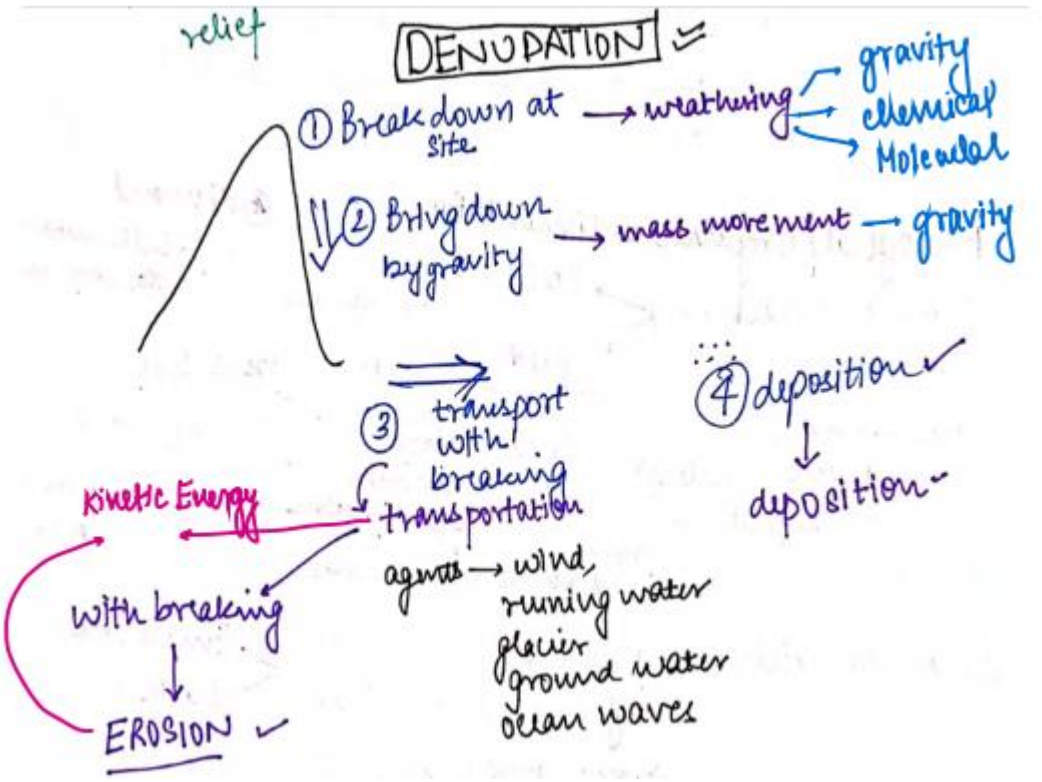
EXOGENIC FORCES: land wearing forces (Destructive)

- **Exogenic** processes are a direct result of stress induced in earth materials due to various forces that come into existence due to sun's heat.
- Due to energy from : Insolation, thermal gradient, slope gradient (due to gravity)
- exogenic process causes gradation - into degradation and aggradation

Denudation:

- All the exogenic geomorphic processes are covered under a general term, denudation.
- The word 'denude' means to strip off or to uncover.
- **Weathering, mass wasting/movements, erosion** and **transportation** are included in denudation.
- Denudation mainly depends on rock type and its structure



Weathering : Due to thermal gradient (more related to climate conditions)
Mass Movement : Due to slope gradient (gravity)
Erosion: Result of Thermal and slope gradient (depend on climate+ gravity)

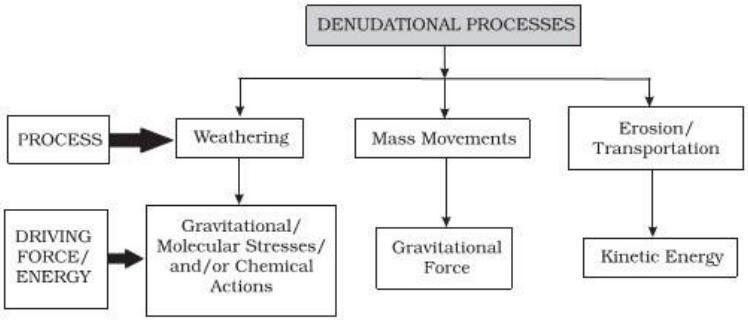
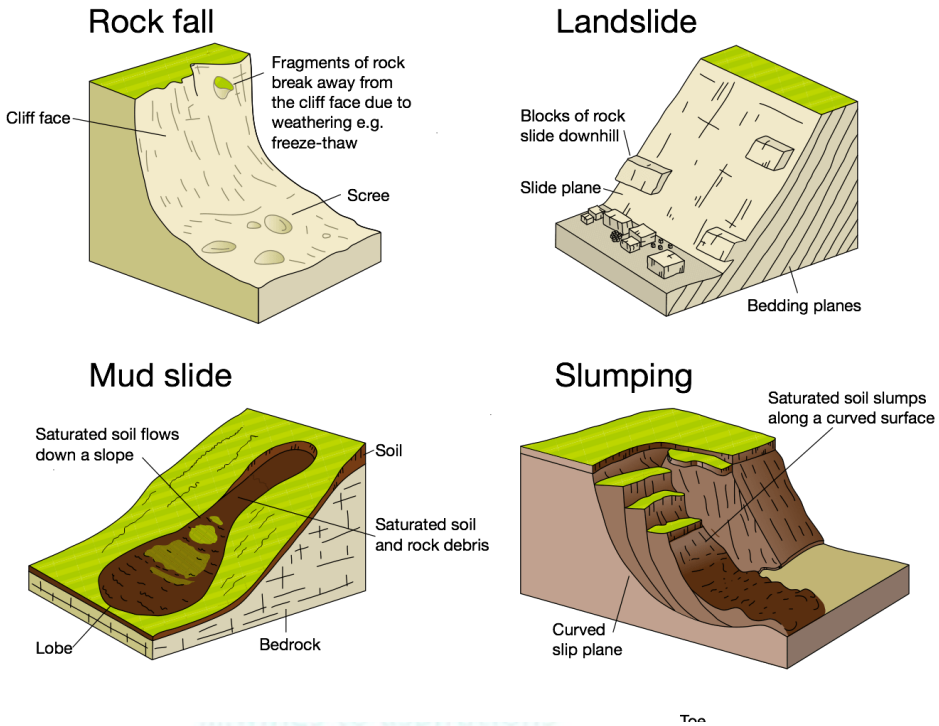


Figure 6.1 : Denudational processes and their driving forces

Mass movement or Mass Wasting :

- refers to the downward movement of rock debris under the influence of gravity.
- No geomorphic agent involved in mass movement
- specific type of geological activity driven primarily by gravity that contributes to landscape change
- mass movement is part of erosion
- Factors favouring mass movements: weak materials, steep slopes, rainfall, and lack of vegetation



Example of Mass Movement/ Mass wasting :

- Mass movements can be slow (creep, heave) or rapid (flow, slide), categorized by their speed.
- Slow movement : soil creep
- Heave (heaving up of soils due to frost growth and other causes), flow and slide are the three forms of movement.
- Rapid movement : mudflow, debris flow, slump, landslide, avalanche

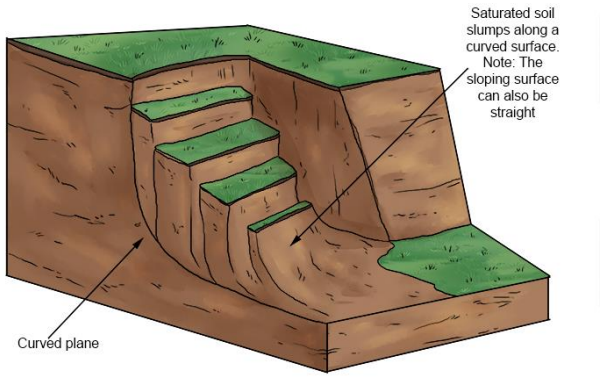


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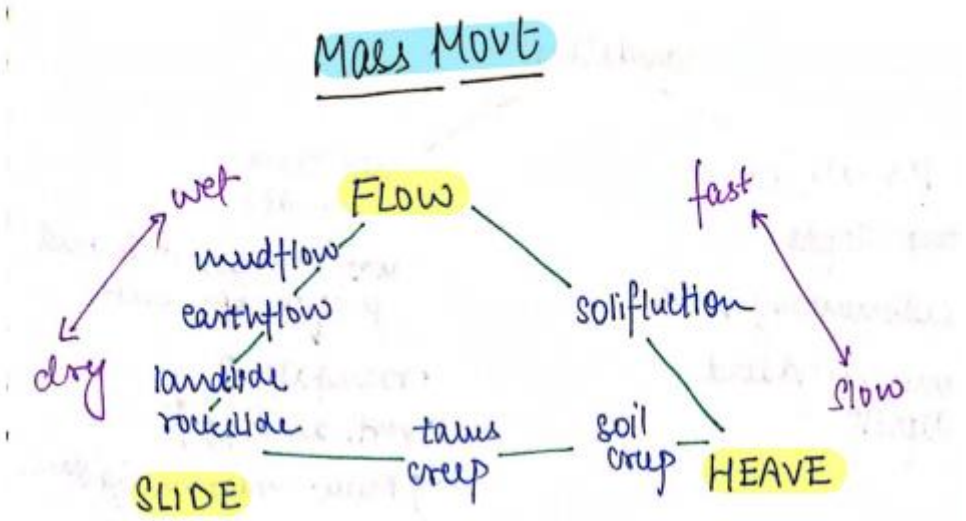
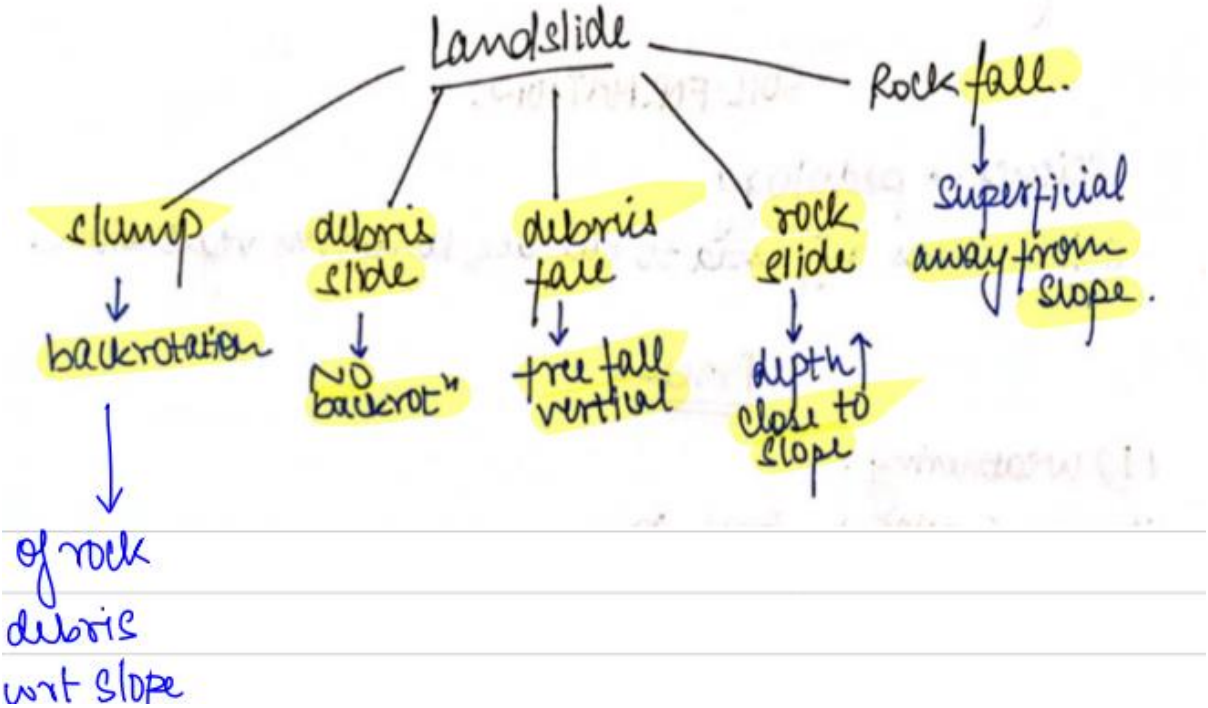
Fig: Slump : slipping of rock debris along a curved slip plane



MOVEMENTS OF LANDSLIDE



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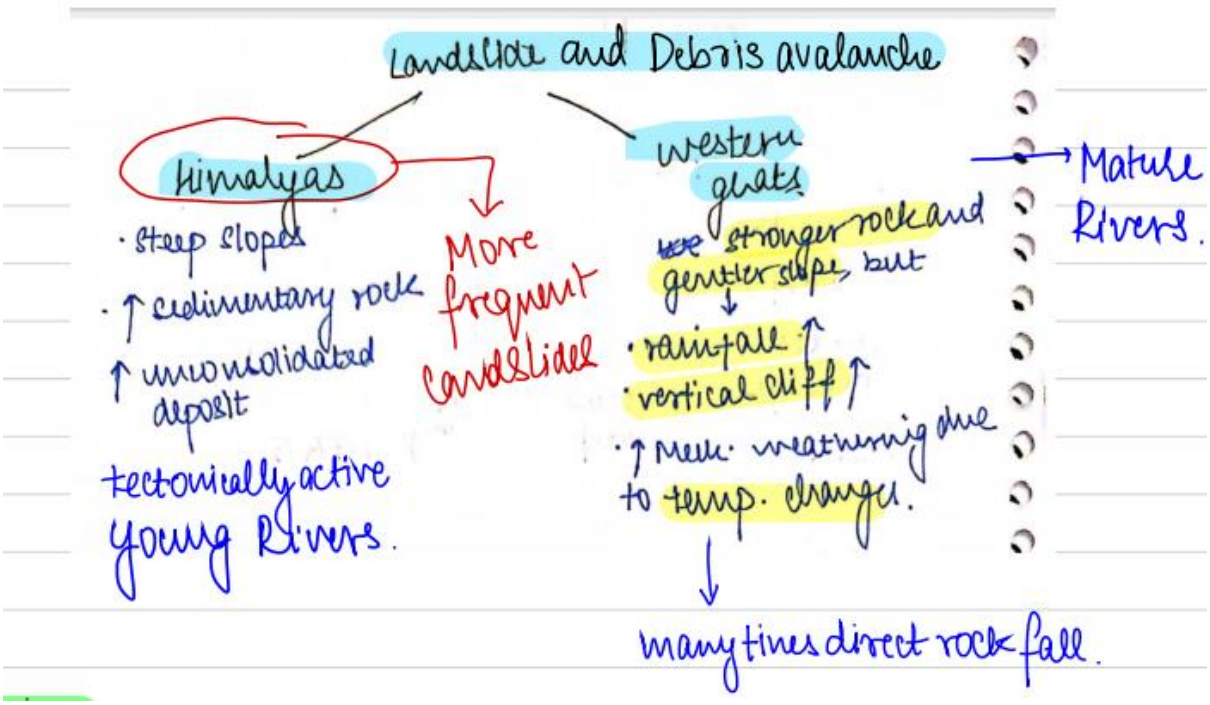

Define Weathering : .

- **Weathering is defined as mechanical disintegration and chemical decomposition of rocks through the actions of various elements of weather and climate**.
- is happening all around the world, all the time. Example : When a chemical reaction is the cause, it's called chemical weathering
- it helps to form Soil and its types .

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Agents of Weathering :

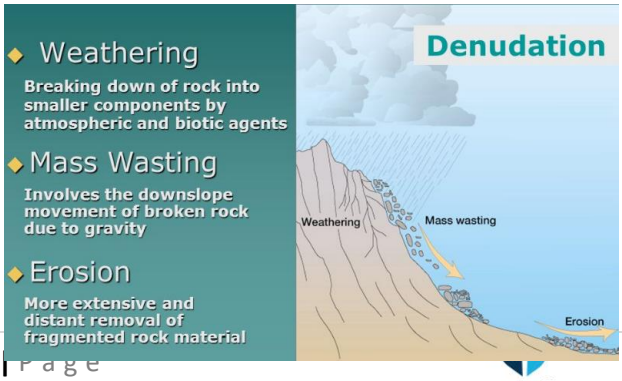
1**Transportation:** The wind, running water, moving ice and sea waves also carry away particles, thus removing one part and settling it in other part is called the process of transportation.

2.Deposition: The material carried out by winds, running water, and moving ice are deposited in some other place is called deposition.

3.Erosion: Erosion is basically a dynamic process, there is always displacement of rocks,

The All Exogenic Geomorphic Process is included in ' Denudation"

Denude Means act of uncovering , and Includes Weathering, Mass Movements, Erosion and Transportation.



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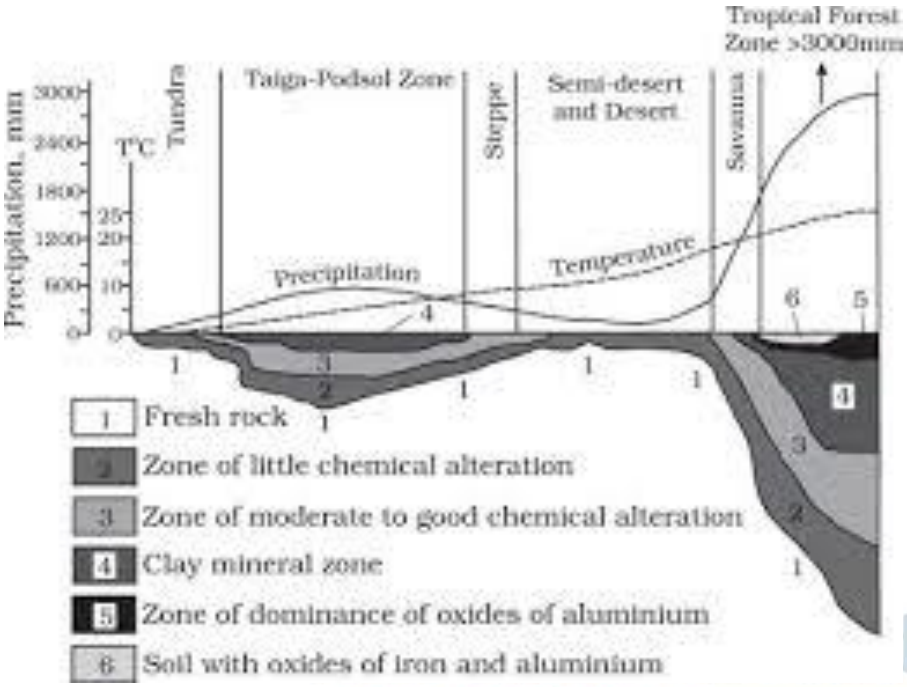
Stages of Denudation

- Weathering : In situ disintegration of rocks and agents of weathering (E+ T+ D)
- Erosion
- Transportation and
- Deposition

Weathering processes are conditioned by many complex geological, climatic, topographic and vegetative factors. **Climate is of particular importance**. Not only weathering processes differ from climate to climate, but also the depth of the weathering mantle



Weathering mantles, i.e. products of in situ rock weathering accumulating through time to form thick bodies of altered parent rock

- The Weathering Mantle is the layer of Soil, Sediment , and weathered rock that has been broken down from the underlying bedrock through various weathering processes .
- Thickness of weathering mantle varies depending on climate conditions and type of underlying rock
- Areas of High rainfall ar likely having thicker weathering mantle .

Concept Relevant for :

- Soil Formation
- Erosion
- Land Use
- Environmental conservation

There are three major groups of weathering processes :
(i) chemical
(ii) physical or mechanical
(iii) biological weathering processes

How does climate affects the rate of weathering (in general formula)

- Chemical Weathering: Hot and Wet Climate (tropical region)
- Physical Weathering : Cold and dry , arid region

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- **Rate of Weathering also depend on type of rocks : Rocks in Tropical Climate experience high rate of weathering (High Temp+ High Rainfall)**

Weathering Rate	Factors Effecting Weathering Rate
Low	Highly resistant minerals Massive rocks (big blocks) Little to no rainfall Low temperatures Little or no soil Little organic activity
Medium	Moderately resistant minerals Average rock size Some rainfall Medium temperatures Soil is present Organic activity is moderate
High	Unstable minerals (easily broken down) Small rock particles Heavy rainfall High temperatures Thick soils A lot of organic activity

Chemical weathering is more important than physical weathering .This is particularly so in the Hot and Humid climates of the equatorial, Monsoon and other sub tropical wet regions. CW is more pronounced in the region of Karst topography and limestone regions

Biological Weathering Process

- Burrowing Animals like rodents
- Plant and Animal waste
- Plants roots

Physical weathering Process:

- Unloading and Expansion
- Granular Disintegration
- Block Separation
- Shattering
- Freezing, Thawing, Frost Wedging
- Salt Weathering

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Five Chemical Weathering Process:

- H+ O+ R+ S+C
- **solution,**
- **carbonation,**
- **hydration,**
- **oxidation and**
- **reduction**

Chemical Weathering Processes: involves alteration of the chemical compositions or rocks and minerals, due to chemical reactions with water, acids or gases in the atmosphere.

A group of weathering **processes viz; solution, carbonation, hydration, oxidation and reduction act** on the rocks to reduce to a fine state.

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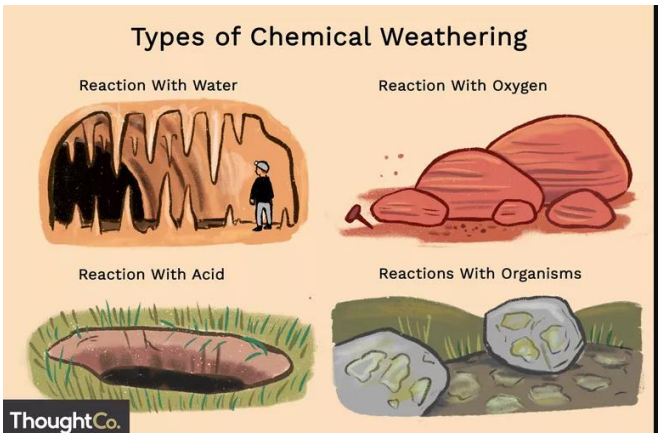

- Solution: Dissolution in water or acid. Minerals like calcium carbonate and calcium magnesium bicarbonate present in limestone are soluble in water containing carbonic acid

- Carbonation: Process of atmospheric carbon dioxide causing solution weathering; common process helping in breaking down of felspar and carbonate minerals

- Hydration: water decomposition- chemical addition of water - Minerals take up water and expand which increases the volume of the material (Calcium sulphate+water= Gypsum). Continued repetition leads to physical weathering through exfoliation and granular disintegration

- Oxidation and Reduction: In oxidation, rock breakdown occurs due to the disturbance caused by addition of oxygen. When oxidized minerals are placed in an environment where oxygen is absent (eg: below water table/ waterlogged areas) reduction takes place.

Ex :

- Meghalaya dense vegetation, high organic content and high rainfall leads to intense chemical weathering . The acidic nature of soil enhances leaching of essential nutrients affecting soil fertility and soil profile.

- Regions in Odisha and Jharkhand , chhatisgarh known for bauxite deposits (intense weathering of aluminium rich rocks under tropical conditions) due to chemical weathering processes over time .

- Water causes both mechanical weathering and chemical weathering

PHYSICAL WEATHERING :

Physical or mechanical weathering processes are influenced by some applied forces.
The applied forces are:

- Gravitational forces like shearing stress, load, and overburden pressure.
- Expansion forces due to crystal growth, animal activity or temperature variations.
- Water pressures regulated by drying and wetting cycles.

Ex Grand Canyon of Colorado river formed due to Physical weathering

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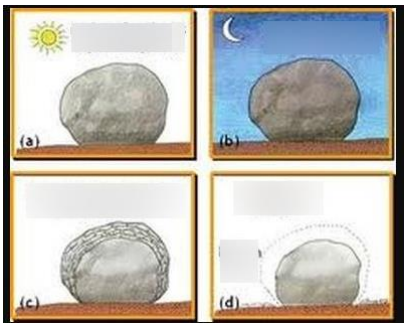
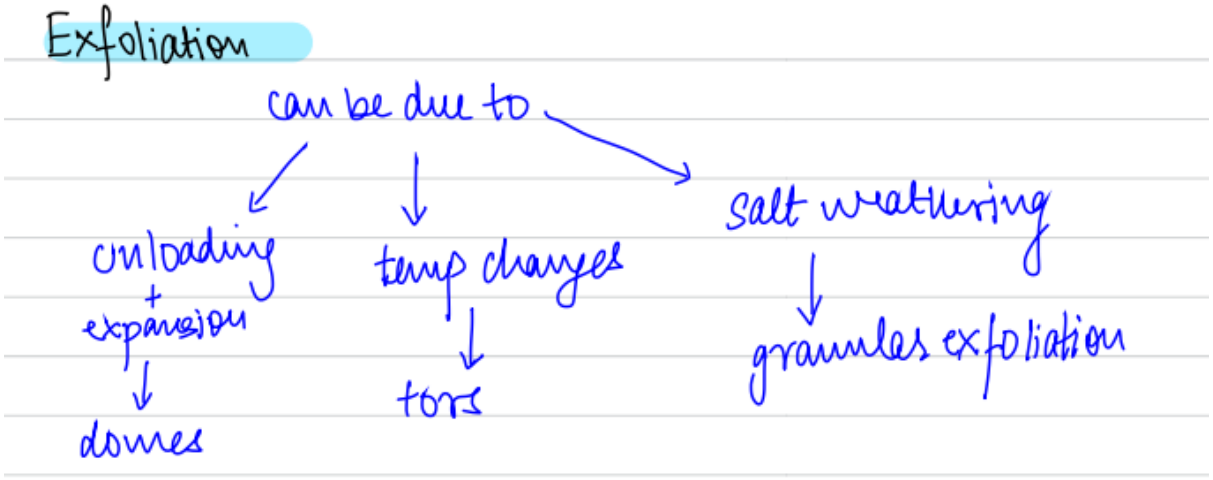
Thermal Expansion and contraction : Rocks can expand when heated and contract when cooled . This repeated cycle can creates stress fractures . in desert region, daily temperature fluctuations can lead to cracking of rocks.

Temperature changes and expansion: Most effective in dry climates and high elevations where diurnal temperature changes are drastic.

- Exfoliation : Process occur when outer layers of rocks are stripped away due to thermal expansion and contraction. Also called as Onion weathering , creates arch shaped and dome shaped features on the exposed landscape.. Exfoliation domes and tors result due to unloading and thermal expansion resp.
- Big, smooth rounded domes are called exfoliation domes
- This process is effective in dry climates and high elevations and arid climates where diurnal temperature variations are extreme.





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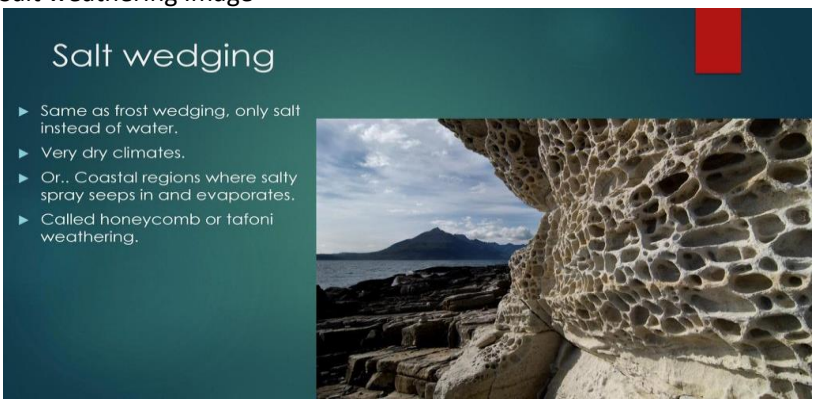
Freezing, Thawing and Frost Wedging

Freezing, Thawing and Frost Wedging: Most effective at high elevations in mid-latitudes where freezing and melting are often repeated.

Freezing involves the transformation of water into ice
Thawing is the process of melting ice back into water, and
Frost Wedging is the mechanical breakup of rocks caused by repeated freezing and thawing cycles

Ex-
The volume of Water is Expand at very low temperature. Ex bursting of water pipes in the polar and sub polar regions.
Reason: cryostatic pressure (Outcome of weight and thickness of the ice)

Salt weathering Image



Salt Weathering or Salt Wedging or crystallization weathering

- Type of Physical weathering
- Salts in rocks expand due to thermal action, hydration and crystallisation.
- Salt crystallisation is the most effective of all salt weathering processes
- Crystallization: is a phenomenon in arid and semi arid climates
- Relevant in Regions with high evaporation rates , coastal areas and areas with saline soils exits and Dry climates
- Honey comb weathering found in antartica , arid , temperate and tropical environment .

Examples of Salt weathering region in India

- Thar Desert observed on sandstone and limetsone formations in the desert
- Saline Soils of Punjab and Haryana (improper agricultural practices have led to accumulation of salts in the soil)
- Historical monuments affects like Hampi and fatehpur Sikri

Biological Weathering or Organic weathering :

- **caused by living organisms which can change rocks through physical or chemical means .**
- Roots Expansion - Plant roots can grow in to cracks of rocks ,exerting pressure as they expand , leading to physical breakdown.

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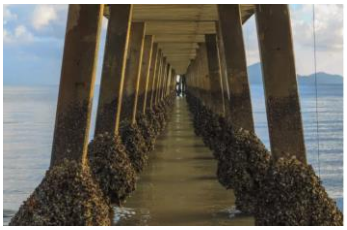
- Organic Acids : Some plants, lichens and fungi produce organic acids that can chemically alter minerals in rocks.
- Burrowing and wedging by organisms like earthworms, termites, rodents etc., help in exposing the new surfaces to chemical attack and assists in the penetration of moisture and air.
- Human beings by disturbing vegetation, ploughing and cultivating soils, also help in mixing and creating new contacts between air, water and minerals in the earth materials.
- Decaying plant and animal matter help in the production of humic, carbonic and other acids which enhance decay and solubility of some elements.

Chemical Weathering From Living Organisms



Significance of weathering to human life

- key exogenic geological processes
- Help in Soil Formation
- Mineral nutrients released during weathering contribute to fertility of soil.
- Help in Nutrient recycling - recycle essential nutrients like potassium, phosphorus, calcium, vital for plant and animal life. this supports ecosystems and agriculture practices
- Landscape formation- shapes valleys , mountains , hills, by wearing down and change physical characteristics of rocks over time .
- weathering affects cultural heritages and monuments so understanding weathering processes is needed for conservation efforts.
- Bio- diversity Supports and Biomes are basically a result of vegetation, and forests rely upon the depth of weathering mantles.
- can influence the composition of groundwater and surface water affecting water quality and availability for human consumption
- Mineral resource availability- weathering lead to concentration of certain minerals and ores facilitating their extraction and contributing to economic development .
- So weathering plays a fundamental role in ecological balance , geological process, resource information and understanding climatic and environmental changes .

LANDFORMS AND THEIR EVOLUTION

- Small to medium tracts or parcels of the earth's surface are called landforms and several landforms together are called landscape.
- Geomorphology is the science of landforms.
- Various geomorphic agents form different types of erosional and depositional landforms

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Landforms

Landforms	Agent of Erosion	Erosional Landforms	Depositional Landforms
Fluvial Landforms	River	Rapids and cataracts	Ox-bow lakes
		Waterfalls	Flood plains
		Potholes	Levee
		Interlocking spurs	Delta
Glacial Landforms	Glaciers	Cirque	Moraines
		Aretes and pyramidical peak	Boulder Clay or Glacial Till
		Bergschrund	Erratics
		U-shaped glacial Troughs and ribbon lakes	Drumlins
		Hanging Valley	Eskers
		Fjord	Outwash Plains
			Kettle Lakes
			Kames
Desert Landforms	Wind	Mushroom Rocks	DUNES-Barchans and Seifs
		Messa and butte	LOESS
		Zeugen	
		Yardangs	
		Isenberg (Island Mountain)	
		Ventifacts and Dreikanter	
		Deflation Hollows	
Coastal Landforms	Wave (Water action)	Capes & Bays	Beaches
		Cliffs & Wave cut platforms	Spits & Bars
		Cave, Arch, Stack & Stump	Marine Dunes & Dune Belts
		Geos & Gloups (blow-holes)	
Karst Landforms	Carbon dioxide rich water	Limestone pavement	Stalactites
		Sinkholes, Doline, Uvala and Polje	Stalagmites
			Calcite pillars

EROSIONAL AND DEPOSITIONAL LANDFORMS MADE BY GEOMORPHIC AGENTS

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1. **Glacial Landforms**
2. **Coastal Landforms**
3. **Desert Landforms by Wind Action**
4. **Limestone Landforms by Groundwater Action**
5. **River Landforms**

RIVER LANDFORMS (FLUVIAL LANDFORMS)

Key Features of Fluvial Erosion: Evolution of River Landscape

- **Corrosion chemical actions that leads to weathering**
- **Abrasion: physical or mechanical erosion of weathering help to form valleys , meanders**
- **Hydration: weathering process where minerals absorb water and expand and breaks**
- **Attrition: rocks fragments collide with each other**
- **Downcutting or vertical erosion: seen in upper course of the river (gorge, canyon)**
- **Lateral erosion or horizontal erosion seen in lower course of the river (meanders ox bow lakes, point bars , levees)**
- **Headward Erosion : erosion at the origin of the Stream channel but in back direction**

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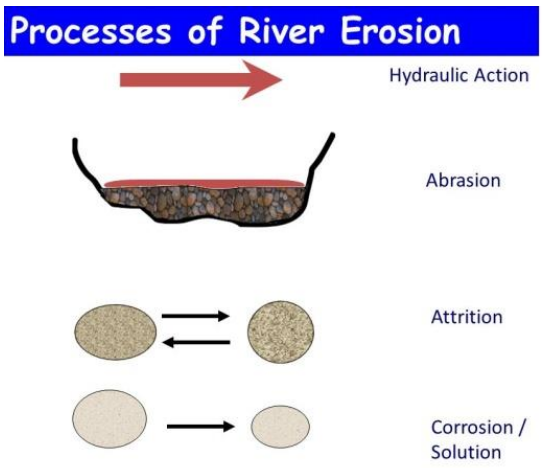

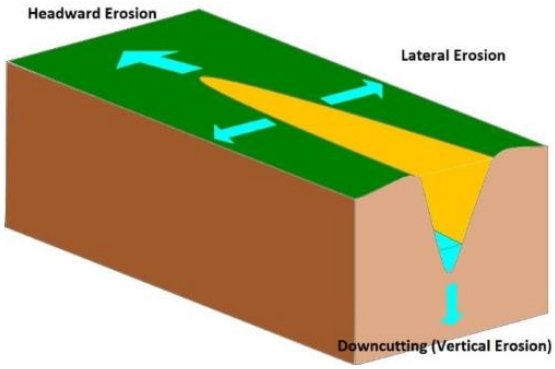

RIVER LANDFORMS (FLUVIAL LANDFORMS)

EROSIONAL	DEPOSITIONAL
Valley and its types Rills, Gully , Gorge, Canyon	Alluvial fans and cone
Waterfalls and Rapids	Natural levees
Potholes and Plunge Pools	Point Bars
terraces	Meanders and Ox bow lake
Entrenched or incised meanders	Temporary islands -eyots
Peniplains	Braided channel and Delta and its types

Valleys Its evolution starts from narrow rills to long, wide gullies and eventually to valleys. Various types of valleys, such as V-shaped valleys, Gorges, and Canyons, may form depending on rock type and structure

Gorge :

- A gorge is a deep and narrow valley with very steep to straight sides
- A gorge is almost equal in width at its top as well as its bottom.
- Gorges are formed in hard rocks.
- Example Indus Gorge in Kashmir

Canyon

- A canyon is a variant of the gorge.
- Unlike Gorge, a canyon is wider at its top than at its bottom.
- A canyon is characterised by steep step-like side slopes
- Canyons commonly form in horizontal bedded sedimentary rocks
- Example Grand Canyon carved by Colorado River, USA Grand Canyon, Colorado River, USA

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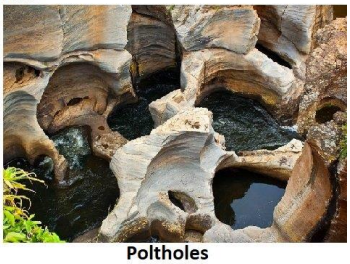
Figure 6.2 : An entrenched meander loop of river Colorado in USA showing step-like side slopes of its valley typical of a canyon

Entrenched meanders or Incised meanders are formed during the youth stage of the River where vertical erosion dominant and very deep and wide meanders can also be found cut in hard rocks
They widen and deepen over time and can be found as deep gorges and canyons in hard rock areas.

Waterfall

Plungepool



Poltholes

- Waterfalls : When Rivers Plunge Down In A Sudden Fall Of Some Height, They Are Called Waterfalls
- Potholes Are Circular Depressions Formed Over The Rocky Beds Of Hill-Streams, Because Of Stream Erosion Aided By The Abrasion Of Rock Fragments
- Plunge pools form at the base of waterfalls due to the force of the water and soft rocks.

Examples :

- Angel Falls In Venezuela Is Considered The Highest Waterfall In The World
- Tugela Falls , Drakensberg Mountains Of South Africa Second Highest Waterfall In The World
- The Victoria Falls Is Considered To Be The Largest Waterfall In The World (Zambezi River')
- Highest Waterfall In India: Kunchikal Falls: Shimoga District, Karnataka 455 Metres(varahi river)
- Reference : Https://Byjus.Com/Govt-Exams/Highest-Waterfalls-India-List/
- Nohkalikai Falls Located Near Cherrapunji Is The Tallest Plunge Waterfall In India.
- Jog Or Gersoppa Falls On Sharavati (A Tributary Of Cauveri) Has A Fall Of 260 Metres. second-highest plunge waterfall in India.

Terraces

- Stepped benches along the river course in a flood plain are called terraces.
- former valley floors and remnants of former (older) flood plains
  - The river terraces may occur at the same elevation on either side of the rivers in which case they are called paired terraces

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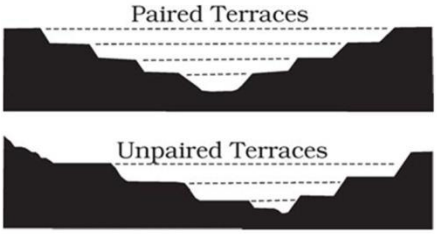


Paired and unpaired river terraces

Gulleys/Rills

- Gulley is an incised water-worn channel, which is particularly common in semi-arid areas.
- It is formed when water from overland-flows down a slope, especially following heavy rainfall, is concentrated into rills, which merge and enlarge into a gulley.
- The **ravines of Chambal Valley** in Central India and the **Chos of Hoshiarpur** in Punjab are examples of gulleys.

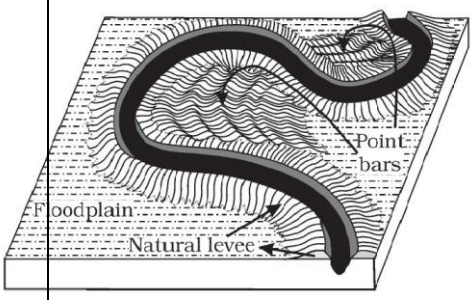
Rapids Fast-flowing, turbulent water with abrupt elevation changes; typically found in steep or mountainous river sections..

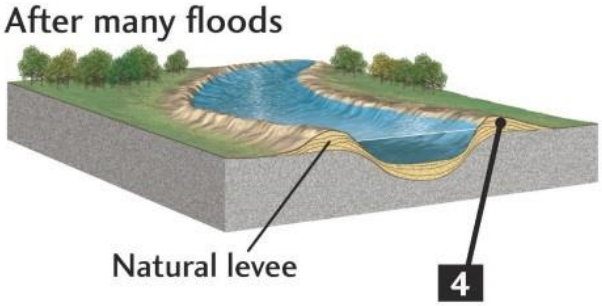
- **Peneplain** (an almost plain) is a low-relief plain which is formed as a result of stream erosion. It is considered to be an **end product of an erosional cycle**.

DEPOSITIONAL RIVER LANDFORMS:

1. Floodplains: Flat areas adjacent to a river that are prone to flooding. During floods, rivers overflow their banks and deposit sediments, enriching the soil and creating fertile land.

Natural Levees : formed as a result of sediment deposition along the riverside . They are low, linear and parallel ridges of coarse deposits along the banks of rivers





Meanders over flood and delta plains formed during mature and old stage of the rivers where stream gradients are very gentle

Meander is not a landform but is only a type of channel pattern.

Theyare formed due to low channel gradients, unconsolidated alluvial deposits, and the impact of coriolis force on water flow

- Point bars are found on the concave side of the meanders of large rivers and are sediments deposited in al linear fashion by flowing waters along the bank
- **Point Bars: These are crescent-shaped deposits of sand and gravel that form on the inside bends of meandering rivers. As water flows more slowly on the inside of the bend, sediment is deposited.**

Oxbow Lakes:

These are formed when a meander in a river is cut off from the main channel, often due to sediment deposition. Over time, the abandoned meander can become a standalone lake. U shaped lake , curve bends of rivers Kanwar Taal, also known as Kabar Taal Lake or Kabartal Wetland, is Asia's biggest freshwater oxbow lake, located in the Begusarai region of Bihar, India. formed due to meandering of Gandak River , tributary of Ganga

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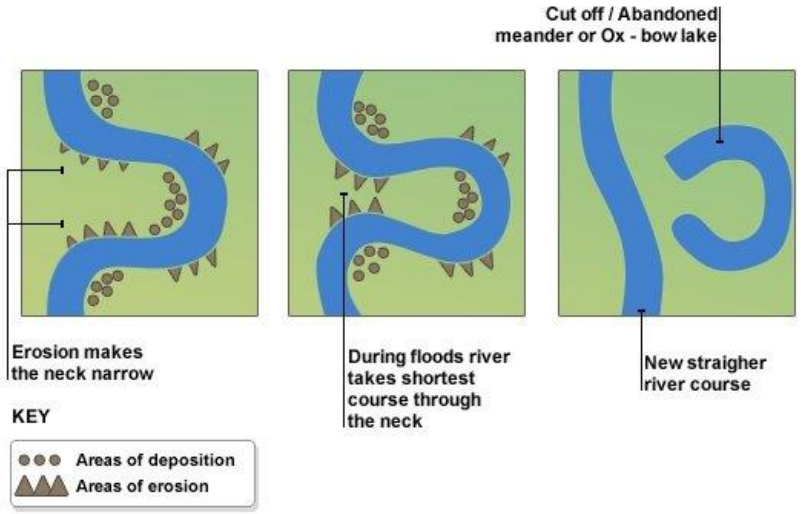


4. Deltas: Formed at the mouth of a river where it meets a larger body of water, deltas are shaped by the gradual deposition of sediment as the river's velocity decreases. Deltas typically have a characteristic triangular or fan shape.

5. Bars: Accumulations of sand or gravel that can form in the river channel itself, either as longitudinal bars (elongated) or transverse bars (perpendicular to the flow). They can shift with changes in water flow.

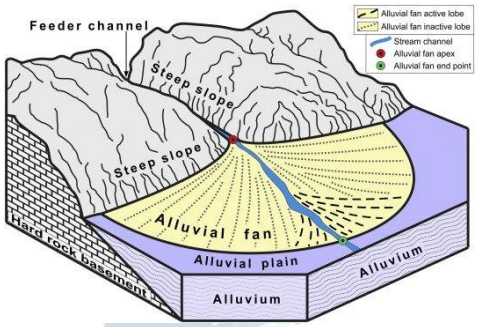
6. Braided Rivers:

When discharge is less and sediment load is more in the valley, channel bars and islands of sand, gravel and pebbles develop on the floor of the channel and the water flow is divided into multiple threads. These thread-like streams rejoin and subdivide repeatedly to form a braided pattern. Deposition and lateral erosion of banks are essential for their formation

Characterized by multiple interwoven channels separated by small islands or bars of sediment. Braided rivers often form in areas with a high sediment load and fluctuating water flow. Ex Ganga and Brahmaputra River

7. Alluvial Fans: form at the base of mountain range or steep slopes , fan shaped or triangular consist of coarse sediments .

Alluvial fans in humid regions have gentle slopes, while arid regions exhibit steep, high cones.



Delta : Form at the mouth of river , gentle slow , and create network of distributaries composed of fine sediments .

Types of Deltas :

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Bird s foot delta

- It s a kind of delta featuring long, stretching distributary channels, which branch outwards resembling the foot of a bird.
- Example the Mississippi River has a bird s foot delta extending into the Gulf of Mexico

Arcuate delta

- Arcuate is the most common type of delta. This is a fan-shaped delta.
- It s a curved or bowed delta with the convex margin facing the sea.
- Arcuate deltas have a smooth coastline due to the action of the waves and the way they are formed.
- Examples - The Nile, Ganges and Mekong river deltas

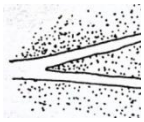
Nile river, Arcuate delta

Cuspate delta

- A few rivers have tooth-like projections at their mouth, known as the cuspate delta. Cuspate deltas are formed where the river flows into a stable water body (sea or ocean).
- The sediments brought down by the rivers collide with the waves. As a result, Sediments are spread evenly on either side of its channel.
- Example Ebro river delta in Spain

Cuspate Delta : This is a pointed delta formed generally along strong coasts and is subjected to strong wave action. There are very few or no distributaries in a cuspate delta.

Example: Tiber river on west coast of Italy.



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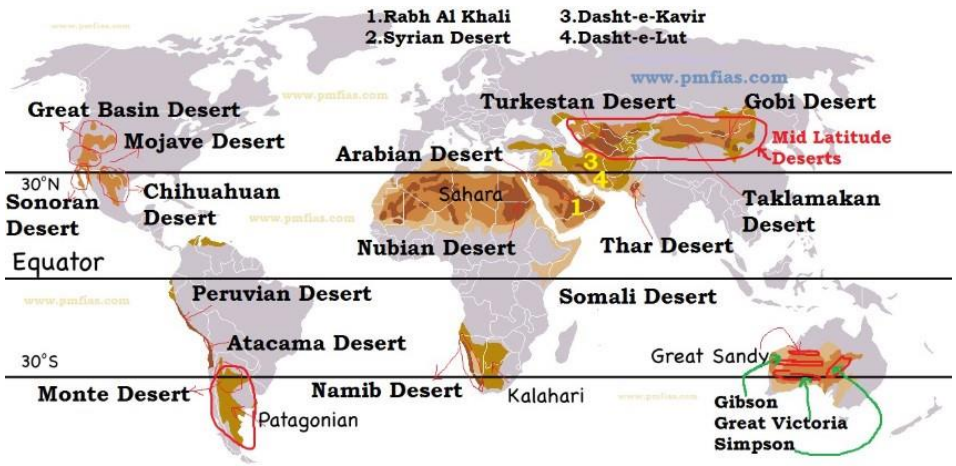
DESERT ARID LANDFORMS

Desert :

- Define : It is an arid region characteriesed by extremely high or low temperatures and has scarce vegetation.
- **Covers 20 % World Geographical Region**
- **High Temperature; Rapid Rate of Evaporation, Insufficient Rainfall**
- **Weathering Predominant by : Geomorphic Agent - Wind and Water**
- **Temperature basis : Hot Desert and Cold Desert**
- **Location basis : : Sub Tropical Desert; Coastal Desert; Polar Desert**
- **Hot Desert Found in Western Side of the Continents (15 to 30 Degree Latitude in both Hemisphere)**



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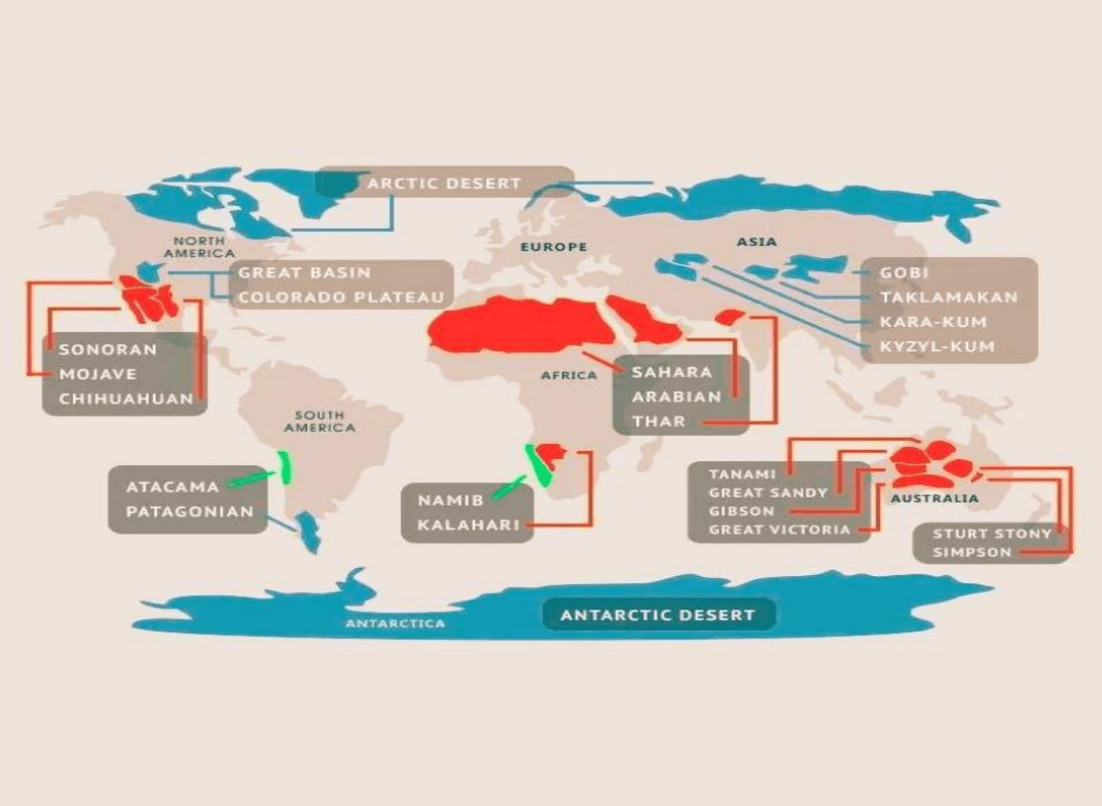
Note : https://ncert.nic.in/ncerts/l/gess210.pdf --- Life in Desert



Cold Desert : Temperate Desert / Polar Desert

- Cold Temperature and low rainfall of less than 25cm
- Located in high altitude in the interior of the continent
- The world's largest cold desert is found in Antarctica.
- Atacama, Pantagonia and Gobi Desert, Taklamakan In India - Karakoram desert - Ladakh and Lahaul and Spiti Valley of Himachal Pradesh
- Karakoram Desert - Black Sand and Red Sand called Kyzyl Kum Desert

TYPES OF DESERT

- **Mountain Desert : Steep Slopes, Irregular Edge and High Peaks and Ranges (Tibesti Mountain and Ahaggar Mountains of Sahara Desert)**
- **Hamada - Rocky Desert (Sahara Desert) elevated plateau of rocks**
- **Reg - Mixture of sand, gravel and stones ; Stony Desert (Libya and Egypt)**
- **Erg - Sandy Desert (Rubh Al Khali, Saudi Arabia)**

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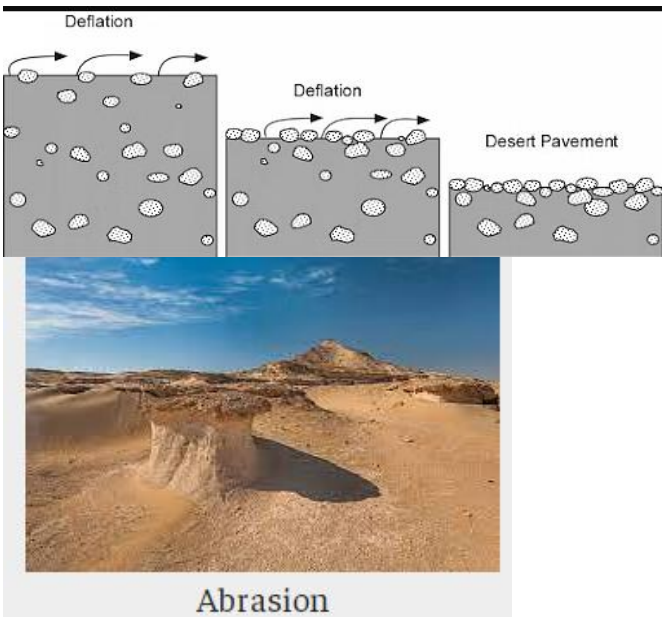
- **Badlands : Arid Areas eroded by rainstorms into gullies and ravines (Arizona USA; Chambal Ravines of Madhya Pradesh)**

Mechanism involved in geological process in shaping Desert Landforms



Wind erosion is carried out in desert areas in mainly three ways Deflation, Abrasion and Attrition

- **Deflation- removal of loose fine grained particles from the ground rocks**
- **Abrasion - Rock Surface scratched and polished ; more effective at rock base**
- **Attrition - Particles rolls against one another in a collision they wear each other**

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Erosional Desert Landforms	Depositional Desert Landforms
Rocks Pedestals - Mushroom Rocks	Sand Dunes: Barchans, Seifs (wind)
Yardangs and Zeugen Topography	Loess (wind)
Mesa and Butte Topography	Bajada (Water)
Inselbergs - Island Mountain- Monadnock	
Deflation Hallows or Blowouts	
Demoiselles and Dreikanter(Ventifacts)	
Pediment and Pediplains	
Playas - Shallow Lakes of Desert	

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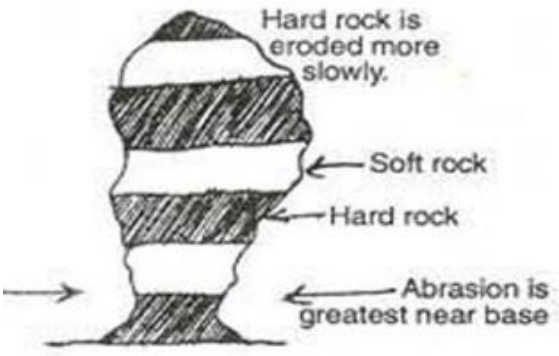
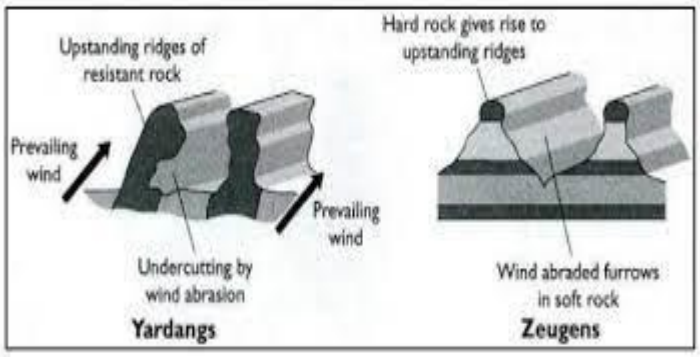
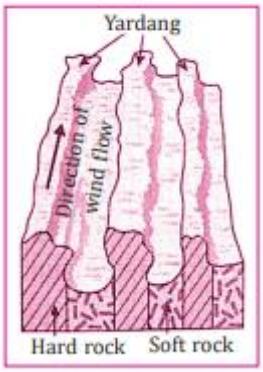


Rocks pedastal - Mushroom rocks

- **erosional desert landform created by wind action by deflation and abrasion process**
- Mushroom rocks which have a slender stalk and a rounded, pear-shaped cap. Table rocks have broad, flat tops.
- Pedestal rocks stand tall like pillars.
- **Alternate hard and soft rock pillar eroded near base**





Zeugen and Yardangs topography

- **Formed by wind erosion in Desert landscape**
- Zeugen: These are tabular masses that have a layer of soft rocks lying beneath a surface layer of more resistant rocks
- Yardangs: Instead of lying in horizontal strata upon one another, the hard and soft rocks of yardangs are vertical bands and are aligned in the direction of the prevailing winds
- **Yardangs are sharp sinuous ridges and parallel depressions**
- **Yardangs- Slopes of both sides are asymmetrical**
- **Zeugens- Slopes of both sides are symmetrical**
- **Soft and hard rocks alternate but in different patterns**
- **Yardangs - shaped by wind Deflation and abrasion**
- **Zeugens - shaped by wind abrasion and Saltation**
- **Zeugens are more height than Yardangs**

- **Inselbergs : German word-** Isolated Residual Hill or mountains ; steep slope and rounded tops (Kalahari Desert, West Australian)
- Demoiselles : Resistant rock Pillars above soft rocks result of erosion

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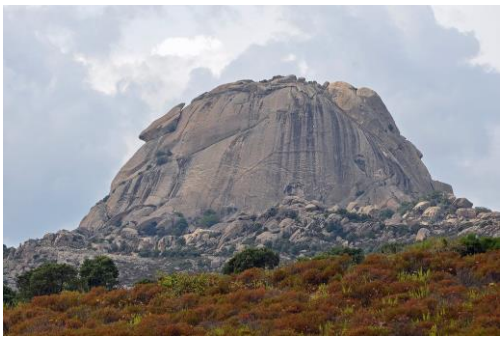

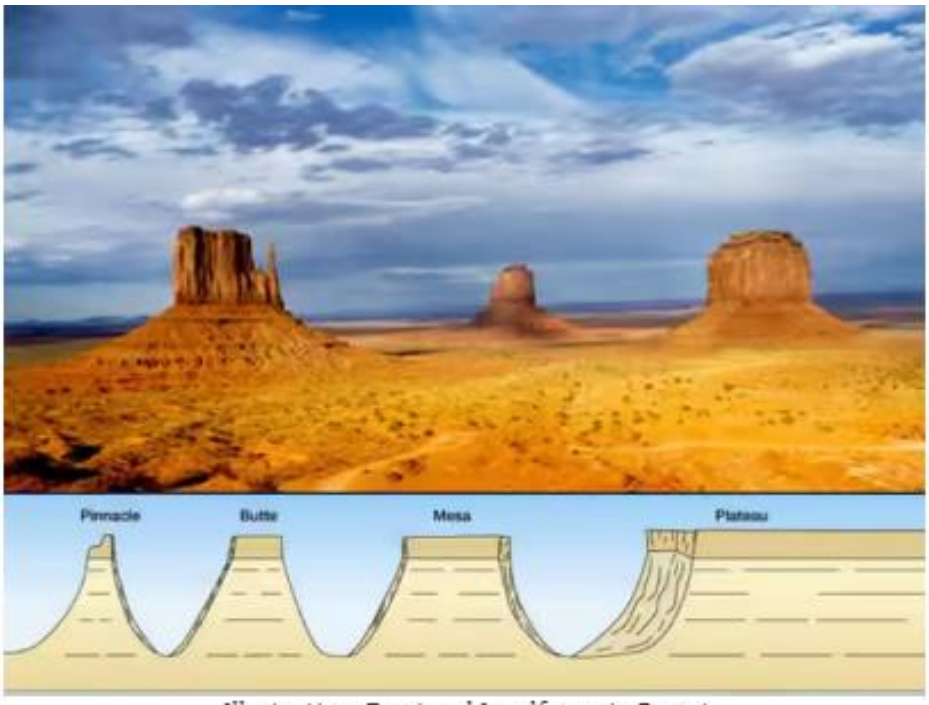

Illustration: Erosional Landforms in Desert

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- **Mesa:** (Spanish word -Table) Resistant top with steep sides
- **Mesa : flat table like landmass with resistant horizontal top layer and steep sides**
- **Mesa reduced to buttes by continued erosion. These are separated by Canyons**
- **Butte - isolated flat topped hills**
- **Erosional Process : Plateau - Mesa- Butte- Pinnacle (Decreasing pattern)**

- **Deflation Hallows : Shallow Depressions blowouts -** removal of loose and unconsolidated sands by wind .
- Ventifacts are sharp edges pebbles faceted by sand blasting by wind abrasion. Among the ventifacts, those with the three wind faceted surfaces are known as Dreikanter.

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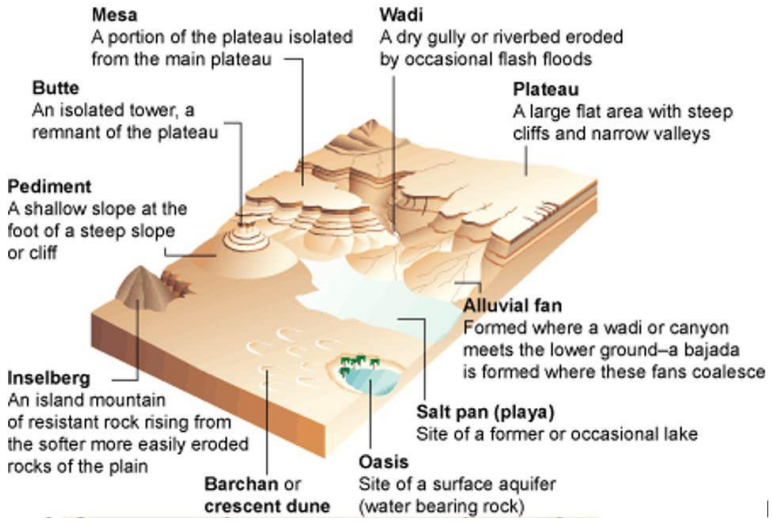
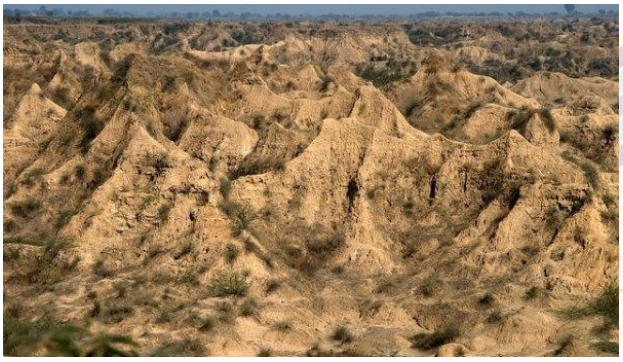
- **Pediment : Erosional plains at base of Mountain scraps**
- **PediPlains: High Relief is reduced to Low Featureless Plains in arid and semi arid region**
- **Playas : Wind erosional landforms, Shallow dry lakes or flat bottom depression**
- **Alkali Flats: Plain Playas covered by Salts**





Badland Topography

- **Landscape created by deep, narrow gullies, steep slopes, Spare Vegetation**
- **Formed by water erosion in Arid Region**
- **Occasional rainstorms produces rills , gullies, ravine , valley and erode weak sedimentary formations**
- **Ex Chambal Ravines - India ; Arizona and Dakota Ravine of USA**

DEPOSITIONAL LANDFORMS

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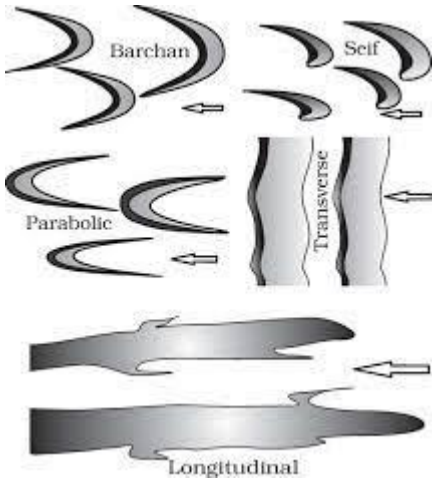


Sand Dunes

- **Barchans - crescent shaped sanddunes away from wind direction**
- **Parabolic Dunes - Reverse Barchans with same wind direction; U shaped and partially covered with vegetation**
- **Seif - Sword Shape (Arabic Word) Long, Narrow sand dunes parallel to wind direction.** It is similar to barchans but has only one wing due to shift in wind condition.
- **Longitudinal dunes - Sand Dunes Parallel to Wind direction**
- **Transverse Dunes : Sand Dunes Perpendicular to wind direction**
- **Star Dunes :** Have a high central peak, radically extending three or more arms

Loess :

- **are Aeolian Sediments of wind**
- **formed by accumulation of Windblown dust and silt , fine and mineral rich material ;**
- **fertile Regions**
- **Ex = large deposits found in China (wind blow from Gobi Desert)**
- **Pampas of Argentina , Ukraine and Mississippi Valley of USA**

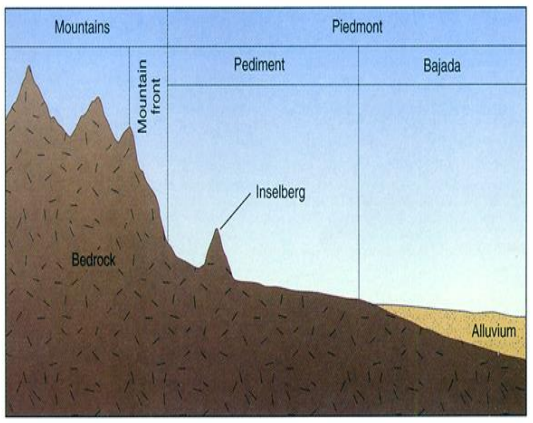
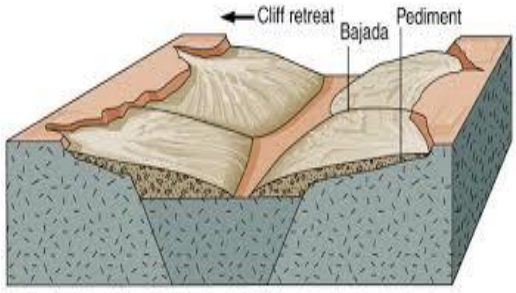


FIGURE 12.4
Profile from mountain into valley, showing the mountain front and the piedmont, with pediment, inselberg, and bajada.



Bajada:

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- **Depositional Feature of Alluvial material by intermittent stream (water)**
- Alluvial fans combine to create a bajada.
- **formed by coalescence of alluvial fans**
- **found in arid areas**

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GROUNDWATER lANDFORMS

Groundwater plays a significant role in eroding landmasses and shaping landforms, especially in regions with calcium carbonate-rich rocks like limestone and dolomite

KARST TOPOGRAPHY

- **Named After :** Karst Region in the Balkans adjacent to Adriatic Sea
- Formed in Which Rocks: Limestone Rocks , Dolomitic region and gypsum.
- Features : Rocks are permeable, thinly bedded and highly jointed and cracked
- Karst Topography created Erosional and Depositional Landforms
- Distribution in India

→ Vidhya Region in South West Bihar
→ Himalayas - JK and Himachal Pradesh- near Dehradun
→ Pachmarhi region MP
→ Bastar Region Chhatisgarh
→ Vizag near Bora Caves
→ Meghalaya - Siju and Krem puri caves

Created by : Chemical Weathering processes by Groundwater (Solution and deposition)

Carbonation : Carbon dioxide from the air or soil can dissolve in water to form carbonic acid which can dissolve limestone and help to form cave formations. Karst Limestone topography region creating hollow rocks

Erosional Landforms :

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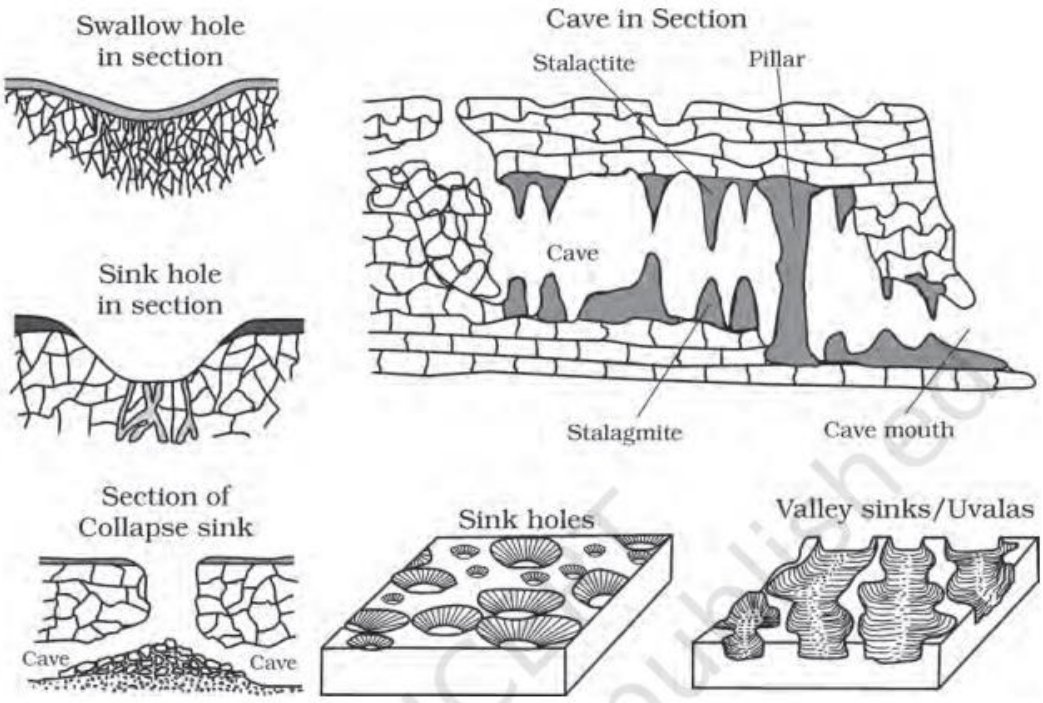

Figure 6.8 : Various karst features

- Swallow Holes or Ponor, Sinkholes, Lapies and Limestone pavements

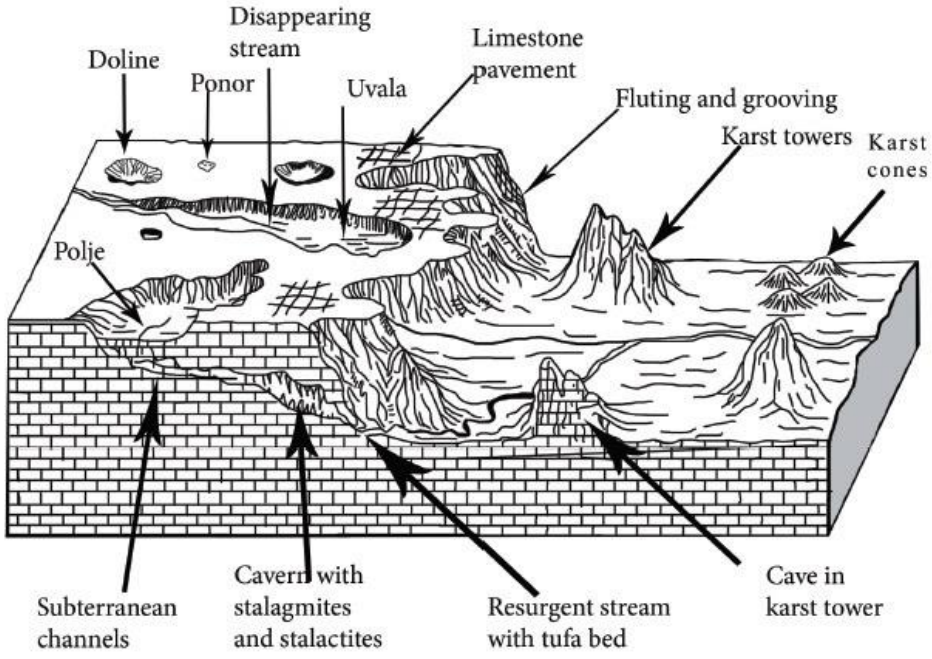

Figure 4.20 Karst features

The features of Karst Topography are listed down below:

1. **Ponor or Swallow Hole in Section** – Small to medium sized round to subrounded shallow depressions formed on the surface of limestones through solution
2. **Sink Holes** – Depressions that are circular at the top and funnel shaped or cylindrical pipe. at the bottom
3. Doline or Collapse Sinks : when number of swallow holes coalesce, a larger hollow is formed . A broader term for sinkholes
4. Uvala or valley sinks : When sink holes and dolines join together because of slumping of materials along their margins or due to roof collapse of caves, long, narrow to wide trenches called valley sinks or Uvalas form.

5. **Poljie : Large flat plain floor depressions**

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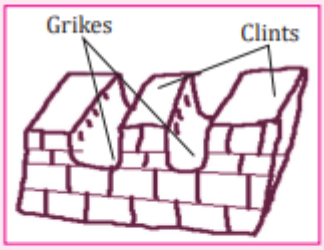
- Karst Towers: Steep, isolated limestone towers or hills formed through extensive erosion.

- Lapies (or Karren or ridges): extremely irregular with a maze of points, grooves and sharp ridges or lapies, formed on the surface of limestone due to chemical weathering.
- The lapie field may eventually turn into somewhat smooth limestone pavements
- Karst Valleys: Valley formations that develop in karst areas, often U-shaped and characterized by steep sides.

6. Blind Valleys: Valleys that do not have surface drainage; water disappears into the ground.
7. Caves- Natural underground spaces formed by the erosive action of water. Caves having openings at both the ends are called tunnels

Limestones are well jointed and it is through these joints and cracks that rain-water finds its way into the underlying rock. Progressive widening by solution enlarges these cracks into trenches and a most intriguing feature called limestone pavement is developed. The **enlarged joints** are called **grikes** and the **isolated , rectangular blocks** are termed **clints.**

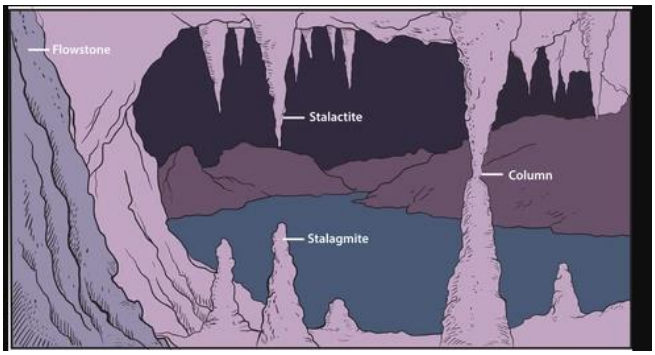


The landforms of chalk are rather different from those of other limestones. There is little or no surface drainage and valleys which once contained rivers are now dry. These are often called **coombes**

Depositional Landforms in Karst Topography : Stalactites, Stalagmites and Pillar

formation of Speleothems or cave deposits :

- refers to mineral deposits formed from groundwater within underground caverns.
- is a geological formation by mineral deposits that accumulate over time in natural caves



- Cave formations can include:

-
- Stalactites: Mineral formations hanging from the ceiling. Broad at their base, and taper towards the free-hanging ends.

-
- Stalagmites: Mineral formations rising from the ground. typically originating from dripping water from the cave ceiling.

-
- Columns or Pillar - Formed when stalactites and stalagmites meet.

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- Flowstones: Deposits on the cave floor formed by seepage water and water flowing out of stalagmites .Sheet-like deposits formed by water flowing over the cave surface.
- Dripstones: Calcite deposits formed from dripping water in dry caves
- Drapes or Curtains: Needle-shaped dripstones that hang from the cave ceiling
- Helictites and Heligmites: Dripstones growing sideways from stalactites and stalagmites, respectively, with globular helictites called 'globulites.
- Helictites: Curving cave formations that grow from ceilings; formed primarily through capillary action.
- Heligmites: Similar structures growing upward from cave floors

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GLACIAL LANDFORMS :

- The term "glacier" comes from the French word
- Glaciers are masses of ice that move over the land in various forms, covering approximately 10% of the Earth's surface
- **Glaciers are often called "rivers of ice."**
- Glaciers fall into two groups: alpine glaciers and ice sheets
- Alpine glaciers form on mountainsides and move downward through valleys.
- Alpine glaciers are also called valley glaciers or mountain glaciers.
- alpine glaciers create or deepen valleys by pushing dirt, soil, and other materials out of their way.
- Alpine glaciers are found in high mountains of every continent except Australia (although there are many in New Zealand).
- **only 2 major ice caps are present in this world – Antarctica & Greenland**
- When the ice sheets reaches down to the sea they float as ice shelves in polar waters.
- When ice sheets break into individual blocks, these are called icebergs.
- ice sheets :They form **broad domes and spread out from their centers in all directions.**The largest ice sheets, called continental glaciers, spread over vast areas. Today, continental glaciers cover most of Antarctica and the island of Greenland.
- Glacial Landforms can be found in locations that currently have no active glaciers or glaciation processes.

Glacial Landforms

- Glaciations generally gives rise to erosional features in the highlands & depositional features on lowlands
- It erodes its valley by two processes viz. plucking & abrasion.
- Plucking: Glacier freezes the joints & beds of underlying rocks, tears out individual blocks & drags them away.
- Abrasion: Glacier scratches, scrapes, polishes & scours the valley floor with the debris frozen into it.

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GLACIAL LANDFORMS	
Erosional landforms	**Depositional landforms**
Corrie or Cirque or Tarn lake	Outwash Plains or Sunder
Aretes , Horn , Pyramidal Peak and Col	Till or boulder clay
Bergschrund or Rimaye	Moraines
Roche Mountain	Eskers
Crag and Tail Topography	Drumlins (Egg Basket Topography)
Glacial valley, Trough , Hanging Valley , ribbon lakes and Fjords , Truncated spur	Kames and Kettle Topography

Glacial Landforms – Erosional

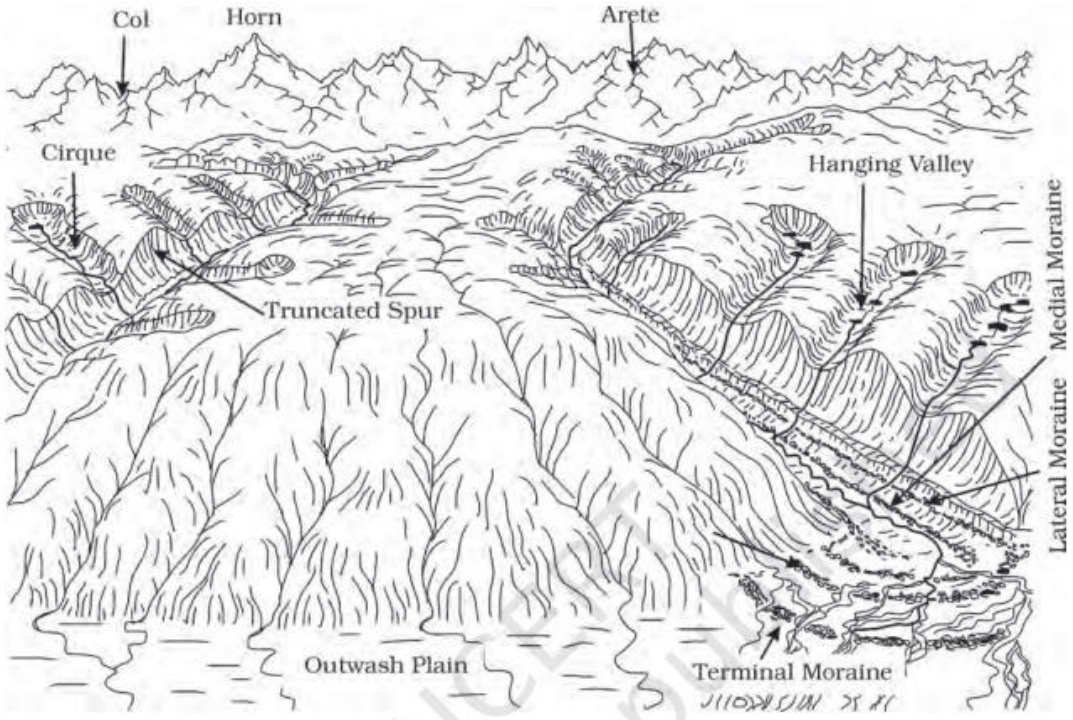

Figure 6.11 : Some glacial erosional and depositional forms (adapted and modified from Spencer, 1962)

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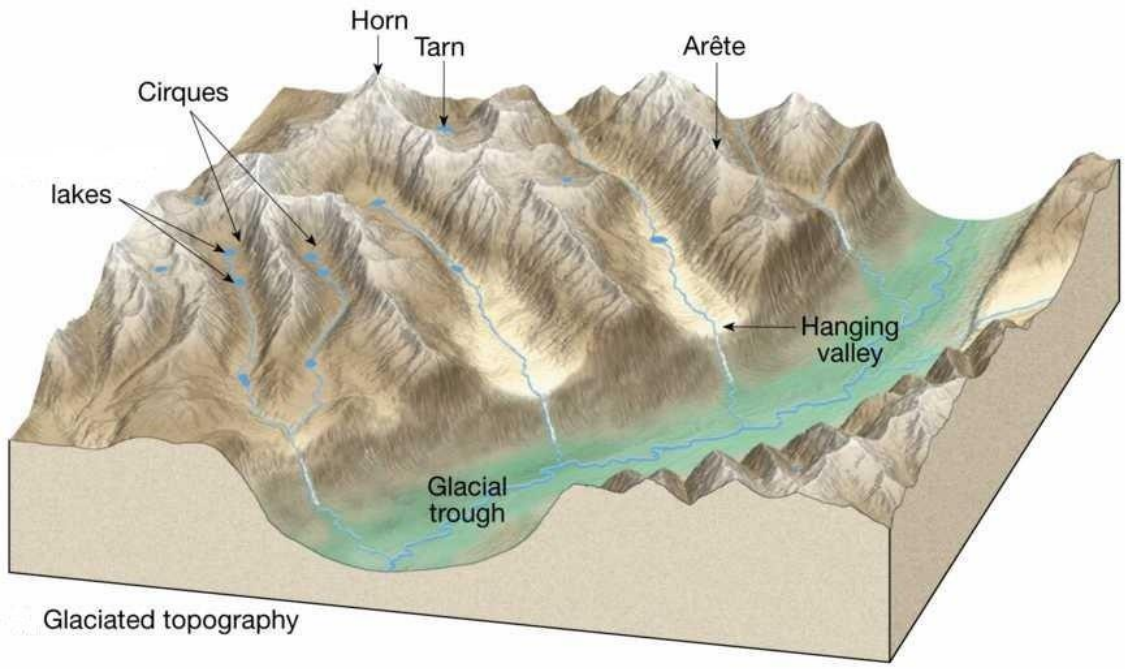
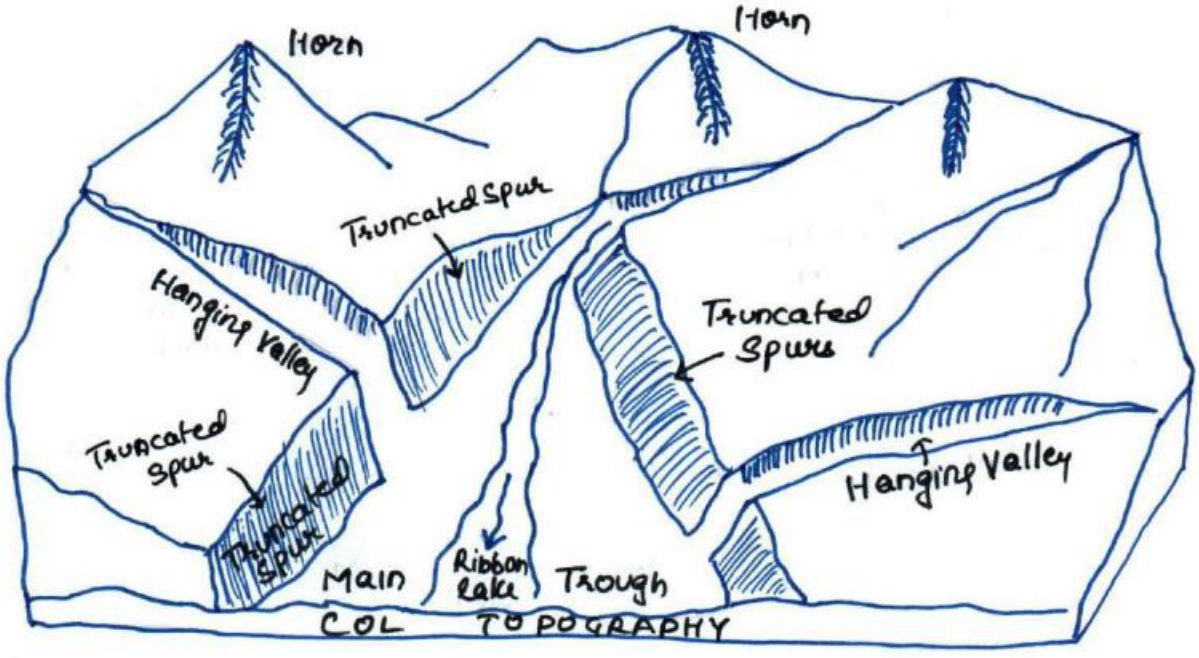


1 Glacial valley / Trough

- It is a 'U' Shaped Valley. It at mature stage of valley formation.
- A steep sided and flat bottomed valley results, which has a 'U' shaped profile.



Turncated Spur - truncated spurs are distinctive landforms created primarily through glacial erosion processes that truncate existing ridges into steep cliffs with characteristic inverted-V shapes

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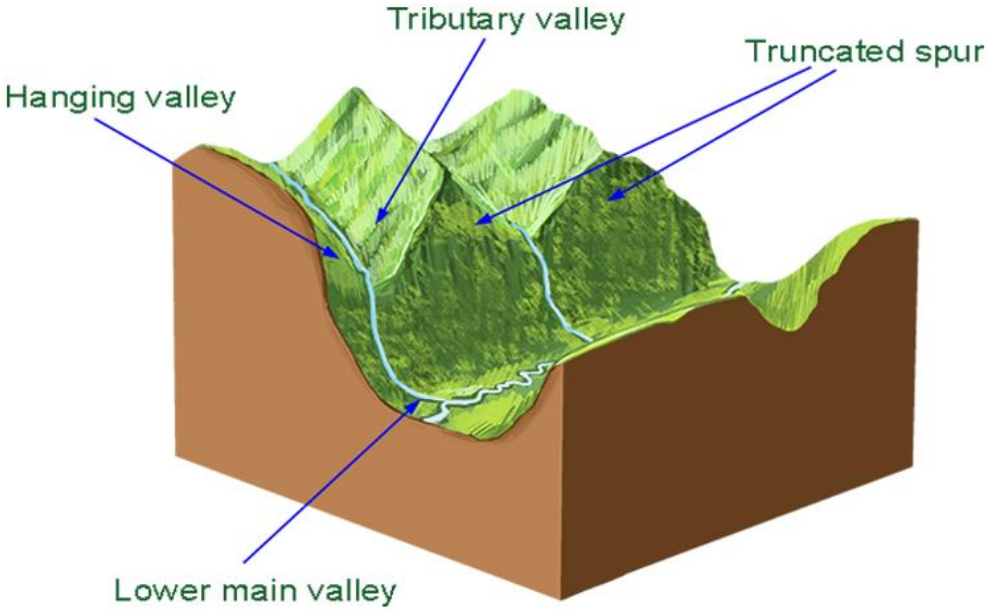

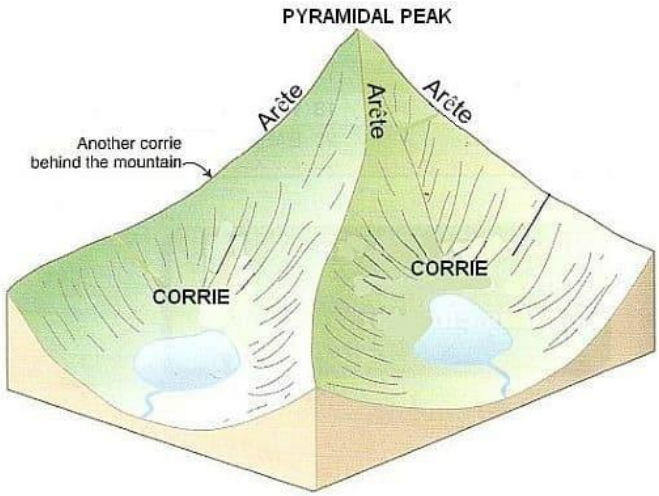

2. Corrie, Cirque or cwm:

- Plucking & abrasion further deepen the depression into a steep horse shoe-shaped basin called Cirque (in French), cwm (in wales) & Corrie (in Scotland)
- It has 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.**

3. Aretes and Pyramidal Peaks

When two corries cut back on opposite sides of the mountain, knife edged ridges are formed called arêtes

- When three or more cirques cut back together, recession will form an angular horn or pyramidal peak.

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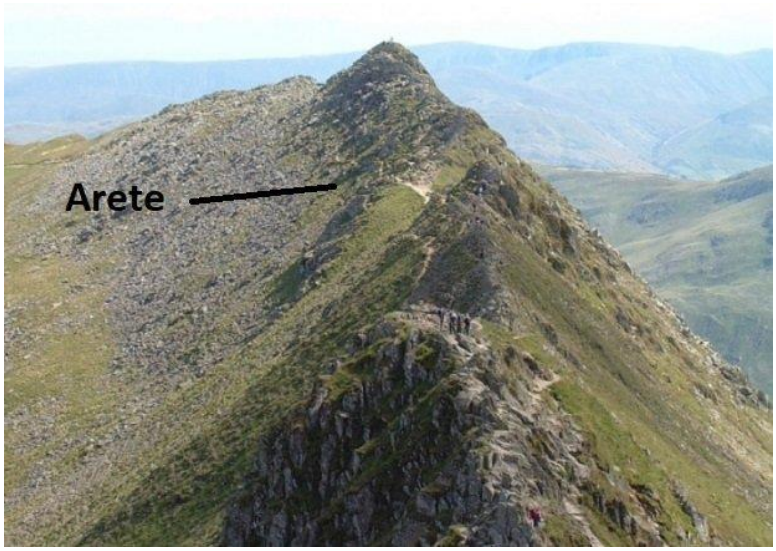

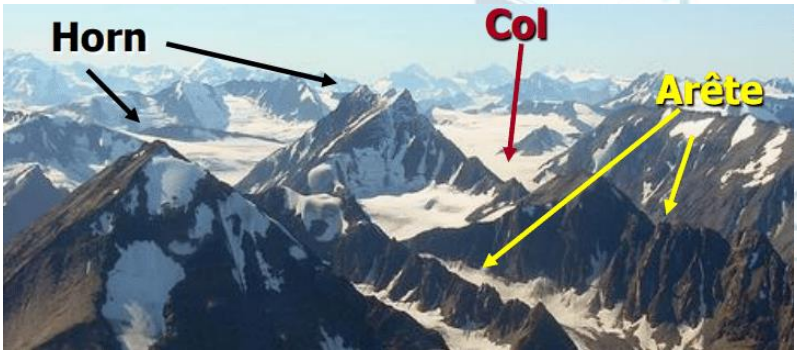

5. Cols

- Cols form when two cirque basins on opposite sides of the mountain erode the arête dividing them.
- Cols create saddles or passes over the mountain.

6. Horns are a single pyramidal peak formed when the summit is eroded by cirque basins on all sides

7. Bergschrund (German) or Rimaye (French): At the head of a glacier, where it begins to leave the snowfield of a corrie, a deep vertical crack opens up called a Bergschrund or Rimaye. this happens in summer when although the ice continues to move out of the corrie, there is no new snow to replace it

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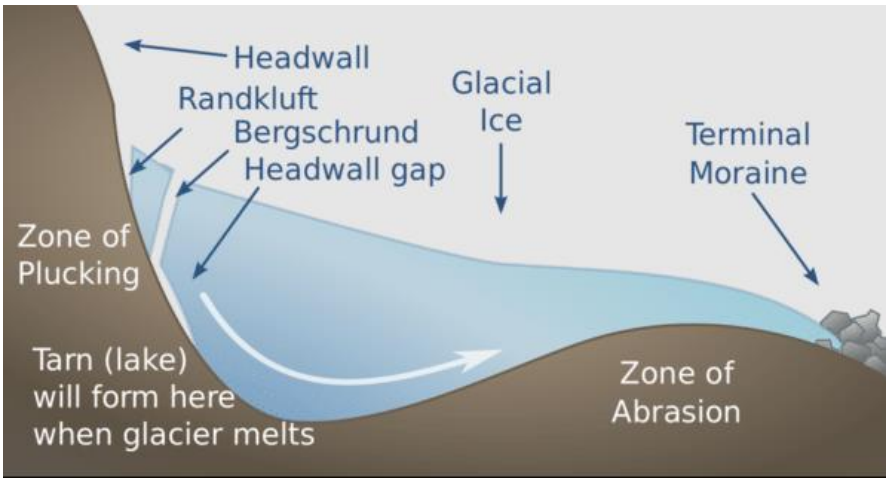
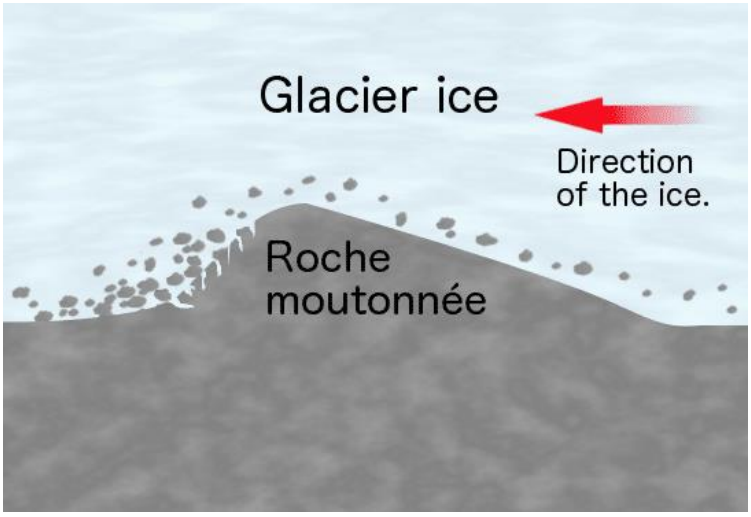
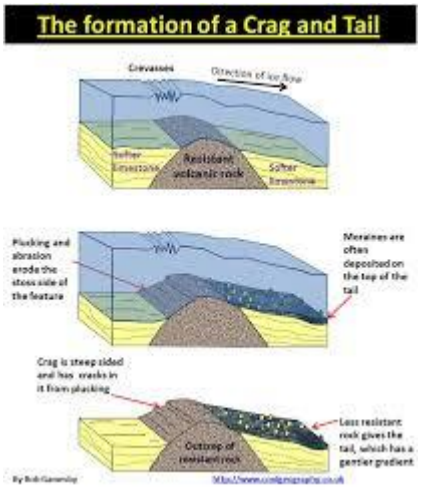


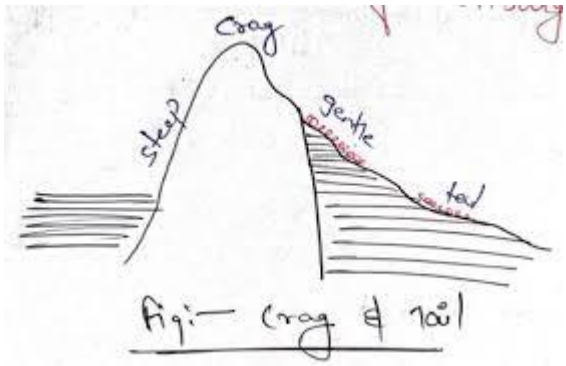
8. Roche moutonnée : Basically, a resistant residual rock hummock or mound, striated by the ice movement.



9. Crag and tail topography

- A crag and tail is a larger rock mass than a Roche moutonnee
- Crag is a mass of hard rock with a steep slope on the upward side, which protects the softer leeward slope from being completely worn down by the oncoming ice.
- Roche Moutonnee: This is a resistant residual rock hummock. The surface is striated by ice movement . Its upstream side is smoothed by abrasion and its downstream side is roughened by plucking





10 . Nunatak-Isolated peaks or mounds surrounded by glacial ice; They resemble small islands within the ice mass and decrease in size over time due to glacial lateral erosion and frost action

11.Paternoster lakes are formed in the low depression of a U-shaped valley.

12 .U shaped glacial Troughs & Ribbon lakes: After the disappearance of the ice, the deep sections, of these long, narrow glacial troughs may be filled with water forming Ribbon lakes also known as Trough lakes or Finger Lakes.

13 Hanging Valley After the ice has melted a tributary valley hangs above the main valley so that its stream plunges down as a waterfall. After deglaciation, meltwater from hanging valleys often forms waterfalls when joining the main valley

- Such Tributary valleys are termed as hanging valleys.

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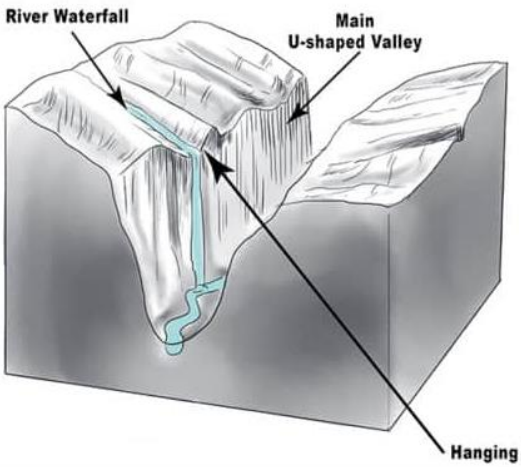
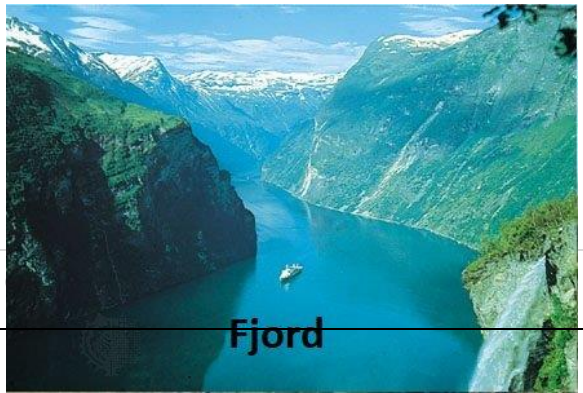


14 . Fjord



- If the glacier flows right down to the sea, it drops its load of moraine in the sea.
- A fjord or fiord is a long, narrow and steep-sided inlet created

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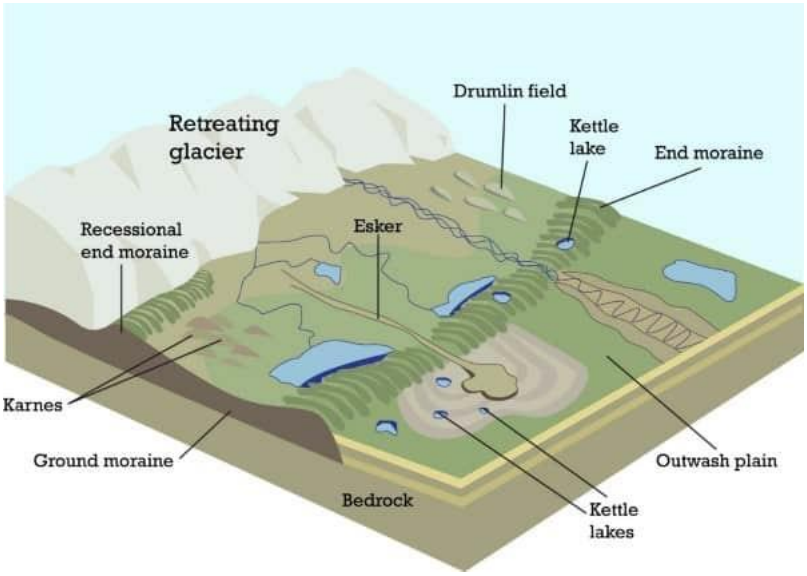
by a glacier

- They are formed where the lower end of a very deep glacial trough is filled with sea water
- If sections break off as icebergs, moraine material will only be dropped when they melt
- Fjords are common in Greenland Norway, Chile, and New Zealand etc.
-

Glacial Landforms – Depositional



Glacial Depositional Landforms

. Outwash Plains

- It is also known as called a sandur.
- It is a plain formed of glacial sediments deposited by meltwater outwash at the limit of a glacier.
- An outwash plain is a plain at the foot of the glacial mountain

2. Boulder clay or Glacial till

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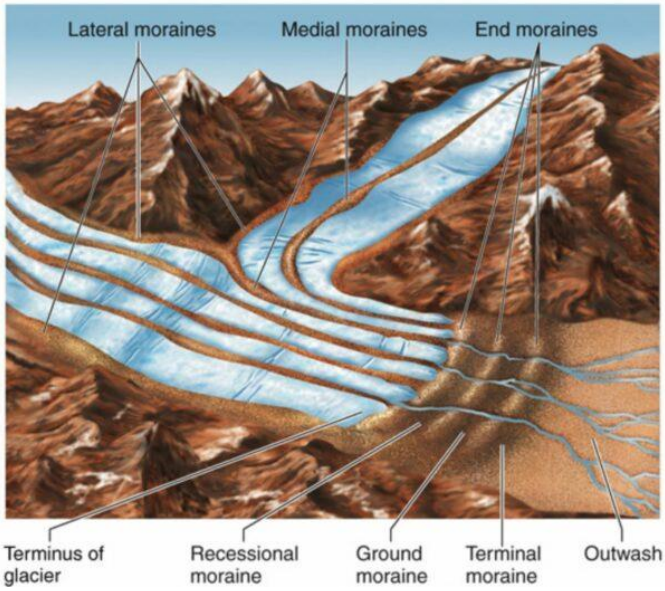
- This is an unsorted glacial deposit comprising a range of eroded materials such as boulders, sticky clays & fine rock flour.

Moraines: Moraines are long ridges of glacial till deposits; named differently on basis of locations they found

Terminal moraines are found at the end (toe) of glaciers, while lateral moraines form along the sides parallel to glacial valleys. These moraines may join to create horse-shoe-shaped ridges.

Medial moraines are found in the center of glacial valleys



Eskers

3. Eskers These are sinuous ridges formed by water flowing beneath melting glaciers. When glaciers melt, water gathers beneath them and carries coarse materials. As the glacier vanishes, these materials form ridges called eskers.

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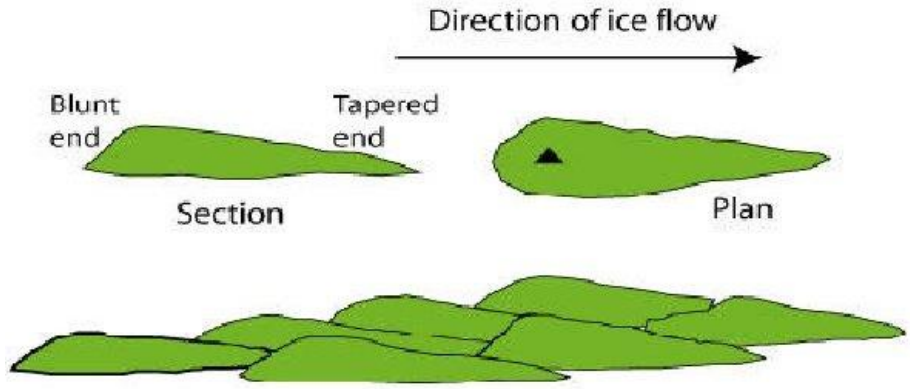
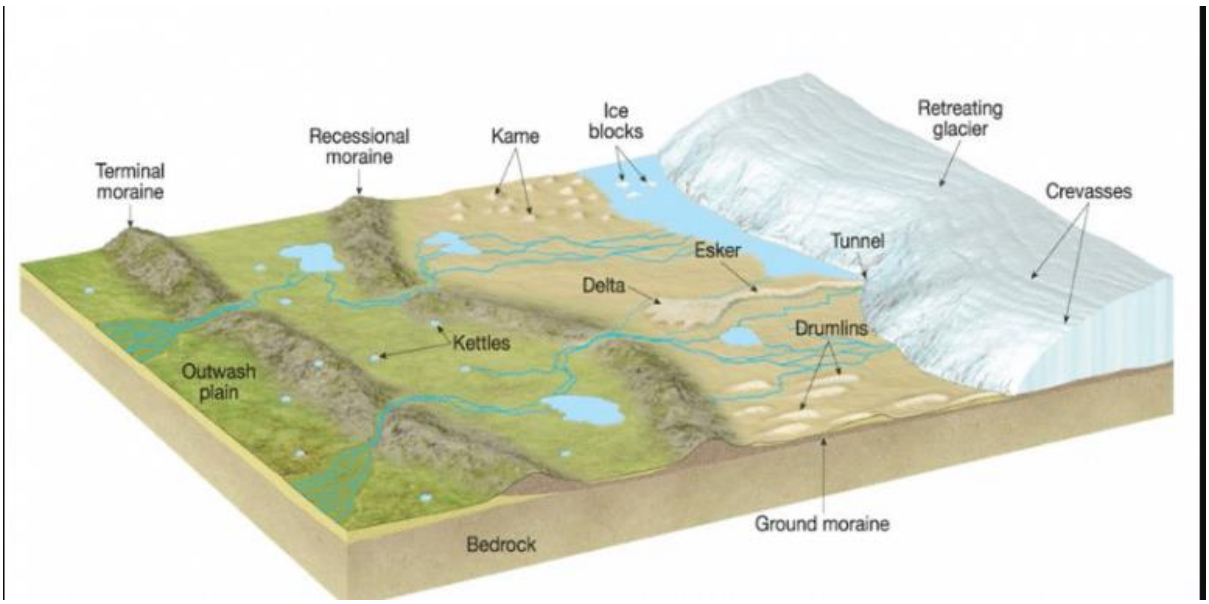


"Basket of eggs" topography

4. Drumlins are oval-shaped hills, made of rocks and dirt. These hills have two ends. One end, called the stoss end, is flatter and steeper, while the other end is called the tail. They are typically the result of glacial deposition and can occur in clusters, creating a "basket of eggs" topography.

or Inverted boat-shaped deposition in a till plain caused by deposition.

- They are widespread in formerly glaciated areas and are especially numerous in Canada, Ireland, Sweden, and Finland.



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6, Kettle lake:: Depressions are formed when the deposition takes place in the form of alternating ridges.

Kettle Holes: Formed when the deposited material in a till plain gets depressed locally and forms a basin.

Kames/Hummocks:: Kames are often associated with kettles, and this is referred to as kame & kettle topography.

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