N.B.K.R. INSTITUTE OF SCIENCE & TECHNOLOGY:: VIDYANAGAR

(AUTONOMOUS)

CIVIL ENGINEERING

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Branch: Civil Engineering

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Course Name: Engineering Geology

Lecture on: Unit III Physical geology

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UNIT II PHYSICAL GEOLOGY

- Factors causing weathering, erosion and denudation.
- Soil as product of weathering and engineering consideration, its profile and types in India.
- Geomorphologic (landforms) features of various geological agents as
- Landforms by water
  - Water fall, Gorges, River meandering, superficial deposits, alluvium,
  - Glacial deposits, laterite (engineering aspects),

- Desert landforms
- Loess, residual deposits of clay with flints,
- Solifluction deposits, mudflows, coastal deposits.

Weathering, Erosion and Denudation

Weathering: Consolidated or crystalline rock continuously exposed to the atmospheric conditions, thus rock become unconsolidated loose rock fragments(sediments) by disintegration and decomposition, this process is defined as weathering.

Therefore various factors are involved in rock weathering, such as

- ✓ Temperature and precipitation changes,
- ✓ Strength and hardness of rocks,
- ✓ Mineral and chemical composition of rocks,
- ✓ Structure and texture of rock,
- ✓ Exposure duration etc.

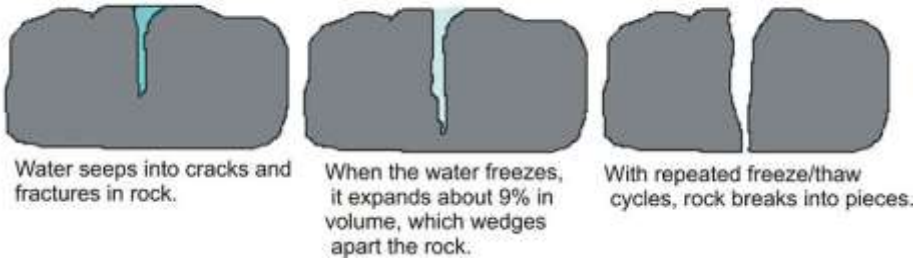
Types of Weathering (Breaking of material)

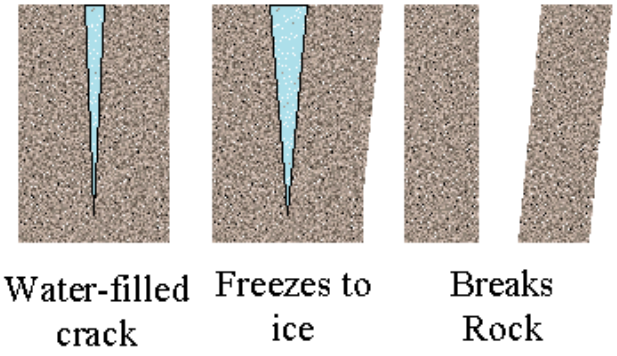
- ❑ **Physical or Mechanical** (Frost –wedging, alternate expansion and contraction (spheroidal weathering) etc. Fraturing through pressure release etc.
- ❑ Chemical-(Redution,Oxidation,Hydrolysis,Carbonation etc).
- ❑ Biochemical or biological(effect of vegetation and animals)
- ❑ Anthropogenic(Minining,crushing etc.

Types of Weathering (Breaking of material)

- **Physical or Mechanical**

Frost –wedging:





Alternate expansion and contraction (spheroidal weathering):

Fraturing through pressure release etc.

Types of Weathering (Breaking of material)

- Chemical weathering(decomposition of rock)

Reduction: The process of removal of oxygen from minerals, Under the conditions of excess water or water logged (less or no oxygen), reduction takes place. $2Fe_2O_3$ (Hematite) - $O_2 \rightarrow 4FeO$ (Ferrous oxide)

Oxidation: is the process of addition and combination of oxygen to minerals. The oxidation is more active in the presence of moisture and results in hydrated oxides.

FeO (Ferrous oxide) + $O_2 \rightarrow 2Fe_2O_3$ (Ferric oxide)

$2Fe_2O_3$ (Hematite) + $3H_2O \rightarrow 2Fe_2O_3 .3H_2O$ (Limonite)

Hydration: Addition of water to substance is hydration, soil forming minerals in rocks do not contain any water and they undergo hydration when exposed to humid conditions. $2Fe_2O_3 + 3HOH \rightarrow$ (Hematite)

Hydrolysis: It is due to the dissociation of H_2O into H^+ and OH^- ions which chemically combine with minerals and bring about changes, such as exchange, decomposition of crystalline structure and formation of new compounds

$HAlSi_3O_8 + 8\ HOH \rightarrow Al_2O_3 .3H_2O + KAlSi_3O_8 + H_2O$

Carbonation: Carbon dioxide when dissolved in water it forms carbonic acid. This carbonic acid attacks many rocks and minerals and brings them into solution.

$2H_2O + CO_2 \rightarrow H_2CO_3$

$CaCO_3 + H_2CO_3 \rightarrow Ca(HCO_3)_2$

Types of Weathering (Breaking of material)

- Biochemical or biological(effect of vegetation and animals)

- Anthropogenic(Minining,crushing etc.

Erosion: The removal of soil, rock, or dissolved material from one location to another location on the surface of Earth's crust is known as erosion.

Factors, which are influencing the rate of erosion are

- ✓**Climate:**Rainfall,Amount,duration,imtensity,frequency et
- ✓**Soil Characteristics:** Structure, Texture, erodibility and infiltration
- ✓**Topography:** Steepness and length of slope.
- ✓**Biological factors:** Vegetation cover, residue mulch and animals etc.

Transportation: Movement of sediment or material from one place to another place by the force of flowing water, high velocity wind, glaciers and ocean currents etc. is defined as transportation.

- ✓Turbulence of water
- ✓Speed of flow
- ✓Viscosity
- ✓Discharge in the river channel
- ✓Nature of sediment (Density, Grain size)
- ✓Quantity of sediments in to the channel.

Ways of stream transportation

- **As solution (solution load)**
- **As suspended load**
- **As bed load(rolled, bounced, and slid along bottom of stream bed).**

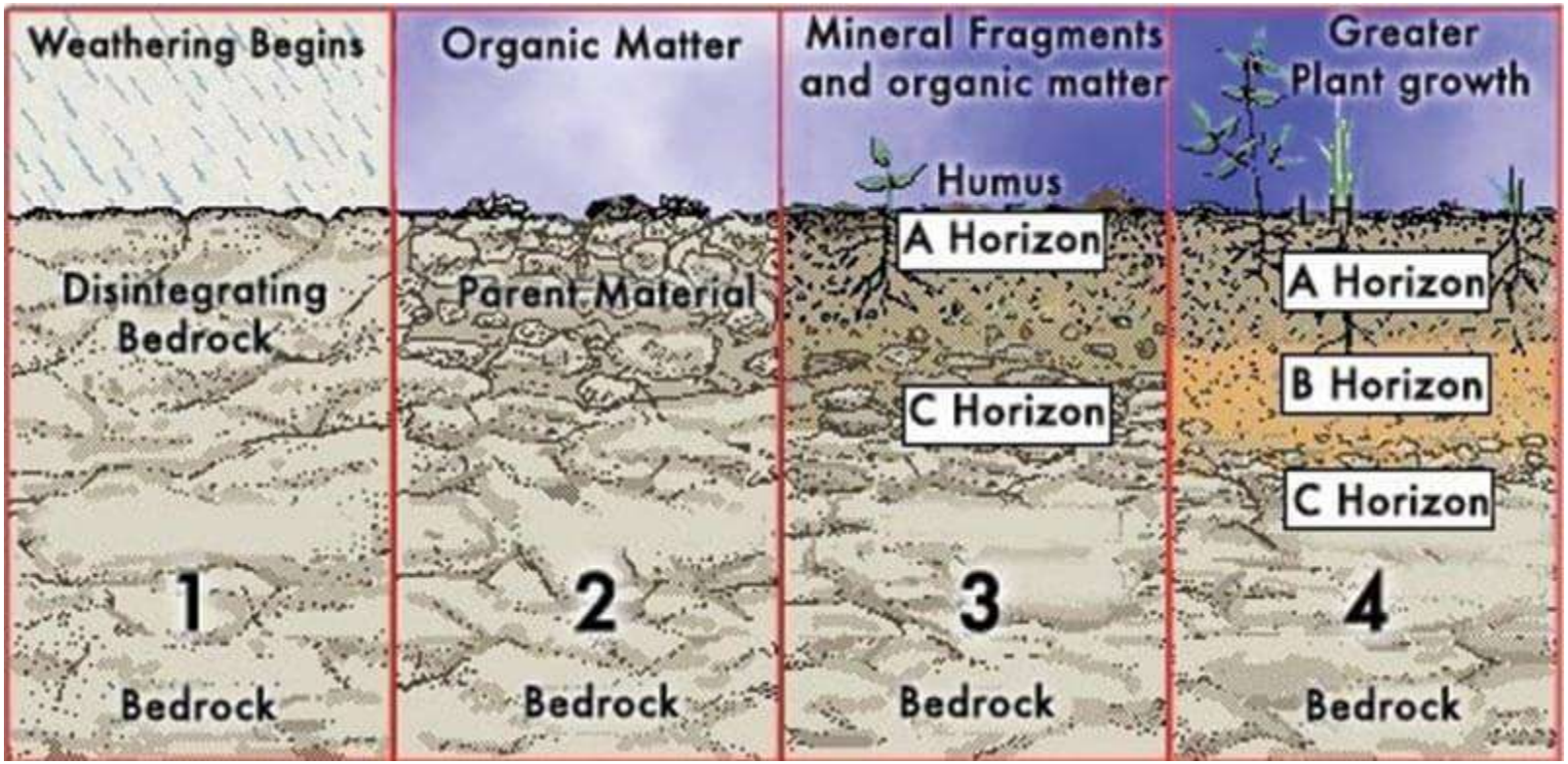
Denudation: Exposure of new surface by total erosion and redistribution of eroded material (Overall effect of weathering and erosion) in an area is known as denudation.

- ✓Climate
- ✓Lithology
- ✓Relief or Slope or surface topography
- ✓Tectonic activity
- ✓Anthropogenic activity

Soil as a product of Weathering

Soil forms as rock is broken down by weathering and mix with other minerals and organic material on the surface of the Earth.

Step 01: Parent material formed by Mechanical Weathering of bed rock.
Step 02: Organic matter formed from parent material
Step 03: Alteration of parent material as organic matter and minerals.
Step 04: Plant growth supported soil with humus and minerals.



Soil and Engineering considerations

Talus deposits: Generally, talus consists of a heterogeneous mixture of soil and rock fragments ranging in size from clay particles to rocks and a meter or more in diameter.

They are found along the lower portions of valley sides, such deposits frequently need to be partially excavated to allow passage of transportation facilities.

The cut slopes are commonly unstable and require constant monitoring and maintenance.

Soil and Engineering considerations

Aeolian deposits:

Loess and

Piping problems occur in loess deposits

Sand dunes

Sand dune migration creates a lot of problems in engineering works particularly in deserts.

E.g. Stabilizing movable sand is a major problem in construction and maintenance of highways and rail roads crossing sand dunes in deserts.

Alluvial deposits or alluvium: These are the deposits formed by river water. Some of the **characteristics of alluvial soils are**

The textural range of the soil vary from gravel to silty clay in both vertically and laterally..

Drainage also vary from very poor to free.

It may also contain organic matter.

The ground conditions are poor in alluvial deposits and generally require raft or deep file foundation.

Soil and Engineering considerations

Glacier deposits: Glacial deposits contain beds pervious sand, gravel and imperious clay or clayey silt. These beds are appear as pockets or lenselike deposits. Therefore heavy structures built in glacial zones may be endangered by differential settlement**.**

Swamps: These soils are filled with decaying vegetable matter and the bearing values of swamp soils is very low. Therefore only light structures can be built on them.

Soil and Engineering considerations

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Aeolian deposits: Loess and sand dunes

Alluvial deposits or alluvium:

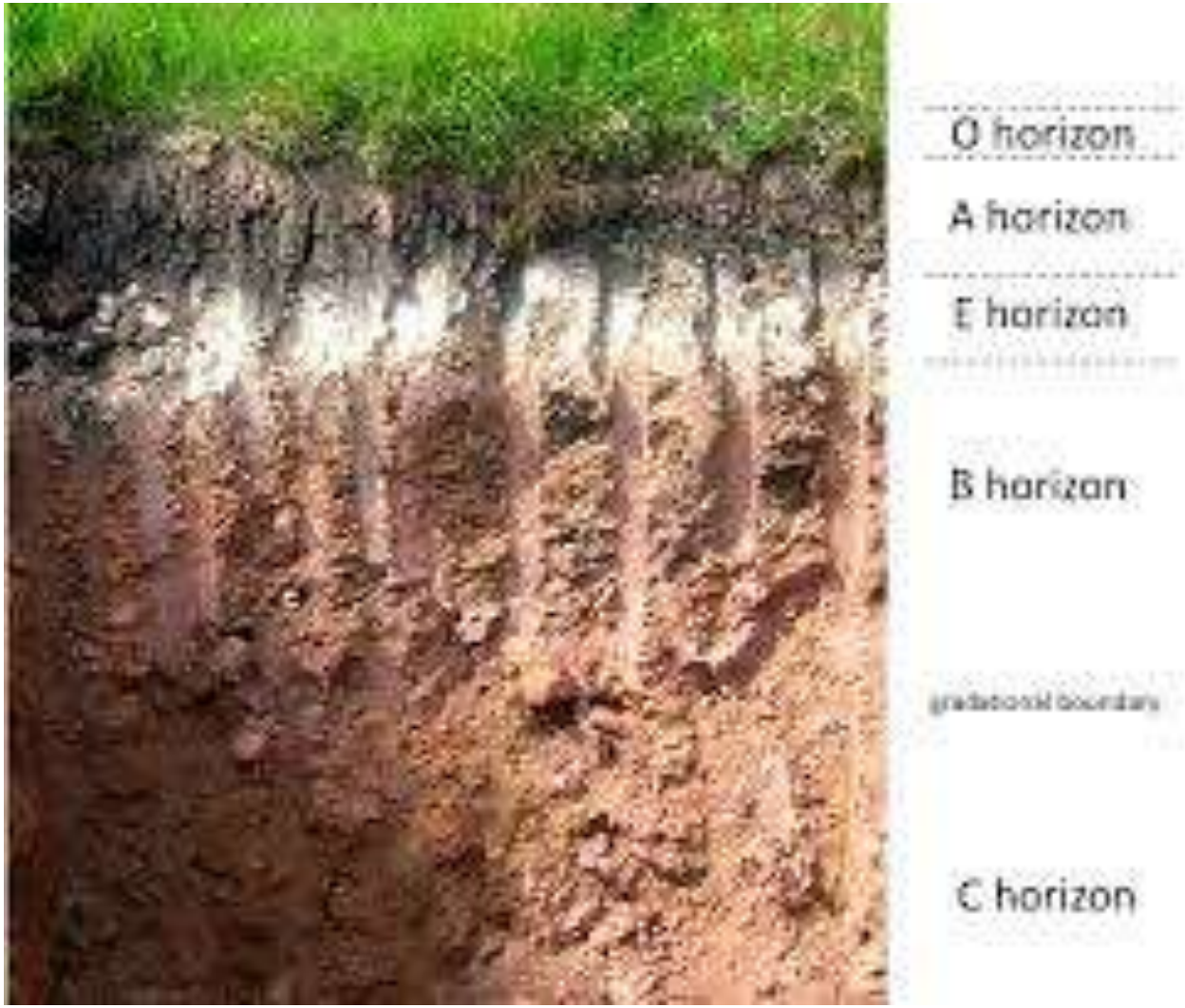
Glacier deposits:

Swamps:

Deltas:

Soil profile

O Hrizon
A Horizon
E Horizon
B Horizon
C Horizon
Bed rock



Soil Types in India

Alluvial Soil: Gangetic plains, Narmada Tapti valleys,Godaari –Krishna deltas.

Laterite soils: Due to extensive leahing, silica is removed from basic igneous rocks(mainly from Deccan basalts) and enriched with iron and aluminium oxides and other hydroxides.

Red soils: Residual weathering of rocks, which are rich in ferromegnesium minerals. It is loamy to sandy in nature.

Black soils: Residual soils derived from the basalts and basic igneous rocks. It is in dark color, Compositionally rich in fine clayey and Mg and Al oxide minerals.

Because of clayey minerals mainly momtmorillonite, it shows expansive nature.

Desert soils: Soils in the desert formed by acumulation of sediments as sand, clay ,carbonates, nitrates and phosphates. These soils occur as sand dunes,aeolian deposits in portions of Jodhpur,Barmer,Jaisalmer and Bikaner districts in Rajasthan.

Salt –affected soils: Saline soils are generally formed by soluble salts like NaCl,CaSO4,MgCl2 etc.

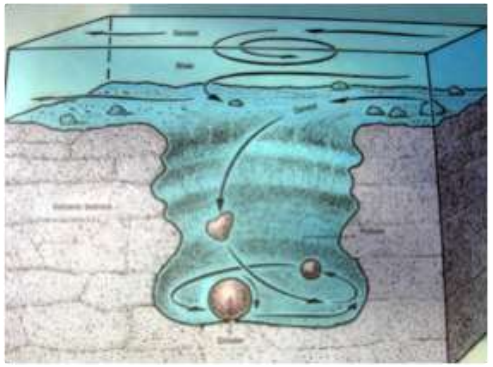
Forest soils: Soils are dark brown color and rich in organic matter. These occur in Uttaranchal,Punjab,Himachal Pradesh,JK,TN.

Peaty and marshy soils: The soils rich in organic matter. These our in coastal areas of Orissa, sundarbans (delta) in parts of Kerala.

- **Landforms of water/River**
  - **Youth stage (Erosional land forms)**
    - ✓Rills, gullies
    - ✓Potholes
    - ✓ V shaped alleys
    - ✓Gorges, Canyons
    - ✓Rapids and water fall
  - **Mature stage(Erosional and depositional land forms)**
    - ✓Alluvial fans or cones
    - ✓River meanders, point bars and ox-bow lakes
    - ✓Flood plains or alluvial plains
    - ✓Natural levees
  - **Old stage(Depositional landforms)**
    - ✓Ox-bow lakes
    - ✓Deltas
    - ✓Braided channels

Rills and gullies: Rill is a small stream channel formed by the erosion of running water on the slope of hill or mountain .
If rill is widen and deepen by high erosion.

Potholes: A small depression formed on the river bed due to localized erosion or hydraulic action of the water in the river is termed as pothole.



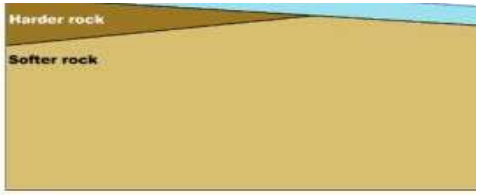
V shaped alleys: A steep sided valley formed due to weathering and vertical erosion of water in the river channel can be defined as V shaped valley.

Gorges: A narrow valley with steep rock slopes formed by the river erosion between the hills or mountains can be defined as gorge.

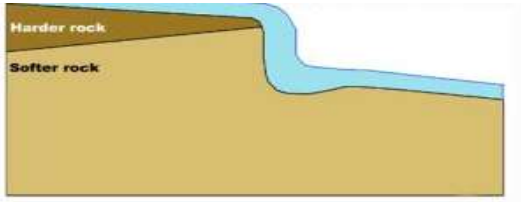
Canyon: Land form like a gorge, but the bottom of the valley broad in canyon.

Water fall: Various steps involved in the formation of waterfall , such as

Step 01: Where the river flows on layer of hard rock ,which laid on soft rock

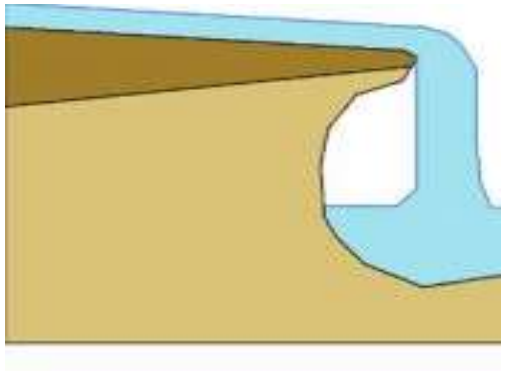


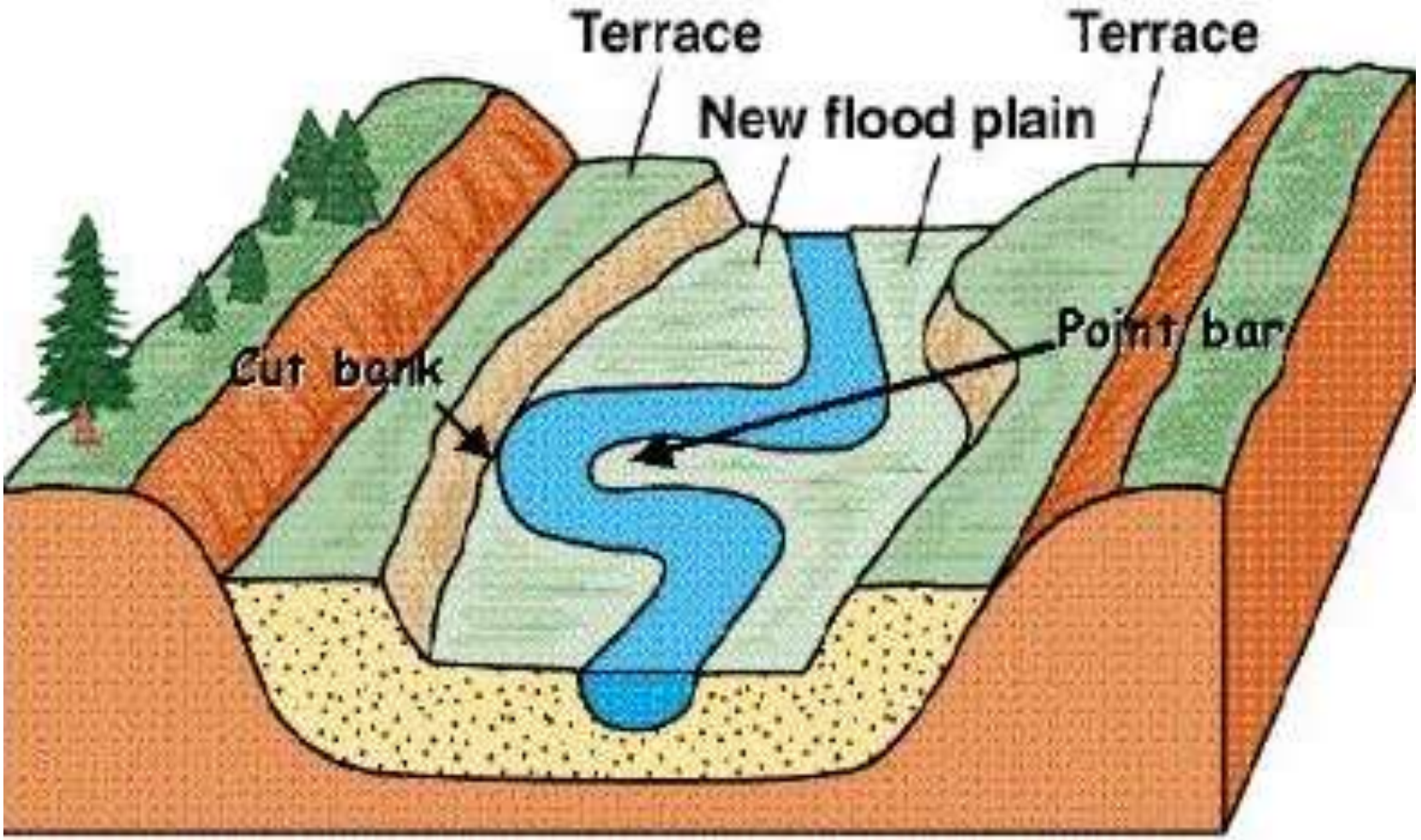
Step 02: As the river passes, the soft rock is eroded at f aster rate forming a step in the river bed.



Step 03: Plunge pool is formed

Step 04: Hydraulic action of water of notch formation continue, the harder rock failure due to no support.

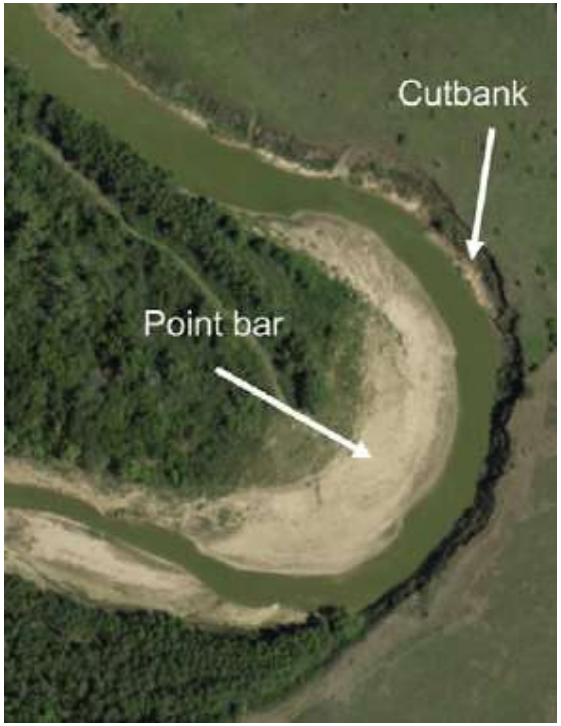



Terrace
Terrace
New flood plain
Point bar
Cut bank

Land forms of river (Mature Stage)

River meanders: Load in the matured river is high, therefore it moves in curved path. These curves or bends in the river channel is termed as river meanders.

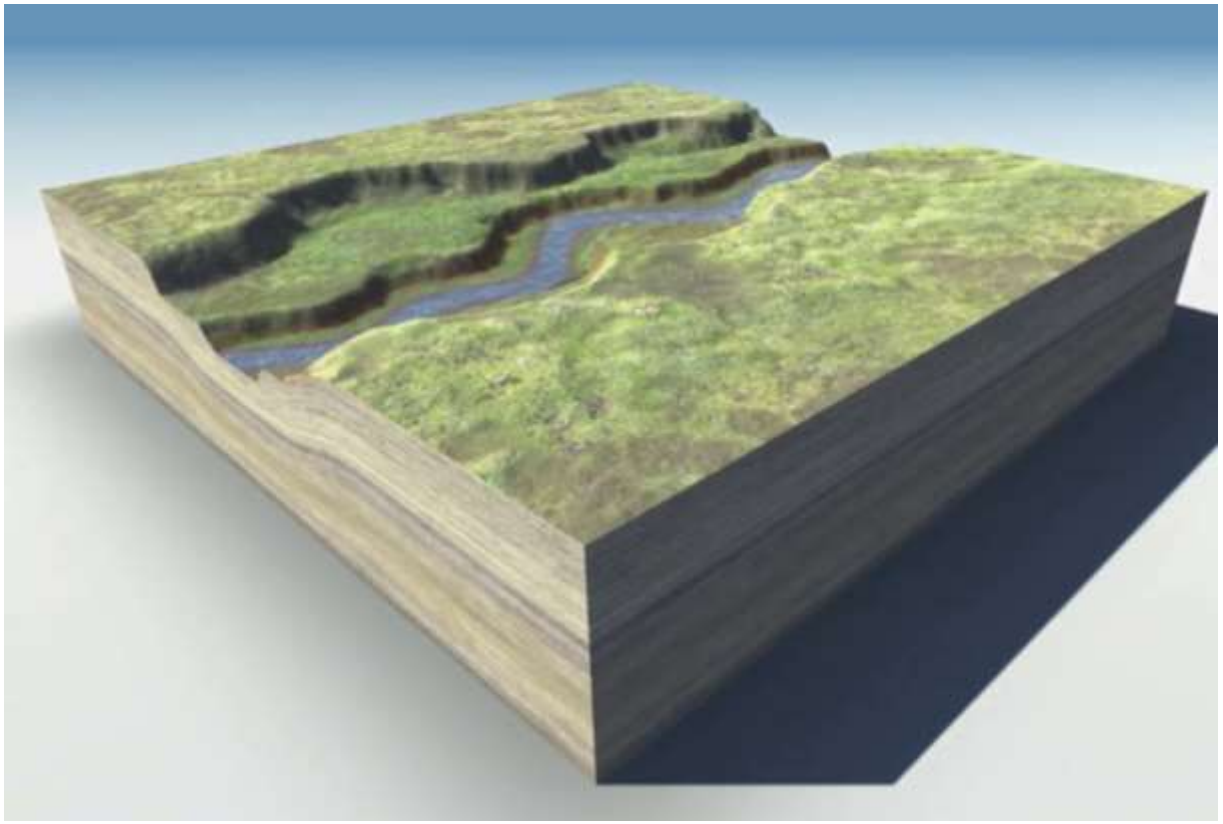
Point bars: Deposition takes place in the inner edge of the meander due to low energy. These depositional landform at inside of the meander is known as point bar.



Ox-Bow lake: Due to silting increase the river meander separated from main river and form a cured lake which is looking like ox-bow or crescent-shape and is termed as ox-bow lake.

Flood plains: Water level rises in a river , this raised water spread in the low ,flat area near the river and forms a plain by deposition is defined as flood plain.

River terraces: Because of frequent floods , flood plains will be formed at different levels in the river channel and forms a step like raised landform is known as river terrace.



Delta: When the velocity of the river drops due to decrease in the gradient or at the rejuvenation or at the old stage, river leaves its load by deposition and forms a cone shaped or delta shape landform is known as Delta**.**

Braided Channel: The velocity of river is very low, so it can be split or bifurcate in to small channels(mainly observed in delta).These small channels are known as braided channel.

WIND:

Bulk movement or directional flow of air including various gases on the surface of the earth with certain speed, on a large scale is defined as wind.

Winds have various aspects:
velocity (wind speed);
the density of the gas involved;
energy content or wind energy.
The wind can travel and transport the sediments for thousands of kilometers.

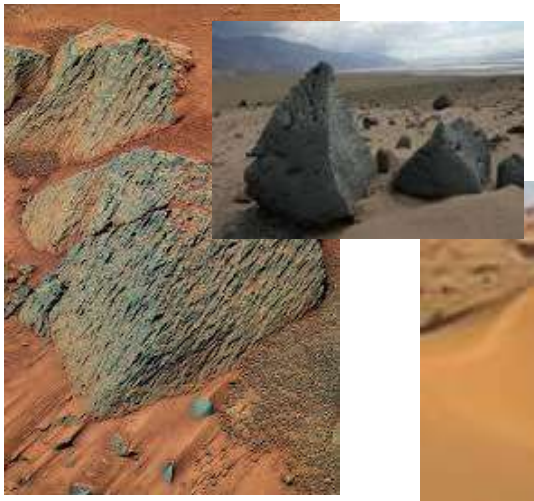
LAND FORMS OF WIND

Erosional Land forms of Wind:

Yardangs

Pedestal rocks

Teeth rock



Vent ifacts:

Blow outs

Desert pavement

Oasis

Depositional Land forms of Wind:

Sand dunes

- Lateral sand dunes
- Transverse sand dunes
- Star dunes

Barchans

Loess

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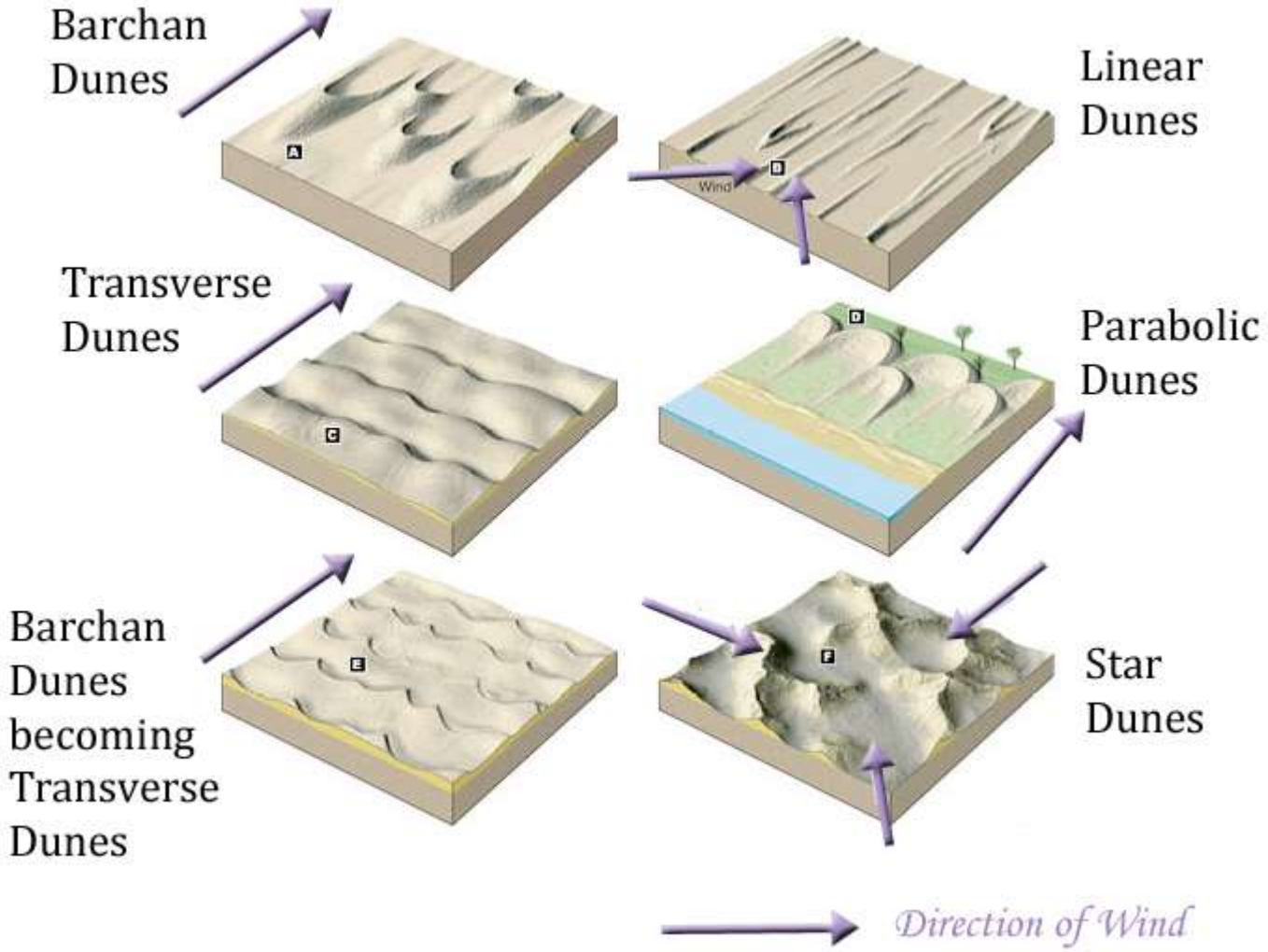

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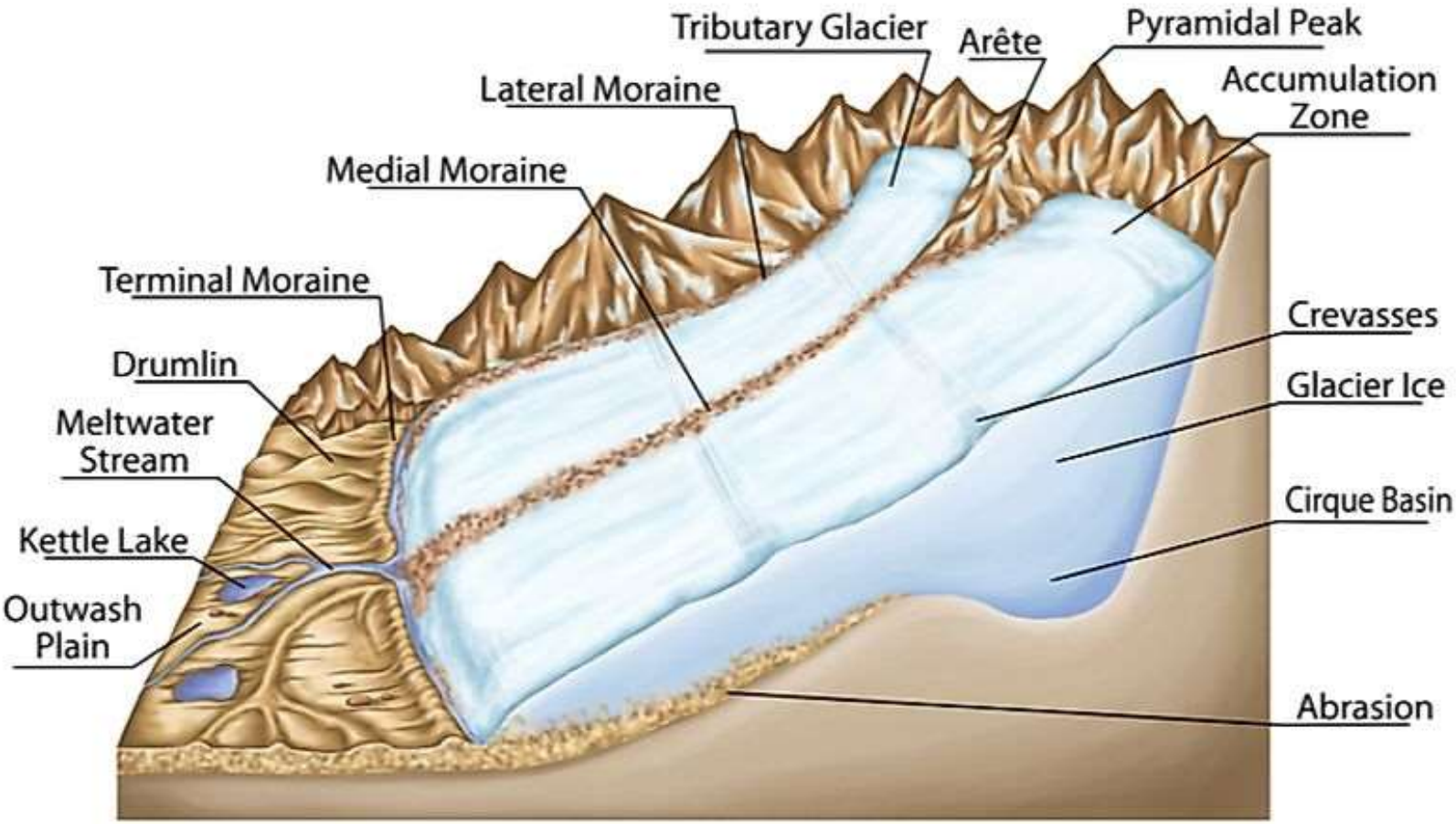
Land forms of Glaciers:



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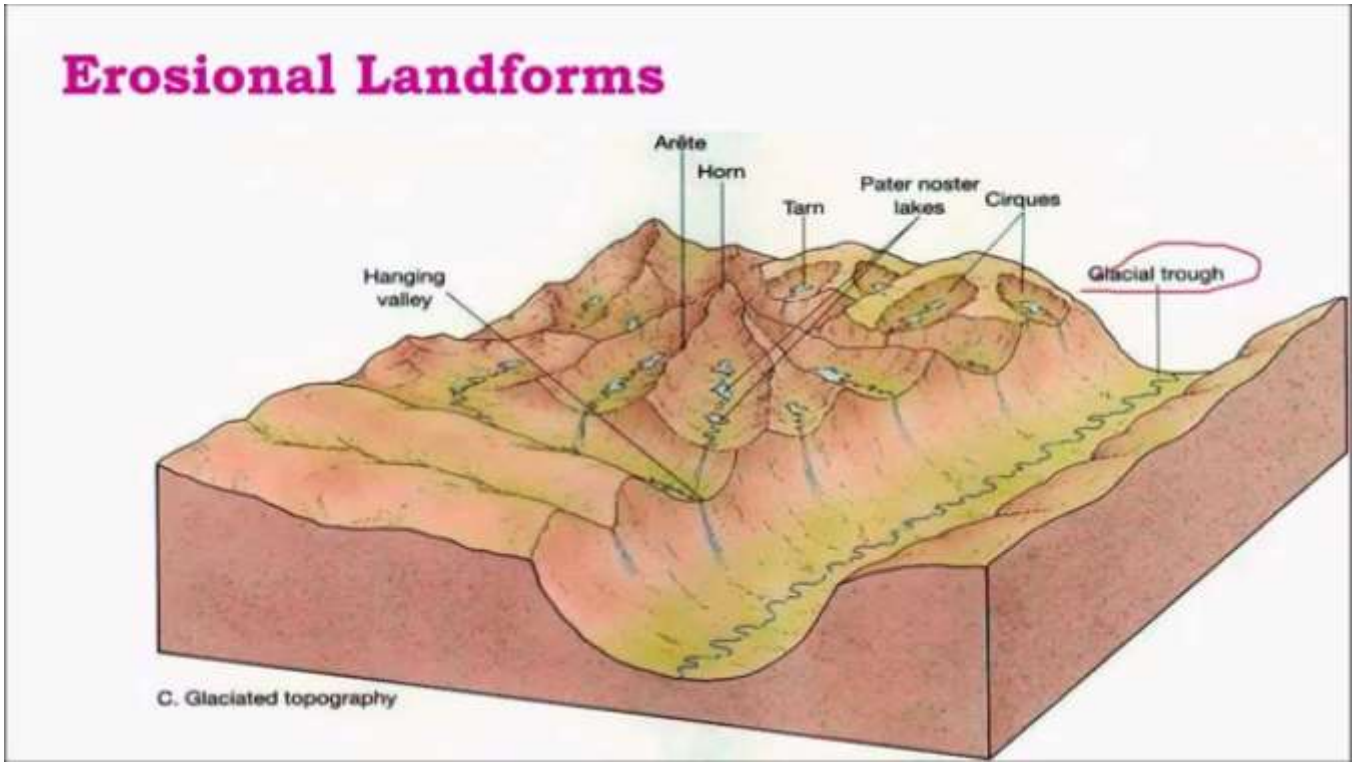
Erosional Landforms of Glaciers:
Cirque or Corris:
Hanging Valleys or U-shaped Valleys,
Fjords/fiords.
Horns and Aretes.



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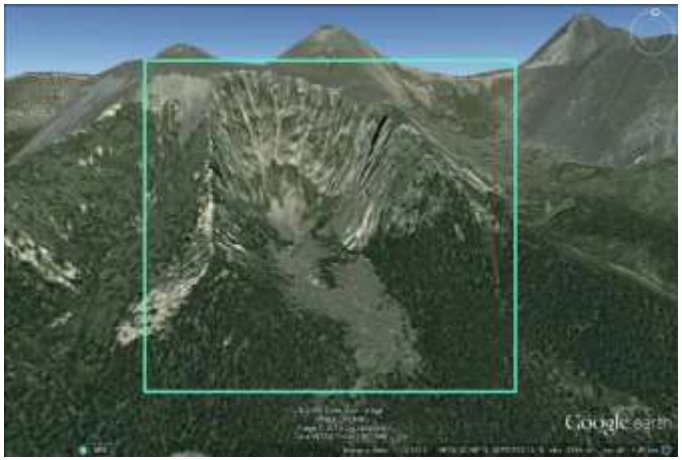
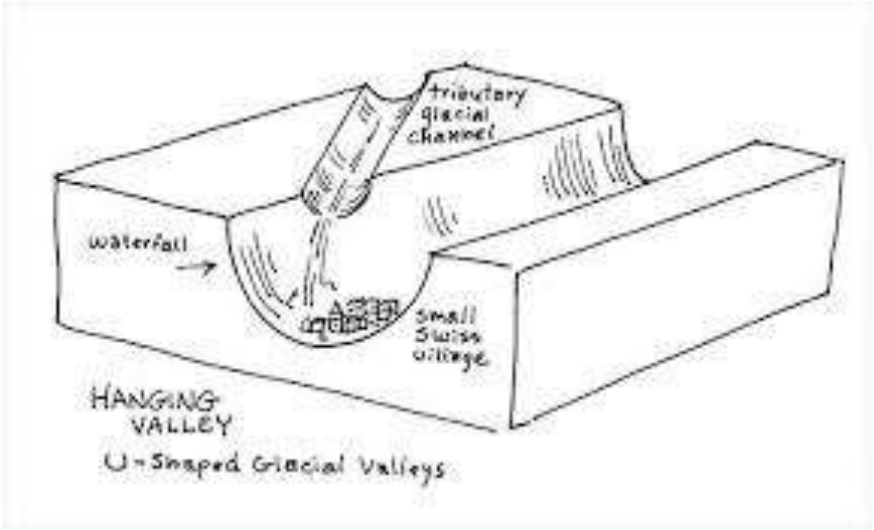
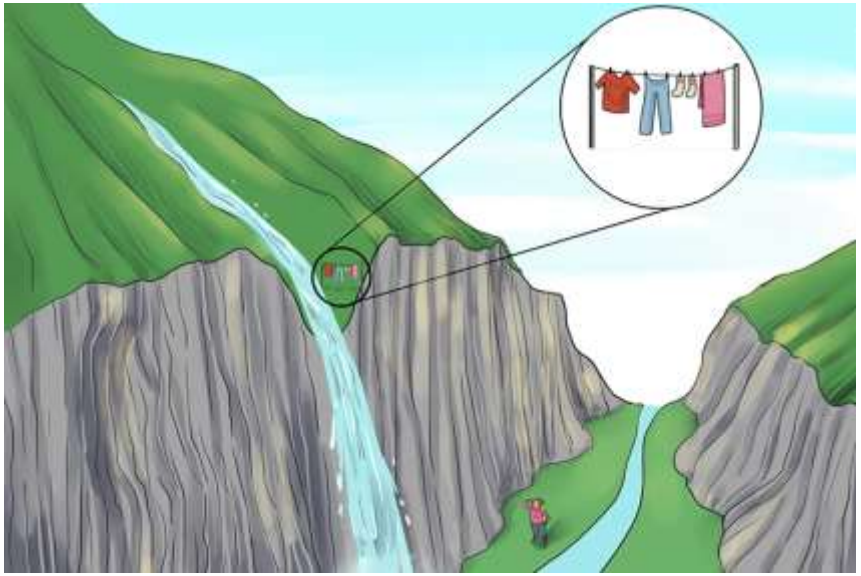
Cirque: They are deep, long and wide troughs or basins with very steep concave to vertically dropping high walls at its head as well as sides.



Hanging Valleys or U-shaped Valleys:
When the tributary glacier merged in to main glaciers the alley formed it is in u shaped and hanging in position is called hanging valley.



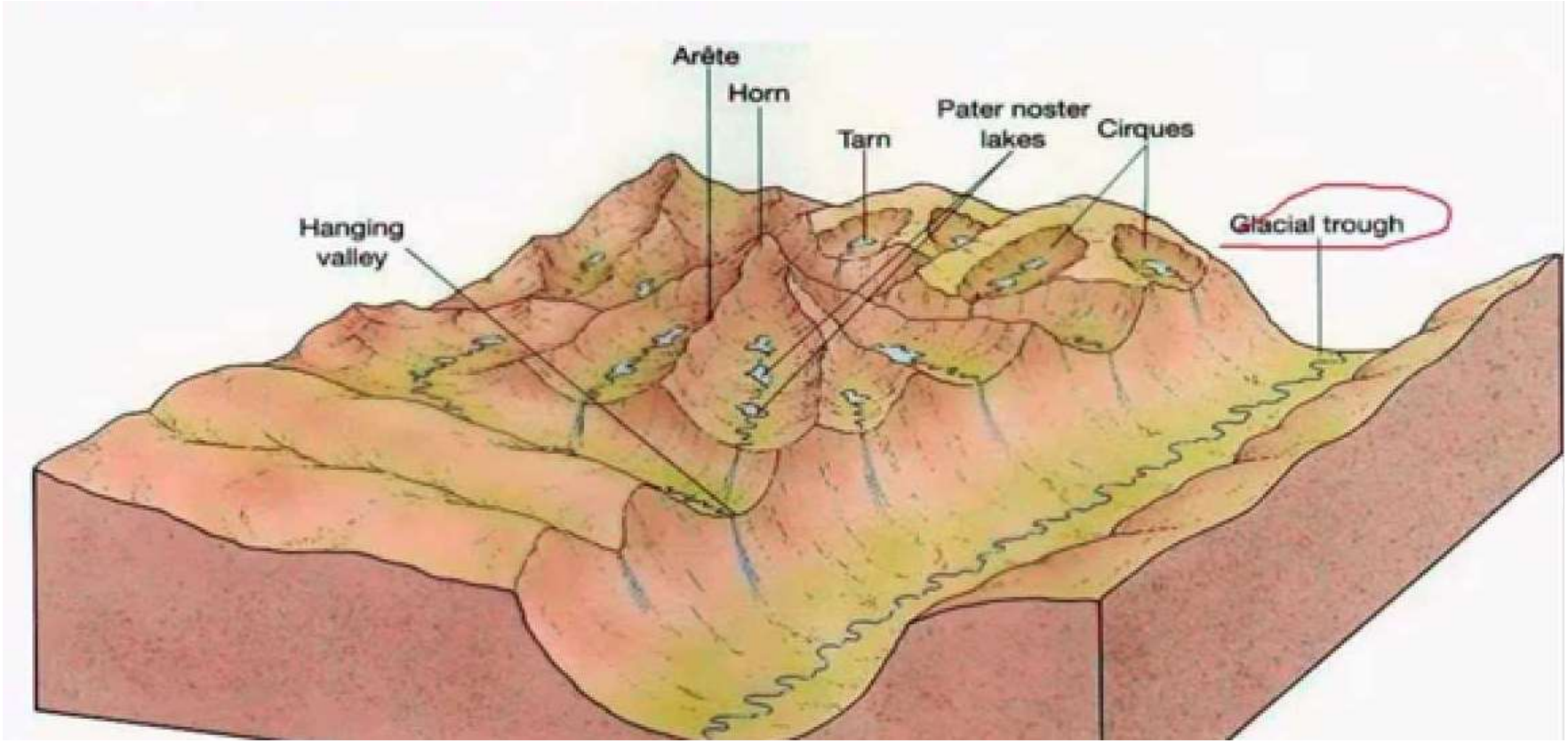


Fjords/fiords. The back water enters in to the glacial valley by erosion and forms the landform as fjord.

Horns and Aretes:

✓A ridge sharp edged ridge like land form is known as arete.

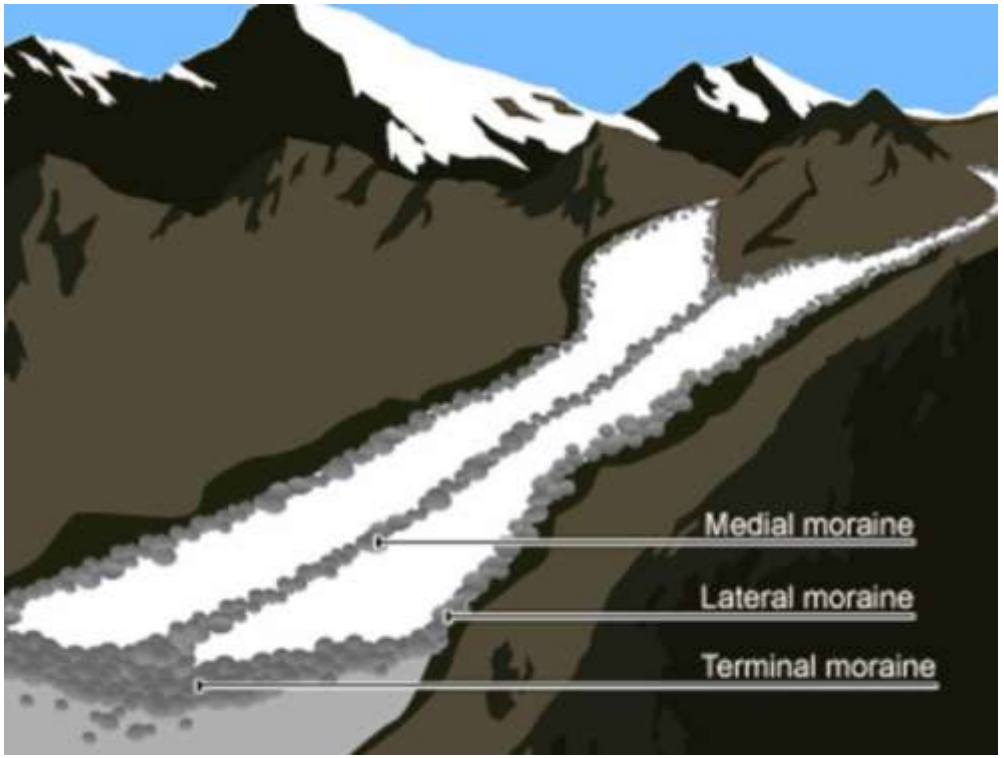
✓Joining vertex of two or more aretes forms the horn or pyramidal



Depositional Landforms of Glaciers:

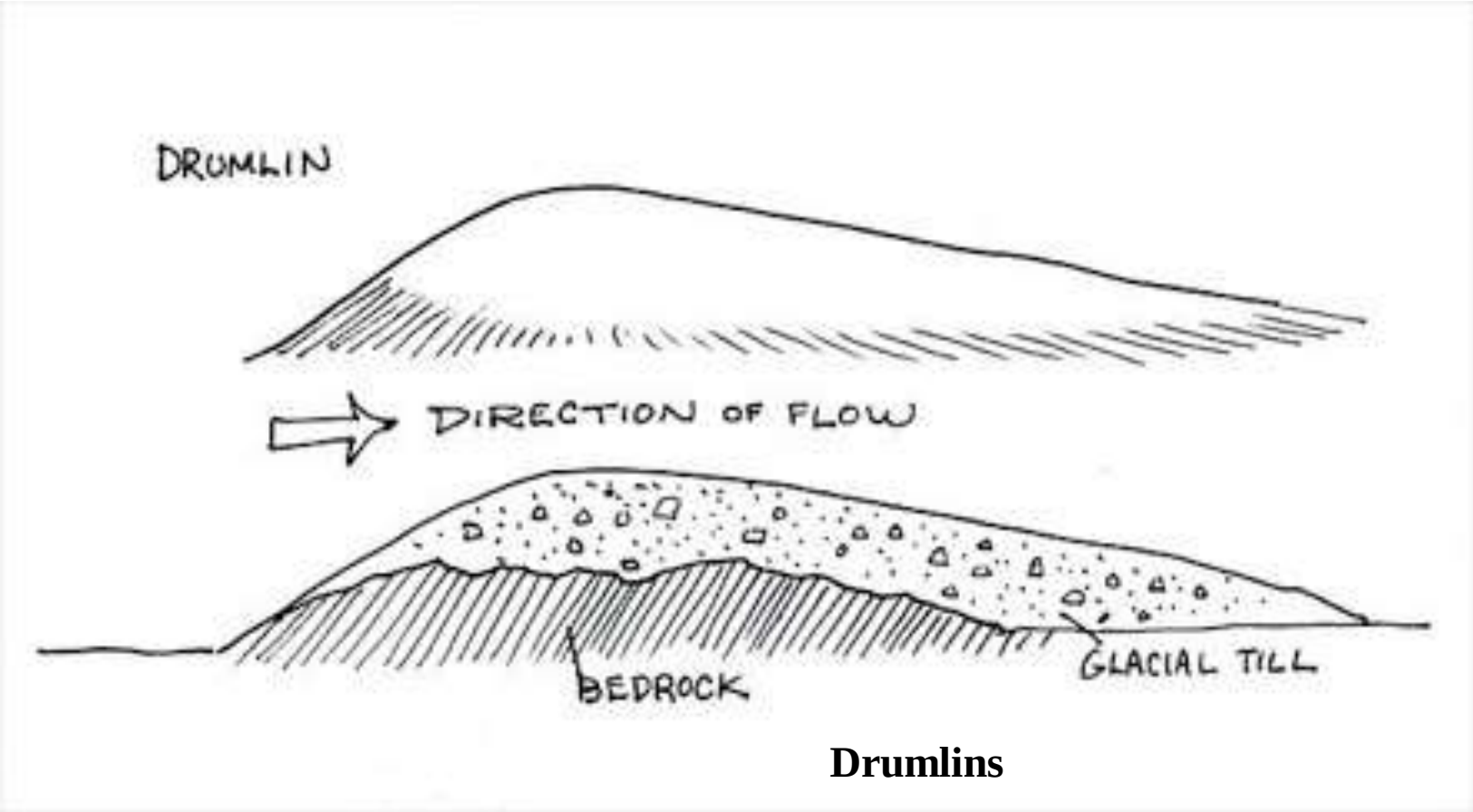
Moraine: Accumulation or deposition of rock debris (till) with different ranges from blocks or boulders (usually faceted or striated) to sand and clay by the glacier. No stratification and sorting or bedding can be observed in moraines.

- ✓Lateral Moraine
- ✓Medial Moraine
- ✓Terminal or End Moraine



Moraines

Drumlins: These are elongated, teardrop-shaped hills of rock, sand, and gravel that formed under moving glacier ice. They can be up to 2 kilometers long.



Drumlins

Eskers: These are ridges with sands and gravels, deposited by glacial melt water flowing through tunnels within and underneath glaciers, or melt water channels on top of glaciers.

Over time, the channel or tunnel gets filled up with sediments.

Eskers

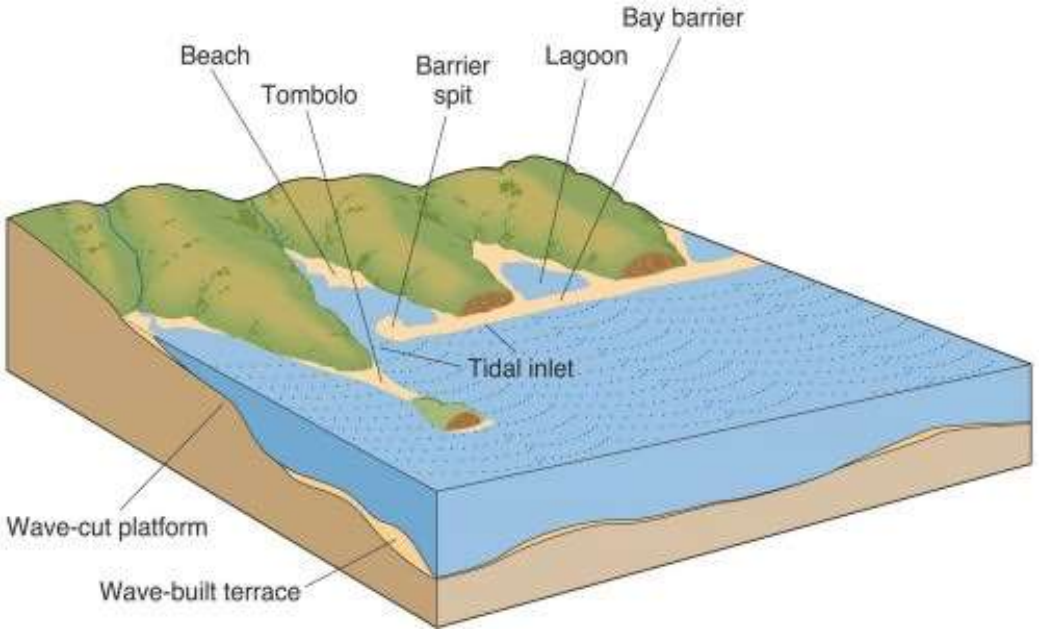
Coastal land forms

Erosional Landforms:

- Chasms,
- Wave-Cut Platform,
- Sea Cliff,
- Sea Caves,
- Sea Arches,
- Stacks/Skarries/Chimney Rock,
- Blow Holes.

✓**Depositional Landforms**:

✓Beach,
✓Bar,
✓Barrier,
✓Spit and Hook,
✓Tombolos et



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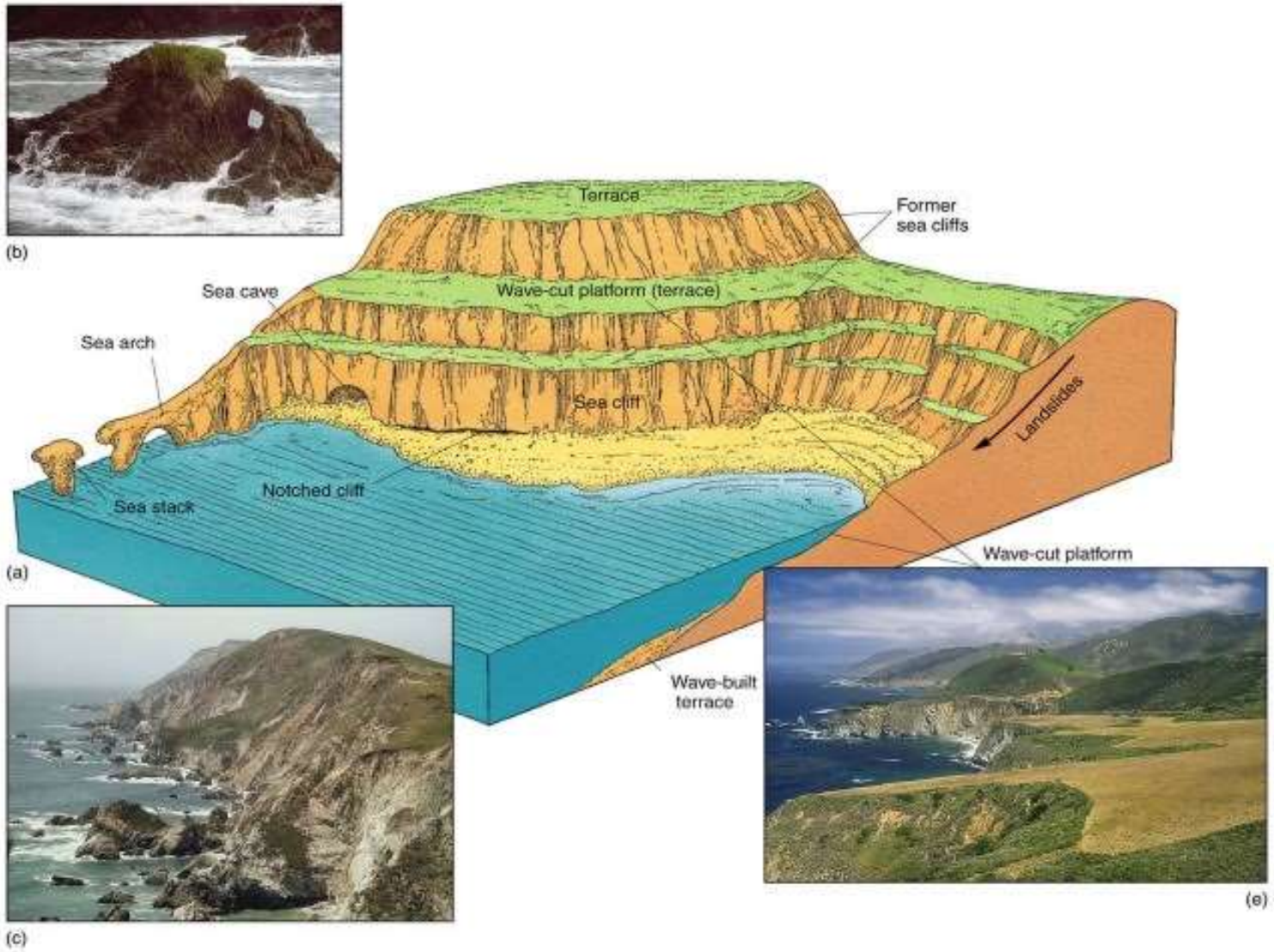

https://www.pmfias.com/wp-content/uploads/2015/12/Marine-Landforms-Wave-Cut-Platform.jpg

Alluvial deposits and Engineering considerations

Alluvium

- Eroded material transported by water and deposited as alluvial(water-laid) soil or alluvium.
- Boulders and coarser gravels expected from the alluvium adjacent to the steep portion of the valley by the head water of streams.

General charactersticks of alluvium

- ✓Small (fines) size deposits are increased as the distance increased from their origin or from the mountain.
- ✓Stratification observed in the alluvium.
- ✓Alluvium normally contains considerable beds of sand and gravel.
- ✓They may also formed as lenslike inclusions of sand and gravel beds.
- ✓Alluvium is also formed near the outer margin of the flood plain as alluvial fans and cones.

Engineering considerations

- ✓Alluvium provides an excellent source for coarse construction material.
- ✓As concrete aggregate
- ✓Pervious material used in highways embankments.

Residual soil deposits and Engineering considerations

Residual soil

- Residual soils are those which remain in place over the parent material from which they are derived.
- These soils formed directly over the parent material by weathering and they may not displaced over long distances.

Laterite as residual soil and rock

Laterite is both a soil and a rock type rich in iron and aluminum and is commonly considered to have formed in hot and wet tropical areas.

Nearly all laterites are of rusty-red in color, because of high iron oxide content. Showing hollow, vesicular, and botryoidal structure.

They formed by intensive and prolonged weathering of the underlying parent rock, like

- ✓Sedimentary rocks (sandstones, clays, limestone)
- ✓Metamorphic rocks (schists,gneisses)
- ✓Igneous rocks (granites, basalts, gabbro)

Step 01:Leaching involves by acid dissolving from the parent rock,

Step 02: Precipitation of insoluble oxides and sulfates of iron, aluminum and silica. by hydrolysis.

Engineering Aspects of laterite:

When moist, laterites can easily be cut with a spade into regular-sized blocks.

Laterite upon exposure to air quickly becomes as hard as brick, and is reasonably resistant to the action of air and water.

crushed laterite as stone or gravel can be used in low-volume roads.

The thick lateritic layer is porous and slightly permeable, so the layer can function as an aquifer.

Laterites are extensively developed as

Primary laterites formed *in situ* on older erosion surfaces probably during the Tertiary.

This lateritisation phase may have been responsible also for the formation of residual bauxite and manganese ores, and for the enrichment of iron ores.

Secondary laterites resulted from erosion of the older laterites. Quaternary deposits include aeolian drift and coastal sediments.

Some of the superficial deposits are used for constructional purposes, especially the laterites.

Superficial deposits refer to geological deposits of Quaternary age.

These are geologically recent unconsolidated sediments may include

- ✓Glacial drift and
- ✓Glaciolacustrine deposits:
- ✓Glaciofluial deposits
- ✓River sand and gravel(Stream channel deposits)
- ✓Floodplain deposits,
- ✓Blown sand
- ✓Beach sands and gravel
- ✓Talus gravels

Superficial deposits and engineering considerations

Glacial till:

It generally provides good foundation conditions for normal foundations but is commonly weathered to a depth of 3 to 4 m, up to 8 m thick in some places.

Bearing capacity near surface may vary depending on the weather conditions, becoming softer when wet and stiffer when dry. The softened near-surface material may need to be removed prior to construction.

An abundance of cobbles and boulders within the till, or the presence of interbeds of gravel, sand or laminated clay and silt, may change the foundation conditions locally and endanger with differential settlement.

Glaciolacustrine deposits:

Laminated clay and silt are generally soft to stiff, finely laminated and sometimes include sand laminae. Such deposits usually have low to moderate compressibility and low strength due to horizontal drainage, so excavations and cuttings in this deposits will require support.

River alluvium:

Fine-grained river and estuarine alluvium may not be suitable for standard foundations due to low bearing capacity and the problem may create by peat or organic clay layers within the alluvium.

Support and dewatering is required as the water table to be near surface. Normally construction should be avoided on peat or specialized construction methods are used.

Solifluction deposits:

✓Deposition of material by slow movement of water-saturated soil on slope is known as solifluction deposits.

✓Mass movement and deposition along the slopes by freeze and thaw process in periglacial regions is known as soliflutcion deposits.

✓These occur in areas where the soil remains frozen and is then is thawed for a short time to become saturated with water.

Solifluction deposits compromise

✓ Poor stratification.

✓If stratified and consist of alternating layers.

✓A common feature in solifluction deposits is the orientation of clasts parallel to the slope.

Debris Flows- These occur at higher velocities than solifluction, and often result from heavy rains causing saturation of the soil with water.

They sometimes start with slumps and then flow down hill forming lobes with an irregular surface consisting of ridges and furrows.

https://upload.wikimedia.org/wikipedia/commons/f/f0/Debris_flow_channel%2C_Ladakh%2C_NW_Indian_Himalaya.JPG

Mudflows- A highly fluid, high velocity mixture of sediment and water that has a consistency like of wet concrete.

These usually result from heavy rains in areas where there is an abundance of unconsolidated sediment that can be picked up by streams.

Thus, after a heavy rain streams can turn into mudflows as they pick up more and more loose sediment.

Mudflows can travel for long distances over gently sloping stream beds.

Because of their high velocity and long distance of travel they are potentially very dangerous.

Mudflows on volcanoes are called ***lahars***.

https://www.researchgate.net/profile/EricDeville/publication/286291175/figure/fig18/AS:669533257883665@1536640576840/Giant-mud-flows-on-the-Kandawari-mud-volcano-in-the-Pakistani-Makran.png

Questions

1. How the rocks are weathered, would you explain the types of rock weathering?
2. What do you understand about chemical weathering and its types?
3. Illustrate various landforms formed by river erosion and deposition.
4. How can you define the term soil, what are the steps involved in soil formation
5. Illustrate the soil profile, what are the various types of soil found in India.
6. What do you mean by glacier, illustrate the various landforms of glaciers
7. Define moraine and describe the its types.
8. How the superficial deposits were formed on the earth surface.
9. Can you illustrate depositional landforms in coastal area?
10. How would you differentiate solifluction deposits, debris flow and mud flow?