U3A

Rivers and sedimentary structures

Introduction

- Rivers vary from those that flow all year round → perennial
  to streams that flow intermittently resulting from high rainfall
  → ephemeral
- the term fluvial → commonly used when describing river features
  → simply means to do with rivers
- the course that a stream follows depends on slope of land and
  geological features such as fracture patterns and rock hardness
- tributaries are smaller streams → supply water and sediments to
  larger stream

Stream profile

- Streams and rivers erode on graded profile

  - uniform curve to base level

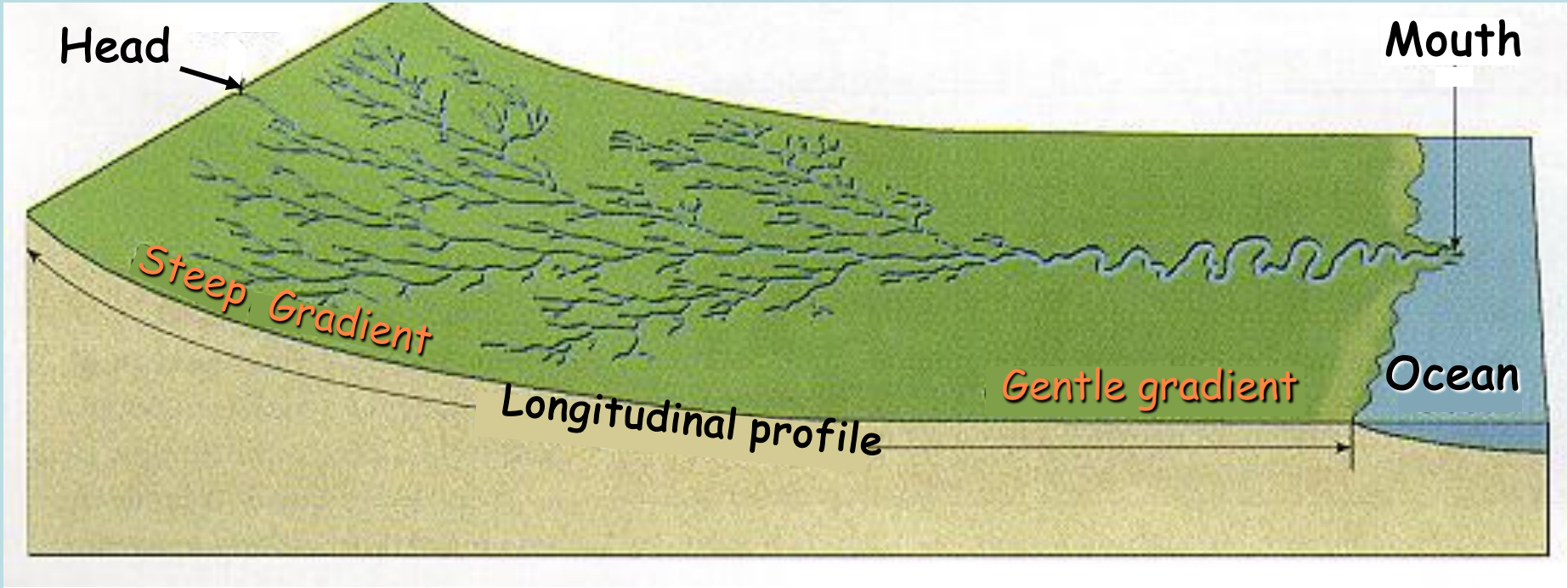
  - steeper upstream from base level

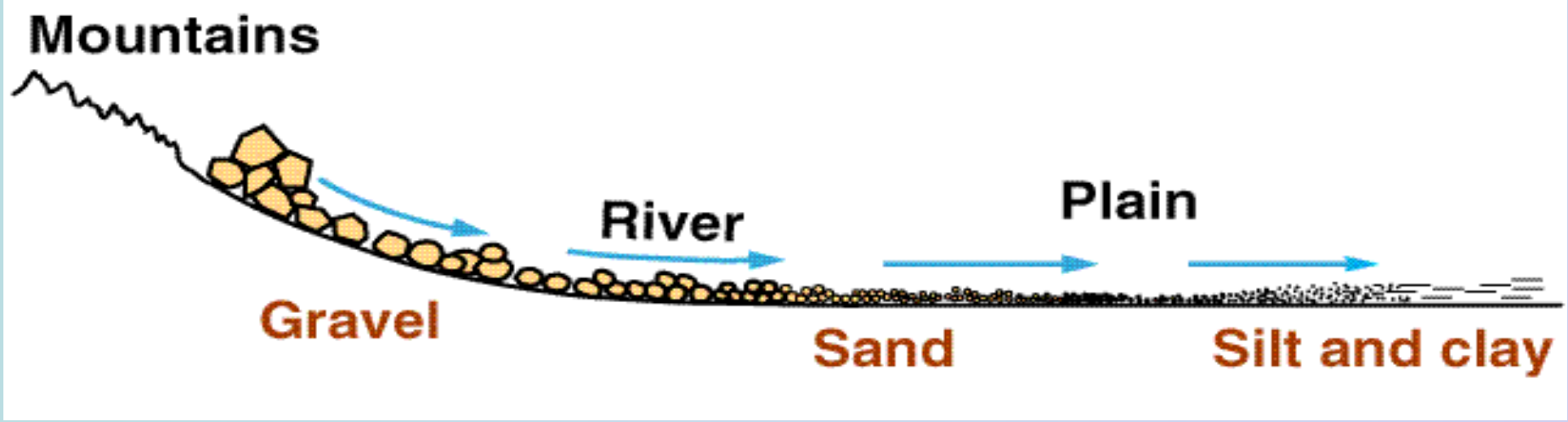
  - gradient flattens towards base level

  - gradient determines erosive power of stream

- profile is generalised → always contains irregularities
- can be divided into stages (or courses) based on gradient and geomorphology
- mountain (headwaters), valley and plain

Stream profile





Headwaters – mountain stage

- Area that provides drainage into one stream → drainage basin. Tributaries supply larger stream with water and sediment
- Headwaters → steep gradients, high energy, fast flow dominated by erosive processes, little deposition occurs
- large rock fragments (boulder, gravel) → broken up mainly by physical weathering in headlands
- coarse gravels and boulders deposited, abundant abrasion → forms finer sediment

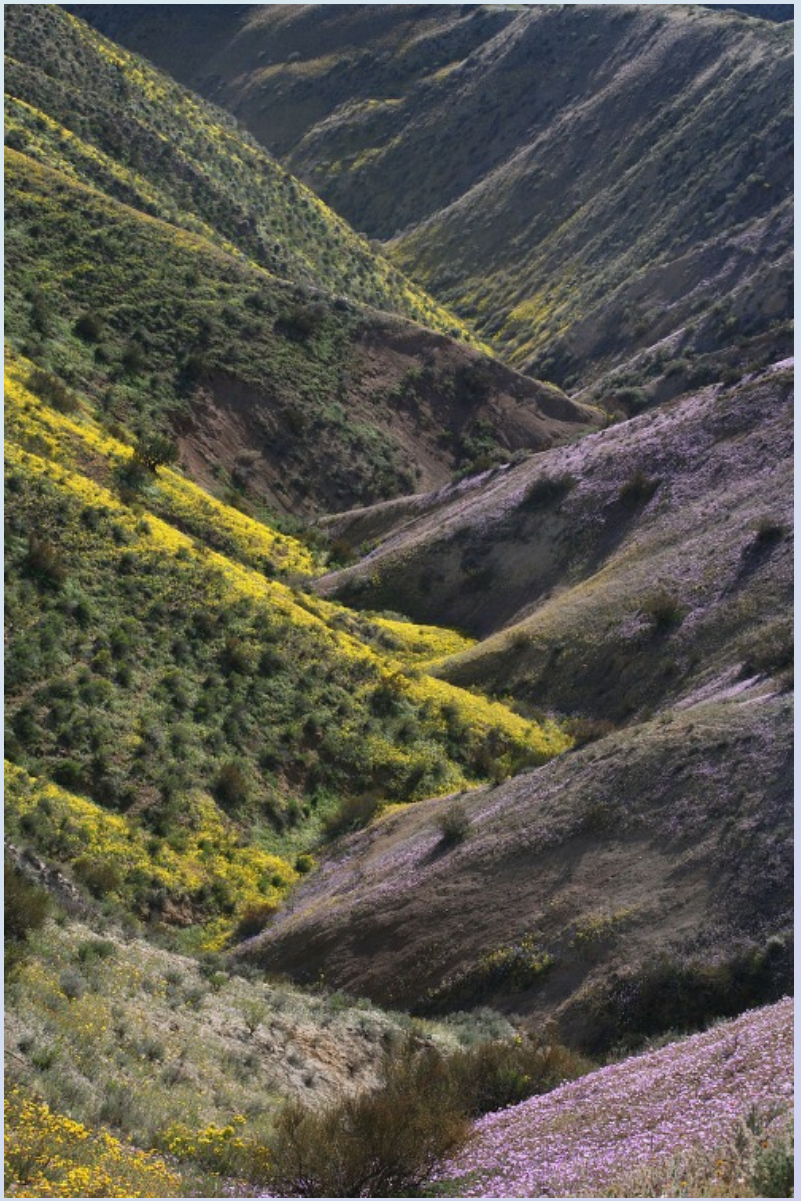
V-shaped valleys

- Erosion in mountain areas forms V-shaped valleys
- as a river cuts downwards, steep sides of valley cause rocks in valley wall to become unstable and collapse
- as walls erode, talus accumulates at base of valley → rivers clean this away at times of high rainfall
- valleys erode headwards i.e.backwards towards mountains

V-shaped river valley, Gunnison River. Colorado

Interlocking spurs

- Rivers not straight → series of interlocking spurs
- interlocking spurs → projecting ridges from opposite sides of valley walls of V-shaped valleys
- result from erosion of weak zones in bedrock
- form zig-zag valley



Interlocking spurs, Caritzo, California

Valley stage

- River slows down with decrease in gradient
- rivers do not form straight valleys → start to meander in the middle section
- downcutting not so prominent as in headwaters area
- deposition occurs as well as some erosive downcutting
- more lateral erosion occurs → trims spurs → valley becomes wider
- as kinks in river develop → erosional powers stronger on outside → stream erodes sideways

Plain stage

- On the plains → very low gradient, no significant down cutting
- valley widens → has removed all ridges and spurs

  deposition is dominant process
- deposition occurs because stream velocity decreases →

  energy insufficient to transport sediment
- fine muddy sediments are deposited from suspension

Formation of flood plains

- Many streams are bordered by floodplains
- floodplain → that part of a valley that is inundated during a flood
- when water overflows its banks onto the floodplain → moves over surface in a broad sheet
- flow pattern significantly reduces stream velocity and turbulence → coarser component deposited in strips bordering channel
- water spreads over floodplain → lesser fine sediment laid down on valley floor

River floodplains

Floodplains along Murray River, South Australia

Braided rivers

- Form where streams with high bed load emerge from mountain regions

  → abrupt decrease in gradient with corresponding drop in energy

- characterised by many channels rather than a single channel

- small anastomosing channels separated by small islands of sediment

- river channel as a whole is wide and shallow

Waimakariri River,

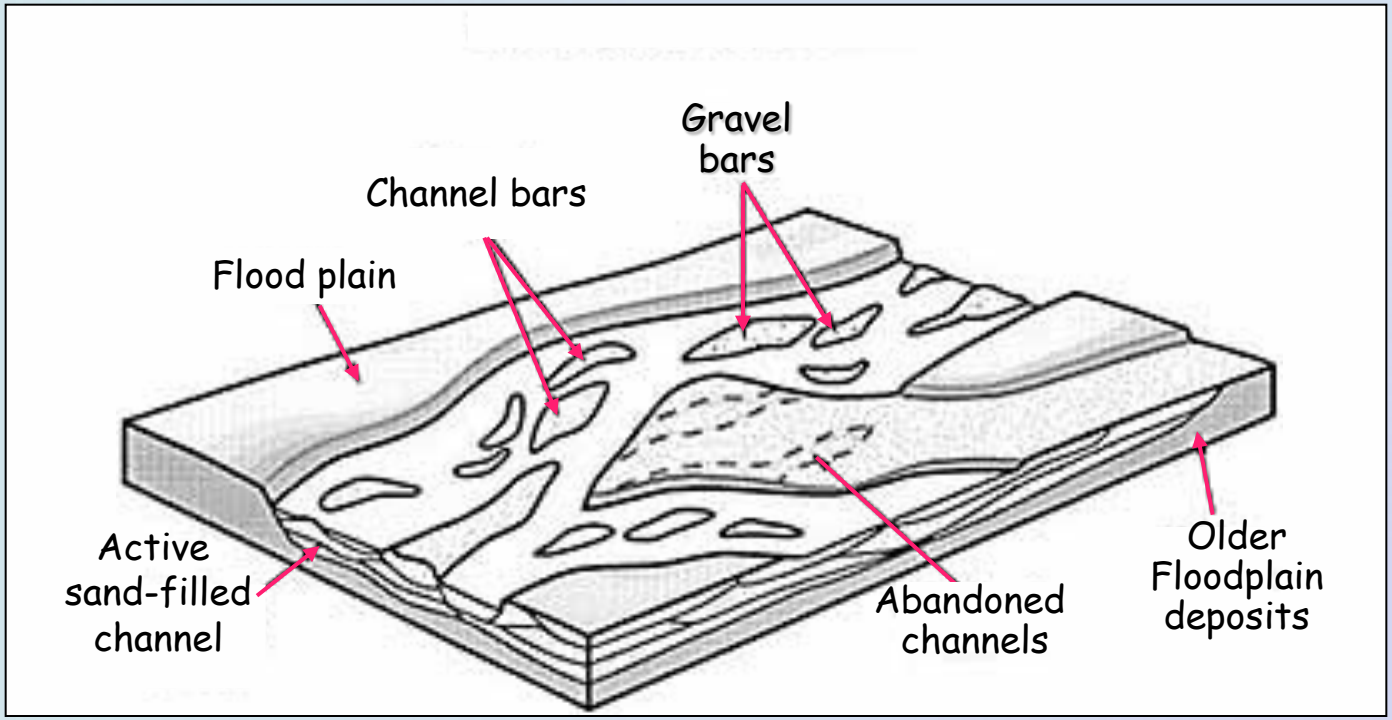
South island NZ

Braided rivers

- A drop in stream velocity (decrease in gradient) → diminishes stream transporting ability
- non-uniform flow, deviation around sediment
- channels contain sinuous dunes
- stream pattern changes constantly (erosion, flooding, deposition)

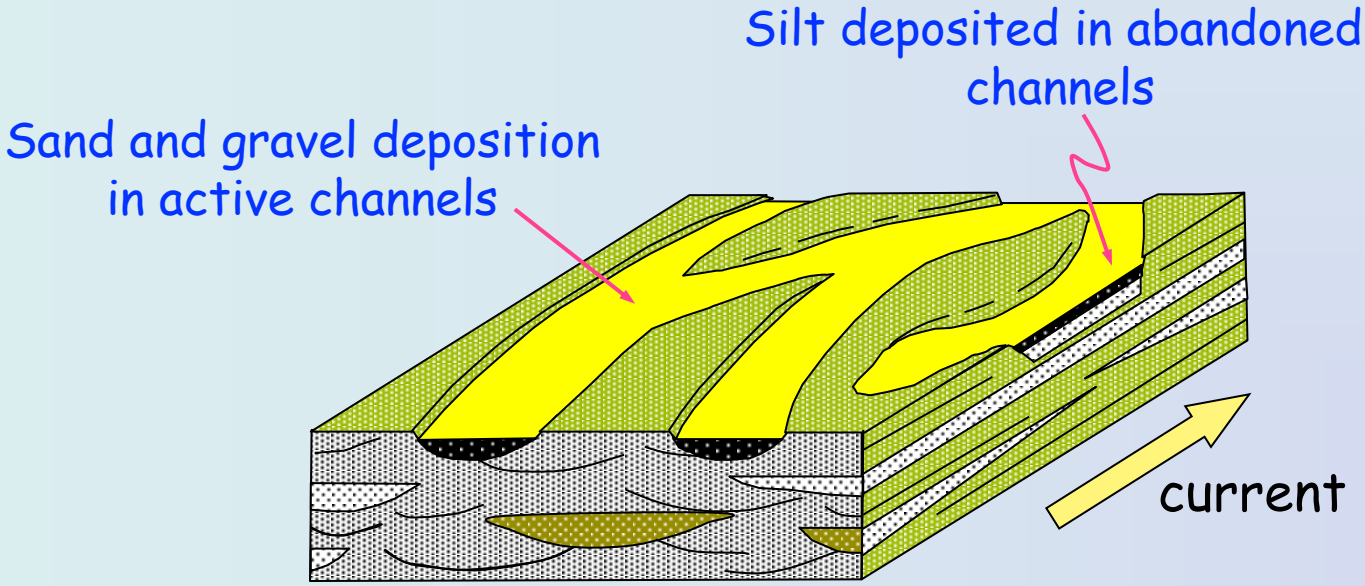
Braided rivers - bars

- Sediments deposited by braided rivers → highly variable, poorly sorted and coarse
- bars (large dunes) form sand flats, separate small channels
- migrate across or oblique to channel and have fairly straight crests



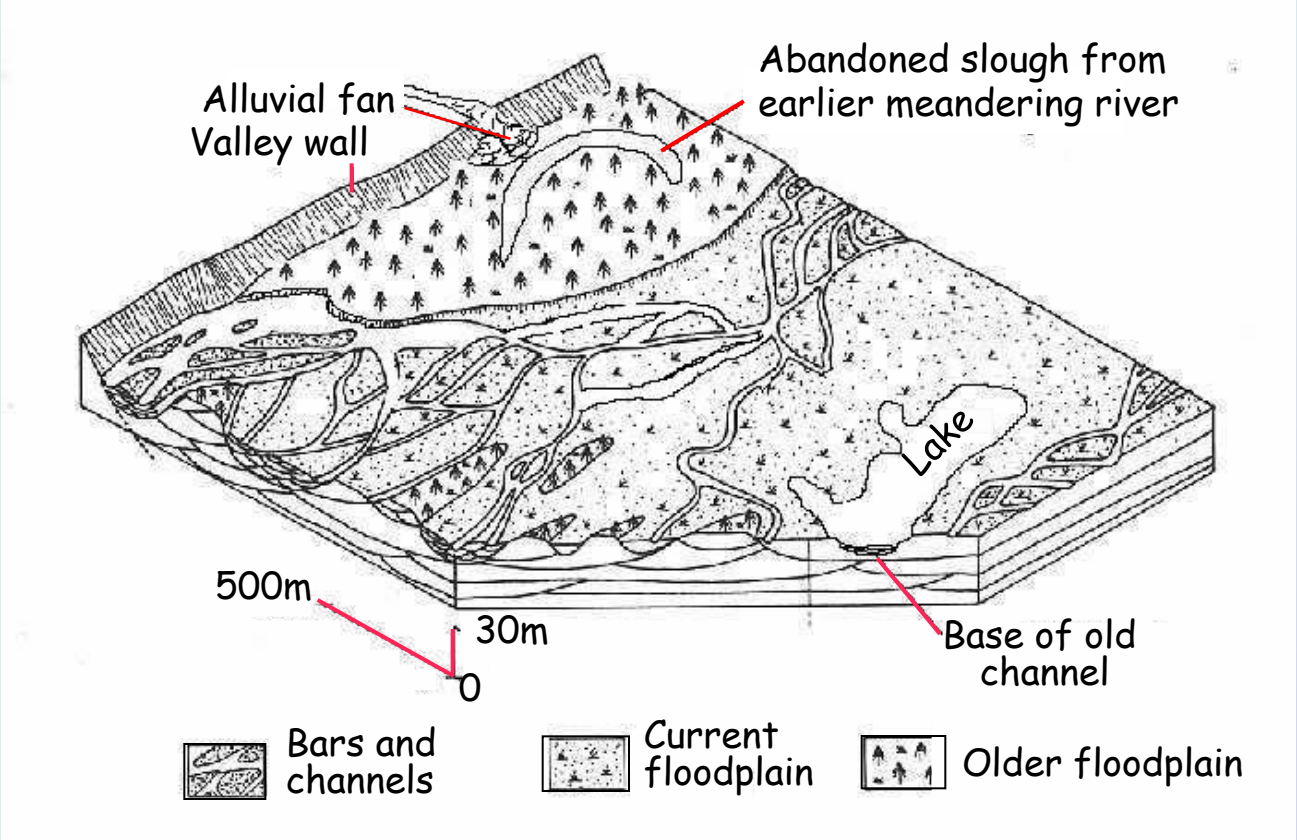
Braided river channel deposits

- Channel deposits form laterally extensive sand sheets
  - result of wide channel systems, course changes
- channel deposits interfinger with flood plain muds
- channel deposits → economically important (gold, tin)



Braided rivers - flood plain

- Flood channel either side of main channel system
  - overbank deposits → deposits on floodplains →laminated silts and clay



Meandering rivers

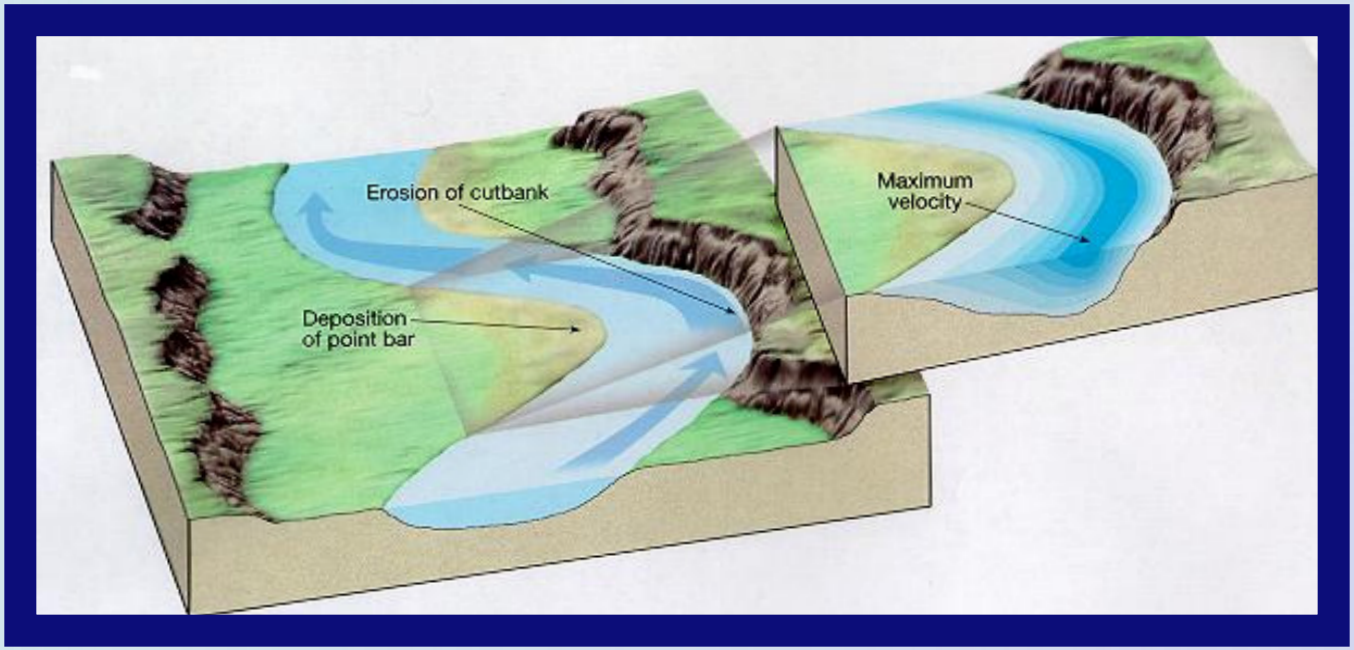
- Regular succession of bends and loops ('meanders')
  - symmetrical, sinuous
- meanders can be excised → oxbow lakes

Meandering rivers

- Decrease in river gradient → velocity of river decreases → river starts to meander
- carries little bed load and little coarse sandy material
- high proportion of suspended (fine) load
- stable banks (of mud)
- same river may be braided in headwaters tract, meandering in valley and plains tract
- during flood events, sediment will be deposited on banks that build up and form natural levees
- next flood needs to be higher to break banks

Meander development

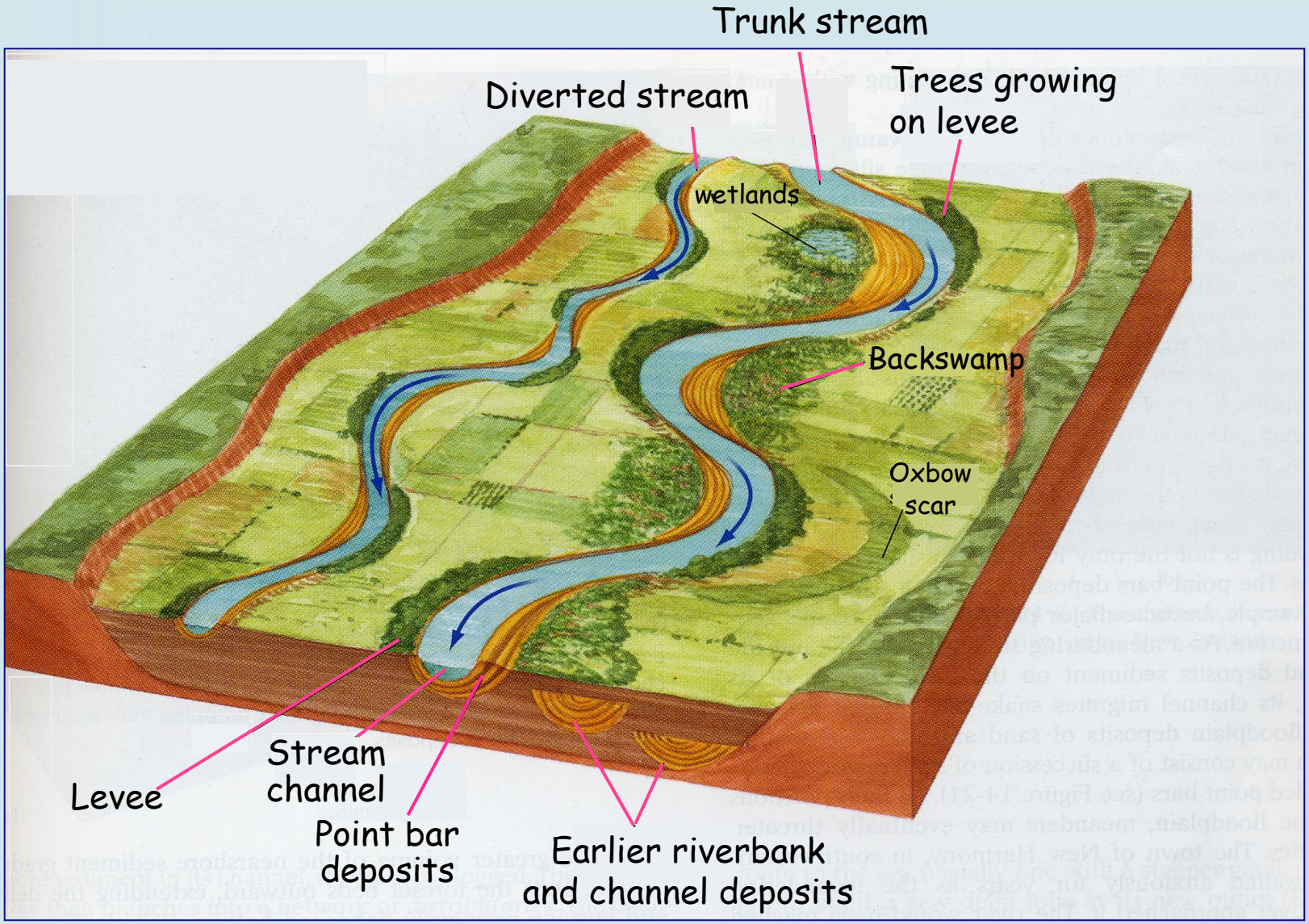
- In lower reaches → one permanent channel
- channels erode on outside of curve, meander develops laterally in that direction
- deposition on inside of curve forms point bar. Erosion occurs more rapidly on outside of bend because of higher velocity



Meandering streams features

- Dunes can form in meandering streams and ripples on surface of point bar
  - preserved as cross-bedding as point bar builds
- flood plain - deposition during floods on either side of valley
  - predominantly mud
  - natural levees form (raised banks)
  - sand occurs near breaks in levee
  - swamps develop on floodplain
- long narrow sand bodies build up in channels
  - flood plain muds on either side

Meandering stream features



Flood plain - natural levee

Mississippi river levee banks exposed above floodwaters

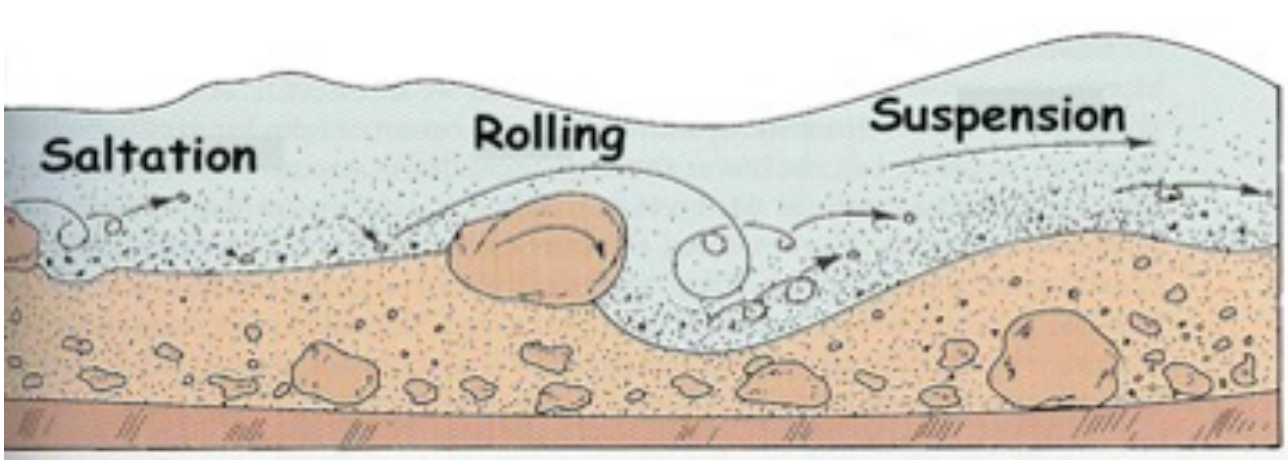
Clastic sedimentary rocks

- Conglomerate
  - formed from poorly-sorted, coarse grained deposits of gravel
  - particles are mostly rounded resistant rock fragments
- Sandstone
  - sand grains (1/16 - 2mm size) cemented together
  - mostly made up of well-sorted quartz particles
- Siltstone
  - fine-grained rock of silt particles (1/256 - 1/16mm)
  - mostly made up of quartz particles
- Shale
  - formed from deposits of clay (<1/256mm)
  - mostly clay minerals

River sediment transport

- For moving water to move grains of sediment, water velocity must exceed a threshold level
- sediment transport depends on grain-size and water velocity
- Grains moved by:
  - rolling
  - saltation
  - suspension

} bedload



Huang He (Yellow River)

- Yellowish colour imparted by high suspended sediment load
- most rivers carry the bulk of their sediment load in suspension
- normal flow → 50% water 50% sediment load
- flood flow → up to 90% sediment, flows like treacle

Bedforms

- As soon as sediment transport begins in a channel, the sediment is moulded into various bedforms
- bedforms → structures in sediment on river bottom that result from river transport and development in channels
- these bedforms may be classified as ripples, dunes, antidunes, cross-beds, planar laminations and other minor forms
- these features studied by taking a channel filled with fine-medium sand → gradually increase water velocity → produce series of bedforms
- by examining bedforms it is possible to interpret the history of a stream and the style of transport of sediments

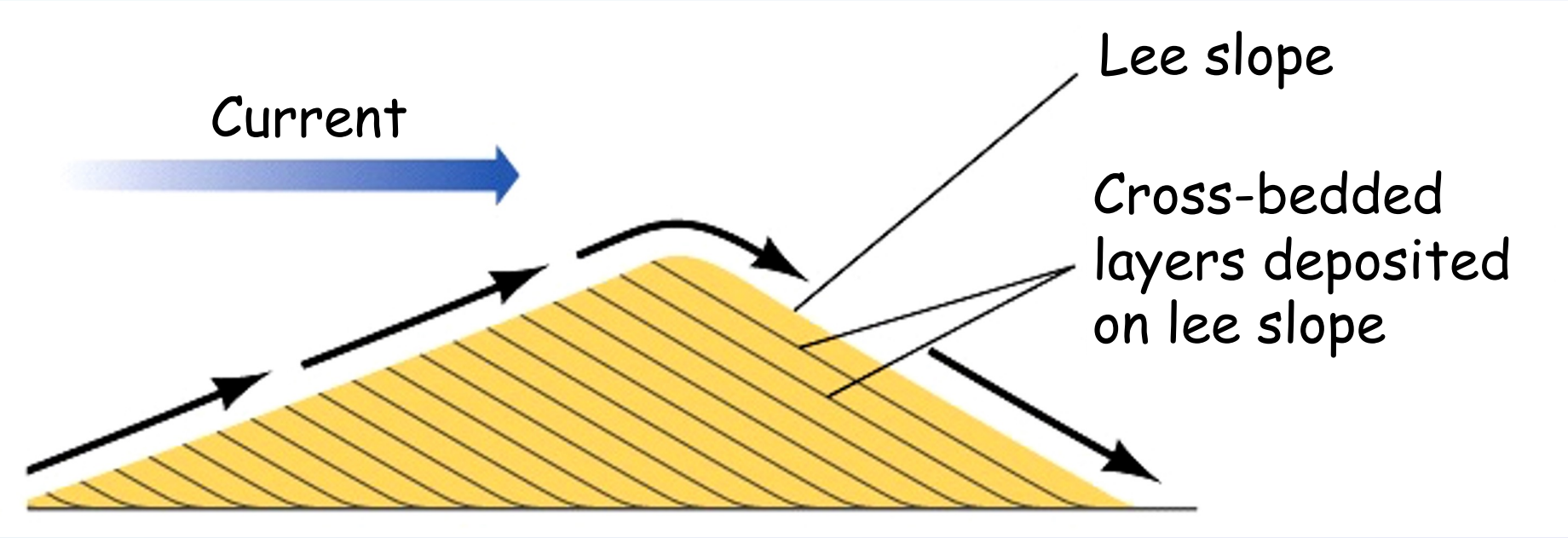
Channel deposit

Bedforms - ripples

- One of the most common structures in river sediments → ripples
  - asymmetric or symmetric 5mm - 3cm high
  - crests straight, sinuous or branching
- ripples migrate by erosion in trough and avalanching down-slope
  - move downstream with uni-directional currents
  - form cross-laminations

Formation of cross laminations

- Asymmetric ripples are the most common sedimentary structures in rivers
- current pushes sand up the slope and over the crest
- ripples move progressively downstream



Cross bedding laminations in recent alluvium, Mountain Creek, near Taemas Bridge, NSW

Ripple marks

- Ripple marks → small waves of sand that develop on the surface of a sediment layer by action of moving water or wind
- ridges commonly form at right angles to direction of motion
- if ripples formed by water moving in one direction → asymmetrical → current ripples
- ripples formed by back and forth movement of sea waves in shallow marine environment → symmetrical → oscillation waves

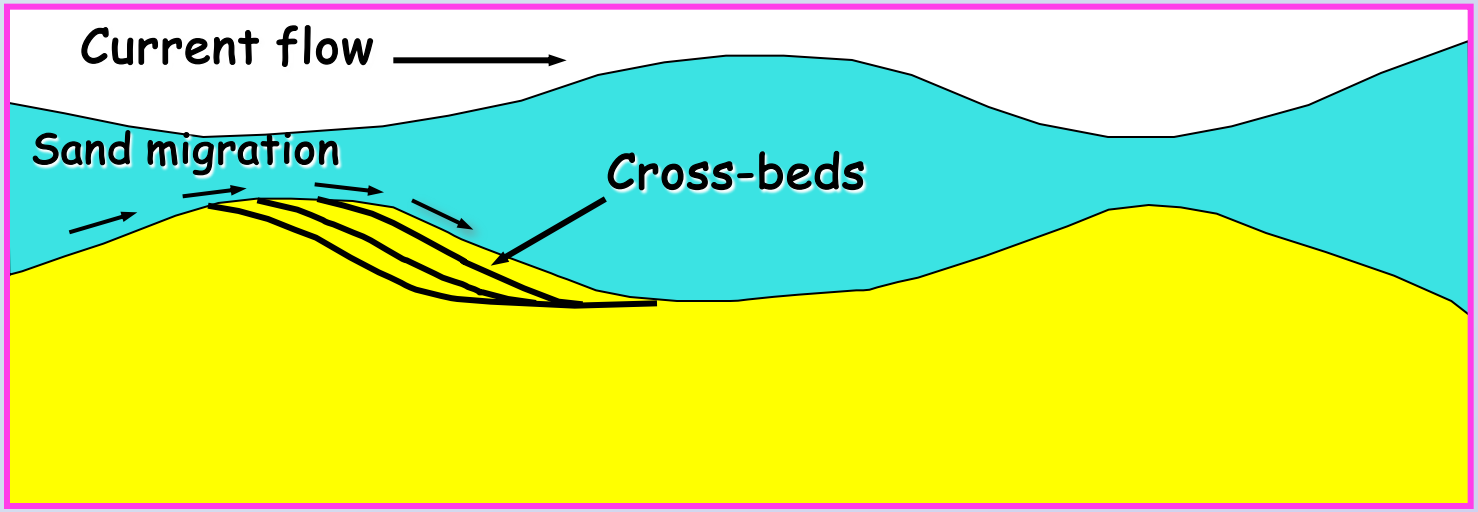
Ripple marks

Asymmetric, sinuous ripples in sandstone

Modern ripple marks in dry creek bed, Weekeroo, Sth Aust.

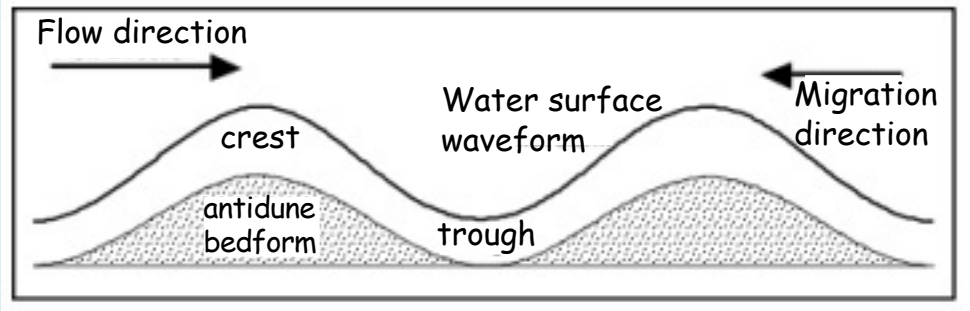
Bedforms - dunes

- Dunes form in deeper fluvial environments when velocity increases, dunes can form
- >5cm high - larger in deeper water, up to several metres
- large scale cross-bedding
  - tangential to lower surface



Antidunes

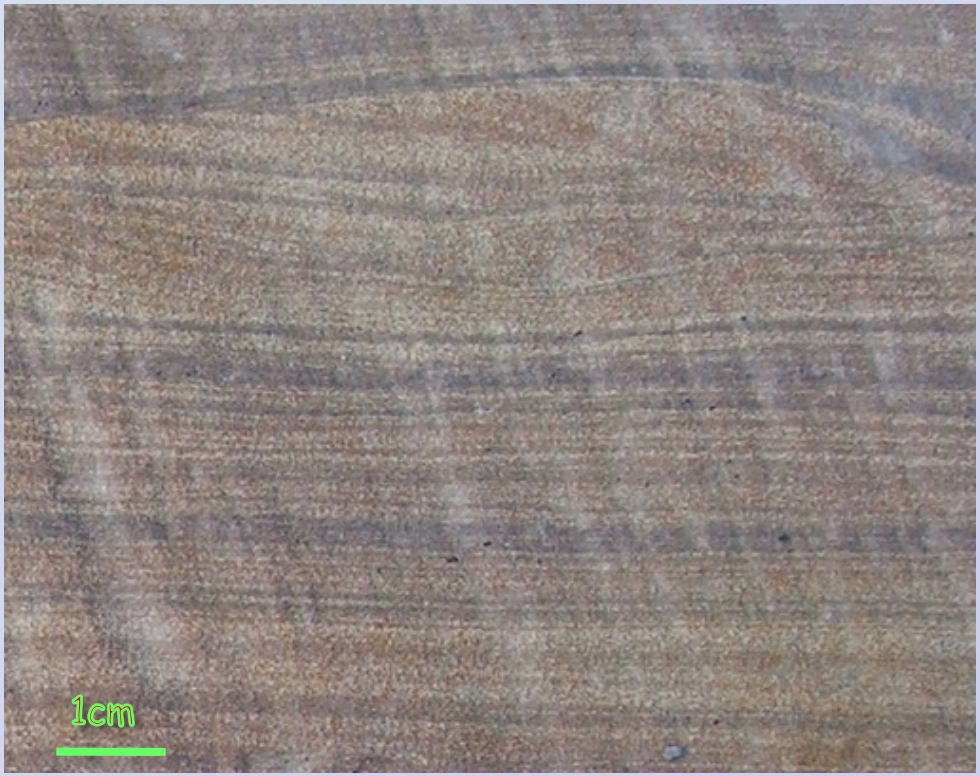
- Antidunes → produced by in-phase, fast, shallow flow
- migrate upstream → low angle upstream cross laminations
- do not form from avalanching → due to accretion on upstream side of bedform



Antidunes in coastal channel, California, USA

Bedforms - planar laminations

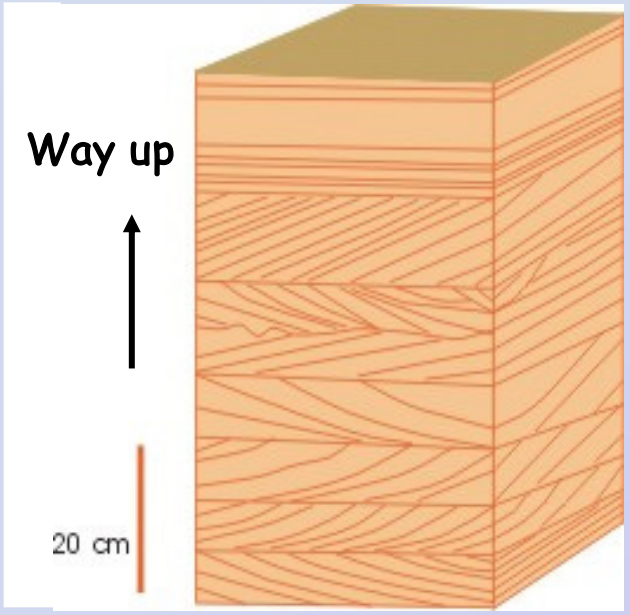
- Planar laminations are planar structures that form within beds parallel to the current flow
- formed by sand when current velocity is high
  - quite thin → after one layer is deposited, next layer deposited quickly
- in low velocity environments mud → deposited from suspension
- mud forms fine laminated layers



Primary Structures 1

- Stratification
  - most sedimentary rocks occur in distinct layers called strata or beds
  - the layers are defined by their colour, texture and resistance to weathering
  - the most obvious feature of most sedimentary rocks

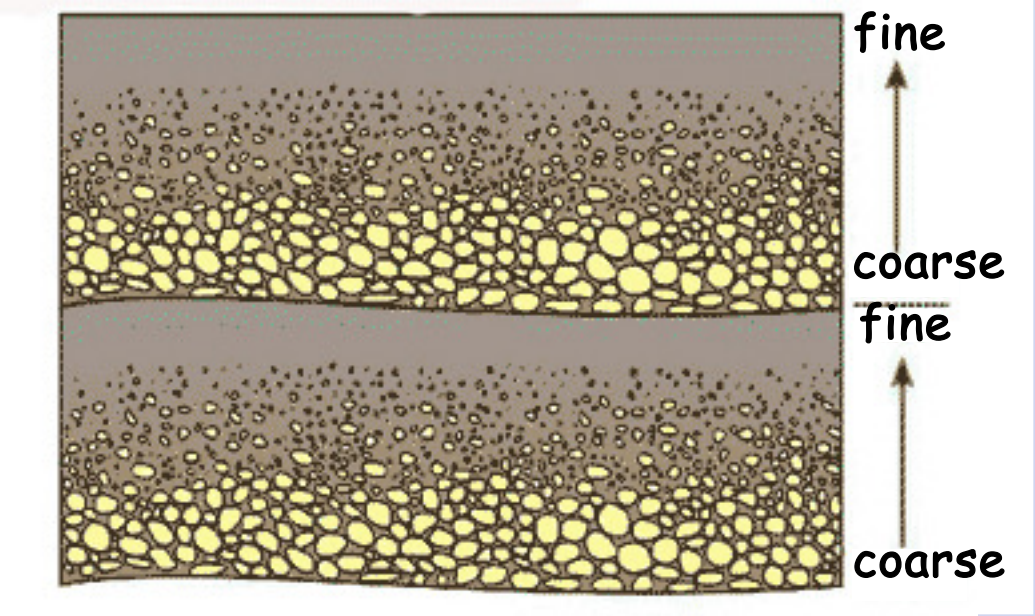
- Cross-bedding
  - layers within a bed are inclined at an angle to the top and bottom of the bed



Cross-bedding, Lake Powell, Arizona

Primary Structures 2

- Graded bedding
  - progressive decrease in grain-size up the bed
  - sandstone or siltstone at base, shale at top
  - very useful for determining the original way up
  - produced by the flow of suspensions of sediment called turbidity currents



Channel lag deposits

- Channel lag deposits → deposits of coarse residual material left as accumulations in a stream channel
- commonly occur as discontinuous lenticular patches that vary in thickness
- fluvial processes can winnow the finer particles leaving the coarser material behind

Channel lag deposit

Load casts and flame structures

- Load casts → type of soft sediment deformation structure
- form in response to unstable density contrasts between sediments
- form as bulbous depressions at base of sediments with differential sinking of soft sediment into less dense sediment below
- Flame structures occur in association with load casts
- sinking denser sediment forces lower density sediment up between the load casts

Load casts and flame structures

Load casts and flame structures, Castle Cove, Vic.