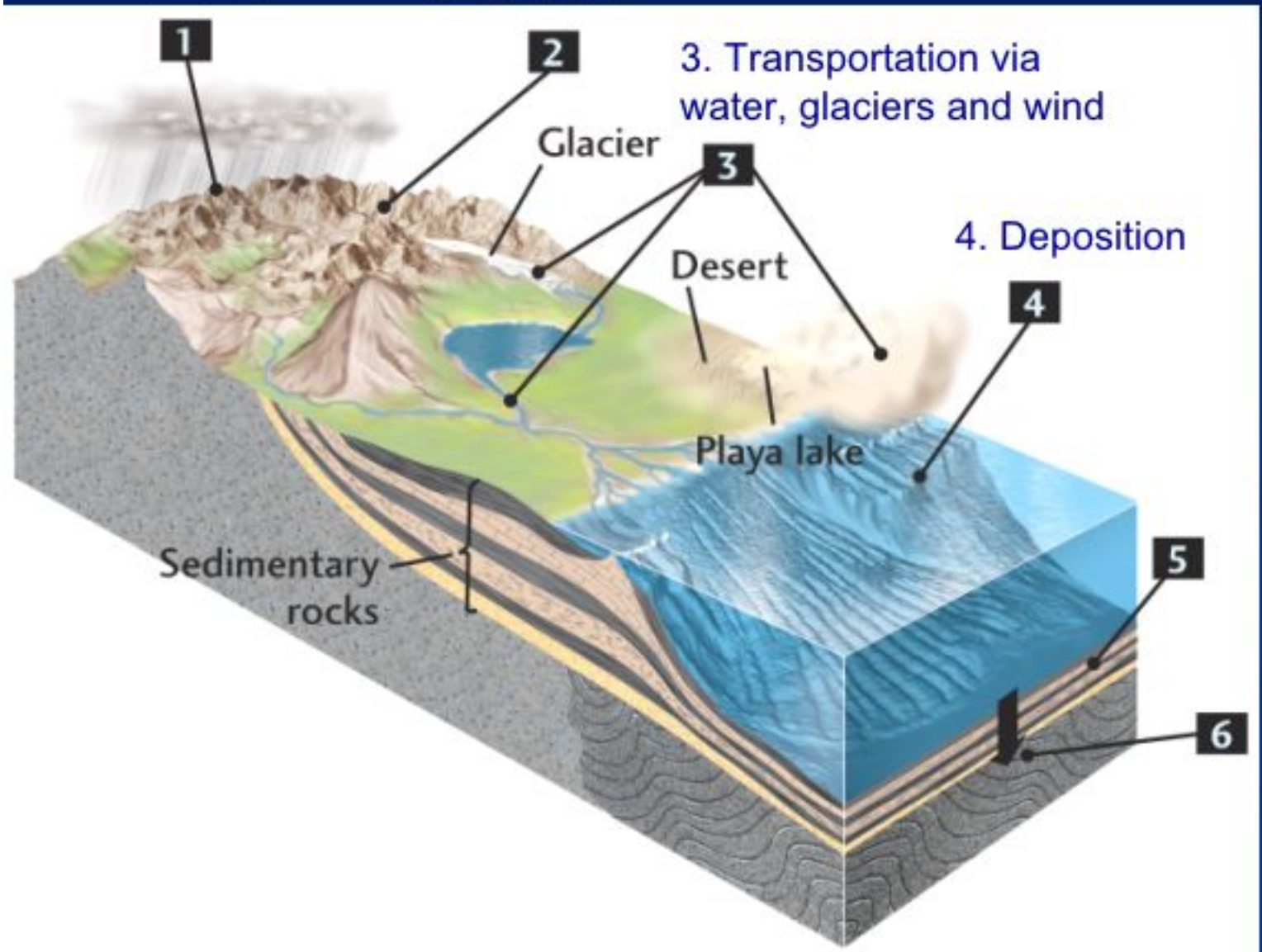
Sedimentary Record

Sediment stages

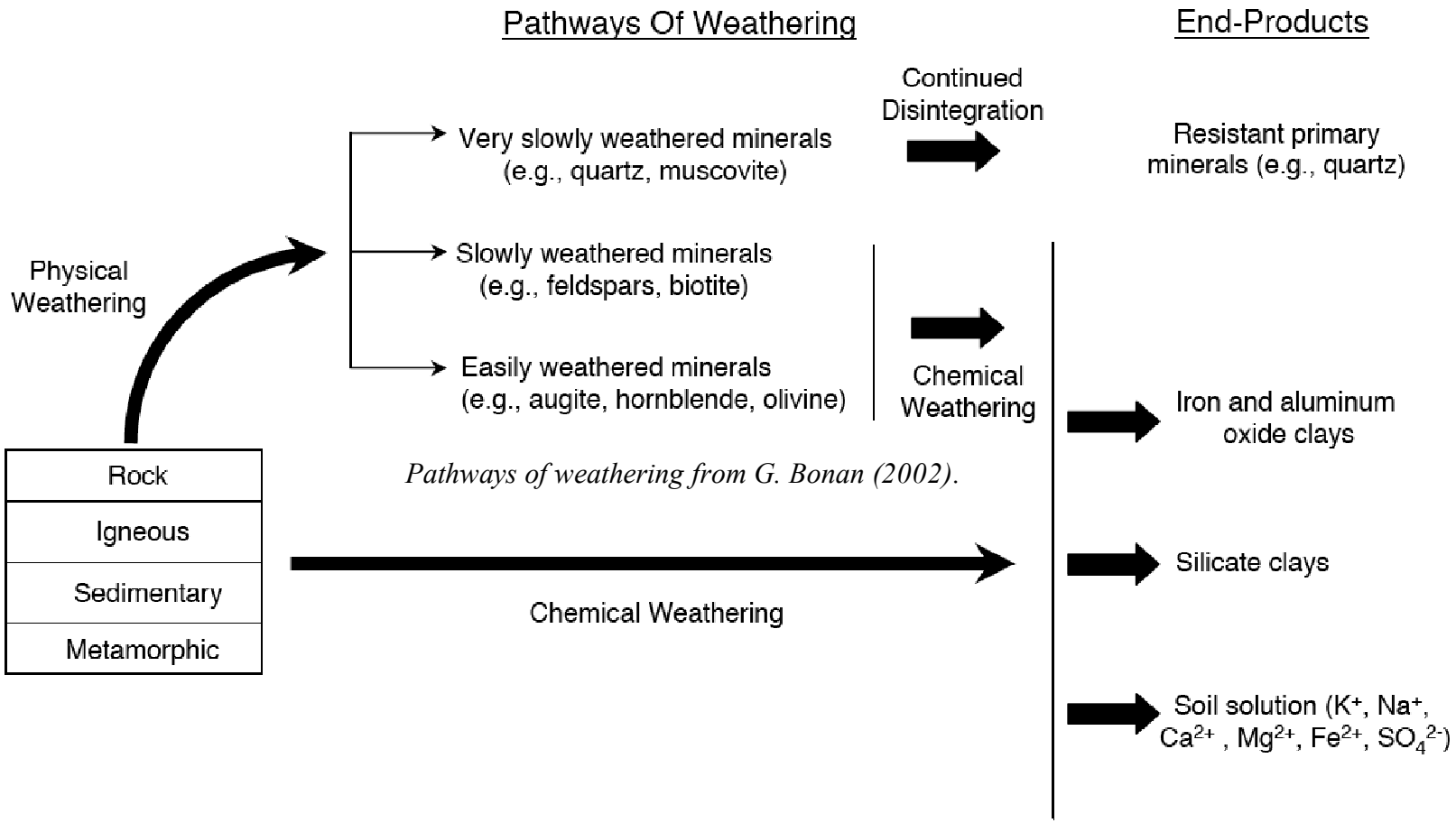
1. Weathering

2. Erosion



5. Burial and compaction

6. Diagenesis



Pathways of weathering from G. Bonan (2002).

From Bonan (2002).

Definitions

Sediment: usually unconsolidated material that is produced on earth's surface by the disaggregation of pre-existing rocks

Sedimentary rock: a consolidated body formed from sediments or *solutes* that are transported and deposited by gravity, biologic activity, or a *fluid* and then *lithified* by the combined effects of *compaction* and *cementation*

Sedimentology: the study of the *production*, *transport*, and *deposition* of sediment

More Definitions

Strata: layers of (usually sedimentary) rock

Stratigraphy:

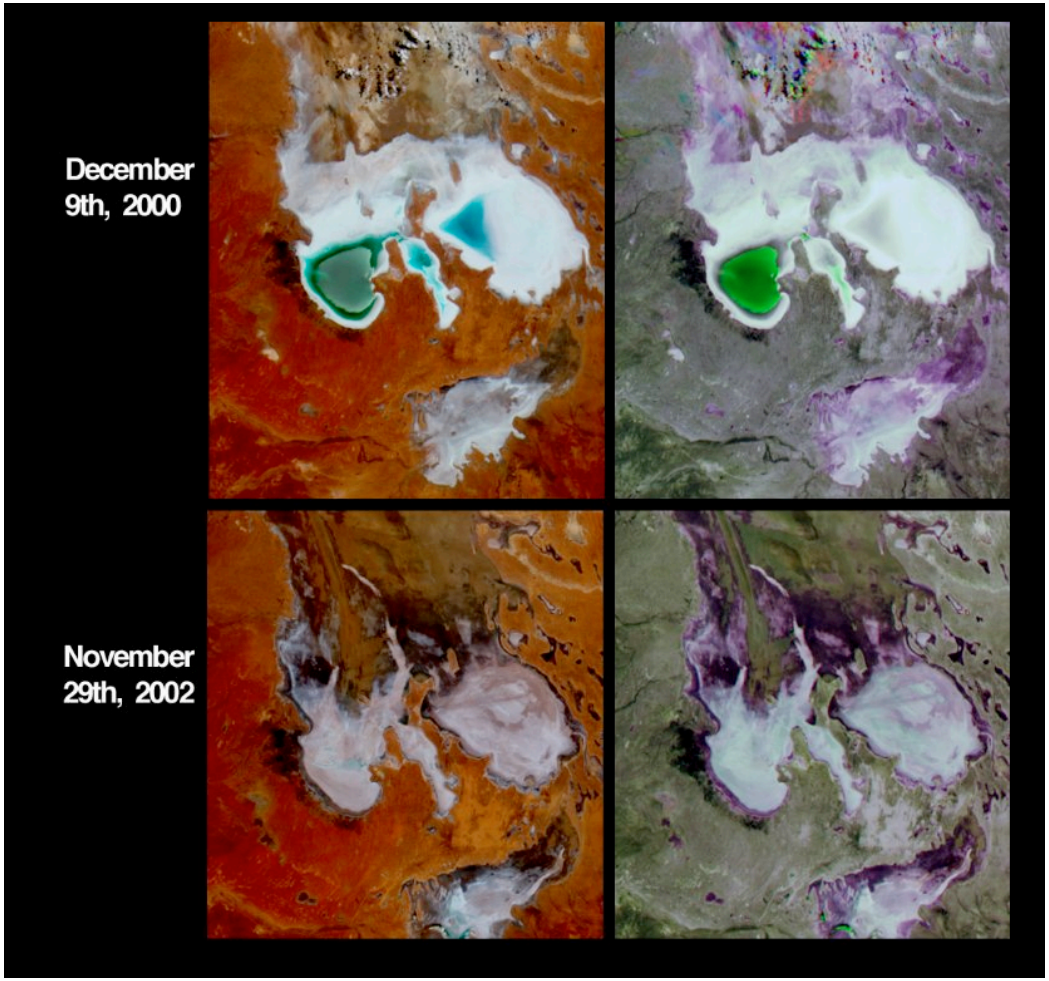
1. The description, study, and/or application of the composition of layered (usually sedimentary) rocks
2. A *succession* of layered rocks; *e.g.*, The stratigraphy of the North West Shelf

Basin:

1. A region of potential sediment *accumulation* generally caused by *subsidence*
2. The largest possible body of related and once-contiguous* strata; *e.g.*, the Sydney Basin

Sedimentary Basins

- Influence of terrigenous sources decreases: high relief continental environments – lowlands – shallow seas – deep sea.
- Sedimentation rate tends to decrease towards central parts of large oceanic basins.
- Basins with low sedimentation rates tend to accumulate sediments relatively rich in biogenic components.
- Chemical sediments (evaporites) commonly form in lowlands (lakes) and special portions of adjacent shallow seas, but rarely in other depositional environments.
- The sedimentary facies of many basin fills do not reflect tectonic basin evolution and specific structural elements.



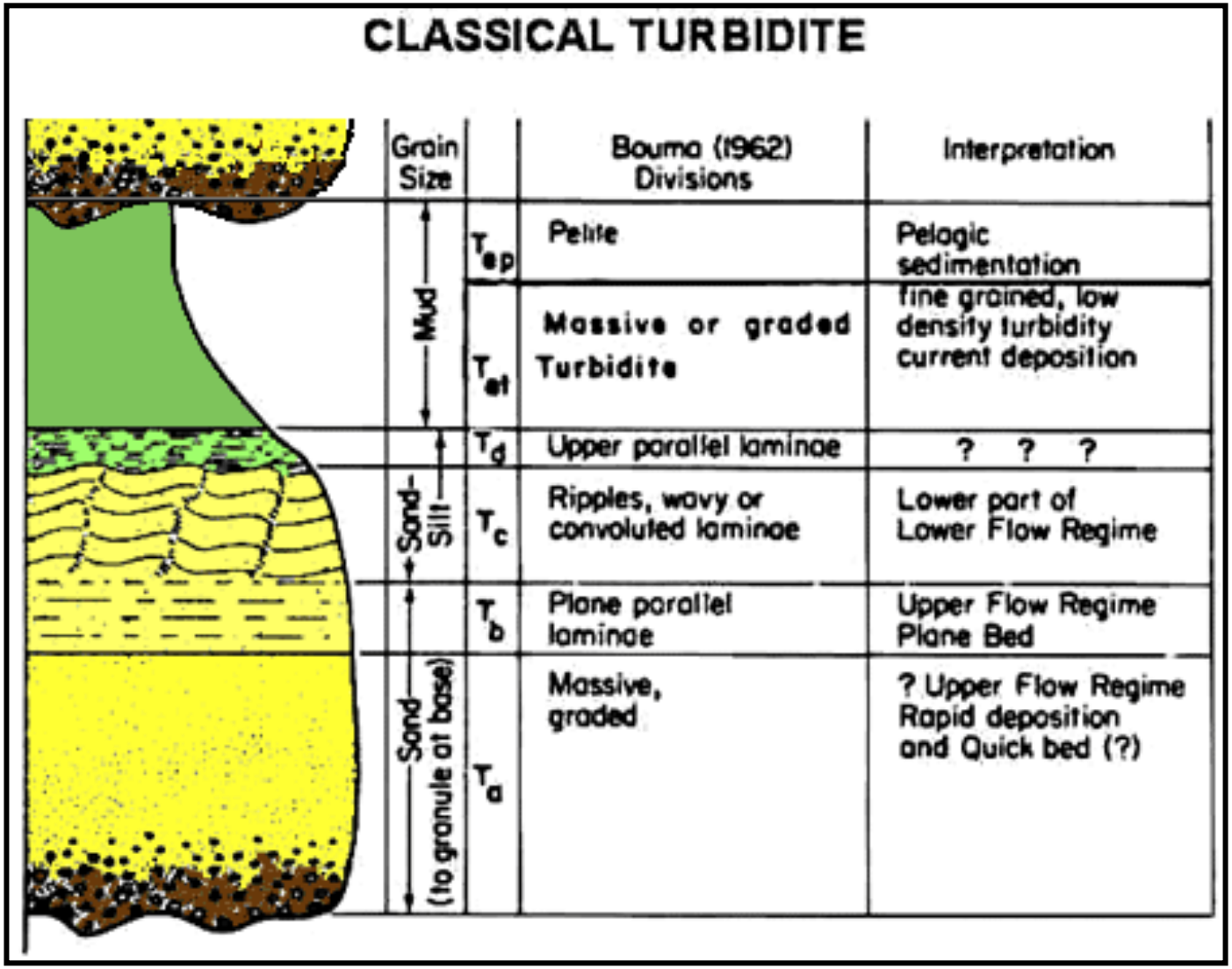
Lake Eyre, image from NASA

Sedimentary Facies

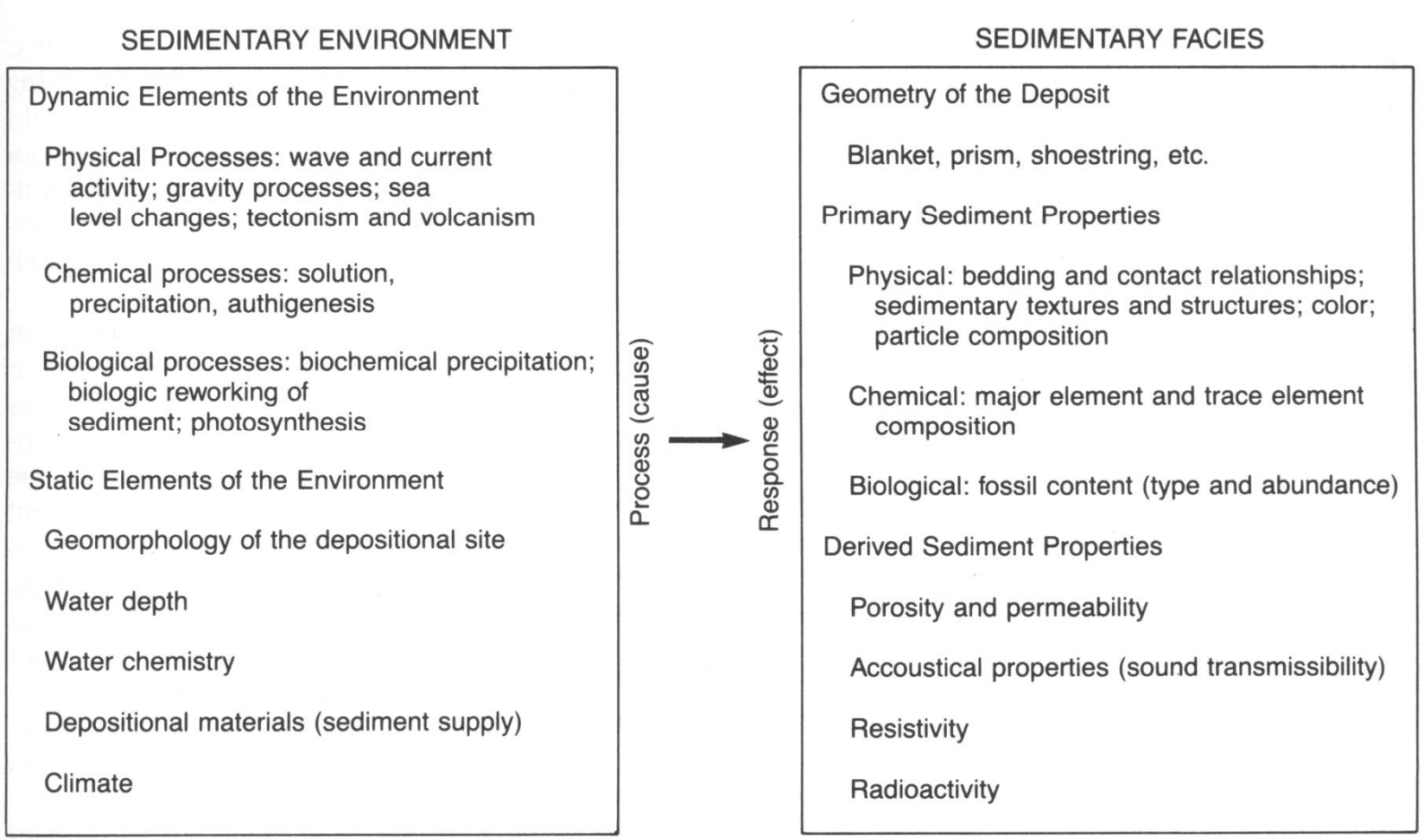
- ***Facies:*** the total textural, compositional and structural characteristics of a sedimentary deposit resulting from accumulation and modification in a particular environment.
  - Grain size, sorting, rounding
  - Lithology
  - Sedimentary structures
  - Bedding type
  - Biogenic component

Example: *well-sorted, moderately rounded, trough cross-stratified, horizontally burrowed & normally graded arkosic coarse sandstone*

Sedimentary Facies



Sed Environments and Sed Facies



Physical Properties

- **Geometry**
- **Lithology**
- **Facies association**
- **Sedimentary structures**
- **Sedimentary textures**

Chemical & Biological Properties

- **Major element composition**
- **Trace element composition**
- **Isotope ratios**
- **Type and relative abundance of organic matter**
- **Relative abundance and ratios of specific species**
- **Endemic v displaced biota**
- **Types of trace fossils**

Lithofacies & Lithofacies Codes

- Sedimentary facies often get reduced to *lithofacies* which detail grain-size, composition, and dominant sedimentary structures only
  - Example: planar cross-stratified gravel, inversely graded massive sandstone
- This has led to lithofacies codes (after Miall, 1978).

Depositional Systems

- ***Depositional system:*** assemblage of multiple process-related sedimentary facies assemblages, commonly identified by the geography in which deposition occurs.
  - Example: nearshore depositional system, deep marine depositional system, glacial depositional system, fluvial depositional system

- *NB* depositional systems are:
  - Modern features
  - Used to interpret ancient sedimentary successions

Sedimentary Depositional Systems

- When a sedimentary section is interpreted from outcrop, and/or associated wells, and/or seismic, it is usually to determine the depositional setting of the rocks and from this predict their character and extent to areas where less information is available. This process of interpretation often encompasses using:

- Sedimentary petrology [mineralogic composition and fabric of the component sedimentary grains and their cements]
- Sedimentary structures and sediment geometry
- Fossil assemblages
- Sequence stratigraphic signal
- Plate tectonic setting

Clastic Coasts

- Deltas, beaches, barrier islands, tidal flats, estuaries
- Controlled by wind waves, tidal waves and wave-generated currents
- Coasts may be erosional (rocky coasts) or depositional

Shoreline Processes

- Sediment supply
- Sediment delivery
- Wave processes
- Wave-induced nearshore currents
- Fairweather vs storm conditions
- Tides
- Wind
- Gravitational processes

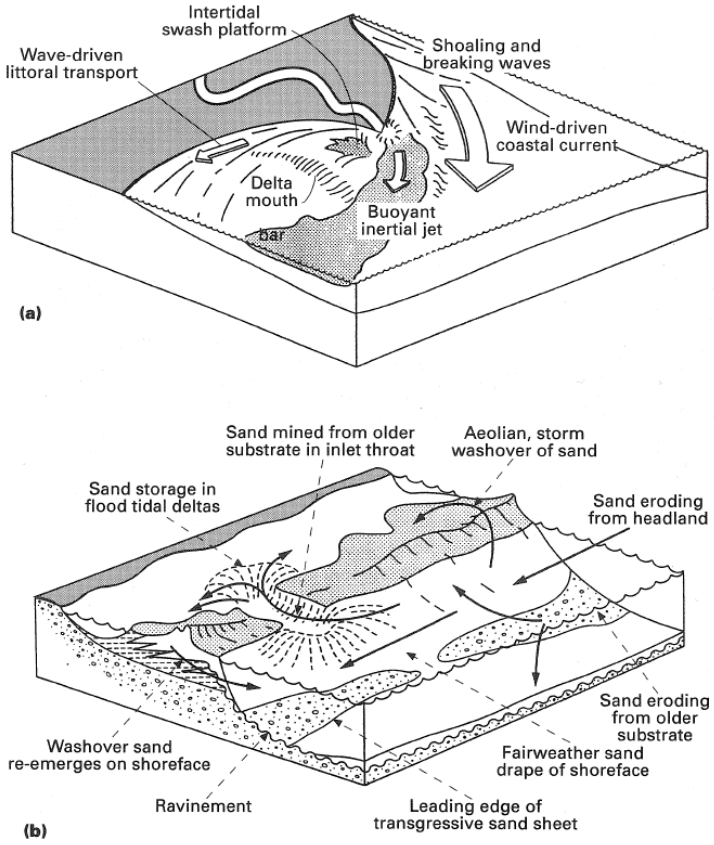
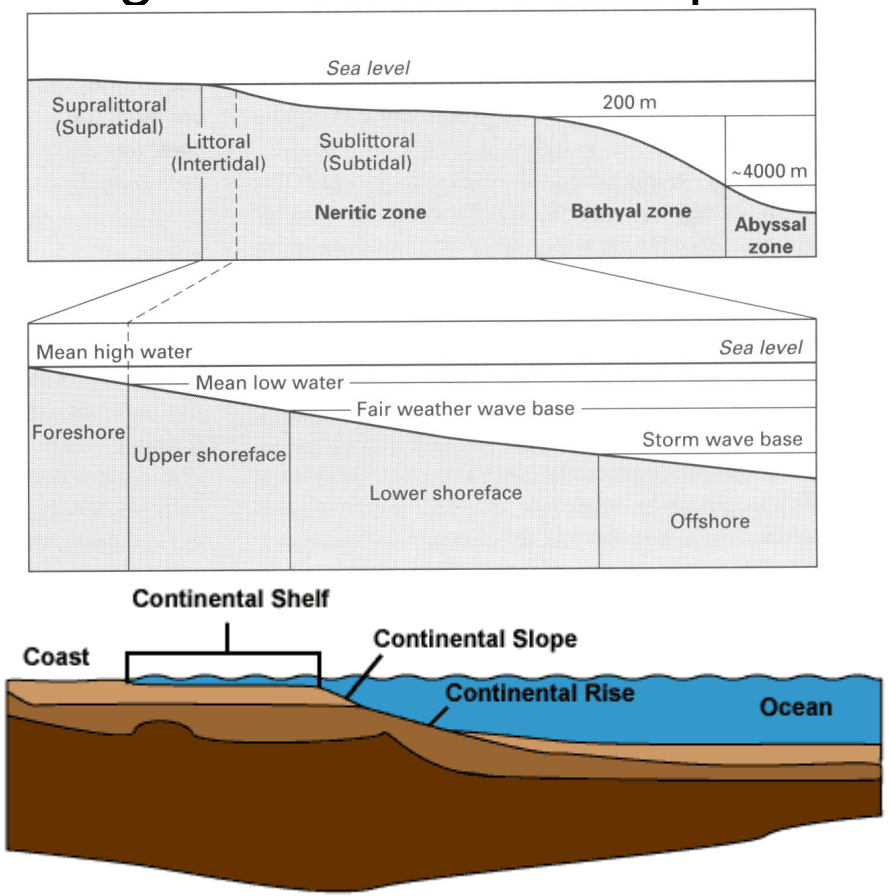


Figure 6.4 Two principal methods by which sediment is transported on to the shelf through the *littoral energy fence*. (a) *River mouth bypassing* – a river flood transports sediment on to a delta mouth bar and beyond. Sand is mostly stored in the mouth bar and slowly re-entrained in the littoral sand stream. Fine sand, silt and clay are carried as a buoyant half-jet and rained on the shelf floor. (b) *Shoreface bypassing* – storm washover sand is buried and eroded as it emerges on the shoreface. Erosion of the shoreface during its retreat allows transport alongshore and on to the shelf (from Swift & Thorne, 1991; Swift, Phillips & Thorne, 1991a).

Shallow marine systems - continental shelf

- Shallow part of the sea floor adjacent to continent with smooth seaward slope terminating at an abrupt change in gradient (ave. 4°) beginning the continental slope.
  - “Distally steepened”

- Width c.75km
  (10 - >100km)
- Depth c.10 - 200m
  (2-500m)
- Slope c.0.1°
  (0.001 - 1 °)



Topography and depth

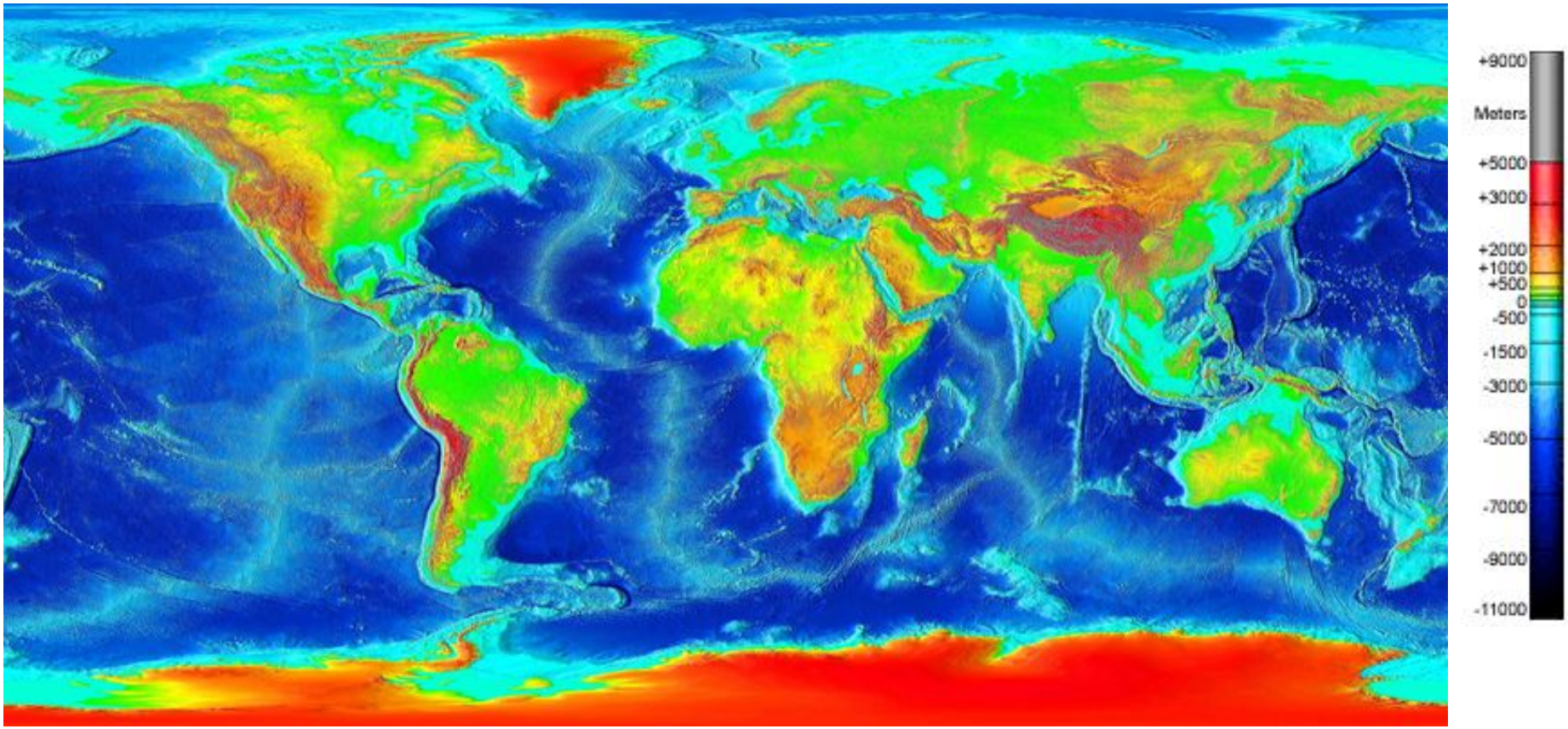


Image from NOAA

NSW continental shelf

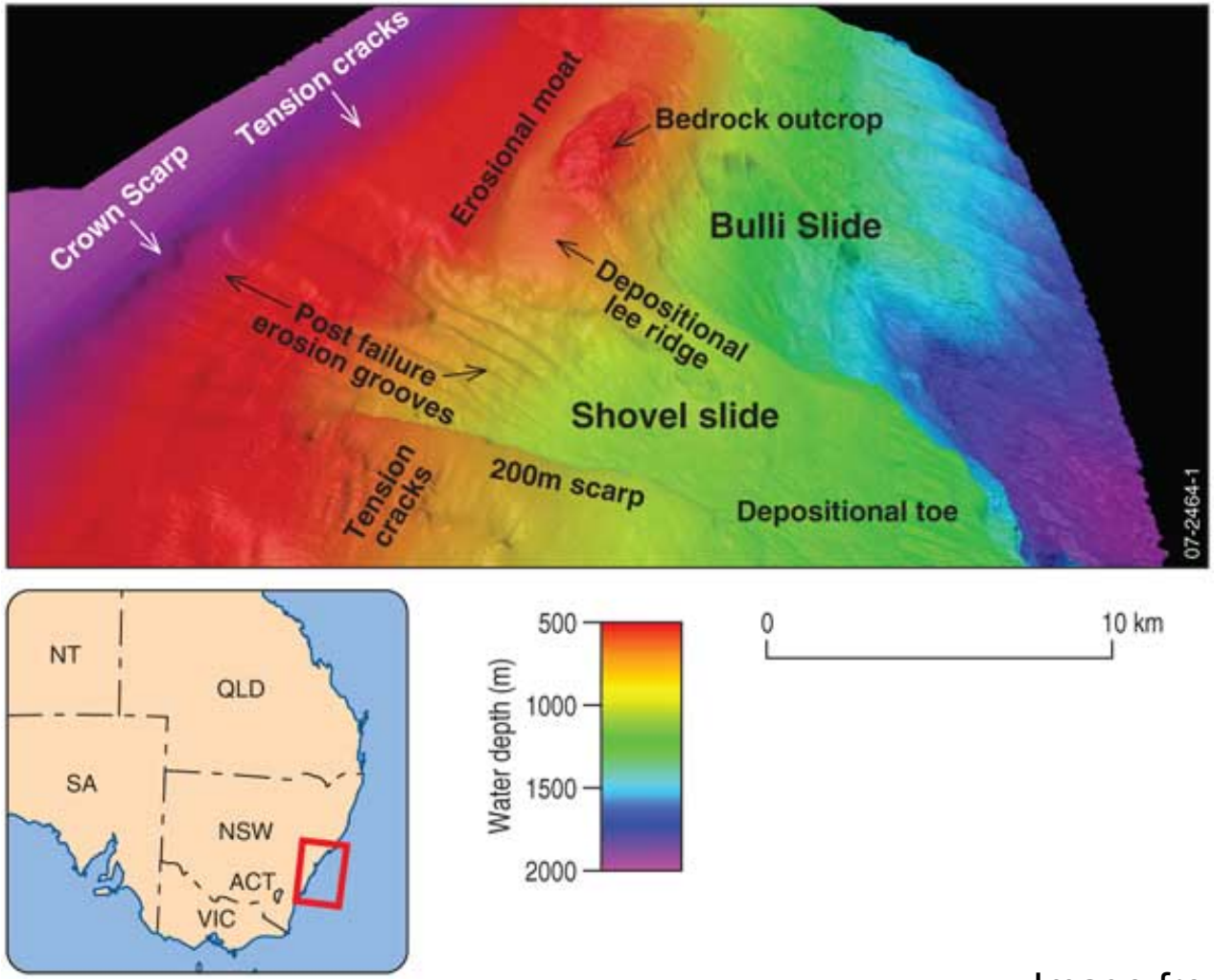
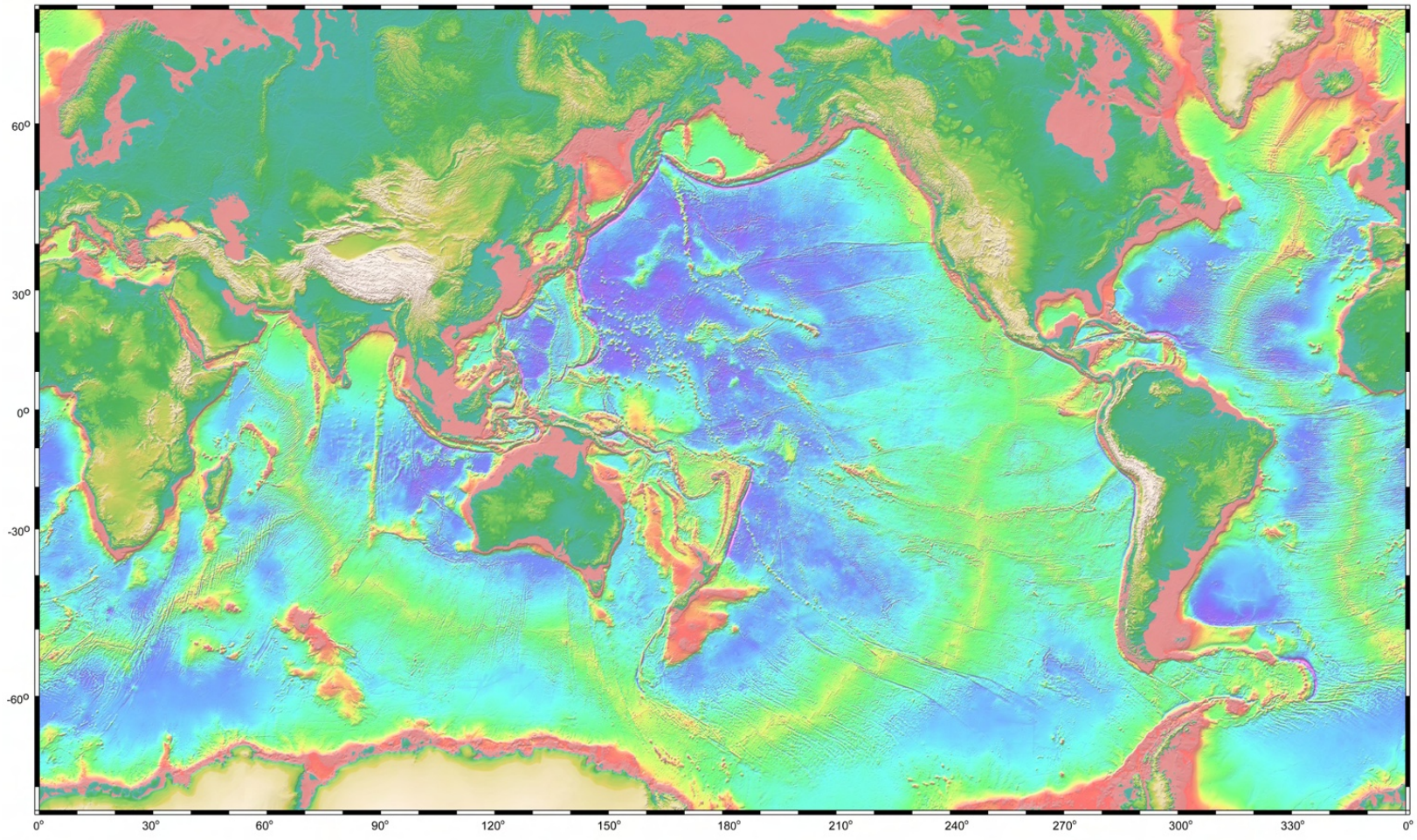


Image from Geoscience Australia

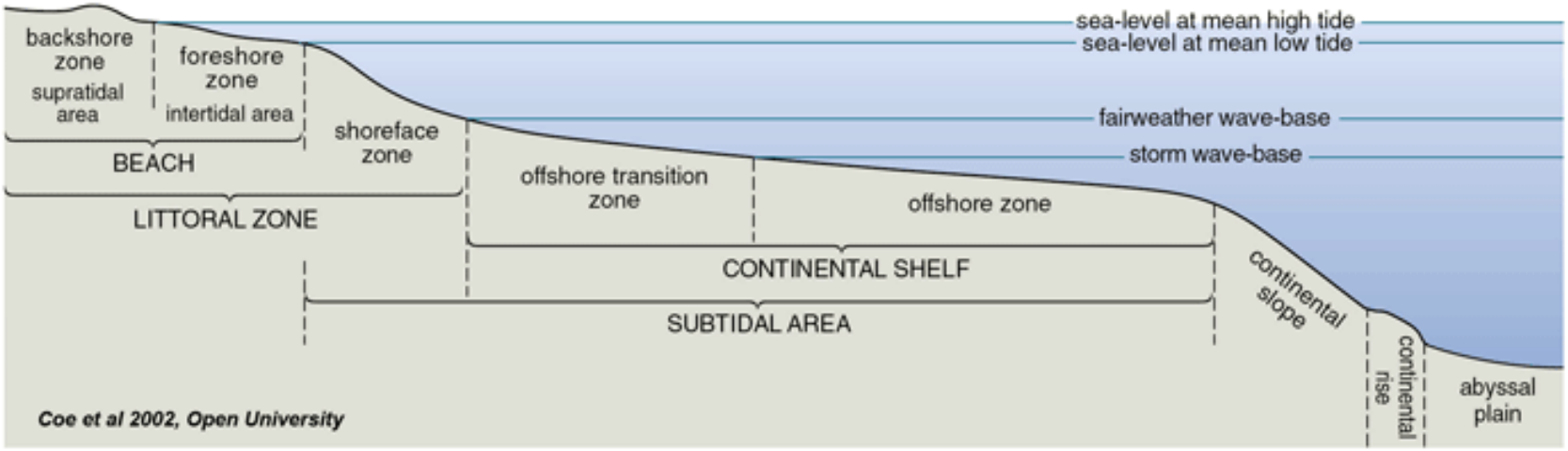
Shallow seas - types

- Pericontinental
  - Ave. 2m/km slope
- Epicontinental (Epeiric seas)
  - Ave. 0.05m/km slope

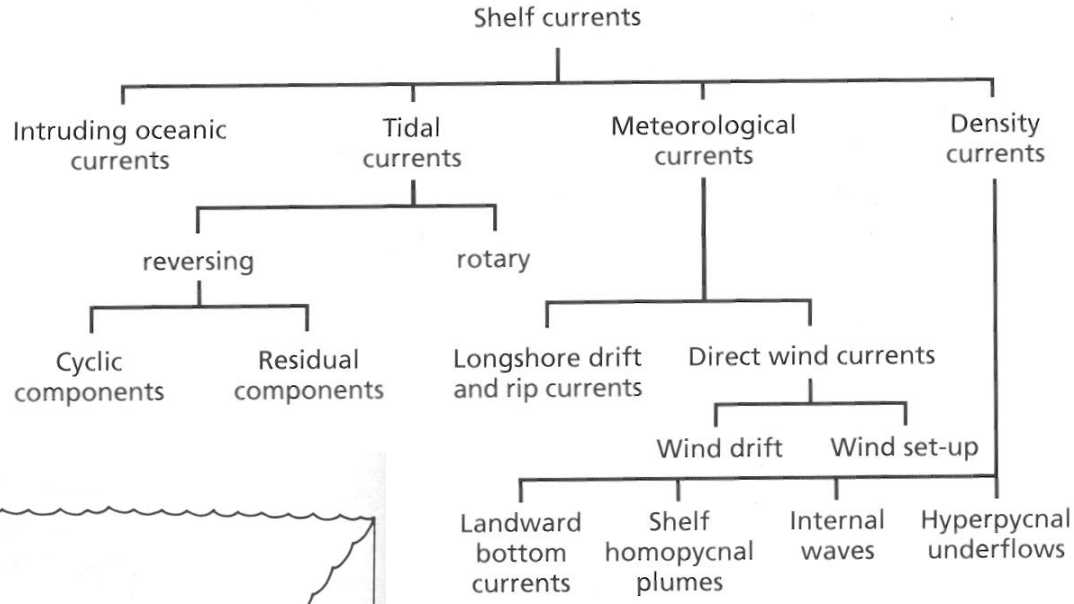


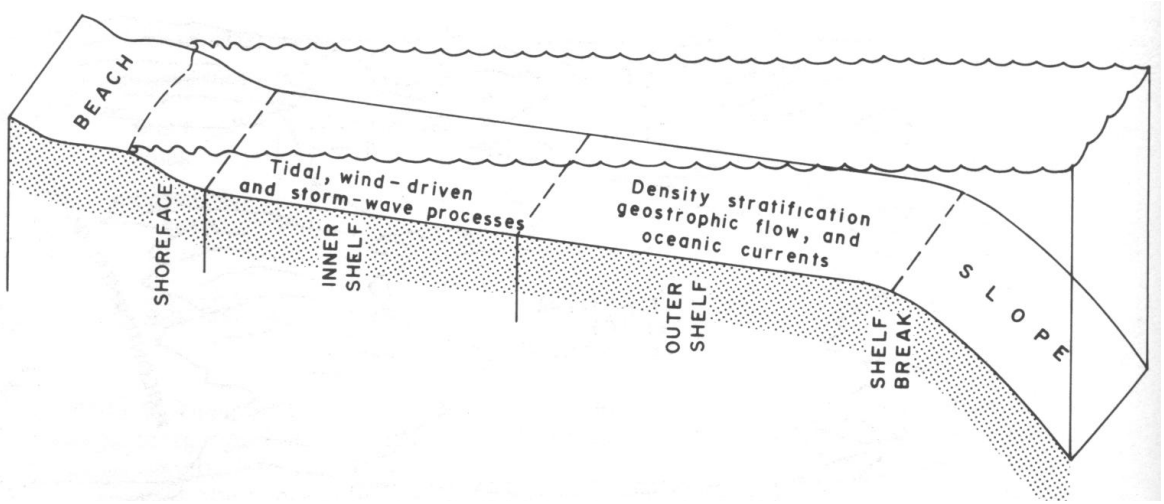
Wave Base and Other Surfaces tied to the position of the sea

- Wave base is the water depth beneath which there is no wave movement. This depth has been determined to be half the distance between the crests of waves. Fairweather wave base refers to the depth beneath the average daily waves while storm wave base refers to the depth beneath storm driven waves and is often much deeper.



- Sediment is dispersed by a complicated fluid dynamical mixture of tidal, wave, wind, oceanic and density currents

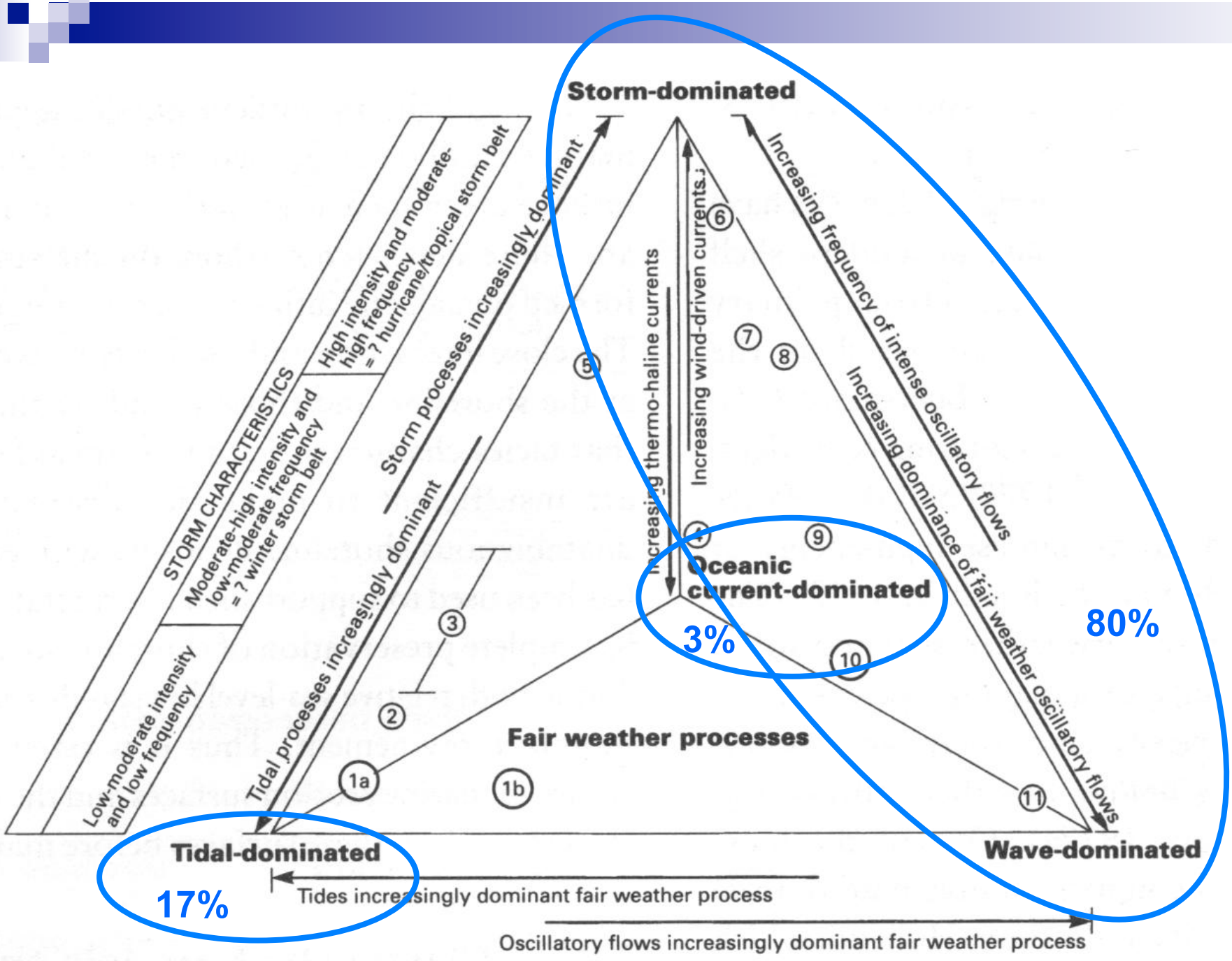




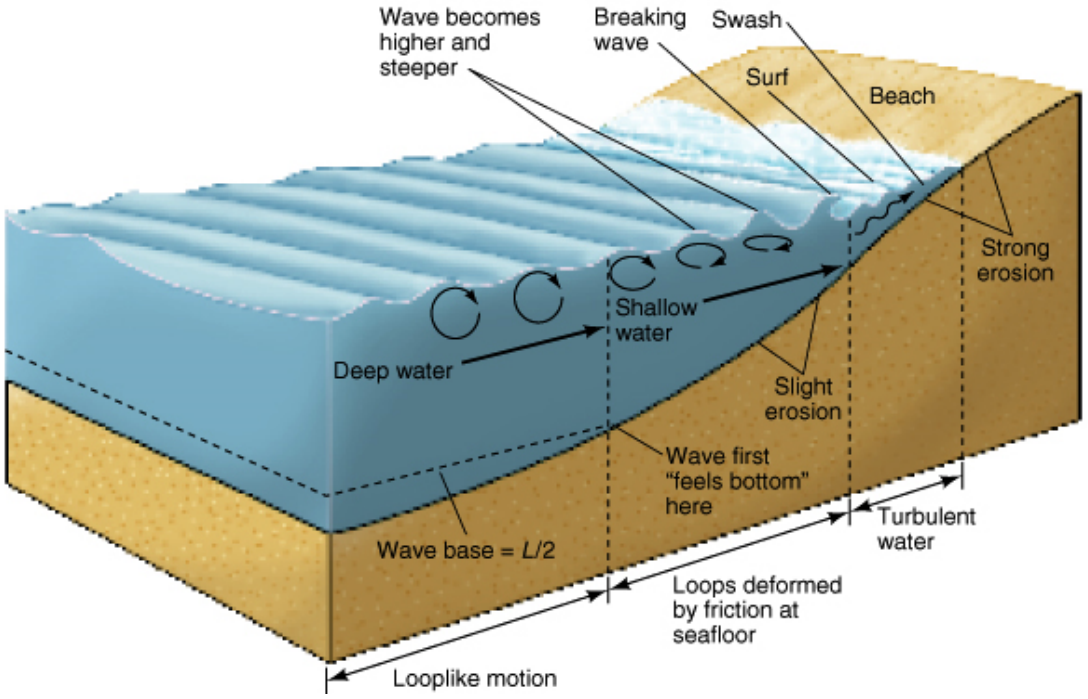
Sediment transport

- Shelf hydraulic regimes characterised by interaction of fairweather processes and storm processes.

- Four main types of shelf based on hydraulic regime
  - Tide-dominated
  - Wave-dominated
  - Storm-dominated
  - Oceanic-current-dominated


Storm-dominated
STORM CHARACTERISTICS
High intensity and moderate-high frequency = ? hurricane/tropical storm belt
Moderate-high intensity and low-moderate frequency = ? winter storm belt
Low-moderate intensity and low frequency
Storm processes increasingly dominant
Tidal processes increasingly dominant
Increasing thermo-haline currents
Increasing wind-driven currents
Increasing frequency of intense oscillatory flows
Increasing dominance of fair weather oscillatory flows
Oceanic current-dominated
3%
80%
Fair weather processes
1a
1b
2
3
5
6
7
8
9
10
11
Tidal-dominated
17%
Wave-dominated
Tides increasingly dominant fair weather process
Oscillatory flows increasingly dominant fair weather process

Storm-dominated shelves



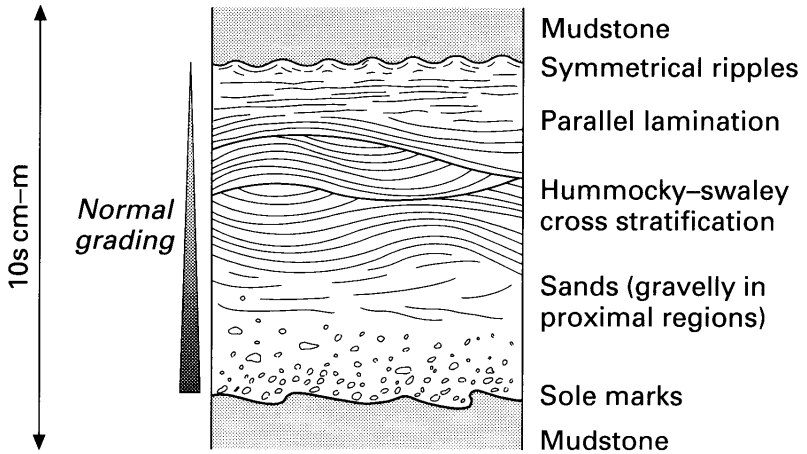
- HCS (Hummocky cross-stratification)
- Tempestites
- Small scours

Hummocky-cross stratification

- Results from re-suspension of sediment where storm waves hit the seabed making a hummock-and-swale topography on the seafloor

Tempestites

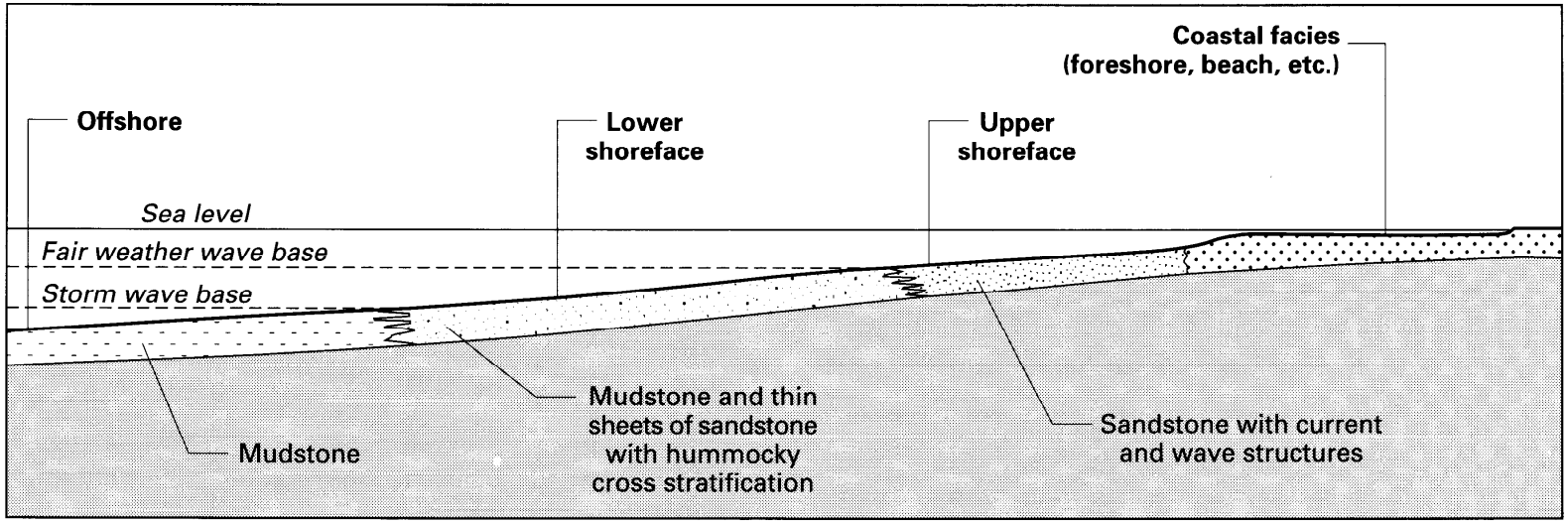
- The deposits that form during storm reworking of sediment on the shelf
- Sudden, catastrophic deposits
- Fining upwards sequence



Small scours

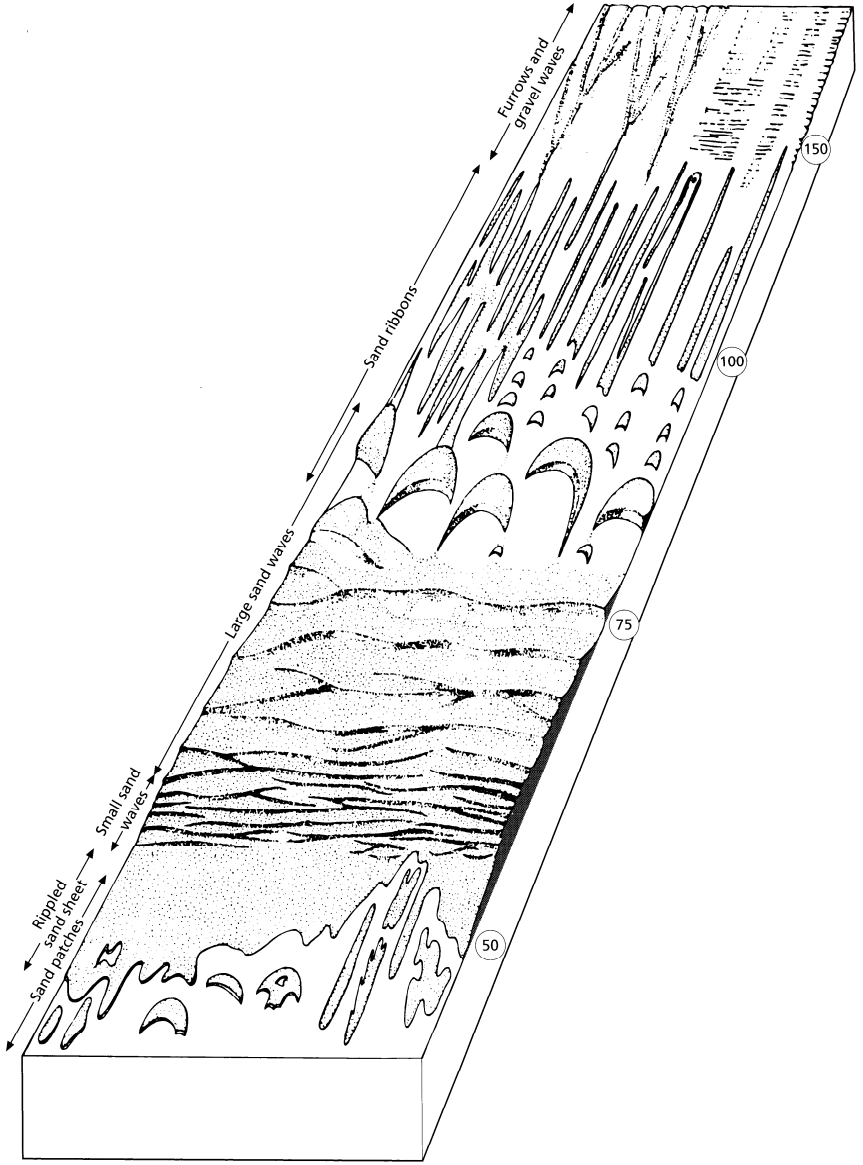
- Fine sand scours in shale

Storm-dominated shelf facies



Tide-dominated shelves

- Tide-dominated shelves are defined as those where the tidal range is macrotidal, greater than 3-4m, and typical tidal current speeds (at mean spring) range from 60 to > 100cm/s. these account for ~17% of the worlds modern shelves



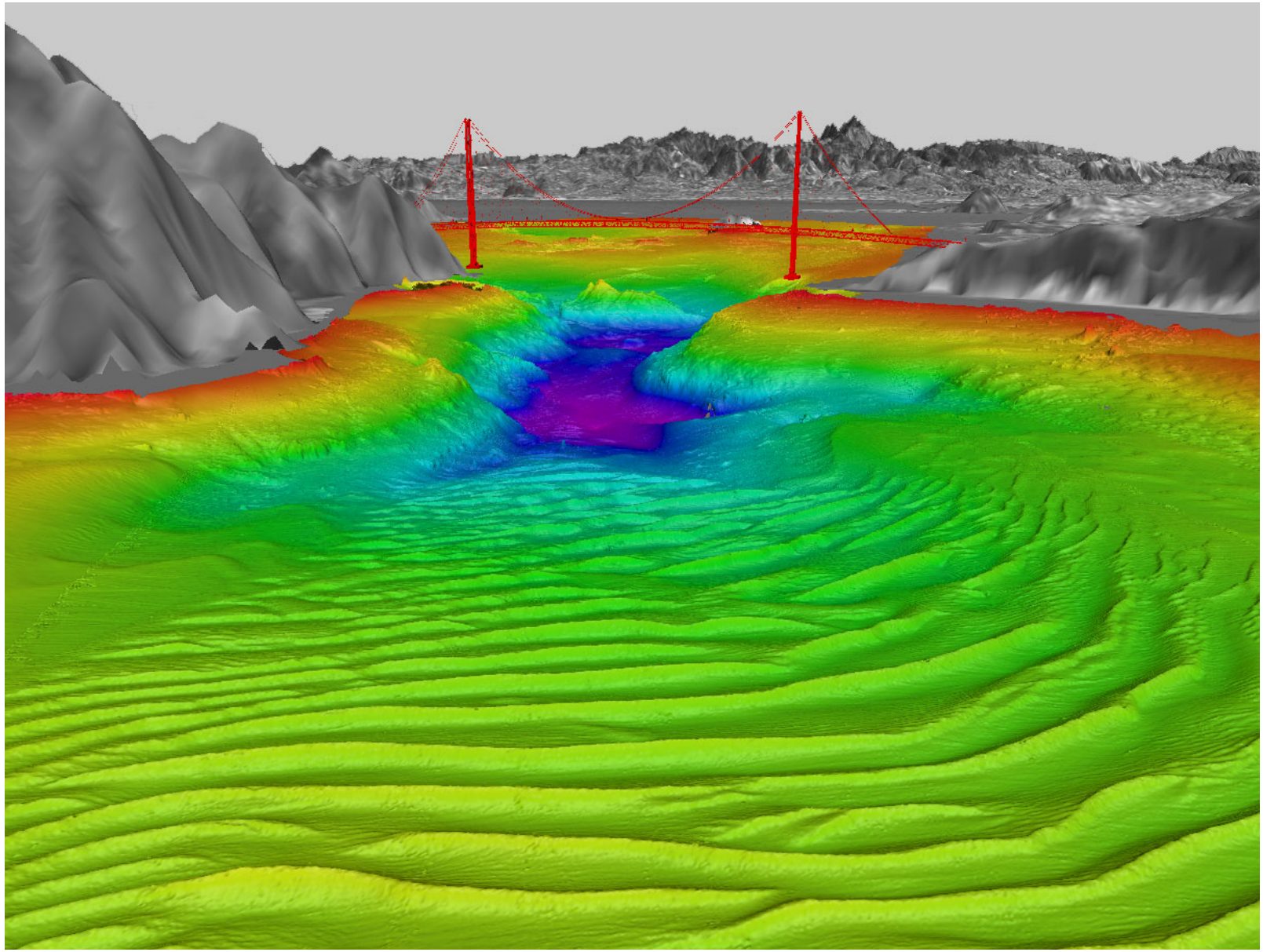
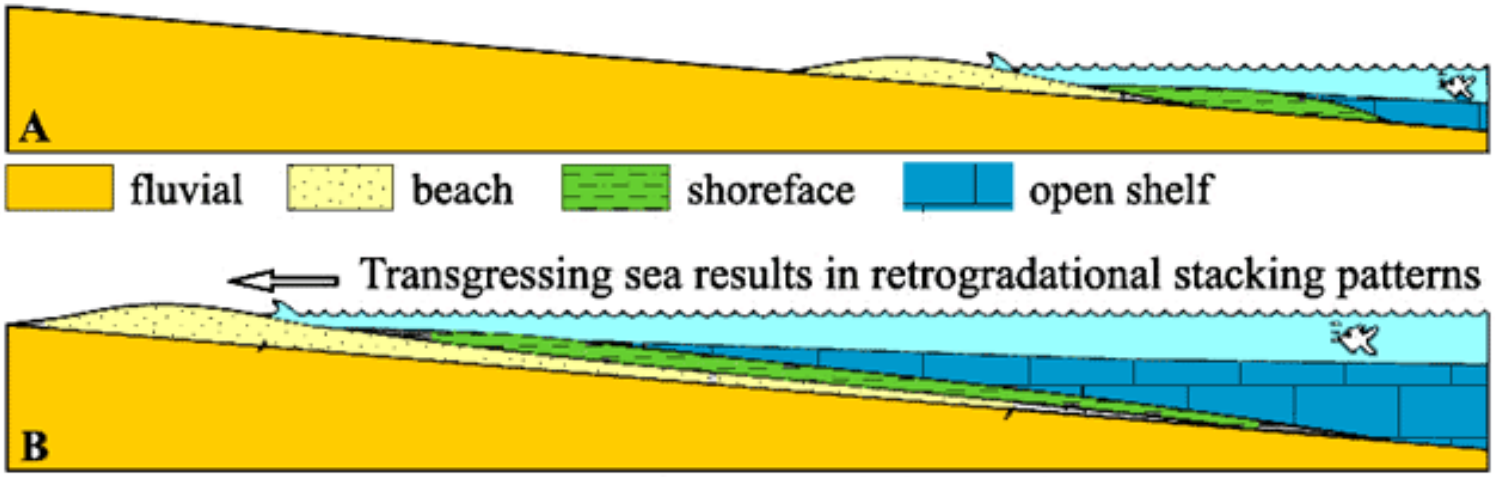


Image from USGS

Transgression

- A landward movement of the shoreline indicated by a landward migration of the littoral facies in a given stratigraphic unit (Mitchum, AAPG Memoir 26)

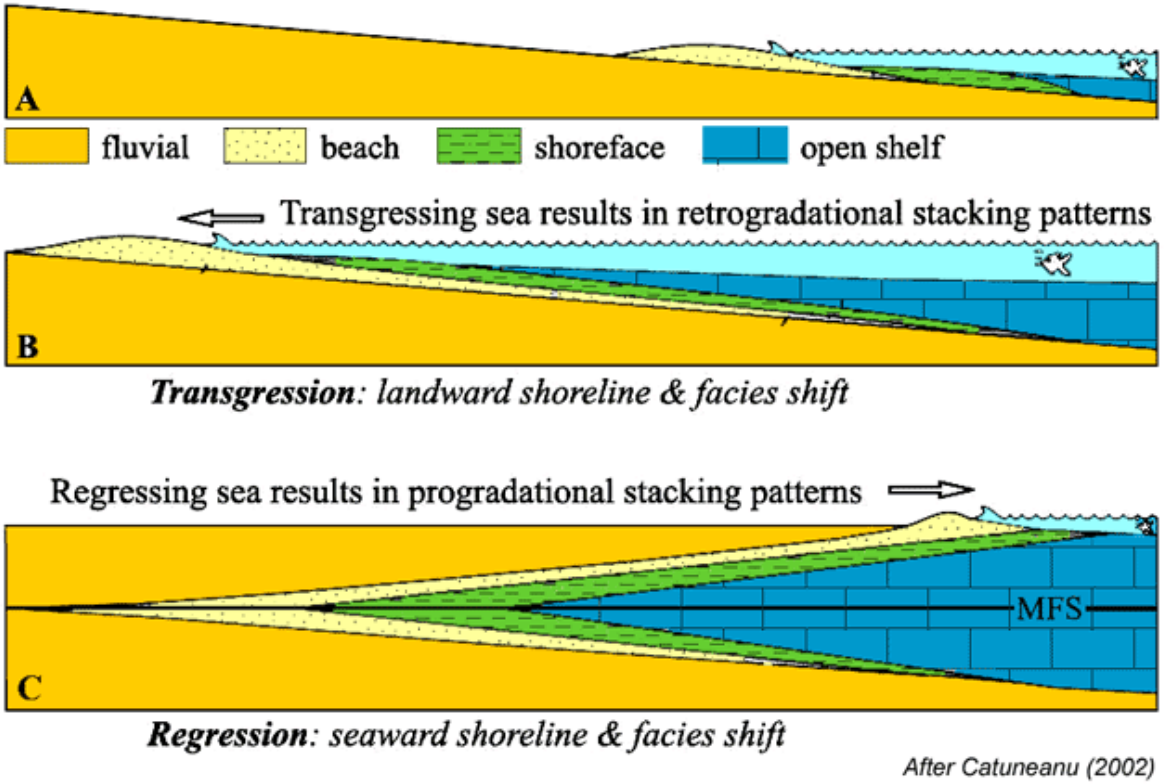
- A transgression occurs when the rate of sea level rise landward exceeds the rate of sediment input and causes an increase in accommodation, initiating the development of a transgressive surface over which the trangressive sediments of the Transgressive Systems Tract onlap and retrograde.



***Transgression**: landward shoreline & facies shift*

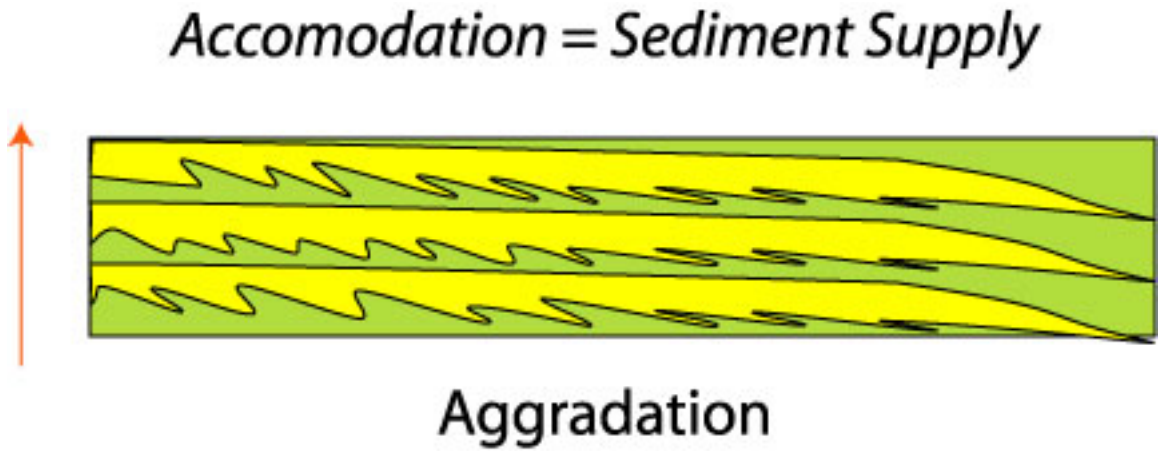
Regression

- A seaward movement of the shoreline indicated by seaward migration of the littoral facies (Mitchum, 1977).



Aggradation

- Vertical build up of a sedimentary sequence. Usually occurs when there is a relative rise in sea level produced by subsidence and/or eustatic sea-level rise, and the rate of sediment influx is sufficient to maintain the depositional surface at or near sea level. Occurs when sediment flux = rate of sea-level rise.



Sea-level vs sediment influx

- If the relative sea level rises and there is a zero or low sediment flux, then transgression results.
- If relative sea level rises and there is a low rate of sediment flux, then retrogradation of the coastal parasequence results.
- If relative sea level rises and the rate of sediment flux matches the sea level rise, then aggradation of the coastal parasequence results.
- If relative sea level rises and the rate of sediment flux exceeds the sea level rise, then progradation of the coastal parasequence results.

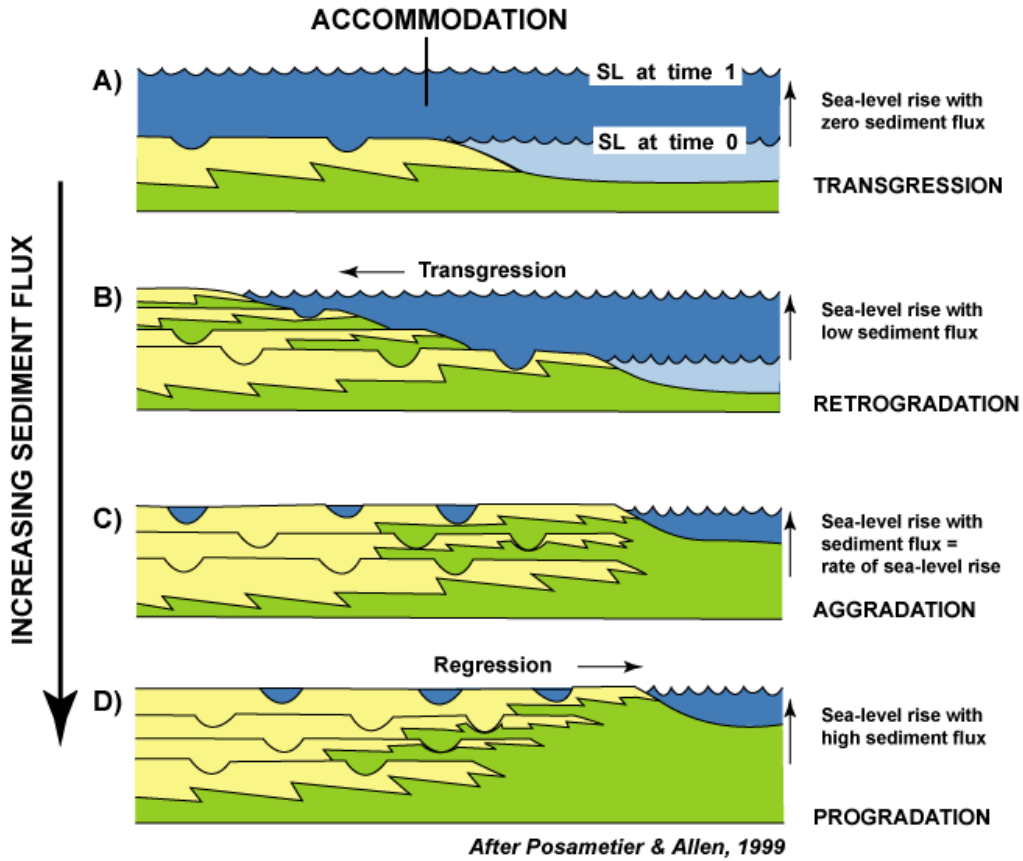


Table 7.1 Coastal and shelf depositional systems, complexes and systems tracts as developed under regressive and transgressive settings (after Swift, Phillips & Thorne, 1991a).

	Regressive settings	Transgressive settings
Coastal settings	Regressive intra-coastal systems tract	Back-barrier systems tract
	Strandplain or chenier plain systems	Beach-dune–washover-fan complexes
	Deltaic-channel–mouth-bar complexes	Tidal-delta–tidal-channel complexes
Shelf settings	Regressive shelf systems tract	Transgressive shelf systems tract
	Regressive shoreface–shelf systems	Transgressive shoreface–shelf systems
	Prodelta plume systems	Sand ridge complexes
	Fine-grained deceleration sheets	Coarse-grained deceleration sheets

Coastal Depositional Systems

- Form proximal to shorelines
- Geographically narrow, geologically important
- Fluid flow transport and deposition
  - Surface waves
  - Tidal waves (not tsunami!)
  - Fluvial input
- Grain-size decreases with deeper water
- Onshore, offshore & longshore sediment transport important
- Net sediment input (often from rivers) often leads to *progradational* geometries
- Important for tracking sea-level changes