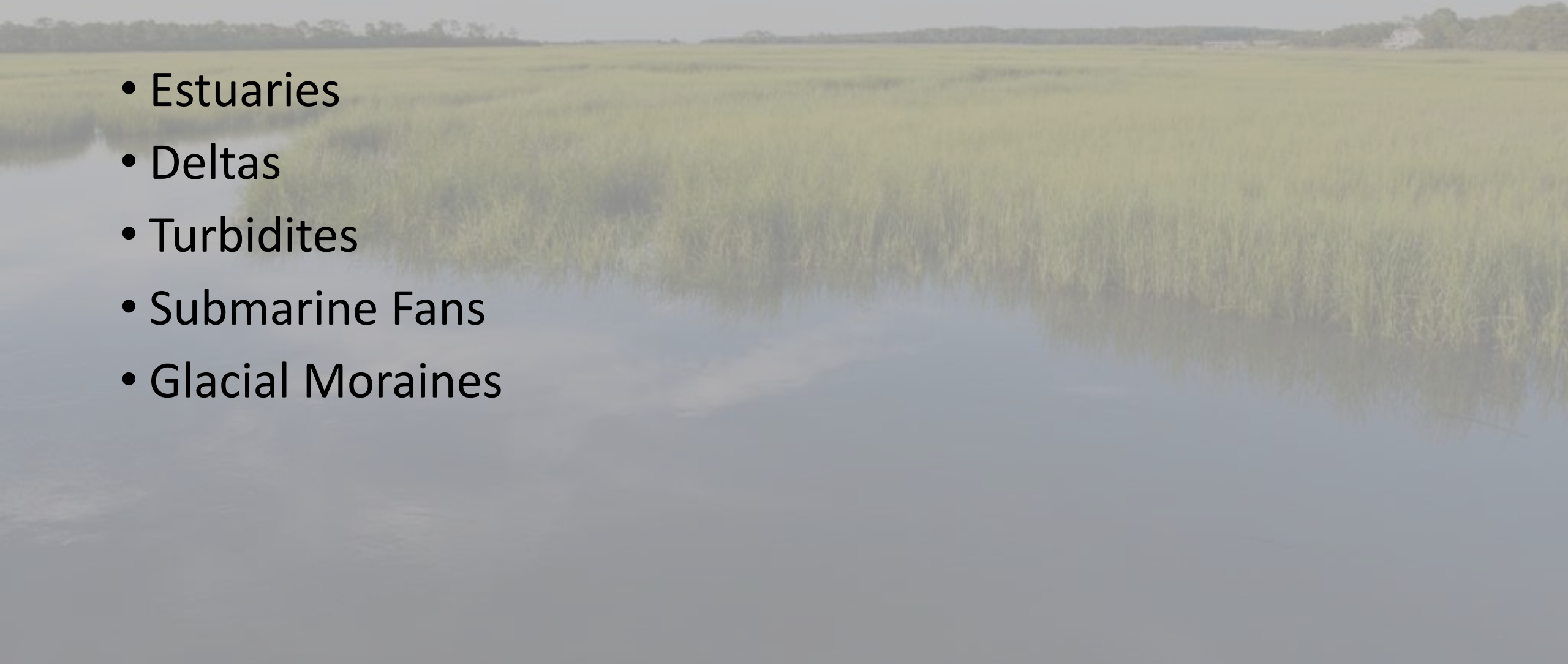
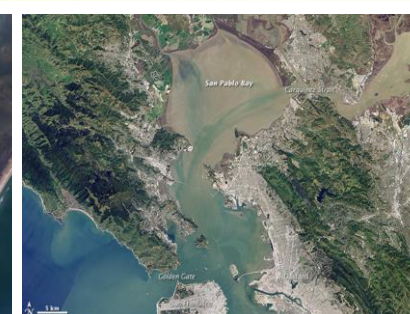
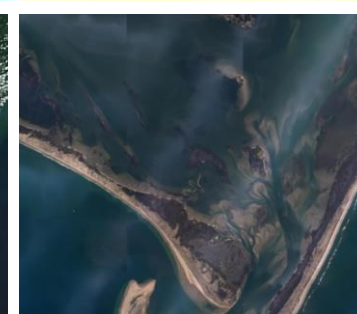
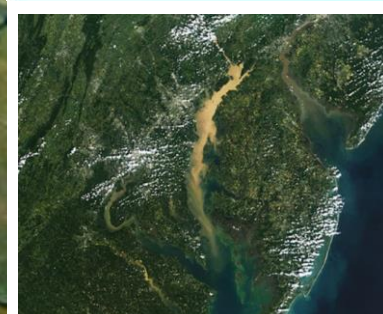


Coastal and Shelf Geomorphology

Topics for this week

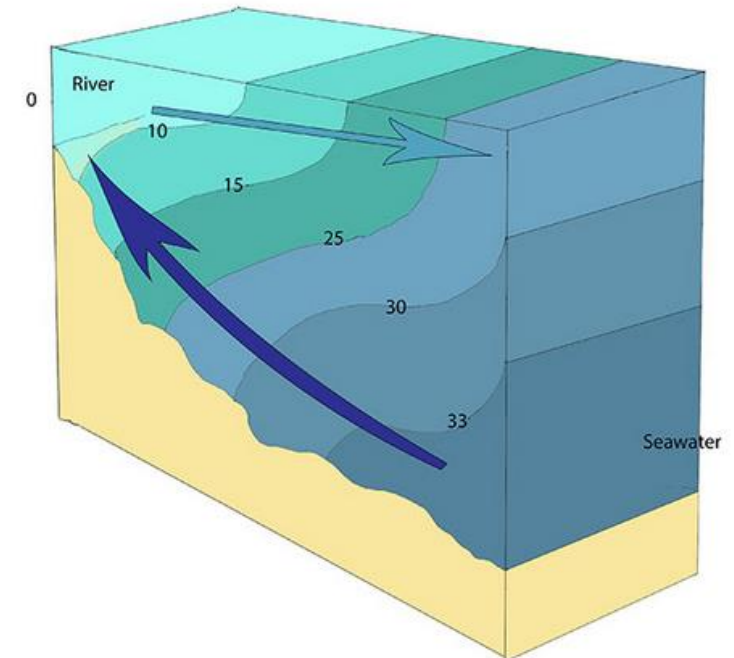
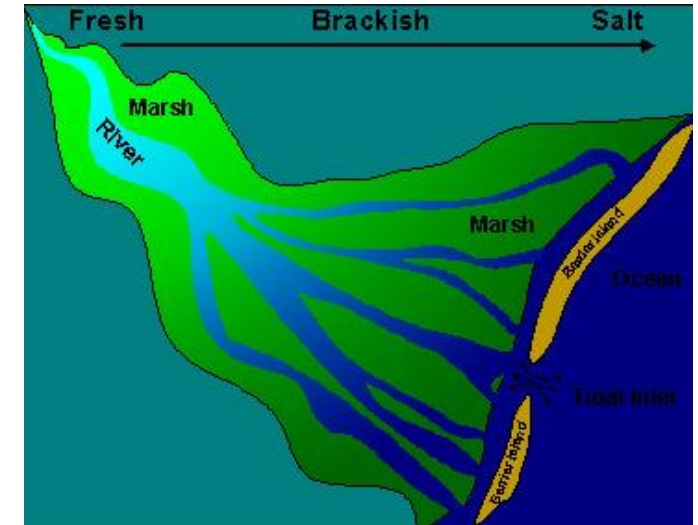
- Estuaries
- Deltas
- Turbidites
- Submarine Fans
- Glacial Moraines





Definitions and Taxonomy First

- Estuary – “a partially enclosed coastal body of brackish water with riverine (or stream) inflow and a free connection to the ocean”
- Estuaries are transition zones and reflect one form or shape (geomorphology) of the constant dynamic balancing between:
 - Tides, waves and salt water
 - Runoff/freshets, river flow and riverine sediment transport

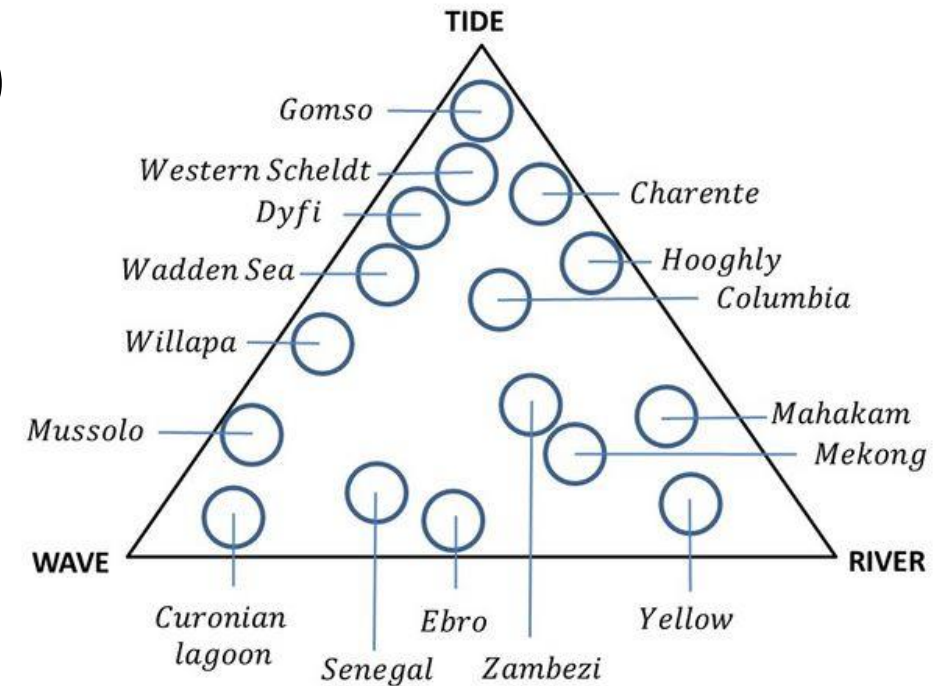


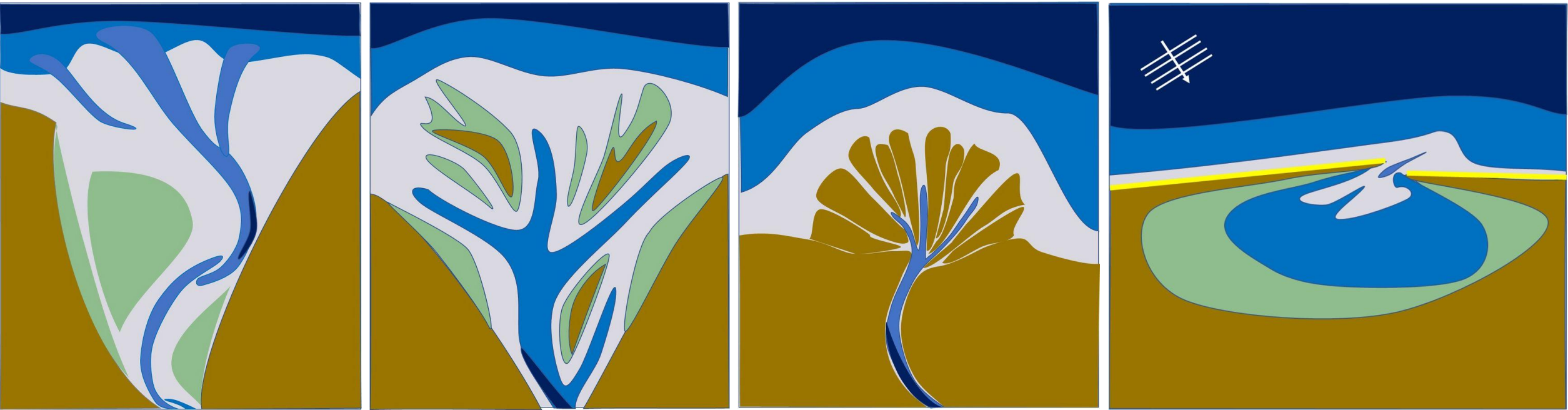
Everything in estuaries is in flux!

- Biological
 - Habitat for juvenile marine species and feeding areas for terrestrial species
 - Common floral (grass) zonation as a function of salt tolerance
- Chemical
 - Salt water is constantly mixing with freshwater
 - The limit of tidal incursion is different within each estuary and even within individual estuaries varies on multiple time scales
 - The interface of salt water and freshwater varies as a function of the magnitudes of opposing forces (and can change over the span of a year)
- Physical
 - Underlying geology can strongly influence estuary shape; the shape of an estuary (and its orientation) can strongly influence the magnitude and timing of tidal incursion
 - Flow in estuaries can be dynamic and unpredictable (or not!)

Estuary Taxonomy

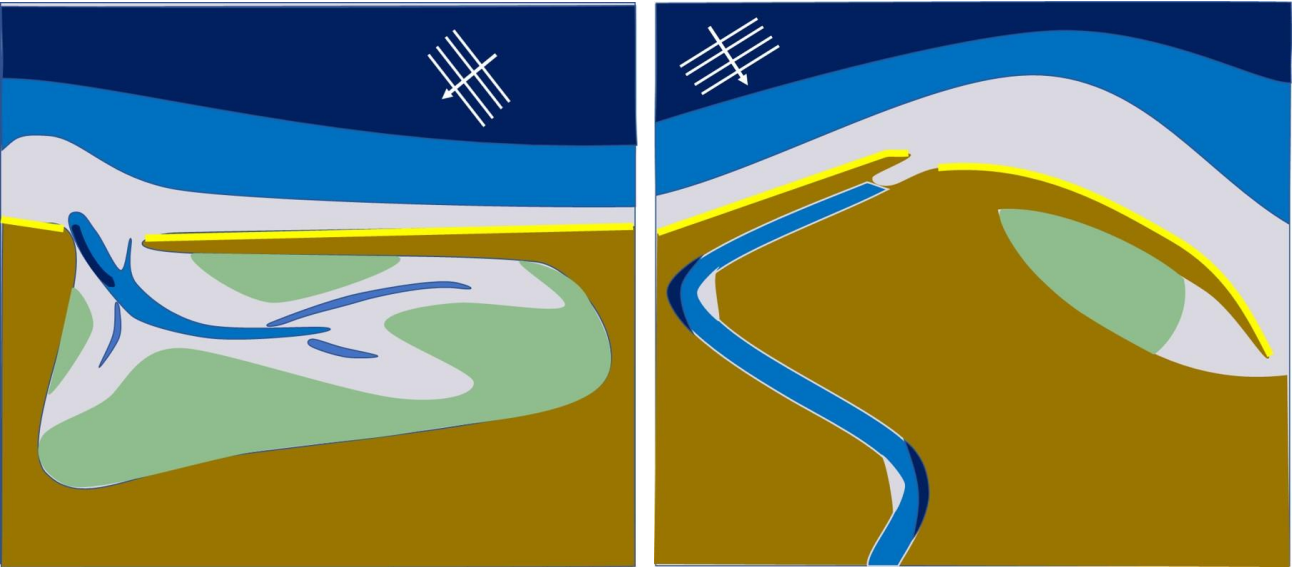
- In terms of **geology**:
 - Drowned River Valleys (ex: Chesapeake Bay, MD)
 - Bar-Built (ex: Cape Lookout; Outer Banks, NC)
 - Tectonic (ex: San Francisco Bay, CA)
 - Fjord (ex: Glacier Bay, AK)
- In terms of **tidal hydrodynamics**:
 - Macro-tidal (max tidal range > 4 m)
 - Meso-tidal (max tidal range < 4 m and > 2m)
 - Micro-tidal (max tidal range < 2 m)
- In terms of **geomorphology/morphodynamics**
 - What is the overall force balancing of tides, waves and river inflow?



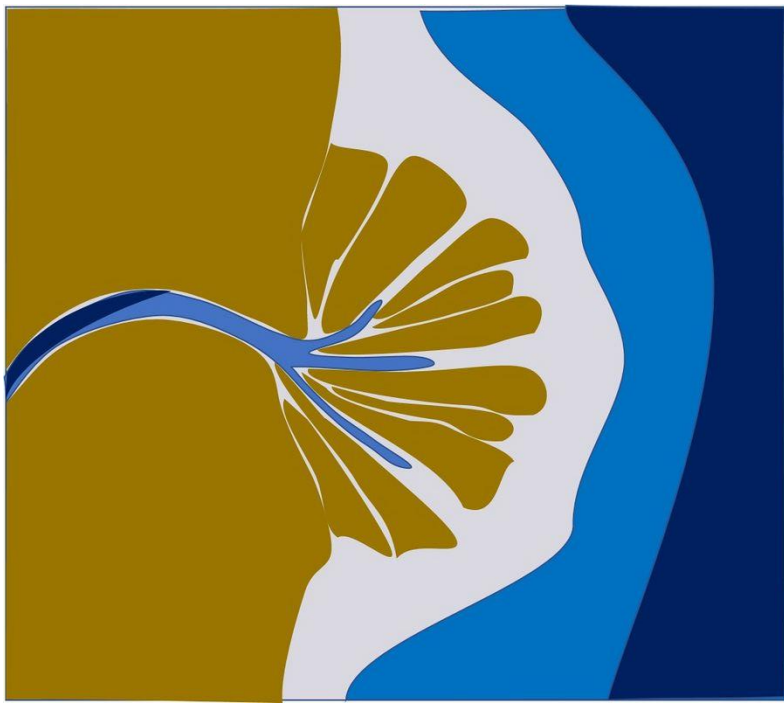


Types of Estuaries

1. Tide Dominated
2. Tide and River Dominated
3. River Dominated
4. Wave Dominated
5. Wave and Tide Dominated
6. River and Wave Dominated

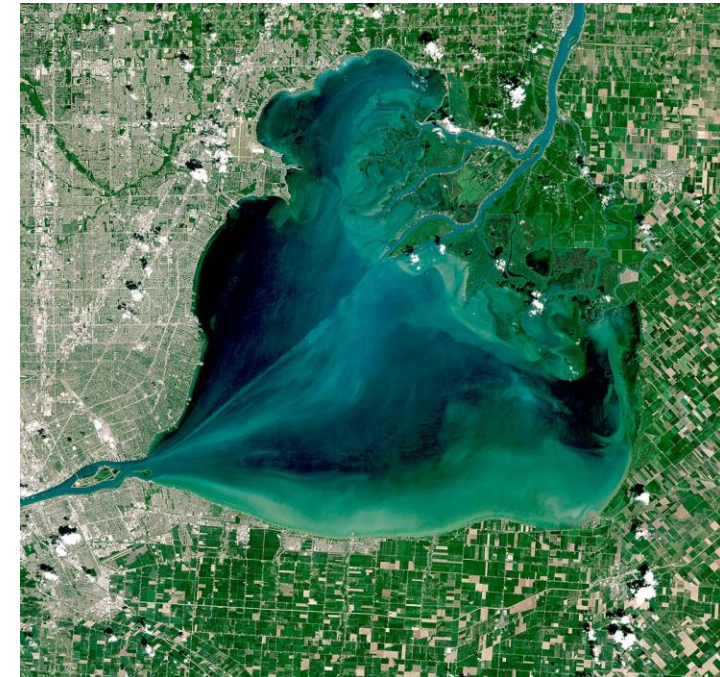


| | |
|--|--------------------------------------|
| | Deep water |
| | Medium water |
| | Shallow water, submarine delta, bars |
| | Intertidal, marsh, mangrove |
| | Supratidal |
| | Beach |



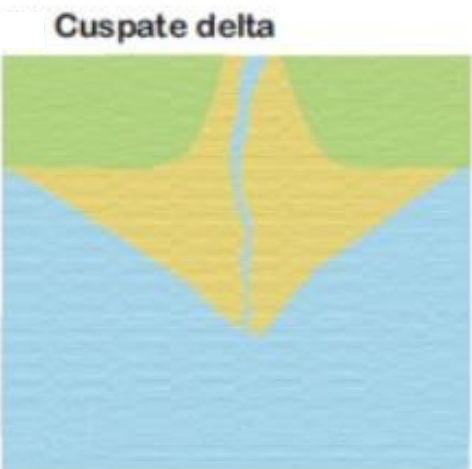
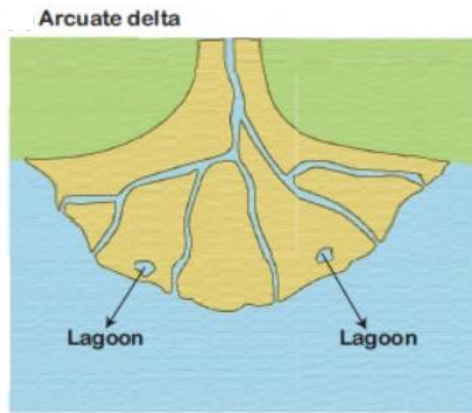
So, what's the difference between a river-dominated estuary and a delta?

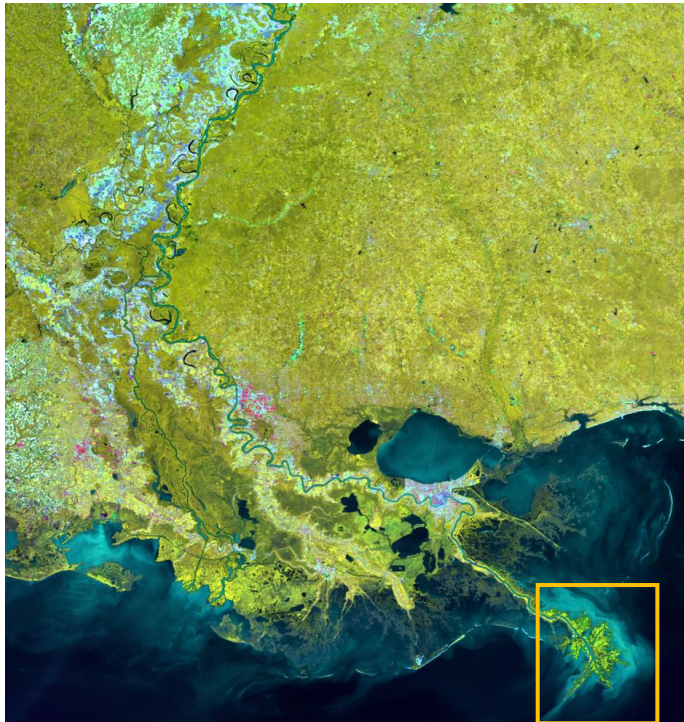
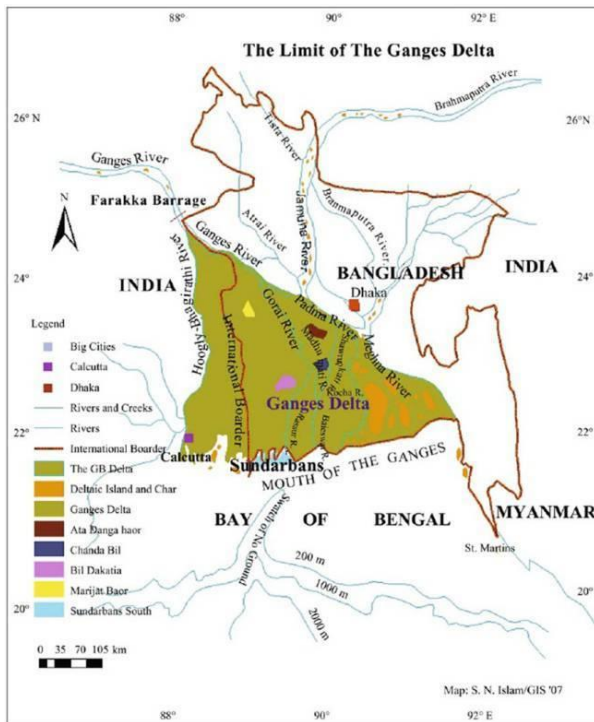
Delta: a landform (often shaped like a triangle) that is created by the suspended sediment that had been carried by a river and is deposited when the river enters a slower-moving body of water



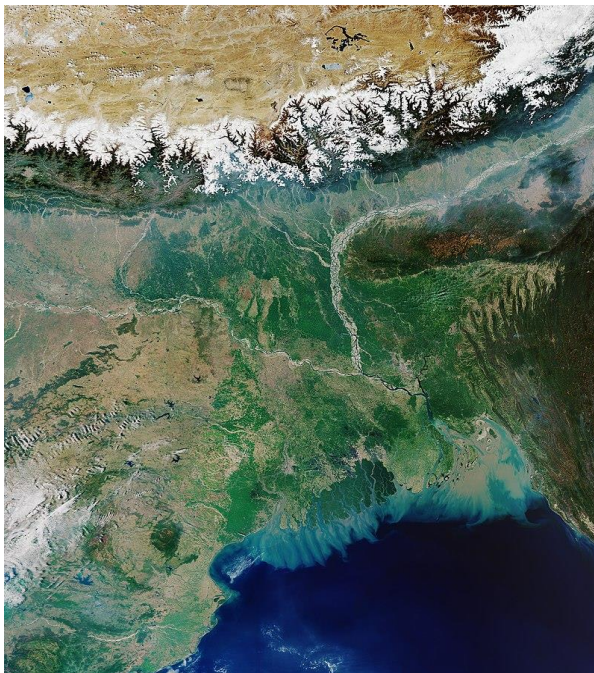
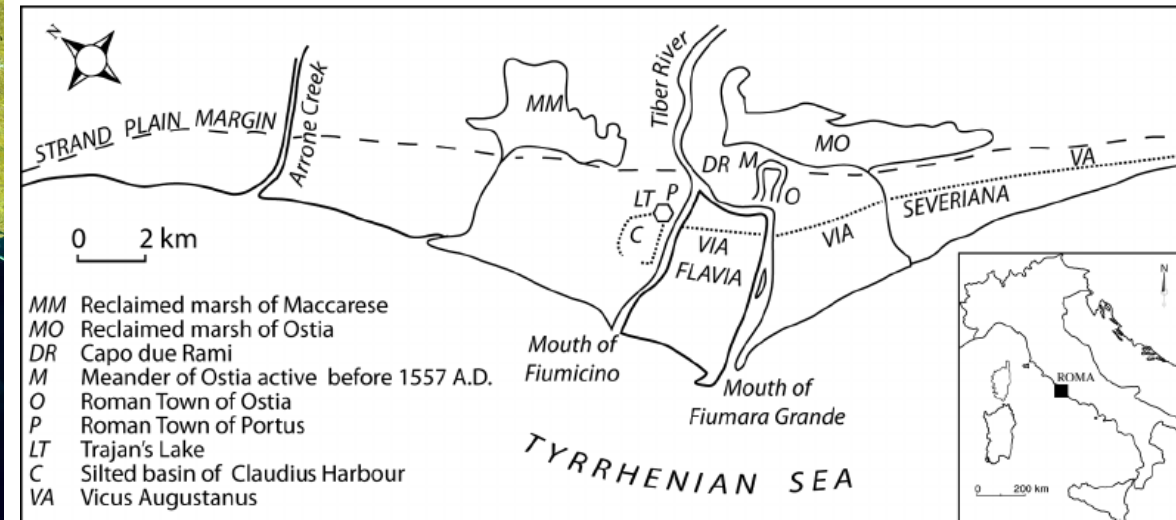
Delta Taxonomy

- Arcuate - fan-shaped; bowed or curved with the convex margin facing the body of water. Relatively coarse sediment with little lateral movement after deposition.
- Birds Foot - shape is the result of strong river flow and weak wave action.
- Cusate - sediments are deposited onto a straight shoreline with strong waves. Waves push/spread the sediments outward



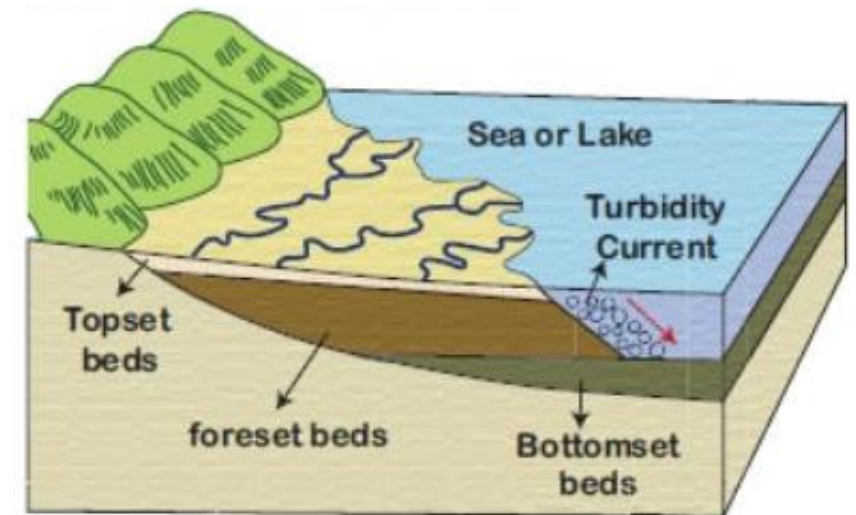
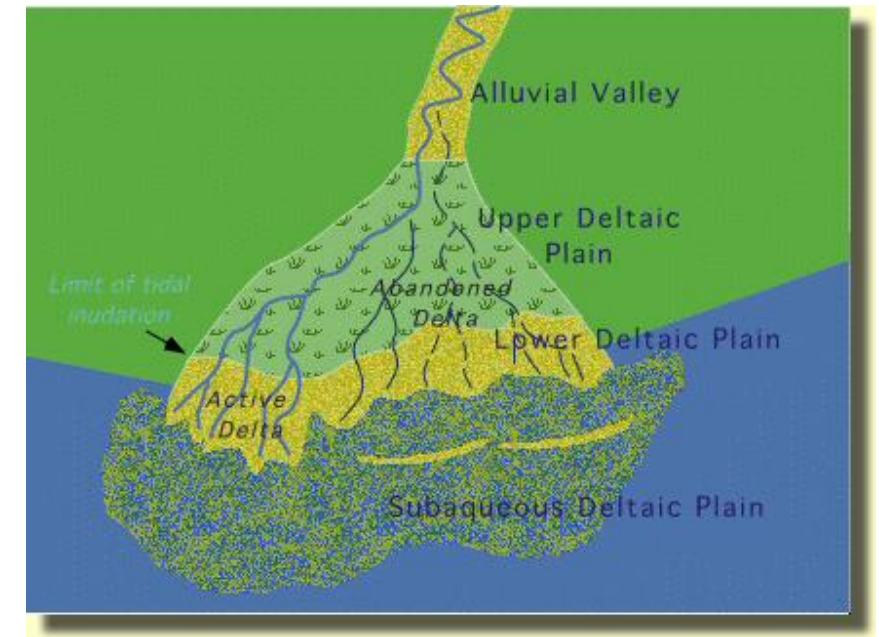


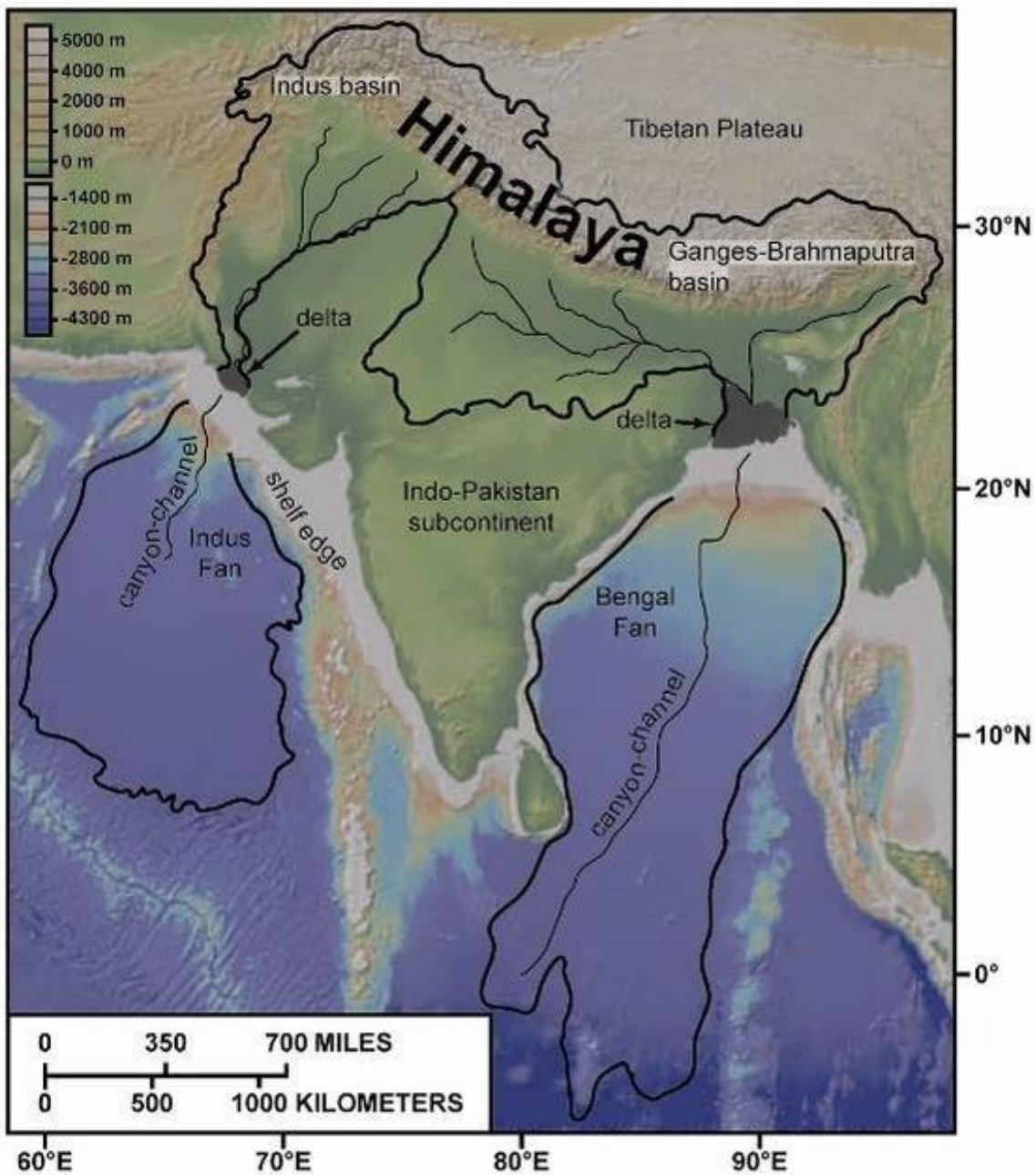
Name your delta type!



Delta Geomorphology

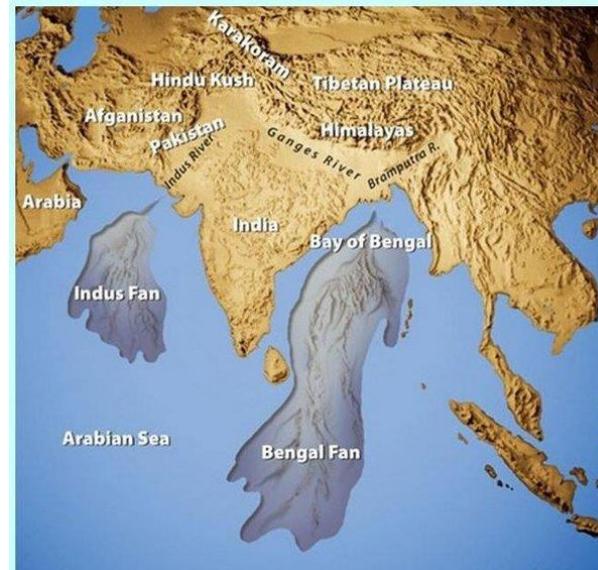
- Sub-aerially exposed portion
 - Upper Delta
 - Lower Delta
- Subaqueous portion
 - Delta slope
 - Pro-Delta
- Cross-Sectional Structures
 - Topset beds
 - Foreset beds
 - Bottomset beds



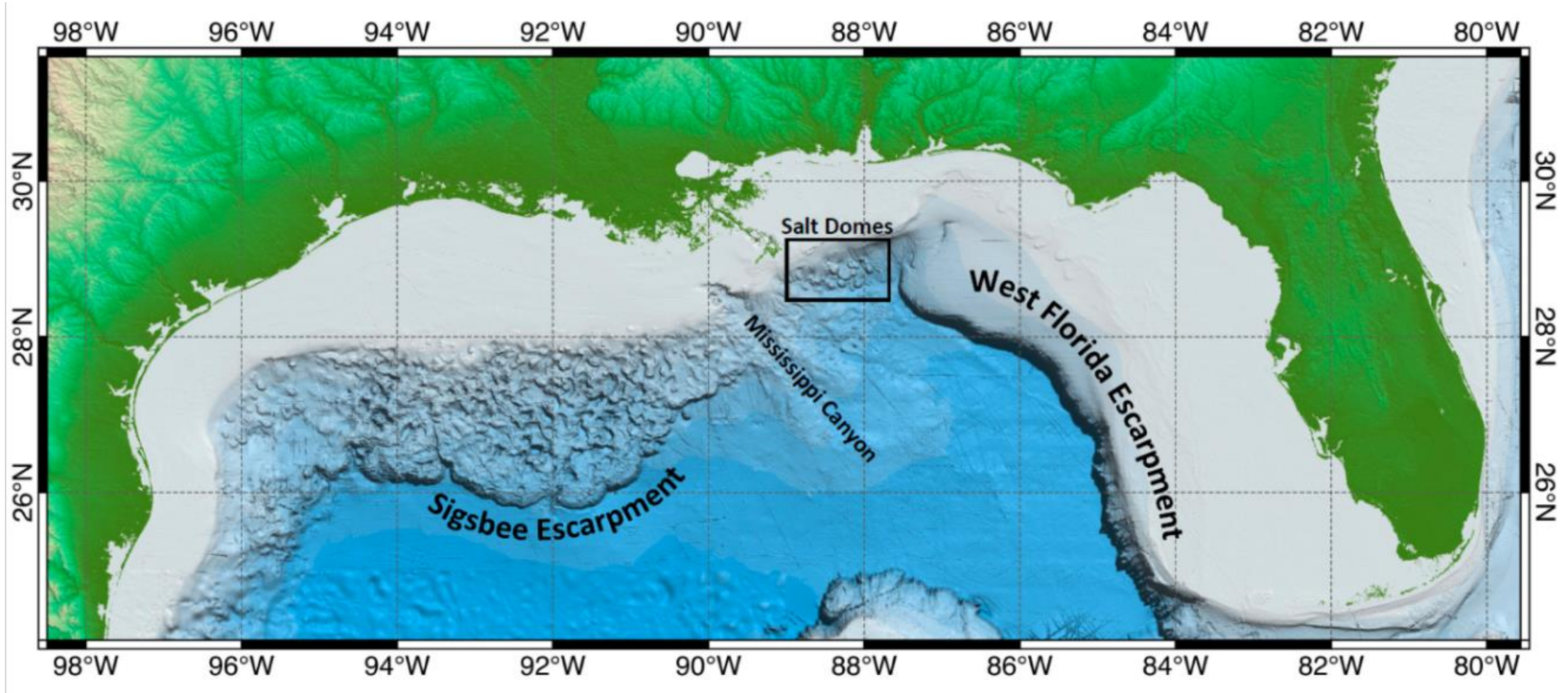
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So, what's the difference between a subaqueous fan-shaped Pro-delta and a submarine fan?

A submarine fan is a fan-shaped or elongate body of sediment on the sea floor that has been deposited by mass-flow processes



But what if there is so much sediment coming down the river and so little tidal and wave action carrying it away that the delta progrades all the way to the edge of the continental shelf? Does it become a submarine fan???



SEISMIC STRATIGRAPHY OF A SHELF-EDGE DELTA AND LINKED SUBMARINE CHANNELS IN THE NORTHEASTERN GULF OF MEXICO

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AND

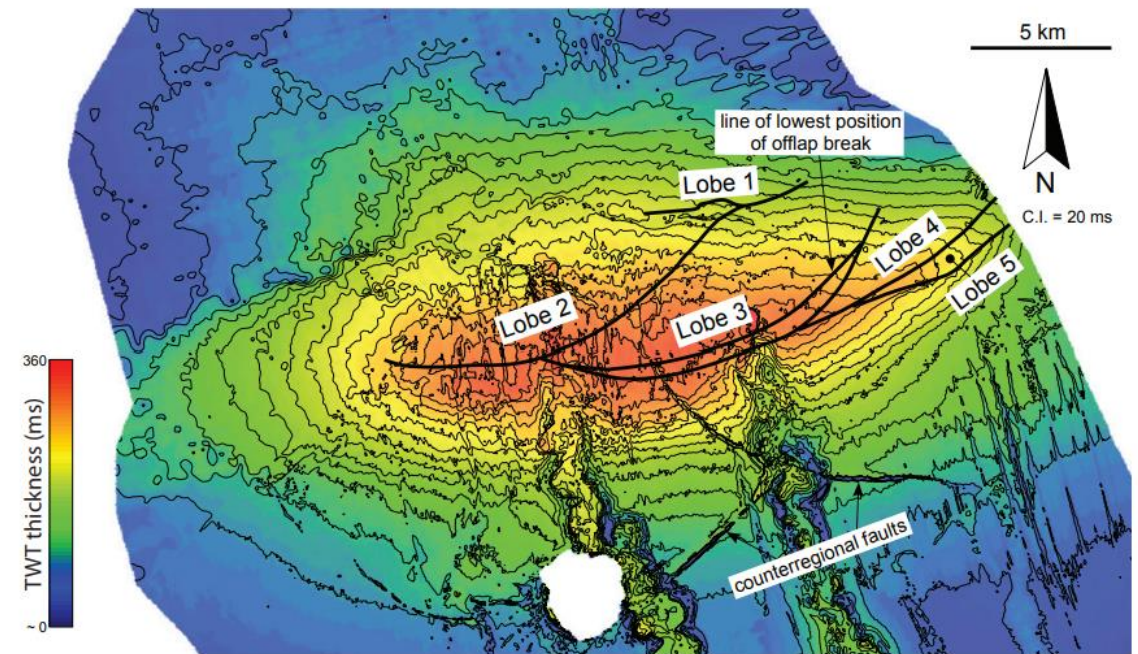
CIARAN O'BYRNE

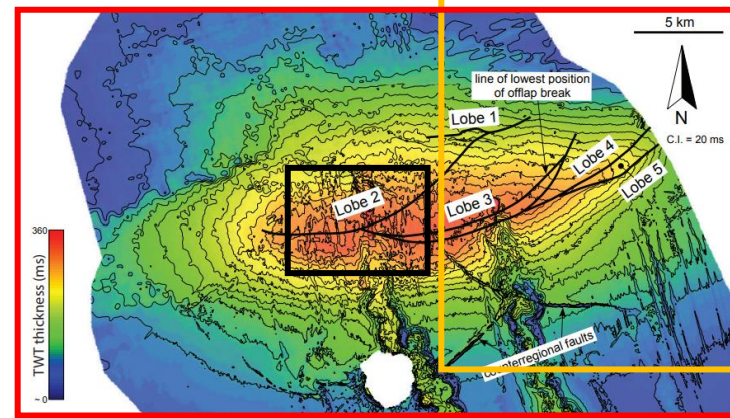
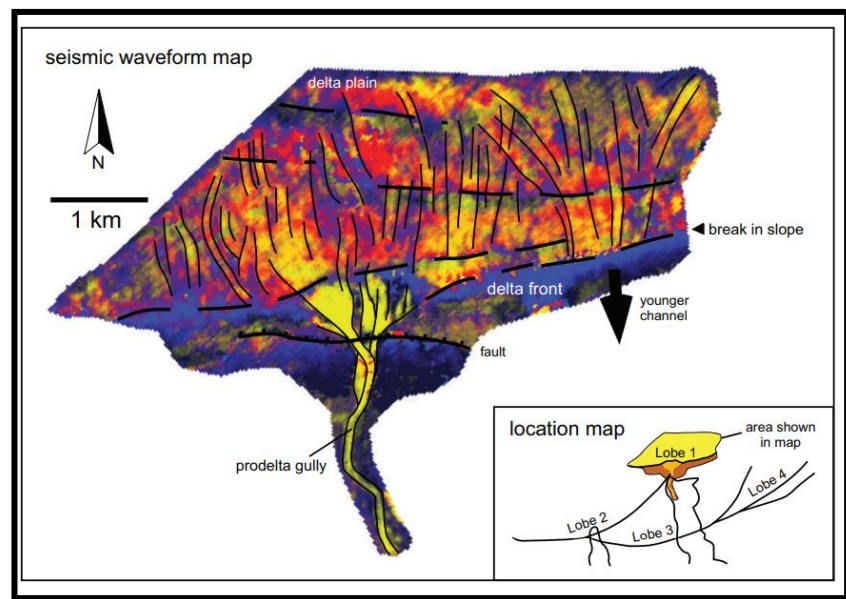
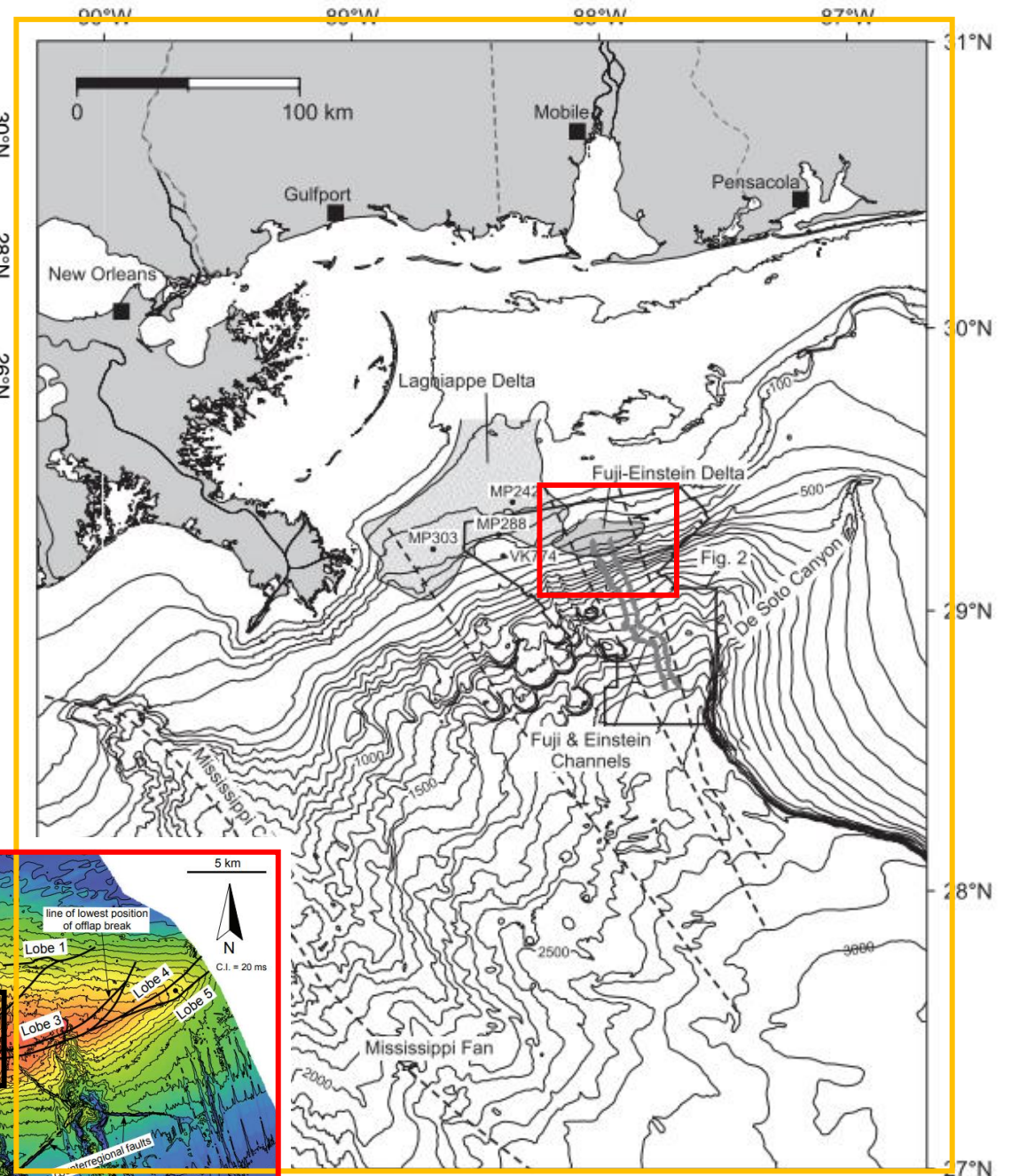
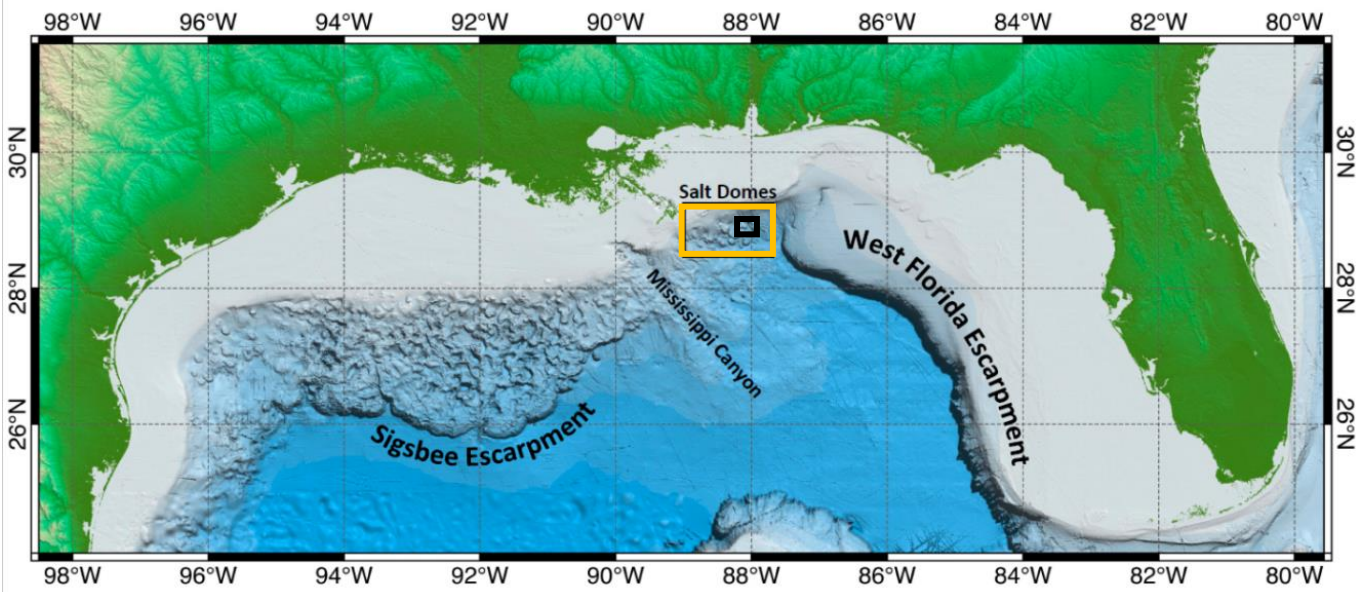
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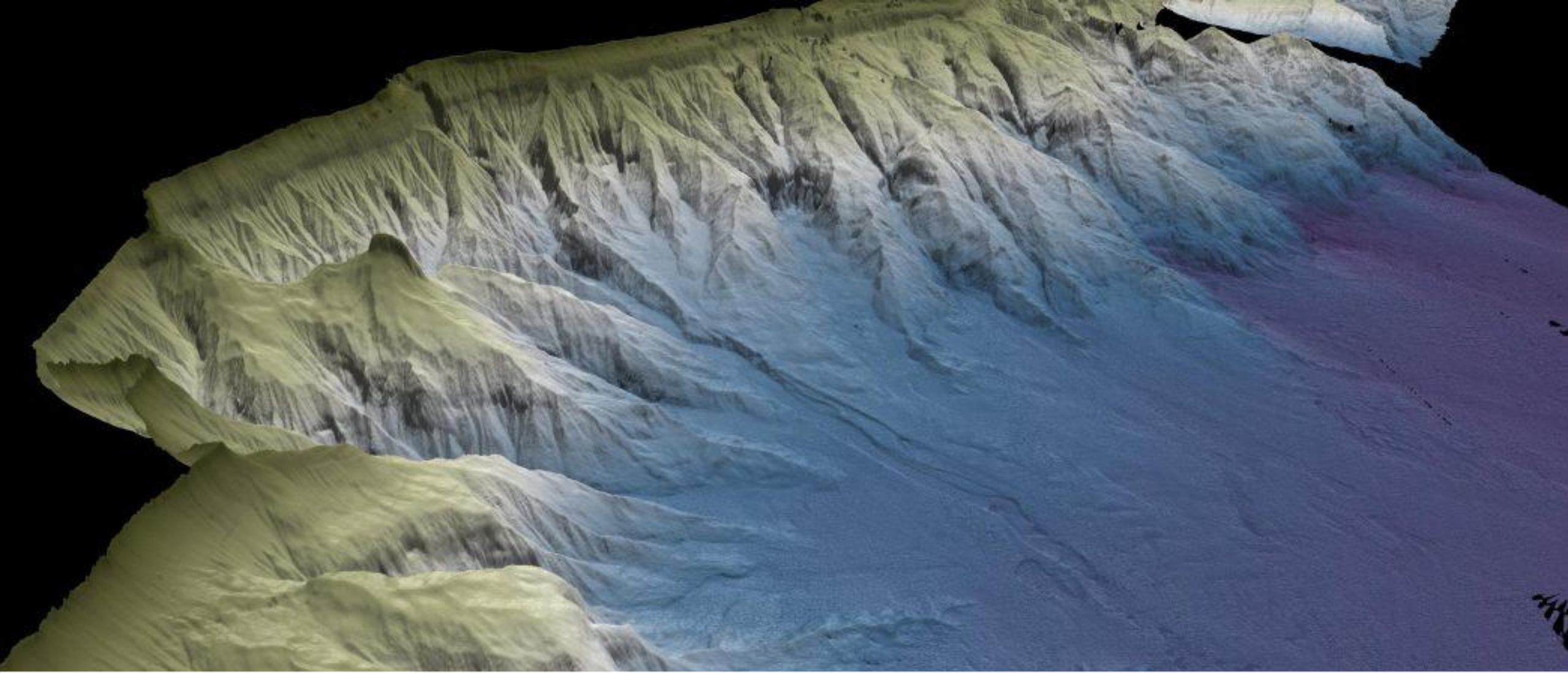
e-mail: ciaran.obyrne@shell.com

Shelf-Edge Deltas (SEDs)

- Deposited during times of shelf exposure due to:
 - lowering of sea level; or
 - filling of shelf accommodation in times of stable sea level and high sediment supply
- *Locally* serve as the main sediment supply for associated deep-water depositional systems, including:
 - canyons
 - channels
 - slope aprons
 - basin-floor fans





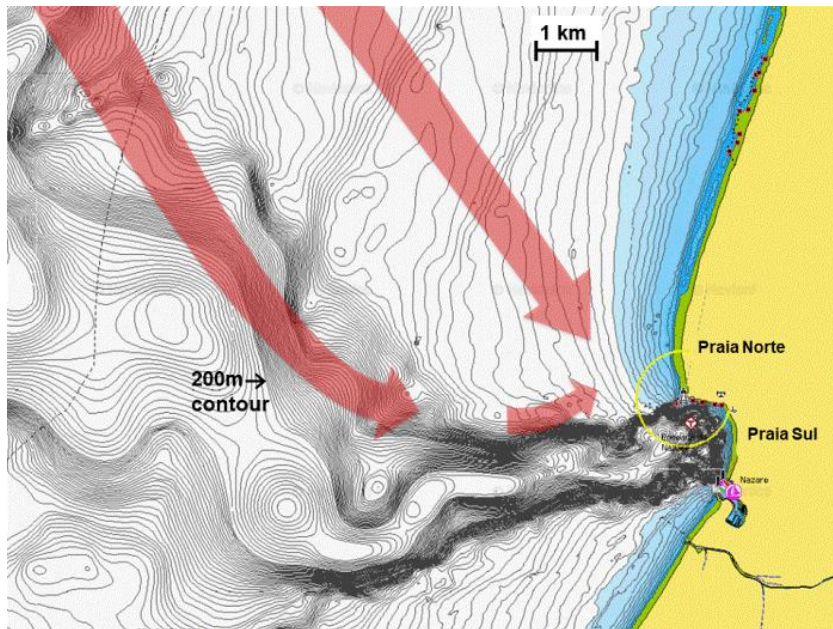


Submarine Canyons and Turbidites



Submarine Canyons

- Significantly shape the edge of the continental shelf
- Narrow (< 1 km) and deep (up to 5 km); may be 400+ km long
- Based on knickpoint location, generally characterized as:
 - Shelf-indenting, sediment-fed canyons – may cross the continental shelf and be linked with current river (fluvial) systems (30%; ~3% in fluvial alignment)
 - Slope-confined, retrograding canyons – originates on continental slope; knickpoint may retrogressively develop (migrate) back up to the shelf edge (~ 70%)
- Facilitate upwelling of cold, deep water (fisheries implications)
- Influence and obstruct placement of underwater pipelines and cables



Submarine Canyons

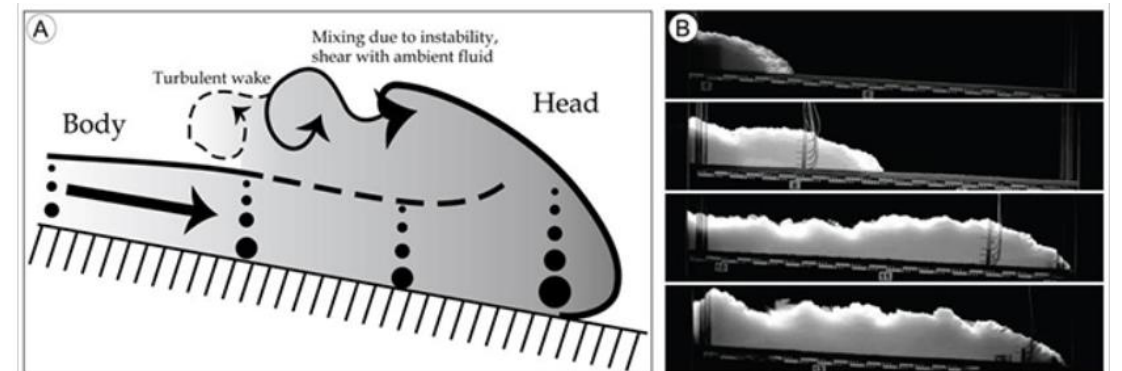
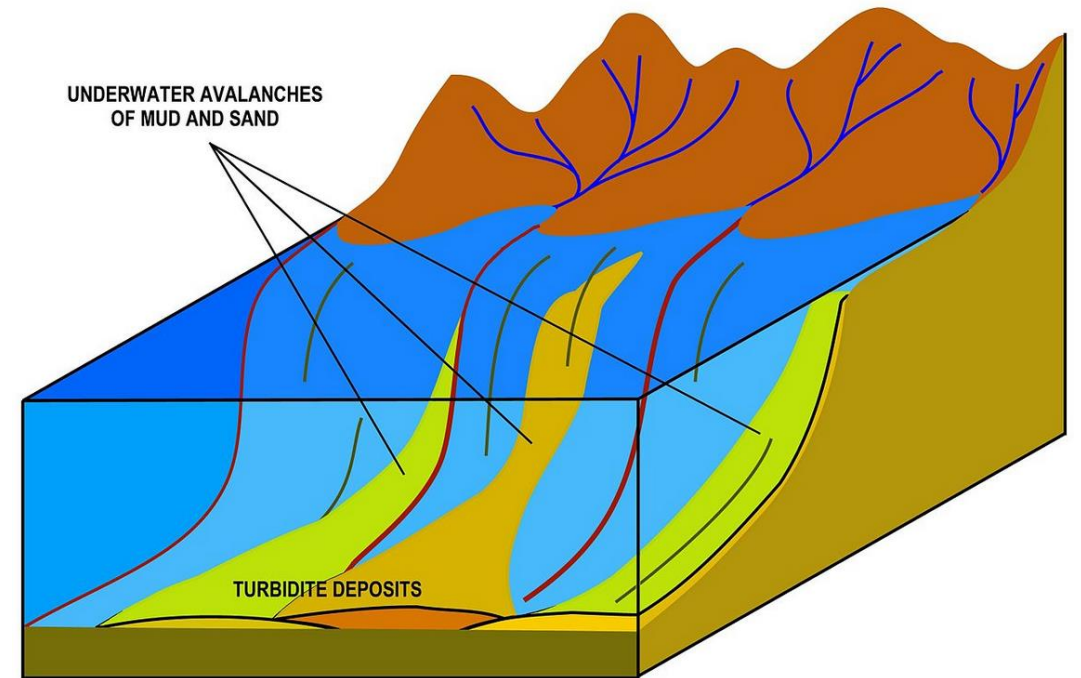
- 9500+ mapped to date
- Evidence of erosion fully down through sedimentary sequences and into underlying hard rock
- Are formed, maintained and propagated by:
 - turbidity currents (erosion);
 - slumping and mass wasting of the continental slope
- May comprise 10-15% of the continental slope
- Occasionally make GIANT waves!



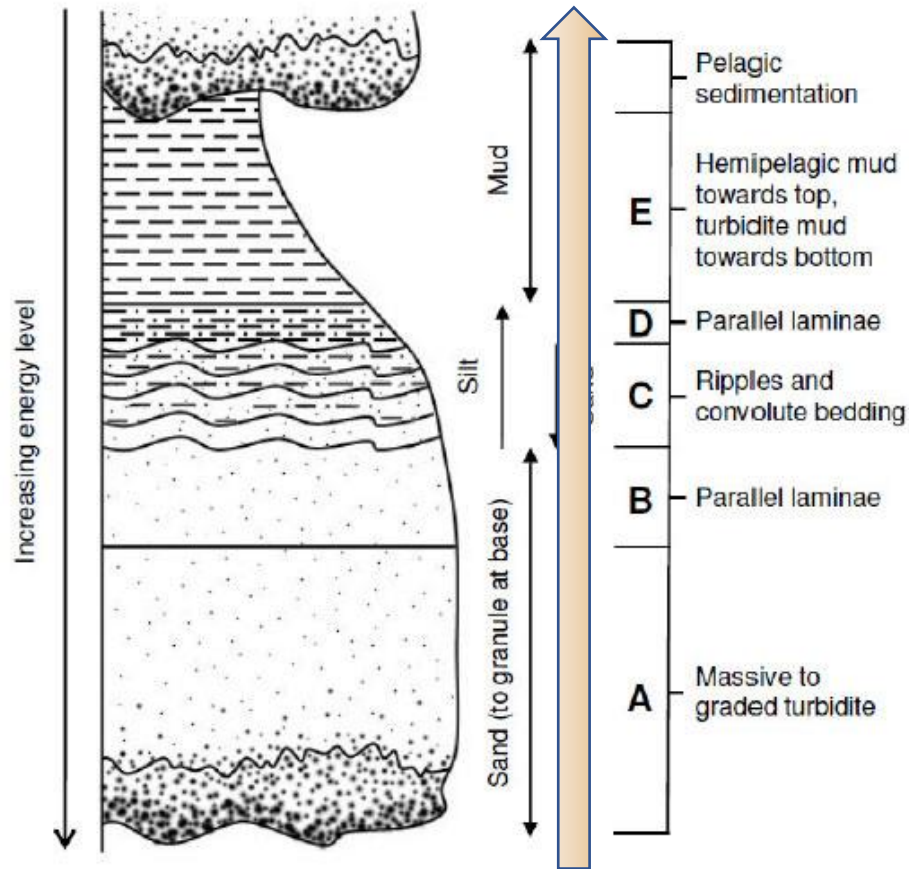
Nazaré, Portugal

What about turbidites?

- Underwater avalanches
- Significant sediment transport from the continental shelf into deep water
- Transport is by density flow – sediment slurry able to move large particle sizes (gravel to cobble)
- Characterized by a ‘fining upwards’ sequence stratigraphy when avalanched materials re-settle







E is the last layer deposited. It results from suspension settling of very fine-grained **CLAYS** where essentially no current exists. Because this layer is easily eroded by subsequent turbidity currents, it is often not present.

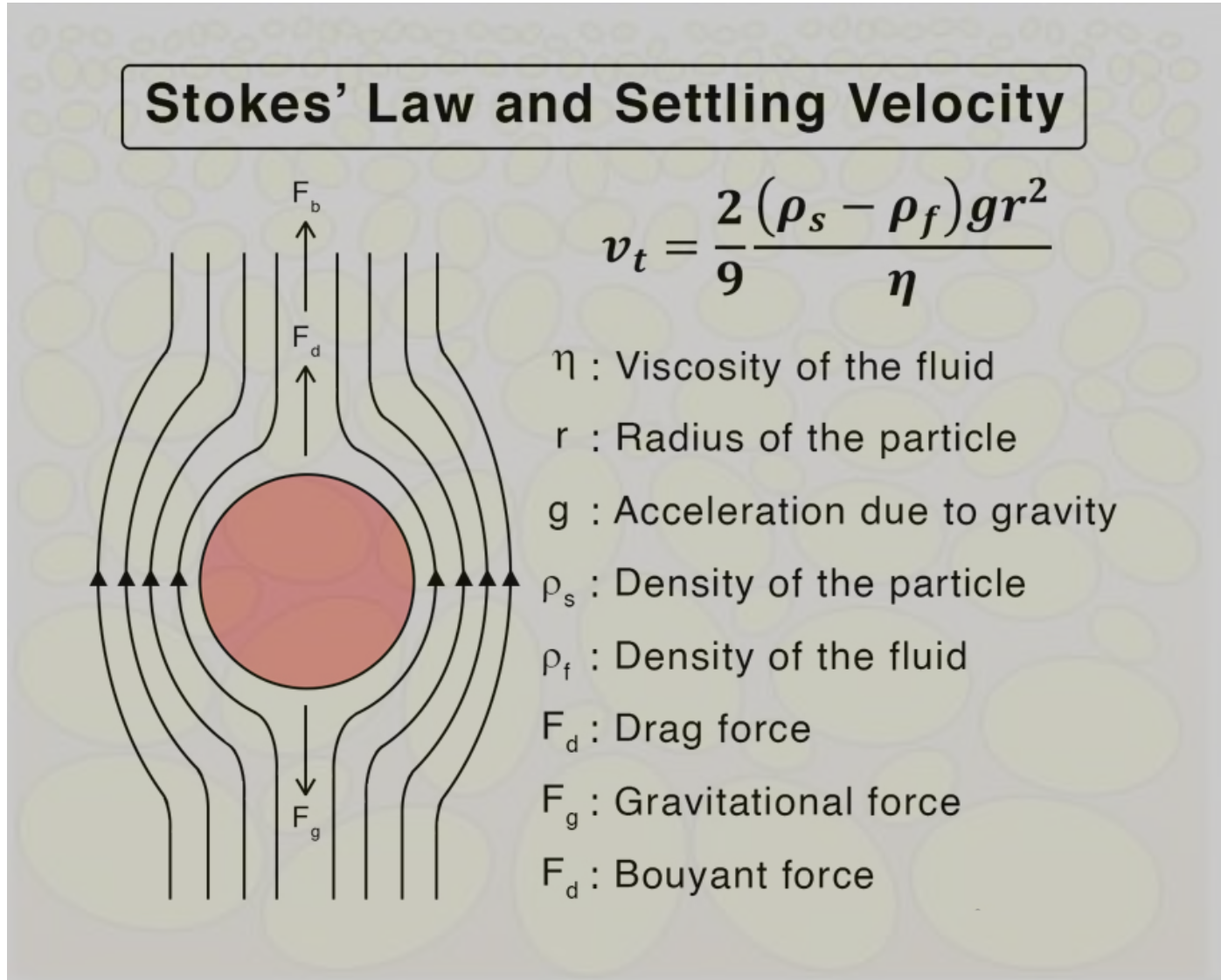
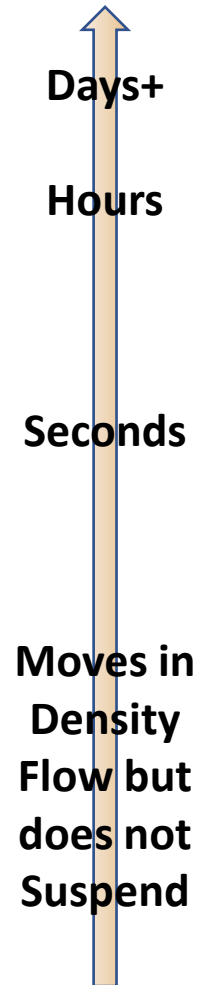
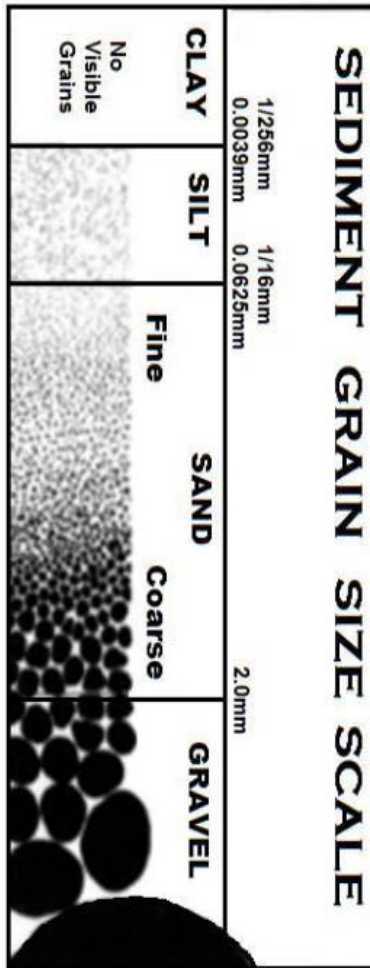
D is deposited by suspension settling where a slight current exists. Subtle changes in current energy causes settling of alternating laminations of coarser and finer **SILTS**.

C is deposited under lower flow regime conditions where there is enough energy for the flow to carry **FINE SAND** by saltation, wherein grains hop and bounce across the surface beneath the flow. As grains settle out, current ripples develop.

B is deposited under upper flow regime conditions where energy is high enough to carry **SAND** by sliding and rolling across the surface beneath the flow. (traction)

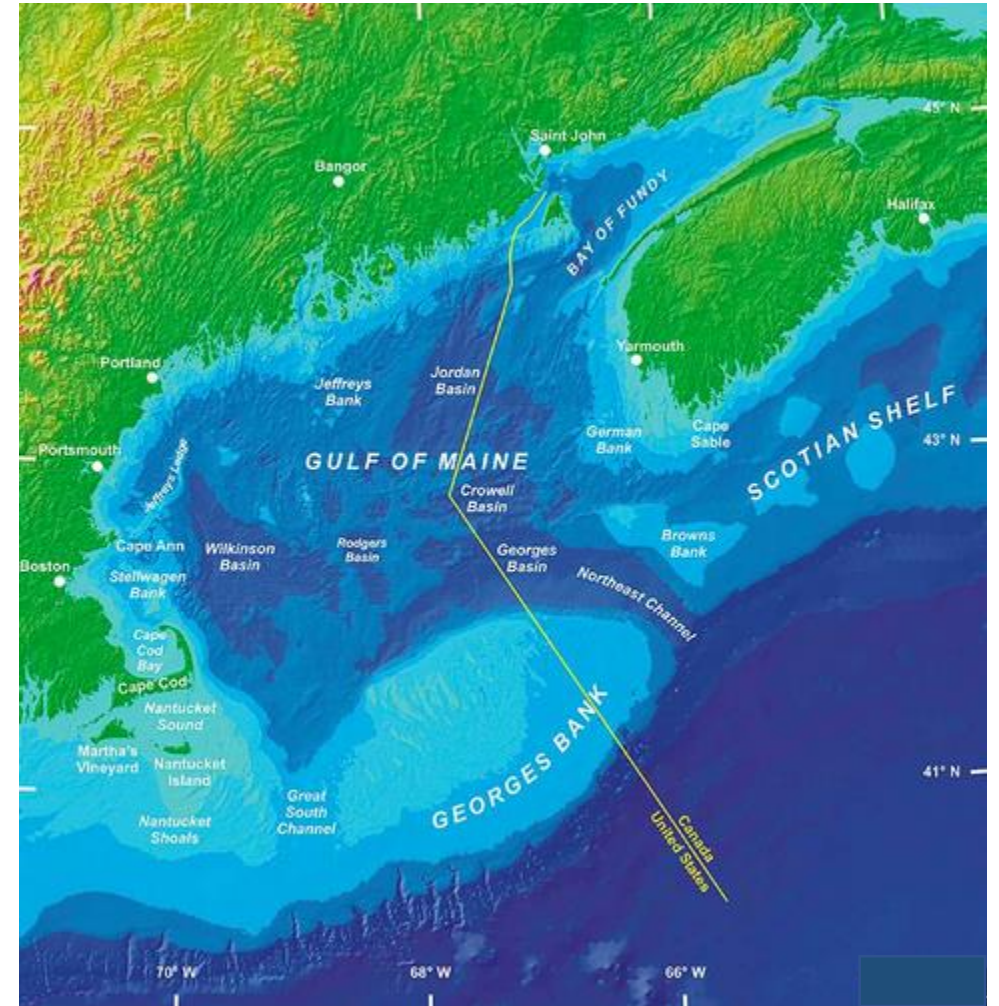
A is the first layer deposited from a flow in which fluid turbulence is high enough to keep the coarsest grains in suspension. When energy drops below a critical level, the **COARSE SAND** settle out all at once to create a massive bed.

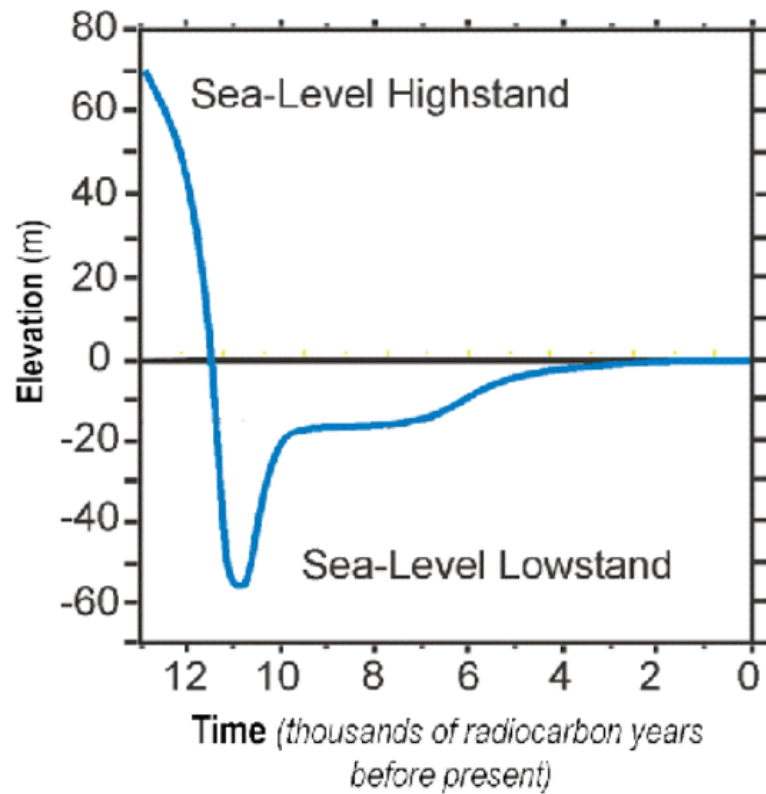
How do we think about particle settling?



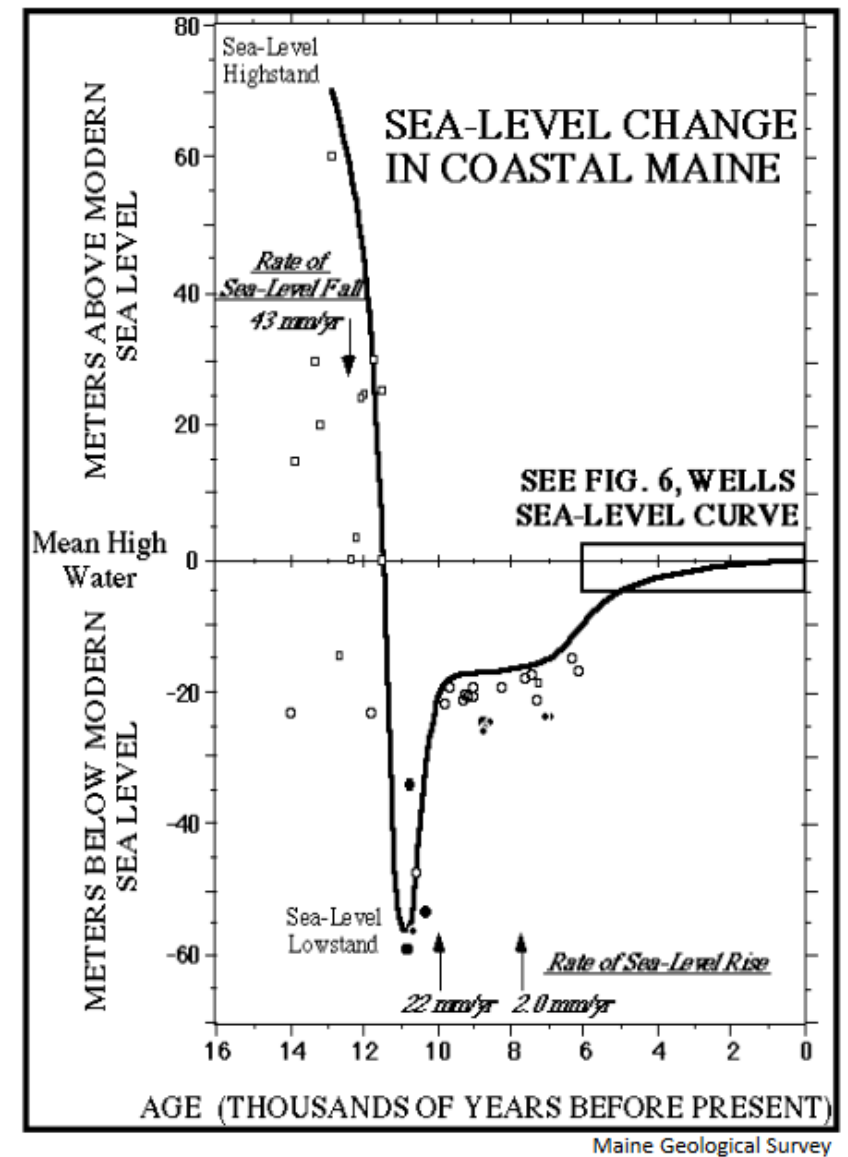
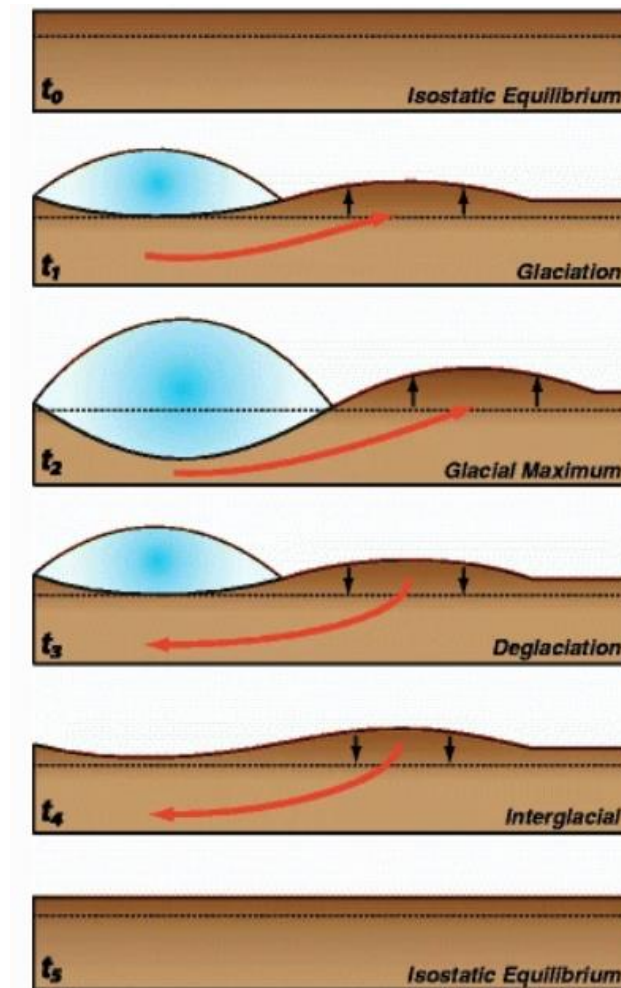
Glacial Moraines

- Materials moved and/or left behind by glaciation
- Coarse-grained to very coarse-grained and often a jumbled mix of particle sizes – this is snowplow action (contrast with turbidite sorting)
- Can be a significant shaper of the shelf and current coastline in previously glaciated areas

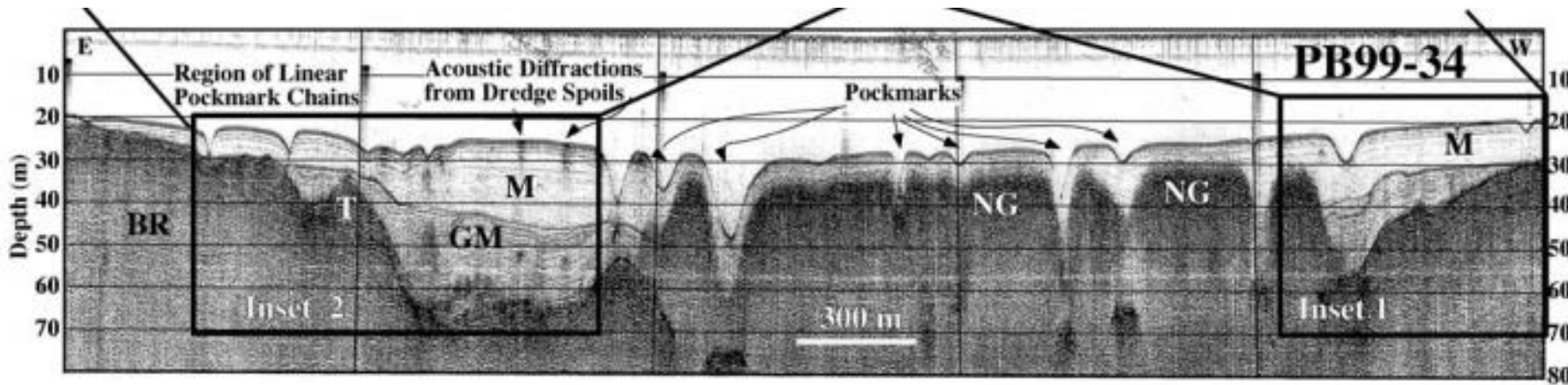
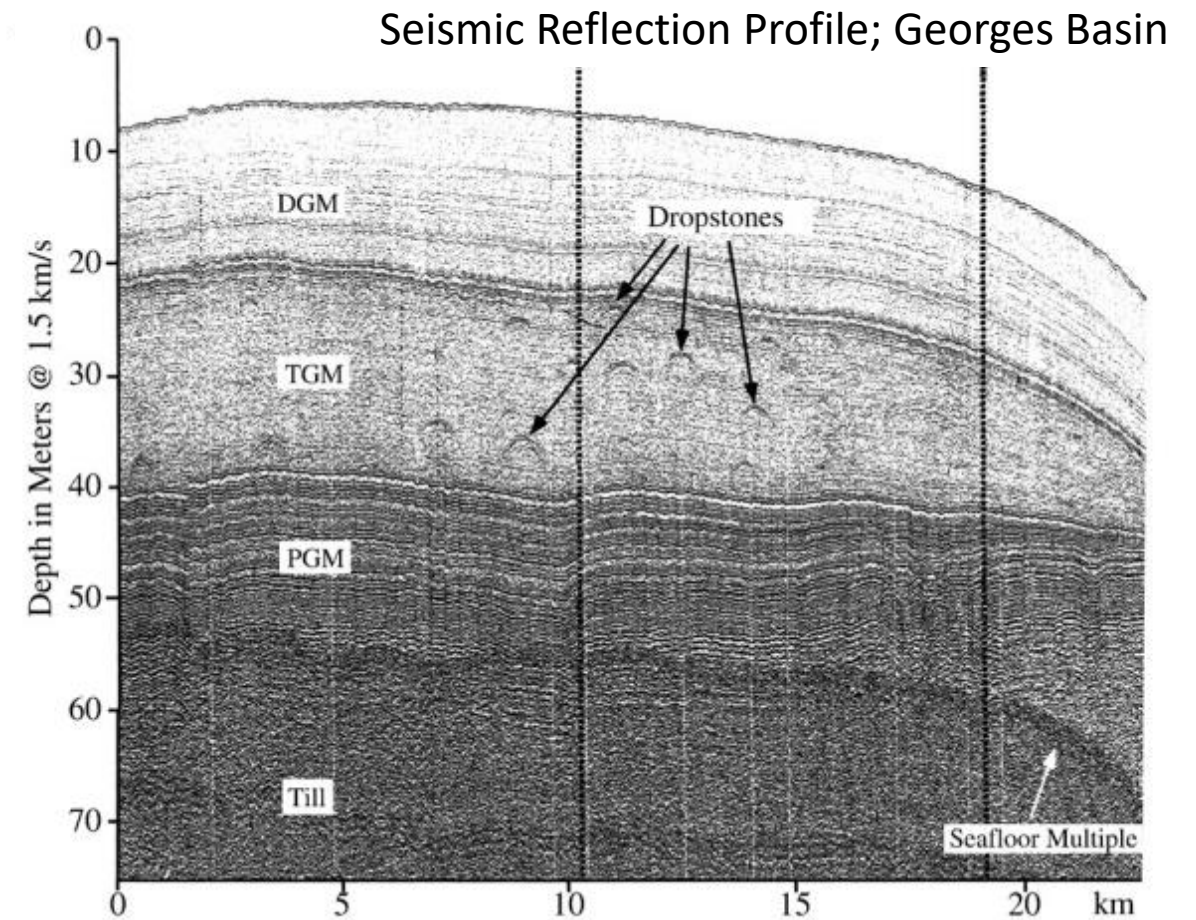
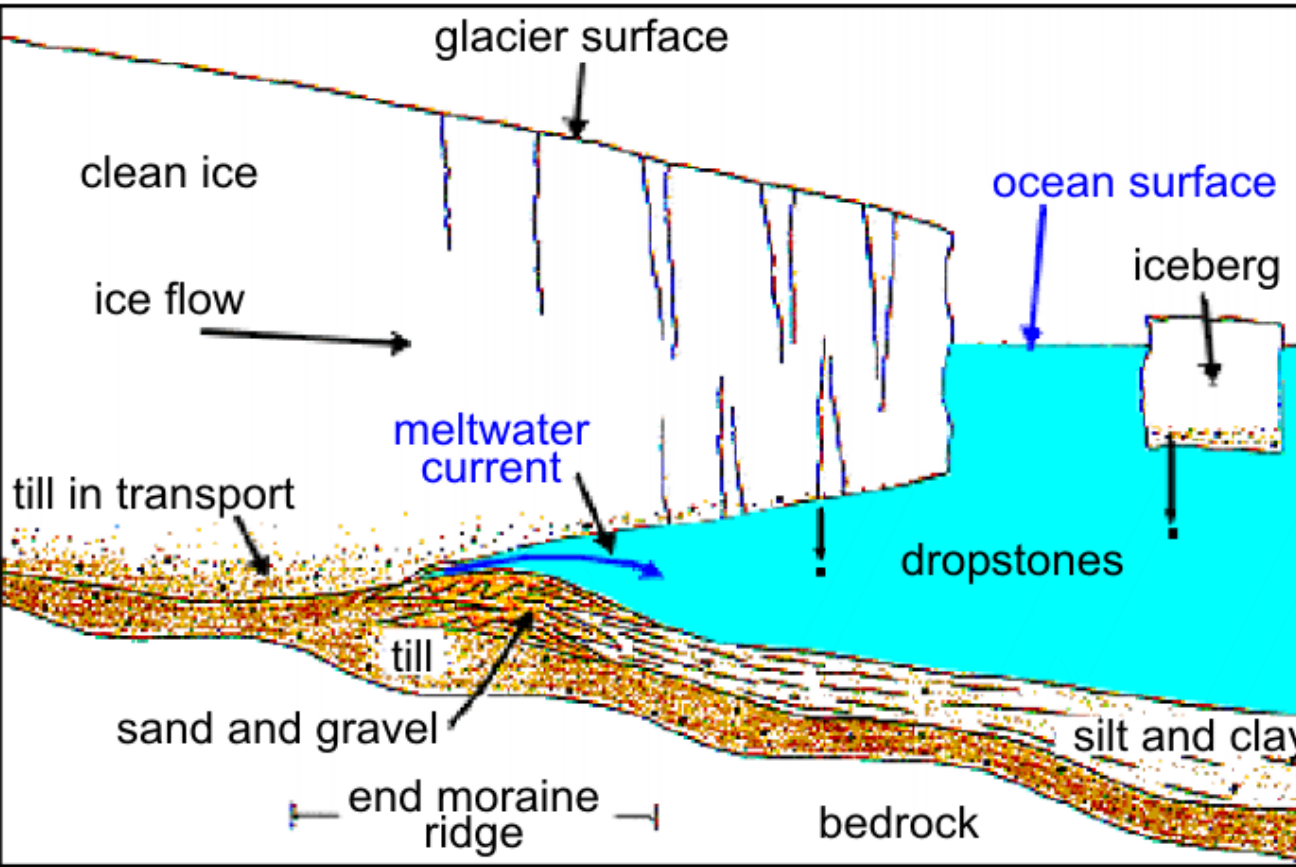




Relative sea level curve for the coast of Maine; glacial maximum ~ 21 kya; ice edge at current Maine coastline by ~16.5 kya



Current rate of rise: 2-3 mm/yr



Seismic Reflection Profile; Belfast Bay

M = Marine
GM = Glacio-Marine
BR = Bedrock
NG = Natural Gas

