



U3A

Surface processes

Coastal processes and landforms

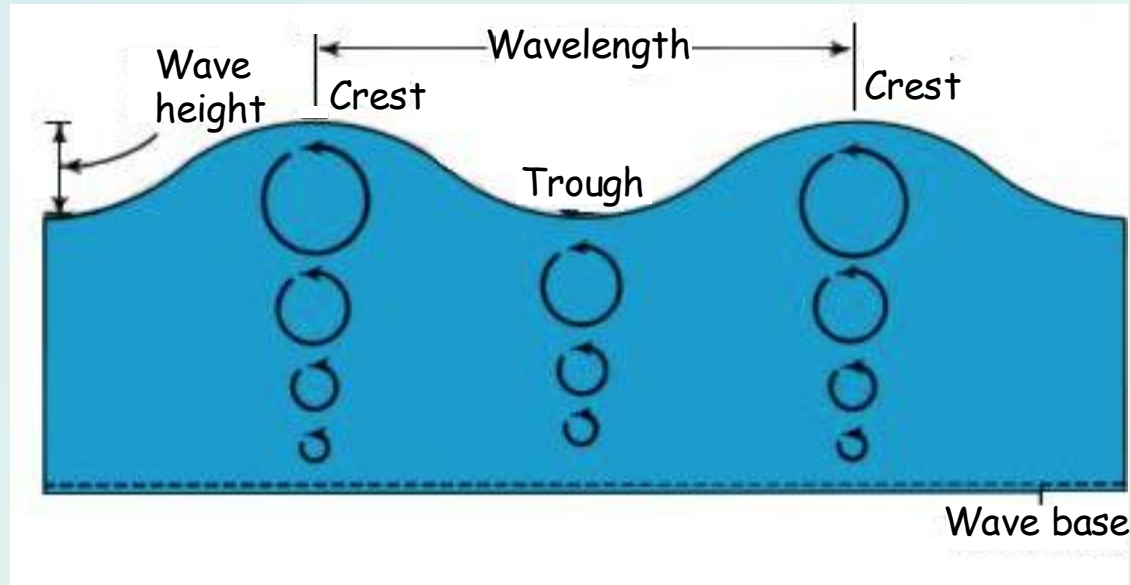
Coastal processes

- Coastal processes (erosion, deposition) dominated by waves
- tidal processes are also important but not as effective as waves
- coastal processes sculpture coastline forming a variety of different landforms
- in Australia the coastline is being constantly sculptured and reformed by wave action

Waves

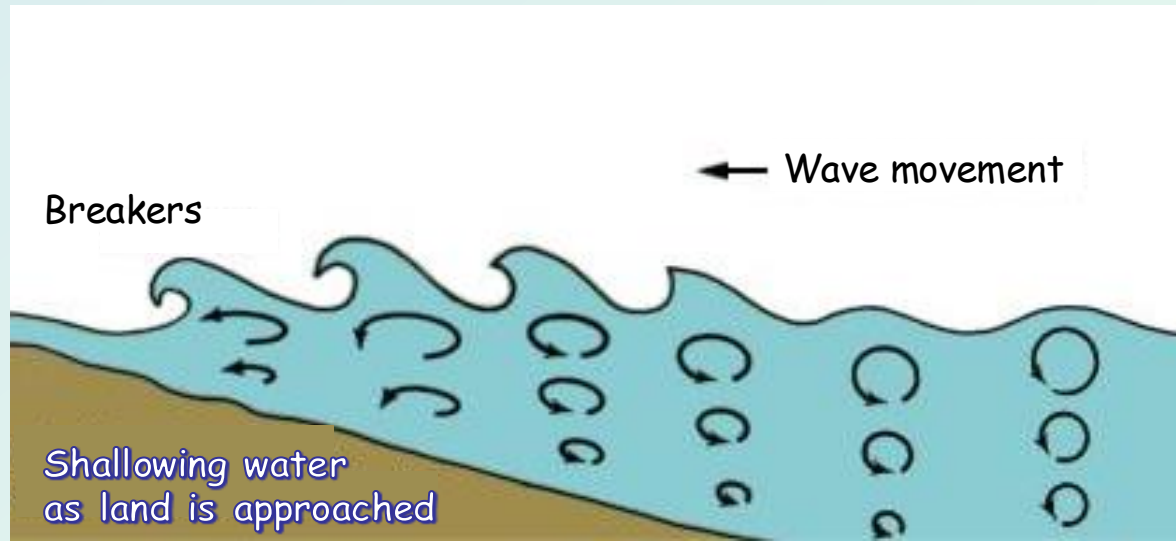
- Waves are dominantly formed by wind blowing over water → travel from loci of formation and hit coast → release their energy
- waves also formed by tsunamis (seismic waves)
 - result from submarine earthquake activity
 - long wavelengths (up to several hundred km)
 - fast moving (500-800kph)
 - low amplitude in open ocean (50 -60cm)
 - waves hit coast → friction with bottom → rise to great heights

Particle motion in deep ocean



- Waves behave differently in deep parts of ocean to shallow parts
- particles in a wave travel circular paths
- the water in a deep-water wave does not move forward
- below wave base ($1/2$ wavelength), wave effects are negligible

Particle motion in shallow water



Shallow water ($\text{depth} < \frac{1}{2}\lambda$) $\rightarrow$ waves are disrupted

- waves interact with bottom
- water movement becomes elliptical
 - back and forth movement on sea floor $\rightarrow$ water ripples

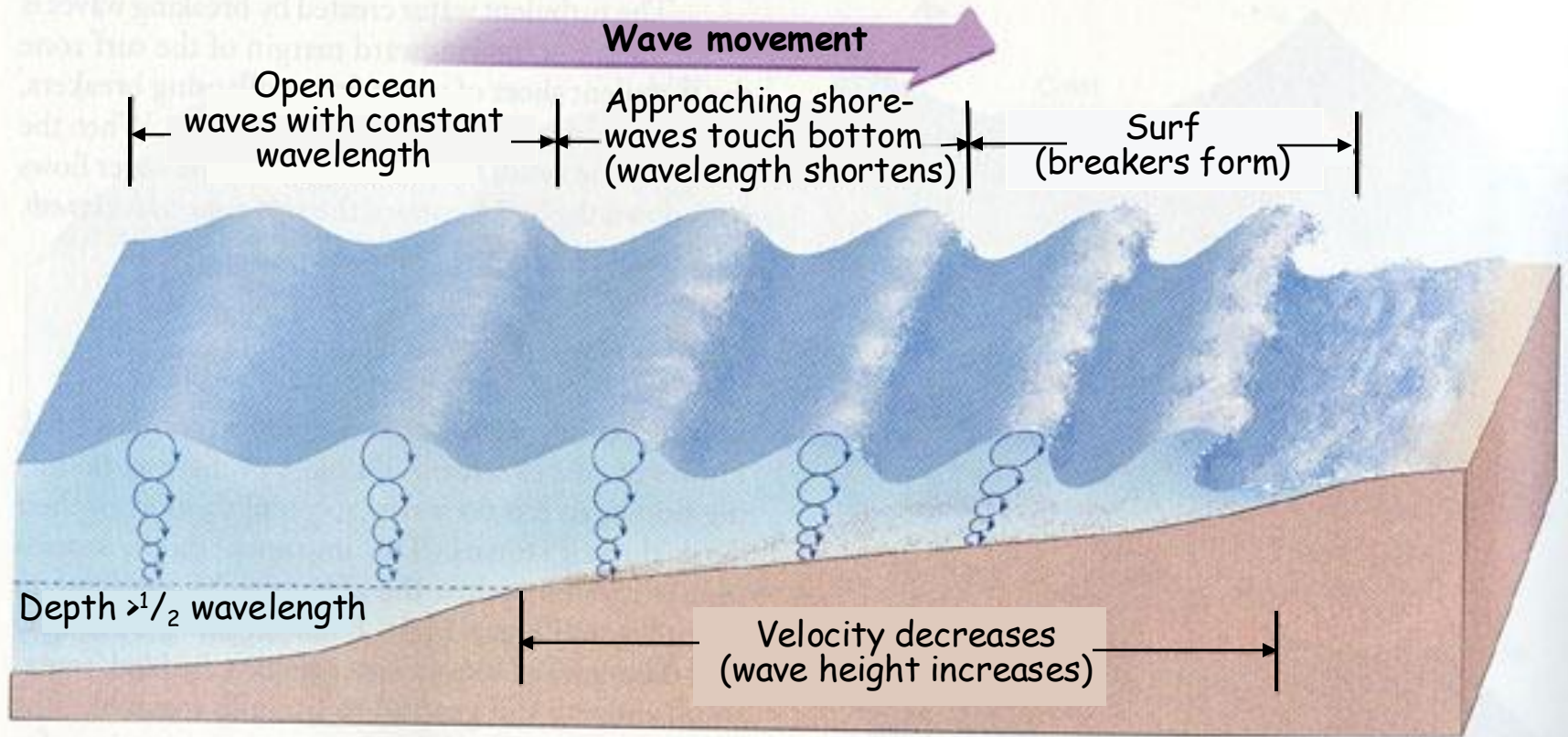
Breaking waves

- Waves come in from open ocean → cross edge of shelf
- react to sea bottom at $\frac{1}{4}$ - $\frac{1}{2}$ wavelength
 - bottom of waves slow down, tops continue on → heights of wave increase
- break on shore
 - water flowing up beach (swash) goes back to sea as backwash (undertow)
 - concentrated in rips



Breaking wave

Breakers

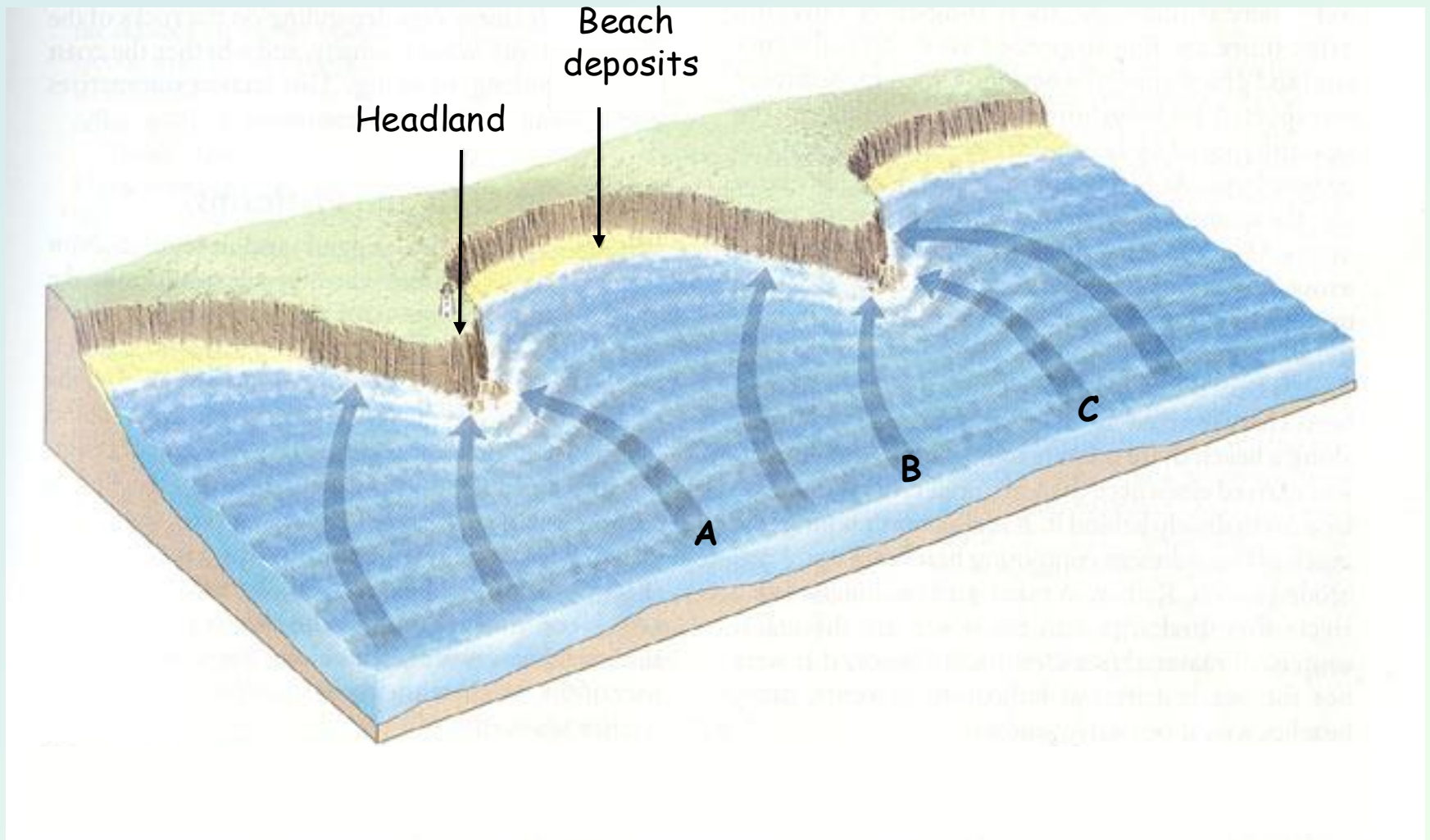


Wave refraction

- Wave refraction occurs where → irregularities along the coastline
- waves slow when they feel bottom → wave refraction
 - waves travel slowly towards headlands
 - faster into bays
- wave energy concentrated on headlands, dissipated into bays



Wave refraction

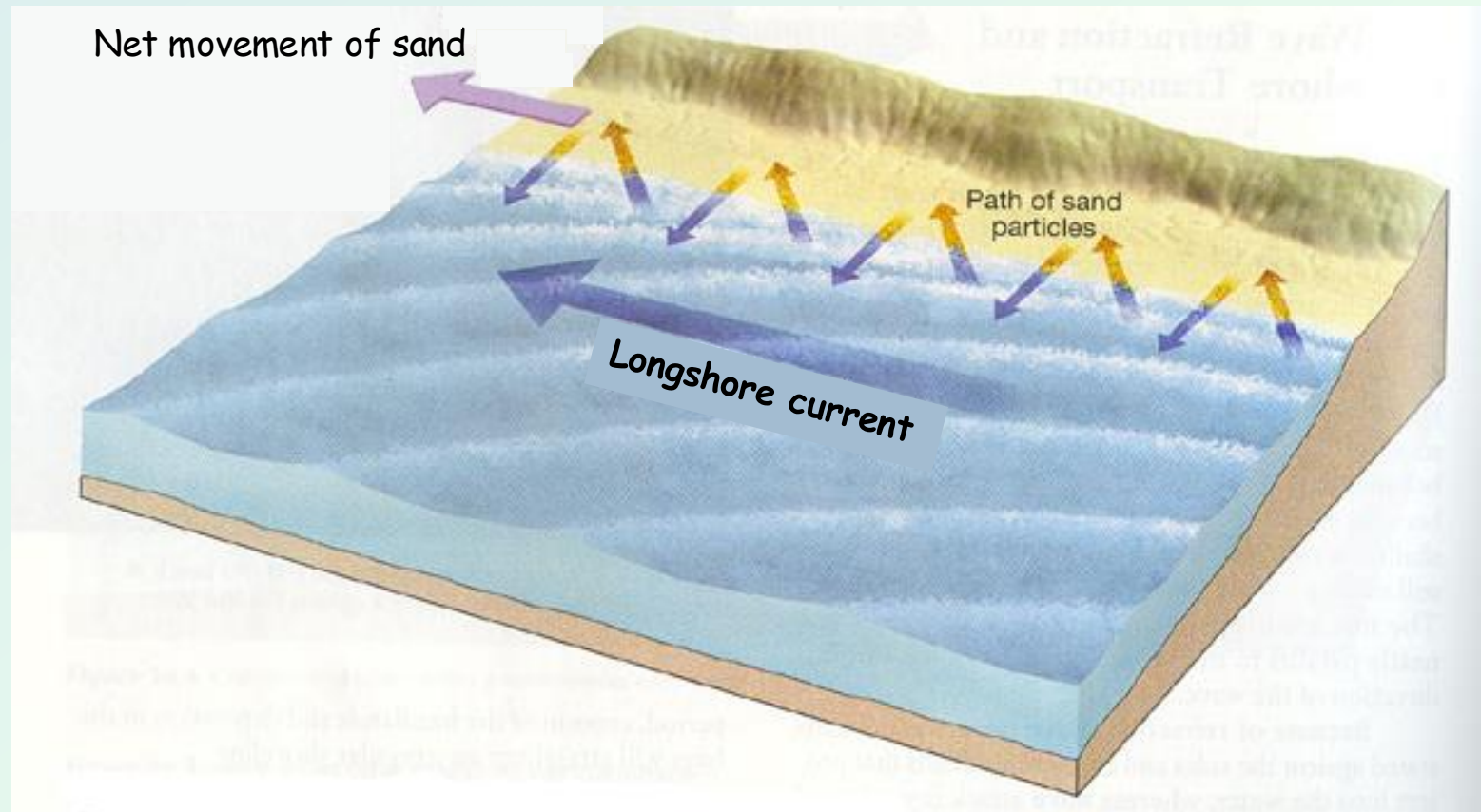


Longshore drift

- Waves do not always move in with wave crests parallel to coast
- it is common that there is an oblique component of wave action on most coasts
- wind direction will blow at an angle to the coast and sediment is transported along the coast → longshore drift
- waves generally recede from beach perpendicular to the shoreline
- longshore drift can produce a number of different coastal landforms e.g. spits, bay mouth bars, barrier islands and tombolos

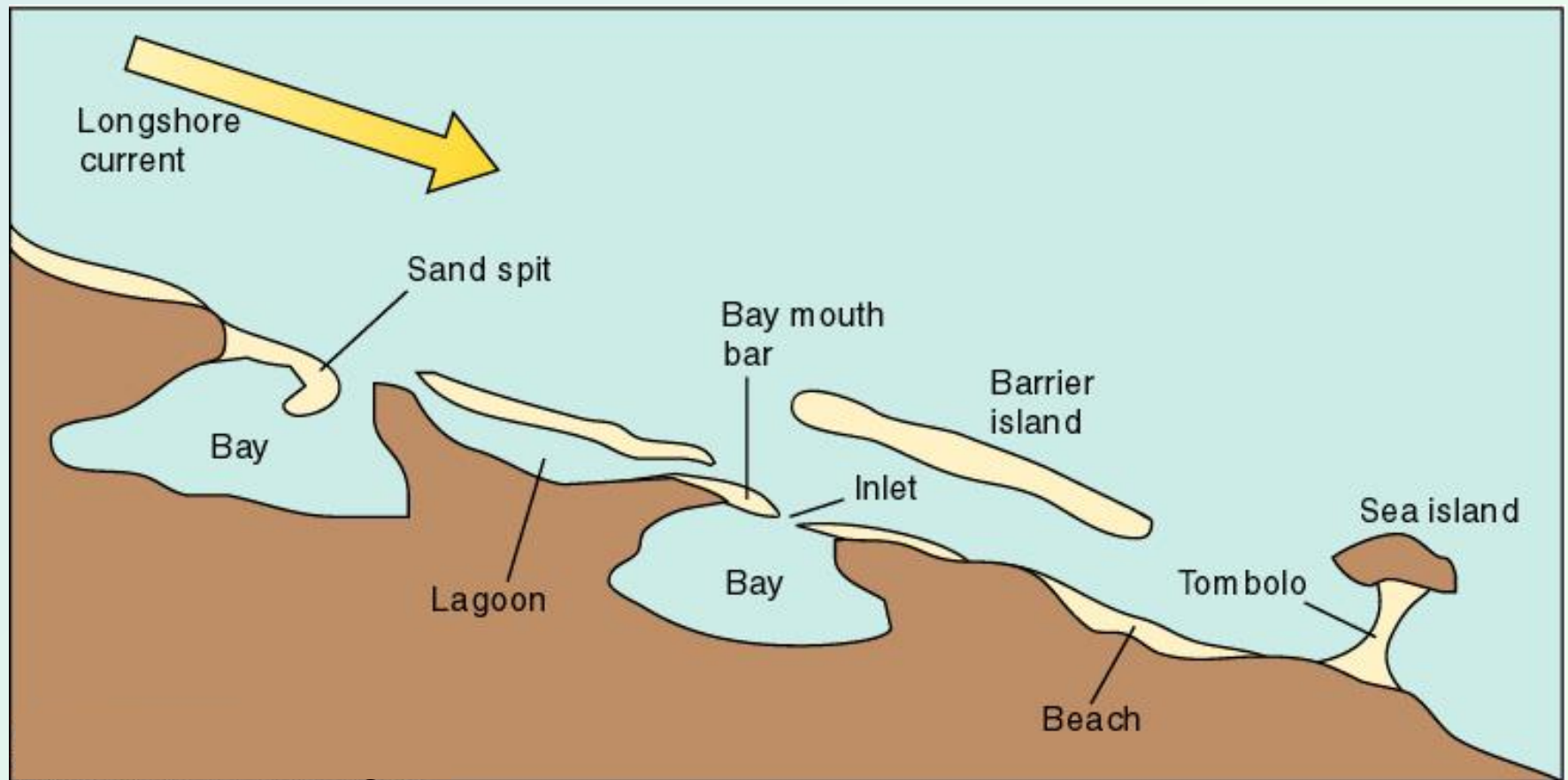
Longshore drift

- If waves oblique to shore (due to wind direction)
 - particles transported obliquely along shore by longshore drift



Coastal landforms produced by longshore drift

- Sand moves along coast due to longshore drift →
sand spits develop where sand slows down at mouth of bay
bay mouth bar if sand closes off mouth of bay

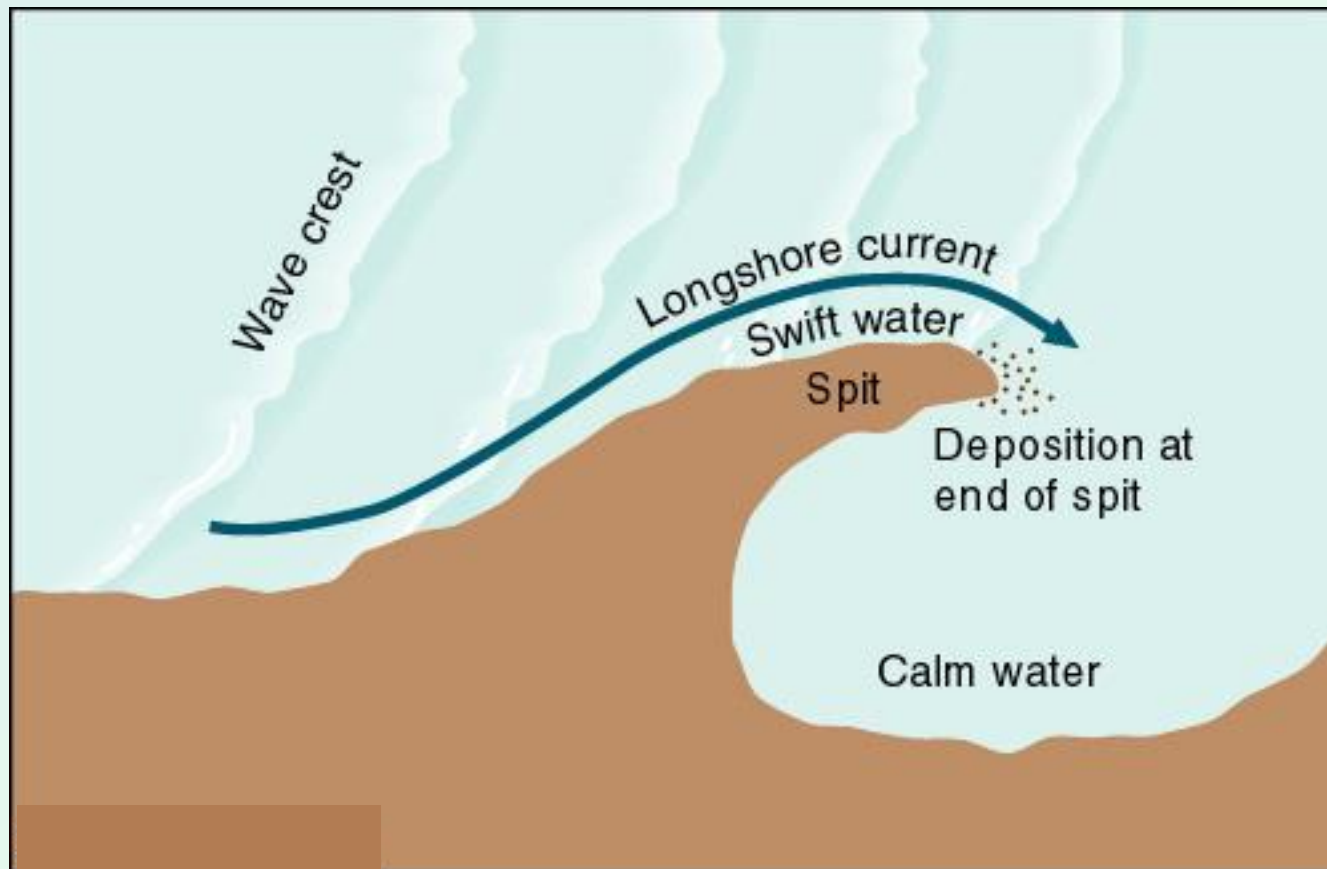


Spit formation

- Where longshore drift encounters an area of deep water (e.g. bay, inlet) → waves lose transporting energy
- sediment being transported → deposited as a spit → finger-like sediment ridge extending from land into open water
- when waves entering bay are strong → spit becomes curved
- a spit that continues across a bay may form a baymouth bar

Spit formation

The longshore current slows down after it goes around a headland. The sand gets deposited at the mouth of the bay, forming a sand spit.





Farewell Spit, New Zealand, South Island

Tombolos

- **Tombolo** → sandy isthmus joining an island to the mainland
- tombolos form through the accretion of sand in the lee of an island where wave energy and longshore drift are reduced



Tombolo near Karystos,
Euboea, Greece

Sand bars

- When sand moves up the coast through longshore drift → it commonly forms bars across river mouths
- sand can accumulate behind breakwaters e.g. Tweed Heads
- to protect marinas and river mouths, groynes are constructed outwards from the coast
- areas on leeward side of the breakwater are depleted in sand
- beaches to N of Tweed Heads became depleted in sand

Bay mouth bar

- **Bay mouth bar** → sandbank that partially or completely closes a bay
- forms where a spit grows across the mouth of a bay
- usually composed of sand or gravel



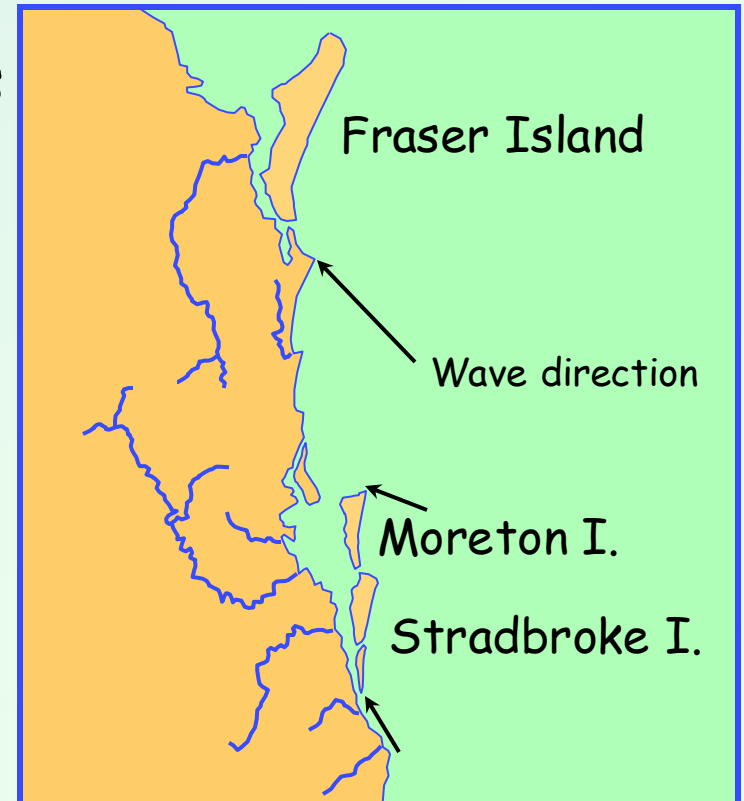
Bay mouth bar at mouth of Klamath River, California, USA

Tweed Heads



Sand barrier islands

- In Australia, longshore drift occurs with large amounts of sand moving N up the east coast of Australia → forms islands
- examples are islands off south coast of Qld e.g. Fraser, Moreton and Stradbroke
- these islands are called barrier islands and are elongate parallel to the coast
- typically separated from coast by lagoons



Wave erosion

- Waves have enormous power, particularly during storms
 - shift blocks weighing >2,000 tons
 - spray can travel at more than 100km/hour
- wave erosion due to several processes eg. hydraulic action, abrasion, dissolution
- main erosion along coastlines results from hydraulic action
- dissolution in water - very effective in limestones

Wave erosion by hydraulic action

- The main erosion that occurs along coastlines results from hydraulic action → water pressure exerted by wave impact
- particularly effective in washing away poorly consolidated material that drops into the ocean
- wave hits jointed, well cemented rock → hydraulic pressure on water in joints → levers off blocks of rocks
- waves can erode cliff faces backwards up to several metres a year
- hydraulic pressure illustrated by blowholes → jets of water expelled with great force

Blow holes

Blow holes are the end product of a long geological process that may take place over thousands of years.

1. Waves impounding on coastal rock platforms and coastal cliffs can fracture the rocks
2. Constant impact can excavate tunnels through the rocks to form caves
3. Hydraulic pressure can compress air in the caves that propagate fractures that project up to the surface
4. Constant attack by the sea causes the rocks along these fractures to crumble and to form a chimney to the surface
5. Subsequent high tides or storms can produce jets of water that may reach heights of 30metres.

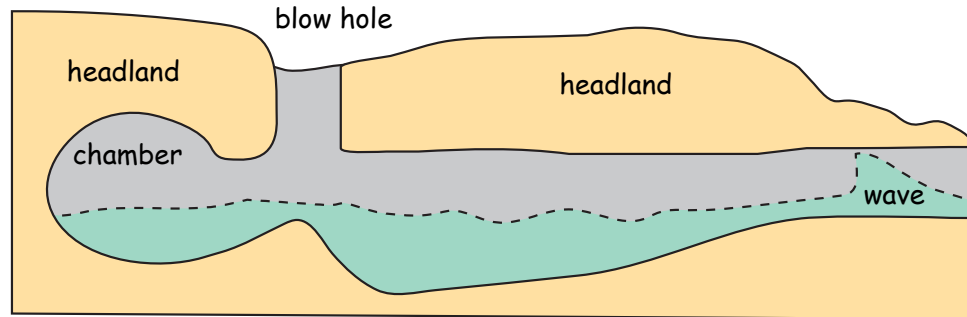
Kiama blow hole

- Kiama blow hole located in NSW town of Kiama ~30Km south of Wollongong
- Kiama headland → composed of Permian latite (alkali-rich andesite) that is intruded by a basalt dyke
- tunnel excavated by sea along basalt dyke → sea cave hollowed out
- the latite is columnar jointed with some columns collapsed to surface producing blowhole
- two blow holes, main blow hole → largest in world

Blow hole sequence

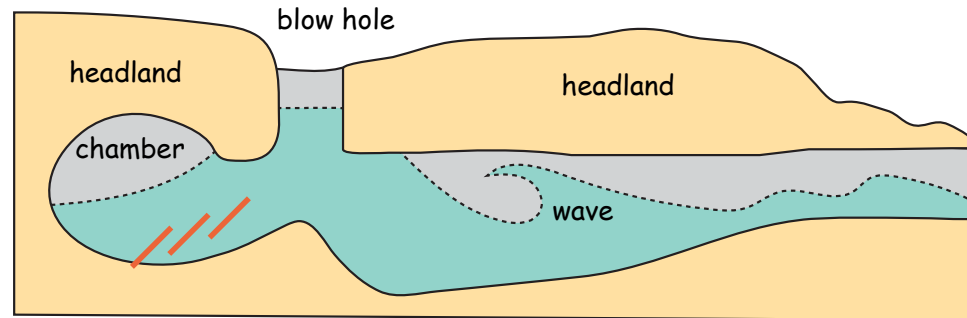
Incoming wave

1.



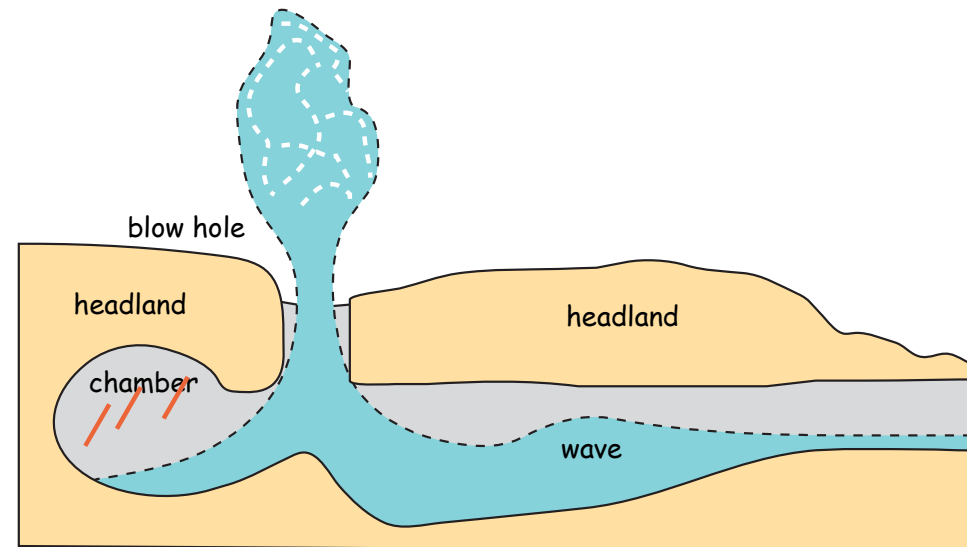
Compresses air in chamber at end of tunnel

2.



As wave recedes →
compressed air
forces water up
through blowhole

3.



Kiama blowhole



Coastal landscapes

- Coastal landscapes → dynamic zones where land meets the sea
- shaped by weathering, erosion and depositional processes driven by waves, wind and seaspray
- exhibit a range of features that are erosional (e.g. cliffs, caves, arches) or depositional (e.g. beaches, dunes, spits)
- a specific type of coastal landscape is determined by the interaction of local geology, wave energy, sediment supply and climate

Wave erosion by abrasion

- Abrasion is caused by transported sediments (particularly sand) abrading rocks as sediment impacts coast
- not so effective in eroding cliffs
- mainly involves mutual wear of rock fragments → flattened and rod-shaped pebbles and well-sorted sand

Landforms produced by wave erosion

- Wavecut platforms

- outcrops that are horizontal or slope gently seawards
- partially or completely exposed at low tide, covered at high tide
- formed by gradual erosion of cliffs by erosive action of waves

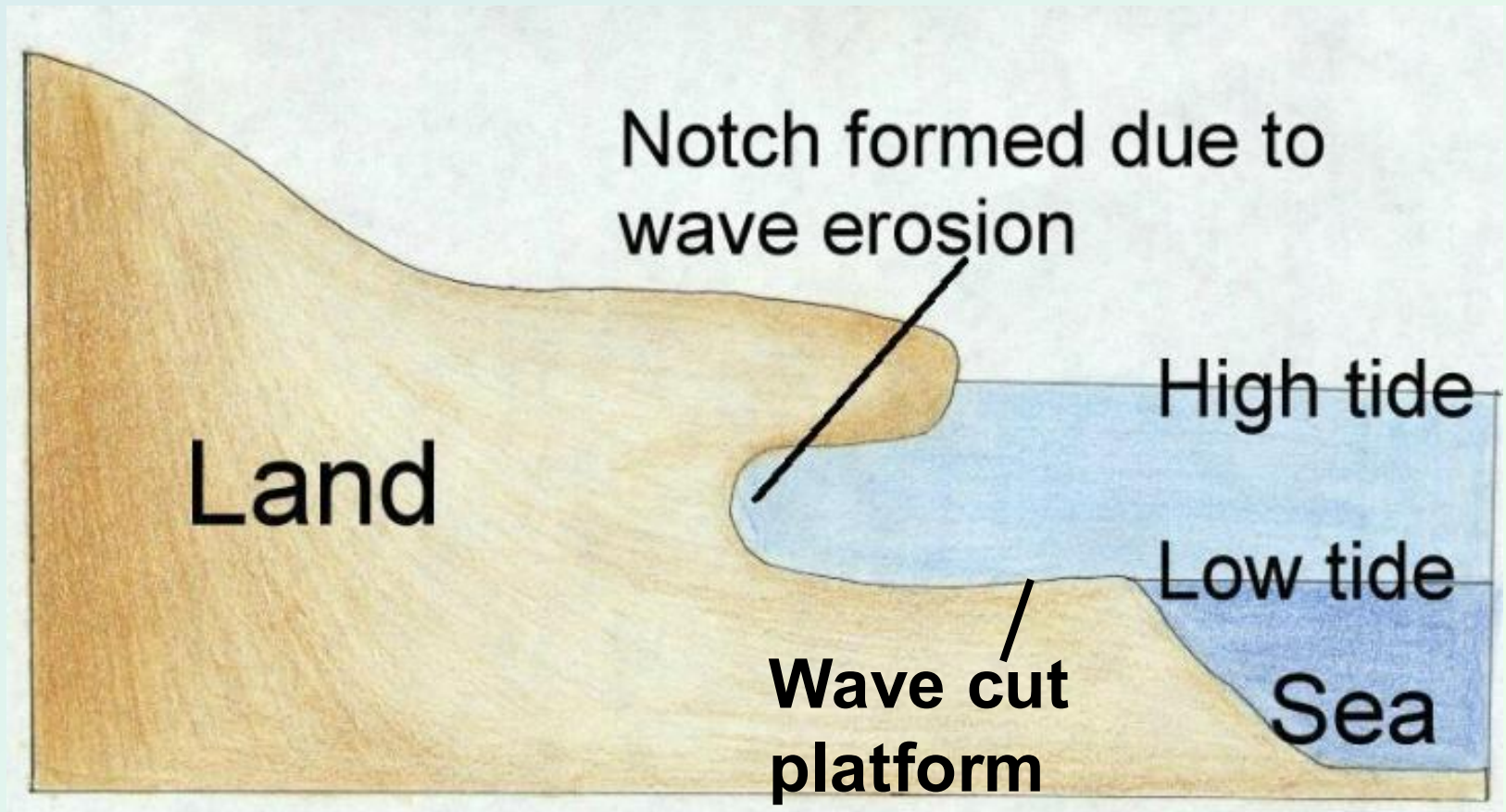
- notch at base of cliff

- can be due to chemical or hydraulic action at base of cliff
- chemical weathering involves dissolution and salt crystallisation

- stacks

- sometimes as a cliff is eroded backwards, there will be more resistant blocks left behind to form stacks

Wave cut platform, notch



Wave cut platform



Wave cut platform, Cape Liptrap, Vic.

Arch

- When two caves formed on opposite sides of a headland as a result of wave refraction unite → form arch
- later when arch falls in, seaward portion of headland → isolated stack forms



Arch, Port Campbell, Vic.

London Bridge collapse



London Bridge arch, Port Campbell
prior to 1990



London Bridge, Port Campbell, 2014

Stacks - Port Campbell, Vic.



Deposition in sandy shorelines

- Deposition in sandy shorelines occurs when energy from waves, currents and winds decreases causing loss of sediment load
→ forming sandy beaches, sand dunes and spits
- key processes involve constructive waves depositing sand with a stronger swash than backwash and longshore drift
- tidal processes also important → not as important as waves
- sand dunes accumulate as wind carries sand inland

Coastal sand dunes

- Coastal sand dunes → dynamic, wind-blown ridges of sand → form natural barriers along beaches
- begin with embryo dune where wind-blown sand is trapped by objects e.g. plants
- build into larger fore-dunes and secondary dunes inland



Sand dunes,
County Mayo, Ireland

Tidal deposition

- Tidal deposition
 - due to movement of sediment by tides
- tides
 - produced by gravitational effect of Moon and Sun on ocean water → approximate 13 hour cycle
- tidal flats (also known as mudflats), crossed by tidal channels
 - may also occur as offshore barriers and dunes that are exposed at low tide

Intertidal flat,
Stewart Island, NZ



Dunes in tidal channels

- Tidal channels → large, sand built bedforms formed by oscillating currents
 - large dunes migrate along channel floor
- areas where one tidal current dominant (most common situation)
 - during one dominant tidal flow, one cross-bed formed
 - tide slackens before turning
 - still water, mud deposited as thin drape
 - during subordinate tide, thin sand unit deposited, some erosion
 - forms "tidal bundles" of cross-beds



Intertidal dunes, Ruapuke, NZ

Tidal flats and sands

- Tidal flats → flat, low-lying intertidal areas where sediments from river runoff or, inflow from tides deposit mud or sand
 - thin layers of interbedded sand and mud
 - sand shows extensive rippling
 - mud is extensively burrowed
- Tidal barriers and dunes
 - composed of sand
 - large scale cross-bedding

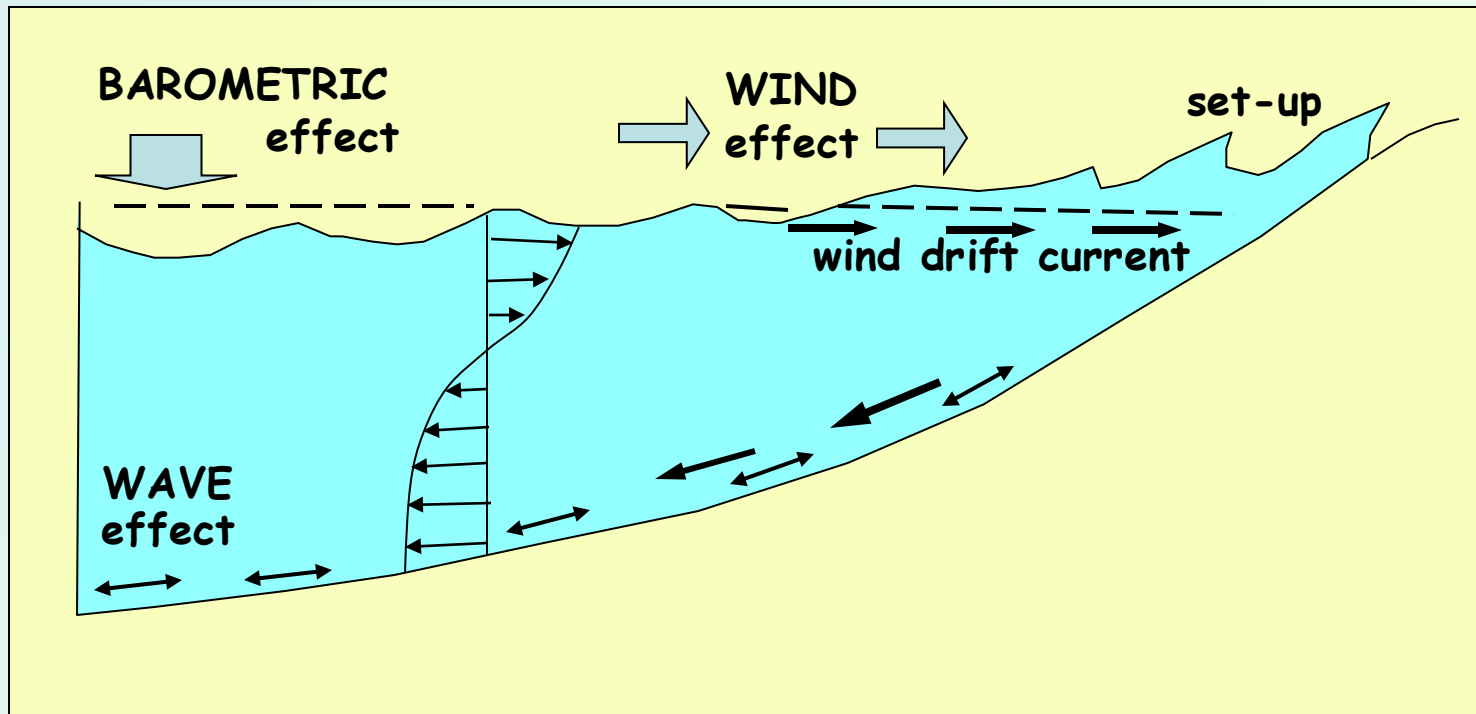


Deposition during storms

- Storm deposition
 - very important and easily recognised in sediment record
 - process where strong wave action and storm surges transport and deposit large volumes of sediment
- during storms
 - barometric effect (low pressure near shore)
 - wind effect (piling up water on coast)
 - temporary rise in sea level along coast "storm surge"
- return gradient current (rip) along sea floor
 - carries sediment eroded by wave action offshore

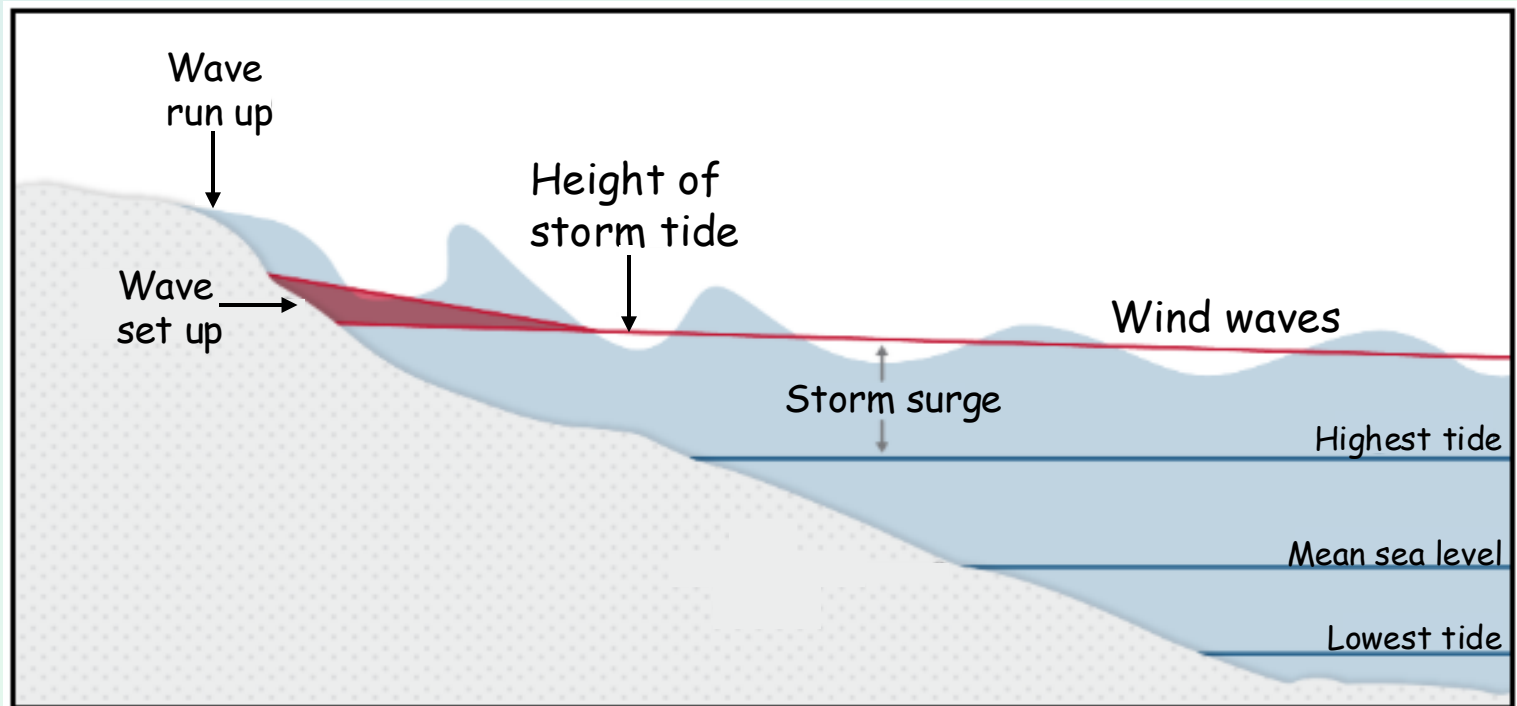
Storm rise in sea level near coast

Temporary rise in sea level near coast → storm surge → increased erosion → increased sedimentation offshore → distinctive sedimentary sequence



Causes of storm surge,

- (1) Wind - strong onshore winds from passing weather systems
- (2) Low pressure - allows sea surface to rise
- (3) Ocean depth and shelf width - shallow coastal waters and wide continental shelves can amplify storm surges
- (4) Timing of astronomical tides



Tempestites

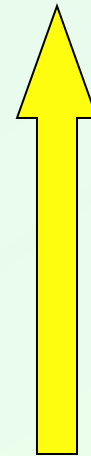
- Storm sediments that form offshore in slightly deeper water
 - get oscillation effect due to extra large storm waves
 - tempestites
- consist of four layers (generalised) :

muds

wave rippled sands

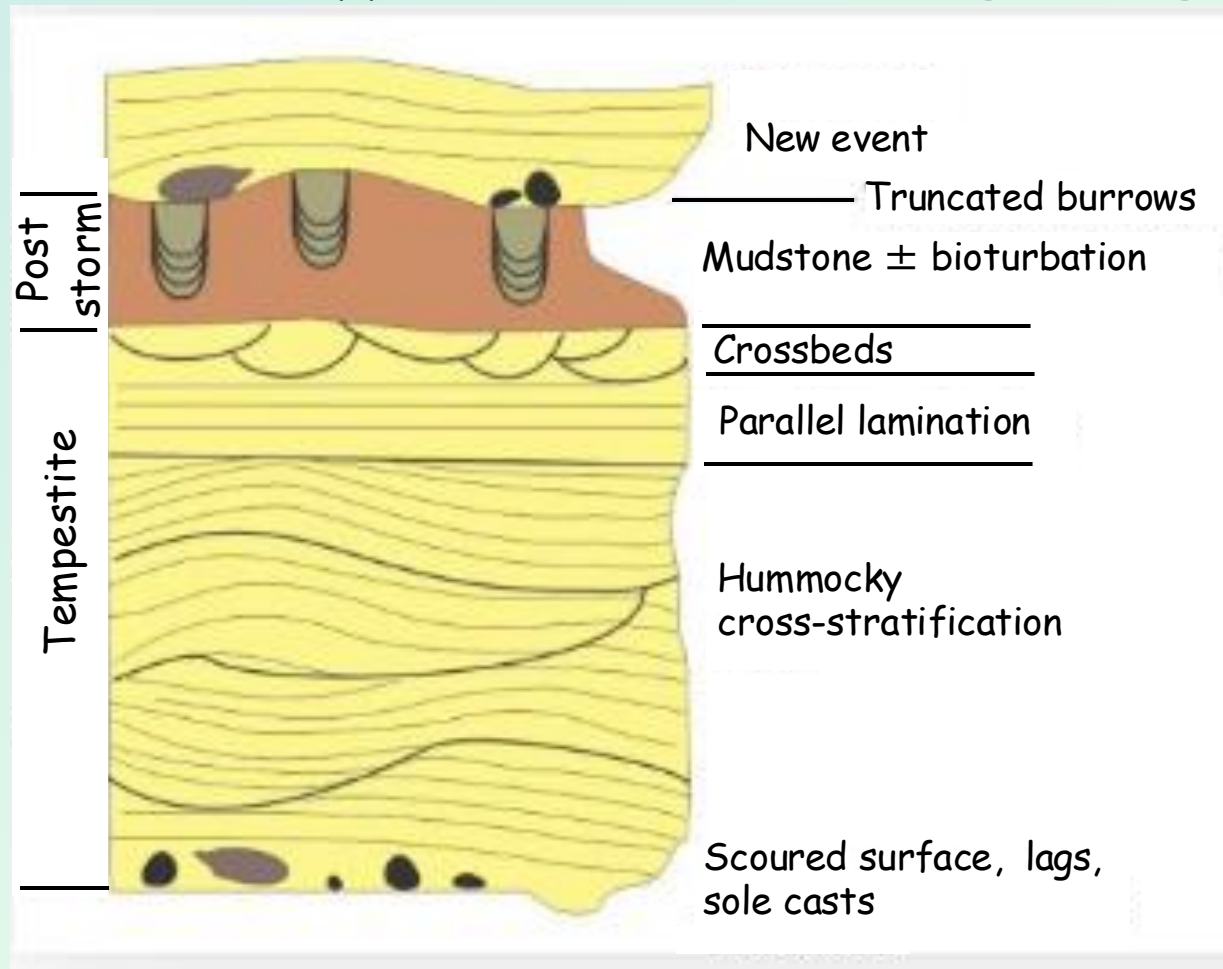
hummocky cross-stratified sands

deposition of coarse "lag" materials



Tempestites

- Lowermost facies → basal erosional surface
- overlying → transitional to cross-bedded lithofacies that include trough, tabular and ripple bedforms indicating waning conditions



Hummocky cross-stratification

Hummocky cross-stratification is characterised by low-angle curved laminations forming hummocks and swales that intersect at various angles. Structure is formed by combined action of oscillatory and unidirectional flows during large storms

