



Unit 4

Lithosphere: Exogenic Processes



Chapter Outline

- 4.1 Introduction
- 4.2 Exogenic Processes
- 4.3 Weathering
- 4.4 Mass wasting
- 4.5 Gradational Processes
- 4.6 The River
- 4.7 Glacier
- 4.8 Ground water (Karst Topography)
- 4.9 Wind
- 4.10 Waves (Coast)



At Mahabalipuram, Chennai, the 6 meter high and 5-metre wide rock estimated to weigh over 250 tons is known locally as Krishna's Butter Ball. Its original Tamil name is "Vaanirai Kal" which literally translates to "Stone of The Sky God"

Look at the figure above Krishna's Butter ball inserted on the top and let's discuss:

- What, do you think, made this rock stone to get this shape.
- Guess how many years it might have taken to get such a shape.
- Think about how it is standing balanced.

Learning Objectives:

- Understand how external forces reshape the surface of the earth.
- Distinguish between physical weathering and chemical weathering.
- Identify the different types of mass wasting and its characteristics.
- Distinguish between the actions of various gradational agents.

4.1 Introduction

Let's recall that you have learned in the previous chapter about geomorphic processes - Endogenic processes in detail. Now we deal with the exogenic processes. The forces which act on the earth's exterior are called as exogenic forces or external

forces. The action of exogenic forces results in wearing down the rock and hence, they are considered as land wearing forces.

4.2 Exogenic Processes

The processes which occur on earth's surface due to the influence of external forces are called as exogenic processes. Weathering, mass wasting and denudation are the major exogenic processes. The elements of nature capable of doing these exogenic processes are termed as gradational agents. For instance, the wind, river, glacier, waves and ground water.

4.3 Weathering

Weathering is the process of disintegration and decomposition of rocks. It is due to the action of climate, plants, animals and other living organisms which cause the rocks to break down physically, chemically and biologically.

There are three types of weathering. They are physical weathering, chemical weathering and biological weathering.

4.3.1 Physical weathering

Physical Weathering is the disintegration of rock mainly induced by elements of weather. It produces smaller, angular fragments of the same rock. It is caused by the change in temperature, pressure, water and wind. Physical weathering is further divided into different categories. They are thermal weathering, frost wedging and exfoliation.

4.3.1.1 Thermal weathering

In arid and semi-arid areas, the temperature increases, heat up and expand the rocks during the day and contract the rock materials when cooling at night. Under extreme temperature conditions, due to alternate expansion and contraction, the rocks crack and eventually split. The thermal weatherings are of two types. They are;

- Granular disintegration and
- Block disintegration

Granular disintegration

Alternate expansion and contraction of minerals of varying properties in the

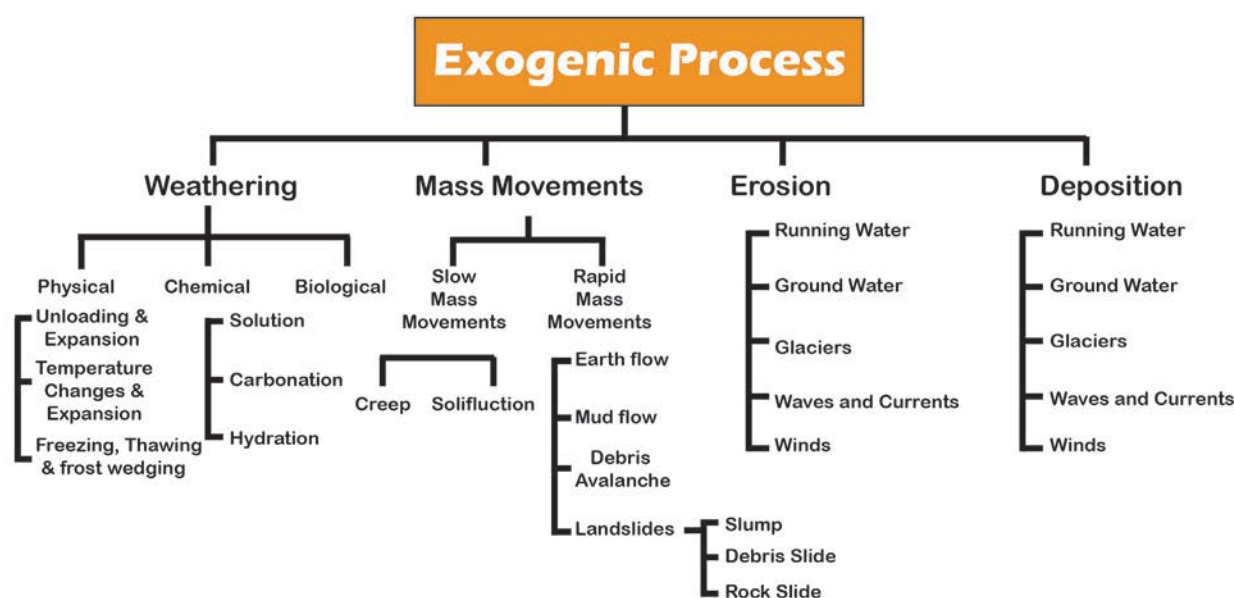


Figure 4.1 Exogenic processes



Rock Exfoliated and Abraided



Figure 4.2 Exfoliated Rock(left) and Granular (right)

rocks due to temperature changes, makes the rocks break down into small pieces (Figure 4.2). Due to this, the breakup of rocks occurs, grain by grain. This is known as **granular disintegration**.

Block disintegration occurs in rocks such as granite rock. So in the areas of jointed igneous or layered sedimentary rocks due to the great diurnal range of temperature, the rocks may break up along the joints and cracks into a large rectangular shaped blocks.

4.3.1.2 Frost Wedging

Almost all liquids contract when frozen, but when water freezes it becomes larger in size or takes up more space. As water expands it puts great pressure on rocks. When water enters into the cracks of

rocks and freezes, the pressure exerted on the rock is enough to wedge the walls of the crack farther apart, thus expanding and deepening the crack. Thus, frost wedging results in weathering of rock.

4.3.1.3 Exfoliation

Rocks generally heat or cool more on the surface layers. The alternate changes in temperature could cause their outer layers to peel off from the main mass of the rock in concentric layers just as the skin of an onion. The process by which curved layers of rock breakaway from the rock beneath them leaving behind dome shaped monoliths is called exfoliation (Figure 4.2). It is also called as 'onion weathering'. Exfoliation occurs commonly in the arid areas.

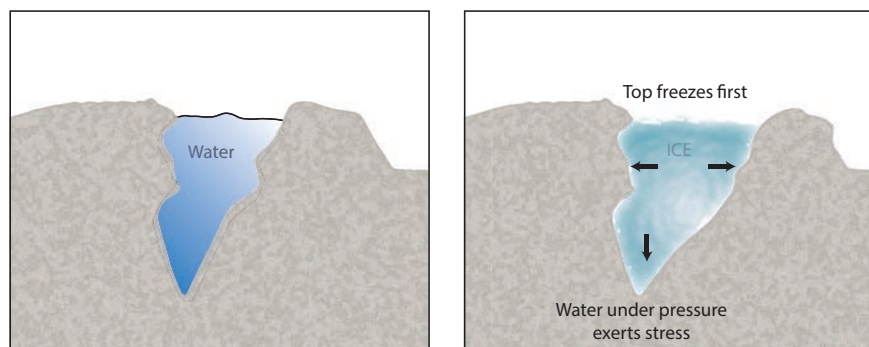


Figure 4.3 Frost Wedging





4.3.2. Chemical Weathering

Chemical weathering is the decomposition of rock. For example it creates altered rock substances, such as kaolinite (china clay) from granite. The types of chemical weathering are as follows:

- i. **Solution:** Some soluble minerals in the rock get dissolved when come in contact with water. Over a long period minerals get washed away from rock and sometimes leading to the formation of caves.
- ii. **Oxidation:** When oxygen combines with water and iron, it weakens the rock and breaks it. Example, rusting of iron.
- iii. **Hydrolysis:** It is the chemical breakdown of a rock substance when combined with water and forms an insoluble precipitate like clay mineral. The most common example of hydrolysis is feldspar found in granite changing to clay.
- iv. **Carbonation:** Carbonation is the mixing of water with carbon dioxide to make carbonic acid. This acid reacts with minerals in the rocks. This type of weathering is important in the formation of caves.
- v. **Hydration:** It is the absorption of water into the mineral structure of the rock. Hydration expands volume and also results in rock deformation. A good example of hydration is the absorption of water by anhydrite, resulting in the formation of gypsum.

4.3.3 Biological Weathering

Biological weathering is the alteration of rock by the action of plants, animals, and man. Burrowing and wedging by organisms like earthworms, termites, rodents, etc., help

in exposing the rock surfaces to chemical changes with the penetration of moisture and air. Human beings by removing vegetation for agriculture and other activities also help in mixing and creating new contacts between air, water, and minerals in the rock materials. Plant roots make a great pressure on the rock materials mechanically breaking them apart.



Figure 4.4 biological weathering

4.4 Mass wasting

Mass wasting is the movement of a large mass of rock, soil and debris downward by the pull of gravity. It is also called a mass movement or slope movement. It may happen suddenly or slowly. Generally, mass wasting is classified by the type of material involved (mud, soil, and rock) and type of motion (**fall**-free-falling pieces, **slide**-material moves along the rock slope and **flow**-material mixed with water).

4.4.1 Types of Mass Wasting

Following are the types of mass wasting:

Rock falls

Rock falls occur when pieces of rock break from a cliff. Frost wedging may also eventually loosen large blocks causing them to fall. The accumulation of rock debris at the base of a steep slope is called **talus**.

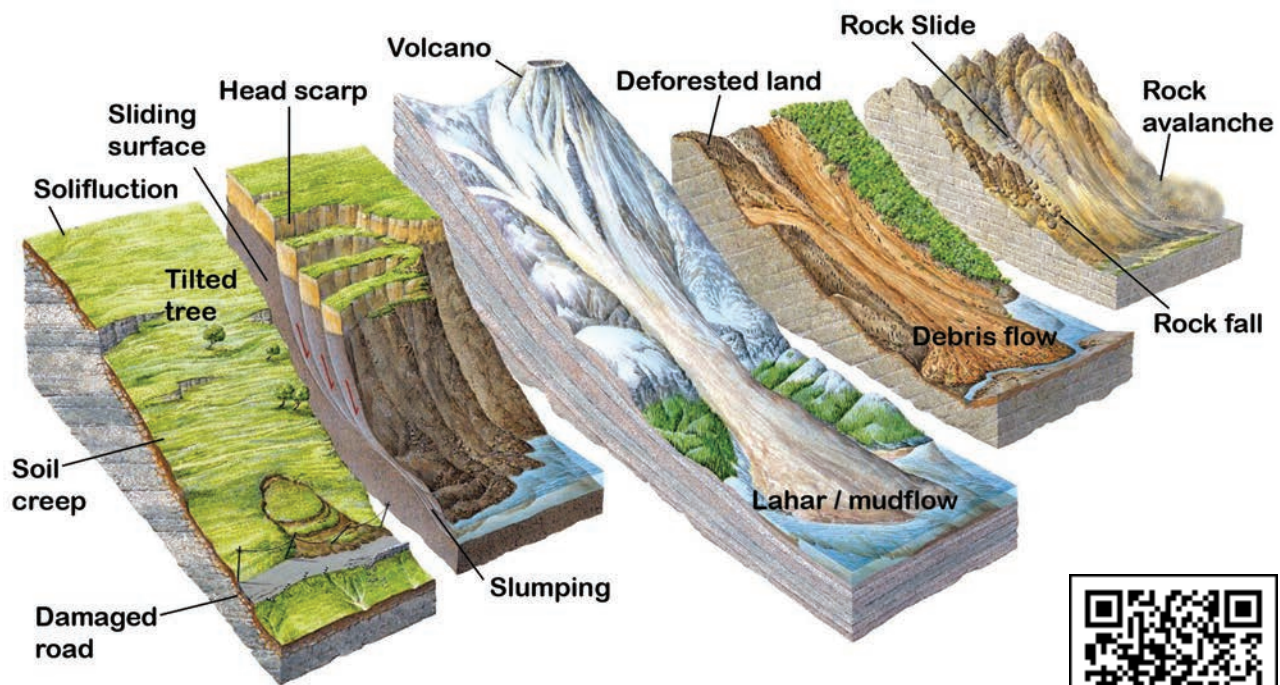


Figure 4.5 Mass movement



Figure 4.6 Rock fall

Rock slides

Rockslides usually follow a zone of weakness. Presence of water increases slippage. Collisions down the slope generally break the rock mass into rubble that eventually results in rockslides.

Land slides

Landslides occur when a large piece of rock breaks off and slides down hill. It is often initiated by earthquakes and very heavy rain.

Slump

Great mass of bed rock moves downward by rotational slip from a high cliff is known as slump. Most common reason for slumping is erosion at the base of the slope which reduces the support for overlying sediments.

Debris Slide

Debris slide is more extensive and occurs on a larger scale than slump but there is a little amount of water. The materials involved in debris slide are a mixture of soils and rock fragments.

Debris flows

Debris flow is defined as mass wasting event in which turbulence occurs throughout the mass. Debris flow includes earth flows, mudflows, and debris avalanches. Debris flow occurs when the rock or soil mass loses coherency when lots of water is involved. Debris becomes mixed up completely and flows as liquid mud. It often carries large boulders which can be

very destructive. When earth material moves down a hillside as a fluid-like mass, it is called an **earth flow**. These flows typically occur in humid areas on steep slopes with thick, clay-rich soil that becomes saturated with water during storms.



Figure 4.7 Debris flow

A mudflow

Mudflow is a liquid mass of soil, rock debris and water that moves quickly down a well defined channel. They occur most often in mountainous semiarid environments. A mudflow originating on a volcanic slope is called a **lahar**.

Debris avalanche

The deadliest type of debris flow is **the debris avalanche**. It is a rapidly churning mass of rock debris, soil, water, and air that moves down steep slopes. The trapped air may increase the speed of an avalanche by acting as a cushion between the debris and the underlying surface

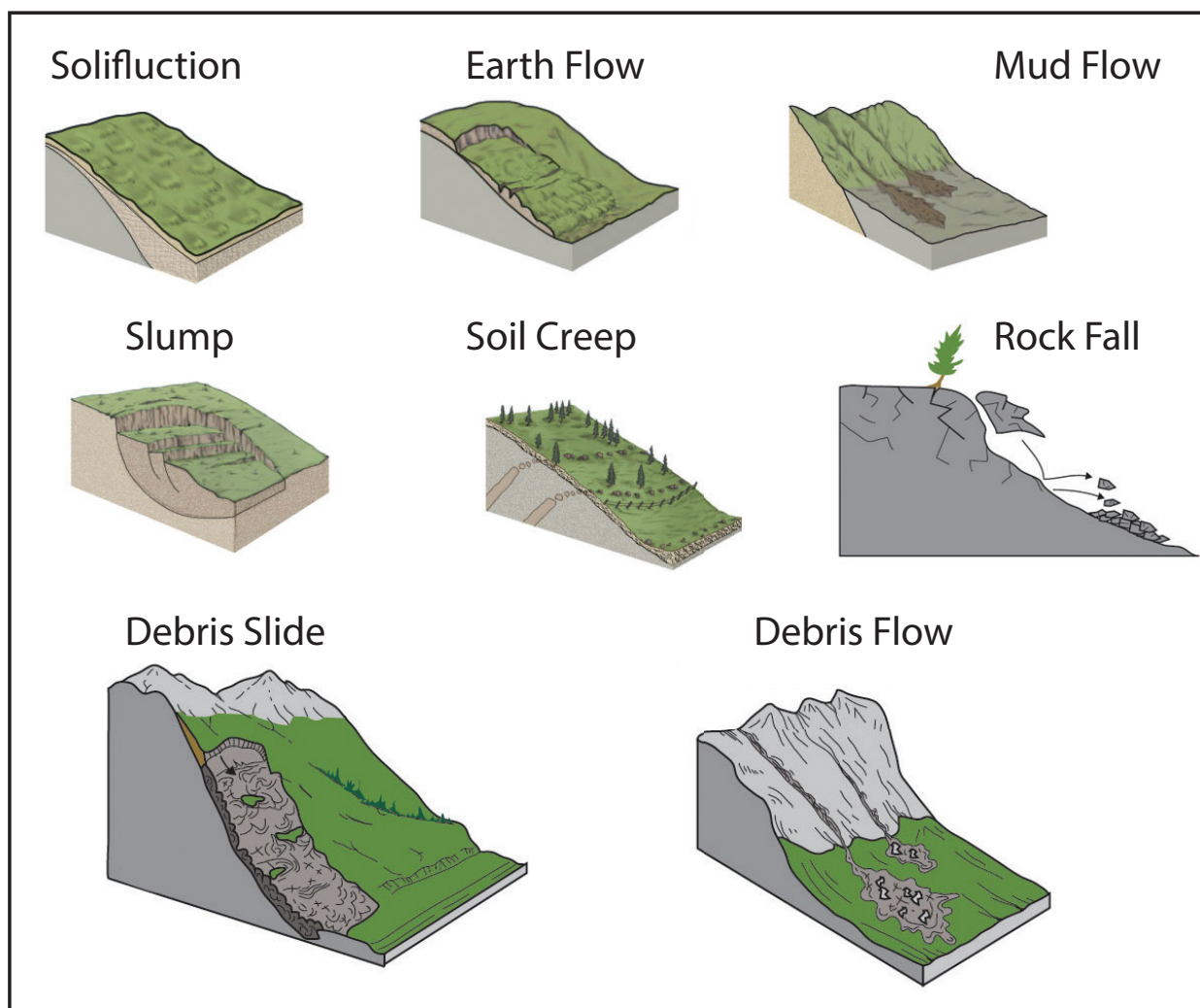


Figure 4.8 Mass Movement



Creep

Creep is a slow and gradual movement of soil downhill. Its velocity is typically less than a centimetre per year. Freezing and thawing contribute the soil creep by progressively moving soil particles down the hill. Creep is manifested at the surface by things like tilted utility poles, fences and trees. Vegetation helps reduce the rate of soil creep.

4.5. Gradational Processes

Gradation is the process by which the earth's surface gets leveled. It can be further divided into degradation, the process of eroding the earth's elevated surface and aggradations, the process of filling up the earth's depressions.

4.5.1 Gradational Agents

The forces which act on the surface of the earth are termed as Gradational agents. Water, wave, wind, ice are the important gradational agents. Let us now discuss the gradational agents one by one.

4.6. The River

The streams have a huge capacity to erode the rock over which they flow. In fact, the formation of the river channel is the result of the erosional capacity of the stream. The erosional capacity of the stream depends on its volume of water and velocity of flow. The river performs three types of work. They are erosion, transportation and deposition.

1. **Erosion:** The breaking of rocks by the river in along its course is called erosion. Erosional work of a river is performed mechanically and chemically. River erosion is carried out in the following ways:
 - i. **Hydraulic action:** It refers to the physical force of the moving water which breaks the rocks in its course.

- ii. **Corrasion (abrasion):** It refers to the breaking of rock in the bed and on the bank by fragments carried by the stream.
 - iii. **Corrosion(solution):** It refers to the dissolving process of soluble minerals by the splashing of stream water.
 - iv. **Attrition:** It refers to the eroded materials carried by the stream strike against each other.
2. **Transportation:** Stream carrying the fragmented materials broken by the stream is called transportation. After erosion, the eroded materials get transported along with the running water. This transportation of eroded materials is carried in four ways:
 - i. **Traction:** The heavier and larger rock fragments like gravels, pebbles etc are forced by the flow of the river to roll along its bed. These fragments can be seen rolling, slipping, bumping and being dragged. This process is called as traction and the load transported in this way are called traction load.
 - ii. **Saltation:** Some of the fragments of the rocks move along the bed of a stream by bouncing continuously. This process is called as saltation.
 - iii. **Suspension:** The holding up of small particles of sand, silt, and mud by the water as the stream flows is called suspension.
 - iv. **Solution:** Some parts of the rock fragments dissolve in the river water and transported. This type of transportation is called solution transportation.
 3. **Deposition:** When the velocity of the stream decreases, the stream deposits sand, silt and other fragments. It is

called as the deposition. When a river moves in a gentle slope, its speed reduces and river begins to deposit its load. The river starts depositing larger materials first and smaller and finer materials are carried further down to the mouth of the river.

4.6.1 Stages of the River

The course of a river includes the upper stage, the middle stage, and the final stage. Each stage of the river is dominated by a kind of work. Let's discuss the stages of a river, the main work and the landforms made in each stage.

1. The Upper Stage

The upper stage of a river is also called the youthful stage or mountain stage. The velocity and speed of the stream are very high because the slope here is steep. The vertical erosion is the most dominant work here. The valley is formed here. The place where a river starts is called a **source**. In the mountain stage, the number of small streams originates from different locations. They are called **Tributaries**. The place

where two rivers join is called as **the confluence**. The mountain which has two river systems draining on either side of the slope is termed as **the water divide**.

2. The Middle Stage

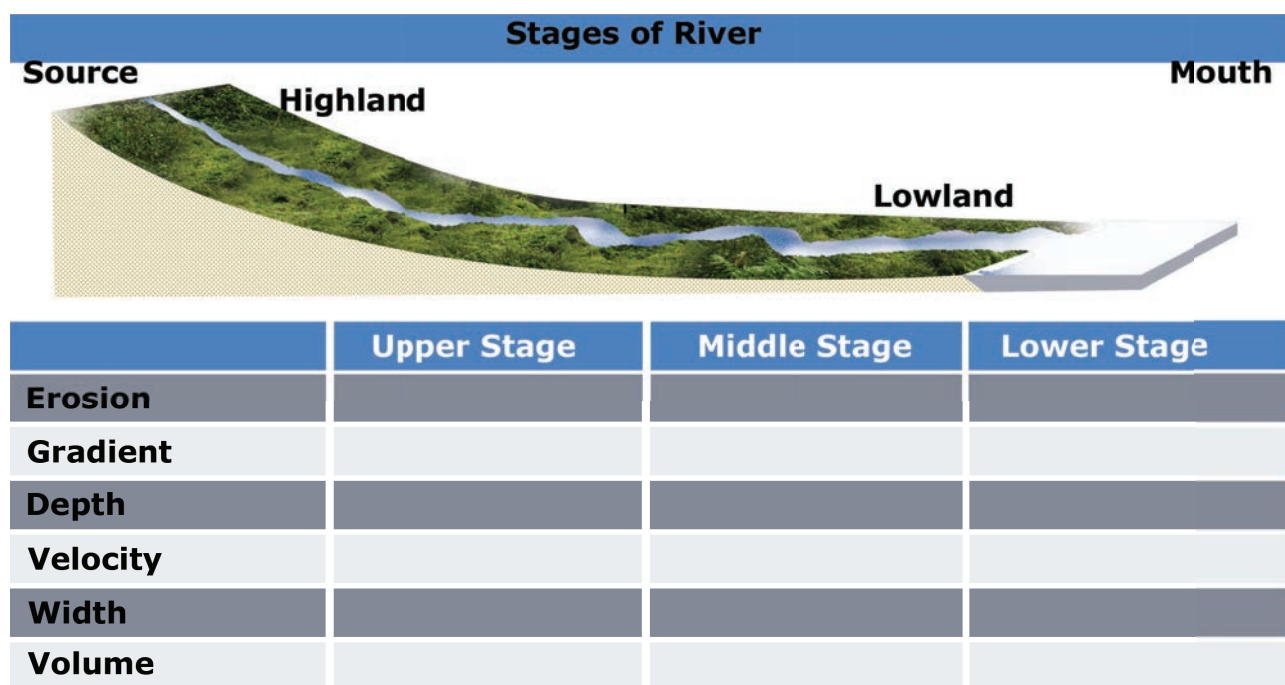
Middle stage is the matured stage of a river. Vertical erosion or deepening of the valley is significantly reduced. Lateral erosion is the dominant work. Due to the lateral erosion of this stage, the widening of the valley occurs. The volume of the river water increases and the slope of river is moderate. The depth of the river is deep here.

3. The Lower Stage

This is the final stage of a river where the valleys are extremely broad and it has generally gentle slope. The valley becomes almost flat which is called a peneplain. Most of the peneplain forms low residual

Students activity

Look at the diagram, read the table of content carefully and fill in the columns with suitable words.





hills with steep slopes which are called as Monadnocks. The main work of the river in this stage is the deposition. The depth of the river is shallow here. When the main river splits into many small rivers, they are called as the distributaries. The place where the river ends is called mouth of the river. (for example: Sea coast, Lake.)

4.6.2 Landforms by the Erosional Work of River

The significant landforms resulting from erosion by rivers include gorge, canyon, V-Shaped Valley, waterfall, pothole, structural bench, river terrace, river meander, ox-bow lake, peneplain, etc.

Gorges are formed due to active down cutting of the valleys. So, a Gorge is a narrow and deep river valley which has steep slopes.



Figure 4.9 Gorge

Canyons are extended form of gorges. Canyons represent very deep, narrow but long valleys. The steepness of the valley sides depends on the nature of the rocks. The Grand Canyon of the Colorado River in the state of Arizona, USA having a length of 482.8 kilometers and depth of 2088.3 meter is the largest canyon in the world. The Canyon of Gandikota is situated on the Pennar River in Andhra Pradesh is known as the Grand Canyon of India.

V-Shaped Valley: The valleys made by the rivers are erosional landforms. The valley is formed in the youthful stage of the river erosion. Due to the steep slope and large volume of water, the river cuts its bed vertically forming narrow and deep river valley. This is called as V-shaped valley.

Rapids and waterfalls

Rapids are stream sections with extremely strong currents, numerous obstacles, and steps in their streambeds. A waterfall is a vertical drop in a streambed. Both water fall and rapids are formed by vigorous erosion. Series of a waterfall in a river is called as Cascade.

Plunge pool

A plunge pool is a deep depression in a stream bed at the base of a waterfall. It is created by the erosional forces of falling water at the base of a waterfall.



Angel Falls, in Venezuela, is Earth's highest waterfall (979 m).



CASE STUDY



Figure 4.10 The Canyon of Gandikota, the Pennar River in Andhra Pradesh

Gandikota, Kadapa district of Andhra Pradesh is known for its spectacular gorge formed by river Pennar that cuts through the Erramala hills. This handsome piece of Nature's architecture is known as the **Hidden Grand Canyon of India**. Magnificent Gandikota fort is located majestically on top of this gorge. Belum Cave found here is the second largest cave system in India. In fact, geologists have also found **surplus deposits of Quartz** in the stalactite and stalagmite formations of the cave. Adjacent to Gandikota fort, lies a magnificent lake that is believed to have been established by emperor Sri Krishnadevaraya using water from the Pennar river.

Grooves

Long and narrow depression at the base of a waterfall made by river runoff is called a groove. The grooves are created by water eroding soil from a hill or mountain in a short period of time.

The swirling movement of the water falling into the plunge pool is called **eddy**ing.

Interlocking spurs

An **interlocking spur**, also known as an **overlapping spur**, is a projecting

ridge that extends alternately from the opposite sides of a V-shaped valley. A river with a winding course flows down the interlocking spur.

Web link:

More at <https://www.livehistoryindia.com/geological-wonders/2017/05/24/gandikota-the-grand-canyon-of-india-2>)



Figure 4.11 Hogenakal waterfalls, Dharmapuri, Tamil Nadu

Pot Holes

The kettle-like small depressions in the rocky beds of the river valleys are called potholes. They are always cylindrical in shape. Potholes are generally formed in coarse-grained rocks such as sandstones and granites.

River Terraces

The narrow step like flat surfaces on either side of the valley floor are called river terraces. They represent the level of former valley floors.

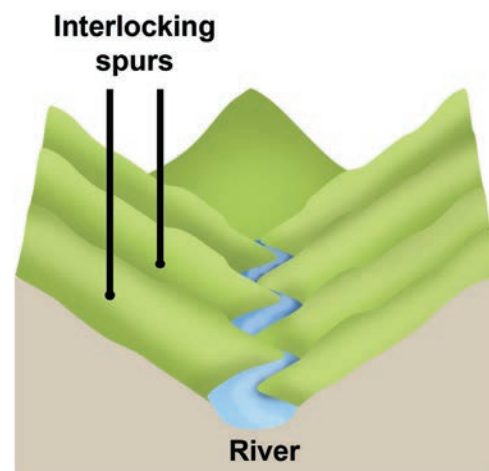


Figure 4.12 Interlocking spurs



4.6.3 Landforms by the deposition of river

1. Alluvial fan

Alluvial fans are often found at the foot of arid or semiarid mountain ranges where intermittent streams flow. An alluvial fan is a fan shaped deposit of gravel, sand and other smaller particles of sediment.

Alluvial fans are found in Kosi river, Himalayan region, Death Valley National Park and along the sides of the Colorado River at Grand Canyon National Park, U.S.



Figure 4.13 Alluvial Fan

2. Peneplains

Peneplains represent low featureless plain having undulating surface and remnants of convex-concave residual hills.

3. Meander

A **meander** is a winding curve or bend in a river. **Meanders** are the result of both erosional and depositional processes. They are typical landform of the middle and lower course of a river. This is formed by vertical erosion, lateral erosion, and deposition within the floodplain.

4. Oxbow lake

Oxbow lake is a free standing body of water formed when the meander is cut

off from the main river. This landform is so named because it resembles horse shoe

5. Levees: Raised bed and a bank of the river due to frequent flooding and deposition of the sediments is called levees.

6. Flood Plain

A flood plain is a flat area of land adjacent to a river. It stretches from the bank of its channel to the base of the enclosing valley walls which experiences flooding during the period of high discharge.

7. Estuary

The word “Estuary” is derived from the Latin word *aestuarium* meaning tidal inlet of the sea, which is derived from the term *aestus*, meaning tide. An estuary is a partially enclosed coastal body of brackish water with one or more rivers flowing into it, and with a free connection to the open sea.

The inflow of both sea water and fresh water provide high levels of nutrients both in the water column and in sediment. Hence, it makes estuaries among the most productive natural habitats in the world. Narmada river estuary is located in Gujarat.

8. Delta

Delta is found in the old stage of a river. It is the triangular shaped landform made up of alluvial deposition in the mouth of the river. It is named after the fourth Greek alphabet called delta. Example, The Ganges Bhramaputra delta is the largest delta in the world.

Types of Delta: Delta is classified into the following based on the shape and kind of the load deposited by the river.

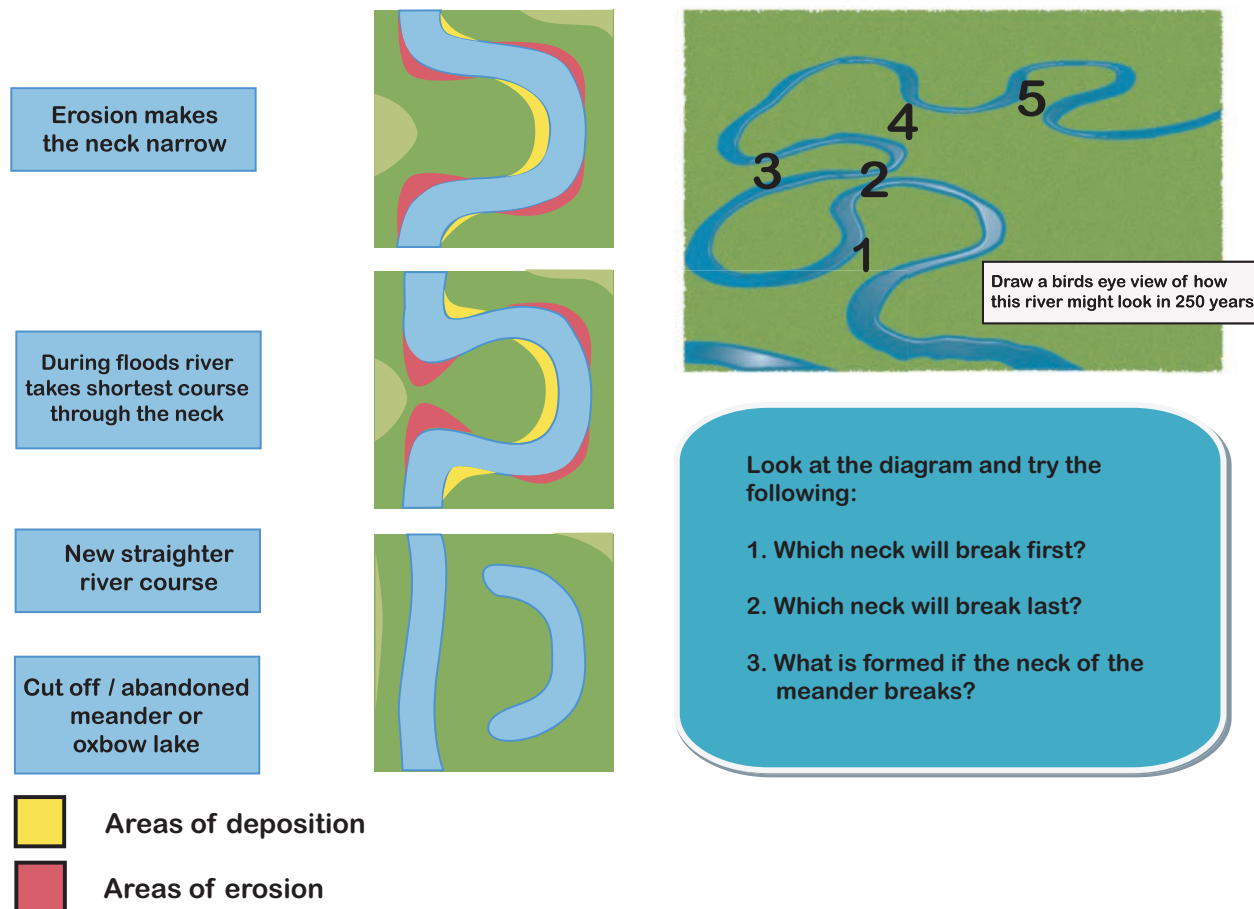


Figure 4.14 Meander

1. **Arcuate Delta:** A bowed or curved **delta** with the convex margin facing the body of water. It is also known as fan-shaped **delta**. Example, River Nile Delta in Egypt and Ganga Delta in India.
2. **Estuarine Delta :** it is formed at the mouth of submerged rivers depositing down the sides of the estuary. Example, Seine River of France.
3. **Birds foot Delta:** They are formed due to deposition of finer materials by river water. Deposited alluvial material divides the river into smaller distributaries. Such delta is also called as finger delta. Example, Mississippi river delta, the USA.
4. **Lacustrine Delta:** It is formed when a river flows into a lake. Example, Lough Leanne river delta, Ireland.
5. **Truncated Delta:** Sea waves and ocean currents modify and even destroy deltas deposited by the river through their erosional work. Thus, eroded and dissected deltas are called truncated deltas.
6. **Abandoned Delta:** when the river shifts its mouth, the delta already made is left abandoned. Such a delta is called abandoned delta. Example, Yellow river delta, China and the Western part of Ganga delta made by Hoogly river, India.
7. **Cuspate delta** is a tooth shaped delta formed when a single distributary

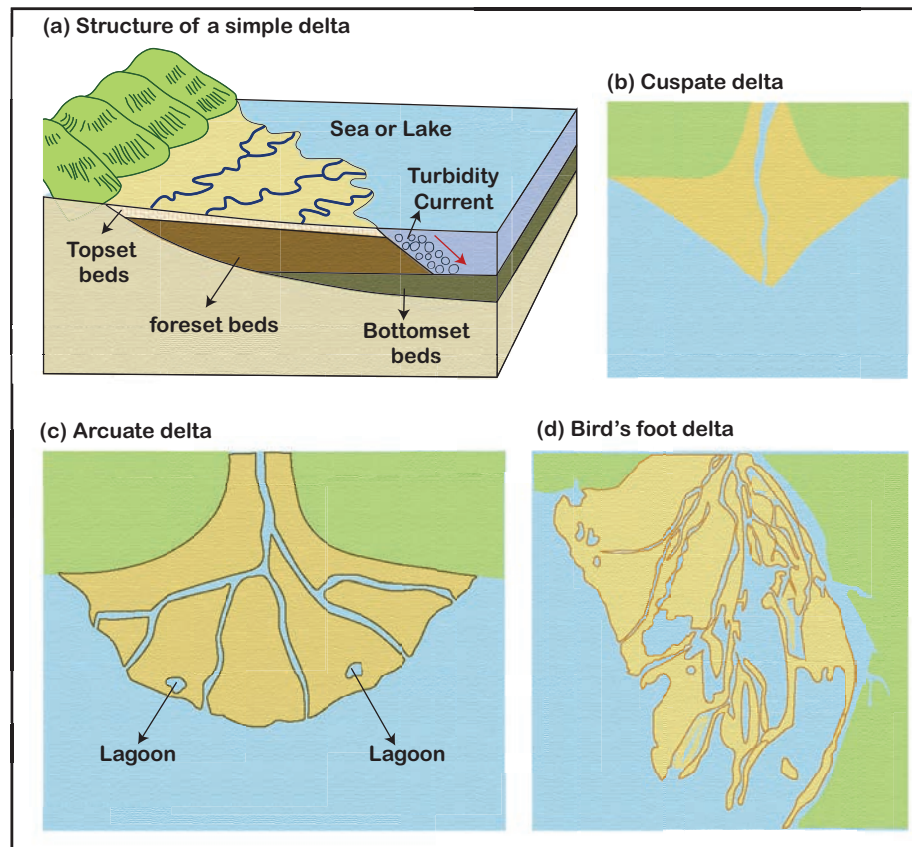
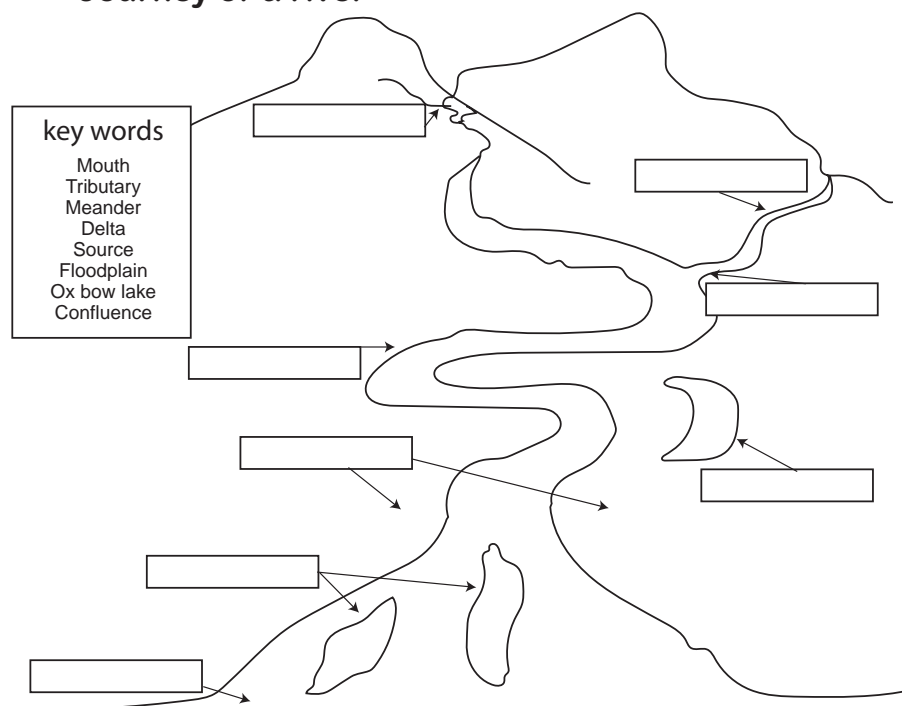


Figure 4.15 Types of Delta

Students activity

Label the following diagram of landforms made by the river.

Journey of a river





flows through and deposits its load on its either side. Example, Tiber River of Italy

4.7 Glacier

A glacier is a huge mass of ice that moves slowly along the mountain slope. The term “glacier” comes from the French word *glace* which means ice. Glaciers are often called “rivers of ice”. It forms where the accumulation of snow exceeds its ablation over many years.

The places where the snow lies for the whole year are called **snowfields**. The imaginary line above which there is a permanent snowfield is known as **the snow line**. The snowfields are always situated above the snowline. The snowline differs according to latitude, amount of snowfall, the direction of the wind and the physical features of the region. Snow starts melting below the snow line. Under the pressure of the upper layers, the lower layers of the snow field begin to melt causing the mass of snow to move down slope as glacier. Glacier moves at an average speed of 1 meter per day. Over 96 percent of the glaciers occur in Antarctica and Greenland.



The world's largest glacier is the Lambert Glacier in Antarctica, more than 96 km wide and 435 km long and 2,500 metres deep..

4.7.1 Types of Glaciers

The Glaciers are of three types. They are;

1. Continental Glaciers
2. Ice Caps
3. Mountain and Valley Glaciers

1. Continental Glaciers

The continental glaciers are found in polar regions. In these areas, all the precipitation is in the form of snow. The snow that falls from year to year gradually gets accumulated. As a result, these regions are covered by an extensive ice mass. This is known as ice sheet or continental glacier. It is estimated that the maximum thickness of the ice sheets of Greenland is 3,400 meter, while the maximum thickness of the ice sheet of Antarctica is 4,776 meter. Sometimes, the ends of the ice sheet projects outwards over the sea. The waves of the sea strike against them and break the ice sheets into blocks of floating ice known as Icebergs.

2. Ice Caps

It is the covering of snow and ice on the oceans of poles. The ice caps can cover vast areas with the extensive accumulation of snow and ice. Example, Svartissen ice cap in Northern Norway.

3. Mountain and Valley Glaciers

These are also known as Alpine glaciers. They flow like tongues of ice down through the mountain valleys from the ice caps. The piedmont glaciers form continuous ice sheets at the base of mountains. The valley glaciers or Alpine glaciers are found in higher regions of the Himalayas and on all such high mountain ranges of the world.

4.7.2 Characteristics of Glaciers

A moving ice mass or glacier possesses certain characteristics of movement, speed, and surface structure. The rate of movement of the glacier is very slow.

The rate of movement or the speed of a glacier depends upon the size of the glacier

and the slope of the valley. Sometimes, the surface of the glacier forms cracks known as **Crevasses**. Crevasses are the deep fissure of variable width in the surface of a glacier. These crevasses are dangerous to the Mountaineers.



Figure 4.16 crevasses

4.7.3 Action of glaciers

The glacier performs three actions namely erosion, transportation and deposition.

A glacier erodes its bedrock by the action of (1) Plucking and (2) Abrasion

(1) Plucking

The glacier plucks big pieces of rocks from the valley floor and creates large grooves or hollows. These pieces are dragged along the valley floor as the glacier moves. The boulders and rocky floor are grounded by mutual contact.

(2) Abrasion

Pure ice is capable of wearing down massive rocks when equipped with angular rock fragments. The glacier can groove, scratch, and chisel the rock surface. It has a powerful abrasive effect.

As a result, a glacier during its lifetime creates various landforms which may be classified into erosional and depositional landforms.

4.7.4 Erosional landforms of Glaciers

The landforms created by glaciers are mainly found in the mountainous regions.

The chief erosional landforms by the glaciers are as follow:

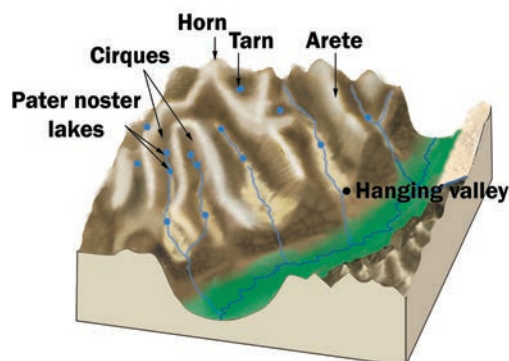


Figure 4. 17: Erosional landforms of Glaciers

1. U-Shaped Valley

U-Shaped Valley is a typical glacial feature. Since glacial mass is heavy and slow moving, erosional activity is uniform in all directions. A steep-sided curved bottom valley has a U shaped profile.

2. Hanging Valley

Hanging valley is formed when tributary glaciers are unable to cut as deeply as main ones and remain “hanging” at higher levels than the main valley as discordant tributaries. These tributary valleys appear hanging over the main valley and enter the main valley at some height.

3. Cirque and Tarn

A Cirque or Corrie is an amphitheater-shaped hollow basin cut into a mountain ridge. It has a steep-sided slope on three sides, an open end on one side and a flat bottom. When the ice melts, the Cirque may develop into a Tarn Lake and the whole thing appears like a big armchair.

4. Aretes

It is a steep-sided, sharp-tipped saw toothed ridges which have undergone glacial erosion from two sides. These comb like ridges are called as arete.

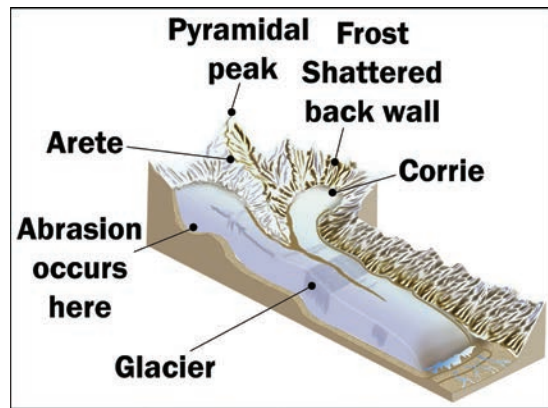


Figure 4.18 Glaciated features

5. Horn

If the summit of the Arete is roughly inclined, it gives rise to pyramidal peaks which are known as horns. Example, Matterhorn of Alps-Switzerland.

6. Nunataks

A rock mass surrounded by ice is called Nunatak. It stands out as an island in the ice.

7. Fjord

The fjord is formed as a steep-sided narrow entrance like feature at the coast of a glaciated region where the stream meets the coast. Fjords are common in Norway, Greenland and Newzealand.

4.7.5 Depositional landforms of glaciers

When the glaciers melt or recede they deposit the rock material, brought by them, forming hillocks of various shapes and sizes. The depositional landforms of the glaciers are;

1. Moraines

Moraines are the piles of dirt and rock that are deposited by a glacier as it moves across the landscape. These debris fields exist in places where glaciers have moved through in the past. There are many kinds of glacial moraines that form. Moraines

are generally classified based on their location.

a) Lateral Moraines

Lateral moraines are ridges of debris that run parallel to the sides of a glacier. This is often accompanied by scraping of the valley sides which means the debris from the moraine creates high ridges above the glacier.

b) Ground Moraines

Ground moraines are glacial depositions formed on the floor of glacial valley. Ground moraines can be deposited in between lateral moraines in the case of many alpine glaciers.

c) Medial Moraines

Medial moraines are ridges of debris that are left down a valley floor at the middle of two glaciers. Both glaciers merge together and their debris combine to form a consistent moraine field along their borders. They are actually the merging of two lateral moraines which continue as medial moraines.

d) Terminal or End Moraines

Terminal or end moraines are left by the end of a glacier. The slower a glacier moves the bigger the moraine will be as the glacier has more time to accumulate outside debris.

e) Recessional Moraines

This recessional moraine runs across the landscape behind a terminal moraine. They are caused by times when the glacier slows or stops in its movement. It is formed because the receding glacier pauses in certain places for a long time before continuing its movement.

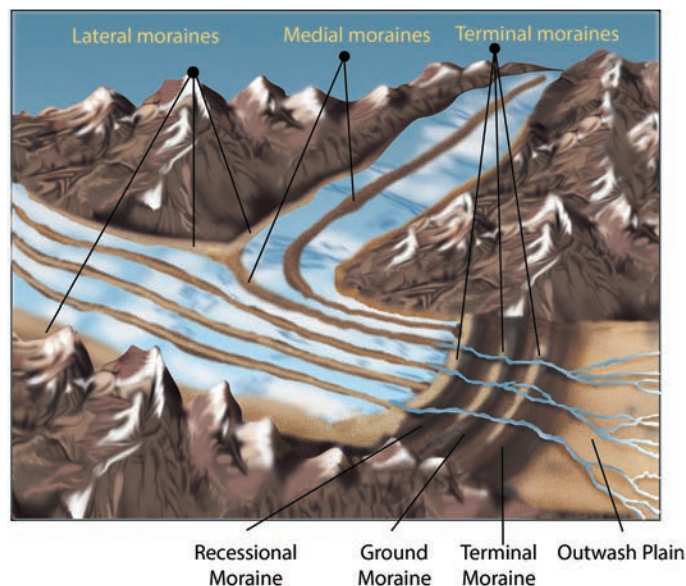


Figure 4. 19 Types of Moraines

2. Outwash Plain

When the glacier reaches its lowest point and melts, it leaves behind a layered deposition of rock debris, clay, sand, gravel, etc. This layered surface is called as an Outwash Plain.

3. Esker

It is a winding ridge of depositions of rock, gravel, clay, etc, running along a glacier in an outwash plain. The Eskers resemble the feature of an embankment and are often used for laying roads.

4. Drumlins

It is an inverted boat-shaped deposition in an outwash plain caused by deposition.

5. Kames

Kames are the number of ridges formed along the ice front.

4.8 Ground water (Karst Topography)

The word “karst” literally means “rocky mountain” comes from a region in former Yugoslavia that includes Croatia and Slovenia. The word is derived from the Slavic word Kras.

What does Groundwater do?

Any limestone, dolomite or gypsum region showing typical landforms produced by the action of groundwater through the process of solution and deposition is called as Karst Topography (Karst region in the Balkans).

4.8.1 Erosional Landforms due to Groundwater

Following are the erosional landforms formed due to the action of groundwater.

1. Sinkholes

A sinkhole is an opening more or less circular at the top and funnel-shaped towards the bottom. When a sinkhole is formed solely through the process of solution, it is called as a solution sink.

2. Doline

A doline is a closed depression draining underground in karst areas. It can be cylindrical, conical, bowl or dish shaped. The diameter ranges from a few meter to many hundreds of meters. The name doline comes from dolina, the Slovenian word meaning *valley*.

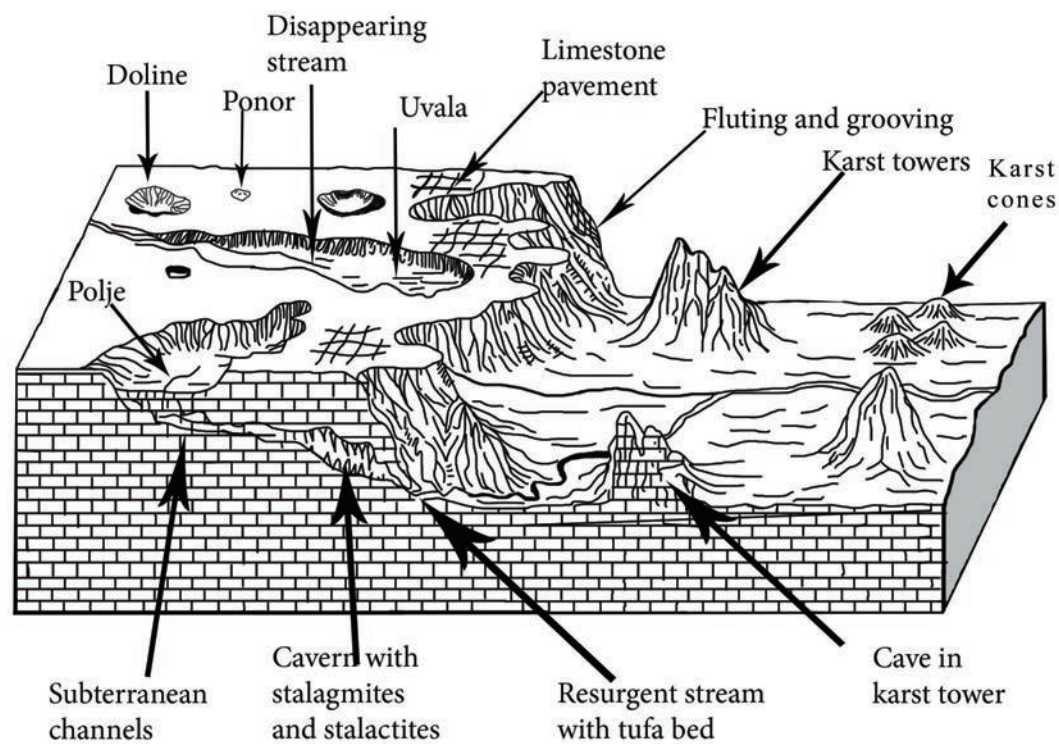


Figure 4.20 Karst features

3. Lappies

Lappies are the irregular grooves and ridges formed when most of the surfaces of limestone are removed by solution process.

4. Uvala

Series of smaller sinkholes coalesce into a compound sinkhole is called uvala.



Figure 4.21 Lappies

5. Polje

Polje is an elongated basin having a flat floor and steep walls. It is formed by the coalescence of several sinkholes. The basins often cover 250 square km and may expose “disappearing streams.” Most of these basins have steep enclosing walls that range from 50 to 100 meter in height, giving rise to the name “blind valley.”

6. Caves

Caves normally have an opening through which cave streams are discharged. Caves having an opening at both the ends are called tunnels.

HOTS

How was the world’s biggest cave, son doong of vietnam formed.



Figure 4.22 Curtains

4.8.2 Depositional Landforms due to Ground water

The following depositional features are formed within caves.

1. Curtains

Rain water drips from long crack in a cave roof forms a continuous strip of calcites. It is called as curtains.

2. Stalactite

Drops of water containing dissolved limestone seep down through cracks in the cave roof. Drops of water lose carbon dioxide and deposit calcite. Overtime deposition of calcite forms pillars hanging down from the roof of the cave. It is called as stalactite and where the stalactite stretches towards the sides are known as Helactites.

3. Stalagmite

Deposition of calcite forming icicles growing upward from the cave floor is called as stalagmite.

Stalactites are calcium carbonate deposits hanging as icicles while Stalagmites are calcium carbonate deposits which rise up from the floor.



Figure 4.23 Stalagmite, stalactite, and pillar



4. Pillars

When both the stalagmite and stalactite join together, it is known as pillar.

4.9 Wind

The wind is the main geomorphic agent in the arid region. Wind in arid region has greater speed which causes erosional and depositional activities in the desert. The landforms which are created by erosional and depositional activities of wind are called as Aeolian Landforms.

Action of the wind

The action of the wind is carried in the following ways;

1. **Deflation:** Removal of sand and dust particles by wind. It forms depression in the desert. When depression is filled with water, it is called as Oasis.
2. **Abrasion:** Action of wind in which sand particles carried by the wind strike against the rock.
3. **Attrition:** Sand particles carried by the wind striking each other is known as attrition.

4.9.1 Erosional Landforms of Wind

1. Deflation Hollows

When deflation causes a shallow depression by persistent movements of wind, they are called as deflation hollows.

2. Mushroom Rock

A mushroom rock, also called rock pedestal, or a pedestal rock, is a naturally occurring rock whose shape, as its name implies, resembles a mushroom.

In deserts, a greater amount of sand and rock particles are transported close to the ground by the winds which cause more



Figure 4.24 Oasis (Top)
Mushroom rock (Bottom)

erosion in the lower part of the rock than the top. These result in the formation of rock pillars shaped like a mushroom with narrow pillars with broad top surfaces.

3. Yardang

Yardangs are extensively grooved, fluted, pitted and irregular rock ridges or reliefs of about 1 to 10 meters high running parallel to the prevailing winds. They are caused by differential erosion. When the sand-laden wind corrades zones of softer or weaker rock between harder vertical ridges from old lake sediment where soft, consolidated rock and bedrock surfaces are eroded into alternating ridges and furrows. Large-scale yardangs are found in Egypt (near Kom Ombo, north of Lake Aswan).

HOTS

Why is mushroom rock eroded more at the bottom than the top?

Zeugen

Zeugen is a landscape of alternate horizontal ridges and furrows made by the action of wind abrasion. It may be as high as 30 m height.

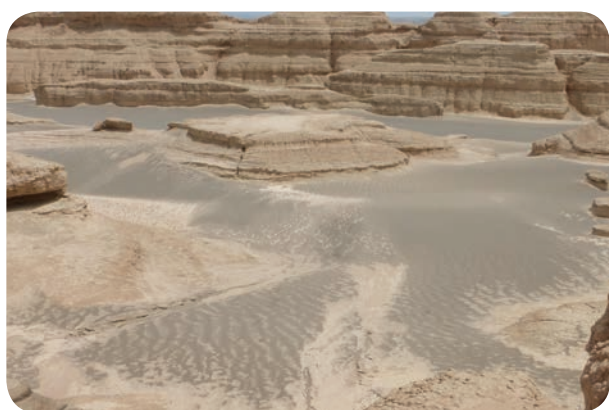


Figure 4.25 Zeugen

4.9.2 Depositional Landforms of Wind

1. Sand dunes

Dry hot deserts are good places for sand dune formation. According to the shape of a sand dune, there are varieties of sand dune forms like Barchans, Seif dune, etc. The barchan is one of the classic desert landforms. It is a crescent-shaped dune with the horns of the crescent stretching out in the leeward direction.

Barchan dunes may reach more than 27 meter in height.

Seif dunes are long ridges of sand. In general they are aligned in the direction of the prevailing wind. The slip face of seif dunes are probably formed by eddies. The depressions between seif dune ridges are

swept clear of sand by the winds. The ridges run for long distances, sometimes several kilometres.



Figure 4.26 Sand Dunes

2. Loess

In several large areas of the world, the surface is covered by deposits of wind transported silt that has settled out from dust storms over many thousands of years. These depositions are called as Loess.

3. Pediplains

When the high relief structures in deserts are reduced to low featureless plains by the activities of wind, they are called as Pediplains.

4.10 Waves (Coast)

Horizontal movement of sea water caused by the wind, rotation of the earth, etc., are called waves.

4.10.1 How do Waves Erode?

Waves carry out the erosive work in the following ways.

1. **Abrasion:** The waves striking against the coast with eroded materials is called abrasion. Abrasion is also called as the corrasion.



2. **Hydraulic action:** The waves force water and air into the cracks in the rock. The parcel of air can be compressed by the surging water and the waves retreat, air expands explosively, weakening the joints and cracks and causing the rock to break. This is called the Hydraulic action.
3. **Corrosion:** The action of dissolving soluble rocks by waves is termed as the corrosion or solution.
4. **Attrition:** Eroded materials like boulders and rocks knock together to wear out into smaller particles. This is called attrition.

Terms related to coast

- **Sea shore** is the zone of land between high tide and low tide
- **Shore line** is boundary between land and water.
- **Backshore** is the beach zone starting from the limit of frequent storm waves to the cliff base.
- **Foreshore** is the portion of the beach subject to wave action during non-storm conditions.
- **Offshore** is the shallow zone of the continental shelf
- **Coastline** is the boundary where the land meets the sea
- **Swash** is the waves washing up the beach.

4.10.2 Landforms by the Erosion of Waves

Erosional landforms dominate rocky coasts but are also found in association with predominantly depositional landforms.

1. **Sea cliff** is steep rocky coast rising almost vertically above seawater is called sea cliff.
2. **Wave Cut Platform:** Rock cut flat surfaces in front of a cliff are called wave-cut platform. They are slightly concave upward. It is also formed when blowhole is collapsed.

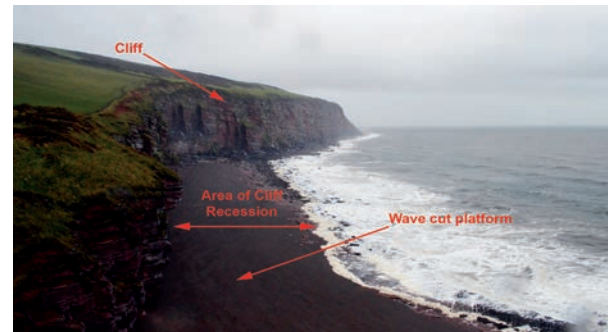


Figure 4.27 Sea cliff and wave cut platform

3. A **sea cave** is a hollow excavated by waves in a zone of weakness on a cliff. The cave depth is greater than the entrance width.

Sea caves usually form at points of geological weakness, such as bedding planes, joints, and faults. A 90 meter long sea cave is found in the Loliem beach in Canacona in Goa. The world's most extensive cave is 1.5 km long Matainaka cave in New Zealand.



Figure 4.28 Sea Cave

4. A **blowhole** may form in the roof of a sea cave by the hydraulic and pneumatic action of waves, with fountains of spray

emerging from the top. If blowholes become enlarged, they may collapse.

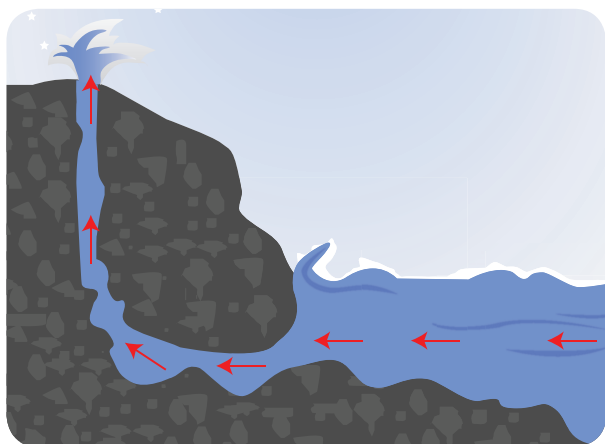


Figure 4.29 Blow hole

5. **Arch** is formed when the sea cave is cut right through by wave action. The arch is termed as sea tunnel if it is comparatively longer.
6. **The stack** is a steep and often vertical column of rock in the sea near a coast, formed by wave erosion. It is formed when the natural arch is collapsed. It is also called chimney rock, needles, columns, pillars, skerries, etc,
7. **Stump** is the worn out stack.

4.10.3 Transportation Work of Waves

The eroded materials are transported by the waves in different ways. The materials involved in the transportation by sea waves include silt, sand, gravel, cobble, pebble and boulder.

4.10.4 Landforms by the deposition of waves

Depositional landforms developed by the sea waves include the beach, bar, lagoon, spit, tombolo, barrier island, etc. Let us see one by one in detail.

1. **Beach** is an elongated stretch of sands, pebbles, gravels, etc deposited along the coast. It can be a sandy beach or pebble beach. Praia da Cassino beach in Brazil is the world's longest beach stretching for 200 km from the Rio Grande to the border with Uruguay. Marina beach, Chennai is the second longest beach in the world.
2. **The Bar** is a stretch of sand deposition off the shoreline. The larger form of a bar is called barrier.

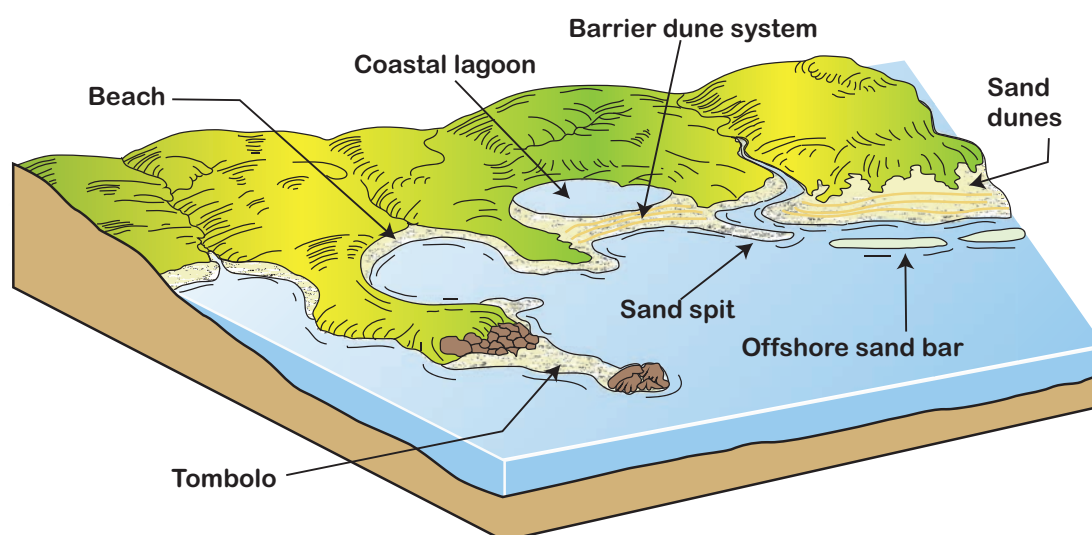


Figure 4.30 Depositional features of Waves



3. **The Lagoon** is enclosed seawater between the bar and the coast. For example, Pulicat lake, located in the Tamil Nadu and Andhra Pradesh is a lagoon.
4. **Spit** is a long, narrow ridge of sand or pebble with one end connected to the coast and the other end running into the sea. For example, Rameshwaram, Tamil Nadu.
5. **A Tombolo** is a bar connecting an island with the coast.

GLOSSARY

1. **Streambed:** A channel in which a stream flow or formerly flowed
2. **Cataracts:** water fall with volume of water.
3. **The Ice Caps:** It is the covering of Snow and Ice on the oceans of poles.
4. **Offshore** is the zone shallow bottom of the continental shelf.
5. **Source of a river:** place where river starts.
6. **Water Divide:** relief having two river systems.
7. **Oasis:** depression in the desert filled with rain water.
8. **Desert:** waste land unfit for human use at the moment.
9. **Snow line:** an imaginary line below which snow starts melting.
10. **Delta:** A triangular shaped fertile land built by river at the mouth.

Evaluation

I. Multiple Choice Questions



1. Which of the following is the chemical weathering process?
 - a. Exfoliation
 - b. Frost Wedging
 - c. Carbonation
 - d. Thermal expansion
2. Feldspar found in Granite changing to clay is the most common example of
 - a. Oxidation
 - b. Carbonation
 - c. Solution
 - d. Hydrolysis
3. Which district in Tamil Nadu has the highest frequency of landslide?
 - a. Nilgiris
 - b. Erode
 - c. Dharmapuri
 - d. Coimbatore
4. The swirling movement of the falling water into the plunge pool is called
 - a. Plunge pool
 - b. Groove
 - c. Rapids
 - d. Eddying
5. A winding curve or bend in a river
 - a. Ox-bow lake
 - b. Flood plain
 - c. Meander
 - d. Levees
6. A bowed or curved delta with the convex margin facing the body of water, also called as fan delta.
 - a. Arcuate Delta



- b. Bird's foot Delta
 - c. Abandoned Delta
 - d. Truncated Delta
7. Coleroon (Kollidam) river is a distributary of
- a. The Bhavani River
 - b. The Palar River
 - c. The Pennar River
 - d. The Cauvery River
8. An amphitheater-shaped hollow basin cut into a mountain ridge by glacier.
- a. Arete
 - b. Cirque
 - c. Horn
 - d. Fjord
9. The formation of irregular grooves and ridges when most of the surfaces of limestone are removed by solution process.
- a. Lappies
 - b. Polje
 - c. Cave
 - d. Nunataks
10. One among the given is formed when the arch is collapsed.
- a. Stack
 - b. Cave
 - c. Blow hole
 - d. Wave cut platform

II. Very short answer

- 11. Define exogenic processes.
- 12. What is an exfoliation?
- 13. How are rock flow, slide and fall different from one another?
- 14. List the types of Delta.
- 15. How is Spit different from Tombolo?

III. Short Answer

- 16. Compare physical weathering and chemical weathering.
- 17. Explain how a cave changes into stack.

- 18. Explain how a meander changes into an Oxbow lake.
- 19. Distinguish between Barchans and Seif dune.
- 20. Explain Moraine and list out its types.

IV. Detailed answer

- 21. List the landforms made by the river and explain any two landforms with diagrams.
- 22. Describe the erosional landforms of wind with diagrams.
- 23. Elucidate the landforms made by the wave erosion and draw the appropriate diagram.

V. Practice

- 1. Make a diorama of landforms made by the wind as a group work and show to the class explaining how each landform is made.
- 2. Group Work: Make a working model of a river course with all the landforms using available materials and demonstrate it in the class.



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- 4. Fundamentals of Geomorphology *Richard John Huggett*



Web Reference

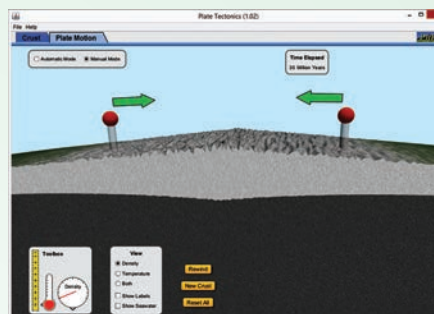
- 1. **Web link:** Read More at <https://www.livehistoryindia.com/geological-wonders/2017/05/24/gandikota-the-grand-canyon-of-india-2>



ICT CORNER

Lithosphere Change is Constant

Through this activity you will learn the land formed by Exogenic processes.

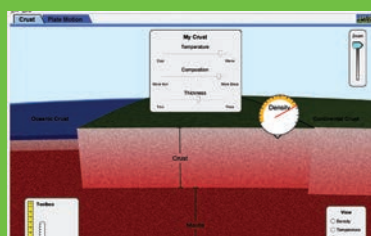


Steps

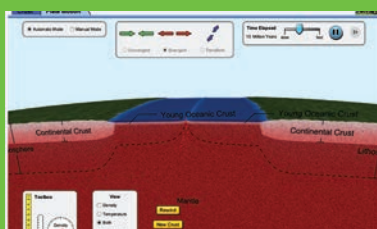
- Use the URL to reach 'Plate Tectonics' simulation page.
- Download JAVA binary file from the page and install it .Click 'Play' button to run the JAVA applet.
- 'Plate tectonics' crust page will open. Modify temperature, composition and thickness of the crust and measure the density and depth using the scale provided.
- Select 'Plate Motion' page and drag the crust form to converge or diverge motion and observe the exogenic process.



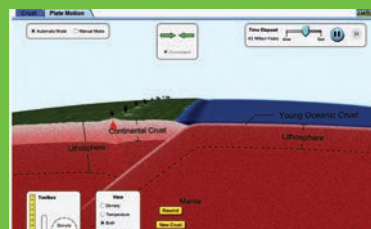
Step 1



Step 2



Step 3



Step 4

Website URL:

<https://phet.colorado.edu/en/simulation/plate-tectonics>

*Pictures are indicative only.



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