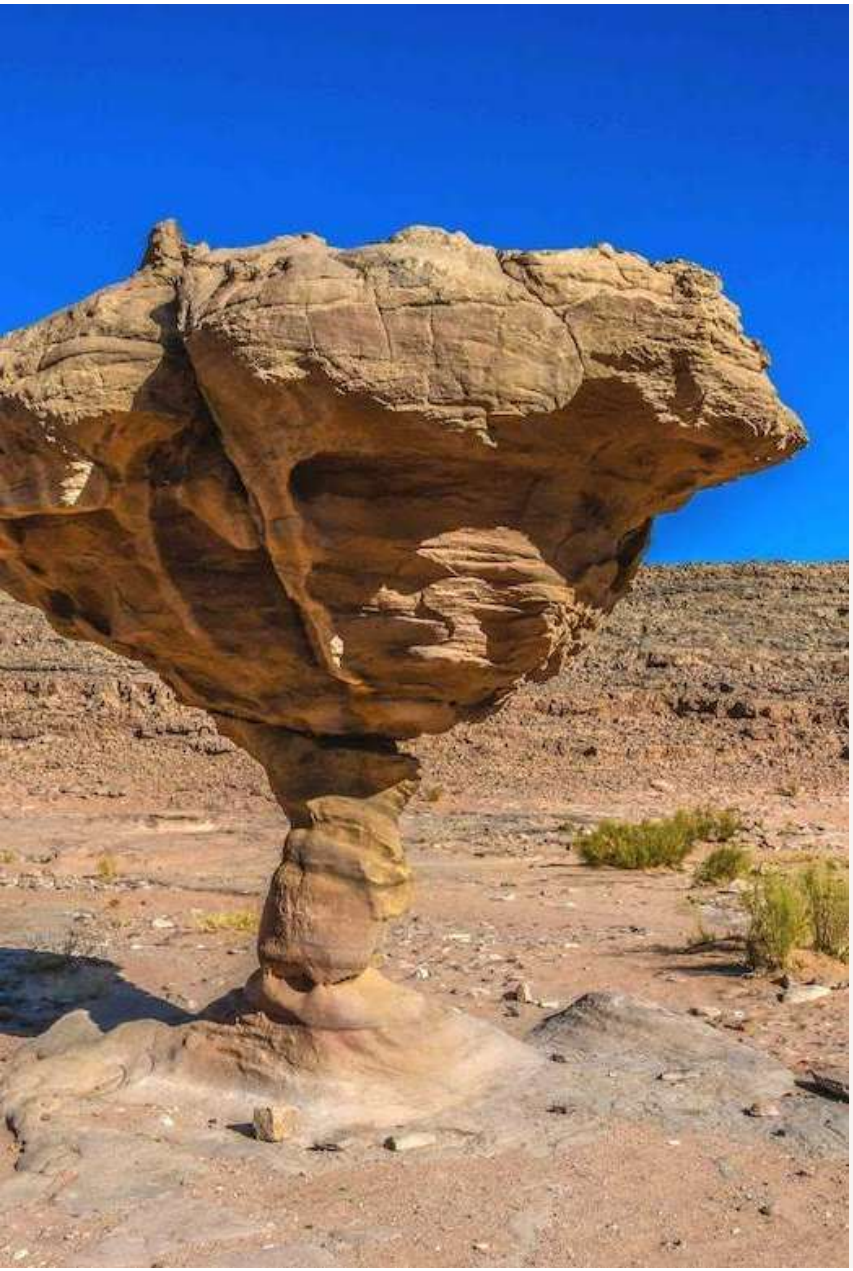

CE 2141 ENGINEERING GEOLOGY AND GEOMORPHOLOGY

Lecture 08~10 – Geomorphic Processes

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Lecture 08~10: Topics

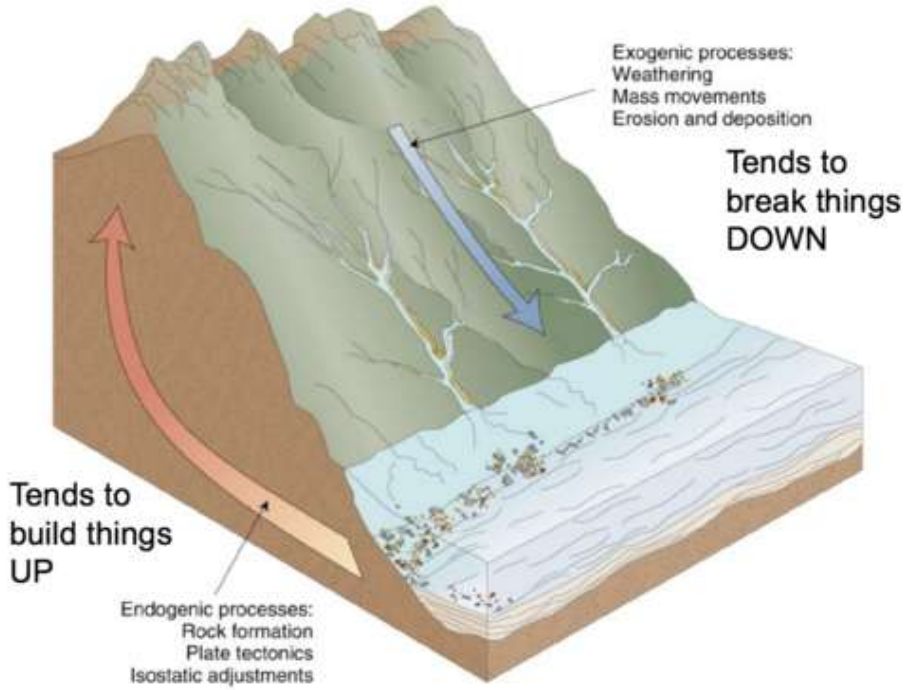
- Outline of Geomorphic Processes: Weathering, Erosion and Deposition
- Erosional and Depositional Landform

Reference Book: Physical and Engineering Geology, SK Garg
and Lecture note of Civil and WRE, BUET

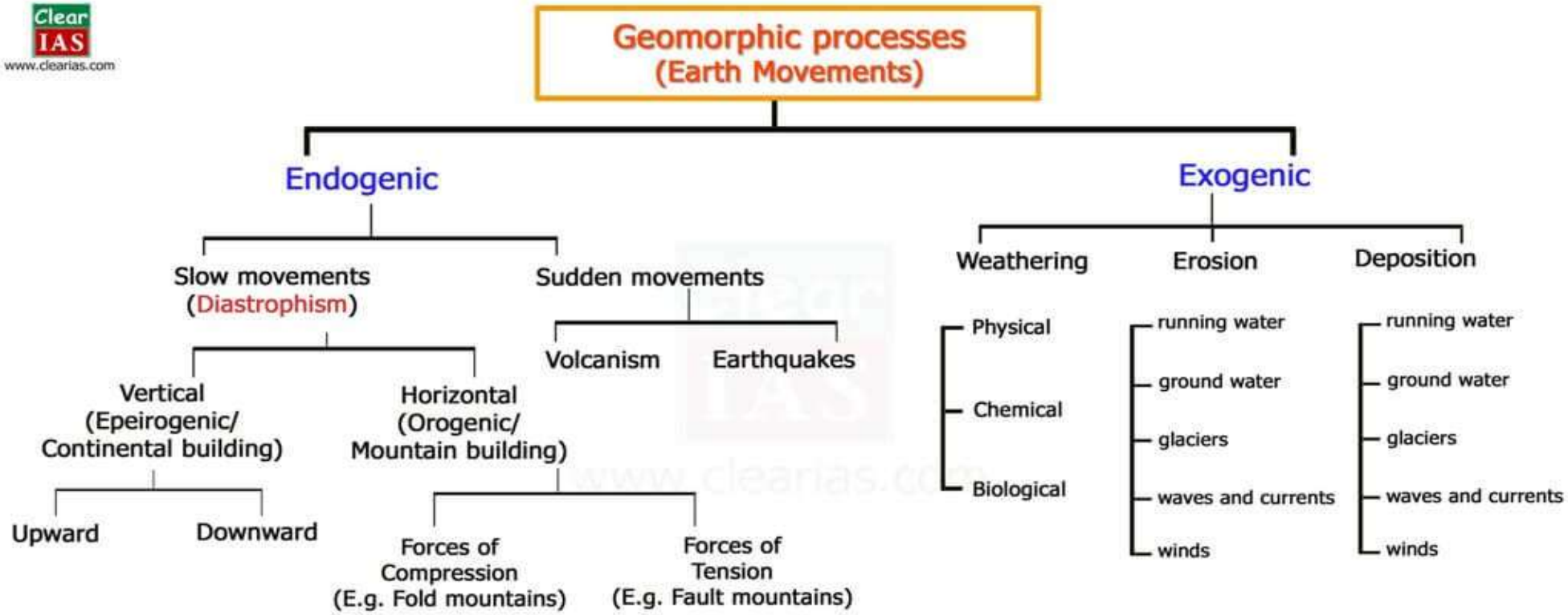
Geomorphic Process

Geomorphic processes are the natural forces that shape the Earth's surface, including both destructive (erosion, weathering) and constructive (deposition) actions.

These processes are driven by factors like water, wind, ice, and gravity, and they work over various timescales to create and modify landforms.

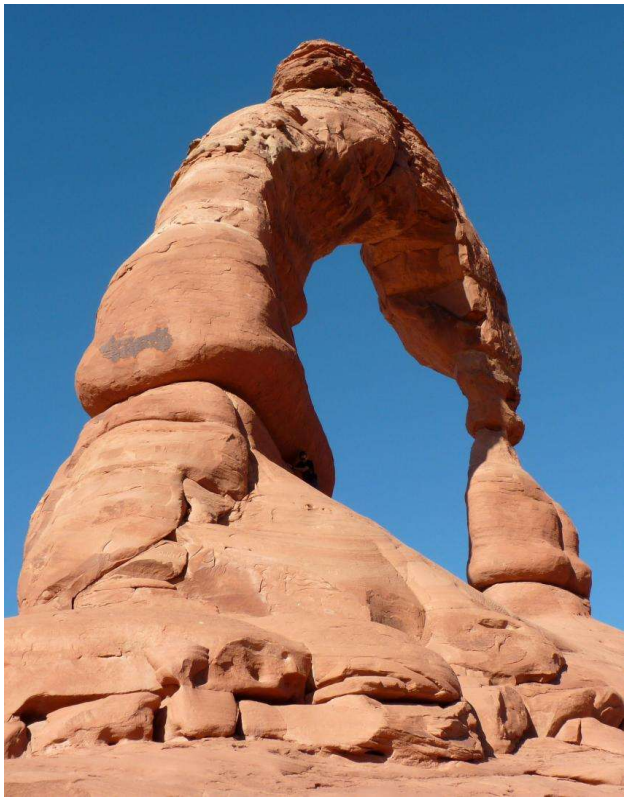


Geomorphic Process



Weathering

- Geomorphic Weathering refers to the breakdown and alteration of rocks and minerals at or near the Earth's surface through physical, chemical and biological processes.
- It's a crucial part of the geomorphic cycle, shaping landscapes by weakening rocks and preparing them for erosion.
- This process occurs in place (in situ) and is distinct from erosion, which involves the movement of weathered materials.



Physical Weathering:

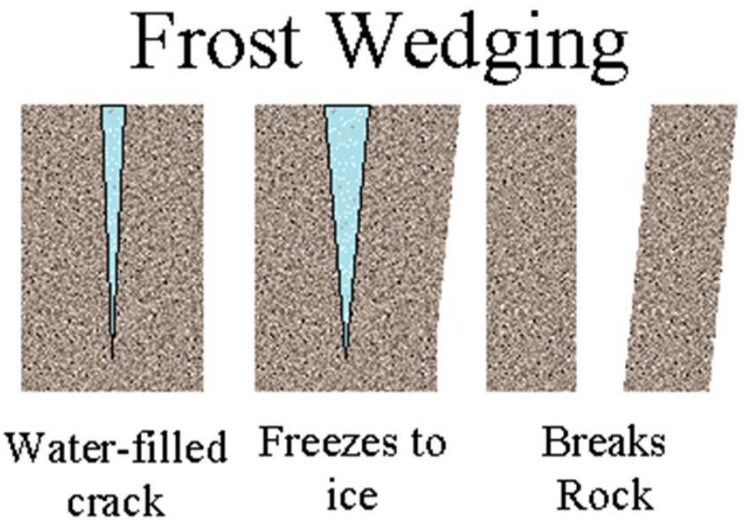
Physical weathering, also known as mechanical weathering, is the process of breaking down rocks into smaller fragments without changing their chemical composition.

This process driven by physical forces like temperature changes, frost action, and wind force, etc.

Types of Physical Weathering:

Frost Wedging

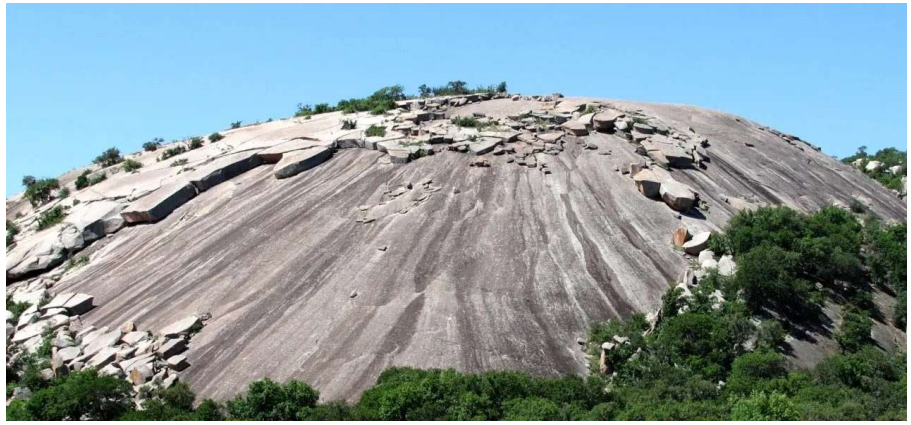
Water enters rock cracks, freezes, and expands, exerting enough pressure to split rocks apart. This cyclic freeze-thaw action is most effective in cold climates with frequent temperature fluctuations around 0°C.



Types of Physical Weathering:

Exfoliation

A type of physical weathering where outer layers of rock peel off in thin sheets or slabs. This process is driven by pressure release and temperature fluctuations, particularly in arid or desert environments where extreme temperature swings are common.



Types of Physical Weathering:

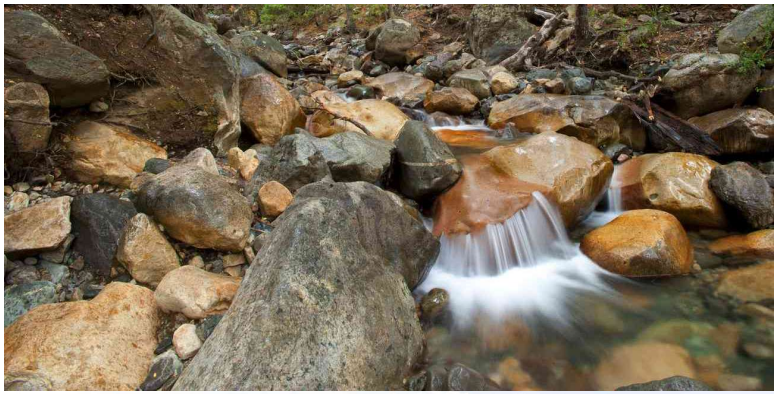
Salt Weathering

The process starts when saline water seeps into deep cracks and evaporates depositing salt crystals. When the rocks are then heated, the crystals will expand putting pressure on the surrounding rock which will over time splinter the stone into fragments.

Types of Physical Weathering:

Abrasion

Wind, water, or ice carrying sand and rock particles physically grind and scour exposed rock surfaces. This creates smooth, polished surfaces and is most visible in riverbeds and desert landscapes.



Chemical Weathering:

Chemical weathering is the process where rocks are decomposed or dissolved by chemical reactions. These reactions, often involving water, acids, and oxygen, alter the rock's mineral composition, leading to its breakdown.

Essentially, it's the transformation of rock at a molecular level.

Types of Chemical Weathering:

Dissolution

Water dissolves soluble minerals (e.g., halite, calcite) from rocks, especially in humid climates. Acid rain accelerates this process by increasing water's reactivity.

Hydrolysis

Water reacts with silicate minerals (e.g., feldspar), breaking them down into clay minerals like kaolinite. This is a key process in soil formation.

Types of Chemical Weathering:

Oxidation

Oxygen reacts with iron-rich minerals (e.g., pyrite), forming rust-like iron oxides that weaken rocks. Commonly seen in reddish-brown weathered surfaces.

Carbonation

Carbon dioxide dissolves in rainwater, forming weak carbonic acid that dissolves limestone and marble. This creates karst landscapes with caves and sinkholes.

Biological Weathering:

Biological weathering is the breakdown of rocks by living organisms, encompassing both physical and chemical processes. It involves the weakening and disintegration of rocks through the actions of plants, animals, and microorganisms.

Types of Biological Weathering:

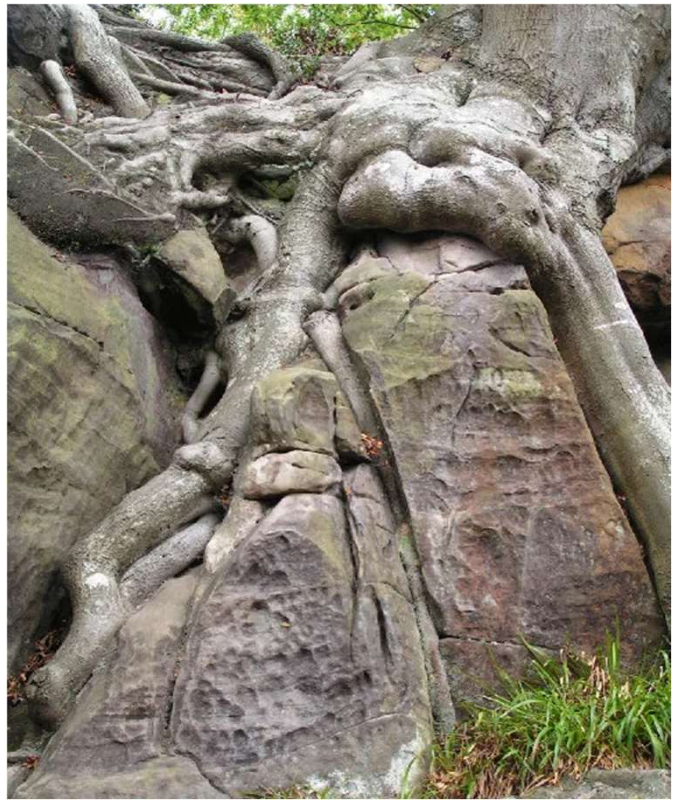
Root Action

Plant roots grow into rock cracks,

exerting pressure that splits rocks apart.

Trees and shrubs accelerate weathering

in rocky terrains.



Types of Biological Weathering:

Lichens & Fungi

Lichens secrete organic acids that dissolve rock minerals, while fungal hyphae penetrate tiny cracks. Common on exposed boulders and cliffs.

Burrowing Animals

Animals like earthworms and rodents expose rocks to air and water by digging, speeding up chemical breakdown. Their waste also adds reactive organic acids.

Microbial Activity

Bacteria and algae produce acids or enzymes that break down minerals. Cyanobacteria, for example, weather rocks in deserts and shorelines.

Erosion

- The process by which the land surface is worn away by the action of water, wind, waves, ice and gravity.
- Erosion is moving of materials from one place to a new location.
- Three processes must take place for erosion: detachment of particles, lifting them, and transporting them.

Erosion by Wind

Wind wears away soil, sand, and rocks and is responsible for the creation of deserts such as the Sahara and the Gobi.

Main effects:

1. Wind lifts small particles and moves them away.

2. Suspended particles may cause erosion on solid objects by abrasion (rubbing).

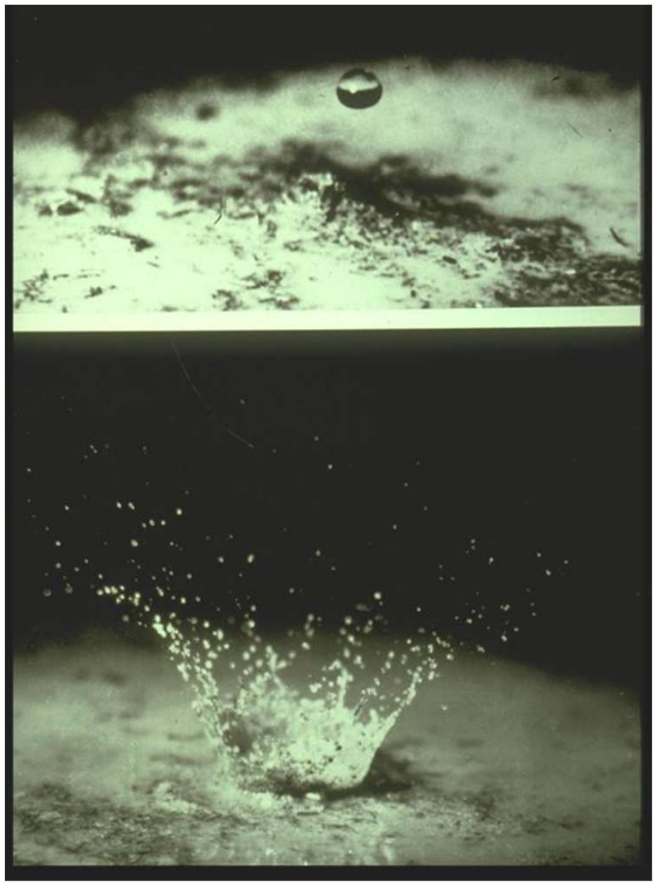
Occurs in areas where there is not enough rainfall to support vegetation.

Erosion by Water

- Water erosion is the process where soil or rock is worn away and transported by the action of water.
- This occurs through various mechanisms, including raindrop impact, surface runoff, and the erosive power of streams and rivers.
- Water erosion is a natural process, but it can be accelerated by human activities like deforestation and poor agricultural practices.

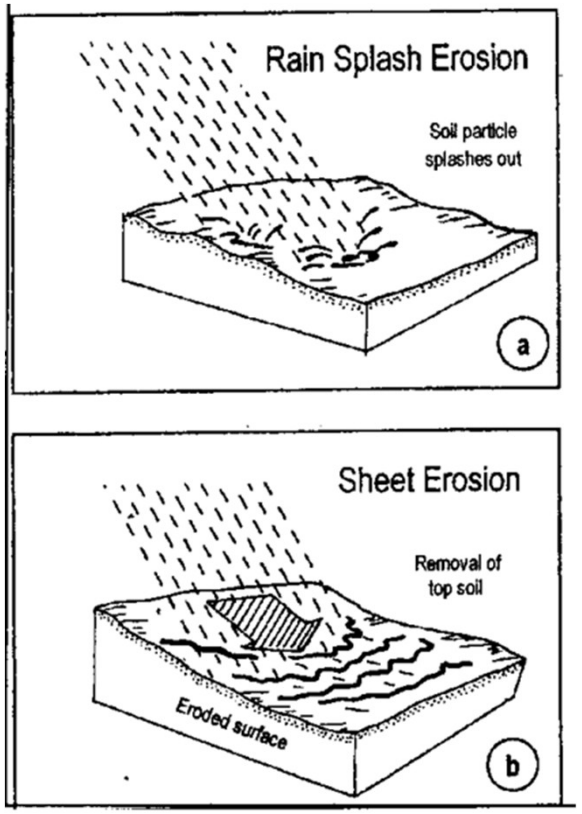
Types of Erosion by Water

- **Splash Erosion** is the detachment and airborne movement of small soil particles caused by the impact of raindrops on soil.
- The energy of raindrops falling on denuded or exposed soils is the key element.



Types of Erosion by Water

- **<u>Sheet Erosion</u>** occurs when raindrops detach soil particles, and water flowing over the land surface carries them away in a thin, uniform layer.
- This process is often hard to notice because it removes soil evenly, but as water flow speeds up, more soil is eroded and transported downhill.



Types of Erosion by Water

- **Rill Erosion** occurs when surface water flow concentrates into small channels, cutting tiny but visible grooves into the soil.
- These small streams of running water remove soil particles, creating networks of shallow channels that can grow larger over time if not controlled.

Types of Erosion by Water

- **Gully Erosion** happens when heavy water flow cuts deep, narrow channels into the soil, creating large trenches that cannot be smoothed out by normal farming.
- These gullies grow bigger over time, washing away soil and making land unusable for crops or grazing.

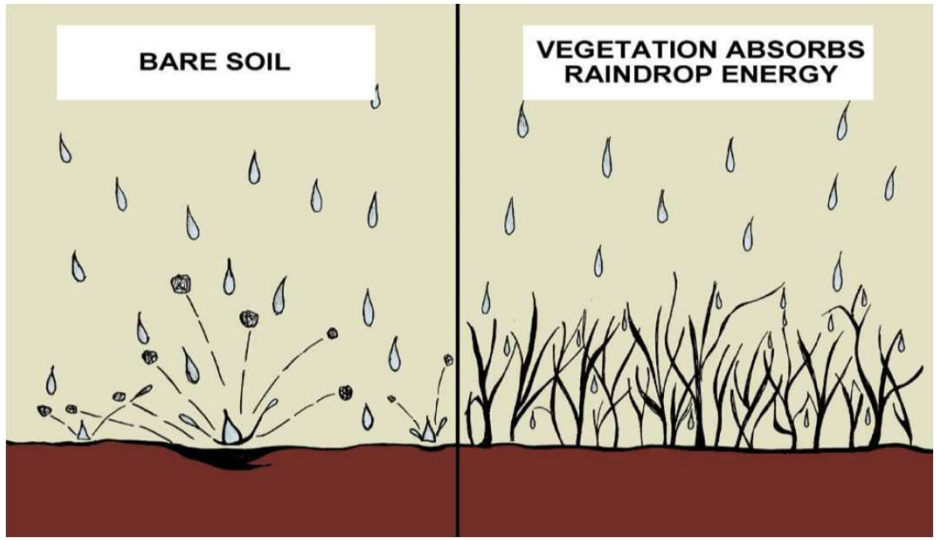
Factors Affecting Erosion

- **Climatic (rainfall and runoff) Factors** As the volume and intensity of rainfall increases, the ability of water to detach and transport sediment increases.
- **Soil Factors** Fine sandy & silty soils are more erodible than clay type soils & those with higher percentage of organic matter.

Factors Affecting Erosion

Vegetative Factors

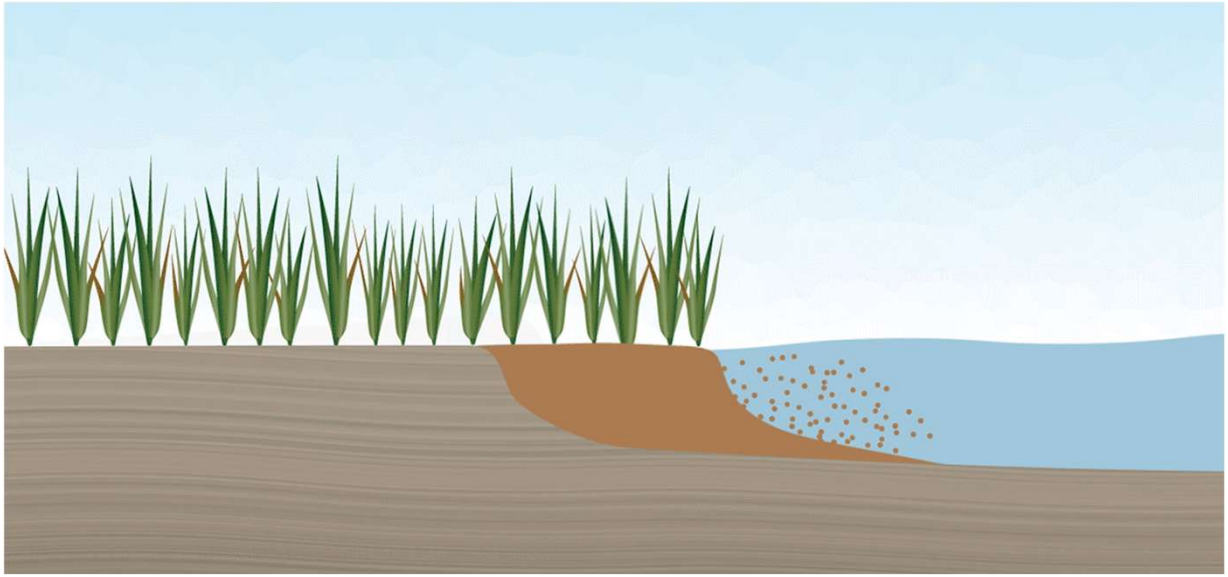
- Absorbs raindrop impact
- Reduces detachment
- Roots hold soil in place
- Slows water flow
- Adds organic material to the soil
- Reduces runoff
- Increases infiltration



Deposition/Sedimentation

The process by which the eroded material is transported and deposited by

- Water
- Wind
- Ice
- Gravity



Deposition - Wind

Wind speed can be related to variations in heating and cooling.

– Fine particles in suspension travel hundreds of km from its original source in the desert.

– Heavier material may be blown along the ground.

– Material is deposited when the wind changes direction or loses its

strength.

Deposition - Water

Running water enters a large, still body of water and its speed decreases

- As the speed of the water decreases, the water's ability to carry sediment also decreases.
- Running water deposits sediments where the slowing water can no longer move them.
- Largest particles are deposited near the shore.
- Increasingly smaller particles settle out farther from the shore, where the water is calmer.

Deposition - Ice

Glacial flows of ice become slower when the ice begins melting

– Outwashes are deposits like those left by rivers.

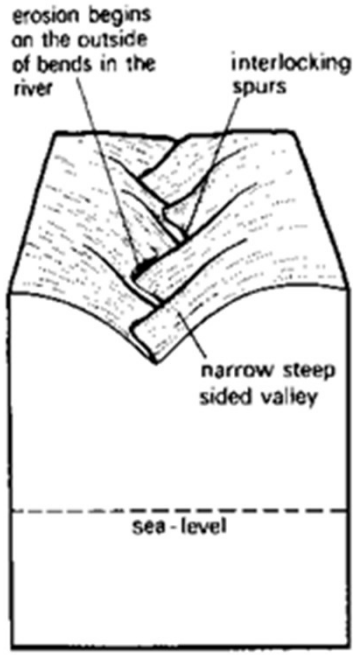
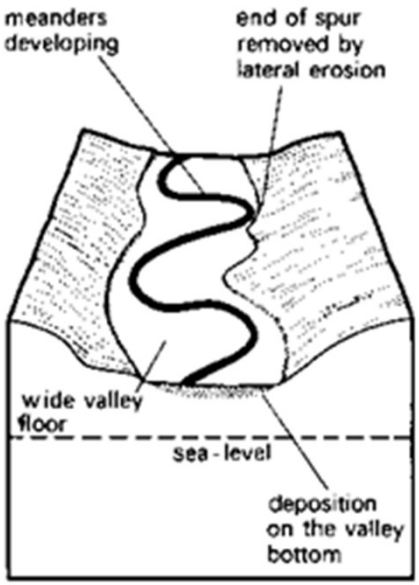
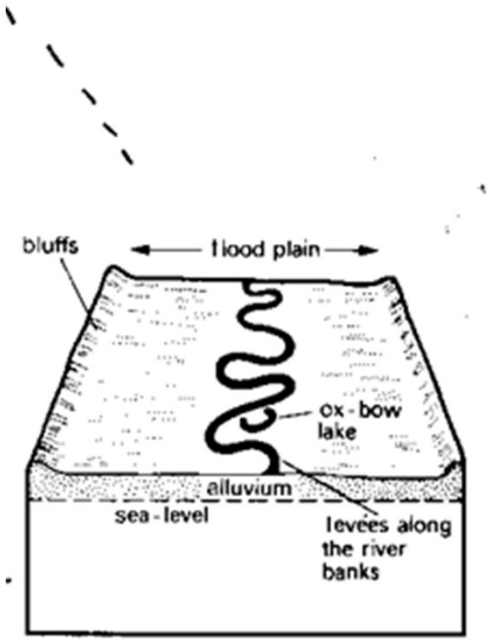
– Large chunks of broken rock deposited at the base and sides of the glacier as it melts and recedes are called Moraines.

– When the glacial ice melts, smaller material is carried by the rivers.

Impacts of Erosion and Sedimentation

1. Change (loss or gain) of soil productivity.
2. Adverse effects on other water resource facilities; erosion of structure, sedimentation in drain.
3. Loss of reservoir storage capacity (due to sedimentation/deposition).
4. Flood impacts.
5. Recreational impacts.
6. Deterioration of water quality.

Stages of Rivers

Young River	Mature River	Old River
		

Stages of Rivers

Young River	Mature River	Old River
Slope of the land – Steep	Less Steep	Nearly Flat
Velocity – Fast	Slowing Down	Very Slow
Type of Erosion – Vally Erosion	Lateral Erosion	No Erosion (depositing sediments)
Shape of the Valley - Straight	Meandering	Very Meandering
Examples – Upper Matamuhuri	Surma	Padma, Lower Mississippi
Special Features – Waterfalls	Oxbow Lake, meanders, flood plain, tributaries	Flood plain, oxbow lakes, delta

Braided vs Meandering Rivers

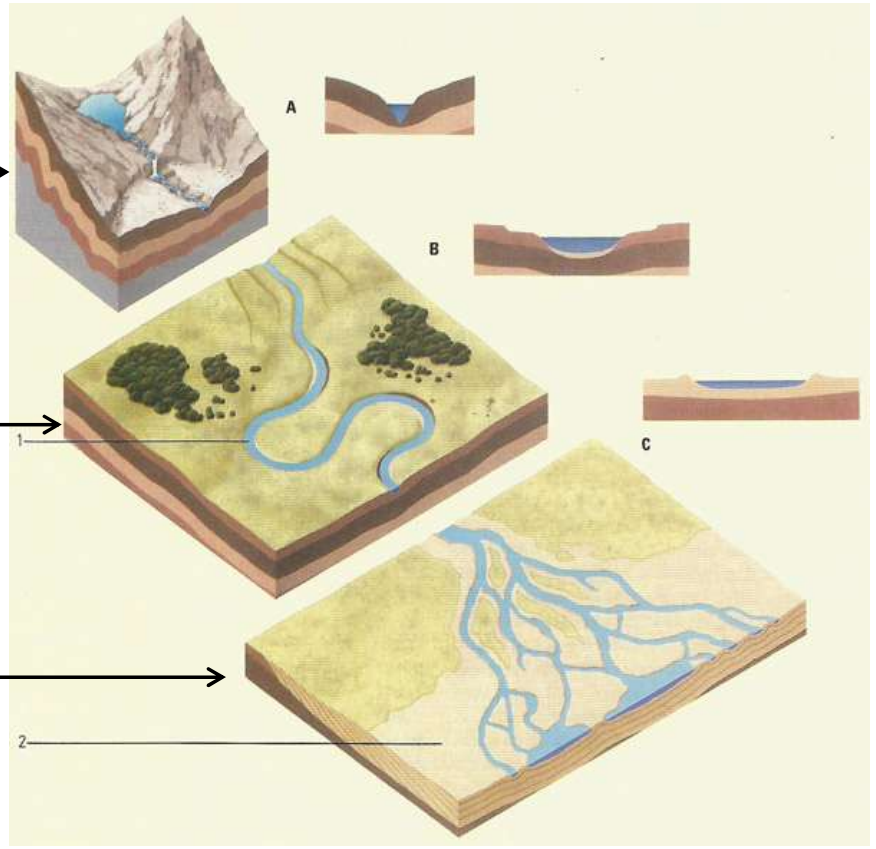
Feature	Braided River	Meandering River
Channels	Multiple, interweaving	Single, winding
Sediment	Coarse bedload (sand, gravel)	Finer suspended load (clays)
Stability	Unstable, rapid bar migration	More stable, predictable
Features	Bars, no distinct oxbows	Point bars, oxbow lakes
Example	Jamuna	Surma

Course of River

Upper Reach →

Middle Reach →

Lower Reach →



Erosional and Depositional Landforms

Upper Reach

River Vally

Interlocking spurs

Waterfall

Alluvial Fan

Middle Reach

Meandering River

Oxbow Lake

Floodplain

Natural Levee

Lower Reach

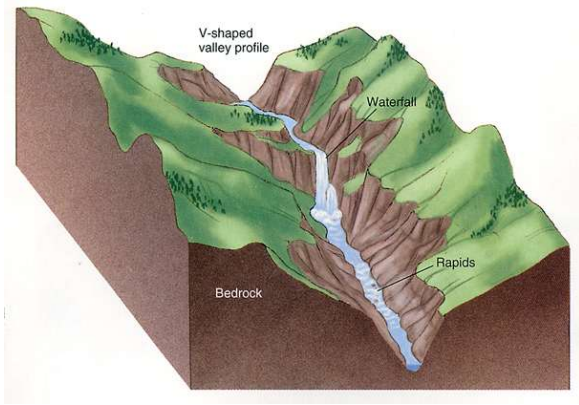
Delta

Char or Shifting Island

Erosional and Depositional Landforms

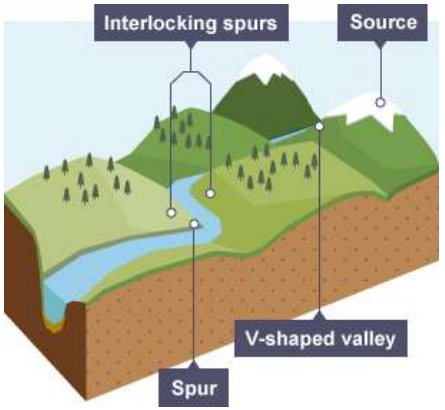
River Vally

Formed by vertical erosion (downcutting) from a river in its upper course, where energy is high.



Interlocking spurs

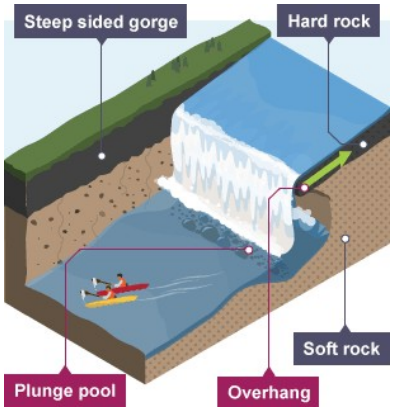
Formed by lateral (sideways) erosion on the outer bank and deposition on the inner bank of a river as it flows across flatter land.



Erosional and Depositional Landforms

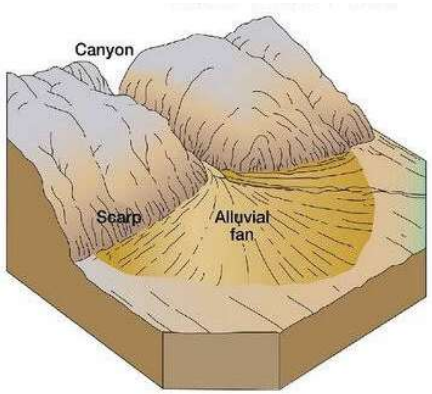
Waterfall

A waterfall is a sudden drop along the river course. It forms when there are horizontal bands of resistant rock (hard rock) positioned over exposed, less resistant rock (soft rock).



Alluvial Fan

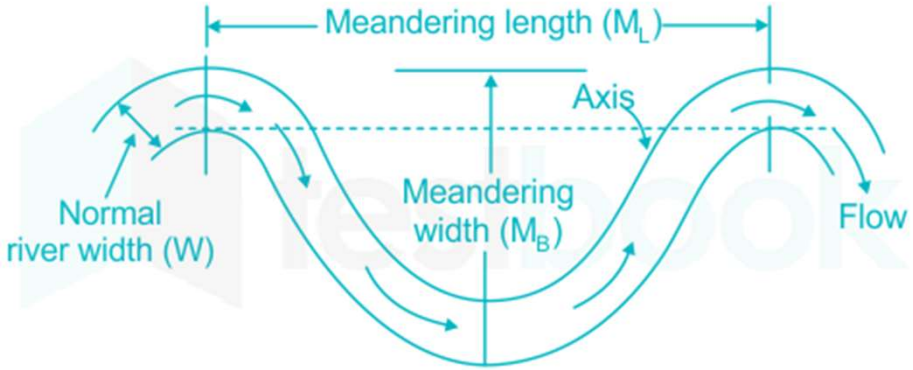
A cone-shaped or fan-shaped deposit of sediment formed when a fast-flowing stream suddenly emerges from a steep mountain valley onto a flat plain, loses energy, and drops its sediment load.



Erosional and Depositional Landforms

Meandering River

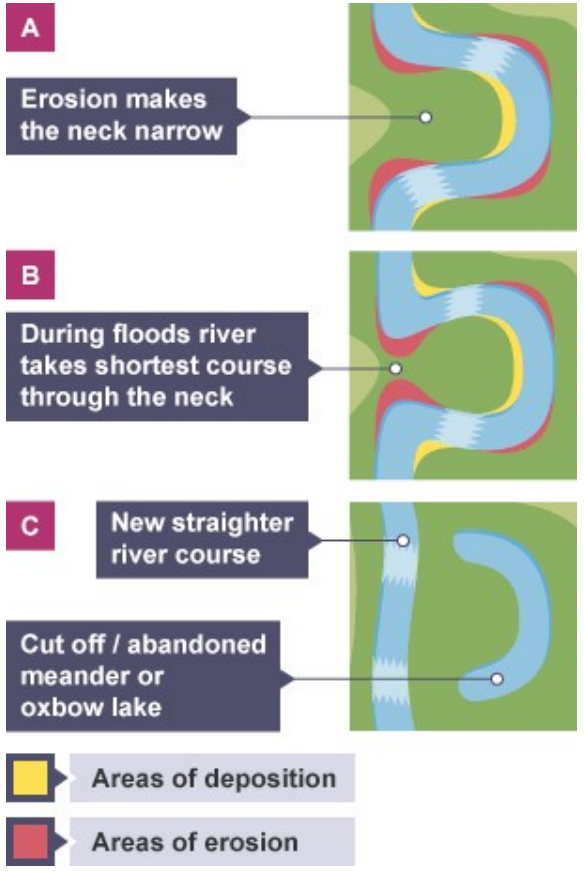
A meander is a natural, winding bend in a river channel, characterized by erosion on the outer bank and deposition on the inner bank, which causes the bend to migrate downstream.



Erosional and Depositional Landforms

Oxbow Lake

Isolated waterbody (lake) from the main river channel formed when a meander bend is cut off from the main river channel due to neck erosion during a flood and subsequent deposition sealing the ends.

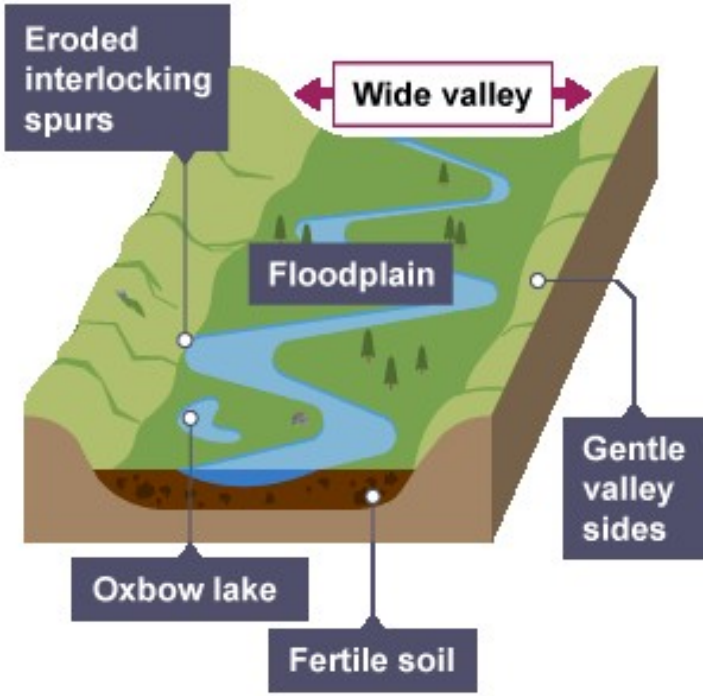


Erosional and Depositional Landforms

Floodplain

Floodplain is an area of land which is covered in water when a river bursts its banks.

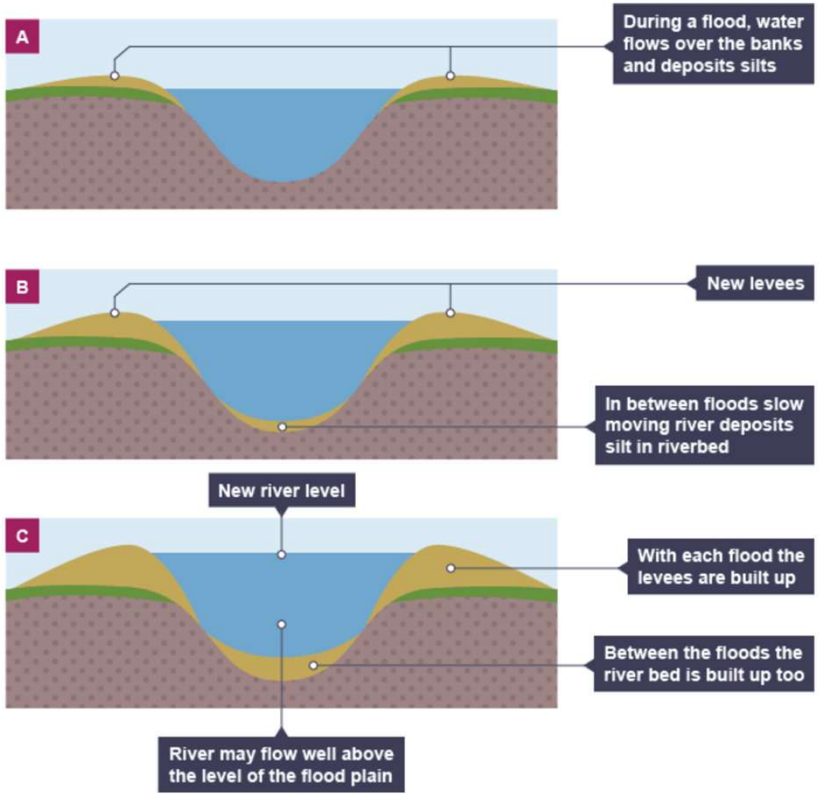
Floodplains form due to both erosion and deposition. Erosion removes any interlocking spurs, creating a wide, flat area on either side of the river. During a flood, material being carried by the river is deposited (as the river loses its speed and energy to transport material). Over time, the height of the floodplain increases as material is deposited on either side of the river.



Erosional and Depositional Landforms

Natural Levee

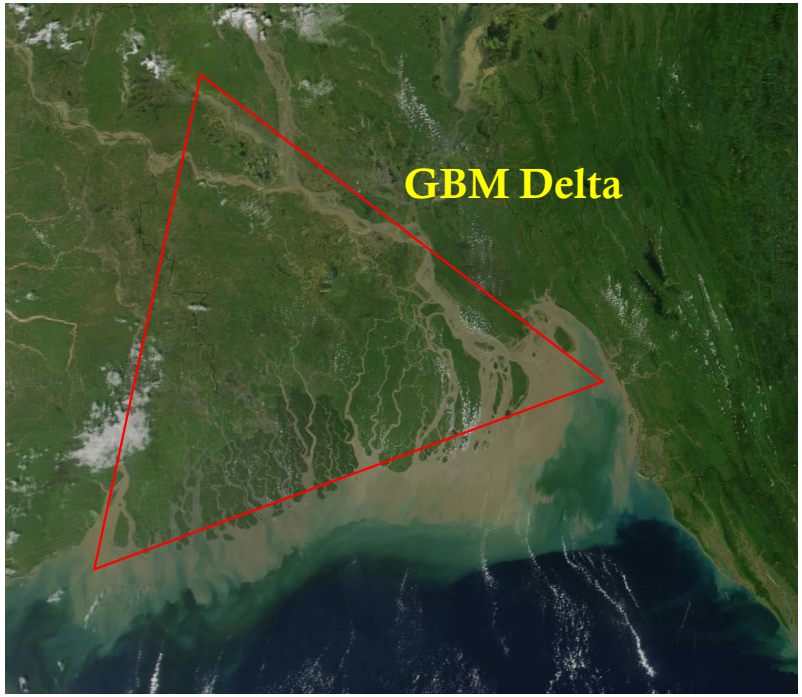
Levees occur in the lower course of a river. When flooding occurs and spread water and mud (sediment) over the land beside it, water slows down and it drops the sediments, right next to the riverbank. After many floods, the piles of sediments next to the river get higher. These raised banks are called levees. They act like natural walls that help hold more water in the river, which makes flooding less likely.



Erosional and Depositional Landforms

River Delta

The creation of a river delta occurs at the river mouth, where the river merges into an ocean or a sea. When the river meets a body of standing water (ocean, sea), its velocity decreases significantly. The river loses its energy to carry sediment, causing the sediment to drop out and accumulate at the river mouth. Over time, these deposits build up in elevation (aggrade) and spread outwards into the larger water body (prograde), forming the delta.



Erosional and Depositional Landforms

Char

A riverine island is land surrounded by a river, often formed by sediment deposition during river floods or by the formation of new river channels that separate land from the main banks. In Bangladesh and India, these islands are often known as "charland" and are characterized by vulnerability to river erosion and floods.