reached.

10.4 FEATURES OF GLACIERS

The head or upper end of a valley glacier is generally marked by one or more large gaping cracks or crevasses known as **Bergs-chrund.** Where the glacial ice passes through a construction in a valley it thick and the rigid crust is thrown into wave-like pressure ridges. On the other hand where the valley opens out, the ice is stretched and cracked into a series of deep crevasses. **Transverse crevasses** develop across a glacier where there is a marked steepening of the slope of the valley floor. Longitudinal crevasses roughly parallel to the direction of flowage are formed where the ice is obliged to spread out. The marginal crevasses point up the valley at about 45 degrees due to the more rapid movement of the central portion of the glacier.

If the valley is deep, the mountain sides are undermined by the moving glacial ice and heaps of rock fragments or immense blocks of rocks gather on the ice at the sides of the valley forming lateral moraines and when two tributary glaciers meet a medial moraine results by the union of two lateral moraines. The debris carried to the terminus of the glacier is deposited about its end as the ice melts and at many places forms a crescent shaped ridge known as the **terminal moraine**.

In the zone below the snowline a good deal of water is usually evident atleast during summer. This is the melt water resulting from the melting of glacial ice. It is seen as small pools and streams on the surface of the glacier. Some of the melt water follows englacial channels for a time and may discharged from the sides of the glacier as springs. The general tendency is for the melt water to accumulate in the form of a stream at the bottom of the glacier and to discharge at or near the terminus from a tunnel. The water from such a channel is often very turbid and whitish because it is charged with finely grounded particles of fresh and unweathered rocks. Two notable features associated with melting and partial draining of melt water are the glacier tables and **moulins**. This slab of rocks or patches of debris on the surface of a glacier may be sufficiently heated by the sun to melt the underlying ice. But large bloks act as a protection from the sun's rays and as the surrounding ice melts away they are left as glacier tables perched on a column of thick glacial ice. The superficial small pools and rills gather into streams which mostly tumble and fall into crevasses and are lost in the depths of the ice. The water carries with it the mud, sand and boulders from the surface moraines. These erode the crevasses and produce vertical shafts that are often referred to as mounting or **glacier mills.**

Check Your Progress

Note: a) Space is given below for writing your answers.

b) Compare your answer with the one given at the end of this unit.

2. Glacier developed cracks within the flowing Ice known as-

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10.5 GEOLOGICAL WORK OF GLACIERS

The geological work of glaciers is expressed in the process of glaciation which is the alteration of the land surface by glacial ice passing over it. Glaciation includes erosion, transportation and deposition. As most glaciers are at present shrinking the eroded bedrock surfaces can be seen and watched as also the making of glacial deposits at the glacier margins. Similar things were observed early in the 19th century by various European Scientists. Chief among such European observers was **Louis Agassiz** who convinced the scientific world with a wealth of irresistible evidence that the landscapes of vast areas of Europe bear the unmistakable hallmark of widespread glaciations. By examining such glaciated districts from where glaciers have melted away and retreated, it can be seen that the glacial erosion takes place mostly well back beneath the glacier and that deposition occurs mostly at or near the outer margin. Glaciers are capable of carrying on great amount of erosional work.

1) Erosion

Glaciers erode the land primarily in two ways. Glacial erosion, like stream erosion, includes abrasion and plucking and is generally preceded by weathering in the form of frost wedging.

First, as a glacier flows over a fractured bedrock surface, it loosens and lifts blocks of rock, incorporates them into the ice and carries them off. Consequently glaciers can carry huge blocks that no other erosional agent could possibly do. This process of lifting out and removal of pieces of bedrock by a glacier is called, **quarrying** or **plucking.** It occurs when melt water penetrates the cracks and joints along the rock floor of the glacier and refreezes. As the water expands, it exerts tremendous coverage that pries the rock loose. In this manner sediment of all sizes, ranging from fine particles as rock flour to big blocks, become part of the glacier's load.

The second major erosional process is abrasion. As the ice and its load of rock fragments move along, there is abrasion on the rocks within the ice. The pulverized rock produced by the glacier is appropriately called **rock flour.** When the embedded material consists of large fragments, long scratches and grooves called glacial striations may be seen. These linear scratches on the bedrock surface provide clues to the direction of glacial movement. On the other hand, not all abrasive action produces striations. When the sediment consists of fine silt sized particles, the rock surfaces over which the glaciers move may become highly polished. A striation or groove does not show as a rule the direction of a glacier. The direction of a flow of the glacier can be determined by rock hills and small knobs that are not symmetrical. Usually the upstream side of a rock hill is predominantly abraded, striated and gently sloping, where as the down stream side is predominantly plucked and therefore has a steeper slope. Such feature of resistant **hummocks** of bedrock moulded by glacial erosion are called **Roches mountonnes** since they resemble sheep lying down or sheepskin wigs placed "face" downward.

Crag and Tail: Another important evidence of glacial erosion is the Crag and Tail. These are features developed when highly resistant obstructions such as old volcanic plugs that lay in the path of the glacial ice like the protending knots in a plank of wood. The crag boldly faces the direction from which they came while the Tail (bedrock with a thin veneer of boulder clay) is a gentle slope on the sheltered side where the softer sediments were protected by the obstruction from the full impact of glacial erosion. An excellent example of crag and tail is the famous castle rock of Edinburg.

Cirques: This is a prominent and notable characteristic feature of Alpine glaciation. A cirque is a steep walled recess, shaped like a half bowl and excavated mainly by frost wedging. A cirque begins to form beneath a snow field or snow bank just above the snow line, on summer days water from the melting snow infiltrate drops and the water freezes and expands, prying out rock fragments. The smaller rock particles are carried away down slope by melt water during thaws. These activities create a depression in the bedrock and enlarge it. If the snow bank grows to be a glacier plucking helps to enlarge the cirque still more but frost wedging continues as water descends the rock wall of the cirque and freezes there. Many cirques have rock basins in their floors usually containing small lakes. After the glacier has melted away, the cirque basin is usually occupied by a lake often called **cirque lake**.

Characteristics of a Glaciated Valley - The glaciated valleys differ in several ways from the ordinary stream valleys. They show innumerable evidences of glaciation. They are described as follow:

(i) A valley which has been vigorously glaciated has a broad bottom and very steep vertical sides that is, it has a U-shaped cross-section or profile instead of the very characteristic V-shaped cross profile of a stream valley. This is because a glacier not only erodes the bottom of its valley but also its sides. Thus the valley is made much broader at the bottom with its sides very much steepened.

(ii) Many glaciated valleys or canyons in mountains are much straighter and more open for long distances than stream eroded valleys. This is because a glacier has a much stronger tendency to take a straight course than river and so the lower ends of the ridges or spurs which project down into the valley alternatively from opposite sides are truncated by glacial erosion.

(iii) In glaciated valleys the tributary valleys show typically a discordance of position. They join the main valley much above its bottom and therefore are called hanging valleys. Hanging valleys often produce spectacular cascading waterfalls, such as those in National Park, California.

(iv) Another striking feature of a glaciated valley in mountainous regions is the presence of cirques at the head of glaciated valleys. Two cirque walls may be cut back towards each other from opposite sides of a mountain mass a very sharp divide known as knife-edge ridge is left between the cirques. Such a jagged knife-edge is called as **Arete.**

A **col** or a gap in a mountain crest forms at a place where the head walls of cirques intersect each other. A **matterhorn** is a bare shaped peak left standing where cir has eaten into it from three or more sides. The most famous example of such horns is the Matterhorn the highest peak in the Alps Mountains in Switzerland.

(v) A less common but nevertheless important feature of glaciated valleys is that glaciers entering the sea may erode their valleys moving below the sealevel. This is because the moving ice is able to displace the water until its depth becomes so great that the ice is beyond up and broken.

The deep bay-like narrow arms of the sea with high steep walls knows as **Fjords** along the coasts of Norway, Sweden, Alaska and Chile are glaciated valleys partly submerged.

Check Your Progress

Note: a) Space given below for writing your answer.

b) Compare your answer with the one given at the end of this unit.

3. What is a cirgue?

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2) Transportation

Unlike streams, a glacier carries its load of rock particles all in a jostling without any sorting so that the deposits made directly from a glacier are not sorted and not stratified. The glacier carries its load in its side and on its top and the load is concentrated on the floor and sides because this is where glacier and bedrock are in contact and where abrasion and plucking are most effective. Most of the rock debris on the surface of a valley glacier has accumulated there by land sliding and slump consists of very particles such as fine sand and silt. Most of these particles are fresh and unweathered, have usually angular and jagged surfaces and are unmistakably the products of crushing grinding. Fine sand and silt produced that way in a glacier is known as rock flour, which is evidently a product of rapid erosion of bedrock by glaciers.

3) Deposition

Glacial deposition takes place mainly in the downstream parts of glaciers where melting and evaporation release rock fragments from the ice. The sediments may deposit directly from the ice. The sediments deposited directly by glaciers or indirectly in glacial streams, lakes and the sea, together constitute **glacial drift.** Glacial deposits are two types.

(i) Those that are directly deposited by a glacier are called glacial deposit namely **glacial till** and (ii) those by glacial streams are called **Glacio-fluvial deposits** or **outwash.** Glacial tills deposited as glacial ice melts and drops its load of rock fragments. Deposits of till are characteristically unsorted, a mixture of many different sizes of sediment. When big boulders are found in glacial till they are called glacial erratics, indicating that they are derived from a source outside the area where they are found. In many areas erratic boulders may be seen dotting pasture and farm land.

Outwash is sorted according to the size and weight of the fragments. Since ice is not capable of such sorting activity, these sediments are not deposited directly by the glacier as till but rather reflect the sorting action of the glacial melt water. Accumulations of outwash often consist largely of sand and gravel that is bed load material.

Perhaps the most widespread features created by glacial deposition are **moraines,** which are simply layers of ridges of glacial till. A **ground moraine** may be described as a sheet of heterogeneous unstratified rock debris which is deposited underneath a glacier which is melting and receding. It consists of very fine material with pebbles or boulders scattered through its mass, it is very often called as boulder clay. The pebbles and boulders are often characteristically striated as a result of abrasion against the bed rock. Ground moraines have a leveling effect, filling in low spots and clogging old stream channels, often leading to a disruption of normal drainage.

Terminal or End Moraines: As the name implies terminal or end moraines form at the terminus or the end of a glacier. Here while the ice front is stagnant the glacier continues to carry and deposit large quantities of rock debris, creating a ridge of till, tens to hundreds of meters high. A terminal moraine is usually crescent or horse-shoe shaped in outline with their concave side towards the head of a valleys valley glaciers often leave loop like terminal moraine ridges across the valleys or at their mouths.

The sides of an Alpine glacier accumulate large quantities of debris from the valley walls. When the glacier melts away, these materials are left as ridges or **lateral moraines** along the sides of a valley. In most glaciated valleys these lateral moraines are more conspicuous than the terminal moraines or ground moraines. If, after a glacier has retreated a considerable distance, its terminus again remains relatively stationary for sometime another terminal will accumulate around it. Such a processional moraine develops during every considerable pause in the recession of a glacier. A very typical example of such recessional moraines is displayed by the great succession of curving ridges south of the lakes Michigan and Erie.

Drumlins: These are unstratified glacial deposits of special and unusual interest. In many areas the glacial drift is molded by a streamline flow of ice into nearly parallel smooth ridges and troughs that range up to many miles in individual length. These forms resemble the streamline bodies of racing automobiles, offering minimum frictional resistance to the ice flowing over them. They are typically low, rounded mounds or hills of glacial till with elliptical bases, with long axes parallel to the general direction of movement of a glacier. They have steeper sides. The example of drumlins is in the region between Syracuse and Rochester, Network where thousands of them rise conspicuously above the level of the Ontario Plain. They are also abundant in Wisconsin and Ireland.

Erratic Boulder Trains: These are boulders of glacial origin left irregularly all over the country during the wasting of a glacier. They vary in sizes ranging from pebbles to boulders as big as small houses. They are erratic or exotic because they are different from the bed rock over which they are situated now. Erratic boulders are extremely abundant in New York and New England as well as Tibet and Malla Johar in Trans Himalayan region. In some areas that have been glaciated by ice sheets, erratics derived from some distinct kind of bedrock, are numerous and spread out in fan-like shape and are called boulder trains.

Glacio-FIuvial deposits: In regions where the melting of glacier is in progress several streams are formed on the surface at the margins and at the bottom of the glacier. During summer great torrents carry boulders, pebbles, sand I, and fine rock flour. Most of glacio-fluvial sediments are carried beyond the terminal moraine. The glacio-fluvial deposits are confined to the width of the valley and build valley train, which are crudely stratified.

Outwash Plains: When the front of a great glacier pauses for a considerable time upon somewhat flat surface or broad plain, the melt waters emerging from the ice spread in a network of streams and deposit their debris more of less uniformly over the surface forming outwash plain. Outwash plains are of course somewhat more stratified. Their deposits often are composed of gravel and coarse sand at or near the terminal moraine and farther away their deposits are fine sand and silt.

Kettle Holes: Depressions usually 3 to 30 mts deep with no outlets and steep sides are often found in outwash plains. Such depressions are known as kettle holes and they result from the melting of blocks of ice which become separated from the glaciers during its retreat and buried in the outwash material.

Kames: These are hills commonly 15 to 45 mts high more or less conical in shape, formed by stratified glacial debris. They may be isolated or may occur in small groups or may be associated with unstratified glacial moraine at the terminus. When they occur between the hills, it gives rise to the so called **"knob and kettle"** topography. They occur generally in valley bottoms but sometimes on hill sides. They are formed at the margins of large glaciers by debris laden streams which dump the material, usually gravel and sand, as they emerge from the ice. Sometimes they form Kame-moraine ridges partially in association with the terminal and recessional moraines.

Eskers: These are long usually winding (or separate ridges) low ridges of stratified glacial debris mainly consisting of gravel and sand. They are found in the region of the ground moraine. They are usually less than a mile long and their crests are narrow and even. They are generally so symmetrical that they often look like artificial railway embarkments. They were formed by deposition in streams choke with glacial debris either in channels on glacial in tunnels beneath the ice.

Glacial Lakes: A continental glacier covers all the land including the divides between different drainage basins. If a land surface in front of the glacier slopes toward the ice edge melt waters from the glacier accumulate against the high land and the margin of the ice which serve as a temporary dam that prevents the water from following its former course. In this way large areas may be flooded, forming marginal glacial lakes. Such lakes exist until an outlet is cut across the lowest point in the divide. Numerous examples may be cited of such glacial; lakes formed along the margins of the continental ice sheets that covered parts of Europe and North America, during the Pleistocene Ice Age. The glacial lake of Agassiz and the Great Lakes of North America are the best known examples of glacial origin.

Glacial Lake sediments: The cold waters of marginal glacial lakes have a higher density than the water at moderate temperatures. For this reason the settling of silts and clays is much retarded and so the fine sediments in suspension become diffused throughout the lake water and are deposited over the floor of the entire lake basin. The fine-grained sediments are laid down in plainly separated annual layers called **varves.** Glacial varves commonly consist of alternate laminae, one of which was laid down during the summer and the other during the winter. The summer band consists of light coloured coarse silt where as the winter band is darker in colour and fine grained and thinner. Each varve represents a year. By careful study and analysis it has been possible to estimate the rate of recession of a continental ice sheet on glaciers.

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of this unit.

4 . Name any five glacial deposits –

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10.6 EFFECTS OF GLACIATION ON RELIEF AND DRAINAGE

Valley glaciers have brought about considerable topographic changes by straightening, deepening, widening and steepening the sides of their valleys and modified the divides into cirque basins, aretes and matterhorns. The continental ice sheets of the great ice age have not profoundly altered the relief of the country over which they moved and though many hills and low mountains were somewhat scoured and rounded off and many valleys were deepened and widened, the major relief features were almost left unaffected by ice erosion during the passage of ice sheets. The vast continental glaciers left the country somewhat less rugged than it was before glaciation. The movements of the ice of continental ice sheets caused the mantle of soils to be removed from their place of origin, mixed up and transported often for long distances. Over the eastern and central Canada ice erosion predominated over deposition while farther south and southwest glacial deposition, predominated. This explains why eastern parts of Canada are generally characterized by bare rock ledges or thin soils, where as deep glacial soils generally prevail over New England, the upper Mississippi valley etc.

The effects of glaciation upon drainage are very profound. Many pre-glacial valleys were more or less completely filled with glacial debris, causing new streams to follow on courses very much different from those of the predecessor of pre-glacial valleys. In other cases streams were crowded out of their valleys by the ice itself and forced to erode new channels elsewhere. Many such new channels have been held to since the disappearance of the ice. Immediately prior to the great Ice age, the combined Allegheny and Mononagahela rivers flowed north-wide into the Erie lake basin instead of through the Ohio Valley as at present. Accumulation of much glacial debris across the northwestern Pennsylvania caused the change. In many such cases where streams were forced to find new channels this have carved out picturesque gorges usually containing waterfalls, The famous Niagara Gorge and Niagara falls are excellent examples.

Most of the several thousands of lakes in Northern parts of North America are the direct results of the glaciation of the Pleistocene Ice Age. Even the great lakes were not in existence before the Ice Age. Some of these lakes occupy the rock basins scoured out by glacial erosion but most of them fill basins, which were formed by glacial drift deposits blockading valley causing the streams in them to be locally ponded.

10.7 EXISTING GLACIERS

Greatest of the present day glaciers are the vast ice sheets or continental glaciers occupying much of the Greenland, Iceland and Antarctica. The lesser ones are the ice caps that occur in the Arctic Islands of the Spitz bergen Scandinavia and Iceland. Of the valley glaciers that exist now a days the Alpine type are the most abundant. They are best known in the Alps Mountains where there are at least 2,000 of them. The most prominent among them is the Great Aletsch Glacier which is over 14 kms long.

The great Himalayan Mountains support a magnificent system of very large high altitude valley glacier. The largest of these is the Fed chenko which is 60 kms long. Kedarnath and Kanchenjunga found in Kumaon and Nepal Himalayas support many valley glaciers. The Andes in South America support many valley glaciers. Several of them flow into tide water where they break off to form ice-bergs. Southern Alaska of U.S.A. is a wonderland of lofty mountains, vast fields of perpetual snow and numerous valley glaciers of large size.

The Great Ice Age: As early as 1821 European scientist Louis Agassiz was the first to recognize features characteristic of glaciation in places at considerable distances from the existing glaciers. He naturally inferred that the glaciers must once have covered wide areas that are now free from ice. Gradually through the work of many scientists information on the character and extent of former glaciation, was added to the growing body of knowledge until today we have a fairly good and comprehensive picture of the former glacial epochs.

During the last period of geological time in the Cenozoic era known as the Pleistocene period most of the North America and Europe was covered by vast and thick ice sheets. This ranks as one of the most interesting and remarkable occurrences of geological time. The total area overwhelmed by thick ice masses approached nearly eight million square miles. Half of this was in North America where the ice radiated from three main centers, namely Labrador, the Keewatin district bordering the Hudson Bay and Cordilleran ranges of the West America. Much of Europe up to Urals and beyond was under ice. A subsidiary' ice cap radiated from the Alps and the Himalayas,and other mountain ranges of Asia were similarly glaciated. In the Southern Hemisphere,New South Wales and Tasmania were glaciated. Newzealand was largely shrouded in ice and so were the extensive tracts of Patagonia and Southern Chili. The Antarctica sheet, like that of Greenland, was thicker and more massive and extensive than it is today.

The climatic change evidently led to a general lowering of the snow line and was clearly worldwide in their effects. Detailed studies of the glacial drift have shown that glaciation was not confined to the effects of a single great advance and retreat of ice. In many places around the Alps, four successive sets of boulder clays, moraines and outwash gravels were preserved showing that glaciation was repeated four times during the Pleistocene period. The intervals between the major glacial epochs are known as the interglacial epochs which are represented by ancient soils and locally by lake and river deposits sandwitched between old and younger bed of glacial or glacio fluvial drift. Some of the interglacial beds contain plant remains and, therefore, provide valuable information as to the climatic conditions at the times when they were deposited.

10.8 CAUSES OF GLACIATION

Through the course of glacial and interglacial epochs, world temperatures have fluctuated rather considerably, the change from a non-glacial climate to glacial climate in middle latitudes requiring an average reduction of about 6 degrees centigrade. For the causes of this fluctuations of temperatures, many hypotheses have been advanced, brief summaries are given below.

Heat Distribution Hypothesis : Changes in the bodily movements of the Earth such as the eccentricity of the Earth's orbit and the inclination of its axis to the ecliptic have been thought to be the probable causes of glaciation. These are real periodic changes accompanied by corresponding changes in the climate. If the variations reached extremes sufficient to account for the glaciation of the Pleistocene, there thought to have been several such or similar ice ages throughout the reckoned geological time. Actually there was only one another similarly great ice age at the close of the carboniferous period.

Solar Radiation Hypothesis : This is yet another hypothesis based on astronomical data. It relies upon the observed variations in the solar constant or the quality of heat reaching the outer surface of the earth's atmosphere. At present this is just less than 2 calories per square minute and it has varied as much as 3 percent since continuous measurements were began by the Smithsonian Institution of Washington of U.S.A. in 1918. **Sir George Simpson** proposed a theory on the large scale changes in the solar constant in the geological past. He assumed' that increased solar radiations would raise temperatures increasing planetary circulation of the atmosphere, precipitation and cloudiness. The cloudiness and precipitation in low latitudes would produce a fluvial climate. In high latitudes cloudiness would decrease the melting of increased snowfall. As a result, glaciers would begin to expand in both polar hemispheres and an ice age would begin. Continued rise of heat at the earth's surface, however, would eventually destroy these glaciers and an interglacial epoch would set in. As the radiation diminished, the process would reverse. Glaciers would form once again and a second glaciation would begin ending only when radiation had decreased to a point where precipitation was inadequate to support the glaciers. They would waste and the second glacial period would end. This is a unique theory in that it calls for glaciation with rise 'of temperature and two glaciations per cycle. If we assumed that two large fluctuations of temperature took place, then the radiation curve would produce four glaciations which is the case in the Pleistocene Ice age.

Solar Topography Hypothesis This is due to Professor **R.F. Flint**, an eminent American geologist, who recognized the topographic theory with variations in solar radiations. Briefly this theory states that only during periods of high continents, the variations in solar radiation produce continental glaciation. It recognizes an intimate connection with high lands and glaciers. If the radiation minimum is coincide with low temperatures of high and extensive continents, then glaciers advance. Wastage of glacial ice would occur with a radiation maximum. This theory seems to answer most of the objections raised in regard to other hypothesis. Still, it is based partly on the facile assumption that modern, small scale fluctuations of solar radiations were much greater, in the past.

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of this unit.

5. What are the causes of glaciations?

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10.9 SUMMARY

A body of ice consisting mainly recrystallised snow, flowing on the land surface in a manner similar to that of a river is called glaciers. Glaciers originate in valley heads and move down like ice streams. Glaciers vary in size. Glaciers are classified on the basis of their form as cirque glaciers, valley glaciers, piedmont glaciers and ice sheet. The glaciers move very slowly and are not more than a few feet per day. The movement of glaciers resembles to that of rivers. The centre moves more rapidly than margins. The head or upper end of a valley glacier is marked by one or more large gaping cracks or crevasses known as Bergs-Chrund. Transverse and Longitudinal crevasses are the other features of glaciers.

The geological work of glaciers includes erosion, transportation and deposition. Glacial erosion includes abrasion and plucking and is generally preceded by weathering in the form of frost wedging. The features of erosion are the crag and tail, cirques etc. The glaciated valleys differ in many ways than that of stream valley. Presence of cirques at the head of the glaciated valley is the striking feature of glaciated valley. Glaciers carry rock particles without sorting and deposits made by glaciers are not stratified. Usually a glacier carries rock debris on its sides because this is where glacier and bed rock are in contact and where abrasion and plucking are more effective.

The sediments deposited directly by glaciers constitute glacial drift. Glacial deposits are of two types namely, directly deposited by glaciers (glacial till) and by glacial streams, (glacio-fluvial or out wash). Glacial till deposits are unsorted and the depositional features are the moraines which are simply layers of till. Glacio-fluvial deposits are well sorted due to glacial melt water. The terminal or end moraines are formed at the end of the glaciers. Drumlins, erratic boulder trains, out wash plains, kettle holes, kames, eskers, glacial lakes etc are the depositional feature of glaciers. Glaciation effects the relief and drainage. Valley glaciers brought about considerable topographic changes by straightening, deepening, widening and steepening of the sides of the valley. Many pre-glacial valleys were more or less filled with glacial debris and will affect drainage. Greatest of present day glaciers are occupying Greenland, Iceland and Antarctica. The causes of glaciations are the heat distribution, solar radiation and solar topography.

10.10 CHECK YOUR PROGRESS-MODEL ANSWERS

1) Glacier may be defined as a large mass of ice consisting mainly of recrystallised snow moving slowly on a land mass.

2) Crevasses.

3) Criques are the circular depressions formed by plucking and grinding on the upper part of mountains slopes.

4) Moraines, drumlins, erratic boulder trains, outwash plains, kettle holes, kames, eskers etc are the features of glacial deposits.

5) The causes of glaciations are the heat distribution, solar radiation, solar topography etc.

10.11 MODEL EXAMINATION QUESTIONS

I. Answer the following questions in 30 lines.

1. Describe the erosional activity of glacier and resulting forms.
2. Describe the deposits formed by glacial action.

II. Answer the following questions in 10 lines.

1. Give an account of the types of glaciers.
2. What are the characteristics of a glaciated valley?
3. Write briefly about the great ice age.
4. What are the causes of glaciations?

UNIT – 11 LAKES AND SEAS

Contents

11.0 OBJECTIVES

After stydying this unit, you should be able to

- explain the lakes, and their geological work
- describe seas and their geological work

11.1 INTRODUCTION

Lakes and seas are acting as agents of external geological processes; Lakes feed freshwater to the rivers and serves as settling basins in the drainage system. The deep seas or oceans supply moisture to the atmosphere. Seas are the depository sites for debris derived from land and carried by the rivers.

11.2 LAKES

A lake may be defined as a natural inland depression or basin containing appreciable amount of water which is generally stationary or quiet, though in certain lakes there may be flowing current as in the case of Lake Eerie. They vary in size from small ponds to immensely large bodies of water covering thousands of square kms, such as the great lakes of North America. Majority of the lakes occur above sea levels at all altitudes up to several hundreds of meters, the highest lake being the Lake Titicaca on the borders of the countries of Peru and Bolivia in South America.

The waters in the lakes may vary in chemical composition from the soft, fresh and pure waters of a mountain lake fed by glaciers to the bitter and concentrated waters of the Great Salt Lake or the Dead Sea. Their composition depends largely upon that of the rocks over which the waters that feed them have passed and the extent to which they have been concentrated with mineral salts. Lakes are known to vary in depth from a few feet of shallow water covering low depressions to the rocky basins over 5,000 feet deep as in the case of Lake Baikal in Siberia. Relatively few lakes are over 1000 feet deep.

Lakes are widely distributed over the earth's surface occurring in mountainous areas on plateau and even in plains, along valleys and sea coasts. Lakes are formed due to obstructed surface drainage and are only temporary features in the erosional history of a particular land surface. They are more likely to occur in regions where the main water table is at or near the surface.

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of the unit.

1. What is a lake?

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11.2.1 Geological Work

Most lakes have outlet streams that feed the rivers, such lakes consist of freshwater and act as safety valves for the rivers they feed since they tend to regulate the volume of discharge and there by prevent floods just like the modem dams being built by man across the rivers to conserve and regulate the flood waters of rivers. The flood waters of an inflowing stream or river spread out over the wide basin of a lake and raise the water level so slowly, as to cause but slight damage, along the valley of the main outlet stream. In like manner, during the period of drought, the water from lake flows out more slowly and thus lakes aid in preserving the permanent streams.

Lakes serve as settling basins in the drainage system of a certain land surface. Most of the sediments carried into the lakes by streams settle on their floors. Lakes with no outlets act as perfect settling basins but even where there are outlets, many lakes are effective settling basins. Thus the mighty Niagara River which drains the four upper Great Lakes is remarkably clear as it leaves the Lake Erie.

The load of the sediment brought in by the inflowing stream is sorted and gradually dropped on to the lake bottom as the velocity of the water is slowed and finally checked. A very large amount of materials accumulates in the lakes of the world each year but it is much less than the quantity that is deposited on the sea floor. The filtering action of lakes causes the outlet streams to be less effective as agents of erosion since they lack the loads which are the grinding tools of a normal stream.

Lakes exert an influence upon local climate conditions by increasing the rainfall and also by keeping the temperature of the region more uniform and tend to tamper the variations of the weather in the vicinity of lake.

 Several aquatic plants and shell-bearing organisms or both found in large numbers in several lakes. These shells, skeletons and partly decayed remnants of the plants accumulate in the lake basins thus helping to fill them. Such materials found in fossil state in the old lake deposits very often yield valuable evidence as to the nature of the certain phase of life of these distant periods of geological time.

When lakes with no outlets evaporate in dry and arid regions, the various salts held in solution are deposited in layers or beds on the lake floors. There are many examples of such salt deposits in certain geological horizons in different parts of the world.

The erosion work of a lake is in many ways comparable to that of the sea except for the fact that the effects produced in lakes are usually less conspicuous because they are smaller and the waves and the under flow are less powerful. In large lakes, however, the resulting features of lake erosion are practically similar and sometimes cut terraces, cliffs, caves, coves, stacks and arches.

Similarly the deposition in lakes is in the manner of deposition in the sea. Thus beaches, barriers, bars, deltas and wave built terraces are essentially the same whether formed in sea or lake. In lakes there are no deposits comparable deep-sea or abyssal deposits. More or less land derived sediments carried in by streams accumulate over the entire floor of most lakes. Deltas growth in lakes is very strong because of lack of tides in the lake unlike in the sea. A characteristic deposit of fresh water lakes is the Marl, which is a light grey mixture of clay and calcium carbonate. It is often found in beds of 2 to 26 meters thickness.

The chemical deposits precipitated in lakes are probably the most interesting and characteristic. When a salt lake begins to shrink due to evaporation in a dry climate, the minerals in solution become more and more concentrated until deposition of certain salts begins. With continued evaporation leading to desiccation, all the minerals in solution get deposited. Some of the most abundant minerals contained in the waters of the salt lakes are the Halite, Gypsum, Glauber salt, Epsom salt, Magnesium chloride and Calcite. During the desiccation of a salt lake,dissolved substance are deposited in the order of their insolubility. The entry of flood waters during the rainy season may dilute the water enough to check precipitation of mineral matter from solution and the land-derived sediments will accumulate on the lake-floor. It is therefore recognized why alternately layers of clay and sand and one or more beds of salts are often found in old lake deposits. Extensive deposits of soda and borax mark the sites of former lakes as in lakes as in parts of the Death Valley, California.

11.2.2 Swamps

A marsh or swamp is an area of wet, saggy and saturated ground usually filled with decaying vegetable matter. They are closely related in their development to the level of the water table. In such areas the run-off or infiltration of surface water is delayed or even prevented. Many swamps occupy basins that represent a phase intermediate between lake and dry land. Indeed many basins fluctuate between swamps and lakes. Swamps are often the successions to lakes and sluggish streams. Other swamps occupy flat areas in which growth of vegetation alone prevents surface water from creating channels and forming streams. Roots and stems spread the water effectively and keep it dispersed. A marsh or swamp is very much likely to occur wherever there is a wide expanse of relatively flat and poorly-drained land with an abundant supply of water. Such conditions are to be found on the till plains of recent glaciations with poor drainage along the flood plains, deltas of major rivers and also along the coastal regions adjacent to the board but shallow continental shelf. Excellent examples of swamps or marshes are found in north central United States and adjacent parts of Canada and also in eastern part of Russia.

Sediments that accumulate in swaps contain a large proportion of organic matter such as peat (partly decomposed plant matter formed in swamps). Aquatic vegetations such as, water weeds and rushes grown in shallow water close to the shore. Dead plants are attached and decomposed by bacteria beneath the water surface. The bacteria exert certain waste products that are toxic in nature. When these toxic products reach a certain concentration the bacteria cannot any longer thrive and get killed and the partly decomposed plant substance is preserved, when dry peat is combustible in some regions it is used as a fuel and indeed it is the first step in the transformation of vegetable matter into coal. Swamps also accumulate inorganic sediments mostly clay and silt. A complete gradation exists from mineral sediments to peat and this gradation is reflected in the occurrence of impure clayey coal representing deposits in ancient swamps into which streams were bringing mineral particles.

Many natural products useful to mankind are won from lake water or from the deposits that accumulate in lakes and swamps. Saline lakes have exclusive deposits of Calcium Carbonate in the form of white chalky marl. This is useful for agriculture and also to some extent in the manufacture of cement. The diatoms that lived in certain lakes contributed to beds of diatomaceous earth useful as an abrasive and refractory. In many parts of Europe extensive deposits of peat are used as sources of domestic fuel. Several reclaimed marshlands and swamps have yielded very large tracts of rich high humus soil, a fertile belt for agriculture. This is so several places in Hotland, Eastern parts of U.S.A.

11.2.3 Origin

Lakes may have originated in many ways. Most lake basins are the result of gradational processes but some are due to volcanic activity. The important types of lake basins are briefly described below.

Basins formed by glaciations: Lakes are generally numerous in areas recently covered by glacial ice. Glacial lakes are either due to erosion or deposition or both. Of these the most numerous by far have resulted from the deposition of glacial debris in such a manner, so to obstruct the drainage of valleys. Many thousand lakes of Minnesota, Wisconsin, Newyork and New England belong to this category. Numerous lakes of different sizes in Tibet are considered to have been formed by the obstruction caused by glacial moraines in river valleys.

Glaciers may blockade valleys and thus cause ponding of waters. Lakes of this type occur in the Alps, Greenland and Alaska. The great lakes of North America constitute the most remarkable group of big lakes in the world. Lake Superior, the largest fresh water lake in the world, is 1,180 feet deep. The Great lakes cover a very large area of about 95,000 Square miles. These immense basins were primarily gouged out by ice along the sites of broad preglacial valleys.

Quite a good number of glacial lakes have been eroded or excavated by the direct action of flowing ice example the cirque lakes in Sierra Novada, Cascade and Rocky Mountains, the Alps and the Himalayas. Finland alone has more than 60,000 glacial lakes. A preglacial valley partially blocked by deposition of drift may give rise to a chain of lakes.

Basins formed by streams: Lake Basins are formed both by degradation and aggradational work of streams. At certain places the two processes have been active in the formation of a lake basin. Many shallow lakes are formed upon flood plains by streams that wander in meandering loops over the valley flats. Where the streams cutoff the neck of a meander, the abandoned part of the channel remains a crescent shaped Ox-bow Lake. Similarly further down the river valley on the delta surface, the water in the main channel breaks, through the levels and forms branching channels or tributaries. As a result of uneven deposition of sediments by the network of tributaries on a delta, certain shallow basins are completely surrounded by the deposits and so converted into the delta lakes. The delta of the Nile, Danube and Mississippi rivers show such basins.

Basins formed by the action of groundwater: When the roofs of the caves and caverns in limestone country collapse resulting in the formation of sink holes, they are filled with groundwater forming small lakes. A number of lake basins in Florida were formed in this way and other examples are found in the Karst topography of Kentucky and Tennessee.

Lake basins are also formed by waves and shore currents, due to wind activity, by mass movement, with diastrophism and by volcanic activity.

11.2.4 Destruction of Lakes

In course of time lakes may slowly disappear due to the following reasons.

(i). By filling with sediments: Streams flowing into lakes carry sediments, most of which accumulates on the floors of lakes. By this process lakes may become completely filled and thus get destroyed.

(ii). By filling with organic remains: In humid, temperate climate regions, plants grow profusely in the shallow border portions of lakes. As the plants die their remains accumulate to form bogs which encroach from all sides and the lakes become completely filled. Thus accumulation of vegetable matter and also shells of animal lead to lake-filling.

(iii). By cutting down outlets: The dams of lakes, especially those formed of glacial debris usually consist of loose, incoherent materials which can be easily cut into by outlet streams. By this process, a lake surface may be reduced gradually until the lowest level of the lake basin is reaching, thus causing the destruction of the lake.

(iv). By removal of ice dams : Where a lake is formed due to blocking of a tributary valley by a glacier and consequent ponding of water, the shifting of the glacier may allow escape of the water. Similarly melting of the glacier may also lead to destruction of lakes.

(v). By evaporation: In arid regions evaporation may exceed intake to such an extent that, the lake basins become dry.

(vi). By diastrophism: Small lakes may be drained through fissures formed during earthquake disturbances. Large lakes may be destroyed by the down-faulting of their outlet areas.

11.2.5 Types of Lakes

The important types are salt or saline lakes, alkaline lakes, and playa lakes.

Salt or Saline Lakes : Salt or saline lakes may be formed in either of the following two ways viz., (i) by accumulation of saline matter in lakes with no outlets and (ii) by cutting off anus of the sea either by diastrophism or deposition of sediments particularly in the form of a delta. To the second category belong some of the salt lakes like the Caspian Sea which is the largest body of inland saltwater known.

The Salton Sea occupies the lowest part of a great desert depression extending from Southern California to the head of the Gulf of California. The Colorado river has built an extensive alluvial fan deposit across the depression, thus separating the Salton Sea from the Gulf of California.

Salt lakes are less numerous than the fresh water lakes. They do not have outlets and invariably occur in arid regions particularly in those of interior drainage like the Great basin area of western U.S.A. In such regions the precipitation and inflow are not sufficient cause the lakes to overflow the lowest points of their basins to form outlets. Increased evaporation in the dry and desiccate climate leads to the concentration of mineral salts in the water and thus a fresh water lake in the beginning may eventually become a salt lake since there is no outlet and the mineral matter gets steadily increased. The Great Salt Lake in Utah is the most renowned example of a salt lake.

The Dead Sea of Palestine (now part of Israel and Jordan) lies in the lowest position of the Jordon river valley which was formed by sinking of a long narrow block of earth's crust between two nearly vertical parallel faults. It covers an area of nearly 500 Sq. miles. Its depth is about 1300 feet and its surface lies about 1300 feet below general sea level, making it the lowest lake in the world.

Alkaline Lakes: Lakes containing excessive amounts of alkaline carbonates are commonly referred to as alkaline lakes. They occur at many places in Egypt, Hungary, and Venezuela etc. They are special types of saline lakes and found also along the western part of the Great basin in USA. Mono lake in east central California is an excellent example of this nature being rich in salt and soda. There are a good number of alkaline lakes called dands in sand province of Pakistan.

Playa Lakes: Shallow, flat-bottomed depressions are formed by weathering and wind action in many desert areas. During the wet seasons they are flooded by waters from intermittent streams and when the water supply ceases, they shrink and finally disappear by evaporation, leaving in their beds, deposits of alkali salts that are often as much whitish as freshly fallen snow. Such lakes are characteristic features in the deserts of the Great basin. Similar lakes exist in the desert of Arizona and New Mexico.

11.2.6 Indian Lakes

Lakes are few and far between in a large country as the Indian subcontinent. There are only a few lakes in the peninsular region. A few lakes have also been formed along the coast by bars and deltas. Along the Western coast of Kayals these are separated from the Arabian Sea by narrow bars. On the East Coast of the Peninsula the notable are the Pulicat Lake in Andhra Pradesh, situated just a few tens of kms north of Chennai. The Chilka Lake is situated on east coast of Orissa.

Kolleru Lake: The Kolleru Lake is a large fresh water lake in the coastal district of Krishna in Andhra Pradesh. It is formed probably due to the outward and lateral growth of two big deltas of the mighty rivers of Krishna and Godavari. It is very shallow and elliptical in shape and covers an area of about 150 kms and it is being gradually silted up by small streams that flow into it of which Budameru is well known.

Sambhar Lake: This lake is of unique nature. It lies on the border of Jodhpur and Jaipur, about 64 kms west of Jaipur city in Rajasthan. It is situated at an elevation 1200 ft above mean sea level, with an area of nearly 120 kms. It is generally dry in summer leaving a marshy patch. It is filled with saline muds and has been worked as a source of common salt for centuries.

Lonar Lake: This is an unusual circular depression in the deccan traps in the Buldana district of Maharashtra. It is about a mile in diameter and nearly 300 ft. below the level of the surrounding country. It is occupied by shallow water during the monsoon but becomes dry in hot weather showing encrustations of sodium carbonate locally called Urdo and Sodium chloride. This lake is surmised to be a crater lake probably of volcanic origin associated with deccan trap activity in the distant geological past.

The Nal: This is a large saline lake of nearly 80 square kms in area situated about 75 kms south west of Ahmadabad. The waters are blackish when the lake is full and become markedly saline in the hot summer. It may be an arm of the sea cut off between Saurashtra and Gujarat.

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of this unit.

3. Name some Indian lakes.

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11.3 SEAS

In common the terms sea and ocean are used synonymously to refer to large continuous bodies of salt water covering large parts of the earth's surface. But in scientific terminology the oceans are larger bodies of salt waters occupying huge basins between the continents like the Pacific, Atlantic and Indian oceans. The lesser bodies of salt water are called the seas like the North Sea, Yellow Sea and the Arabian sea etc. These are called **epicontinental seas** which occupy the narrow platforms (continental shelves) that border the lands nearly everywhere. They are also known as **shelf seas** as they are landward extensions of the open and broad oceans. Other bodies of shallow water lying within the continental regions and having less open connections with the ocean are called **Epeiric seas.** The Baltic sea and the Hudson Bay are good examples of such Epeiric seas. A Mediterranean Sea is special type of Epeiric Sea with a depth of several thousands of feet. The Mediterranean and Caribbean Sea are examples of this category.

11.3.1 Relief Features

The surface of the sea or ocean is the datum or reference plane for all topographic and geologic survey. All level surfaces are theoretically parallel to the mean sealevel, which is assumed to be constant.

The topography of the sea floor, contrary to the belief of people of few generations ago, is by no means smooth but the profile is as much rugged and diversified as the land surface. Long mountain chains, isolated hills and mountains including volcanic cones, broad mountainous featureless plains, trenches and canyons mark the ocean floor as much the same way as they mark the land surface.

The ocean basins occupy about 2/3 of the earth's surface but there is an excess of water and so the basins are more than full. Its waters, therefore, spread out over the low borders of the continental masses covering them to depths that vary from zero to hundreds of meters but with average about 70 fathoms at the outer edge. In places this submerged continental fringe is more than 160 Kms. wide. Here, some of the important topographic features of the ocean bottom are described below.

Continental shelf: This is the nearly flat submerged border of a continental mass, mostly less than 100 fathoms below mean sea level it varies in width up to 320 kms. but with an average of about 64 kms. This continental shell slopes seaward about 2 mts. per km. from the shoreline to about 70 fathoms where the sea bottom begins to descend more abruptly into the abyssal depths. In many places the bottom material is mostly solid rock but sand, mud or even gravel may exist. Sinking of the coast line or rise of the coast line brought about by diastrophism or gradation may profoundly change the configuration of the shore lines.

Continental Slope: Beyond the 70 fathoms line the slope of the ocean bottom generally becomes more abrupt. Its lower edge grades imperceptibly into the main floor of the deep sea.The continental slope varies in width upward from a few tens of kms. but it is nearly every where a feature of the border of the ocean basin. Its area is a little more than twice of the continental shelves. The continental slopes are thought to be margins of the alimental masses composed of relatively higher rocks that grade seaward into heavy rocks underlying the ocean basins proper.

Deep Sea Floor: It lies seaward of the base of the continental slope and it is not a featureless plain but seems to possess a great variety of irregular features like ridges both broad and narrow, submerged mountain chains, and flat topped peaks. One of such most outstanding features is the Mid-Atlantic ridge that extends from Iceland nearly to Antarctica, mostly lying under about 2700 meters of water and about 1800 meters above the deeper portions on either side. The Hawaiian Islands stand on one such great submarine ridge that is more than 3,200 kms. long in the Mid-Pacific area.

Submarine Canyons: At many places the continental slopes and outer parts of continental shelves are characterized by deep V-shaped, steep walled valleys called submarine canyons. Some of them have tributaries with a dendrite pattern like that made by stream erosion on land. Some canyons lie off the mouths of rivers such as the Indus, Hudson or Columbia. Their lower reaches extend to depths of as much as 1,800 to 2,700 metres below sea level. Their walls in places are rocky.

Sea Mounts and Guyots: A remarkable feature of the ocean bottom is the presence of a series of submarine mountains aptly referred to as sea mounts that are more than 900 meters high on the deep sea floor. Most sea mounts shape conical tops, but some have flat tops and they are called guyots now submerged to depths of about 1 to 2 thousand meters may represent volcanic peaks which were truncated by wave erosion in the geological past or capped with broad coral reefs and subsequently were drowned by subsidence of the ocean floor or by rise of the sea level.

Trenches and Deeps: These are long narrow deep basins in the ocean floor. They are most conspicuous in the Pacific ocean, several of them being curiously close to its coasts, at the foot of the continental slopes of the west coasts of South America or along the front of island areas as illustrated by the Aleutian trench. Other notable trenches are the Kurile trench, Japan Trench, Mindanao or Philippine trench, Marianas Trench, the Java trough in the Indian Ocean and Peutro Rico trough in Atlantic.

The deepest soundings have been obtained in these trenches like 10,332 meters in Philippine trough and 10,692 meters in the Marianas trough. The origin of these deep sea troughs and trenches is little known but it is well-known that they lie along active and mobile belts of the earth’s crust as is indicated by the fact that numerous earthquakes originate beneath or near these troughs and trenches.

Mid Ocean Ridges: These are found in all of the major oceans and represent more than 20 percent of the earth’s surface. They are certainly the most prominent topographic features in the ocean. They form an almost continuous mountain range, varying in width from 500, to 5,000 kilometers which extends for some 64,000 kilometers. The crusts of the ridges marked by deep cliffs or rifts and are flanked by ridges and lines of peaks that extend outward for hundreds of kilometers. The axes of the ridges are marked by frequent earthquakes and are characterized by a much higher heat flow through the crust. The rifts at the centre of the ridge known as median valleys, are the sites where new magma wells from the asthenosphere below, continually creating new oceanic crust.

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of this unit.

4. What are seas?

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5. Name any three relief features of seas?

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11.3.2 General Features

The general features of seas include the nature of sea water, temperature, density and pressure, forms of life in the sea.

The nature of sea water: The sea water contains about half of the elements known to man, of which the chlorides predominate and these give the sea water its saline nature or saltiness. The mineral matter accounts for 3.44% by weight of sea water. For a cubic mile of sea water this percentage amounts to 152 million tons and this gives us the idea of the immensely large may, fantastic amounts of mineral matter present in the oceans of today.

Through millions of years of geological time the rivers and streams the world over have been slowly adding dissolved substances to the oceans. Some of these such as Iron, Silica and Calcium are used up in the life processes by animals and plants that live in the ocean and in effect removed from sea water. The most abundant salt by far in solution is the common salt which is nearly 78% of the dissolved matter. The other principal constituents in solution are chloride and sulphate of magnesium, the sulphates of calcium and potassium. **Murray** estimated that if all the dissolved matter in sea water be precipitated, it would form a layer about 50 meters thick over the entire ocean floor. In addition to the salts in solution, there are gases dissolved in sea water supplied by the living organisms and submarine volcanoes. The principal gases are nitrogen, oxygen and carbon-dioxide.

Temperature, Density and Pressure: The temperature of the ocean depends entirely upon the solar radiation. It varies greatly from the equator to the poles. At the equator the surface temperature averages about 80 degrees F. where as in the Polar Regions it is 28 degree F. near the freezing point of the sea water. The temperature of the sea water generally changes from the surface to the 600 fathom line, where it is about 39 to 40 degrees F. Nearly two- thirds of the ocean water is cold and the heavy cold waters that originate in polar and sub polar regions creeping towards the equator, dominate the circulation of the modem oceans and influence the general climate of the bordering lands. The normal specific gravity of sea water is about 1.025 slightly higher than the pure fresh water. In cold polar seas it increases to 1.028, whereas in warm tropical seas it may decrease to 1.022. Changes in the density with changes in temperature, pressure, dilution and concentration are responsible for certain currents in the ocean. The pressure increases with depth in accordance with well known hydrostatic laws. One cubic foot of sea water at the surface weights about 64 pounds. Accordingly at a depth of 330 meters the pressure naturally is 64,000 pounds per square foot. At a depth of 12,000 meters it will be more than 1,100 tones per square foot

Forms of life in the sea: Both animals and plants live in various forms and countless numbers in the sea. The animals range in size from ultramicroscopic unicellular forms to the giant sized whales. Lower orders of animals are much more common and numerous than the highly evolved ones. Among the higher forms of animals are whales, seals, walruses, sea turtles and several kinds of fishes. The plant forms are mostly simple sea weed which range in size from the minute diatoms to those of tens of meters long.

The whole of the surface waters of the many seas are crowded with teeming millions and billions of microscopic algae which are busy, with the help of sunlight and chlorophyll, converting the inorganic substances in sea water into organic compounds which in turn supply not only the food for the majority of marine animals which live on the surface and intermediate depths of the sea but also at the myriads of creatures living near and on the sea floor, the level to which the sun rays can hardly penetrate. The marine environment has been conveniently divided into several life zones, each characterized by certain forms of fauna and flora.

Littoral Zone: This zone includes the area exposed between the high and low sides. In this zone the ebbing tide lays bare the sea bottom and the high tide covers it with tide waters. It is always within the influence of strong waves. Due to this, living conditions are somewhat difficult and organisms must either be firmly attached to the bottom or burrow into the mud. Some forms find refuge in tidal pools. Certain varieties of sea urchins (echinodenns) occupy holes that they make in solid rock.

Neritic Zone: This extends from the low tide mark to the edge of the continental shelf. Since the water is less than 130 meters deep, the sun's rays can light up the whole area, food is abundant and vast numbers of different species of organisms thrive on each other and on the materials in solution in sea water. It is established that a greater abundance of life per unit area flourishes in this zone than in any other place on earth.

Bathyal Zone: This zone extends from 70 fathoms line to 1,000 fathom line. The higher parts of the area receive a little amount of sunlight but even there the plant life is very much restricted. The floor of the sea in this zone has a prolific animal life despite the fact that the plant life is limited. Since the rate of deposition of sediments is slow, bottom dwelling scavengers destroy much of the organic matter. The calcareous sediments consist largely planktonic shells and the siliceous deposits are mainly diatoms and sponge spicules.

Pelagic Zone: This zone includes the waters of the wide expansive sea that lie beyond the littoral zone. The life of this zone includes the floating planktonic forms as well as the free swimming forms of the ocean. Algae and diatoms are the most common plants and many varieties of animals in habit this realm. Their resistant inorganic skeletal remains contribute abundantly to the formation of several sedimentary rocks.

Abyssal Zone: The abyssal or deep sea zone includes all the portions of the sea below 1,000 fathom line. It receives no sunlight, its temperature is near freezing at all times and the pressure is greater than 1 ton per square inch. Since the plants that require sunlight cannot thrive in this environment, the animal that depends upon plant food must live on those that which settle from the surface, waters. The shells and bones of animals that live on abyssal bottoms indicate that only highly specialized creatures are able to survive at such depths.

It is usually believed that life on earth first appeared in the sea or in the brackish waters of the coastal swamps. With its introduction, biochemical activity ensured which profoundly influenced the conditions in the marine environment. Many and varied organisms that live in the sea have hard parts made up of calcium carbonate or of silica and these later contributed to the formation of limestones and siliceous deposits. It is largely through the living organisms and their ability to precipitate calcium carbonate or amorphous silica that the cementing materials for other sediments are obtained. Thus life in the sea is a rock builder and hence a geological factor of great importance.

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of this unit.

5. The marine environment is divided into several life zones. Name them.

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11.3.3 Geological Work of Seas

Erosion: Most of the geological work of the seas is accomplished by the surf, shoreward of the line of breakers, when a wave dashes against a rocky shorecliff, water is forced into many cracks and crevices causing a hydraulic pressure which tends to disrupt blocks in the face of the cliff. Also many fissures and cracks are filled suddenly with compressed air which on retreat of the waver has its pressure released quickly thus produce explosive recoil which dislodges sometimes even large masses of rock. The very impact of a wave against a shore consisting of loose materials is sufficient to force off rock materials from the cliffs. The erosion by impact and quarrying is comprehensively called **hydrauliking.**

Waves also erode by abrasion as the rock fragments quarried out by the waves or rolled down into the water are hurled back by the waves, against the shore. Rock fragments are thus effective tools in cutting the shore line under-cutting the promontories. The overhanging rock then topples into the sea and more tools are worn by corrosion and undergo reduction in size or attrition as they are carried back and forth as on a wash board. Shells and rocky materials are reduced by grinding between coarse pieces. They are worn down to finer and finer sizes as they are dragged and rolled to and fro on the beach by the moving water. A minor factor in the removal of rock material by waves is the solvent action of sea water. This is particularly true of calcareous rocks where organisms increase the activity of the water and hence it's solvent action. Currents scour the bottom in shallow water and thereby assist in coastal shore erosion. The shallow surf zone with a vertical thickness of not more than 10 metres may therefore be described as an erosional knife edge or saw cutting horizontally into the land, and beyond the surf zone fine rock particles are moved and loose sediments are redistributed but little erosion of bedrock takes place.

Results of Wave Erosion: Where waves are at work ceaselessly cutting into a shore of at least a moderately high land, a steep front facing the sea soon develops. This is called sea- cliff. At first the waves may attack the whole face of the cliff but after a time the cliff becomes so high that the waves attack only its lower portion where a horizontal notch or nip at the base is formed as a result of sawing action of the waves.

On rocky coasts the continued advance of the sea by erosion and retreat of the sea cliff produces beveled rock bench, the Wave Cut terrace partly exposed at low tide. A multitude of such features as groves, furrows, testify to abrasion of its surface in the turbulent surface.

Unusually resistant rocks may be left standing as reefs called Rock reefs. In places were turning water from the spray and splash of storm waves rotate the water and sediments caught in small rock basin grinding the holes deeper and producing the familiar tidal pools. They are much common on many sea coasts.

In rocks which are highly jointed wave erosion may quarry out sea caves. If erosion breaks through the roof of top of the cave, if forms a blow hole called Gloup in England or Spouting Hom. Since most rocks are closely jointed, caves may be expected along any rocky shore line subjected to vigorous attack by waves. If part of the roof of such a sea cave collapses or if two sea caves on opposite sides of a sharp headland or promontory unite, a natural bridge or sea arch results. The waves will continue to batter the arch until it collapses. In such cases the seaward rock mass becomes an island or sea stack sometimes called chimney rock or skerry. A famous example of such sea stacks is the Old Man of Hoy in the Orkney Islands. It is an isolated jointed column of colored sandstone 180 meters high.

Due to differences in the resistance of rocks occurring on the sea shore, waves easily erode them differentially. Rock with joints is eroded easily to form coves while the more resistant rocks stand out to form headlands. In detail a shoreline of coves and headlands become quite irregular or crenulate. In unconsolidated rocks such as gravel, sand, and clay, a cliffed shore line may remain almost straight.

A wave cut terrace on subsequent uplift becomes a plain of marine erosion. The surface of newly raised plain of marine erosion is usually smoother than that of a peneplain of river erosion with which it has a close resemblance, but the erosion remnants left by the waves are steeper sided than those on a peneplain formed by stream erosion. A conspicuous marine terrace with an average altitude of 30 metres faces the sea at many places along the coast of southern California. Another remarkable example of the long plain or erosion with steep sided isolated masses of rock (former Islands) rising above its surface occurs on the east coast of India.

Deposition : The Marine deposits on viewed in a broad way there are two important classes of marine deposits, (i) those laid down in shallow water comparatively near the borders of the land on the continental shelf and the continental slope and (ii) the deep sea deposits laid down on the floor of the deep oceans.

Shore deposits: Storm waves commonly toes up coarse material far high on the shore out of reach of the ordinary waves or long shore currents also leads to deposition.

Beach Deposits: The term beach is used broadly to indicate the entire area along the sea extending from the line reached along the sea by high tide to the low tide mark. The loose material ranging in size from very fine rock particles or sand to large boulders which is shifted and ground up by the action of waves, under low and shore currents is called a beach ridge or embankment. But along rocky cliffs much of the beach may be nearly barren of deposits, whereas along sandy cost a sandy beach may be nearly continuous. Local accumulations of gravel or sand in bays are bay head beaches. Where most of the beach cobbles and pebbles are flattened disc shaped ones produced by gliding wave motion, they may overlap to form a single beach. By far the greater numbers of beaches are made mainly of quartzose sand. Local concentration of native gold, Magnetite (in the form of black sand), Zircon, Rutile, and Monazite may occur in deposits called beach places. Wind-blown sands derived from beaches commonly pile up on shore as coastal deposits.

Barrier Beaches: On a number of gently sloping sandy shores the waves and currents have built up ridges of sand to form strips of land some distance off shore. Such ridges are known as **Barrier Beaches** Offshore islands or island bars. The area behind the barrier beach is more or less completely shut off from the open sea as a **lagoon.** The origin of these barrier beaches is not very clearly understood. One possible explanation is that these were begun as relatively beaches on a nearly flat sea bottom during the recent ice age when the sea level was much lower than it is at present. As sea level was slowly restored to its original position f the waves gradually might have driven the beach ridges upwards and landward to their present positions. It is not worthy that the valleys behind the lagoons are dawned by the post-glacial rise of the sea-level. Barrier beaches are very common along the Atlantic coast from New Jersey Southward and along the Gulf coast of Texas.

Spits and Bars : A long shore current shifts sediments parallel to the coastline, but owing to the tendency of current to continue in a straight line it fails to follow and indentation that may be produced by a narrow bay of any origin. Where the long shore current passes from shallow to deeper water at the entrance to such bays, deposition of sediment is certain to take place. A ridge which becomes a land projection or spit is thus built up. When a spit is built almost or entirely across the entrance to the bay it becomes a **baymouth bar.**

Bars are cut off indentations and tend to simplify the form of the coastline. Islands become connected with the mainland or with each other in a similar manner. Such islands are said to be tied and the bars acting as the line of connections are called **Tombolos.** They are numerous along the New England coast of United States.

If the free end of a spit is beaten by violent storm waves or by those seasonal and the terminal materials thus turned back may be deposited as curved spit or **hook.** By prolonged deposition the curved end of the hook may be extended until it reaches the main land and forms a **loop.**

Where sediment laden shore currents are deflected seaward on both sides of a point of land, a projecting spit with curved or cusped sides is built up as cuspate spit or a large scale cuspate foreland. Cape Canaveral Florida and Cape Fear, North Carolina in U.S.A, are outstanding examples of such cuspate forelands.

Wave-Built Terrace : Where a cliff and wave-cut bench are being eroded by wave action, die eroded materials are ground up and may be gradually shifted over the bottom to the deeper water at the seaward edge of the wave-cut bench and there get deposited. A very considerable **wave built terrace,** may be formed by this process in course of time. The continental shelf in such cases may be a combination of wave-cut benches and wave built terrace.

Shallow water features such as sea-cliffs, wave-cut benches, beach, and barrier beach, spit may often be preserved for sometime after elevation of the shallow sea bottom into land. On the other hand various features formed by waves and currents are subject to change from season to season and from year to year. Therefore a beach spit or bar may show different outlines within a short span of time of a decade or so. Thus shorelines may have changed in their outline very considerably during certain periods of geological time.

Marine Deposits: The regions or environments of marine deposition or sedimentation include the shallow epi-continental seas, the continental slopes and the deep sea floor sediments of this nature and cover quite large portions of the earth's land surface at present as sedimentary rocks. Such sedimentary rocks are now being laid down in the modem ocean basins.

According to their location on the sea floor marine deposits are classified as follows,

i) **Littoral deposits** formed between high and low tides ii) **Neritic** or shallow water deposits that collect on the continental shelf and at similar depths elsewhere between low tide and 100 fathoms line iii) **Deep** sea deposits consisting predominantly muds and oozes. . The muds are deposited on the continental slope generally referred to as the **Bathyl zone** while the oozes belong the much deeper portions of the sea bottom called **Abyssal zone.**

Littoral Deposits: Where the continents and oceans meet are accumulated certain sediments derived from the land as well as from the sea and therefore a mixture of both. These sediments accumulate along the shore zone and also in the lagoons and estuaries. This **Littoral zone** conditions of deposition are not every where the same. Some consists of bare rock platform, others are nearly vertical sea cliffs, and still others are composed of gravel, sands, mud shells and shell fragments. The sediments of the littoral or shore zone are derived mainly from the shore by the wave action. The waters are aided by frost action by undercutting and by the wind. The work of the wind is more important in generating waves and currents that carry sediments to the beaches. The beach deposits vary with either boulders of large cobbles or both. Where the supply of finer materials is extensive even or exposed coasts the materials may be pebbles or even sand. The grinding action is cause by surf rolling up and down the beach dragging the boulders and cobbles and pebbles bad and forth over each other and over the rock bottom. As agitation causes and the sediment are finally deposited they are graded in the order of size from the shore onward into the sea

Neritic or Shallow Sea Deposits: Neritic zone is that portion of the ocean basin extending from the low tide level to an average depth 70-100 fathoms. It includes the major portions of the continental shelf together with the epi-continental seas (as the Baltic Sea, Hudson Bay). It covers about 11 million square miles, in tracts varying in width from a few miles to several hundreds of miles as in the North Sea.

The shoreward portion of the shallow sea bottom lies within the range of wave and current action. When such currents are generated the sediments are sorted out in such manner that the coarser rock materials are deposited near the shore and they grade into finer deposits seaward. In general rock bottom and coarse sediments occur off rocky points or sea-cliffs on shore. Wherever strong current effect the bottom such coarse sediments occur in places like between islands and narrow straits. Sand prevails on the continental shelf off sandy coasts or in areas of moderate currents. Mud's are deposited off large river mouths, in sheltered areas near the shore and in depressions on the continental shelf.

The greater bulk of the shallow sea deposits is made up of debris derived from land by way of streams, glaciers, dust, sand storms, shore erosion and explosive volcanoes. Part is contributed by corals, calcareous algae, shell fish and chemical precipitation, where the supply of land detritus is small, the sediments may consist chiefly of the remains of organisms and chemical precipitates.

The structural features of the off shore marine sediments are variable. Deposits near the shore are usually lenticular in shape with much cross bedding and a great variation in size of particle. Ripple marks and current bedding are characteristic features of shallow water deposition. Where the sea floor has steep slopes the sediments may slump and develop crumpled and irregular bedding places. In deeper waters the strata are more or less uniformly thick and the chemical sediments may show well defined seasonal laminations.

Terrigenous Sediments: Beyond the continental shelf the ocean bottom descends rather abruptly to the deep sea floor with an average depth of 4 kms below the surface. This is the continental slope which begins at an average distance of about 6 kms from the shore. It is in general covered by fine sediments of terrigenous materials which remain in suspension for a long period. These are called the **blue mud** and owe their color to the presence of organic matter and to the deoxidized condition of the iron. They grade landward into shallow water deposits and on seaward side they pass into the oozes and the **red mud** of the abyssal depths.

The blue mud cover an extensive area of about 15 million square miles, and they have been encountered at distances as great as 200 miles off shore and out from the mouths of great rivers such as the Amazon, they extend to a distance of 1000 miles. Volcanic mud, scarite and pieces of pumice may be strewn over to the sea bottom at places even at distances of several hundreds of miles from the land. This organic matter contributes to the deoxidizing agents of the blue mud zone but probably little is preserved in fossil form.

Pelagic Deposits: These are made up of organic oozes and red clay of the abyssal zone, The oozes is largely composed of the remains of marine organisms belonging to a group called plankton. This includes the uni-cellular marine plants called diatoms and animals like foraminifera and radiolarians and certain floating mollusas known as pteropods. This plankton predominantly made up of diatoms are present in such large number that they turn the surface of the sea into a kind of a vegetable soup called Plankton soup. Form this prolific overhead source the sea floor received a slow and steady rain of plankton shells which have escaped destruction by being eaten or by being dissolved in the sea water. In the bathyal one they make a large contribution to form blue and green mud. Both of which are characterically calcareous deposits. In the abyssal zone the plankton shells, accumulate with little contamination from other source to form the deep sea oozes which together with red clay constitute the pelagic deposits. These deposits are named according to the most abundant organic remains composing them. Thus these are the globigerina oozes, pteropod oozes, the diatom oozes and the radiolarian oozes.

The composition and distribution of the deep sea oozes depend upon the temperature of the surface waters and the depth of the underlying ocean floor. Diatoms thrive well in cold Arctic seas which are evidently unfavorable for other forms, radiolarians, on the other hand, are especially abundant in warm, tropical waters. Foraminifera of which globigerina are common found in both tropical and temperate regions.

The globigerina and other calcareous foraminifera shells dissolve more rapidly than the radiolarian and other siliceous forms as they sink to the bottom where the solvent power of the sea water increases with depth. Only a few large varieties succeed in reaching the depths of about 3,000 fathoms. The siliceous remains persist to greater depths, some of them down to even 5,000 fathoms.

Radiolarian Oozes: It is essentially a variety of red clay that is notably rich in the remains of radiolarians. diatoms and sponge specula are also commonly present. It occurs in the tropical beds of the Indian and pacific oceans.

At greater depths of the ocean the bottom is covered by very fine red clay (usually almost chocolate brown) which is composed of terrigenous clay, insoluble portions of the plankton shells and other organic matter. Volcanic ash and meteoric dust from the skies are also included. Secondary products found in the red clay include black nodules of manganese dioxides and crystals of various silicate and other minerals. The Red clay occupies about 40 million square miles, of the ocean bottom and most of it in the Pacific Ocean.

11.4 SUMMARY

Lakes and seas are acting as agents of external geological processes. Lakes feed freshwater to the rivers. A lake may be defined as a natural inland depression or basin containing appreciable amount of water. The water in lakes may vary in chemical .composition from, soft, fresh and hard. Lakes are widely distributed over the earth’s surface. Lakes serve as settling basins in the drainage system. The sediments brought in by the inflowing streams are sorted and gradually deposited on the lake bottom. The erosion work of lakes is like seas and the erosional feature includes cutterraces, cliffs, caves, stacks, arches etc. The depositional features of lakes are beaches, barriers, bars, deltas, wave built terraces etc.

A swamp is an area of wet, saggy and saturated ground usually filled with decaying vegetable matter. Lakes may have originated in many ways. The important types of Lake basin are basins formed by glaciation, basins formed by streams, basins formed by the action **of** groundwater, basins formed by wave actions & shore currents, basins formed by wind action; basins formed by diastrophism, basins formed by volcanic activity and basins of unusual origin.

The destruction of lakes occurs with filling of sediments, organic remains, cutting down outlets, by removal of ice dams, by evaporation and by diastrophism. The important lake types are salt lakes, alkaline lakes and playa lakes. The most prominent Indian are kolleru lake, sumbhar lake, lonar lake, The nal lake etc.

Seas or oceans are the large continuous bodies of salt water covering large parts of earth's surface. Oceans are occupying large basins between the continents where as seas the narrow platforms that border the lands. The relief features of seas are the continental shelf, continental slope, deep sea floor, submarine canyons, sea mounts and gadgets, trenches and deeps, mid oceanic ridges etc. The general features of sea are nature sea water, temperature and density, life in the seas. The marine environment has several zones namely littoral zone, nerotic zone, bathyal zone, pelagic zone and abyssal zone, the depositional features of seas are the barrier beaches, spits and bars, wave built terrace etc.

11.5 CHECK YOUR PROGRESS-MODEL ANSWERS

1. A lake may be defined as a natural inland depression or basin containing appreciable amount of water.
2. The causes of origin of lakes are glaciation, streams, action of groundwater, wave action and shore currents, wind action, mass movement, diastropism, volcanic activity, unusual origin etc.
3. Kolleru lake, Sambhar Lake, Lonar lake, The Nal lake etc.
4. Large continuous bodies of salt water covering large parts of the earth surface are called seas.
5. Continental shelf, continental slope, submarine canyons, trenches etc.
6. Littoral zone, Neritic zone, Bathyal zone, Pelagic zone, Abyssal zone etc.

11.6 MODEL EXAMINATION QUESTIONS

I Answer the following questions in 30 lines each.

1. Discuss the geogical functions of lakes.
2. Describe the geological work of seas.

II Answer the following questions in 10 lines each.

1. Describe origin of lakes
2. What are lake deposits
3. Describe topography of seafloor
4. What are marine deposits

UNIT-12 WIND

Contents

12.0 OBJECTIVES

After studying of this unit, you should be able to

- define wind
- describe the geological processes of wind
- explain the wind deposits
- explain the deserts

12.1 INTRODUCTION

The earth's atmosphere is mostly made of air and the wind is nothing but air in motion. Winds are regarded as current of air moving more or less parallel to the surface but their flow is often turbulent moving upward and downward, twisting and turning even within the atmosphere itself. The primary cause of such movement is the differences in air pressure created by differences in heating by the sun. Heated air expands and raises, cooler, air descends or flows in along the ground to take its place. Winds are, therefore, essentially, currents carrying load of moisture and dust from high pressure to low pressure regions. They distribute not only moisture as water vapour to fall as rain in favorable conditions but also carries, fine-grained rock particles such as dust and sand on the earth's surface. Since these materials are land derived, the geological action of wind is more important over the land than over the sea.

12.2 GEOLOGICAL WORK OF WIND

Wind is an important geological agent of erosion, transportation and deposition of rock material though, it is much less effective than running water. The velocity of the wind increases rapidly with height above the ground surface just as the velocity of the stream, increase upward from the channel floor. In the zone a few feet above the ground surface the average velocity of upward motion in an air eddy is approximately one fifth the average forward velocity of the wind. This velocity of upward movement is of great significance in the transportation of smaller particles by the wind. The materials moved by the wind can be divided into two sizes namely sand and dust. Wind-driven sand averages between 0.15 mm and 0.30 mm and is seldom finer than 0.06 mm. Wind erosion is mostly of two types- **deflation** and **corrosion.** Both accomplish removal and transportation of rock material but the first is done without the aid of tools where as the second namely corrosion requires the assistance of grinding materials.

12.2.1 Wind Erosion

Already loosened particles of rock such as dust and fine sand are picked up and carried from one place to another. This activity is very strikingly conspicuous in regions were vegetation is either sparse or lacking. In such regions the impact of wind itself is sufficient to remove large quantities of earthy matter by the process of **deflation** (Latin deflare-Flow away). Eddies, whirl winds and updrafts which help the wind to lift and remove its load in this way. Thus many exposed lands are swept free of loose material which is carried away as fast as weathering produces it. A more spectacular method of wind erosion that of corrosion and abrasion whereby the wind employ its load of sand as a cutting tool natural sand blast. By this process rock surfaces in the way of such wind are scored an grooved. In arid region such grooves are very conspicuous and where the winds have flight variation of direction, the grooves show a parallel alignment and their sides are forms often strongly fluted. Many odd-shaped land forms are the result. These are undercut **ills** with caves, mushroom rocks, table rocks and pedestal rocks . A familiar of wind abrasion is the “frosting” and ultimate destruction of plate glass of windows of the houses which are directly exposed to hard winds. Wind-driven sand has its latest erosive power somewhat relatively close to the ground because the lower and heavy fragments not being lifted high. They accomplish the greatest work. Telegraph poles in desert regions are often cut down by wind erosion and hence must be heavily protected at bases. Pebbles and boulders on deserts sometimes have more or less angular faces carved upon them by wind erosion. Such leveled stones are called **Einkanter** or simply **Ventifacts Dreikanter** (meaning one or three edged). Ventifacts is defined as a stone that shaped and polished by wind.

Einkanters are apparently formed by the cutting of pebbles under conditions of a constant direction of the wind while Dreikanter are formed when the pebbles were over led as a result of undermining so that several facets are developed in succession. It may pointed out here that corrosive action of the wind is much less generally effective cutting and sculpturing of rocks than was formerly thought of by geologists. Stream erosion even in desert regions seems to accomplish more than wind erosion because though rainfall is scanty, it rains very heavily. When it does as “Cloudburst”, In desert regions of high relief torrential streams rush down the stream courses carrying heavy ads of rock derived from the abundant weathered rock material lying almost unprotected by vegetation.

The greatest geological work accomplished by the wind seems to be deflation, picking up and transportation of really large quantities of finer materials which were either laid down through the agency of running water or were produced by weathering.

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of this

1. What are the processes involved in wind erosion?

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12.2.2 Wind Transportation

The method by which rock particles are carried by wind according to size, shape and specific gravity of the particles and with the blowing wind. In general, dust particles are carried in **suspension** and sand particles by **traction** chiefly by rolling or creep. A gentle breeze can carry dust in suspension and roll fine whereas a strong breeze with a velocity of 25 miles per hour can move sand grains a millimeter in diameter, and gales and hurricanes can carry sand in suspension to heights of hundreds of feet and can roll along the ground pebbless 5 to 6 inches in diameter.

A **Whrilwind** or devil wind is a strong upward moving current of air that may lift fine particles very high above the surface and may drift some distance from the pit origin. A **tornado** is a much violent whirling mass of air with much greater lifting but of slight gradational effect. It originates as a column of whirling air in the storm. Tornadoes are known to lift heavy objects and to transport them several miles. Under the motive power of the wind loose grains of sand may be picked from surface, carried for some distance forward and dropped again in a series of bouncing moments known as **saltation.** This impulse together with the drag of the wind on the over which it is blowing causes a forward motion or creep of the loose sand. Saltatic creeps are the most important factors producing the movement of the drifting sand.

The sources of wind load are very much varied. The Chief source is the rock formed by weathering and corrosion. Flood-plain and sand bar deposits of dried beach sands and glacial moraines commonly serve as intermediate source. Violent explosions supply tremendous quantities of very light angular rock dust. The wind of transportation by suspension is notably different from its capacity for rolling, separation of rock particles occur depending upon the method of transportation. Ger the separation removes clay, dust and silt from the larger and heavier particles of sands. Just like winnowing of grain, this is done by the wind.

12.2.3 Wind Deposition

Whenever and wherever the wind loses its ability to transport deposition of sand and dust from the air occurs much as in streams of water. The sand grains close to the ground move relatively slowly and are deposited early, whereas the suspended particles travel faster and farther before dropping to the ground. Wind deposits show a progressive decrease in the diameter of the particles with increasing distance from the sources. Generally there is also a difference in topography between sand deposits which occur in heaps and mounds near the source and the deposits consisting chiefly of clay and silt which occurs as a general blanket over the ground farther from the source.

Sand Deposit: Deposits of sand tend to assume certain characteristic and recognizable shapes. The particles are large and are usually sorted. Winds heaps sand deposits into mounds and ridges called **sand dunes**. They are common along sandy shores of lakes and the flood plains of the streams flowing through sandy areas. In fact, wherever loose sand is available in abundance on land, dunes are likely to be formed especially if there is persistent wind direction.

A dune begins to develop where there is a slight irregularity of surface or some obstacle, such as a boulder, causing a local check in the velocity of the wind with the resultant, deposition of some of the load it carries. Once the piling up of the sand has started, its growth is accelerated, by its own shape and size. In its early stage a dune is an oval sand pile with the wind flowing swiftly and freely over it. But sooner a lag in the wind velocity develops on the *leeward* side because of air swirls and funnel winds set up in the wind shadow or the protected zone. As the height of the sand increase the summit of the pile advances faster than the leeward foot, a crest is formed and a steep slope or **slip** face develops down which sand grains slide or roll. The lateral margins of the developing dune also may be dragged forward with the wind to produce wing-like extensions or horns in the direction. On the windward side of a typical dune the mid-profile normally shows a long gently slope about 10 to 15 degrees from the horizontal and on the leeward side, a steeper slope or slip face with an angle of 20 to 30 degrees.

Since, most of this moving sand, sliding down the slip face previously was taken from the front margin of the windward side, swept up the slope and dropped at the crest, the continual transfer produces a slow migration of the dune in the direction of the wind movement. The rate of migration of sand dunes is of course determined by several factors. Usually, it does not exceed a few mts per year but in few cases may be as much as 30 or more meters/year. As dune migrates, it gradually looses part of its sand and thus shrinks in size. During their growth and forward migration these sand dunes may cover valuable farmlands and forests. Dunes seldom attain heights greater than a few hundred meters although some dunes in the great Sahara desert of Africa are said to be more than 30 meters high.

If the wind has a constant or prevailing direction, the dunes assume the normal plan and profile. But variable winds tend to produce the characteristic profile with change in wind direction and so the typical form is lost in the confused sand pile that results. In regions, such as deserts and semi deserts where the dunes are best developed on a grand scale, normally two types are recognised. They are **transverse dune** or **barchan** and **longitudinal dune or Seif**.

Barchans: A Barchan is a crescent shaped sand dune with a gentle slope on the windward side on the outer curve and having the wings or horns of the crescent drawn out with the wind on the leeward side. It is a streamlined dune produced by wind blowing from one direction only and any variation in wind direction tends to destroy its typical form.

These dunes are formed, where supplies of sand are limited and the surface is relatively flat, hard and lacking vegetation.

Seifs or Longitudinai dunes: This is a sand dune resembling in plan the outline of an Arabian sward. It is developed by several winds having set but in somewhat different directions. It may be considered as a sort of modification of the typical type of barchan dunes. Seifs are well-developed in Arabia, Libya and the Fresh Sahara and the deserts of Australia.

Transverse dunes: In regions where vegetation is sparse or absent and sand is very plentiful, the dunes form a series of long ridges that are separated by troughs and oriented at right angles to the prevailing wind. Because of this orientation, they are formed as **transverse dunes.** Typically many coastal dunes are of this type. In addition they are common in many arid regions.

Dune Structure: An ideal section of a dune shows the bedding of the gentle windward side cutting shortly across the steeper beds of the slip face. As the dune is sheared off again in the process of migration or by variable winds and the sand redeposited the complexity of the cross-bedded internal structure may be much increased. Beds of rounded grains of more or less uniform size usually quartz, and the truncation of layers with many change in the direction of bedding inclination are the typical characteristics of sand dunes of all ages.

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of this unit.

2. What is a Dune?

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Ripple Marks are common on sand dunes and on sand surfaces associates with them. They are formed by friction at the inter-face of wind and sand under the sorting action of surface creep, the coarsest grains collecting at the crests and the finest in the troughs.

Dust and Clay Deposits: Slackening of the wind allows is suspended load to settle slowly out of the air. Rain and snow are even more effective in rapidly clearing the air. The occurrence of mud-rains and dust-colored snowfalls are well-known. Dust deposits in general are widespread and without special forms and hence escape much of our attention but their total bulk is undoubtedly large. Wind-blown deposits are generally called *Aeolian* deposits. Some of the wind-laid dust deposits are of such magnitude as to deserve a special mention. Dust that is of volcanic composition and origin is called volcanic ash. It is derived from volcanic explosions and eruptions and many of its particles are often glassy, and sharp. Surface dust originating chiefly from desiccated glacial outwash or from desert areas have given rise to deposits called loss.

Loess: It is non-stratified yellowish or buff-coloured silt, intermediate in texture between clay and sand. It is composed of small angular mineral fragements of quartz, felspar, hornblende, calcite and others, all of them slightly weathered. In thickness, the loess may range froma few meters to 10 metres or more metres in the Central United States. In China loess deposits reach few hundred metres in thickness. When exposed in banks of guilies or excavations, the loess reveals a remarkable property of standing in vertical cliffs even though the material is not cemented together. This is probably due to the fact that the grains are sufficiently angular to interlock rather than roll or slide over each other as most sand grains tend to do.

On account of its texture and freshness of its minerals, loess makes fertile soils as in the mid western states of the U.S.A., like Iowa, Illinois or Missouri or the Rhine basin in Europe. There are many evidences to show that loess is a wind deposit. The very fine size of the particles is-highly indicative of its aeolian origin. The loess material blankets the divides, hill slopes indiscriminately as if it had settled from the air. Most of the deposits are generally considered to be aeolian deposits closely related to the pleistocene glaciation of large parts of North America, Europe and Asia. Many exposures of loess show that, they are intimately associated with glacial till and outwash deposits. The loess deposits of China are known to reach an enormous thickness of 1000 ft. in shensi and adjoining provinces. This loess is believed to have accumulated from silt blown in from the deserts of central Asia by the prevailing westerly winds. It is so easily eroded by wind and rain wash that certain roadways laid in it, through the wear of centuries of travel have become depressed into deep narrow canyon like profiles.

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of this unit.

3. What is loess?

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12.3 DESERTS-GEOLOGICAL PROCESSES

In arid and dry regions wind is the dominant gradational agent. Often wind is seasonal and may blow for days on end from a single direction only. In such areas called desert regions the sky is generally clear, the atmosphere persistently dry and the diurnal variation in temperature. There is little or no soil and naturally the vegetation is sparse and sometimes totally lacking since the average annual rainfall is very meager. When it rains, it is generally in the form of cloud bursts and the torrents dash down the slopes with great amount of erosion of the surfaces. Many of the deserts are closed drainage basins. The run off from each gully is heavily loaded and spreads over the gentle surface of the central basin' and drops its load of sediment in apron-like fans. The turbulent waters and their journey in the temporary **playa lakes** at the foot of the slopes where desiccation takes place. The dry ravines called **wadies,** become channels through which the wind is tunneled and their walls are worn and polished by the wind-drived sand. Sand may be blown into dunes but the fine rock particles and dust from the dry playas are caught by the wind and blown beyond the confines of the basin leaving behind only larger fragments like coarse sand and pebbles called **Lag-stones.** Accumulating over a long period of time, the entire surface is covered with these rock fragments to form a **desert pavement**. Lag-stone may often show a shining black or brown iron and manganese crust known as **desert-varnish.**

The relative intensities of various geological processes in the desert regions vary very much from their intensities in moist regions. As a result, the land in a desert region lack the soil and sediments show distinctive characteristics. In desert regions the weathering is mainly mechanical and necessarily the regolith is thinner, less continuous and often coarse-grained. Since mechanical weathering is controlled by joints in the parent bed rock, rock fragments tend to break off along joints, leaving steep, rugged cliffs. Hills cut by erosion from flat lying layers of rock with cliff slopes are the, buttes and **mesas** which are quite common in such dry regions.

In many valleys of the desert regions streams in floods effectively undercut the side; slopes of the valleys causing them very often to cave in, as the flood subsides, the load is deposited rapidly creating a flat floor of alluvium. The result is a steep sided flat-bottomed structure called the **Box-canyon,** which is the characteristic feature of many dry regions.

Check Your Progress

Note: a) Space is given below for writing your answer.

b) Compare your answer with the one given at the end of this unit.

4. What is Box-Canyon?

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12.4 SUMMARY

Wind is nothing but air in motion. Wind is an important geological agent of erosion, transportation and deposition. The materials moved by the wind can be divided into two sizes namely sand and dust. Wind erosion is mostly of two types namely deflation and corrosion. Because of wind erosion many features like undercut hills with caves, mushroom rocks, table rocks, pedstal rocks are getting formed. Einkanter and Dreikanter are getting formed by the cutting of pebbles with wind. Wind erosion is effective in desert regions. Rock particles are carried by blowing wind. The source material for wind transportation is generated with weathering and corrosion. Whereever wind loses its ability to transport, the particles will get deposited. Sand is deposited in the form of sand dunes. Barchans and seifs are sand dunes. Barchans are crescent shaped sand dunes. Ripple marks, dust and clay deposits, loess are the other deposits of wind.

12.5 CHECK YOUR PROGRESS-MODEL ANSWERS

1. The processes involved in wind erosion are deflation and abrasion.
2. A dune is a mound or ridge of sand deposited by wind.
3. Loess is silt, usually accompanied by some clay and some fine sand.
4. The steep sided flat-bottomed structure in the deserts is called the **Box-canyon.**

12.6 MODEL EXAMINATION QUESTIONS

I Answer the following questions in 30 lines each.

1. Describe the geological work of wind.
2. Describe the deposits formed by wind.
3. Explain about deserts.

II Answer the following questions in 10 lines each.

1. Explain processes of wind erosion
2. How are sand dunes formed?
3. What are ripple marks?