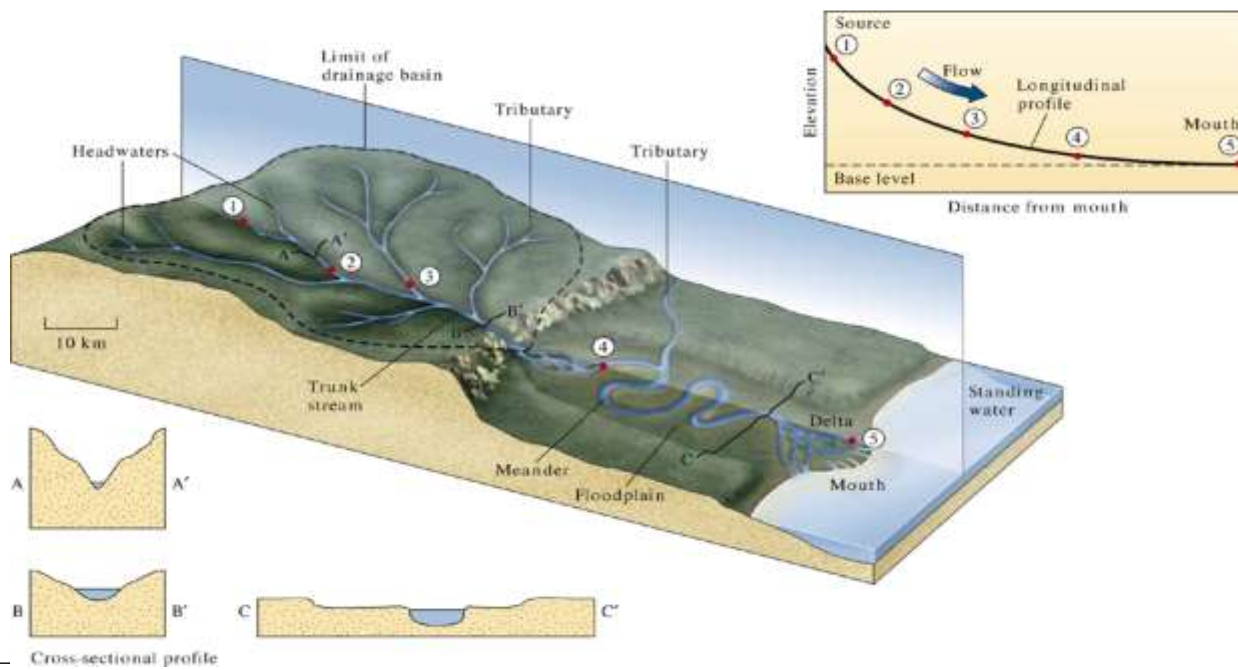
GGY 4031 LECTURE NOTES 7d DEPOSITIONAL ENVIRONMENT Marginal Marine

DELTAIC DEPOSITIONAL ENVIRONMENT

- **Delta:** defined as discrete shoreline formed at a point where a river enters the ocean or other water bodies, and as such it is formed where sediment brought by rivers builds out as a body into the **lake or sea.**
- **Deltaic environments:** are gradational to both **fluvial** and **coastal** environment

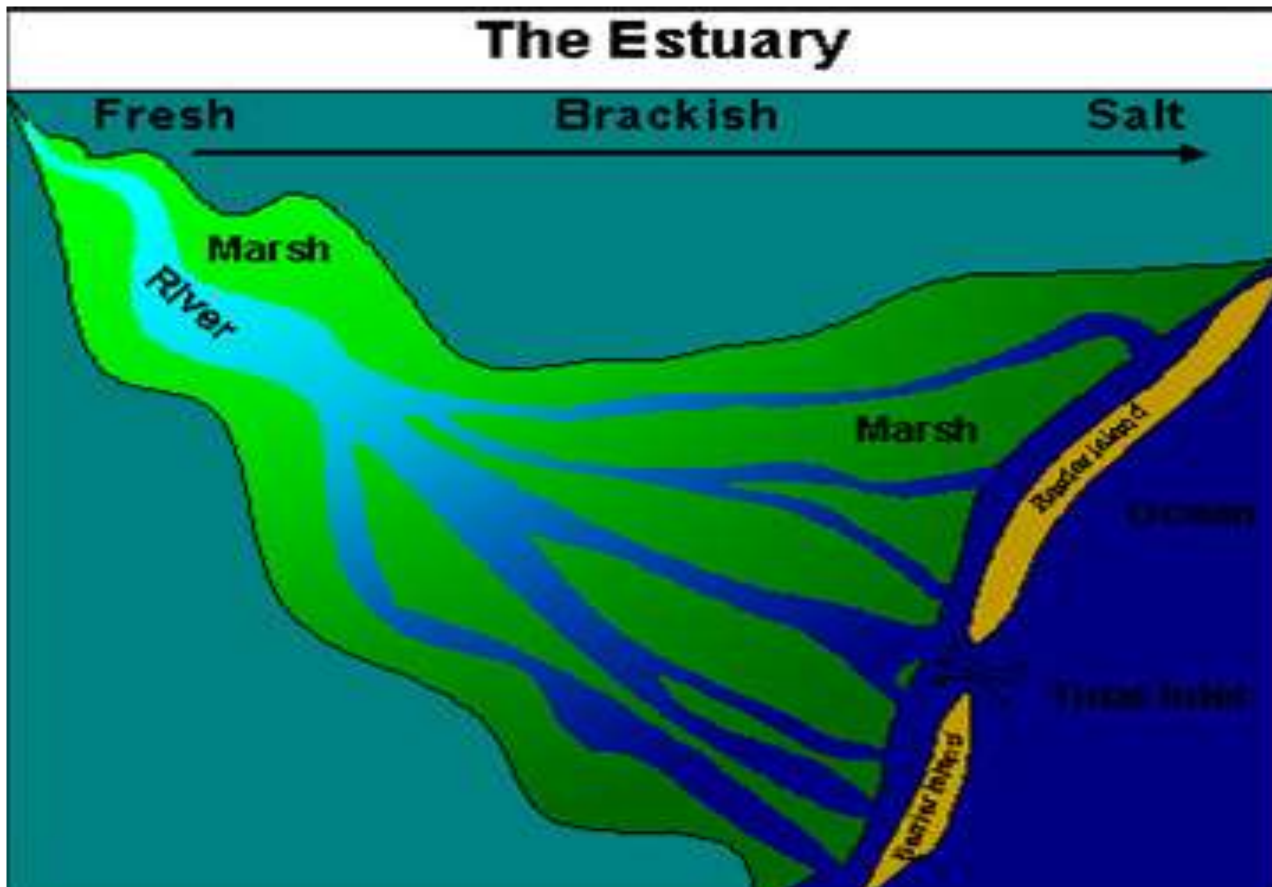


DELTAIC DEPOSITIONAL ENVIRONMENT

- **Estuary:** is a river mouth where there is a mixture of fresh water and sea water with accumulations of sediments within the confines of the estuary, but without build-out into the sea

<u>**NOTE:**</u>

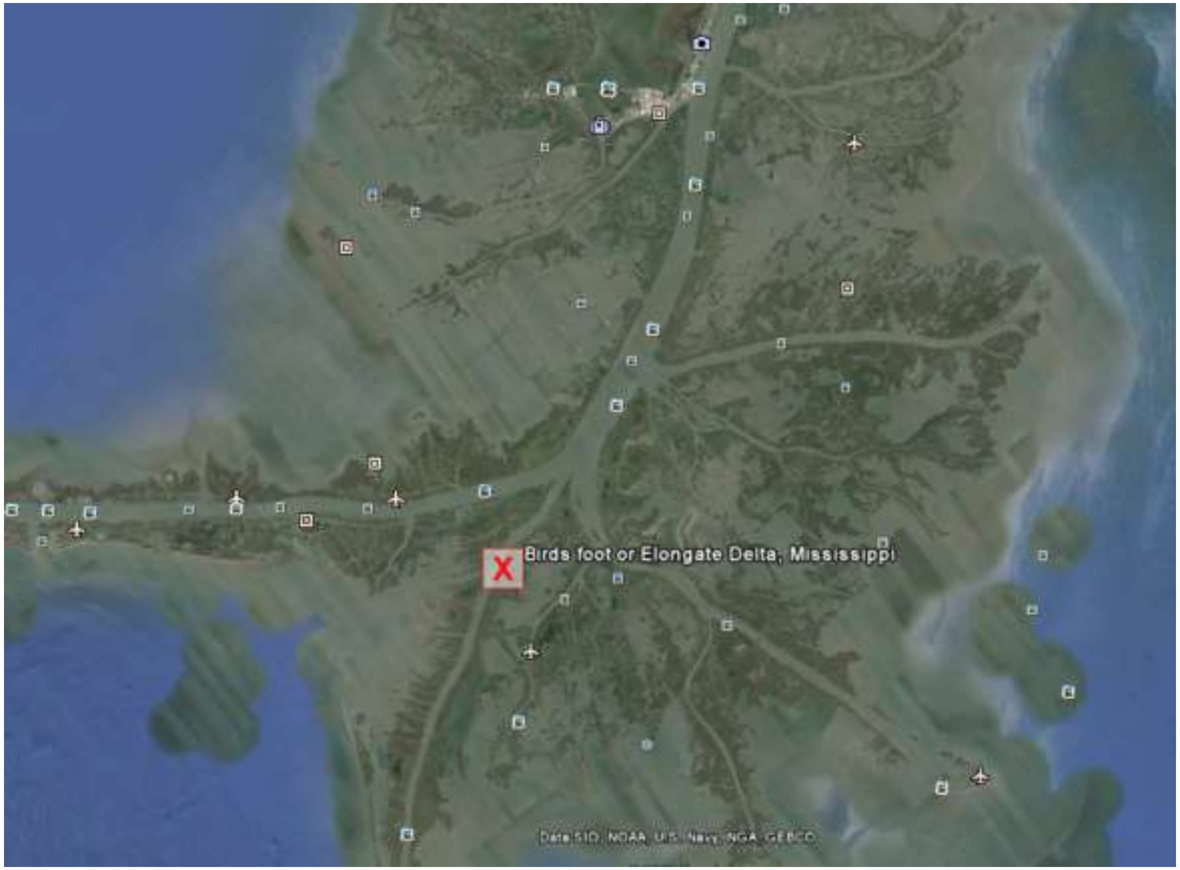
Estuaries form a transition zone between river **environments** and maritime **environments**.



Delta Morphology

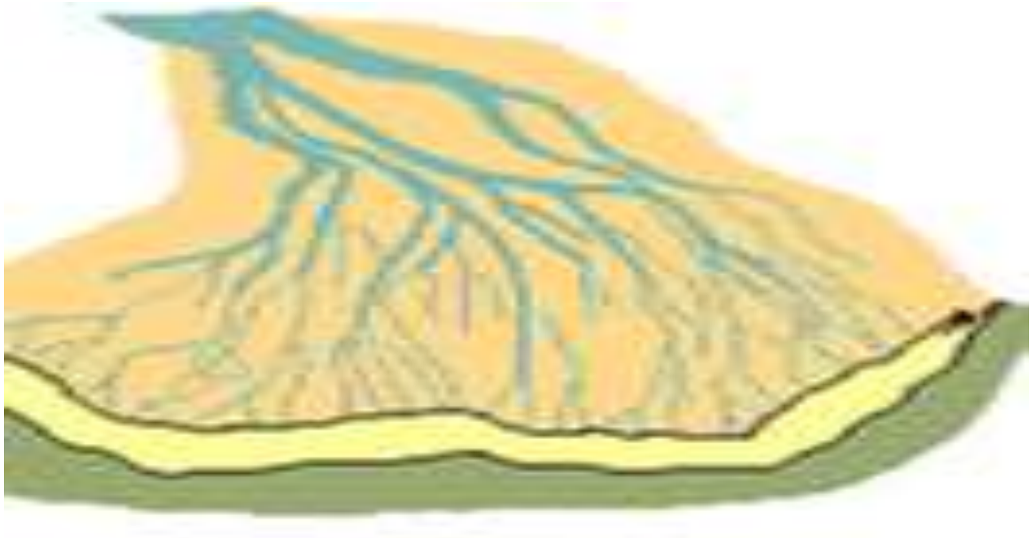
- **Elongate**
- **Lobate**
- **Cuspate**

•Elongate type (birds foot)



Delta Morphology

- **Lobate type**



Delta Morphology

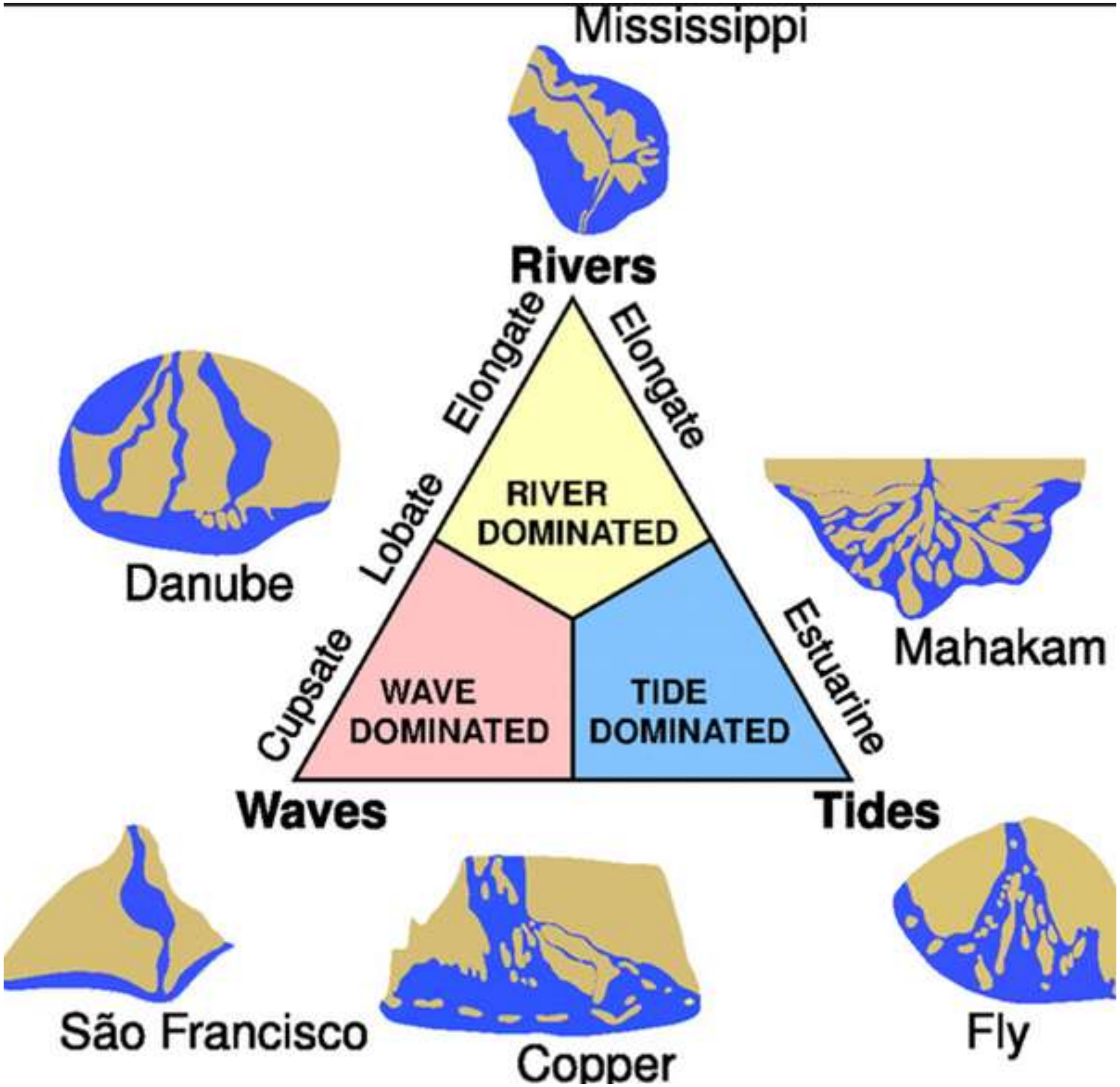
- **Cuspate type**

Ebro Delta →

A cuspate delta is shaped like a tooth by:

- gentle but regular opposing currents in the water body the river flows into,
- Longshore drift
- Strong waves that approach the coast head on

Delta Classification



Delta Classification

<u>**River Dominated:**</u> occur in microtidal settings with limited wave energy, where delta--lobe progradation is significant and redistribution of mouth bars is limited

❑Characteristics

•River processes are more dominant than either tidal or wave processes

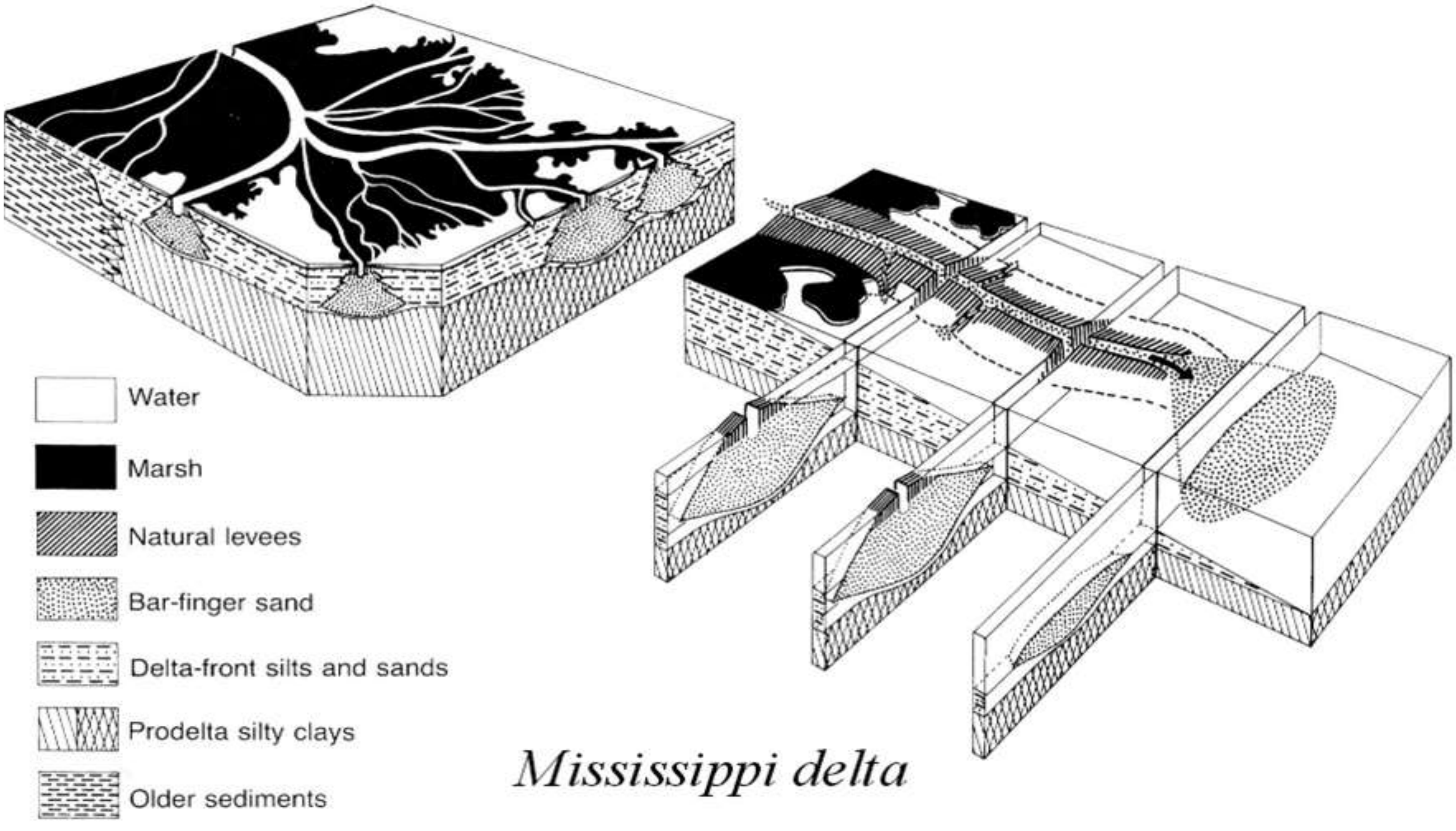
• Usually characterized by high sediment and water discharge

•Elongate to lobate in plan shape

•Muddy bulk composition (interdistributary areas), but with sandy channel facies, distributary mouth bar facies, and bar front facies

Delta Classification

Fluvial-dominated deltas



Mississippi delta

Delta Classification

•**Tide Dominated:** exhibit tidal mudflats and mouth bars that are reworked into elongate sand bodies perpendicular to the shoreline. A striking feature of a tide-dominated delta is that it has many linear structures parallel to the tidal flow and perpendicular to the shore (shown below).

•Tidal currents may overwhelm river flow in areas with high tidal range

• River mouth sediments may be redistributed by tidal action

•Estuarine to irregular in plan shape

•Mixed sediment composition

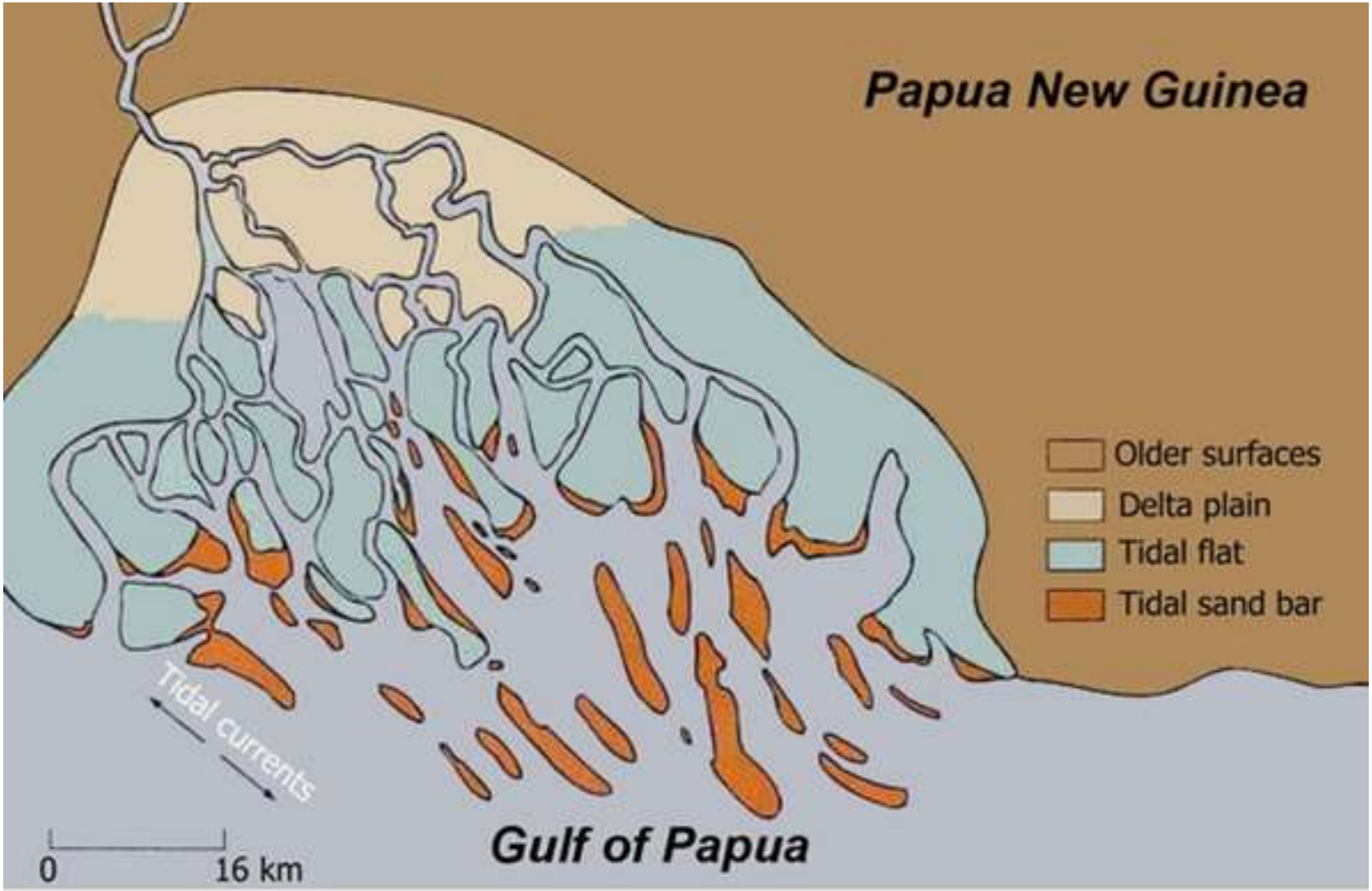
– Muddy estuarine areas

– Sand-filled channels

– Sand ridge

Delta Classification

- Tide-dominated



Delta Classification

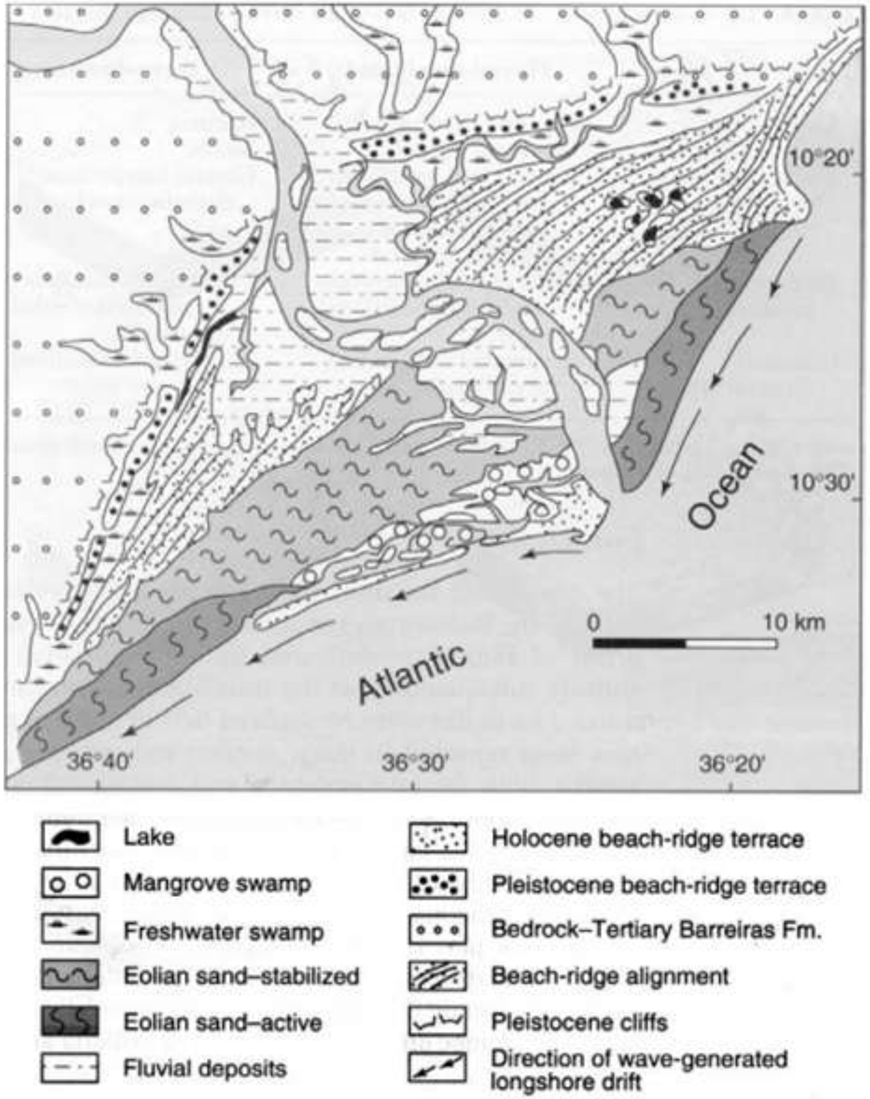
•**Wave Dominated:** are characterized by mouth bars, reworked into shore--parallel sand bodies and beaches

❑Characteristics

- In areas of strong wave activity, river mouth sediments may be reworked and redistributed to form wave-built beaches, barrier bars, spits, beach ridges
- Overall shape is smooth, arcuate to cuspate
- Composition is mainly sand

Delta Classification

Wave-dominated deltas



São Francisco delta, Brazil

Main Processes Influencing Delta Systems

- Climate
- Relief
- Fluvial Discharge (water volume and time variation)
- Sediment load and type
- River mouth processes
- Tidal Processes
- Wave energy

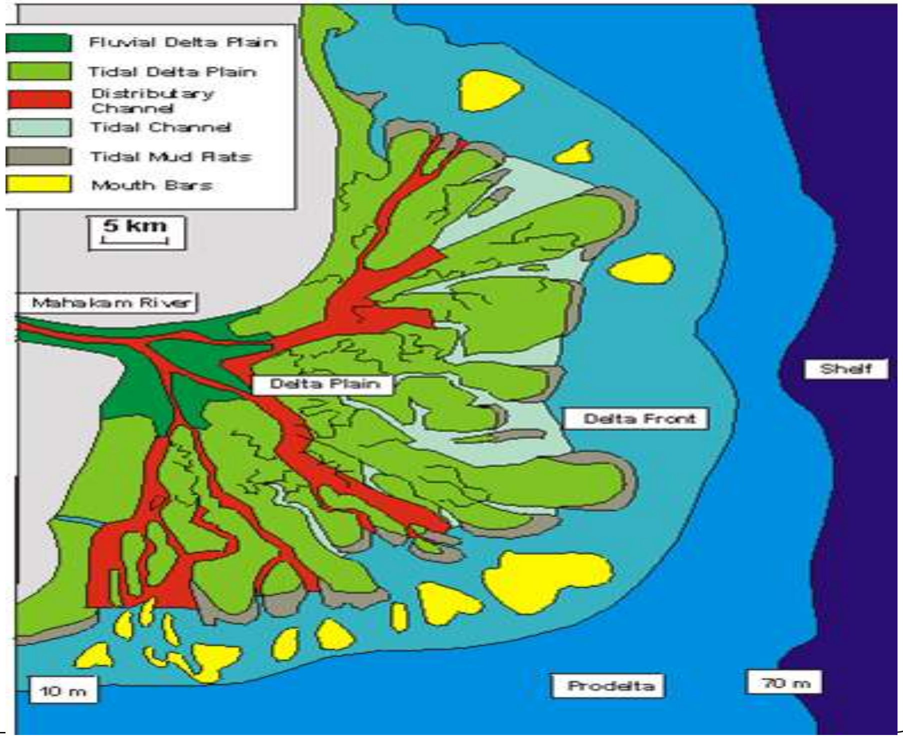
Deltaic Facies

•Subaerial **delta plain**

•Subaqueous **delta front**

•**Prodelta**

•**Delta plain:** They are low-lying areas which are cut by active and abandoned distributary channels. **Delta plains** are commonly characterized by distributaries and interdistributary areas.



Deltaic Facies

• **Upper delta plain** (above high tide): is gradational with floodplains, lacks marine influence and typically has large flood basins, commonly with freshwater peats and lacustrine.

–River channel deposits, lacustrine delta-fill deposits, floodplain deposits

• **Lower delta plain** (between high-and low tide):is marine influenced (e.g., tides, salt-water intrusion) and contains brackish to saline interdistributary bays (e.g.,shallow lagoons, salt marshes, mangroves, tidal flats)

–Interdistributary bay deposits, crevasse splay, natural levee, abandoned distributary deposits

Deltaic Facies

Delta front (from low tide to ~ 10m subsea)

–Distributary mouth bar deposits, pro-delta distal bar deposits

• **Prodelta** (seaward of subaqueous delta)

–Fine-grained marine sediments

Constructional vs. destructional phases

- Constructive phase occurs when input of sediment is sufficient for **progradation**

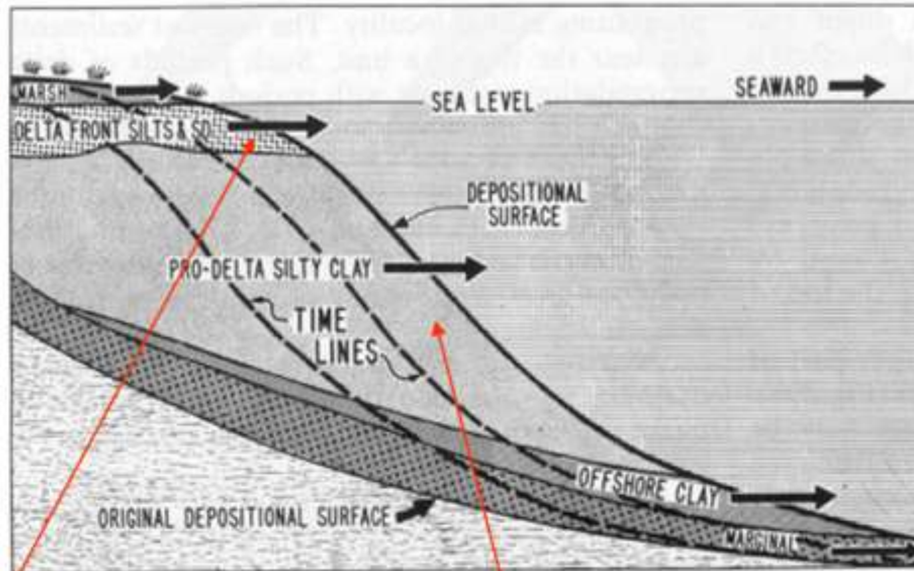
–Prodelta fine sediment is overlain progressively by delta-front silts and sands, distributary mouth sands, and upper delta plain deposits

- Destructive phase occurs when a delta lobe is abandoned or during major **transgression**

–Erosion and redistribution of sediments rather than seaward growth

Deltaic Facies

Delta progradation



Delta plain:
Non-marine fluvial to distributary channel to finer marsh-, lake-, or interdistributary bay

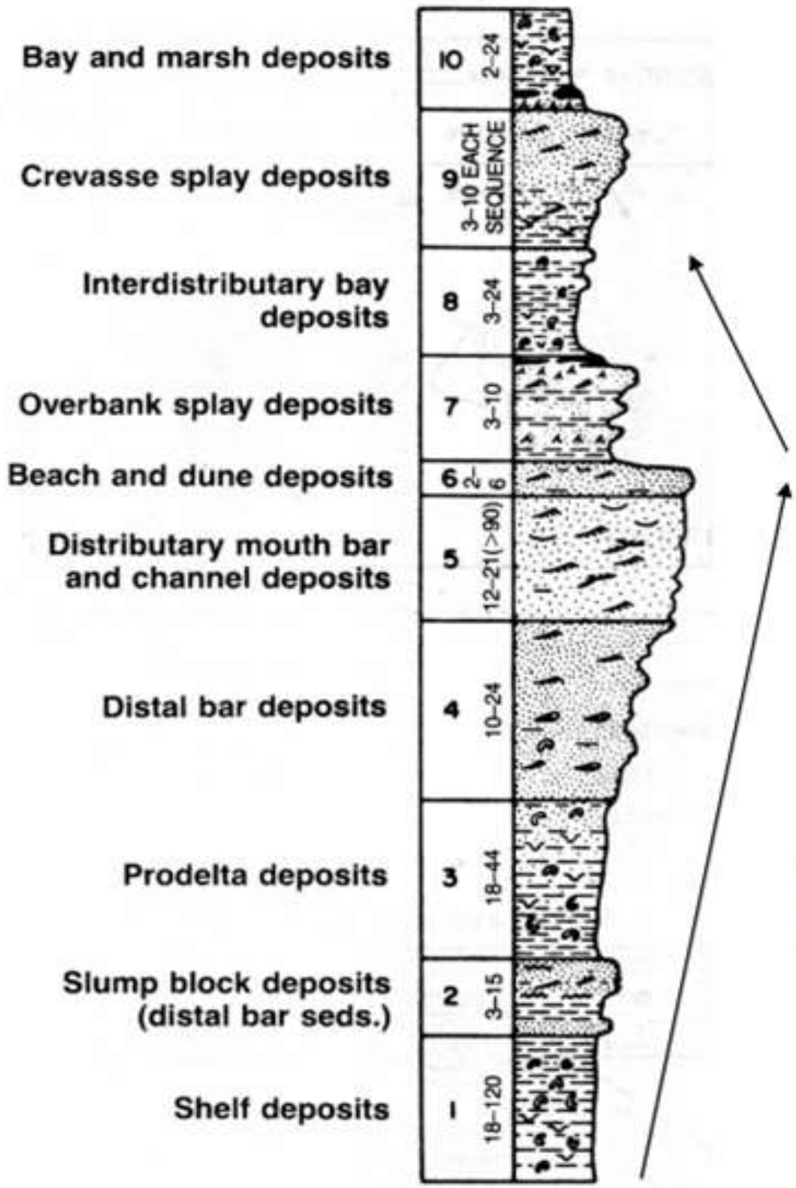
Delta front:
Distributary mouth Bar to distal bar to silts

Prodelta:
Marine silts and muds

Vertical facies associations

- Delta progradation results in an overall coarsening-upward sequence(usually 50-150m thick) overlain by finer delta plain deposits (2-15m thick)
- Progradational cycles may be stacked, depending on history of lobe abandonment

Vertical facies associations



Finer-grained
delta plain deposits

Coarsening-upward
sequence

Estuary environmental setting

- Influence by river, tides, and waves
- Salinitymay vary withinan estuary at any
given time, or seasonally
- Proximal partsof estuaries are riverdominated
- Distal partsof estuaries may be:

–Wave-dominated

–Tide-dominated

Wave-dominated estuary

- High wave energy at mouth of estuary
  - Estuary mouth sand bar
  - Quiet water in central part of estuary (muds)
- Water is partially mixed to well-stratified
  - Fresh vs. marine density stratification
- High river energy at head of estuary
  - Bay-head delta sediments

Tide-dominated estuary

• High tidal energy at mouth of estuary, all the way to tidal-fluvial transition

–Estuary mouth tidal sand bars

–Generally higher overall energy than wave-dominated estuaries

• Water is well mixed

–no density stratification

• Ripple and dune bedforms common

–Foresets may dip in both directions

Estuarine sedimentary facies

• Cross-bedded, bioturbated sands form near estuary mouth and in fluvial-tidal channels

• Laminated, bioturbated mudsform in nonchannel middle and upper parts of estuary

• Fauna is typically low diversity, but possibly high abundance

–typically dominated by mollusks

Vertical succession of estuarine facies

- Depends on whether tide-or wave dominated
- Transgressive sequence will produce landward migration of environments

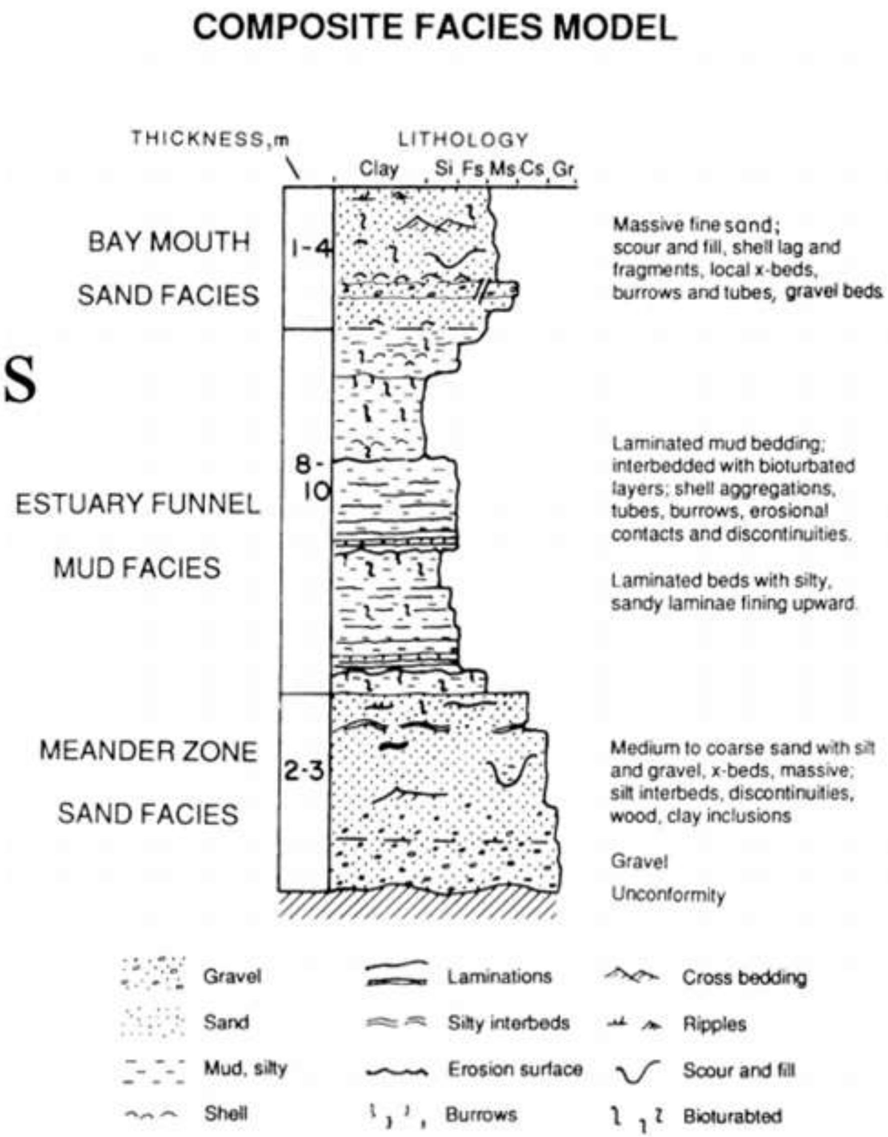
–Estuarine facies above fluvial facies

- Regressive sequence will produce seaward migration of facies

–Fluvial facies above estuarine facies

Transgressive estuarine facies

Transgressive estuarine facies



Tidal flats

Tidal flats, are coastal wetlands (areas that are flooded at high tide and exposed at low tides) that form when mud is deposited by tides or rivers. They are found in sheltered areas such as bays, bayous, lagoons, and estuaries.

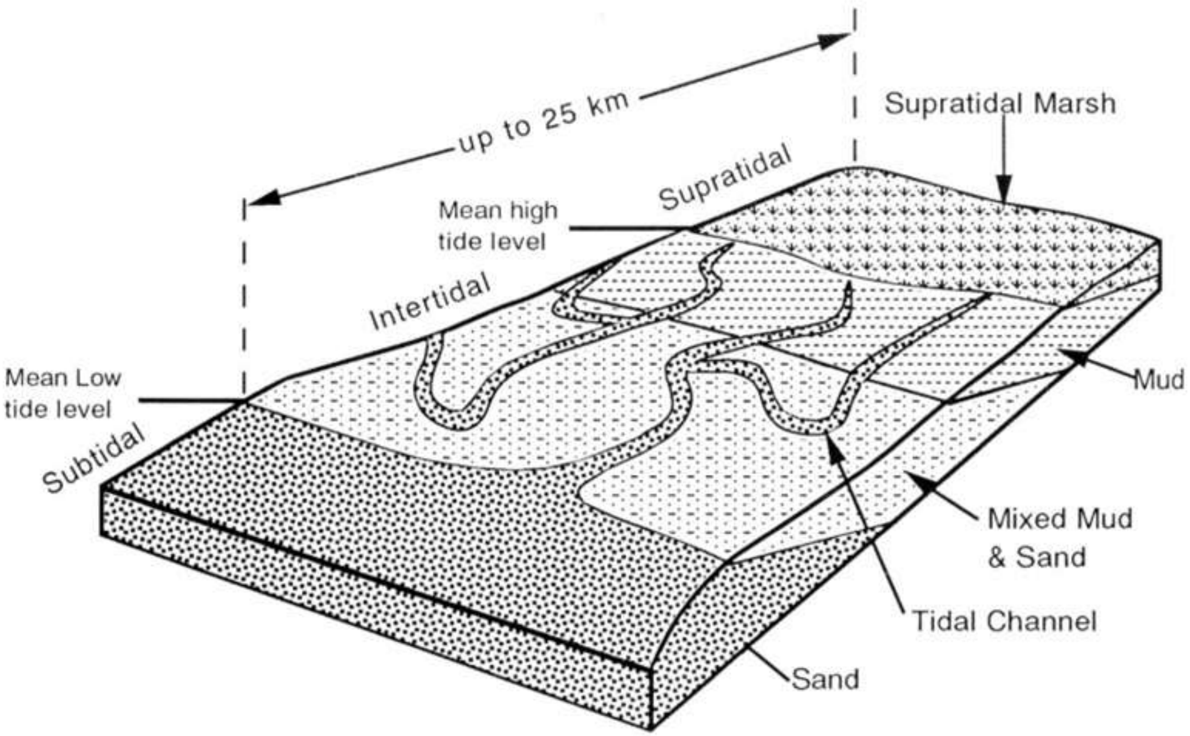
Environmental setting

–Mesotidal to macrotidal (4 to 15 m tidal range), low-relief coastlines where wave energy is minimal

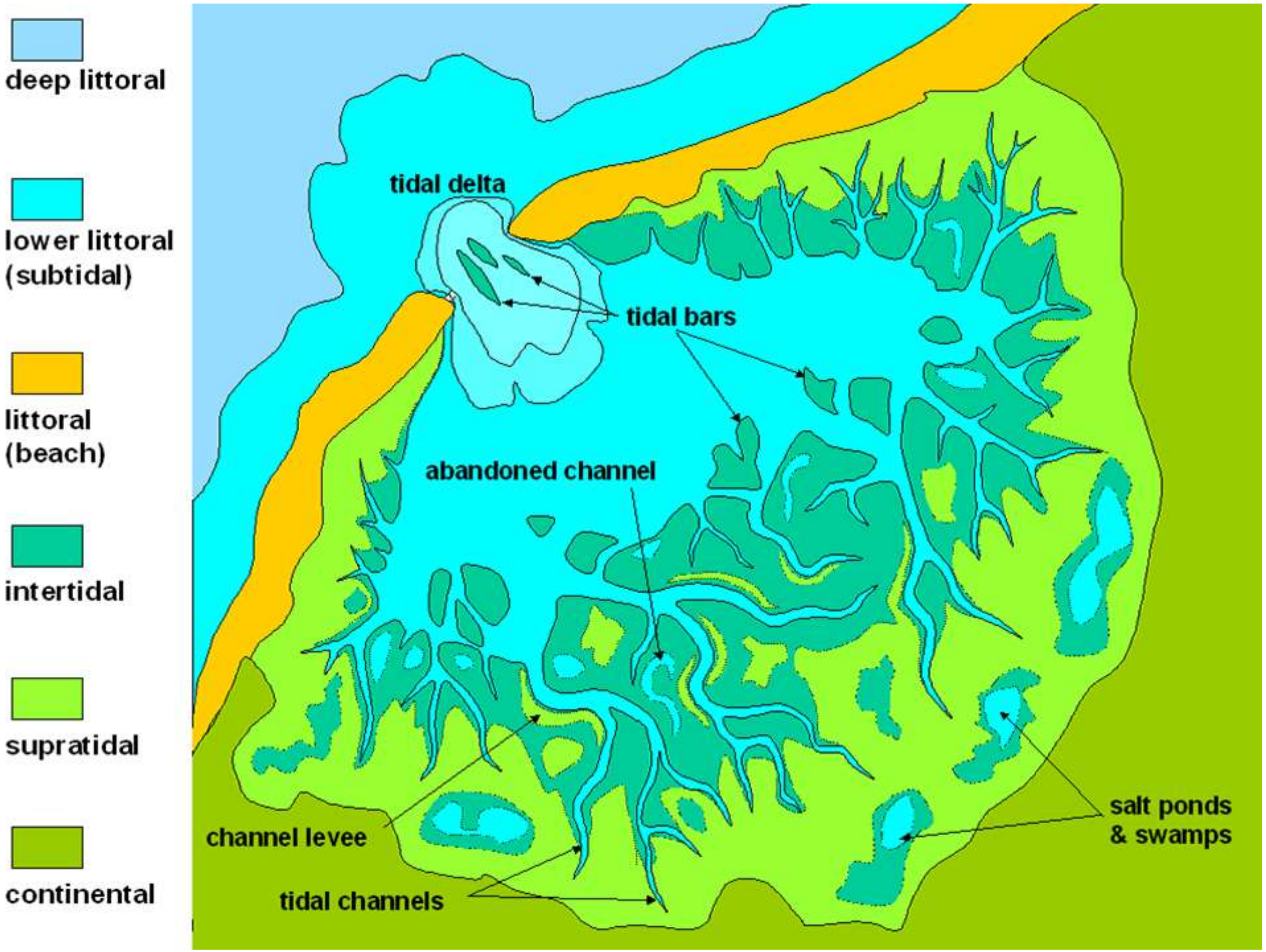
–Also, behind barriers (barrier islands, spits, reefs)

–Characterized by twice-daily flood and retreat of marine water

Tidal flat facies



Tidal flat facies



Tidal flat facies

- **Subtidal zone**

– High tidal current velocities

– Characterized by bedload transport and sand deposition

- **Intertidal zone**

– Between mean high and low tide; no significant vegetation

– Dissected by tidal channels

– Both suspended and bedload deposition (mixed mud and sand)

- **Supratidal zone**

– Heavily vegetated and incised by tidal channels

– Sedimentation from suspension during storm tides

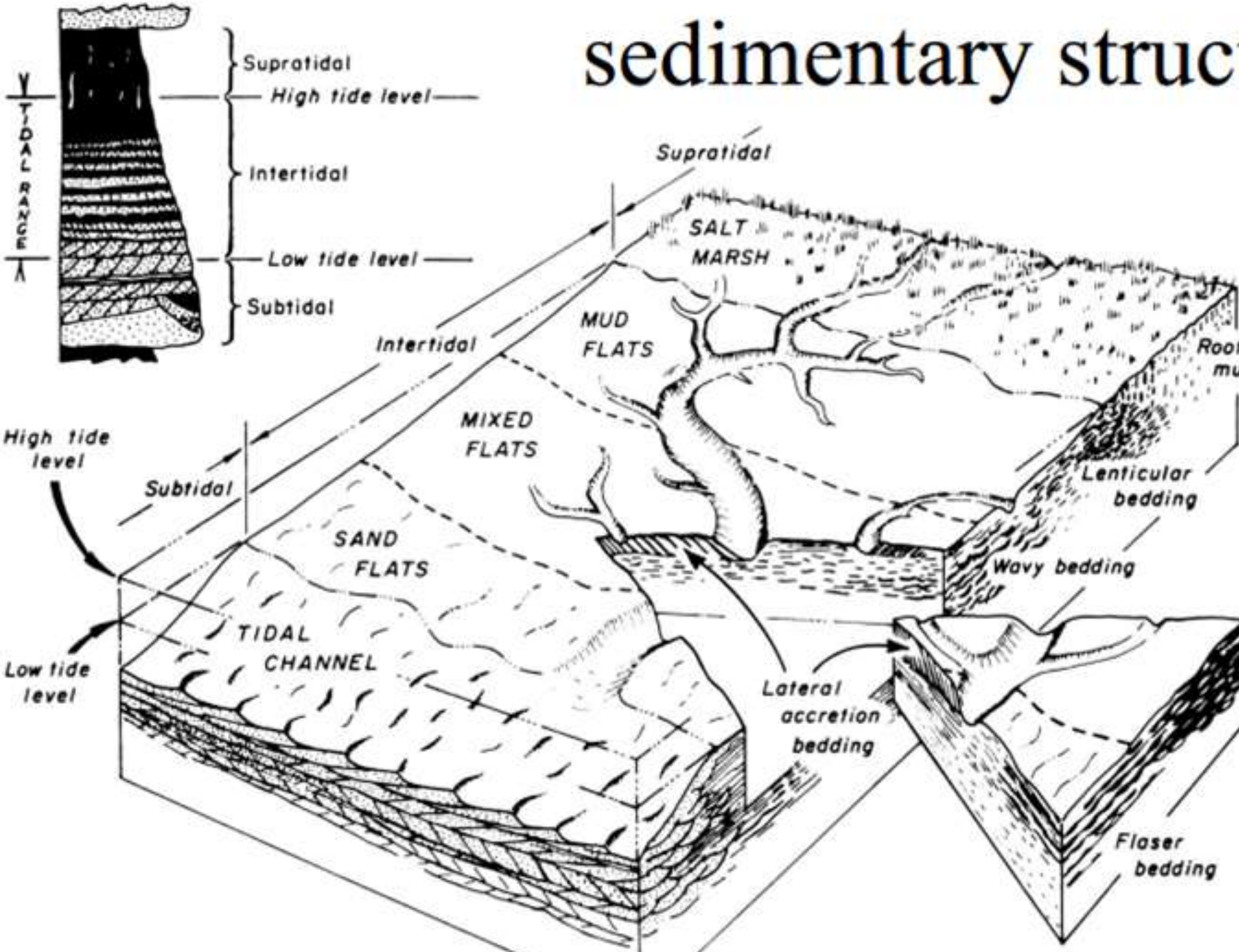
Tidal flat sediments

- Sediments are mostly sand and muds
- **Supratidal zone** characterized by muds with evidence of plant roots
- **Intertidal zone** characterized by mixed mud and sand, with sand in channels
- **Subtidal zone** characterized by sand, with channels and bars

Tidal flat sedimentary structures

- Channels may have dunes and cross-bedding with bimodal paleocurrent directions
- Mixed sandy and muddy sedimentsmay exhibit small-scale ripple cross-stratification, flaser bedding, wavy bedding, lenticular bedding, or finely laminated bedding, bioturbation (Skolithos)
- Supratidal depositsmay be thinly laminated, but with plant bioturbation and evidence of subaerial exposure

Tidal flat sedimentary structures



Vertical facies associations

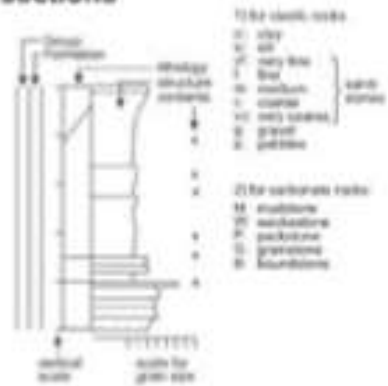
- Tidal flat progradation ***<u>(regression)</u>***will produce a fining-upward depositional sequence

–Subtidal sands overlain by mixed intertidal sediments, overlain by supratidal muds

- Transgression may produce a coarsening upward sequence, or it may destroy intertidal and supratidal deposits through reworking

LEGEND

Legend for stratigraphic type sections



Siliciclastic rocks

- Conglomerate
- Sandstone
- Siltstone
- Claystone/Shale

Carbonate rocks

- Limestone
- Dolomite
- Dolomitic limestone/ Calcareous dolomite
- Marl/argillaceous carbonate

Other layered lithologies

- Coal
- Spiculite
- Evaporite
- Metamorphic rock

Secondary lithological content

- Glauconite
- Phosporite
- Pyrite
- Anhydritic/gypsiferous
- Halitic
- Sideritic
- Calcareous/calcite cement
- Dolomitic/dolomite cement
- Cherty
- Argillaceous/shaley
- Silty
- Sandy
- Nodule
- Carbonaceous
- Coaly, coal lenses or fragments
- Mudclasts
- Caliche nodule

Structure

- Trough cross-bedding
- Tabular/planar cross-bedding
- Herringbone cross-bedding
- Laminated
- Algal laminated
- Cross-bedding, ripple lamination
- Ripple lamination
- Climbing ripple lamination
- Wave ripples
- Lenticular bedding
- Flaser bedding
- Wavy bedding
- Soft sediment deformation
- Enterolithically folded gypsum
- Karst
- Stylolite

Invertebrate fossils

- *Palaeoaplysina*
- Coral
- Colonial coral
- Bivalve
- Gastropod
- Brachiopod
- Bryozoan
- Ostracod
- Trilobite
- Small foraminifer
- Fusulinid
- SP Sponge spicule
- Crinoid
- Ammonoid
- Coquina

Plant fossils

- Root
- Plant fragment
- Wood fragment
- Algae (unspecified)
- Phylloid algae
- *Tubiphytes*

Trace fossils

- Increasing bioturbation

Beach and Barrier Island System

•**Mainland beaches:** long, narrow accumulations of sand aligned parallel to the shoreline and attached to land.

•Beach and barrier island occur in three types:

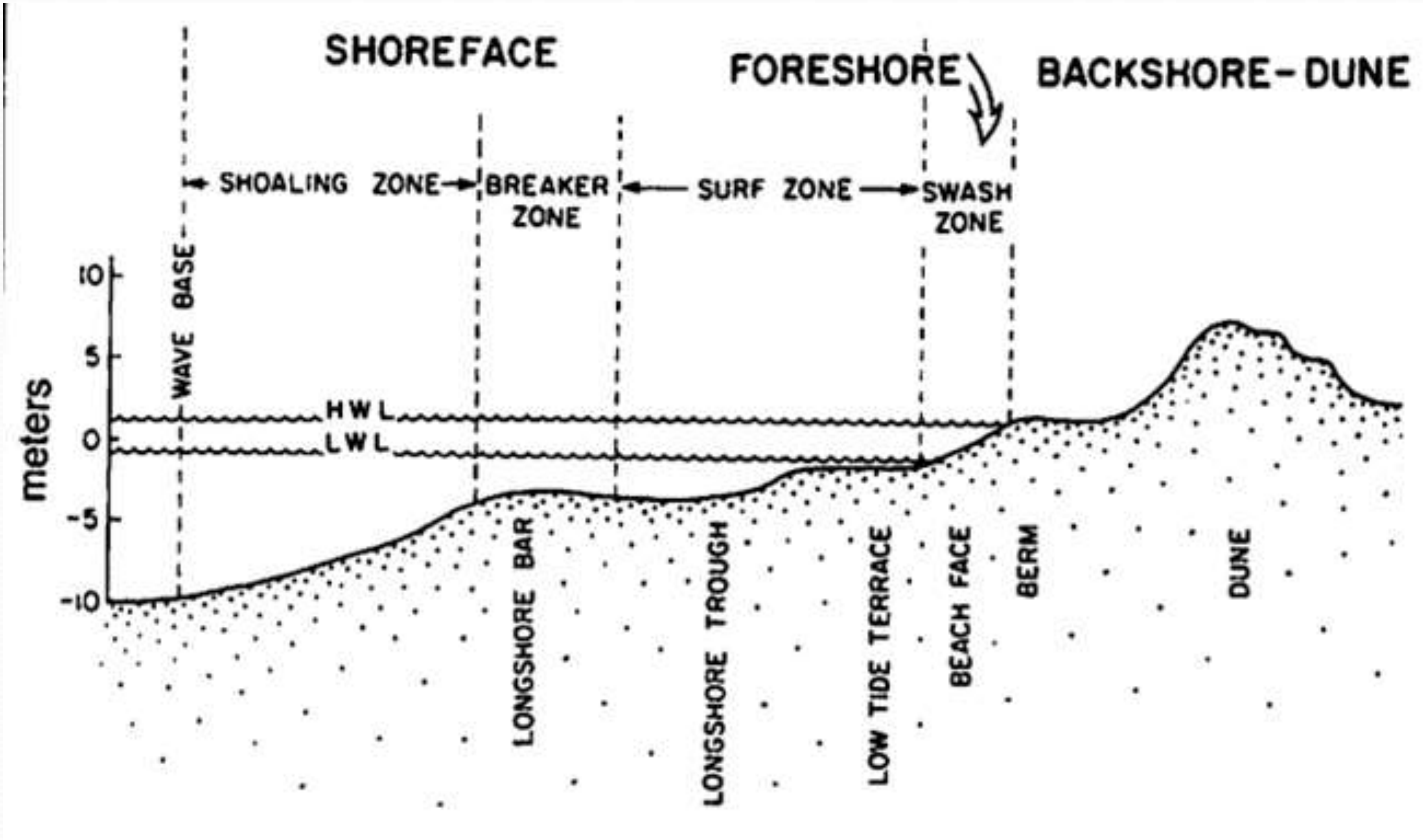
1. A single beach attached to the mainland
2. A barrier island separated wholly or partly from the mainland by a lagoon or marsh.
3. A broader beach-ridge system consists of multiple parallel beach ridges and parallel swales, but which generally lacks well developed lagoons or marshes;

Dorset coast, UK

Beach and Barrier Island System

- The beach is divided into the ***backshore,*** which extends landward from the beach berm above high tide level and commonly includes back-beach dune deposits; the ***foreshore***, which mainly encompasses the intertidal (littoral) zone between low-tide and high-tide levels; and the ***shoreface,*** also called the near-shore,

Beach and Barrier Island System



Beach and Barrier Island System

- **Wave Processes**
- As waves progress shoreward into the shallow shoaling zone, forward velocity of the waves slows, wave length decreases, and wave height increases. The waves eventually steepen to the point where orbital velocity exceeds wave velocity and the wave breaks, creating the **breaker zone.**
- Breaking waves generate turbulence that throws sediment into suspension and also brings about a transformation of wave motion to create the **surf zone.** In this zone, a high-velocity translation wave causing landward transport of bedload sediment and generation of a short-duration “suspension cloud” of sediment.

Beach and Barrier Island System

•At the shoreline, the surf zone gives way to the **swash zone**, in which a rapid, very shallow swash flow moves up the beach, carrying sediment in partial suspension

•Swash Zone followed almost immediately by a **backwash** flow down the beach. The backwash begins at very low velocity but accelerates quickly. (If heavy minerals are present in the suspended sediment, they settle rapidly to generate a thin heavy-mineral lamina).

Beach and Barrier Island System

•Wave processes (summary)

 Normal waves of moderate to low energy tend to produce a net landward and alongshore transport of sediments thus building up beaches.

Storm waves cause erosion of the beach and a net displacement of sediments in a
seaward direction.

Sediments tend to be well sorted, positively skewed deposits (better sorted coarser
half than finer half).

Heavy minerals tend to accumulated on swash zone due to the slow backwash flow

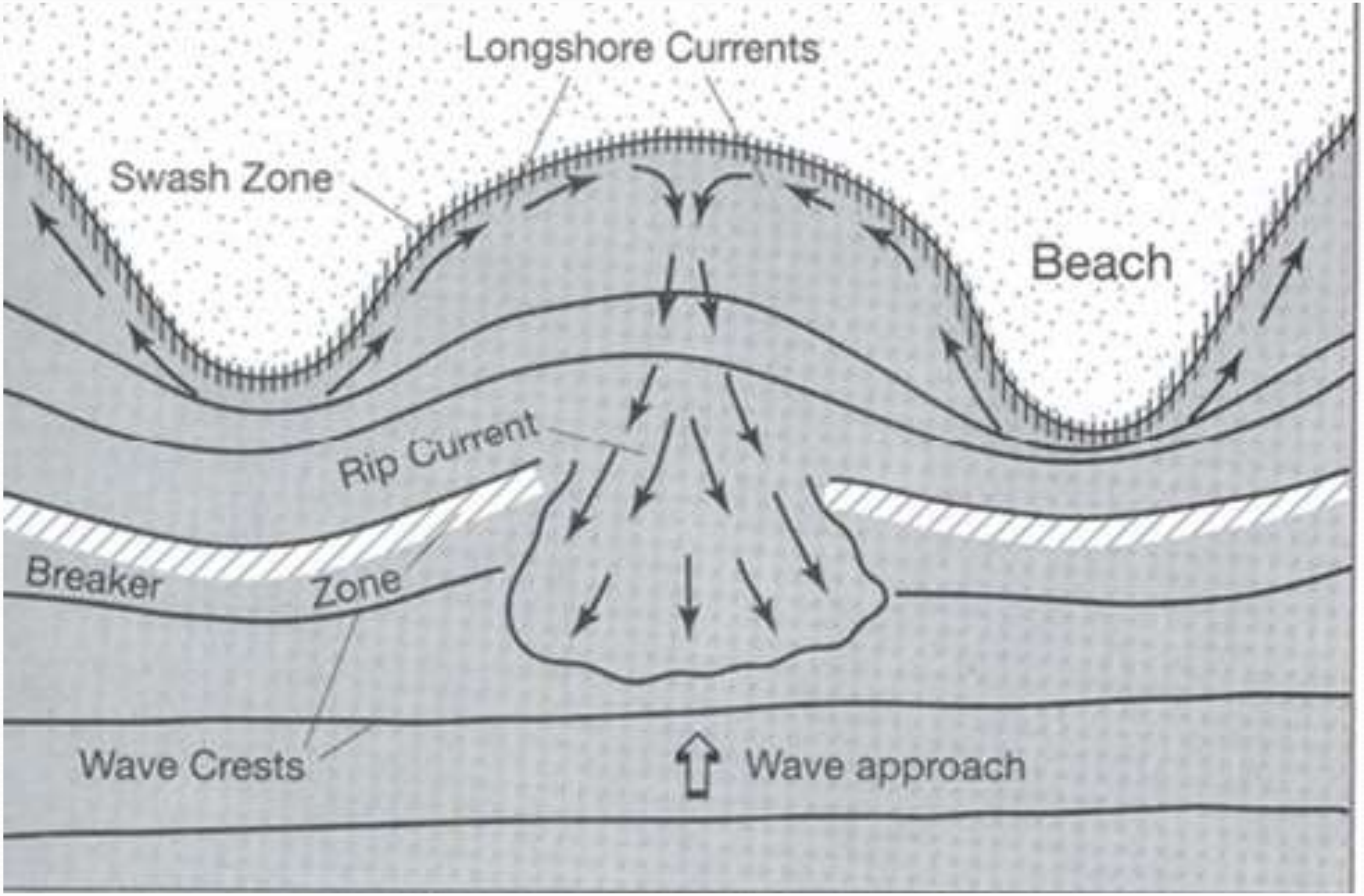
Beach and Barrier Island System

Wave-induced currents

As breakers and winds pile water against the beach, they create not only wave but also two types of unidirectional currents:

- **Longshore currents:** These currents move parallel to shore following longshore troughs, which are shallow troughs in the lower part of the surf zone.
- **Rip currents:** Where two opposite-directed longshore current meet and there is a topographic low between sand bars, the current moves seaward as a narrow, near-surface currents. These currents may entrain considerable sediments in suspension and carried out to sea by surface flow.

Beach and Barrier Island System



Beach and Barrier Island System

- **Depositional setting**

Beach deposits: Backshore

A zone dominated by intermittent storm-wave deposition and aeolian sand transport and deposition.

Faint, landward-dipping, nearly horizontal laminae, interrupted locally by burrows. These beds may be overlain by small- to medium-scale aeolian trough cross-bed sets, which are commonly disturbed by root growths and burrows of land-dwelling organisms.

Beach and Barrier Island System

Beach deposits: Foreshore

- Predominantly of fine to medium sand but may also include scattered pebbles and gravel lenses or layers.
- Sedimentary structures are mainly parallel laminae, which dip gently (2-3 degree) seaward.
- Thin, heavy mineral laminae are commonly present, alternating with layers of quartzose sand.
- Antidues maybe formed.
- High-angle cross bed dips landward caused by migration of foreshore ridges

Beach and Barrier Island System

Shoreface deposits

 Shoreface can be divided into upper, middle, and lower shorefaces, which correspond roughly to the surf, breaker, and outer shoaling zones.

Upper shoreface (surf-zone)deposits: Form in an environment dominated by strong bidirectional translation waves and longshore currents. Multidiretional trough cross beds are common with trace fossils such as Skolithos

Beach and Barrier Island System

Middle shoreface (breaker zone):

•Form in high-energy conditions owing to breaking waves and associated longshore and rip currents. Sediments are mainly fine- to medium grained sand, with minor amounts of silt and shell material, that may display both landward- and seaward-dipping trough cross-beds as well as subhorizontal plane laminations. Trace fossils consisting of vertical burrows (such as Skolithos and Ophiomorpha) are common.

Beach and Barrier Island System

Lower shoreface (outer shoaling zone):

Form under relatively low-energy conditions and grade seaward into open-shelf deposits. They are composed dominantly of fine to very fine sand but may contain thin, intercalated layers of silt and mud. Sedimentary structures can include small-scale cross-stratification; planar, nearly horizontal laminated bedding; and hummocky cross-stratification. Trace fossils such as Thalassinoides may be common

Beach and Barrier Island System

• **Facies**