Notes

4

RUNNING WATER, MOVING ICE, WIND AND SEA WAVES

In the previous lesson, we have discussed many geological processes which are active on the surface and contribute to shaping the earth. These exogenous (external- over earth's surface) and endogenous processes result in ultimate gradation and reducing the uneven earth into level surface. The land features very rarely remain in their original form, shape, size, texture and to some extent its colour also continiouslly changes. These agents of gradation have a major role in erosion, transportation and deposition of weathered rocks. These forces play a vital role in modifying the land features.

The gravity and gradients (slope of an area) plays an important role in shaping various landforms through agents of gradation. The most important geological agents capable of eroding, transporting and depositing the mass from one place to the other are: Running Water (Fluvial landforms by rivers and streams); Glaciers (Glacial landforms by glaciers); Wind (Aeolian landforms by wind) and Sea Waves (Marine landforms by waves). In this lesson we will learn about various erosional and depositional landforms formed by various different of gradation.

OUTCOMES

After studying this lesson, learner:

- describes the importance of various erosional and depositional features produced by action of running water;
- explains the important erosional and depositional features produced by glaciers;
- explains the erosional and depositional features formed by the wind;
- explains the various erosional and depositional features formed by sea waves and
- evaluates significance of running water, moving ice, wind and sea waves for humans.

Notes

4.1 FUNCTIONS OF RUNNING WATER: EROSION, TRANSPORTATION AND DEPOSITION

Rivers play a significant role in shaping the landscape. Rivers transport water by gravity from source of origin to ocean on its journey. The river passes through three courses- upper, middle and lower course during this journey and creates many erosional and depositional features.

Courses of River

The path or route in which a river flows from its point of origin known as 'mouth of river' to its destination i.e. sea or ocean is called the course. The river course can be broadly divided into three sections:

i. The upper course or the stage of youth or the youthful stage or mountain course.

ii. The middle course or the stage of maturity or mature stage

iii. The lower course or the stage of old age or old stage

Table 4.1

Courses of river valley

Features	Upper Course	Middle Course	Lower Course
Source	Glacier or underground (karst)		
Slope gradient	Very steep	Open gently sloping valley	Almost flat or shallow gradient. Gentle slope with floodplains with flat and wide
Discharge of water	Less amount as single stream initially	Large amount as many tributaries join the main river	Very large
Depth of river bed/bed load	Shallow / heavy bedload	Deeper / more suspended sediment	Deep
Velocity	Very high velocity water gushes down from steep valleys	Moderate	Low and slow movement of water

Channel and valley shape	Narrow channels with steep valley	Flat and moderate steep sides. Wider and deeper channels	Flat floor with gently sloping sides. Very wide and deep channels.
Major landforms created	Rapids, waterfalls, canyons, gorges, 'V' shaped valleys	Meanders, oxbow lakes, floodplains, levees, river cliffs, slip off slopes	Deltas, distributaries

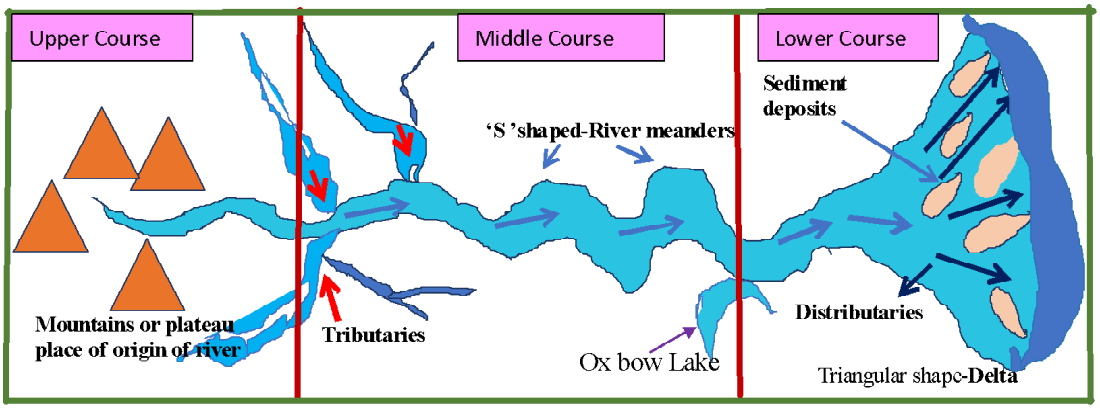


Fig. 4.1 Courses of River Valley

4.2 RUNNING WATER: LAND FROMS

a. EROSION

The cutting and removal of rock debris by the river is called river erosion.

Erosional Landforms

Many erosional landforms are made by running water. They are -

i. **'V' shaped valleys-** The valleys are created by erosional action of rivers in the upper course. At this stage vertical erosion is more dominant compared to lateral erosion. The fast-flowing rivers with steep gradients create this valley. As the river flows downhill at high speeds it removes maximum sediments from the bottom as compared to the sides of the river channel. This process is called down cutting. Weathering helps in widening a valley at the top giving it a typical 'V' shaped cross section. The valley has very steep walled sides along with a narrow floor.

Fig. 4.2 'V' shaped valley by river Zanskar in Ladakh, India

ii. **Gorge and Canyons-** Hard and resistant bedrock hinder the widening of the valley at the top but down cutting process continues with the vigour of the river which can lead to formation of gorge. A river valley with almost vertical walls is called a gorge. For i.e. Indus gorge, Pakistan Kali Gandaki Gorge, Nepal and the gorge of Gandikota formed by Pennar river in the state of Andhra Pradesh whereas a canyon is very deep gorge with vertical walls and steep sides can stretching for hundreds of kilometres i.e. Grand Canyon created by river Colorado in the USA Fish River Canyon, Namibia and Laitlum canyon, Meghalaya.

Deep gorges also develop in limestone regions in plateau regions and in rocks lying in dry climates. The narrow and very deep gorge or the canyon with vertical walls is also known as 'I' shaped valleys.

iii. **Waterfalls and rapids-** A waterfall is a steep descent made by a river over rocky slopes or ledges . The rivers fall with great velocity and lateral erosion predominates and plunge pools are formed at the base of waterfalls. The streams flow from soft rock to hard rocks. Both lateral and vertical erosion takes place. In most cases the soft rocks (like limestone or sandstone) get eroded and the water falls from a hard ledge of granite or other hard rocks. Waterfalls are also called cascades. For eg. Niagara Falls at the USA and Canada border. Jog falls, India. Victoria falls, Zambia etc. Rapids formed in areas of shallow fast-flowing water in younger streams. There are many tiny waterfalls created within the stream. Adventure sports like water rafting are very common in zones where there are rapids in river channels. For e.g. white water rafting in Rishikesh, India.

Fig. 4.3 Waterfall

b. TRANSPORTATION

River carries rock particles from one place to another. This activity is known as transportation of load by a river. The load is transported in four ways- (a) Traction (b) Saltation (c) Suspension (d) Solution actions as discussed in previous lesson. It helps in transporting various types of sediments and debris load from one place to other by running water.

c. DEPOSITION

When the stream comes down from hills to a plain area, the surface slope becomes gentle. The decrease in energy hampers transportation; as a result, part of its load starts settling on its own. This activity is known as deposition. Deposition takes place either due to decrease in slope or due to fall in the volume or velocity of river water. Deposition takes place usually in plains and low lying areas. When the river joins a lake or sea, the whole of its load is deposited.

Depositional landforms

(i) **Alluvial fans-** When rivers flow down the steep mountain slopes into the valleys they drop their load of coarse - sand and gravels as their sudden decrease in velocity. The load deposited generally acquires a fan-like shape; therefore they are called alluvial fans.

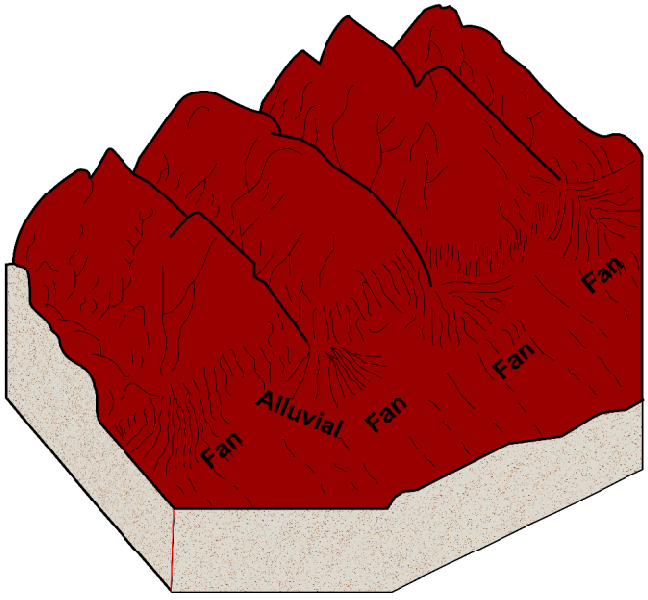


Fig. 4.4 Alluvial Fans

ii. **Meanders-** The term is derived from River Meanders in Turkey which makes winding paths while flowing downstream. When the river is flowing in a relatively plain area even small obstructions on the way forces the river to swing in loops to go around the obstacles. These "S" shaped loops are called meanders.

Notes

iii. **Floodplains and Levees-** Vertical erosion has almost ceased in the lower course and in this stage the river is carrying heavy loads of debris and many tributaries join the main river. In this course the river is rich with large volumes of water and sediments that are brought down from upper and middle courses. The work of the river is totally depositional and it is building up its bed and floodplains. Annual flooding causes spreading of large quantities of sediments over the low- lying areas adjacent to the banks of the river channel building a fertile floodplain.

A raised ridge of coarse material is formed along the river banks of the river. Such ridges are called levees.

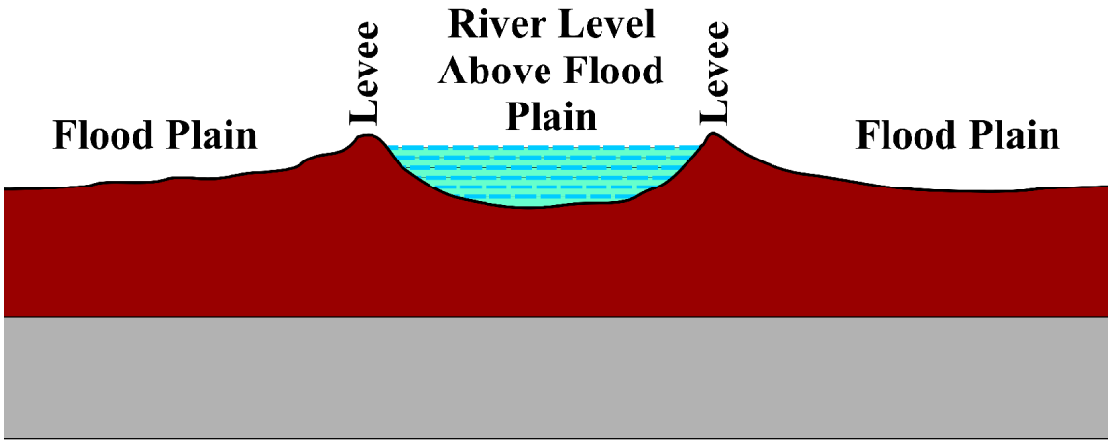


Fig. 4.5 Floodplain and Levees

iv. **Braided streams-** Large sheets of material both fine and coarse are deposited on the level bed and the river splits into a maze of channels. Such stream is called a braided stream.

v. **Ox- bow lakes-** In the lower course of the river the meanders are becoming very pronounced. The outer part or the concave bank is rapidly eroding so that the meander becomes a circle. A time comes when the river changes its course and the river cuts through the narrow neck of the meander. The now cut off portion of the meander looks like a crescent shape (half-moon or bow shape) and initially it has some water so called as Ox Bow Lake. Over the time it becomes a swampy and marshy area and slowly gets totally dried up as the river channel is now far away and recharge of water is not present.

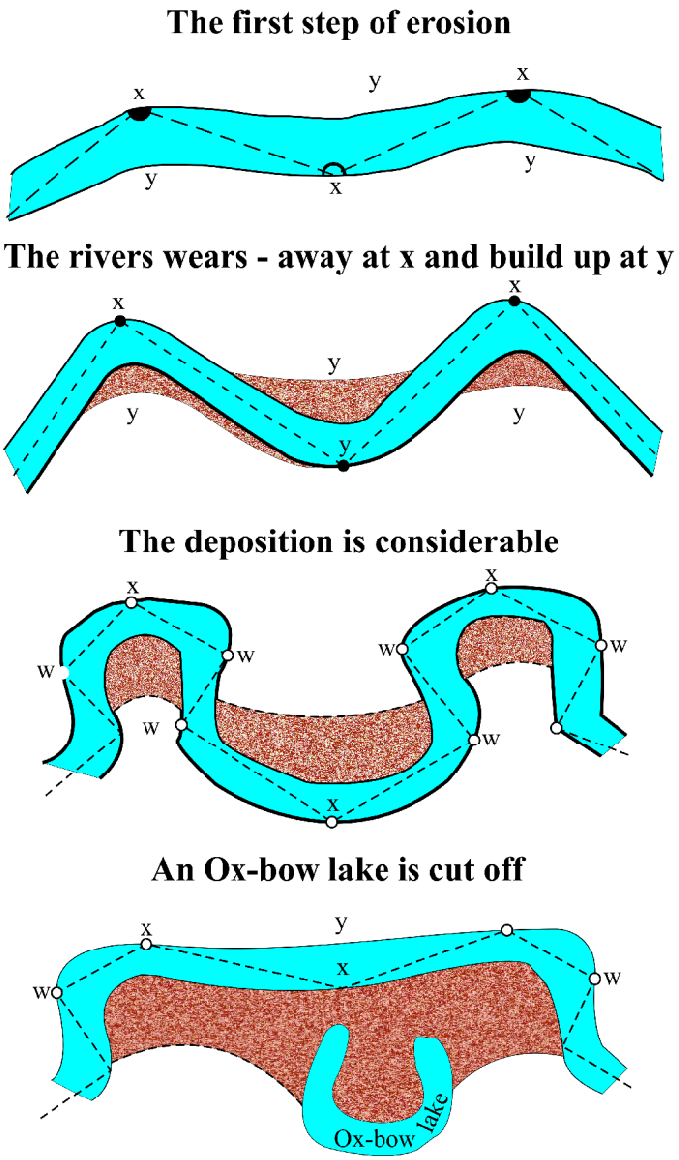


Fig 4.6 Meander and Ox bow lake (formation and shape)

vi. **Delta-** The word delta originated from Greek letter (△) which has great resemblance to river Nile delta. Delta is a triangular feature with its apex pointing up stream and has a fan shaped area of fine alluvium. The world's largest delta is made by river Ganga and river Brahmaputra known as Sundarban delta

Favourable conditions for the formation of Deltas

i. There should be active lateral and vertical erosion in the upper course of the river to provide large amounts of sediments.

ii. Shallow sea water adjoining the delta.

iii. Tideless and sheltered coast.

iv. There should be no strong current at the river mouth which may wash away the sediments.

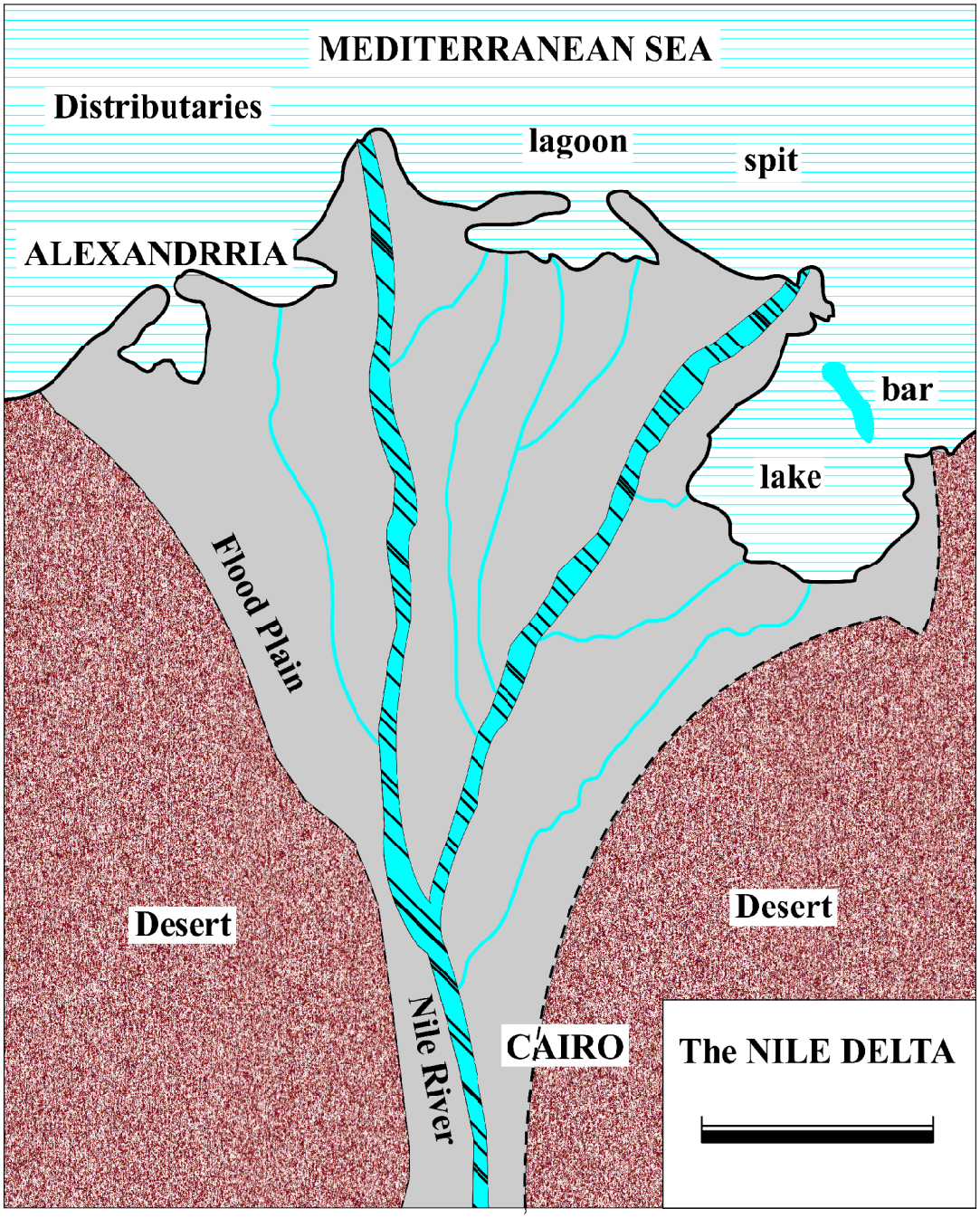


Fig . 4.7 Delta

Distributaries- In the delta region the river has deposited large loads of alluvium at the mouth of the sea. These sediments act as barriers for straight flow of river water and rivers that split into numerous channels in the delta region are called **distributaries.**

Some rivers fall from cliffs and high ridges before meeting the sea or ocean. As there is not enough flat area so rivers fall like waterfalls and form estuaries instead of deltas. **Estuaries**

Notes

are funnel shaped channels from which rivers fall into the sea and make small deposit of sediment at the beach. Two west flowing rivers Narmada and Tapi as they fall from western ghats makes estuaries before joining Arabian sea.

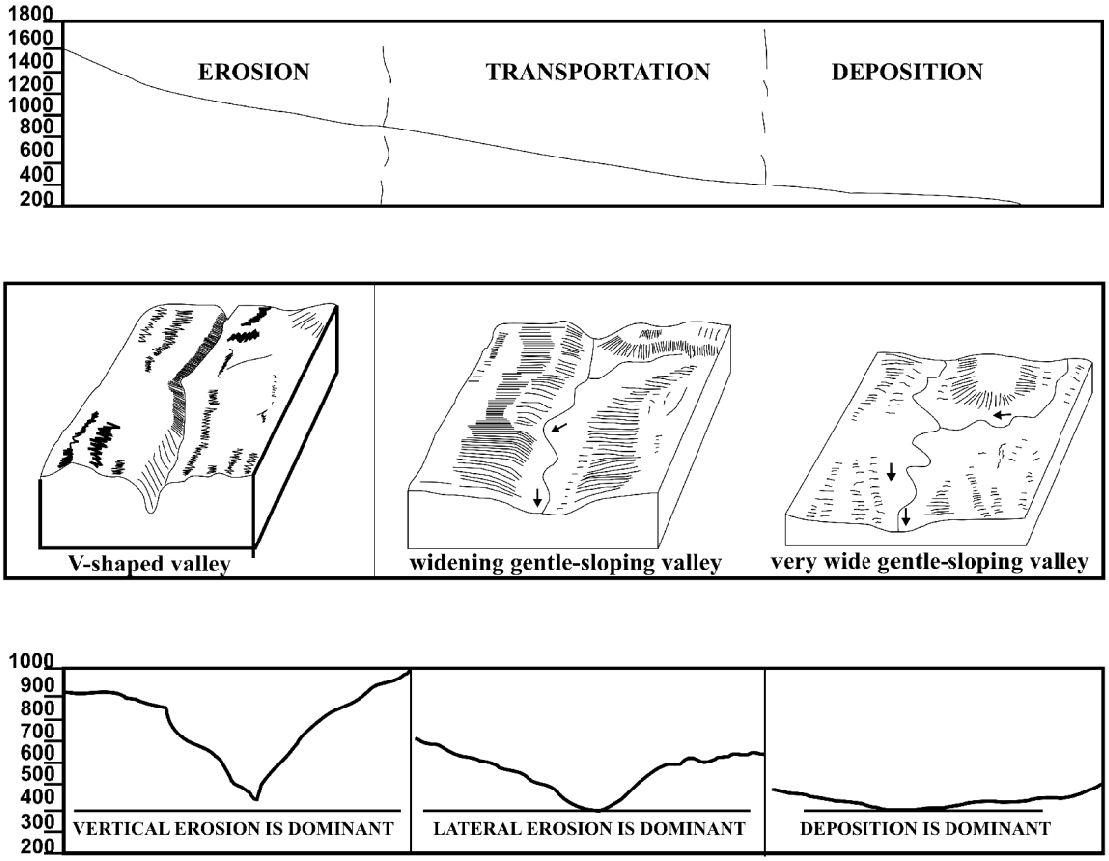


Fig. 4.8 Course of River

Significance of running water

- Rivers provide a source of freshwater.
- River water gets replenished within a short timeframe.
- Rivers carry water and nutrients from one place to another.
- Rivers play an important role in the water cycle.
- Seventy five percent of earth's surface water is drained by rivers.
- Rivers provide habitat for plants and organisms.
- River water is used for drinking, domestic, agriculture, trade and transportation, recreation and other commercial and industrial uses.
- Rivers play an important role as a renewable source of energy for e.g. Hydro power.

INTEXT QUESTIONS 4.1

1. Which are the three courses of the river?

   (i) ……. (ii) ……(iii) …….

2. Name four ways by which river erosion takes place.

   (i) ……. (ii) ……(iii) ……. (iv)……..

3. Name three erosional landforms.

   (i) ……. (ii) ……(iii) …….

4. Name four ways by which river transports its load.

   (i) ……. (ii) ……(iii) ……. (iv)……..

5. Fill in the blanks

   (i) The triangular shaped depositional feature formed by the river is called……....

   (ii) The meanders cut off from the main river forms a lake known as …….....

   (iii) River Narmada and Tapi forms ……at the west coast of India instead of a delta.

   (iv) The river splits into numerous channels at the delta are called…….....

4.3 GLACIAL EROSIONAL AND DEPOSITIONAL LANDFORMS

Glaciers are thick masses of moving or flowing ice sometimes also called rivers of ice. The glaciers originate on land with favourable climatic conditions and compaction and recrystallization of snow where seasonal accumulation is more than seasonal melting.

Snow fields - In the regions where the temperature always remains below freezing point precipitation occurs in the form of snowfall. It's a region that displays a net annual accumulation of snow surpassing net melting rates. Wherever the rate of snow melting or its evaporation is lower than the rate of snowfall in a year the snow accumulates in great masses of ice. Permanently snow-covered areas of this type are called snow fields. Snow fields are found above the snow line and their height varies from location to location. Snowline is an imaginary line which defines the limits of snow accumulation in the snowfield above which there is continuous and positive snow cover.

Notes

DO YOU KNOW?

Snow line is the lowest limit of permanent snow cover. Various factors influence the location of snow line altitude, latitude, amount of rainfall, direction of wind, slope of the land and exposure to sunlight

In regions experiencing snowfall, the snow keeps on accumulating in the layer one above the other. Its overlying pressure makes the lower layer more granular, hard and compact. The layers of snow under pressure start turning into ice and this pressure of the overlying layers makes the solid mass of ice mobile or moving ice under its own weight is called a Glacier. Movement or velocity of the glacier is very slow and it moves from a few centimetres to few metres in a day.

The glaciers are divided into two major types according to their location or area of origin-

- Polar
- High altitude mountain areas.

Glaciers can be broadly divided into two broad categories

(i) Continental glaciers

(ii) Mountain or valley glaciers

i. **Continental glaciers -** Thick ice sheets covering vast areas of land are called as a **continental glaciers.** It is a massive accumulations of ice that covers large areas of continents and regions in polar areas. The thickness of ice in such areas can go up to thousands of metres. The glaciers of this type are built up at the centre and move outward in all directions. Continental Glacier is mainly found in Greenland (1.7 million sq. km), Antarctica (around 18.8 million sq. km) and the Arctic circle (around 15.6 million sq km). The precipitation in this region occurs in the form of snowfall each year which accumulates over these regions because the amount of melting is very less or slow as compared to the amount of snowfall received thereby covering large continental areas by glaciers. 10 percent of the land area is covered by glacial ice, ice caps and ice sheets.

ii. **Mountain or Valley Glacier** When a mass of ice from a high mountain region starts moving down in the existing valleys it is called a **valley glacier or mountain glacier**. The slope and width of the valley has an impact on the size of the glaciers. Where the valley is broad the glaciers spread outwards and where the valley is narrow glacier contracts. Fedchenko glacier situated in Central Asian Pamirs range in central Tajikistan

Notes

is the world's largest valley glacier found outside polar regions. It is about 70 kms long. Longest Glacier in India is Siachen glacier in Karakoram range which is 172 km long. Gangotri Glacier, Uttarakhand is 25.5 km long. There are many small glaciers in other parts of Himalaya and their length varies from 5 to 10-kilometres. Some of the major river of India i.e. Ganga and Yamuna originate from Gangotri and Yamunotri. Many glaciers are found in Swiss alps, Canadian Rockies and Andes Mountain ranges.

Types of landforms produced by Glaciers

Like other agents of gradation, glaciers also do the work of erosion, transportation and the deposition as glaciers require certain physical and climatic conditions for their occurrence. Most of the features created by them are found in areas affected by glacial action.

a. Erosional work of glacier

As glaciers move over the land, it drags rock fragments, gravel and sand along with it. These rock fragments become effective erosive tools. With their help glacier scraps and scours the surface rocks with which they come in contact. This action of glaciers leaves scratches and grooves on the rocks. Some of the important landforms created by glaciers are-

i. **Cirques or corrie** – Snow accumulates at the upper end of arm-chaired or bowl-shaped depressions formed at the head of the glacial valley are called cirques. The structure of the cirque has steep walls on three sides with one side open on the valley front. The cirques are like a cradle of the glacier where it is formed by plucking rock and intense freezing and thawing (causing frost shattering) from the side. It makes steep walls and scoop out at the base of the glacier in which snow accumulates and ice formations flowing away from the cirque. In certain areas the deepest part of these cirque hollows is filled with water called as cirque lakes or tarn.

ii. **"U" shaped valley-** The Glaciers do not carve out a new valley like a river but deepens and widens the pre existing valley by smoothening the irregularities. In this process the glaciers broaden the sides of the valley. The shape of the valley formed in this manner resembles the letter "U". Such a valley is relatively straight, has a flat floor and nearly vertical sides. The glacial valleys are flat bottom and steep walls caused by shear stress and glacial erosion along valley walls.

iii. **Hanging Valley**- Just like tributaries of rivers there are tributary glaciers also which join the main glaciers carve U-shaped valleys. However, they have less volume of ice than the main glaciers thus their rate of erosion is also less rapid. As a result, their valleys are not as deep as the main glacier. Due to this difference in deepening the valley of the tributary glacier is left at a higher level than the main

glacier. The valley of the tributary glacier just looks like hanging downwards at the point of its confluence with the main valley. This type of topographical feature is called hanging valley. This feature is visible when ice has melted in both the valleys. When the ice in the hanging valley melts, a waterfall is formed at the point of confluence of this stream with the main river.

iv. **Crevasses –** These are cracks which appear on the top of the glaciers and head walls of cirques.

v. **Aretes, Cols and Horns-**Aretes are saw – toothed ridges in which there are multiple ridges in series and rows and they divide two cirques. Cols are shallow passes between two high points of the mountain. They have sharp edge passes or saddles between two adjacent cirques. Horn is pyramid shaped mountain peaks which is formed by erosion on three sides by 3-4 cirques on each side of the peak. Example: Matterhorn in Switzerland.

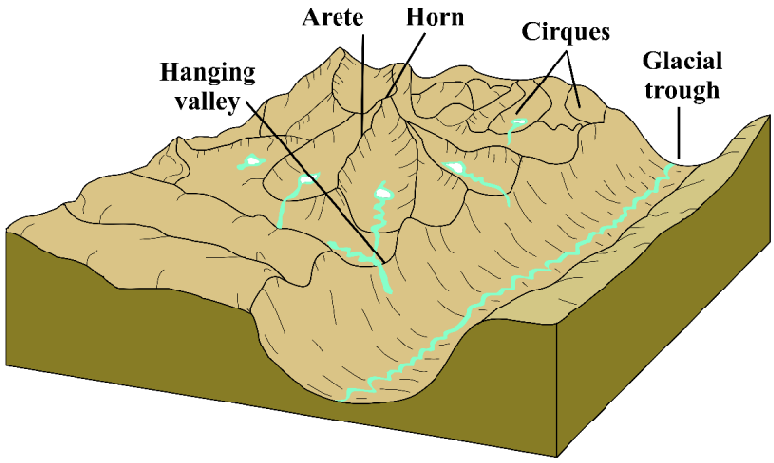


Fig. 4.9 Various glacial erosional landforms

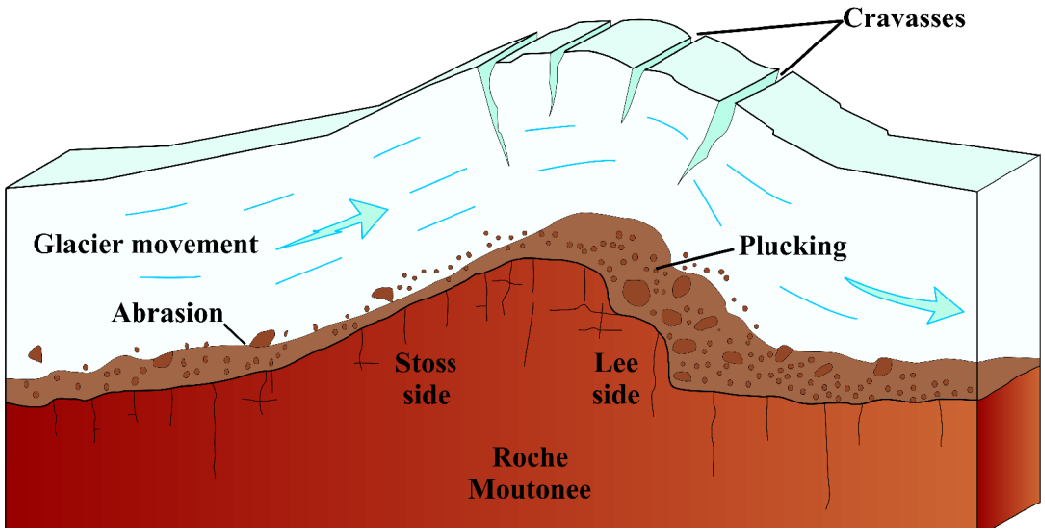


Fig. 4.10 Erosional processes of glaciers and crevasses

Fig. 4.11 Valley glacier in Sonmarg, Jammu and Kashmir, India

b. Transportation work of glaciers

Although glaciers move very slowly, it drags with it large boulders and rock fragments. Glaciers get its material from mountain slopes, valley bottom and from air. This material is called the load of glaciers.

c. Depositional work of glaciers

Eroded debris gets deposited when glacial ice melts and the sediments get deposited by moving glaciers or melt water flowing away from the glaciers. All deposits derived from glacial processes are called glacial-drifts.

Types of debris-

i. **Till**- Debris deposited directly from glacial ice constitutes poorly sorted materials like boulders, rocks and even rock flour**.**

ii. **Outwash**- Sorted and stratified debris which is deposited by melt waters. When glaciers melt or retreat, it deposits its load to different parts. The debris is directly deposited by ice, which is not sorted or layered marked by mixed of material and lack of stratification. This type of debris deposited in its glaciers is called moraines or till.

Depending upon their location in the valley moraines are of four types-

- **Terminal moraine** – This type of moraine is found along the front of the glacier and has a ridge-like structure which acts like a dam. Water accumulates between the front of the glacier and forms lakes. When the glacier melts, the debris is deposited at the end of the valley glaciers in the form of a ridge. It is called terminal moraine. The moraine material ranges from fine clay to large angular boulders.

- **Lateral moraine-** The moraine which is deposited on either side of a glacier is called lateral moraine. It is formed along the sides of the ice stream chiefly from material which are contributed from the valley sides above the glaciers by weathering, snow slides, avalanches or other types of mass wasting. Lateral moraines are frequently patchy and may and may not be present in both sides of a trough
- **Medial moraine-** When two glaciers join each other their lateral moraine also joins. Moraines thus formed on the confluence of two glaciers are called medial moraines.
- **Ground moraine-** It consists of deposits left behind in areas once covered by glaciers. It is seen only after the glacial ice has disappeared by melting.

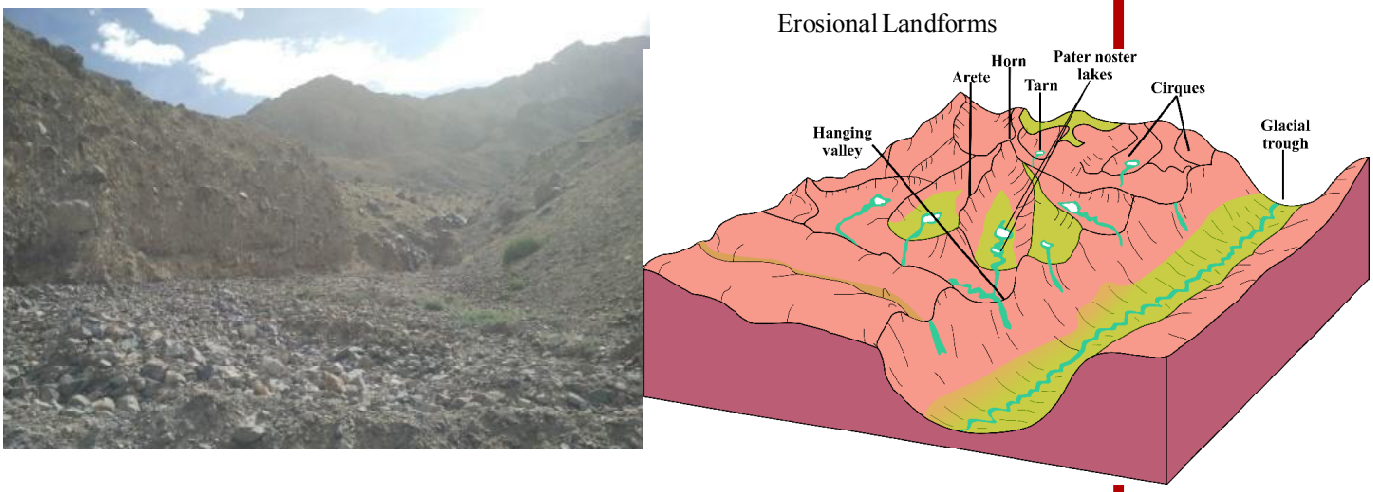


Fig. 4.12 Erosional and Depositional landforms

DO YOU KNOW?

Sea ice, Iceberg and Glacial drift

Sea ice- The floating ice of the oceans is formed by direct freezing of ocean water due to extremely low temperatures in polar areas.

Iceberg- They are mass of glacial ice floating in the ocean that has broken off a glacier and the block of ice has drifted into tidal waters. Nearly 5/6th of iceberg is submerged in water, only a very small part is visible over oceans.

Glacial drift- It is a general term for all varieties and forms of rock debris deposited by ice sheets.

Notes

Significance of Glaciers for humans

- Glaciers ice have shaped and created many landforms in middle and high latitudes.
- Glacial ice sheets affect global climate.
- Glaciers reflect sunlight.
- Volume of ice caps and melting rate of glaciers has impacts on the sea level.
- Glacial ice affects global heat transport on earth.
- Glaciers are giant freshwater reservoirs and support life systems on the earth and also influence our day to day lives either directly or indirectly. Three quarters of all freshwater in the world is in the form of glaciers.
- They provide drinking water. Many rivers in the world originate from glaciers and snow melts. Himalayan rivers have a glacial origin.
- Melting glacial water is used for irrigation of crops.
- The cold runoff from glaciers also affects the downstream water temperatures

INTEXT QUESTIONS 4.2

1. Write two types of Glaciers on the bases of location.

   (i) …….. (ii) …….

2. Fill in the blanks

   (a) The moving mass of ice and snow are called …….

   (b) The region permanently covered by snow and ice is called ……..

   (c) Lowest limit of permanent snow is known as……

3. Identify and categorise erosional and depositional landforms made by glaciers from the given list-

   Cirques, medial moraines, 'U' shaped valley, crevasses, till, ground moraines

4. Mark as True or false

   (a) Glaciers are small reservoirs of freshwater.

   (b) Glacier lakes are made by moraines.

Notes

(c) Glacier runoff affects the downstream water temperature.

(d) Glacier melt has impact on the sea level rise.

(e) Crevasses are deposits made by glaciers.

4.3 WORKING OF SEA WAVES

The coastal zone is the part of the land surface influenced by marine processes and formed by the sea waves near by the sea. It extends from the landward limit of tides, waves, and windblown coastal dunes, and seaward to the point at which waves interact significantly with the seabed.

There are atmospheric processes including temperature variation, precipitation and winds, while the major marine processes are waves and tides, together with water temperature and salinity. The coast also supports rich ecosystems, including salt marshes, mangroves, sea grass, and coral reefs. The diverse coastal ecology is favoured by the shallow waters, abundant sunlight, terrestrial and marine nutrients, tidal and wave flushing and a range of habitat types.

There are three processes active in the Oceans; out of these the following modify the coasts:

1. Tides
2. Waves
3. Currents

Let us understand the role played by sea waves in shaping the coastline.

Erosional work of sea waves

Like rivers and glaciers sea waves also play a vital role in eroding and creating land features. Distinct processes like corrosion, abrasion, attrition and hydraulic action plays an important role in the erosion process by sea waves.

Factors affecting sea wave erosion

- **Influence of waves-** The volume of water has a great influence on the waves. Larger the volume of water, the bigger the waves created.
- **Characteristics of the coast-** Factors such as height of cliffs near the coast, their rock structure, vertical and horizontal alignment of the coast, quantity of debris along the coast on the beach also affects the sea erosion.

Coastal Processes and Landforms

Erosional and depositional landforms of coastal areas are the result of the action of ocean waves.

Notes

Erosional Coastal Landforms are formed along rugged, high-relief, tectonically-active coastlines. It includes sea cliffs, sea caves, and sea arches.

Erosional landforms

Coastal erosion is dependent on wave size, angle and frequency. They are focused where waves contact the coast.

i. Sea cliffs

They are a very distinctive feature of marine erosion. Steep rocky coast rising almost vertically above sea water is called sea cliff. The steepness of a true-vertical cliff depends on variation in geological structure, lithology relative rate of subaerial weathering and erosion of cliff face. The maximum impact of the sea waves is observed on the lower part of the cliff specially. If it is made up of soft rocks like limestone, rocks eroded more rapidly than the upper part. Most of the time upper parts are made of harder rocks and the upper part of the rock is thus left projecting out towards the sea. After some time, due to the weight of the projecting part it falls into the sea leaving behind a vertical wall which is called a cliff. Number of cliffs can be seen in Konkan coast of India.

ii. Sea caves

Waves crash into headlands eroding weaker parts such as cracks. In areas where the lower part of the coastal rock is made up of softer material and whereas the upper part is made up of harder rocks. Due to differential erosion a hollow is created in the lower part of the rock. The wave pounds against the hollow and air present inside the hollow gets compressed. When the wave comes out of the hollow air is also released and it expands. The continuous compression of the air in the hollow, the rocks are subjected to a great pressure. The crack or the hollow starts to widen in the lower part and it keeps on enlarging. With passage of time, they attain the form of a sea cave. It can be undercut causing the roof to collapse due to lack of support for the roof. This helps the cave get larger. The formation of sea caves depends upon the nature of the coastline and the force of waves.

iii. Blow hole

As the cave gets larger, waves start to hit into its back wall and on impact are sent crashing into the roof of the cave where erosion occurs.

The erosion of the cave roof can lead to a blowhole, where waves continue to erode upwards and through the top of the headland. This is quite rare and needs a vertical crack line to be exploited.

Notes

iv. Sea Arches, Stack and Needle

They are natural openings through the mass of boulder clay or limestone. Over time the waves continue to widen the walls of the arch leaving less support for the roof, leading to its collapse. This leaves a new headland on the landward side of the arch and the old wall still standing on the seaward side. This old wall is called a stack or a pillar and is also subject to erosion by the sea. As it erodes it gets thinner at its base and parts of it collapse leaving a narrower pillar called a needle.

v Wave cut Platform

Wave-cut platforms are horizontal benches in the tidal zone extending from the sea cliff out into the sea. If the sea level relative to the land changes over time (becoming lower with respect to the land due to uplift), multiple wave-cut platforms (terraces) are the result. There are emergent Coastlines Tectonic forces lift coastlines faster than sea level rises. Therefore, cliffs and marine terraces tower above the sea.

Transportation

Coastal Transportation - Wave action creates strong currents parallel to shore. Large waves move beach sand offshore. Small waves push it back on shore. The eroded material is transported by sea waves. The materials transported by sea waves are gravels, silts, cobbles and pebbles. Sometimes boulders and other marine products like minerals and plankton etc can also be transported.

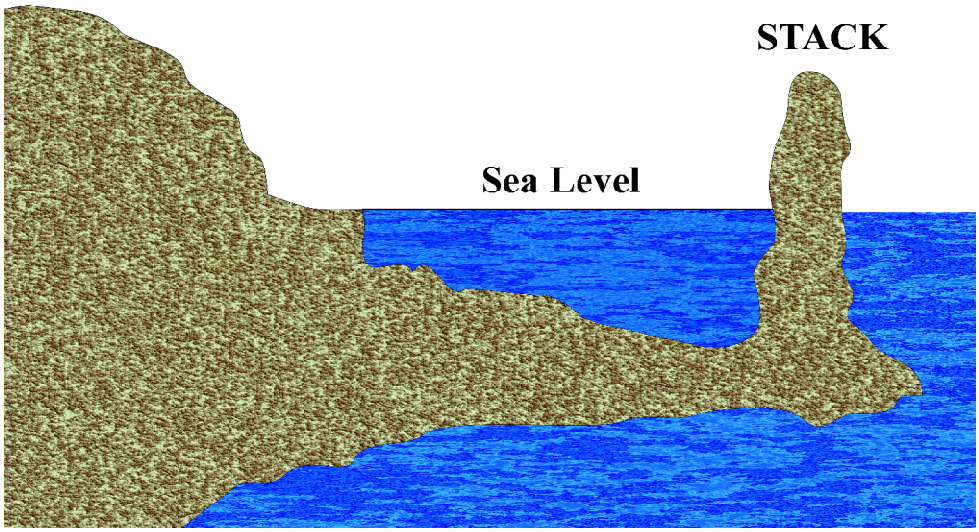


Fig. 4.13 Stack

Depositional Landforms

i. Beaches

Beaches act as natural barriers between waves and upland features, such as dunes. A beach is a narrow, gently sloping patch of land that lies along the ocean or sea. It is also found near river and lakes. They are composed of erodible, unconsolidated sand, gravel, rocks and seashells which may be moved by waves and wind. The wider and higher the beach, the more wave energy is dissipated before reaching the shoreline. Gentle, long period waves found in calmer weather, known as swells, tend to move sediment onshore, building up the beach. Steep waves associated with storms and strong winds tend to transport sediment offshore, eroding the beach. If the shore is gently sloping, wave energy can be dissipated over a longer distance, causing less erosion. Wind blowing across the beach can move finer grained particles, shaping, and, in some cases, eroding the beach. Windblown sediment will continue to move until it reaches a barrier, such as vegetation, which reduces the wind speed and causes sediment to be deposited. It is this accumulation that forms dunes. Radhanagar Beach, Havelock island, Andaman and Nicobar island; Agonda beach Goa, Marina Beach, Chennai, are a few famous beaches of India Seminyak beach, Bali, Indonesia; Santa Monica Beach, California, USA etc. are some more examples.

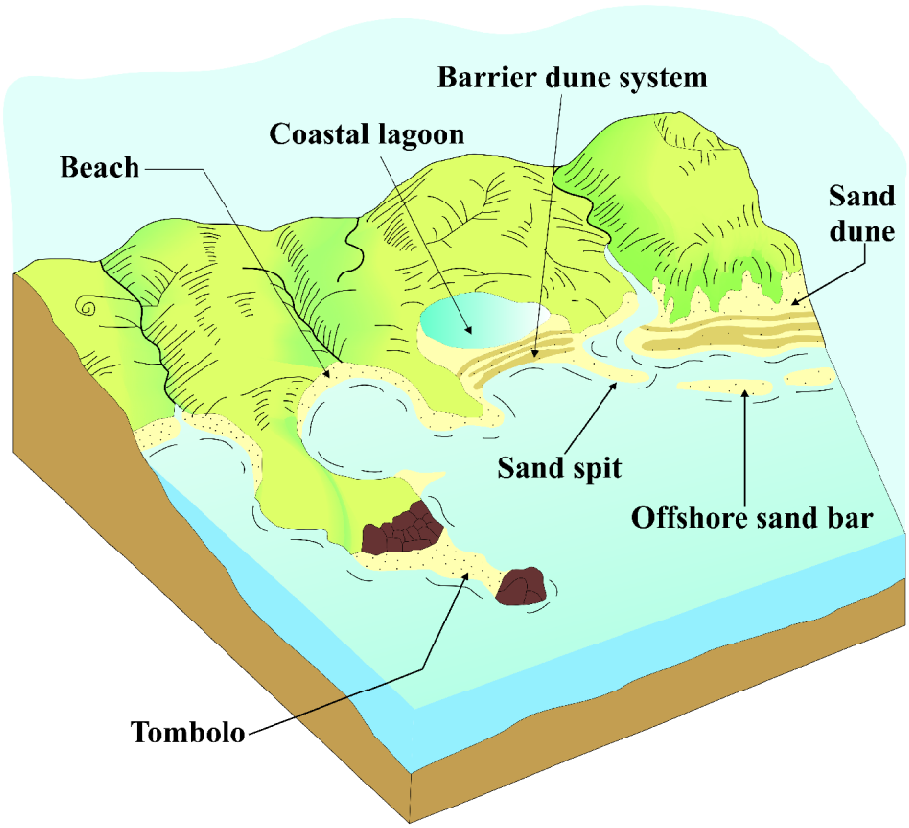


Fig. 4.14 Depositional landforms by Sea waves

Notes

ii. Offshore Bars

Offshore bars are underwater deposits of sediment that form parallel to the shoreline. They can act as wave barriers, if large enough, by forcing waves to break farther offshore than they normally would. This reduces the amount of wave energy that reaches the shore. Bars are formed from deeper water sediment, or from material carried away from a beach during times of high wave activity or higher-than-normal water levels. Spits are formed when one end of the bar is attached to the coast and the other end extends to sea. It is composed of sand and gravel brought by waves. Lagoons are formed by deposition of sediments by waves and currents on both ends of the bars thereby enclosing a part of sea water between the bar and coast. This enclosed region is filled with saline water and called Lagoon. The lagoon has a narrow passage through which it is connected by sea. Vembanad lake in west coast and Chilka and Pulicat in east coast are examples of lagoons in India.

iii. Dunes

Dunes are mounds or ridges of sand deposited by the wind immediately landward of the beach. Primary dunes are closest to the beach and are usually lightly vegetated with grasses, while secondary dunes are farther landward and may have a denser vegetation cover that can include shrubs and trees. Vegetation can trap and hold windblown sand on dunes. If large enough, primary dunes can provide protection from flooding and wave action for the upland area, and may replenish some sand to eroded beaches. If a primary dune is breached, secondary dunes (if present) provide erosion and flooding protection to landward areas.

Significance of Waves for humans

- The motion created by waves plays a vital role in transporting energy all around the globe.
- Also helps shape the coastlines.
- Ocean waves are an important element in the mechanism that controls heat balance of the planet.
- They are part of delicate balance of nature of movement of offshore and onshore by waves,
- Waves are very important for weather forecasting and for climate modelling.
- Provides resources and other benefits for the coastal communities.
- Helps in shipping industry and offshore industries,

Notes

- The waves hitting the beaches and seashores keeps earth's crust cool, especially areas which have molten lava.
- Waves also have influence on creating high and low tides which is very useful for fishing,
- Waves are useful for recreational activities like surfing etc.

INTEXT QUESTIONS 4.3

1. Factors affecting erosion by ocean and sea waves

   (i)……(ii)…….

2. Fill in the blanks

   (a) …….are underwater deposits of sediment that form parallel to the shoreline.

   (b) …….are horizontal benches in the tidal zone extending from the sea cliff out into the sea.

   (c) Waves are very important for weather ……and for …….modelling.

3. Rearrange the following relief features made by depositional and erosional action of sea waves-

   Sea caves, Bars, Beaches, Sea cliffs, Arches, Sea stacks, coastal dunes

4.4 WORKING OF WIND OR AEOLIAN

Wind is a powerful geological agent to create and destroy landforms. Wind is capable of eroding, transporting and depositing the surface materials. Aeolian landforms are features of the Earth's surface produced by either the erosive or constructive action of the wind. The word "Aeolian" is derived from "Aeolus", in Greek meaning, the god of the winds. In deserts, semi-arid and along sandy shorelines areas of the world where wind action moves sand and mineral particles when they are dry and the areas are without much vegetation or barriers.

Wind and its Features

Circulation of air over the earth's surface cause the wind to blow. Wind has the ability and force to lift the earth's loose particles laying on the ground surface may be lifted in air by the mechanisms like - a) Deflation b) Abrasion c) Saltation d) Deposition (as introduced in lesson 3) the turbulent eddy actions and by sandblasting of windborne particles helps in creating new Aeolian landforms.

Notes

Winds adopt three mechanisms for eroding the mass -

- Lift
- Bombardment and
- Drag

The **Lift** results from a combination of wind velocity and turbulence. There is a threshold (critical) velocity which is a function of particle size and cohesion and turbulence which changes in wind speed & direction. As turbulence increases, susceptibility of particles to lift increases.

Bombardment is the collision of moving particles with stationary ones or with solid surfaces. It has abrasion. In this process there is also collision with the solid surfaces. **Drag** also initiates sliding and rolling. It doesn't lift particles off the ground. The power of wind to erode surface particles is controlled primarily by two factors: wind velocity and surface roughness. Erosive force increases exponentially with increases in wind velocity. The power of wind to erode surface particles is controlled primarily by two factors: wind velocity and surface roughness. Erosive force increases exponentially with increases in wind velocity.

Desert environments are characterised to assist in wind erosion by following ways -

a. Very low mean annual rainfall of less than 50 mm

b. Absence of vegetation

c. Very high daily and annual range of temperature

d. Dust storms

e. High velocity winds and

f. Dominance of sands

Erosion by Winds

Winds are the most widespread geomorphic agents in the deserts, arid and semi-arid regions. Wind erosion generally takes place above the ground and thus wind velocity plays a major role in determining the degree of Aeolian erosion. Wind erosion is effective only up to 180 cm above the ground surface. Maximum wind erosion occurs at short distances. Unlike rivers and glaciers, winds erode the rocks from all sides because of their variable directions.

Some of the erosional landforms of the wind are:

i. Blow Outs or deflation basins

Rocks that are exposed to the sand blasting of prevailing winds become pitted, grooved, and polished. Deflation basins, called blowouts, are hollows formed by the removal of

particles by wind. Sand grains are rolled and the entire bed is lowered, in some cases up to one metre, resulting in shallow depressions called blowouts. This depression may be a few metres to as much as a kilometre across. Depressions are formed in the deserts due to removal of sands to a greater extent. The size of the depressions varies from small hollows to big hollow deeps. A desert pavement is a typical desert surface. It is covered with closely packed, interlocking angular or rounded rock fragments of pebble and cobble size, formed by the gradual removal of the sand, dust and other fine grained material by the wind and intermittent rain. The Qattara Depression of Egypt is the best example.

ii. Yardangs

Yardangs are elongated ridges formed wind oriented with the prevailing winds. Yardangs are larger hill-sized features sculpted by the wind. Yardangs are composed of cohesive silts and clays, sandstone, or limestone. They develop in regions with strong unidirectional winds.

iii Mushroom rock

When the composition of rock is mixed where there are alternate layers of soft and hard rock the rock is subjected to wind abrasion with differential erosion results. More sediment load is carried by wind at lower heights so erosion is more at the base or near base of the rock. The upper blowing winds carry less sediment load as it becomes heavy to carry so erosion at the upper part of the rock is less. This gives the mushroom rock its famous shape of top and base thin. These rocks resemble rock pillars shaped like mushrooms. Such types of formation can be seen in Sahara Desert in Africa and Thar desert in India.

Features made by deposition

Aeolian or wind deposits are distinguished from other continental deposits by a number of specific features. They are:

a. Irregular cross-bedding

b. Gentle dipping

c. Steep and

d. Orienting in different directions making different shapes.

The grains of Aeolian sands are generally well-rounded due to prolonged transportation by wind. Sometimes, they are well-polished. The depositional landforms of wind are:

Notes

i. Ripple marks

Ripple marks are very small features produced in unconsolidated sediments or sand dunes at right angles to the wind direction. They stretch laterally for long distances. Ripple marks are produced where there is some irregularity on the surface. Sand ripples develop transverse to the wind direction. Their wave-length is hardly 1 metre. When there are stronger winds blowing the ripple marks can vanish.

ii. Sand dunes

Landform is created by the movement of sand by wind. The dunes are like small mounts, ridges or hills. Sand dunes are a very prominent feature of desert areas. The coarser materials are deposited in drifts in the shape of crest or definite summit or hills or ridges, called dunes. An ideal dune has a long windward slope rising to a crest and a much steeper leeward slope. A sand dune may be defined as a mound or ridge of wind-blown sand, rising to various heights up to 50 m. It is found in hot deserts and above high-water mark on low-lying coasts where sand is constantly renewed by onshore winds blowing across the sandy beaches. Desert sand dunes are generally characterised by the absence of natural vegetation.

For dune formation certain conditions are necessary such as,

(i) a fairly continuous sand supply;

(ii) a constant wind strength and direction; and

(iii) an obstacle or series of obstacles to trap the sand.

Types of Sand dunes

Some of the major types of sand dunes are;

a. **Barchan -** They are crescent (half-moon) or arc-shaped, appear convex in shape and are primarily formed by wind from one direction. Most common type of sand dune and found in sandy deserts all over the world. Two "horns" face downwind on this type of dune, with the steeper slope known as the slip face facing away from the wind.

b. **Transverse dunes-**Transverse dunes are asymmetrical in shape, and from where light to moderate winds blow from a constant direction. These dunes take the shape of a series of crests and troughs whose peaks are perpendicular to the direction of prevailing winds. These dunes appear like sea waves.

c. **Seif or longitudinal dunes-** They are long narrow ridges that are parallel to the direction of prevailing winds. The winds come from different directions. The winds blow straight along the corridors between the lines of sand dunes and sweep the corridors clear of

sand. Narrow rows elongated which could be many hundred kms long but their troughs the lower portion is almost without sand and some can reach height up to 100 mts. Such types are commonly seen in the Sahara Desert, North Africa, Arabia and can also be seen in western part of the Thar desert of India.

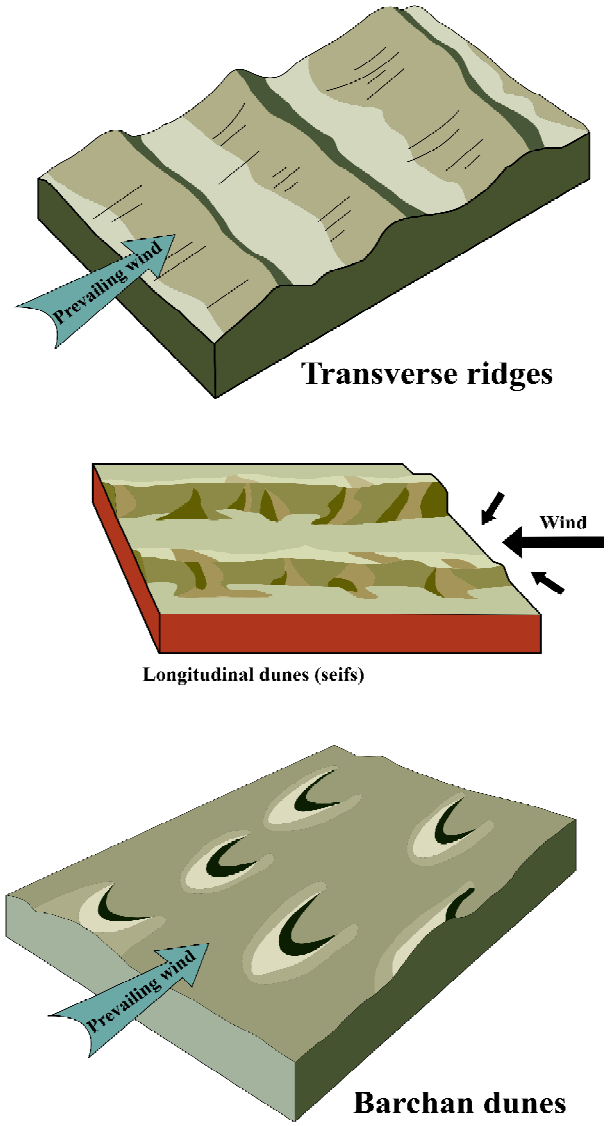


Fig. 4.15 Types of Dunes

iii. Loess

It primarily located close to desert floor or crust. The word originated from German word Loess which means loose or un- consolidated. The particles are silt-sized and yellow in colour the deposits are very thick and have homogenous unstratified silt deposits. They are made up of fine loamy soil with high contents of lie. They are very porous and

Notes

very cohesive and water seeps in the subsurface very rapidly and the top surface is always dry. The loess areas are very soft so when roads are constructed in these areas witness frequent sinking of the soil and roads also sink with it. For eg extensive deposits in northwest plateau region of China the thickness can be 30 m deep commonly but can reach up to 100 m. The material is so loose that it is picked up my winds from central Asia to far flung regions in South and Southeast regions.

Significance of Wind for humans

- Wind increases the turbulence in atmosphere.
- Movement of water vapour, clouds and various forms of precipitation so winds allow humidity to occur.
- Winds also helps in circulation of various gases for example providing supplies of carbon dioxide resulting in greater rates of photosynthesis and oxygen movement for direct consumption by the humans.
- Winds also help in generating renewable sources of energy in the form of wind energy through wind mills. Wind energy is used for various purposes like electricity, milling grains, water pumping etc.
- Winds also help in sailing ships and aeroplanes.
- Winds provide sea breezes (winds move from sea to land) and land breezes (winds move from land to sea.
- Winds help in plants pollens to move from one place to other and also assists in flight of birds.

INTEXT QUESTIONS

1. Name three mechanism of wind erosion.

   (i) ..... (ii)..... (iii).....

2. Name major erosional landforms created by action of wind.

   (i) ..... (ii)..... (iii).....

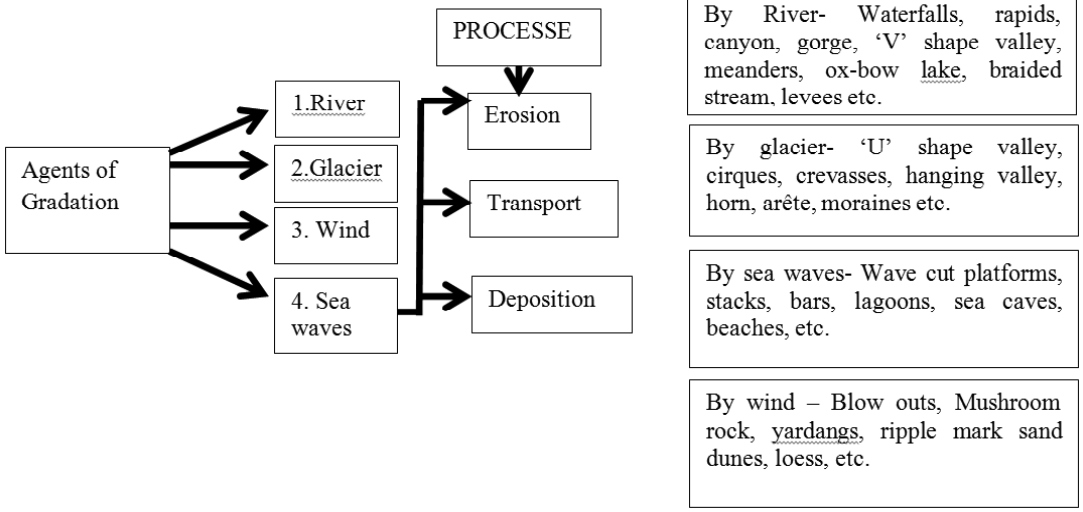
3. Name major depositional landforms created by action of wind.

   (i) ..... (ii)..... (iii).....

4. In which regions of the world maximum deposits of loess found?

.....

WHAT YOU HAVE LEARNT



TERMINAL QUESTIONS

1. Explain any three topographical features made by erosional work of rivers.
2. What is the difference between estuary and delta?
3. Differentiate between following
   (a) 'U' shaped and 'V' shaped valleys
   (b) Flood plain and braided streams
   (c) Lagoon and bars.
4. With the help of diagrams explain ox-bow lake, delta and natural levee.
5. Define glaciers. Distinguish between continental and valley glaciers.
6. What is a hanging valley? How are hanging valleys different from 'U' shaped valleys ?
7. What are moraines? Elaborate various types of moraines.

Notes

8. Explain two major factors affecting sea wave erosion.

9. Discuss formation of beaches and give two examples of beaches in India.

10. Describe favourable conditions in the desert environment assisting in wind erosion.

ANSWERS TO INTEXT QUESTIONS

4.1

1. (i) Upper course
   (ii) Middle course
   (iii) Lower course
2. (i) Abrasion or corrasion
   (ii) Corrosion or solutions
   (iii) Hydraulic action
   (vi) Attrition
3. (i) 'V' shaped valley
   (ii) Waterfalls and rapids
   (iii) Gorges and canyons
4. (i) Traction
   (ii) Saltation
   (iii) Suspension
   (iv) Solution
5. (a) Delta
   (b) Ox-Bow Lake
   (c) Estuaries
   (d) Distributaries

Notes

4.2

1. (i) Valley or mountain glaciers

   (ii) continental glaciers

2. (a) glaciers

   (b) snow- field

   (c) snow-line

3. Erosional features-cirques, 'U' shaped valley, crevasses
   Depositional features- medial moraines, till, ground moraines

4. (a) False

   (b) False

   (c) True

   (d) True

   (e) False

4.3

1. (i)) Influence of waves

   (ii) Characteristics of the coast

2. (a) Offshore bars

   (b) wave-cut platform

   (c) forecasting, climate

4.4

1. Name three mechanism of wind erosion

   (i) Bombardment

   (ii) Drag

   (iii) lift

Notes

2. Name major erosional landforms created by action of win

   (i) Mushroom rock

   (ii) Blowouts

   (iii) Yardangs

3. Name major depositional landforms created by action of wind

   (i) Dunes

   (ii) Loess

   (iii) Ripple marks

4. In which regions of the world maximum deposits of loess found- Extensive deposits in northwest plateau region of China

MODULE -3

The Domain of the Water on the Earth

5. Hydrological Cycle and Ocean