EWCE 471
Coastal Engineering

Lecture 11-12: Deltas and Its Characteristics

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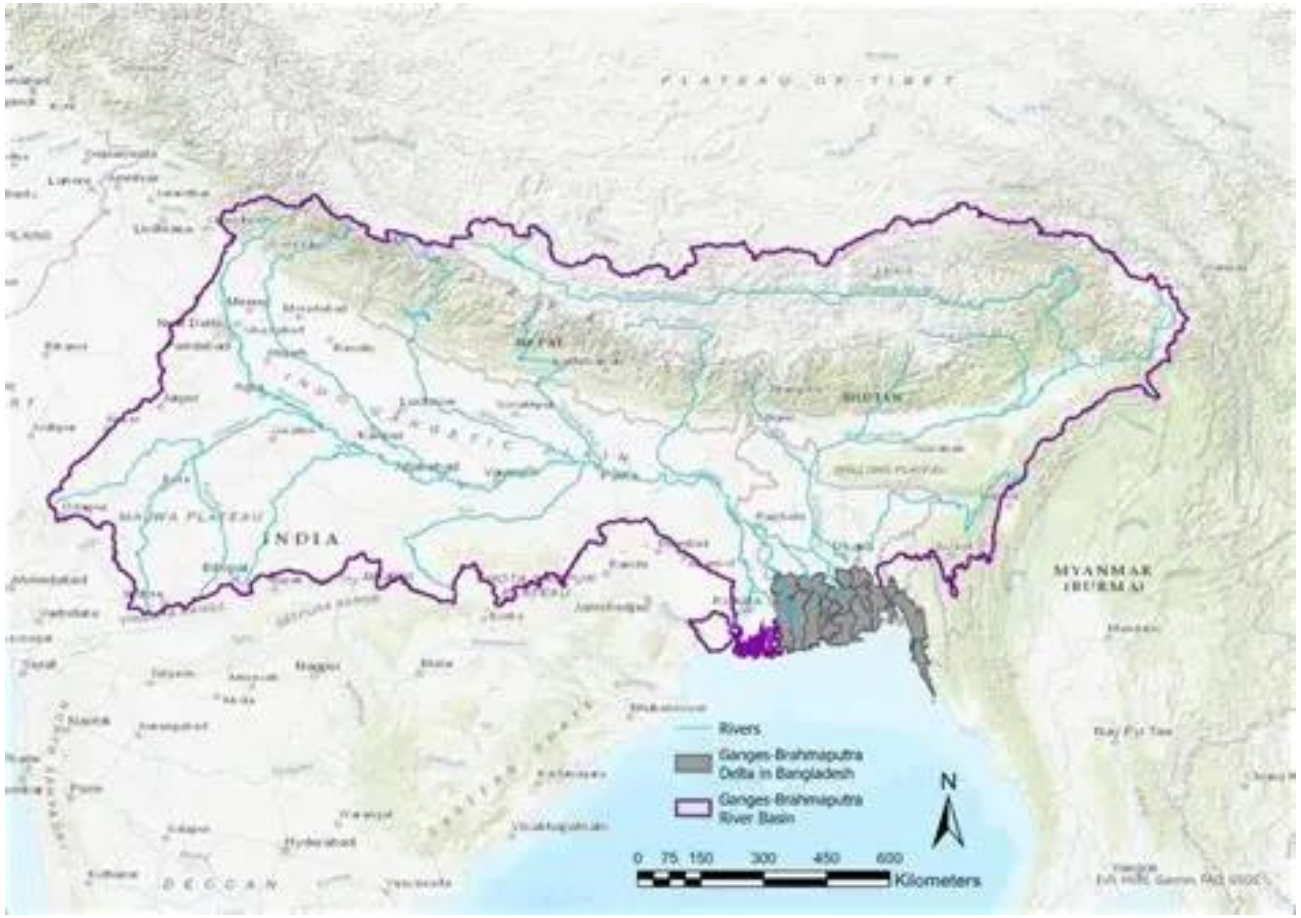
Introduction

- When a river reaches a lake or the sea, the water slows down and loses the power to carry sediment.
- The sediment is dropped at the mouth of the river.
- Some rivers drop so much sediment that waves and tides can't carry it all away.
- It builds up in layers, forming a delta.
- Some deltas are so large that people can live on them.
- Deltas are named after the Greek alphabet 'delta' for its commonly triangular shape by Greek historian Herodotus in the 5th century. These come in a variety of shapes and sizes.

What is Delta?

- A delta is a feature of river deposition at the end of a river at its mouth where it reaches the sea or a lake.
- They can be very large and can span hundreds of km across.
- They are comprised of coarse to fine alluvial material and are characterized by a complicated crisscross network of distributaries.
- River deltas form when a river carrying sediment reaches:
  - a body of standing water, such as a lake, sea, ocean, or reservoir,
  - another river that cannot remove the sediment quickly enough to stop delta formation, or
  - an inland region where the water spreads out and deposits sediments.

What is Delta?



Ganges-Brahmaputra Delta

How delta is formed?

- A delta is an alluvial landform where the mouth of a river flows into an ocean.

Formation of Delta:

The formation of a delta is a long and gradual process.

- **Erosion and Transport:**
  - In its upper course, the river erodes rocks and soil.
  - It carries sediments (clay, silt, sand, gravel, organic matter) downstream.
- **Loss of Energy at the Mouth:**
  - As the river reaches its mouth, it loses energy and competence and therefore slows down.
  - The reduced energy means it can no longer transport all its sediment.
- **Deposition of Sediments**
  - This reduction in speed results in the deposition of its load. Vegetation also increases the rate of deposition by slowing down the water.
  - Coarser materials (sand, gravel) deposit first, closer to the river mouth. Finer materials (silt, clay) settle farther out into the sea or lake.

How delta is formed?

❑ Formation of Delta:

❖ Formation of Distributaries

- Over time, these factors result in the build-up of sediment both outwards and in height. Later, a system of multiple, dividing channels forms within the delta, and these are called distributaries. These divide at points of channel blockage and come together again to form a maze of active and inactive channels.
- These distributaries spread out and deposit more material.

❖ Delta Growth:

- Over time, continuous sediment deposition creates a triangular or fan-shaped landform projecting into the sea — the delta.

Flocculation Process in Delta Formation

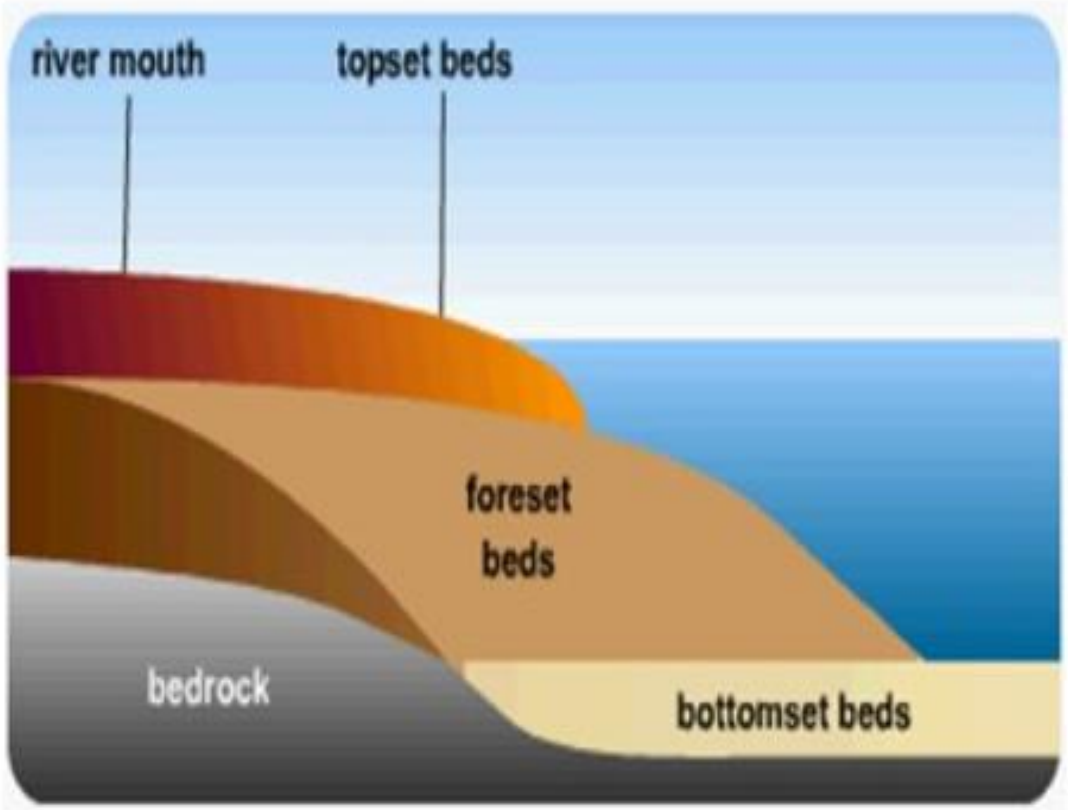
- When rivers like the Mississippi reach the sea, the meeting of fresh and seawater produces an electric charge, which causes **clay particles** to collect together and settle on the seabed. This is a process called flocculation.

- An important process aiding in the deposition of the river's load is flocculation. This is the process by which tiny particles in suspension like clay and silt (which under normal freshwater conditions would likely never fall out of suspension) coagulate with the salt in the water by chemical reaction and become heavy enough to 'sink' and be deposited. Then it is called brackish water.

- As these sediment particles flocculate and therefore increase in size, they are deposited under the influence of gravity. The sediment deposited in a delta is laid down in layers or beds, each containing various types of sediment.

Composition of a Delta

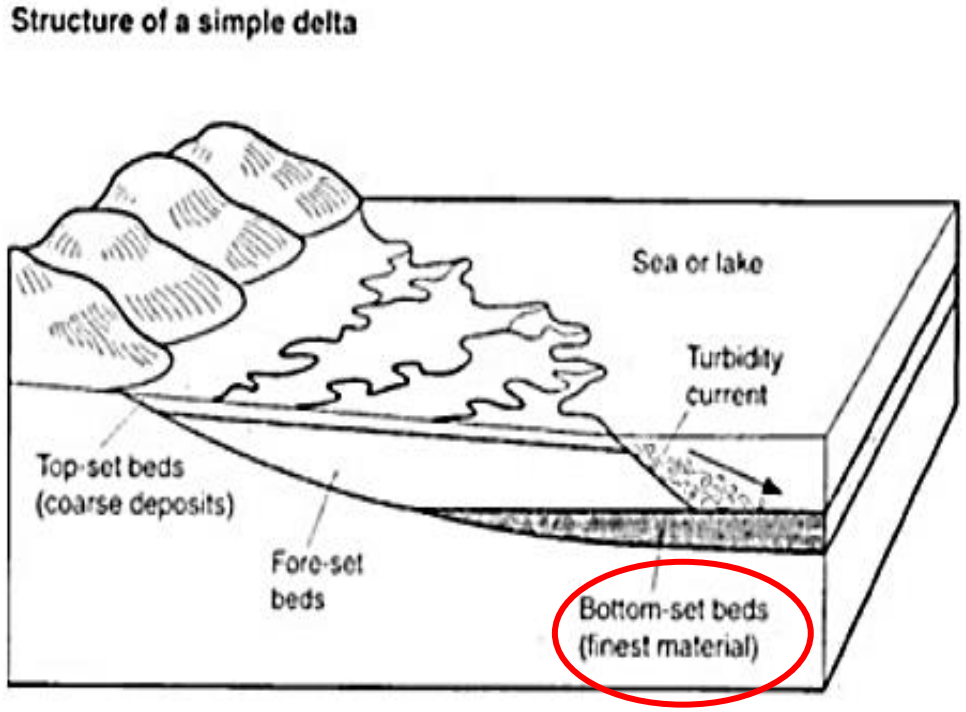
- Deltaic deposits are composed of three types of depositional layers, each with different types of sediment:
  - Bottomset beds
  - Foreset beds
  - Topset beds



Composition of a Delta

Bottomset beds –

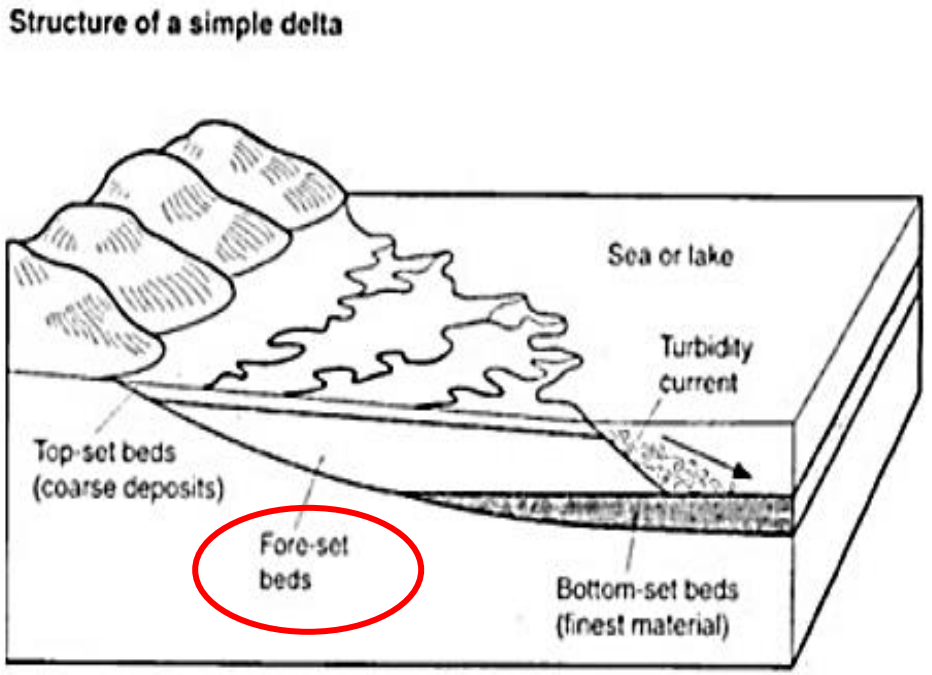
- Bottomset beds are nearly horizontal or flat layers of fine clay and silt that form the mouth of the river and the active delta front.
- These are the very finest particles that travel the furthest before very low velocity/flocculation leads to their deposition.



Composition of a Delta

Foreset beds-

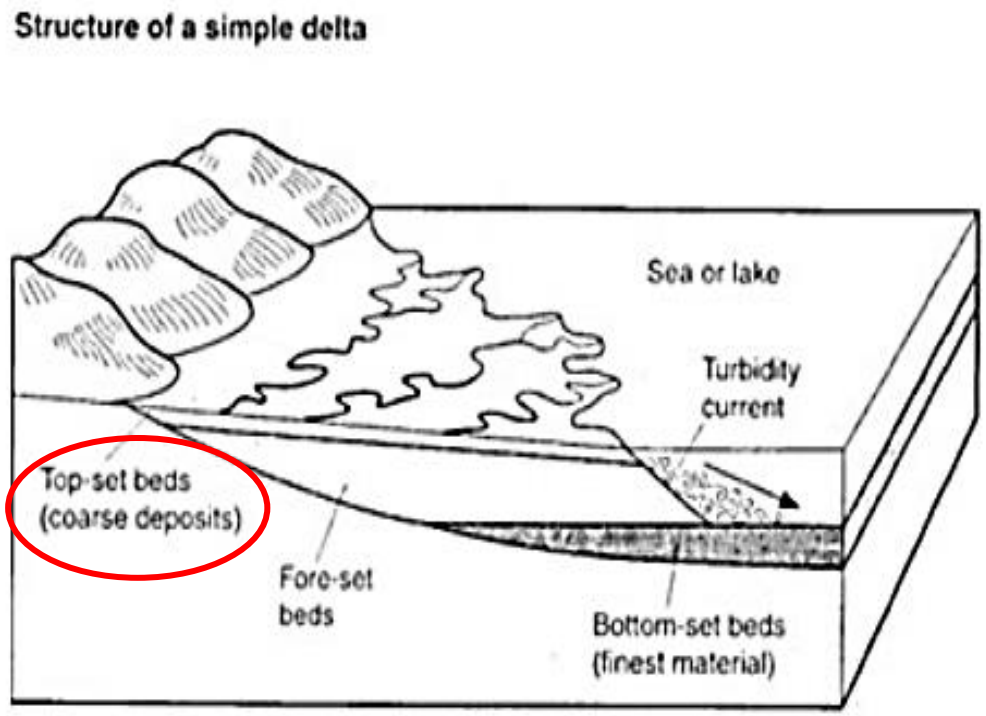
- Closer to the mouth, yet still underwater, are foreset beds of sand and gravel that slope steeply toward the bottomset beds at angles of 5 to 25 degrees.
- They make up the main body of deltas.



Composition of a Delta

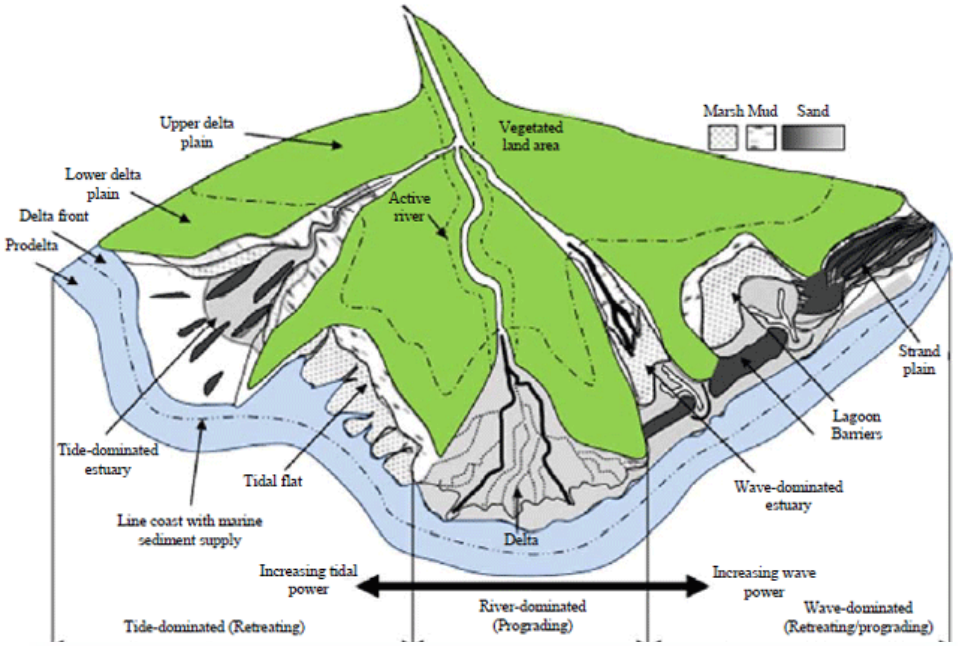
Topset beds-

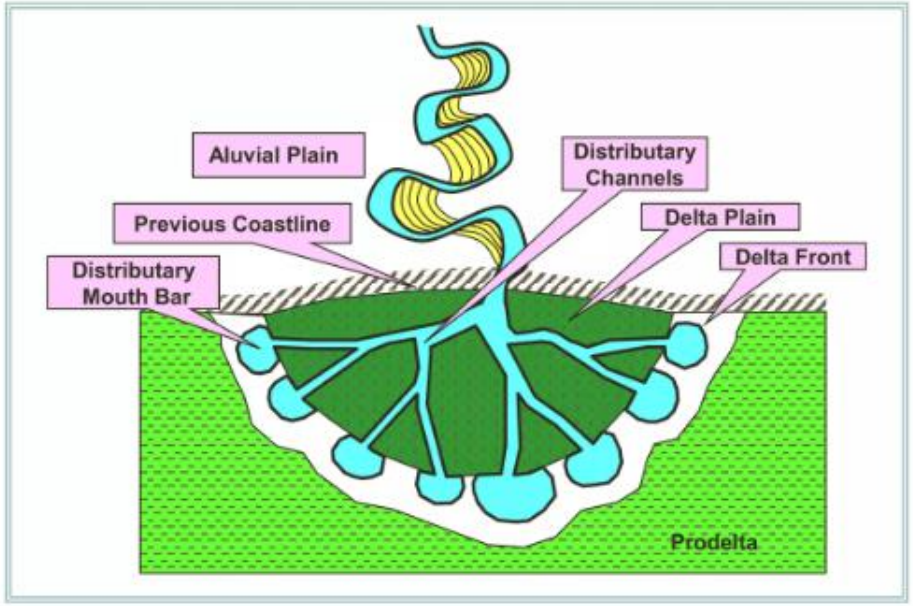
- These are thin, horizontal layers of different sizes – coarser sand and gravel (deposited first as the river loses energy) as well as finer material from the suspended load that are deposited on the surface of the delta on top of the foreset beds.

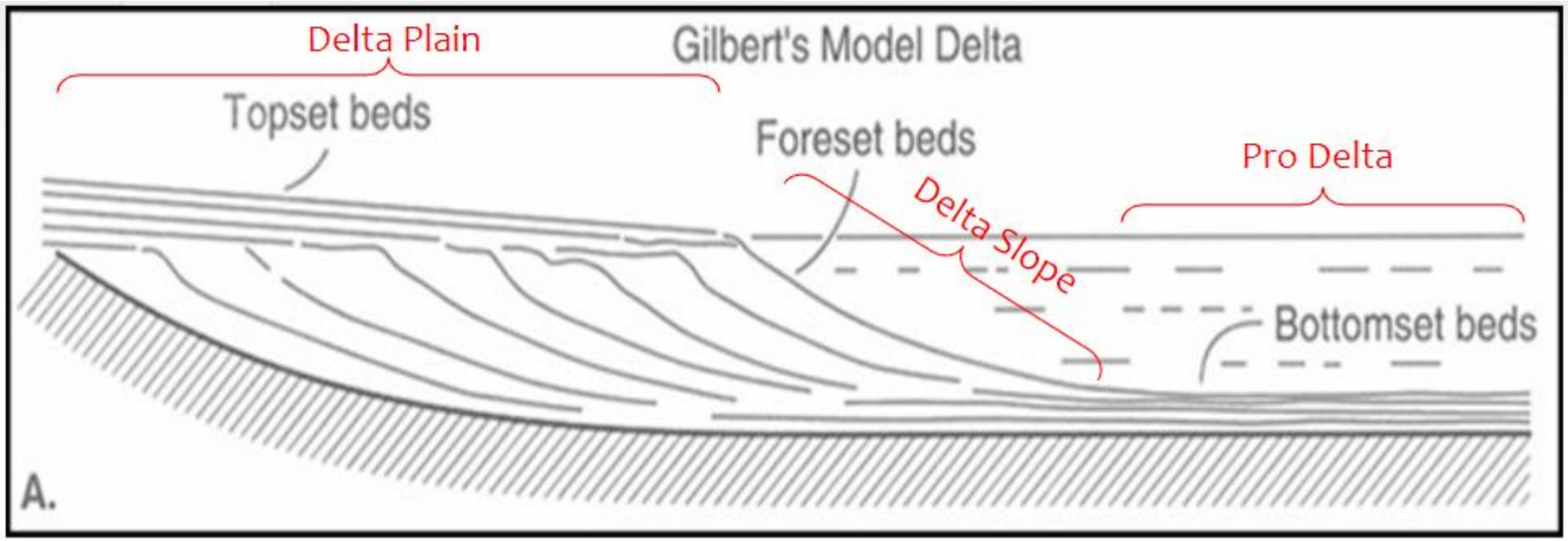


Morphology

- Three geomorphological elements:
  1. Delta plain
     - Subaerial (the part of a delta that lies above sea level, built up by river deposition and shaped by river channels and distributaries)
     - Flat swampy plain
     - Fluvial process generally predominate
     - Incised by fluvial distributary channels
  2. Delta front
     - Shallow submarine platform
     - Most sand accumulates (mouth bars)
  3. Prodelta
     - Most distal;
     - Water depth > 10-15m
     - Bulk suspension settles out







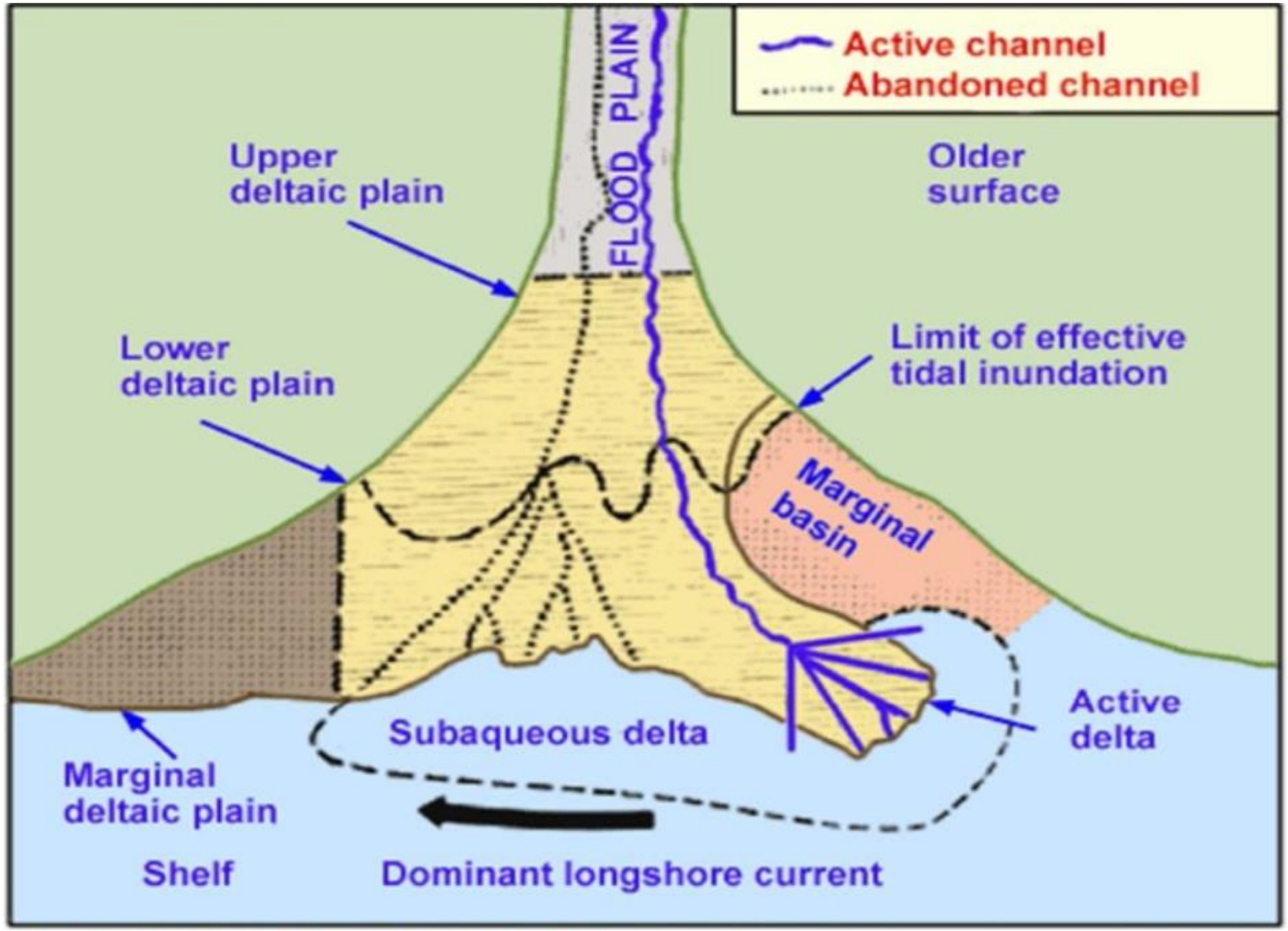
- The delta plain is divided into:
  - Upper deltaic plain- entirely fluvial
  - Lower deltaic plain- modified by tides
    - Tidal flats, mangroves, marshes
- Delta slope- deposition of fluvial sediment
- Pro delta - deposition of marine or lacustrine sediment

Parts of a Delta

- Fully formed deltas are typically made up of **three** parts. These parts are:
  - The upper deltaic plain,
  - The lower deltaic plain and
  - The subaqueous delta

  } **Delta plain**

- Topset beds form the deltaic plain and are subdivided into two regions:
  - The upper deltaic plain, which is not affected by tides and
  - The lower deltaic plain, whose boundary with the upper deltaic plain is defined by the upper limit of tidal influence.


Active channel
Abandoned channel
FLOOD PLAIN
Upper deltaic plain
Older surface
Lower deltaic plain
Limit of effective tidal inundation
Marginal basin
Active delta
Subaqueous delta
Marginal deltaic plain
Shelf
Dominant longshore current

Upper Deltaic Plain

- This is the part of the delta that is farthest inland i.e., nearest to the land.
- It lies above the high tide mark and is not affected by the action of waves or tides.
- It is usually the area with the least water and the highest elevation.
- The river or stream that forms the delta begins to divide in this area into smaller channels called distributaries, which carry sediment towards the delta's edge.

Lower Deltaic Plain

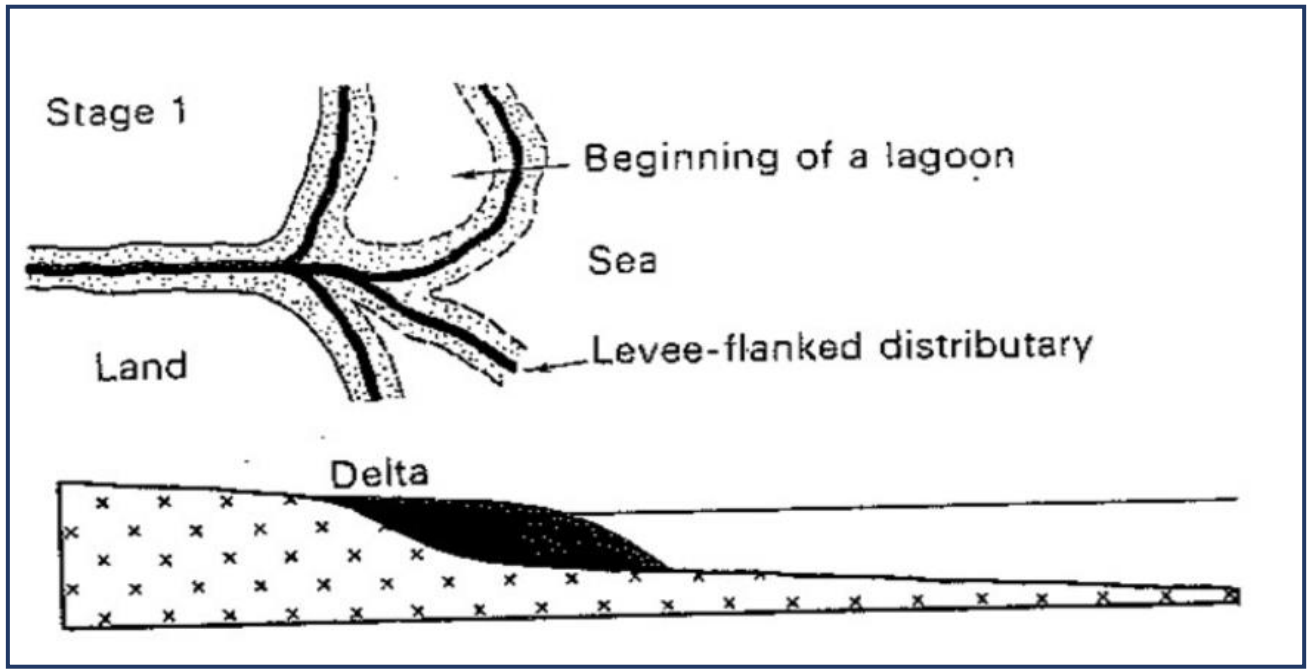
- This lies immediately seaward of the upper deltaic plain, in the middle of the delta.
- It occupies the area between high and low tides and, thus, periodically lies underwater.
- The landscape is affected by the action of distributaries, tides, and waves.
- It is a transition zone between the dry upper delta and the wet subaqueous delta.

Subaqueous Delta

- That part of the delta that lies below the low tide mark.
- It is closest to the sea or body of water into which the river flows.
- This area usually lies past the shoreline. And as a result, lies completely underwater.

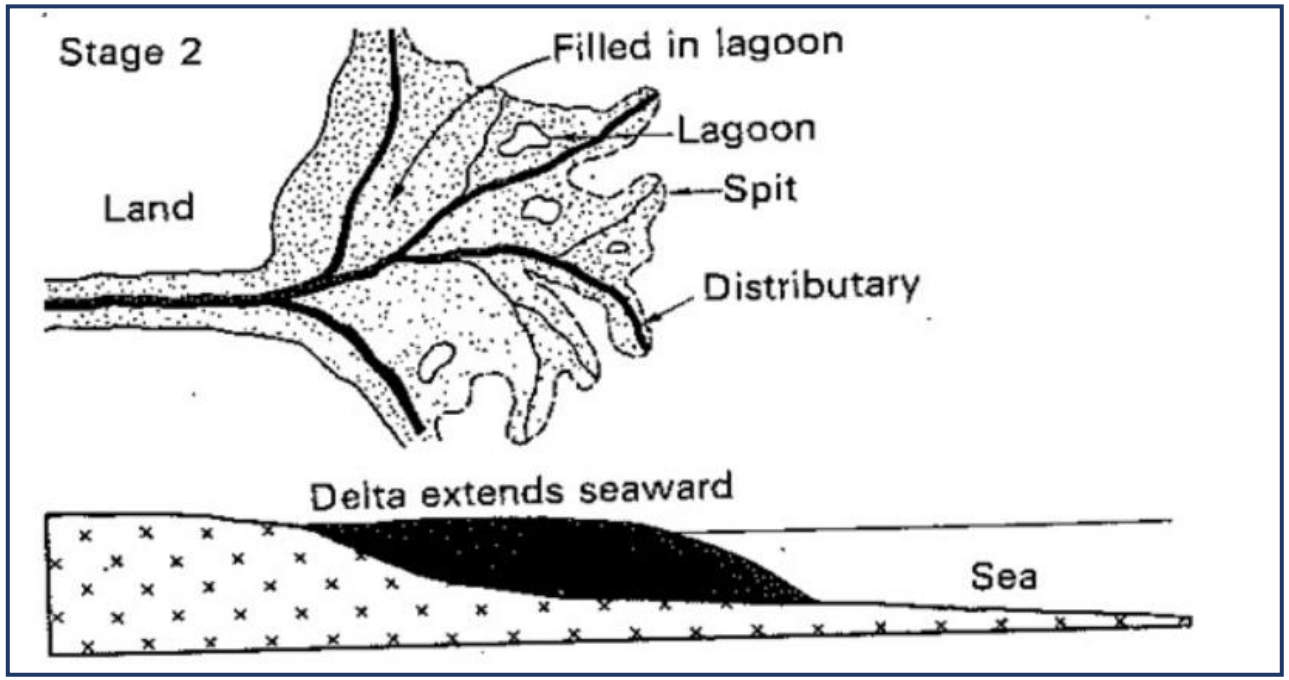
Stages in Delta Formation

- **Stage 1:**
  - ➢Deposition divides the river mouth into several distributaries.
  - ➢Spits and bars arise and lagoons are formed.
  - ➢The levees of the river extend into the sea via the distributaries.



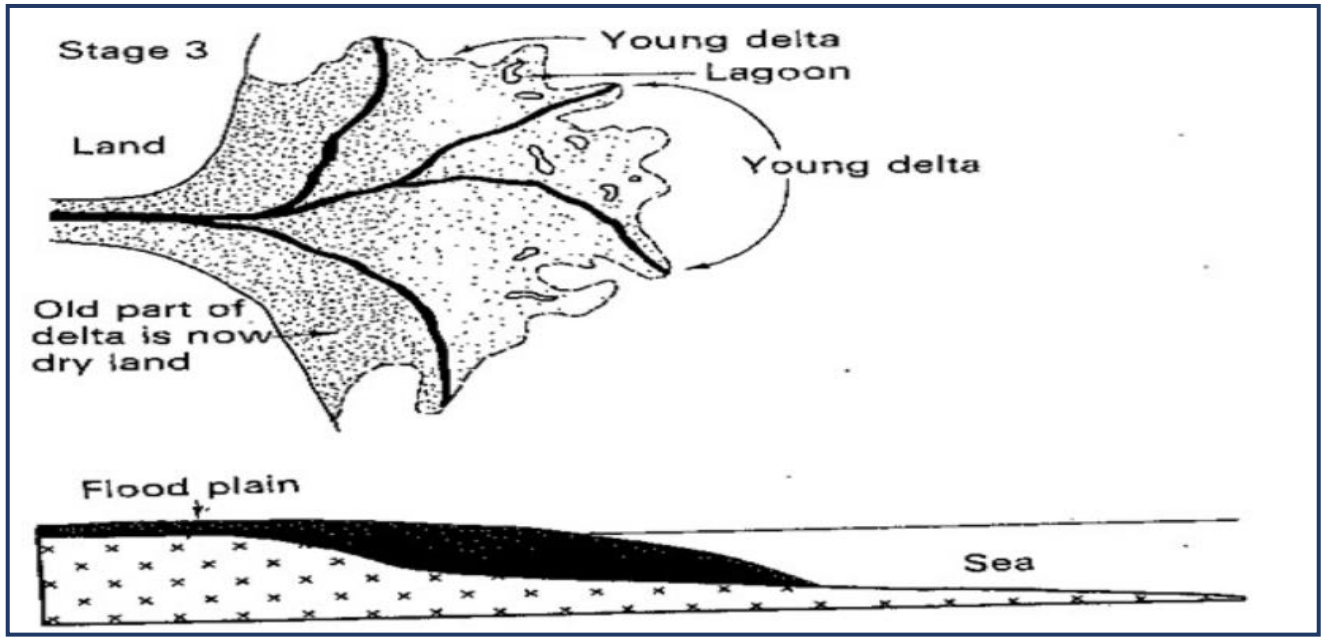
Stages in Delta Formation

- **Stage 2:**
  - ➢The lagoons begin to get filled with sediments and become swampy.
  - ➢The delta begins to assume a more solid appearance.



Stages in Delta Formation

- **Stage 3:**
  - ➢The old part of the delta becomes colonized with plants and its height is slowly raised as a result.
  - ➢Swamps gradually disappear and this part of the delta becomes dry land.



All three stages can be seen in most deltas. As a delta grows larger, the old parts merge imperceptibly with the flood plain, and they no longer have the appearance of a delta.

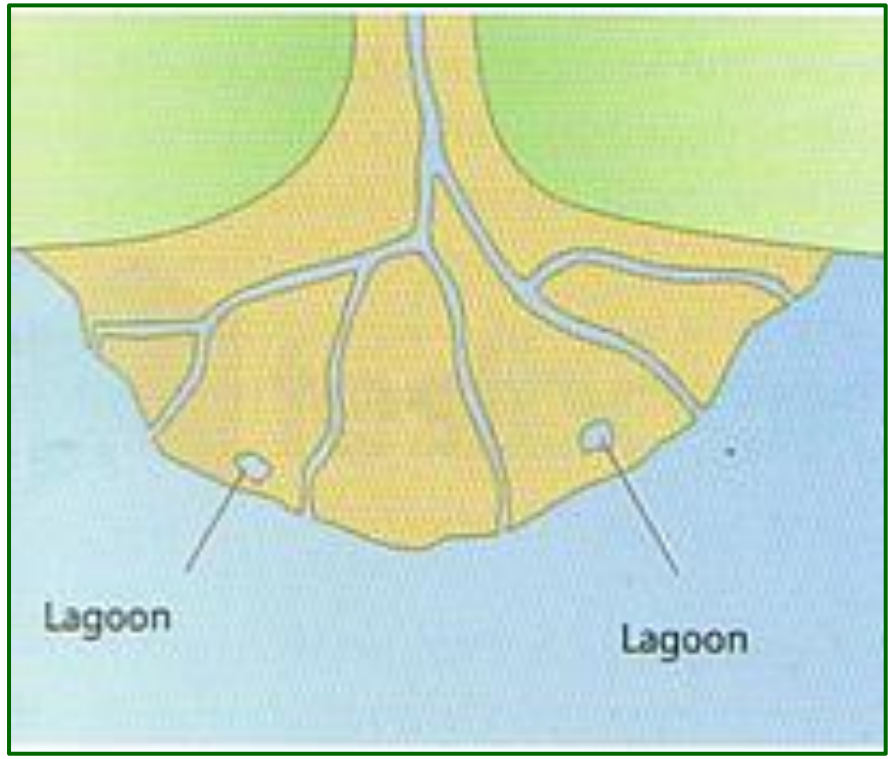
Types of Deltas

- Types based on shape
  - Arcuate
  - Digitate
  - Cuspate
- Types based on controls of deposition
  - River-dominated deltas
  - Wave-dominated deltas
  - Tide-dominated deltas
  - Gilbert deltas
  - Estuarine deltas

Types of Deltas Based on Shape

Arcuate delta-

- ✓ has a rounded, convex outer margin.
- ✓ crossed by many short, well-defined distributaries, these types of deltas are composed of relatively coarse sediments like gravel.
- ✓ Wave and river activity are fairly well balanced.
- ✓ A good example is the Nile delta in Egypt which is dominated a little more by tidal and wave action.



Types of Deltas Based on Shape

Digitate/ Bird's Foot delta-

- ✓ Where delta formation is river-dominated and less subject to tidal or wave action, a delta may take on a bird's foot shape.
- ✓ Fine sediments and shifting distributaries mark this river-dominated delta.
- ✓ The Mississippi delta on the Gulf of Mexico is an example of a bird's foot delta.



Types of Deltas Based on Shape

Cuspate delta-

- ✓ Where the material brought down by a river is spread out evenly on either side of its channel. It is like a tooth and is shaped by gentle, regular, but opposing, sea currents or longshore drift.
- ✓ Few distributaries are found in cuspate deltas.
- ✓ The Tiber Delta in Italy and the Ebro Delta in Spain are classic examples.



Types based on controls of deposition

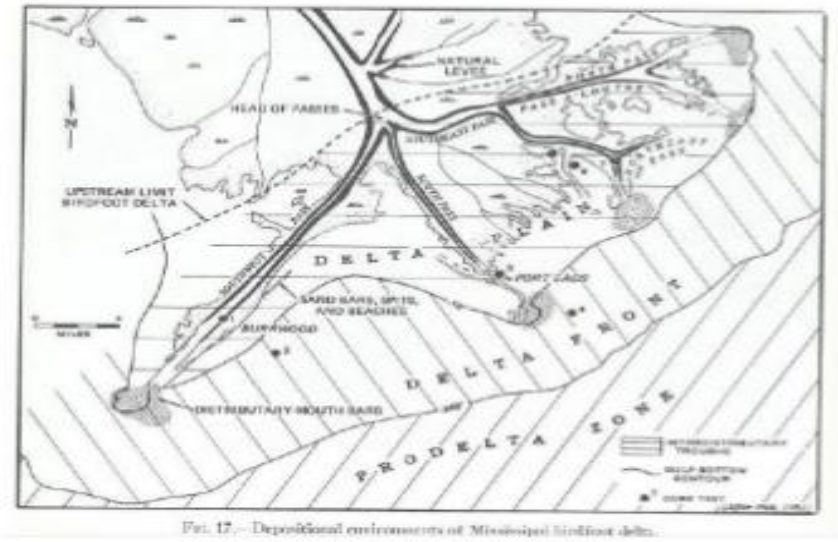
River Dominated Delta

- A river-dominated delta is a type of delta where fluvial (river) processes are stronger than marine processes (waves and tides).

- Long, narrow mounds of sediment called levees build up along the sides of the narrow distributary channels.

- A river-dominated delta, such as the Mississippi Delta, Louisiana, USA, is sometimes called a bird's foot delta because of its shape.





Types based on controls of deposition

Tide Dominated Delta

- Deltas that undergo strong tidal interaction are classified as tide-dominated deltas. As sediment travels out of the delta into the sea, high tides and flood tides confine sediment on the delta plain, and low tides carry sediment seaward.

- Tide-dominated deltas typically occur in locations of large tidal ranges or high tidal current speeds.

- In situations where the strong tidal current is stronger than the sediment supply, the delta tends to be very small. Tide-dominated delta has many linear structures parallel to the tidal flow and perpendicular to the shore.

Types based on controls of deposition

Tide Dominated Delta

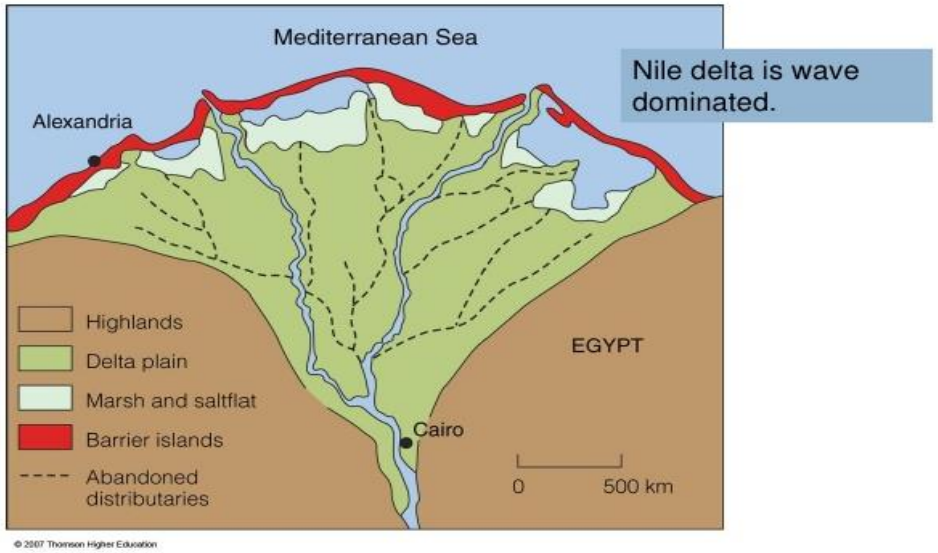
- The massive Ganges-Brahmaputra delta, in India and Bangladesh, is a tide-dominated delta, shaped by the rise and fall of tides in the Bay of Bengal.



Types based on controls of deposition

Wave-dominated deltas

- Wave-dominated deltas are characterized by relatively high wave energy at the mouth compared to tide energy and are distinguished from wave-dominated estuaries by high river energy.
- The Nile Delta (shaped by waves from the Mediterranean Sea) and the Senegal Delta (shaped by waves from the Atlantic Ocean) are both wave-dominated deltas.



Types based on controls of deposition

Gilbert deltas

- Gilbert deltas are formed as rivers deposit large, coarse sediments. These deltas can form in oceans, but they are usually found where rivers from mountains flow into freshwater lakes.

- They are steeper than the flat plains of wave-dominated or tide-dominated deltas.

- Lacustrine deltas are good examples, such as the Kander River Delta in Lake Thun, Switzerland, and the St. Clair River Delta in Canada.

Types based on controls of deposition

Gilbert deltas



Types based on controls of deposition

Estuarine deltas

- When a river is located near coasts that have large tidal variations, they do not always form a traditional delta. They instead form estuaries, or a river that meets the sea.

- Estuarine deltas form as a river does not empty directly into the ocean, but instead forms an estuary. The load is deposited along the sides of the estuary.

- The Yellow River is an example of an estuarine delta.

Types based on controls of deposition

Estuarine deltas



The Yellow River

Sea Level Rise

- Sea level rise is an increase in global mean sea level as a result of an increase in the volume of water in the world's oceans.

- The two major causes of global sea level rise are thermal expansion caused by warming of the ocean (since water expands as it warms) and increased melting of land-based ice, such as glaciers and ice sheets.

- The oceans are absorbing more than 90 percent of the increased atmospheric heat associated with emissions from human activity.

Relation between Global and Local Sea Level

- Global sea level trends and relative local sea level trends are different measurements.

- Just as the surface of the Earth is not flat, the surface of the ocean is also not flat—in other words, the sea surface is not changing at the same rate globally.

- Sea level rise at specific locations may be **more or less than** the global average due to many local factors: **subsidence, upstream flood control, erosion, regional ocean currents, variations in land height, and whether the land is still rebounding from the compressive weight of Ice Age glaciers.**


THANK YOU