

After weathering, geomorphic agents operate the landforms to change.
Land form: small to medium tracts or parcels of the earth's surface are called landforms.
Several landforms together are called landscape
Each landform has its own shape, size and materials
Geomorphological processes are slow but significant in long run
Every landform has a beginning, they change their shape and composition in course of time.
Due to changes in climate and vertical and horizontal movements landforms change their shape.
Each landform undergoes three stages called youth, mature and old stages
Geomorphology is the science of landforms
Various geomorphic agents bring the changes to the landforms such as running water, moving ice, wind glaciers, underground water, waves by erosion and deposition.
Each geomorphological agent produces its own assemblage of landforms.
Most of the geomorphological processes are imperceptible.
The study of the landforms reveals that the stage structure and process of land forms
They produce erosional and depositional features.

Factors influencing erosion:

1. Rock structures such as fold, fault, joints, fractures, hardness, softness permeability, and impermeability
2. Stability of sea level
3. Tectonic stability of landmass
4. Climate

RUNNING WATER

1. In humid regions rainfall is heavy so running water is dominant agent
2. There are two components of running water

A. OVERLAND FLOW - SHEET EROSION B. LINEAR FLOW - STREAM EROSION

Most of the erosional features are formed in upper course/youthful stage of the river
Depositional features are formed in the lower course/old stage of the river
Steeper the slope more the erosion/gentle the slope more the deposition
Vertical erosion is more in the upper course lateral erosion is more in the lower course

OVERLAND FLOW: it is also called as sheet erosion

Depending on the irregularities of the surface the sheet erosion concentrates into channels
Due to sheer friction of the water narrow channels are formed
They are called rills. Rills develop into gullies, gullies further deepen and converted into valleys
In the early stages downward cutting makes waterfalls, cascades in the middle stages streams cut their beds slower and lateral erosion of valley sides becomes severe.
Later stages, the flat valley is formed with *monadnocks*. This type of plain is called *peneplain*.

Stages of the river

YOUTH

1. Less Streams
2. Less Integration
3. 'V' shaped Valleys Are Common
4. Stream Divides Are Swampy Marshy Areas
5. Water Falls And Rapids Are Common

MATURE

1. More Streams
2. More Integration Of Streams
3. Deep 'V' shaped Valleys
4. Wider Flood Plains
5. Meanders Are Present
6. Rapids And Water Falls Disappear

OLD

1. Smaller Tributaries
2. Few In Number
3. Flood Plains Are Common
4. Natural Levees And Oxbow Lakes Are Also Present
5. Most Of The Landscape Is Just Above Sea Level.

EROSIONAL LANDFORMS

'V SHAPED VALLEY



GORGE



CANYON

DIFFERENCE BETWEEN GORGE AND CANYON

GORGE

1. steep sides
 2. equal width of top and bottom
 3. small in length
 4. they are found in semi arid lands
- grand canyon
brahmaputra gorge

CANYON

1. Step like sides
2. wider at the top and narrow at the bottom
3. Longer in length
4. Found in dry areas ex. Grand

POT HOLES:



1. They are circular depressions
2. formed by abrasion
3. pebbles and boulders get collected in these holes and rotated and make depression wider and deep
4. They keep valley deepened
5. at the foot of the water falls they become plunge pools

PLUNGE POOLS



- Found Foot Of The Water Falls
- Formed Due To Soft Rocks
- They Are Below The Level Of River Bed

MEANDERS



into oxbow lakes

1. Lateral erosion is common in the lower course of the rivers
2. Due to low kinetic energy water is changing its course
3. Generally found in the flood plains
4. When meanders are found in deep and hard rocky areas they are called incised or entrenched meanders
5. Some meanders develop loops which later on converted

6. Some times they deepen the rocks and converted into canyons

RIVER TERRACES



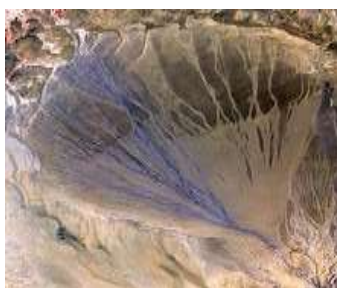
Marking old valley floor
They represent flood plain levels
They may consist of stream deposits
They are formed due to vertical erosion
There may be number of formal flood plains
If they are at the same level they are called paired terraces
If they are found at different levels they are called nonpaired

terraces

Unpaired terraces are found in the areas of slow upliftment areas

Reasons for the formation of river terraces

1. receding water after a peak flow
2. change in hydrological regime due to climatic change
3. tectonic uplift of land
4. sea level changes incase of rivers closer to the sea alluvial fans.



1. Found near the foot of the hills
2. The river break into number of channels
3. Low gradient
4. Coarse load is deposited
5. Low gradient
6. Cone shaped deposit
7. Channels shift their position in the plain
8. They are called distributaries
9. Cones are gentle slope in humid areas and dry lands they have steep slope

ALLUVIAL PLAIN



Formed along the river banks

1. Made of alluvial soils
2. They are divided into two types khadar and bangar
3. Khadar soils are found near the river and bangar soils are found away from the river
4. They are very fertile

DELTA 1. Found near by the mouth of the river 2. Made of fine alluvial soils



1. They are in triangular shape
5. Similar to Greek letter Delta
6. Divided by distributaries
7. Deposited material is

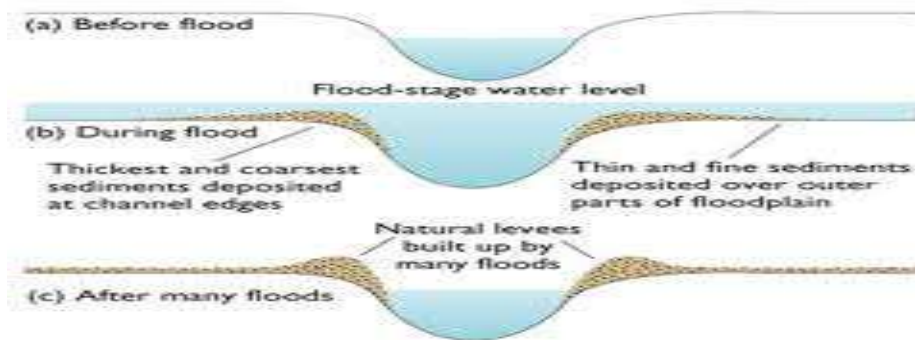
stratified on the basis of size. Coarse material is deposited first and then fine material

GANGA DELTA FLOOD PLAINS



2. Major landforms in the river deposition 2. big boulders are deposited first and then fine material is carried to the longer distance. The active flood plain is found in the river bank where as inactive flood plain is found above the level of river bank. The flood plains in deltas are called delta plains.

NATURAL LEEVES :

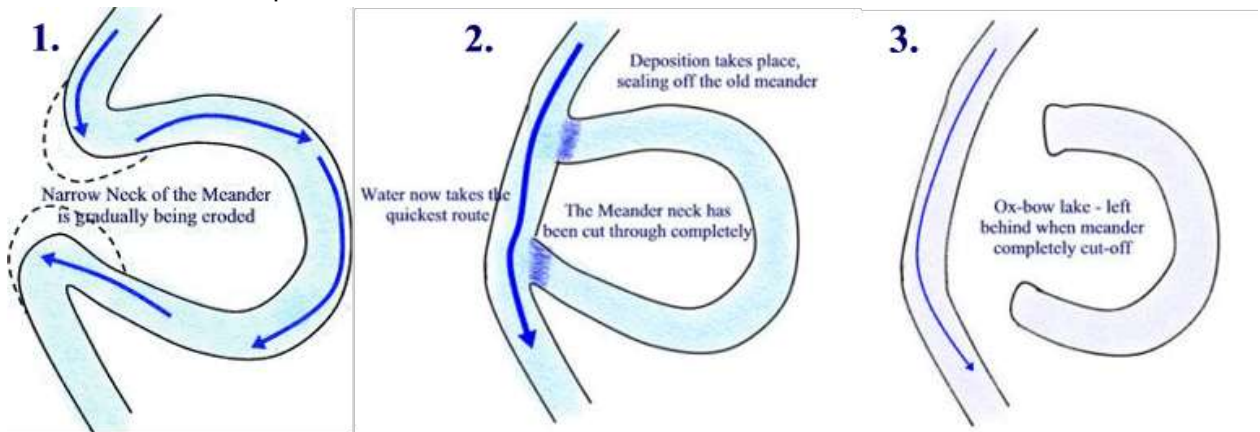


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They are associated with flood plains. found along the flood plains of large rivers. they are low linear, parallel ridges made of coarse material found along the river bank. When river shift laterally a series of natural levees can form

POINT BARS : they are also called as meander bars. 2. found along the convex side of meanders of large rivers. They are uniform in profile. if there are more than one ridge narrow and elongated depressions are found in between the point bars. MEANDERS: loop like channels are called meanders. it is not a landform it is a type of river channel. Reasons for the formation of meanders

1. gentle gradient 2. unconsolidated material make irregularities 3. coriolis force 4. Slight irregularities along the river banks.

Formation of **OXBOW LAKES**: Found along the river bank on the convex side of the meander. Convex side is deposited and concave side is eroded. Concave bank is eroded and also it is called



cutoff bank convex side is long gentle slope. as they grow long loops the curve is cutoff and formed into Oxbow lakes.

BRAIDED CHANNEL

When rivers carry coarse material, there can be selective deposition of coarser materials causing formation of a central bar, which diverts the flow towards the banks; and this flow increases lateral erosion on the banks. As the valley widens, the water column is reduced and more and more materials are deposited as islands and lateral bars developing a number of separate channels of water flow.



KARST TOPOGRAPHY. Any limestone or dolomitic region showing typical landforms produced by the action of groundwater through the processes of solution and deposition is called **Karsttopography** after the typical topography developed in limestone rocks of Karst region in the Balkans adjacent to Adriatic Sea.



Pools, Sinkholes, Lapis and Limestone Pavements

Small to medium sized round to sub-rounded shallow depressions called **swallow holes** form on the surface of lime stones through solution.

Sinkholes are very common in limestone/karst areas. A **sinkhole** is an opening more or less circular at the top and funnel-shaped towards the bottom with sizes varying in area from a few sq. m to a hectare and with depth from a less than half a metre to thirty metres or more.

The term **doline** is sometimes used to refer the collapse sinks. Solution sinks are more common than collapse sinks. Quite often the surface run-off simply goes down swallow and sink holes and flow as underground streams and re-emerge at a



distance downstream through a cave opening. When sinkholes and dolines join because of slumping of materials along their margins or due to roof collapse of caves, long, narrow to wide trenches called **valleysinks** or **Uvalas** form.

Gradually, most of the surface of the limestone is eaten away by these pits and Trenches, leaving it extremely irregular with a maze of points, grooves and **ridges** or **lapies**.

Especially, these ridges or lapies form due to differential solution activity along parallel to sub-parallel joints. The lapie field may eventually turn into somewhat smooth **limestone pavements**.

Caves

In areas where there are alternating beds of rocks with limestone or dolomites in between or in areas where, limestone are dense, massive and occurring as thick beds, cave formation is prominent. Water percolates down either through the materials or through cracks and joints and moves horizontally along bedding planes. It is along these bedding planes that the limestone dissolves and long and narrow to wide gaps called **caves**

Depositional Landforms

Many depositional forms develop within the limestone caves. The chief chemical in lime stone is calcium carbonate, which is easily soluble in carbonated water (carbon dioxide absorbed rainwater). This calcium carbonate is deposited when the water carrying it in solution evaporates or loses its carbon dioxide as it trickles over rough rock surfaces. **Stalactites, Stalagmites and Pillars**

Stalactites hang as icicles of different diameters. Normally they are broad at their bases and taper towards the free ends showing up in a variety of forms. **Stalagmites** rise up from the floor of the caves. In fact, stalagmites form due to dripping water from the surface or through the thin pipe, of the stalactite, immediately below it,. Stalagmites may take the shape of a column, a disc, with



either a smooth, rounded bulging end or a miniature crater like depression. The stalagmite and stalactites eventually fuse to give rise to **columns and**

pillars of different diameters

Difference between stalagmites and stalactites

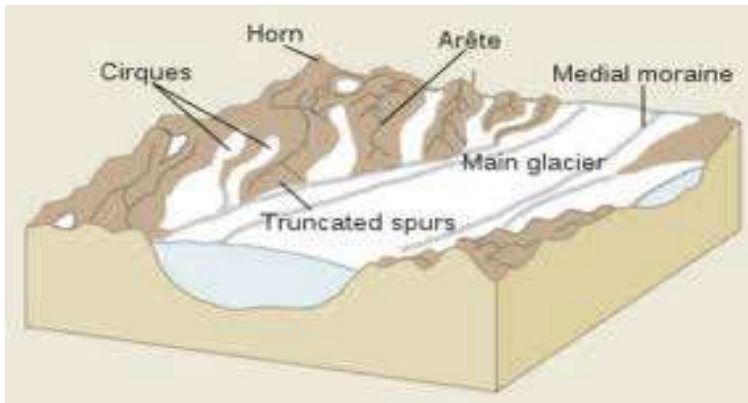
STALAGMITES	STALACTITES
Grow from the floor Broad base Formed due to evaporation of water Broad edge They are pillar shape	Grow from the roof Narrow base Formed due to condensation Sharp edge They are conical shape

GLACIERS

Masses of ice moving as sheets over the land (continental glacier or piedmont glacier if a vast sheet of ice is spread over the plains at the foot of mountains) or as linear flows down the slopes of mountains in broad trough-like valleys (mountain and valley glaciers) are called **glaciers**.

Cirque

Cirques are the most common of landforms in glaciated mountains. The cirques quite often are found at the heads of glacial valleys. The accumulated ice cuts these cirques while moving down the mountain tops. They are deep, long and wide troughs or basins with very steep concave to vertically dropping high walls at its head as well as sides. A lake of water can be seen quite often within the cirques after the glacier disappears.



Such lakes are called **cirque or tarn lakes**. There can be two or more cirques one leading into another down below in a stepped sequence.

Horns and Serrated Ridges

Horns form through head ward erosion of the cirque walls. If three or more radiating glaciers cut head ward until their cirques meet, high, sharp pointed and steep sided peaks called **horns** form. The divides between cirque sidewalls or head walls get narrow because of

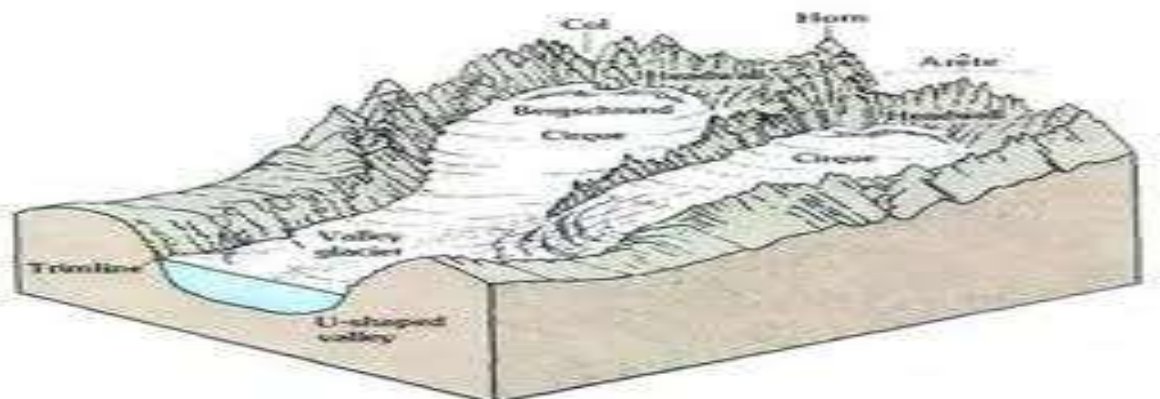
progressive erosion and turn into serrated or saw-toothed ridges sometimes referred to as **arêtes** with very sharp crest and a zig-zag

Outline.
MORAINS



Glacial Valleys/Troughs

Glaciated valleys are trough-like and **U-shaped** with broad floors and relatively smooth, and steep sides. The valleys may contain littered debris or debris shaped as **moraines** with swampy appearance. There may be lakes gouged out of rocky floor or formed by debris within the valleys. There can be hanging valleys

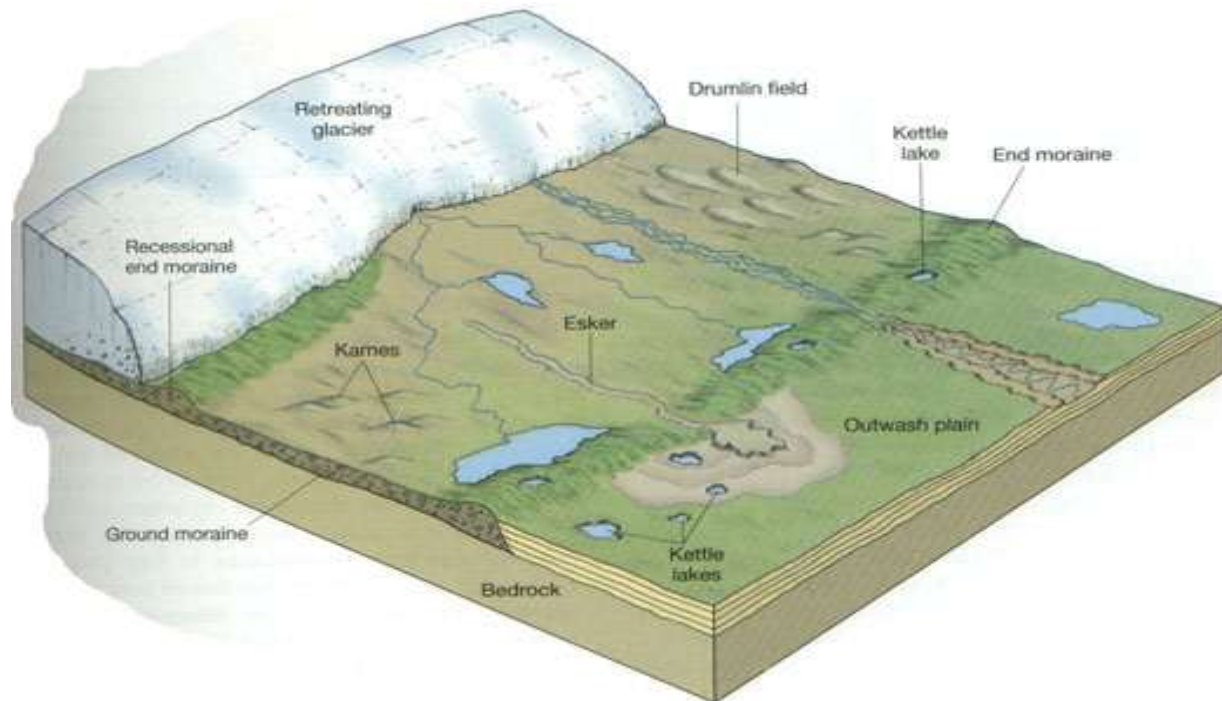


at an elevation on one or both sides of the main glacial valley. The faces of divides or spurs of such hanging valleys opening into main glacial valleys are quite often truncated to give them an appearance like triangular facets. Very deep glacial troughs filled with sea water and making off shore lines (in high latitudes) are called **fjords/fiords**. fiords at the Norway coast

Depositional Landforms



The unsorted coarse and fine debris dropped by the melting glaciers is called **glacial till**. Most of the rock fragments in till are angular to sub angular in form. Streams form by melting ice at the bottom, sides or lower ends of glaciers. Some amount of rock debris small enough to be carried by such melt-water streams is washed down and deposited. Such glacio-fluvial deposits are called **outwash deposits**. Unlike till deposits, the outwash deposits are roughly stratified and assorted. The rock fragments in outwash deposits are somewhat rounded at their edges. Figure 7.14 shows a few depositional landforms commonly found in glaciated areas.



TYPES OF MORAINS

They are long ridges of deposits of **glacial till**. Terminal moraines are long ridges of debris deposited at the end of the glaciers. **Lateral moraines** form along the sides parallel to the glacial valleys. The lateral moraines may join a terminal moraine forming a horse-shoe shaped ridge. There can be many lateral moraines on either side in a glacial valley. These moraines partly or fully owe their origin to glacio fluvial waters pushing up materials to the sides of glaciers. Many valley glaciers retreating rapidly leave an irregular sheet of till over their valley floors. Such deposits varying greatly in thickness and in surface topography are called **ground moraines**. The moraine in the center of the glacial valley flanked by lateral moraines is called **medial moraine**. They are imperfectly formed as compared to lateral moraines. Sometimes medial moraines are indistinguishable from ground moraines.

Eskers

When glaciers melt in summer, the water flows on the surface of the ice or seeps down along the margins or even moves through holes in the ice. These waters accumulate beneath the glacier and flow like streams in a channel beneath the ice. Such streams flow over the ground (not in a valley cut in the ground) with ice forming its banks. Very coarse materials like boulders and blocks along with some minor fractions of rock debris carried into this stream settle in the valley of ice beneath the glacier and after the ice melts can be found as a sinuous ridge called **esker**.

Outwash Plains

The plains at the foot of the glacial mountains or beyond the limits of continental ice sheets are covered with glacio-fluvial deposits in the form of broad flat alluvial fans which may join to form outwash plains of gravel, silt, sand and clay. Distinguish between river alluvial plains and glacial outwash plains.

Drumlins

Drumlins are smooth oval shaped ridge-like features composed mainly of glacial till with some masses of gravel and sand. The long axes of drumlins are parallel to the direction of ice movement. They may measure up to 1 km in length and 30 m or so in height. One end of the drumlins facing the

glacier called the **stoss** end is blunter and steeper than the other end called **tail**. The drumlins form due to dumping of rock debris beneath heavily loaded ice through fissures in the glacier. The **stoss** end gets blunted due to pushing by moving ice. Drumlins give an indication of direction of glacier movement.

COASTAL LAND FORMS

Other than the action of waves, the coastal landforms depend upon (i) the configuration of land and sea floor;

(ii) whether the coast is advancing (emerging) seaward or retreating (submerging) landward.

Assuming sea level to be constant, two types of coasts are considered to explain the concept of evolution of coastal landforms:

- (i) high, rocky coasts (submerged coasts);
- (ii) low, smooth and gently sloping sedimentary coasts (emerged coasts)

HIGH ROCKY COASTS

Along the high rocky coasts, the rivers appear to have been drowned with highly irregular coastline. The coastline appears highly indented with extension of water into the land where glacial valleys (**fiords**) are present.

Along high rocky coasts, waves break with great force against the land shaping the hill sides into cliffs. With constant pounding by waves, the cliffs recede leaving a **wave-cut platform** in front of the sea cliff..

Bars are submerged features and when bars show up above water, they are called **barrier bars**.

Barrier bar which get keyed up to the headland of a bay is called a **spit**.

When barrier bars and spits form at the mouth of a bay and block it, a **lagoon** forms.

The lagoons would gradually get filled up by sediments from the land giving rise to a **coastal plain**.

LOW SEDIMENTARY COASTS

Along low sedimentary coasts the rivers appear to extend their length by building coastal plains and deltas. The coastline appears smooth with occasional incursions of water in the form of **lagoons and tidal creeks**.

The land slopes gently into the water. Marshes and swamps may abound along the coasts. Depositional features dominate. When waves break over a gently sloping sedimentary coast, the bottom sediments get churned and move readily building **bars, barrier bars, spits and lagoons**.

Lagoons would eventually turn into a swamp which would subsequently turn into a coastal plain.

The west coast of our country is a high rocky retreating coast. Erosional forms dominate in the west coast. The east coast of India is a low sedimentary coast. Depositional forms dominate in the east coast.

EROSIONAL LANDFORMS

Cliffs, Terraces, Caves and Stacks

Wave-cut cliffs and terraces are two forms usually found where erosion is the dominant shore process. Almost all sea cliffs are steep and may range from a few m to 30 m or even more. At the foot of such cliffs there may be a flat or gently sloping platform covered by rock debris derived from the sea cliff behind. Such platforms occurring at elevations above the average height of waves is called a **wave-cut terrace**.

EROSIONAL FEATURES OF WAVES



The lashing of waves against the base of the cliff and the rock debris that gets smashed against the cliff along with lashing waves create hollows and these hollows get widened and deepened to form **sea caves**.

The roofs of caves collapse and the sea cliffs recede further inland. Retreat of the cliff may leave some remnants of rock standing isolated as small islands just off the shore. Such resistant masses of rock, originally parts of a cliff or hill are called **sea stacks**.

Like all other features, sea stacks are also temporary and eventually coastal hills and cliffs will disappear because of wave erosion giving rise to narrow coastal plains, and with onrush of deposits from over the land behind may get covered up by alluvium or may get covered up by shingle or sand to form a wide beach.

DEPOSITIONAL LANDFORMS

Beaches and Dunes

Beaches are characteristic of shorelines that are dominated by deposition, but may occur as patches along even the rugged shores. Most of the sediment making up the beaches comes from land carried by the streams and rivers or from wave erosion. Beaches are temporary features. The sandy beach which appears so permanent may be reduced to a very narrow strip of coarse pebbles in some other season. Most of the beaches are made up of sand sized materials. Beaches called shingle beaches contain excessively small pebbles and even cobbles.

Bars, Barriers and Spits

A ridge of sand and shingle formed in the sea in the off-shore zone (from the position of low tide waterline to seaward) lying approximately parallel to the coast is called an **off-shore bar**.

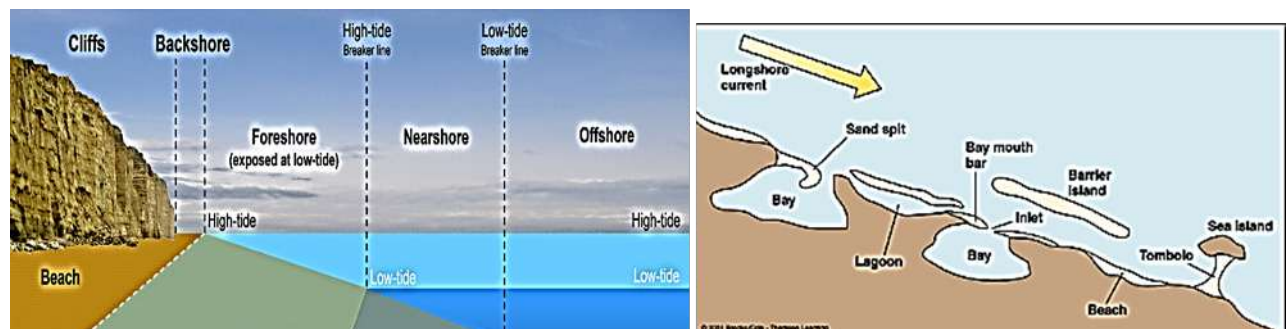
An off-shore bar which is exposed due to further addition of sand is termed a **barrier bar**.

The off-shore bars and barriers commonly form across the mouth of a river or at the entrance of a bay. Sometimes such barrier bars get keyed up to one end of the bay when they are called **spits** (Figure 7.15). Spits may also develop attached to headlands/hills.

The barriers, bars and spits at the mouth of the bay gradually extend leaving only a small opening of the bay into the sea and the bay will eventually develop into a lagoon.

The lagoons get filled up gradually by sediment coming from the land or from the beach itself (aided by wind) and a broad and wide coastal plain may develop replacing a lagoon.

Depositional features of the sea waves



WINDS

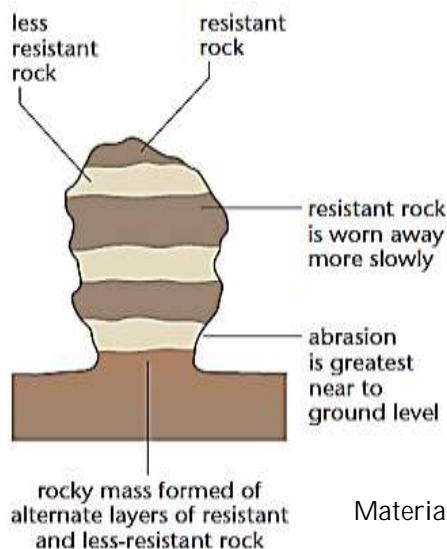
Wind is one of the two dominant agents in hot deserts.

Winds cause deflation, abrasion and impact.

Deflation includes lifting and removal of dust and smaller particles from the surface of rocks.

In the transportation, process sand and silt act as effective tools to abrade the land surface.

The impact is simply sheer force of momentum, which occurs when sand is blown into or against a rock surface



EROSIONAL LANDFORMS

Pediments and Pedit plains

Landscape evolution in deserts is primarily concerned with the formation and extension of pediments. Gently inclined rocky floors close to the mountains at their foot with or without a thin cover of debris, are called **pediments**.

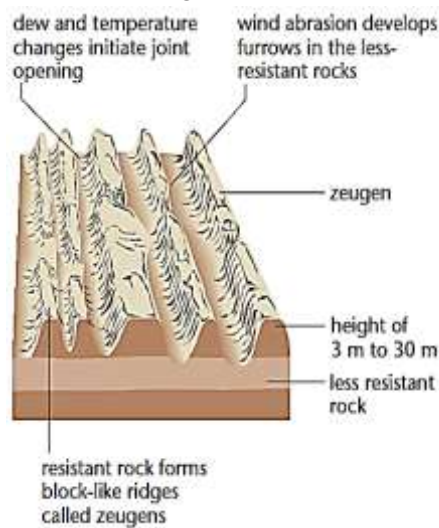
Such rocky floors form through the erosion of mountain front through a combination of lateral erosion by streams and sheet flooding.

Erosion starts along the steep margins of the landmass or the steep sides of the tectonically controlled steep incision features over the landmass. Once, pediments are formed with a steep wash slope followed by

cliff or free face above it, the steep wash slope and free face retreat backwards. This method of erosion is termed as parallel retreat of slopes through back wasting.

So, through parallel retreat of slopes, the pediments extend backwards at the expense of mountain front, and gradually, the mountain gets reduced leaving an **inselberg** which is a remnant of the mountain.

That's how the high relief in desert areas is reduced to low featureless plains called **Pedi plains**.



Playas Plains are by far the most prominent landforms in the deserts. In basins with mountains and hills around and along, the drainage is towards the center of the basin and due to gradual deposition of sediment from basin margins, a nearly level plain forms at the center of the basin. In times of sufficient water, this plain is covered up by a shallow water body. Such types of shallow lakes are called as **playas** where water is retained only for short duration due to evaporation and quite often the playas contain good deposition of salts. The playa plain covered up by salts is called **alkali flats**.

Deflation Hollows and Caves

Weathered mantle from over the rocks or bare soil, gets blown out by persistent movement of wind currents in one direction. This process may create shallow depressions called **deflation hollows**.

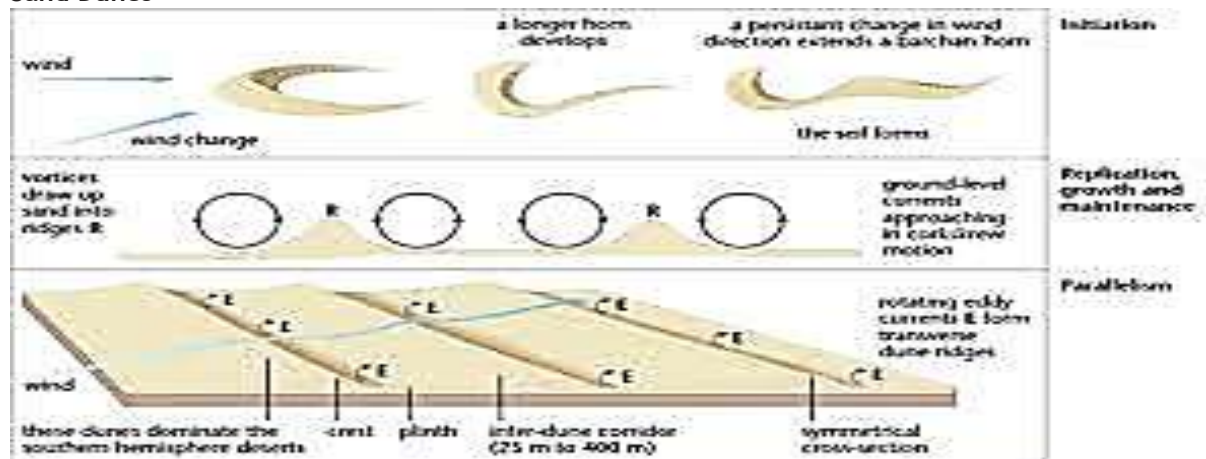
Deflation also creates numerous small pits or cavities over rock surfaces. The rock faces suffer impact and

abrasion of wind-borne sand and first shallow depressions called blow outs are created, and some of the **blow outs** become deeper and wider fit to be called **caves**.

Mushroom, Table and Pedestal Rocks Many rock-outcrops in the deserts easily susceptible to wind deflation and abrasion are worn out quickly leaving some remnants of resistant rocks polished beautifully in the shape of mushroom with a slender stalk and a broad and rounded pear shaped cap above. Sometimes, the top surface is broad like a table top and quite often, the remnants stand out like pedestals.

Wind is a good sorting agent. Depending upon the velocity of wind, different sizes of grains are moved along the floors by rolling or saltation and carried in suspension and in this process of transportation itself, the materials get sorted. When the wind slows or begins to die down, depending upon sizes of grains and their critical velocities, the grains will begin to settle. So, in depositional landforms made by wind, good sorting of grains can be found. Since wind is there everywhere and wherever there is good source of sand and with constant wind directions, depositional features in arid regions can develop anywhere.

Sand Dunes

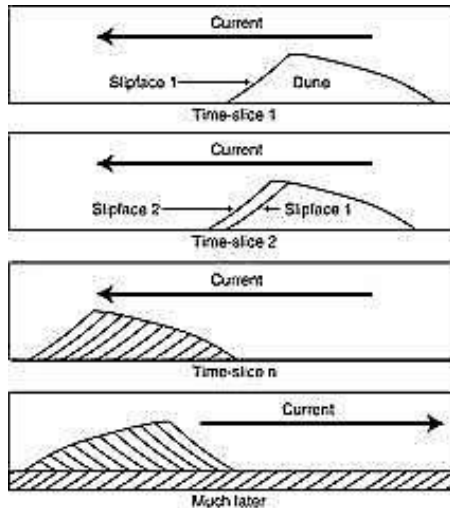


Dry hot deserts are good places for sand dune formation. Obstacles to initiate dune formation are equally important. There can be a great variety of dune forms Crescent shaped dunes called **barchans**

with the points or wings directed away from wind direction i.e., downwind, form where the wind direction is constant and moderate and where the original surface over which sand is moving is almost uniform.

Parabolic dunes form when sandy surfaces are partially covered with vegetation. That means parabolic dunes are reversed barchans with wind direction being the same.

Seif is similar to barchan with a small difference. Seif has only one wing or point. This happens when there is shift in wind conditions. The lone wings of seifs can grow very long and high. Longitudinal dunes form when supply of sand is poor and wind direction is constant. They appear as long ridges of considerable length but low in height.



Transverse dunes are aligned perpendicular to wind direction. These dunes form when the wind direction is constant and the source of sand is an elongated feature at right angles to the wind direction. They may be very long and low in height. When sand is plenty, quite often, the regular shaped dunes coalesce and lose their individual characteristics. Most of the dunes in the deserts shift and a few of them will get stabilized especially near human habitations.

