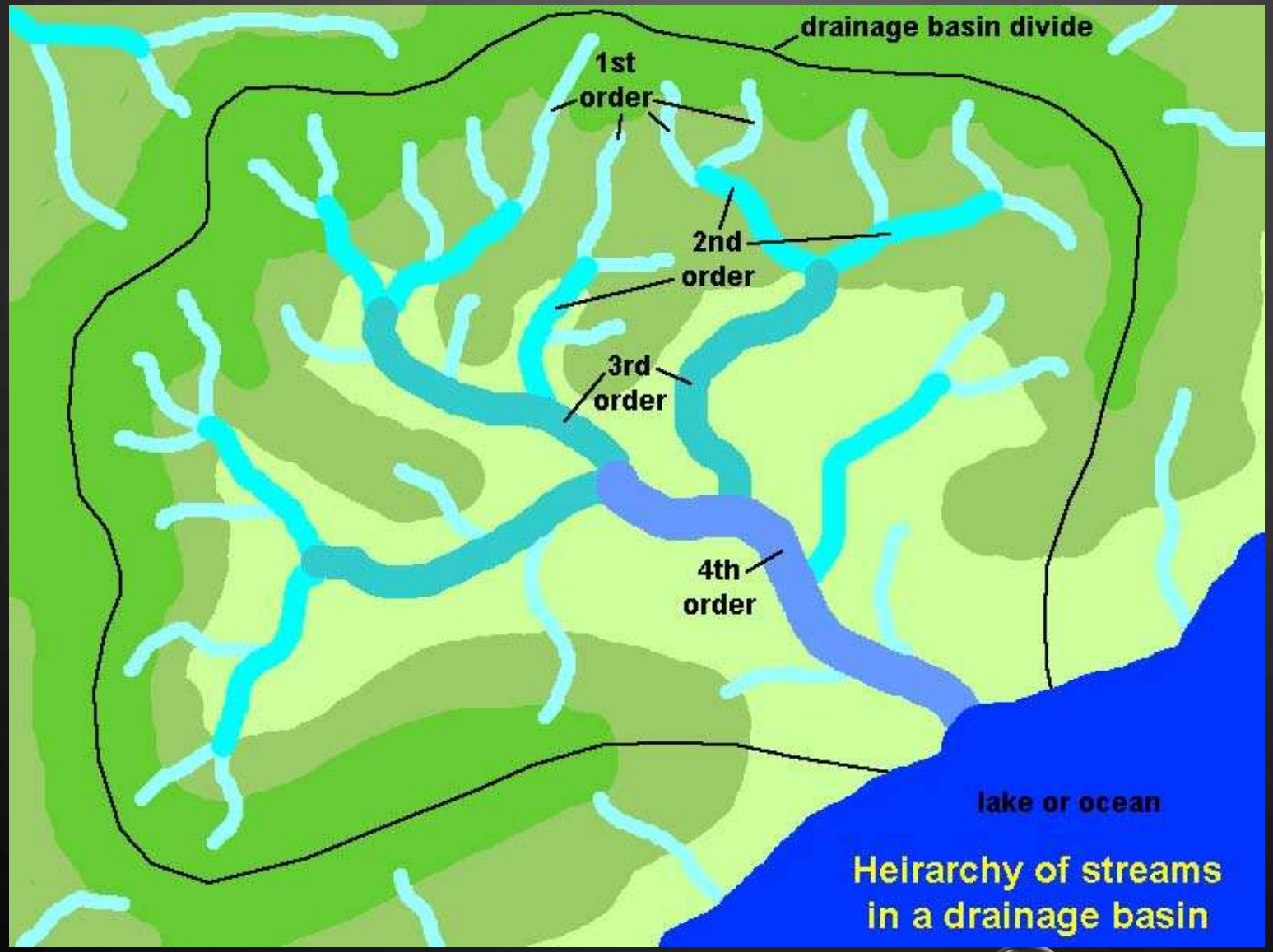
RUNNING WATER AS AN AGENT OF EROSION

☺ RAKESH S

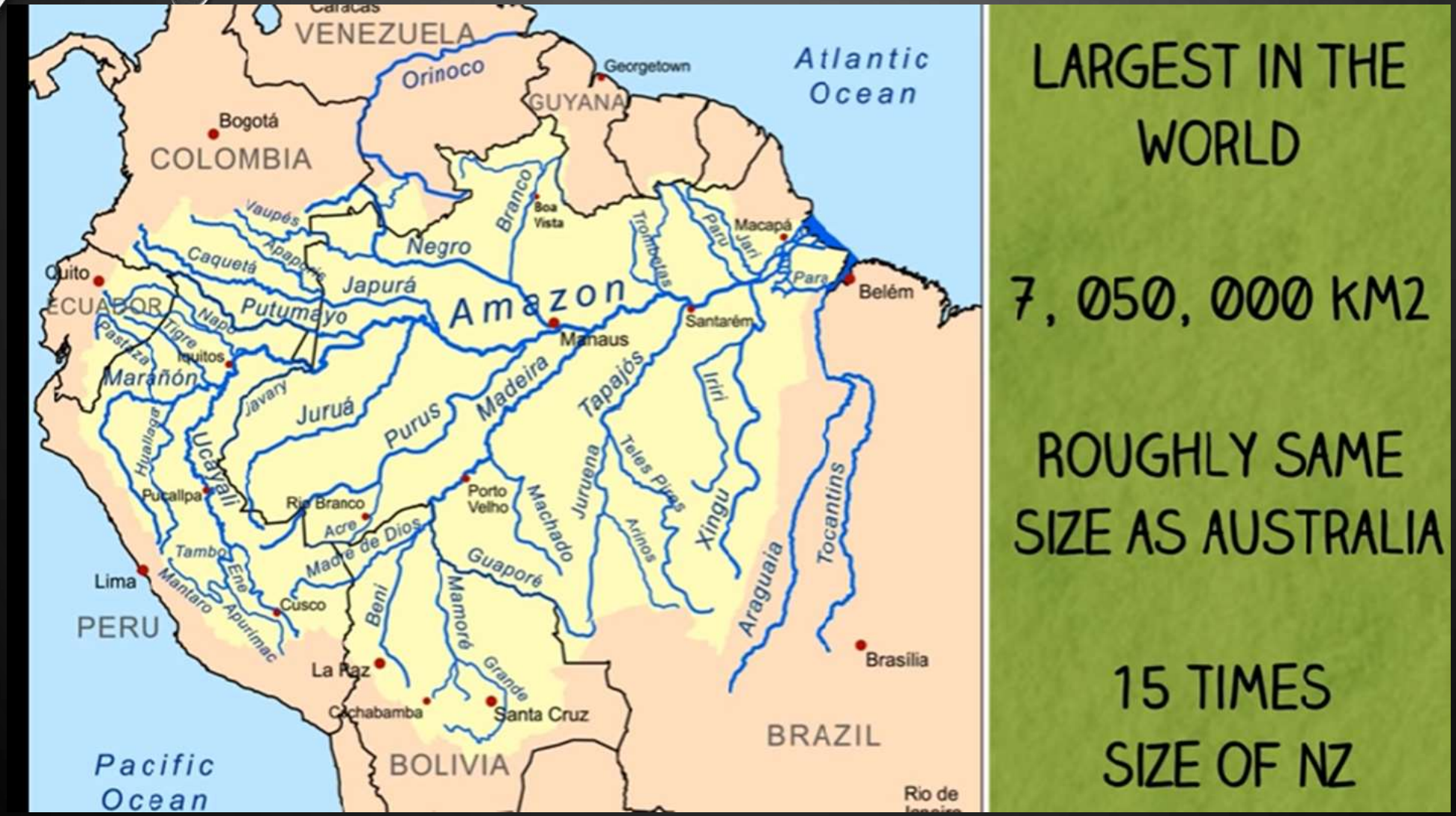
INDRODUCTION

- Almost 71% surface area of the earth is covered with liquid water in form of streams, lakes, rivers, seas & oceans.
- Running water is considered as the most powerful of all the natural geological agents of change
- Wind, glaciers, and ocean waves are all confined to relatively limited land areas, but running water acts almost everywhere, even in deserts.
- One fourth of the 35, 000 Cubic miles of water falling on the continents each year runs off into rivers, carrying away rock fragments with it. Running water breaks down the crust by the impact of rock debris it carries .


drainage basin divide
1st order
2nd order
3rd order
4th order
lake or ocean
Heirarchy of streams in a drainage basin

STREAMS AND RIVERS

- ***Stream and Streamlets:*** Small surface bodies of water flowing in channels of their own
- These streams flowing through a big area and ultimately joining to a single major channel of flow forms the ***River***
- Streams and rivers that collectively drain out all the water received from precipitation and other sources in a given region form the ***Drainage system***
- The region that contributes water to the system so developed is called ***Drainage Basin***



Accounts for 1/5 of worlds river flow


INDIA
DRAINAGE & RIVER BASINS
N
TAJIKISTAN
AFGHANISTAN
PAKISTAN
TIBET
NEPAL
BHUTAN
BANGLADESH
MYANMAR (BURMA)
SRILANKA
Others
Indus Basin
Jhelum
Indus
Chenab
Ravi
Beas
Satluj
Ganga
Luni Basin
Luni
Sambhar
Chambal
Gandhi Sagar
Ganga Basin
Gomati
Ghaghara
Yamuna
Son
Ganga
Padma
Govind Ballabh Pant Sagar
Damodar Basin
Subarnarekha Basin
Brahmani Baitarani Basin
Others
Brahmaputra Basin
Brahmaputra
Lohit
Dhansiri
Barak Basin
Manipur Basin
Kaladan Basin
Mouth Of Ganga
Hugli
Gulf of Kachchh
Sabarmati Basin
Mahi Basin
Narmada Basin
Narmada
Tapi
Gulf of Khambhat
Mahanadi Basin
Hirakud
Mahanadi
Wainganga
Godavari
Penganga
Godavari Basin
Chilika
Nagavali
Vamsadhara
Rushikulya Basin
Sabari
Bhima
Krishna
Krishna Basin
Arabian Sea
Bay of Bangal
Satyapadi Basin
Tungabhadra
Penner
Penner Basin
Pulicat
Cauvery
Palar Ponnaiyar Basin
Cauvery Basin
Lakshadweep Sea
Lakshadweep Islands
Vembanad
Palk Strait
Vaigai
Gulf of Mannar
Andaman And Nicobar Islands
Legends
Basin Boundary
Sub-Basin Boundary
Map not to scale
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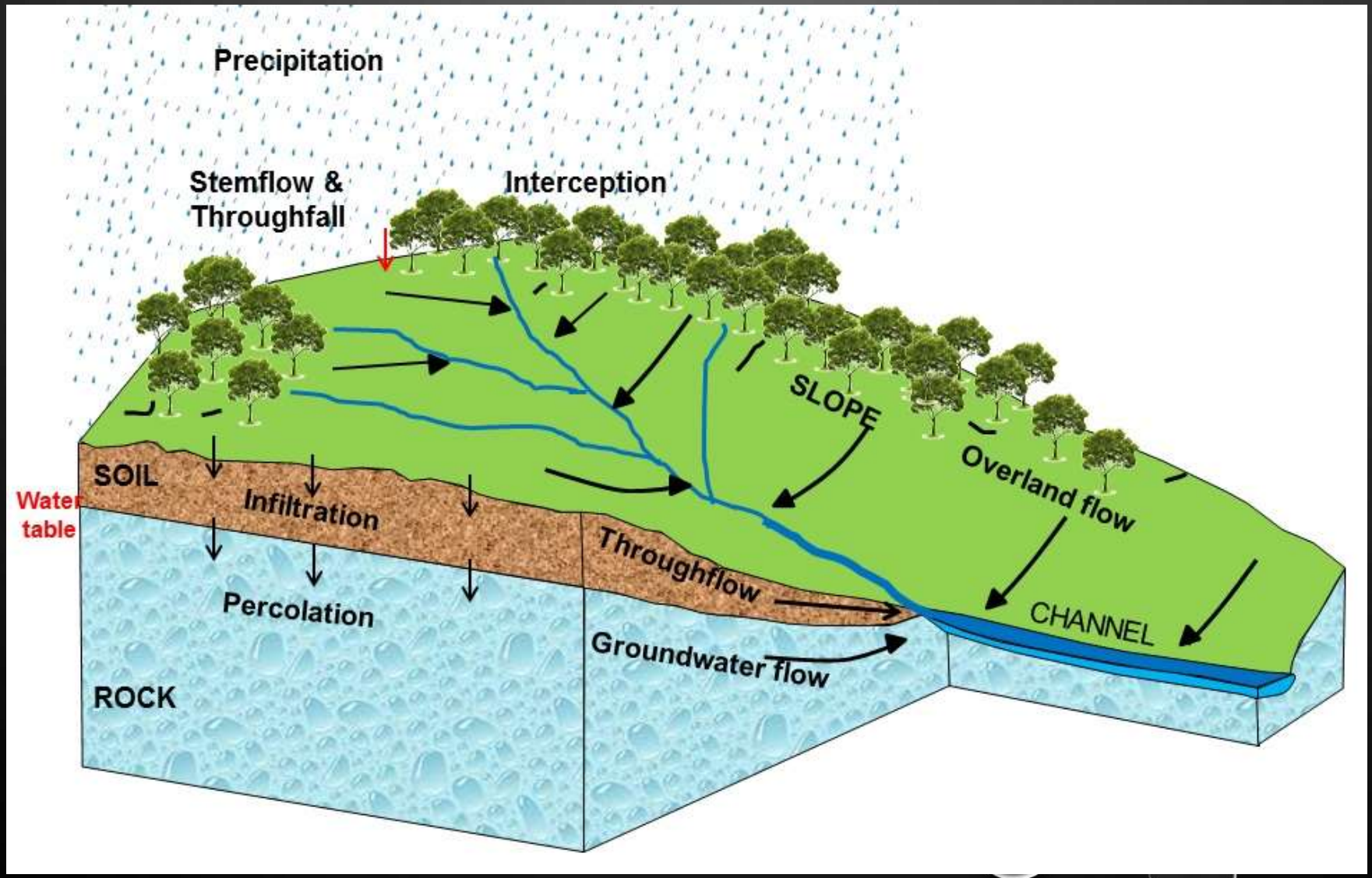
INDIAN OCEAN

SOURCES OF STREAM WATER



SOURCES OF STREAM WATER

1. ***Run Off :*** Greater part of precipitation flows to sea is through the surface, through channels available or carved out by it. This is run off water and it makes a big source of water for streams and rivers.
   - These streams can be *intermittent* or *perennial.*
   - The *intermittent* stream flows often vigorously during and after heavy rains
   - In *perennial* stream, the volume of water varies considerably during different seasons but the river never gets dry

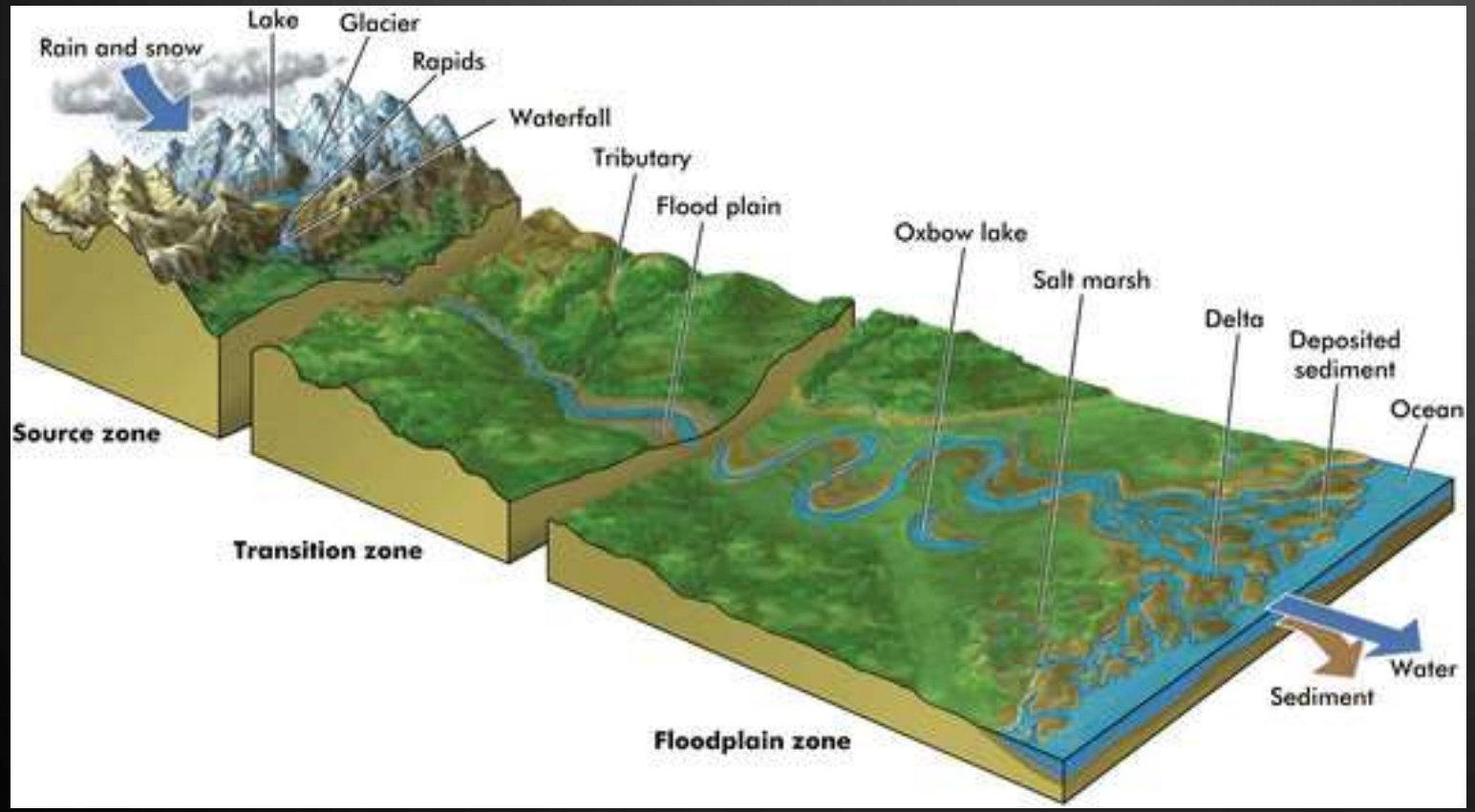
2. Subsurface water :

A good part of the precipitation is absorbed by the soil and rocks and it starts its seaward journey below the surface of the earth. Thin infiltrated water into the earth is called *subsurface water*.

- During its downward journey, it may saturate considerable amount of soil and rocks. Water flowing through this saturated zone is called *ground water* and the upper surface of ground water is called *water table*

3. ***Glacial melt water :*** Glaciers covers more than 10% surface area of earth. It undergo melting during heating or during their downslope movement due to gravity. Glacial melt water contribute some volume to the mountain streams.

RIVER PROFILE



The streams flow in well-defined channels developed and modified by the water itself

RIVER PROFILE

From the place of origin to its final destination to sea, every river channel is characterized with a profile.

The high land from where the river originates is called *head region* and the place where it enters a sea is called *mouth*.

- In the head region the *slope will be higher* and the river flows with high speed and energy, capable of cutting even hardest rocks.

  Vertical erosion is prominent. Numerous deep and narrow *valleys* and many g*orges* and *canyons* are formed in this way.

Degrading streams: Under loaded stream. They have sufficient velocity to carry the entire load and also perform considerable amount of erosion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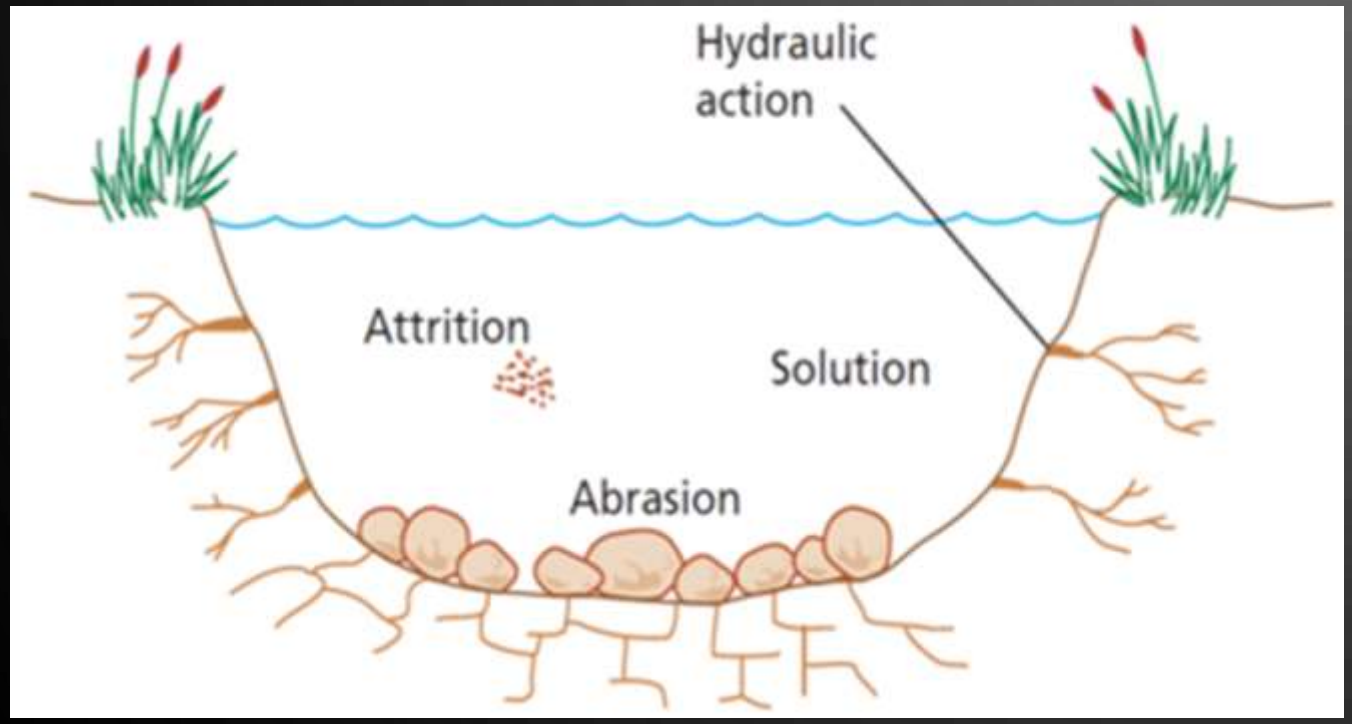
- In the middle region, the streams become mature. It already acquired some load to carry down, its capacity to cut vigorously decreases. It erodes rocks selectively, changes its course where it finds obstruction too hard to remove. This results in *meandering*

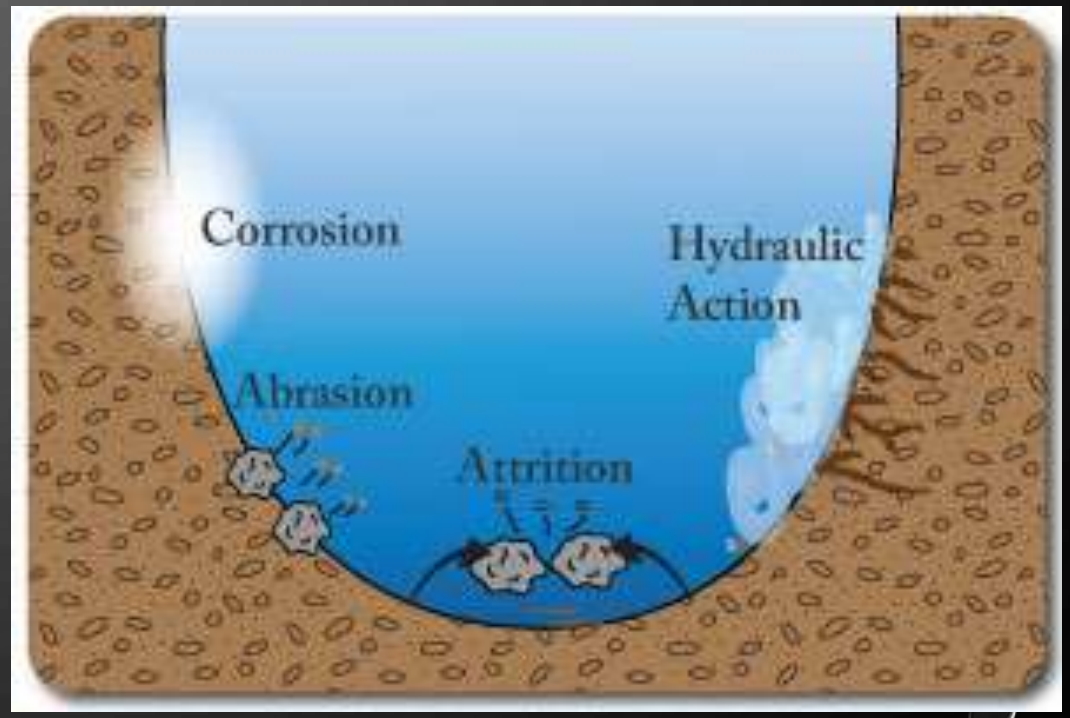
Graded streams: Velocity is sufficient to carry the load. Any increase in velocity gave them erosional property and any decrease in velocity cause deposition

- In the flat lands, the same river behaves very sluggish and tired just able to move ahead to join the sea

Aggrading streams: A part of load gets deposited due to lack of sufficient velocity

METHODS OF RIVER EROSION





RIVER EROSION

EROSION : Process of detachment, transport and deposition of soil materials from one place to another by erosive agents.

- The running water performs erosive work in 5 ways : *hydraulic action, cavitation, abrasion, attrition and corrosion.*

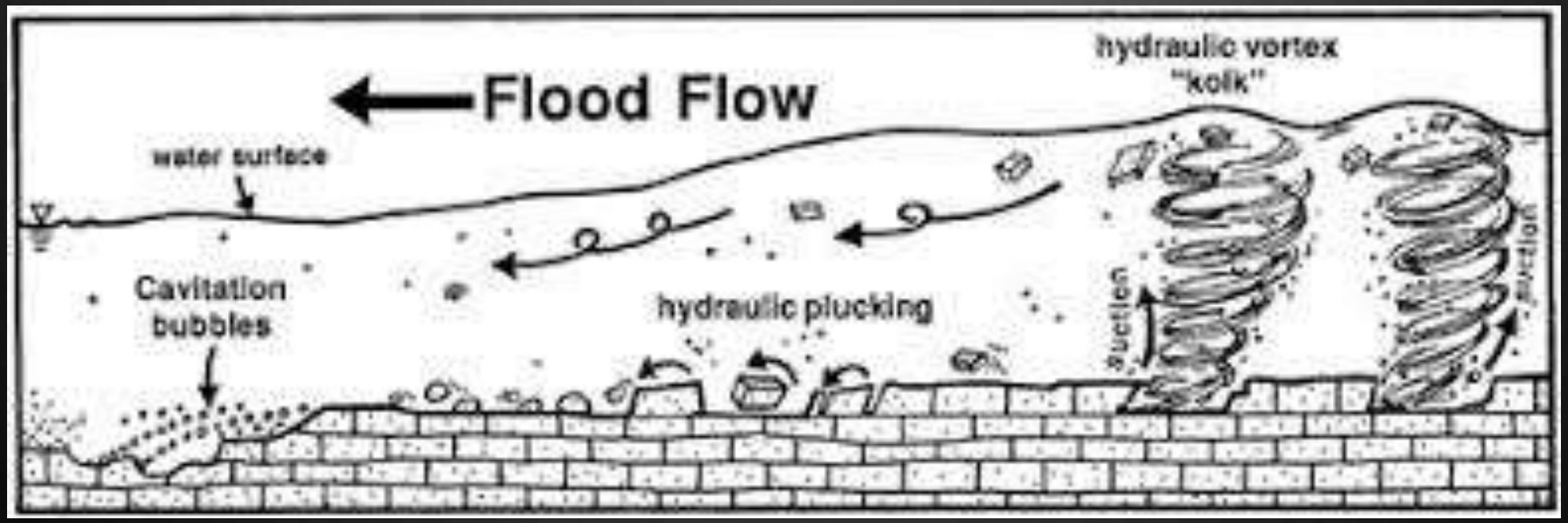
Hydraulic action : It is the *mechanical loosening and removal* of material due to pressure exerted by the running water. Higher the velocity greater the pressure exerted. Weaker planes in rocks such as joints, fissures, cavities, cracks are helpful for the running water in carrying out hydraulic action.

- **Abrasion** : It is the wearing away of rocks along the banks and bedrocks of stream by the running water with help of sand grains, pebbles and gravels that are carried by it. These particles are known as *tools of erosion.* River valleys, waterfalls, escarpments, gorges, river terraces and canyons are *deepen* principally by river abrasion.
- **Attrition** : It is the wearing and tearing of load sediments due to the *mutual impacts and collisions* during their transport.

  This worn out the irregularities and angularities and makes them more spherical and polished

Cavitation : It is a distinct and rare phenomenon. When the river water suddenly acquires exceptionally high velocity(>12m/s) such as in waterfalls, the water pressure at the impinging point equals vapour pressure. This spontaneous change from liquid to vapour and back to liquid *causes sucking out of the material* from the impinging point which creates *holes and depressions*

Corrosion : The slow and steady chemical action of stream water on the rocks. Extend of corrosion depends on the composition of both rock and flowing water. Limestone, gypsum and rocksalt are soluble in water where as sandstones, quartzites, granites and gneisses are hardly corrodible


Flood Flow
hydraulic vortex
"kolk"
water surface
Cavitation
bubbles
hydraulic plucking
suction
suction

RATE OF RIVER EROSION

Depends on:

1. Velocity of stream

   Depends on :

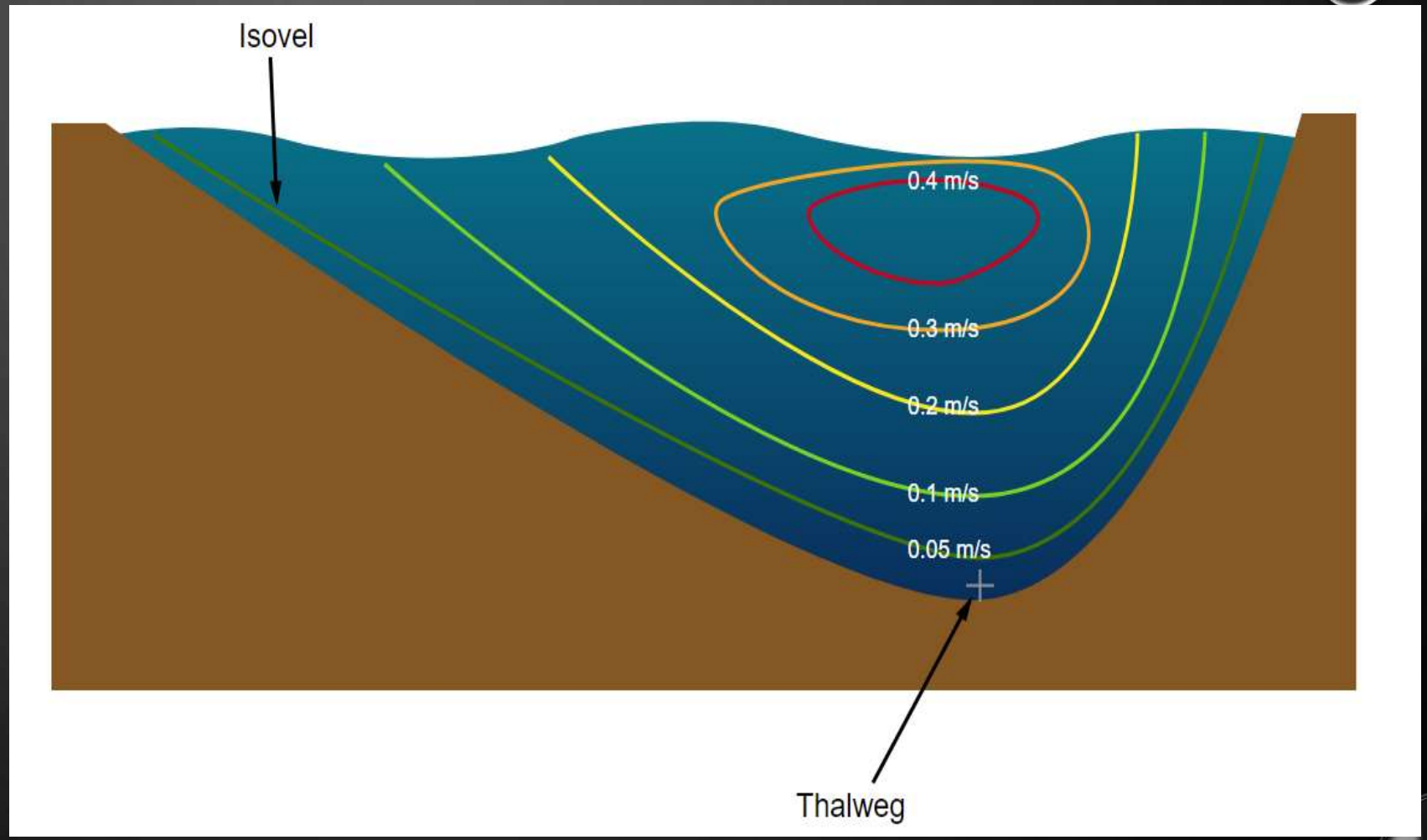
   - Gradient of channel → directly proportional
   - Volume of load → inversely
   - Volume of water in the stream → directly
   - Roughness of channel → inversely

2. Lithology(nature of rocks) *Limestone has lower hardness towards abrasion. Limestone erodes at a higher rate than sandstone.*

3. Volume of sediments(load)

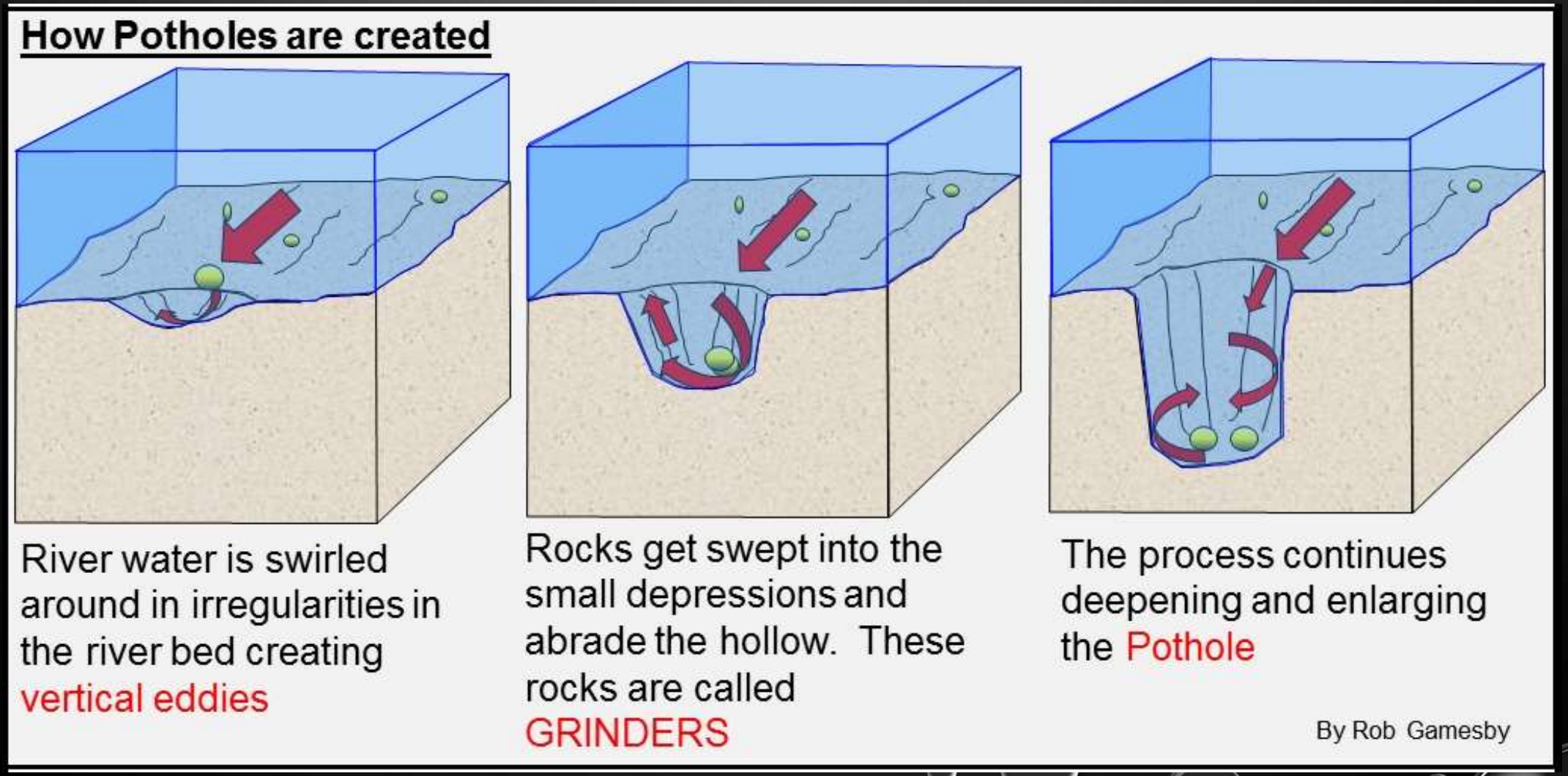
   A fully loaded stream will not be able to carry any further load

THALWEG : A line running along a river's profile linking its deepest points. Normally rivers fastest flow will be through the vertical plane of *thalweg*



FEATURES OF STREAM EROSION

POTHOLES


How Potholes are created
River water is swirled around in irregularities in the river bed creating vertical eddies
Rocks get swept into the small depressions and abrade the hollow. These rocks are called GRINDERS
The process continues deepening and enlarging the Pothole
By Rob Gamesby

- **<u>Pothholes</u>**: Commonly formed in the *softer rocks* by excessive *localized abrasive action*.

There formation is initiated by a simple plucking out of a protruding rock by hydraulic action

DIP SLOPE AND CUESTA

- Dip Slope: Stream completely erodes the overlying soft rocks thereby fully exposing underlying harder layer along its dip
- Cuesta: Gentle slope on one side, and a steep slope on the other. It is the combination of escarpment and dip slope

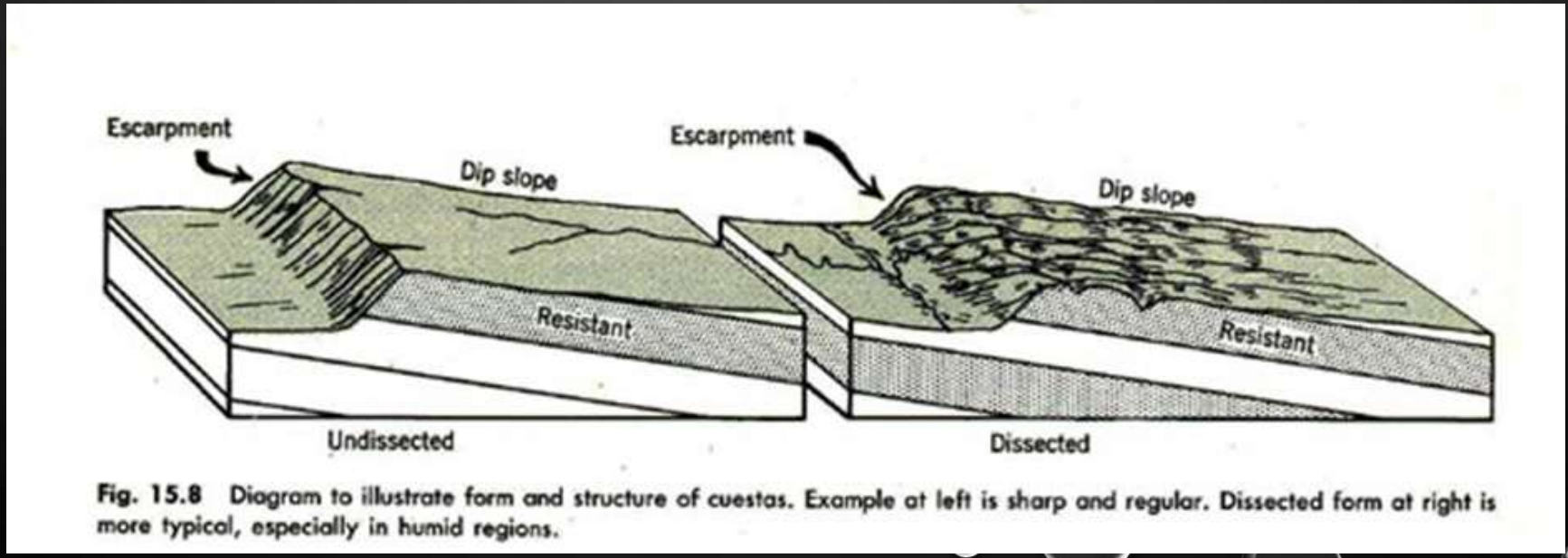


Fig. 15.8 Diagram to illustrate form and structure of cuestas. Example at left is sharp and regular. Dissected form at right is more typical, especially in humid regions.

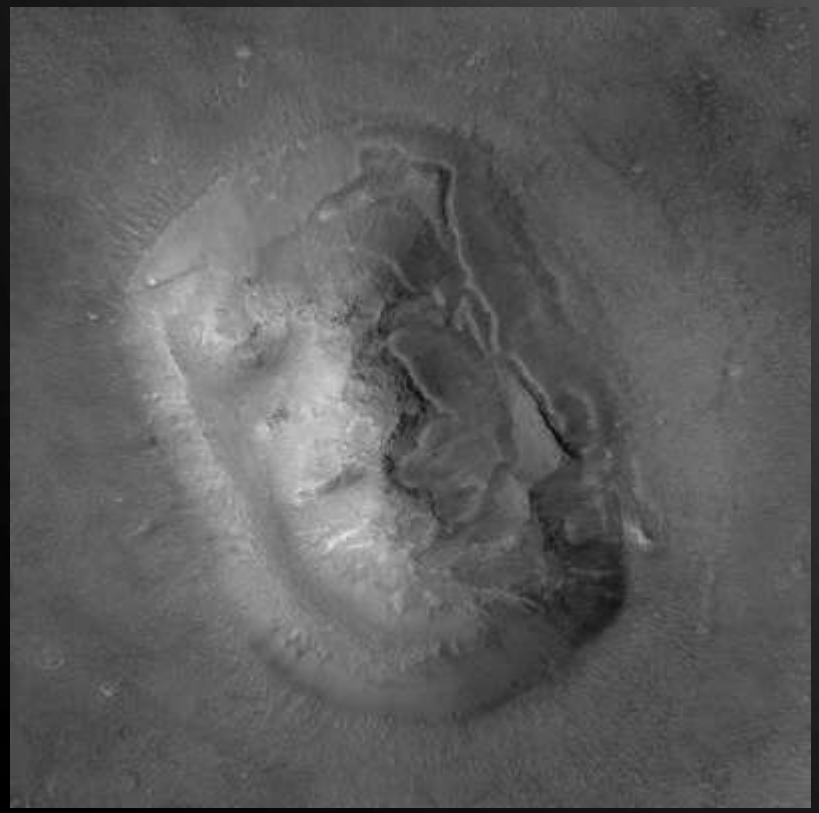
Cuesta in Crimea

MESA AND BUTTE

Caps of hard and resistant rocks over the softer rocks
They were once a part of plateau

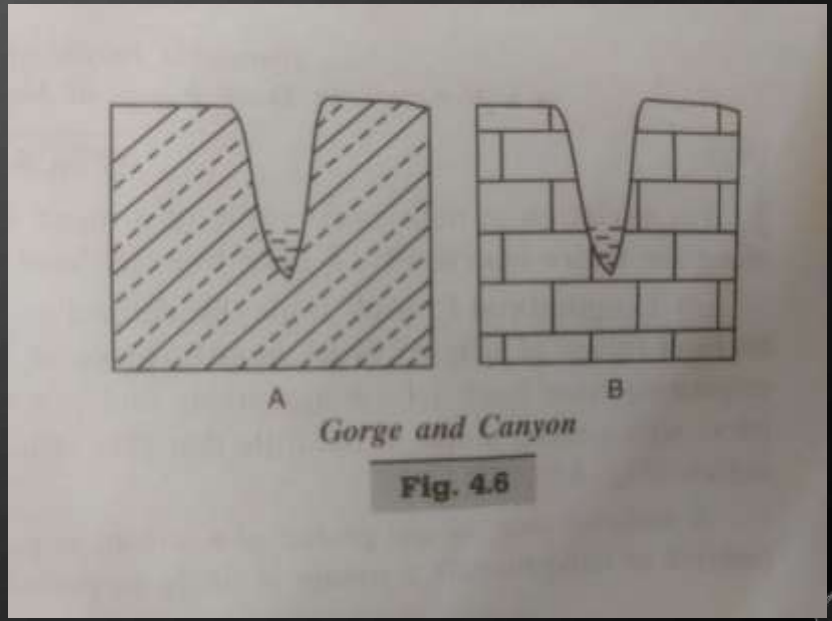
The Mittens and Merrick Butte in Monument Valley, Arizona

Martian mesa



GORGES AND CANYONS

- Gorges are very *deep and narrow valleys* with very steep and high walls on either side.
- Canyon is a specific type of gorge where layers cut down by a river are essentially *stratified and horizontal in altitude*



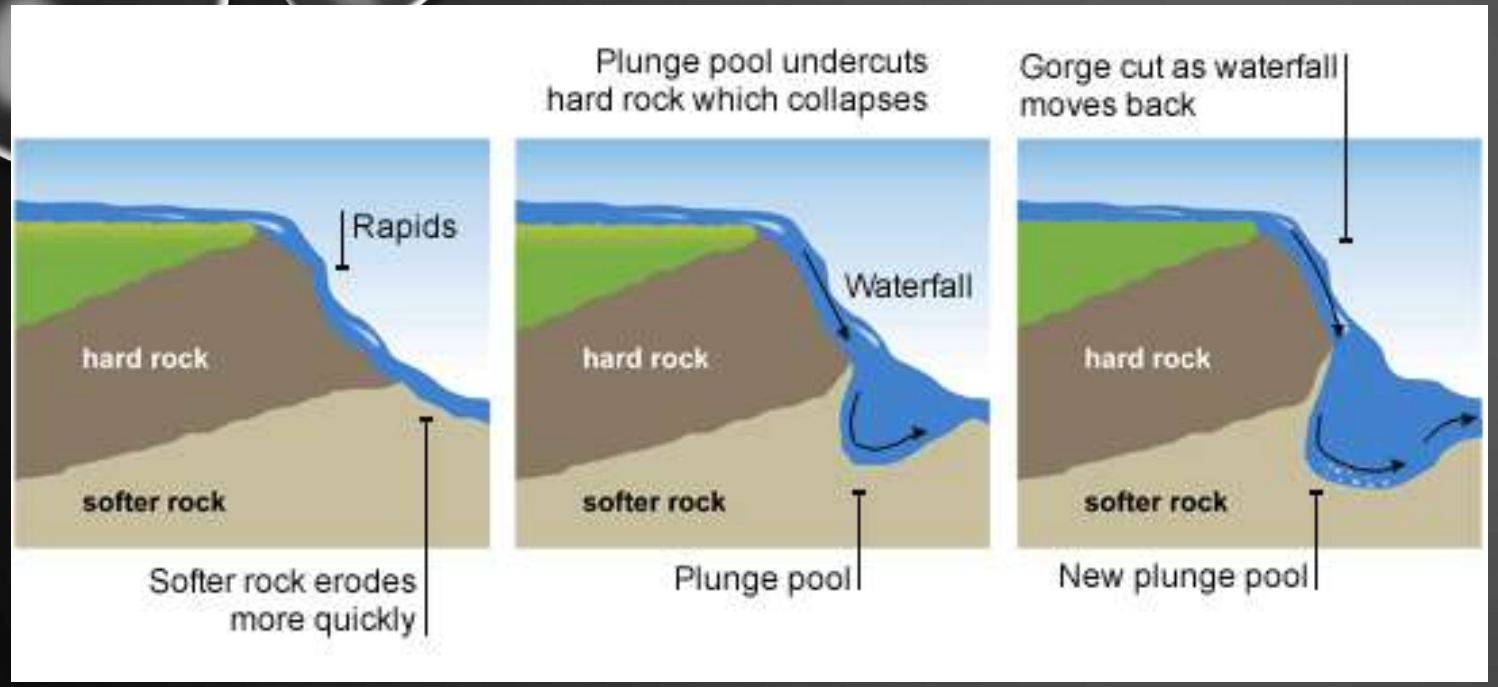
The Grand Canyon, Arizona

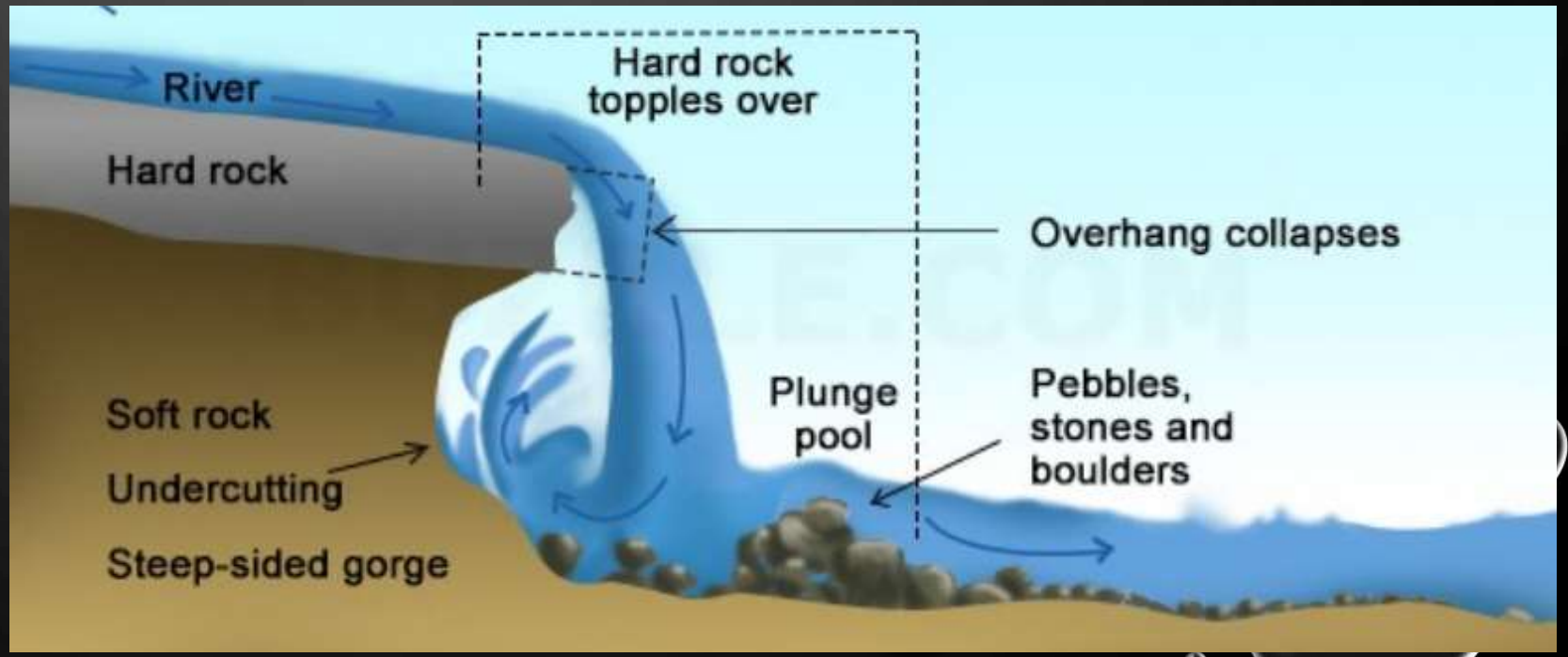
Deepest in the world.
Depth varies from 900 to 1800 meters

Chenab river, India

WATERFALLS

- The stream literally falls instead of flowing.
- Strata of alternate hard and soft characters are favorable for the formation of waterfall
- Falls of smaller heights are called *rapids and cascades*
- Location of waterfall origin may be called *knickpoints*. They are the places of steep drop in elevation


Rapids
hard rock
softer rock
Softer rock erodes more quickly
Plunge pool undercuts hard rock which collapses
Waterfall
hard rock
softer rock
Plunge pool
Gorge cut as waterfall moves back
hard rock
softer rock
New plunge pool


River
Hard rock
Hard rock topples over
Overhang collapses
Soft rock
Undercutting
Steep-sided gorge
Plunge pool
Pebbles, stones and boulders

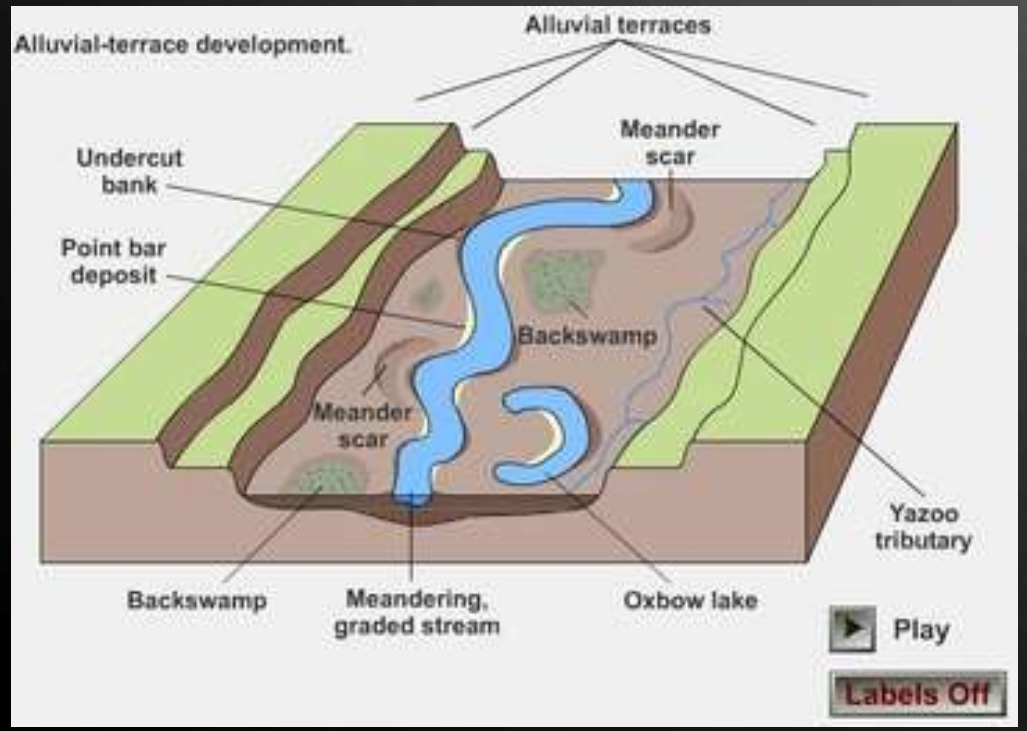
Jog Falls

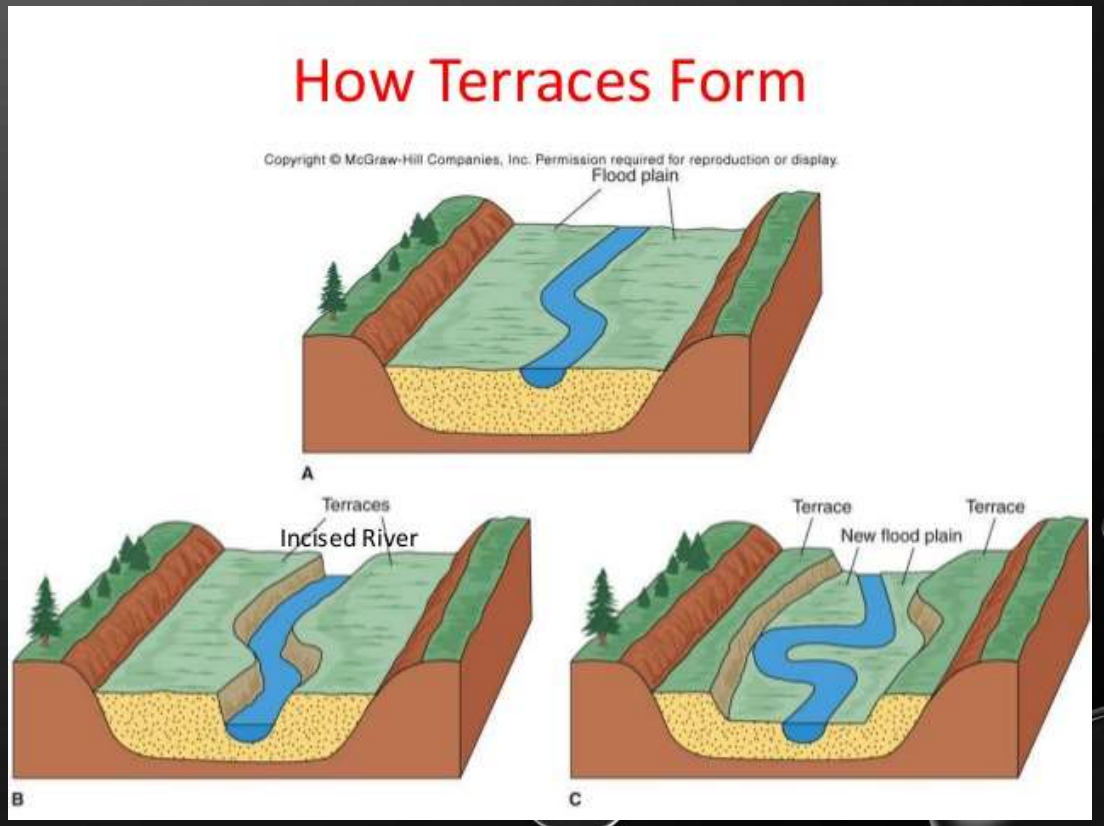
Nohkalikai Falls

Angel falls

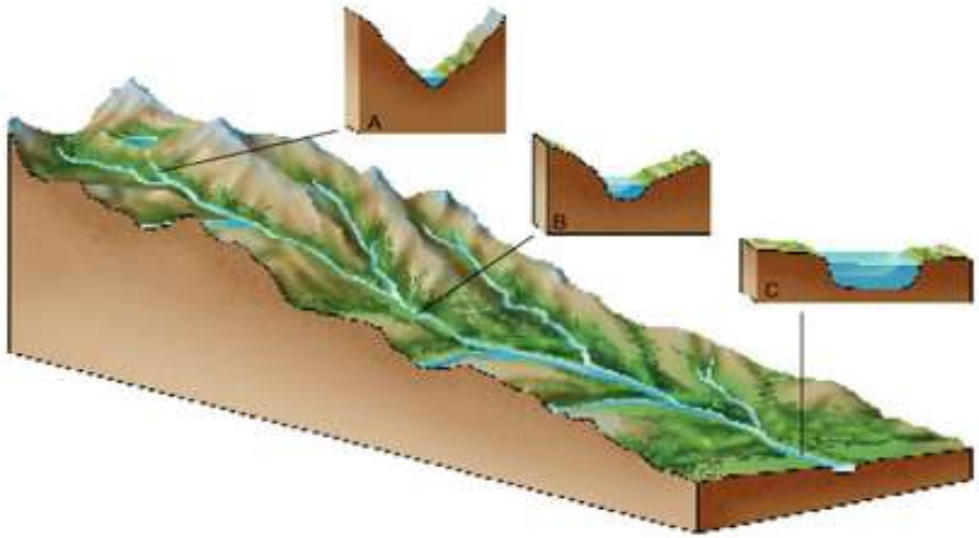
STREAM TERRACES

- Step-like landforms formed by river flow
- Stream cut down its own channel not continuously but in a series of stages.
- They look like steps



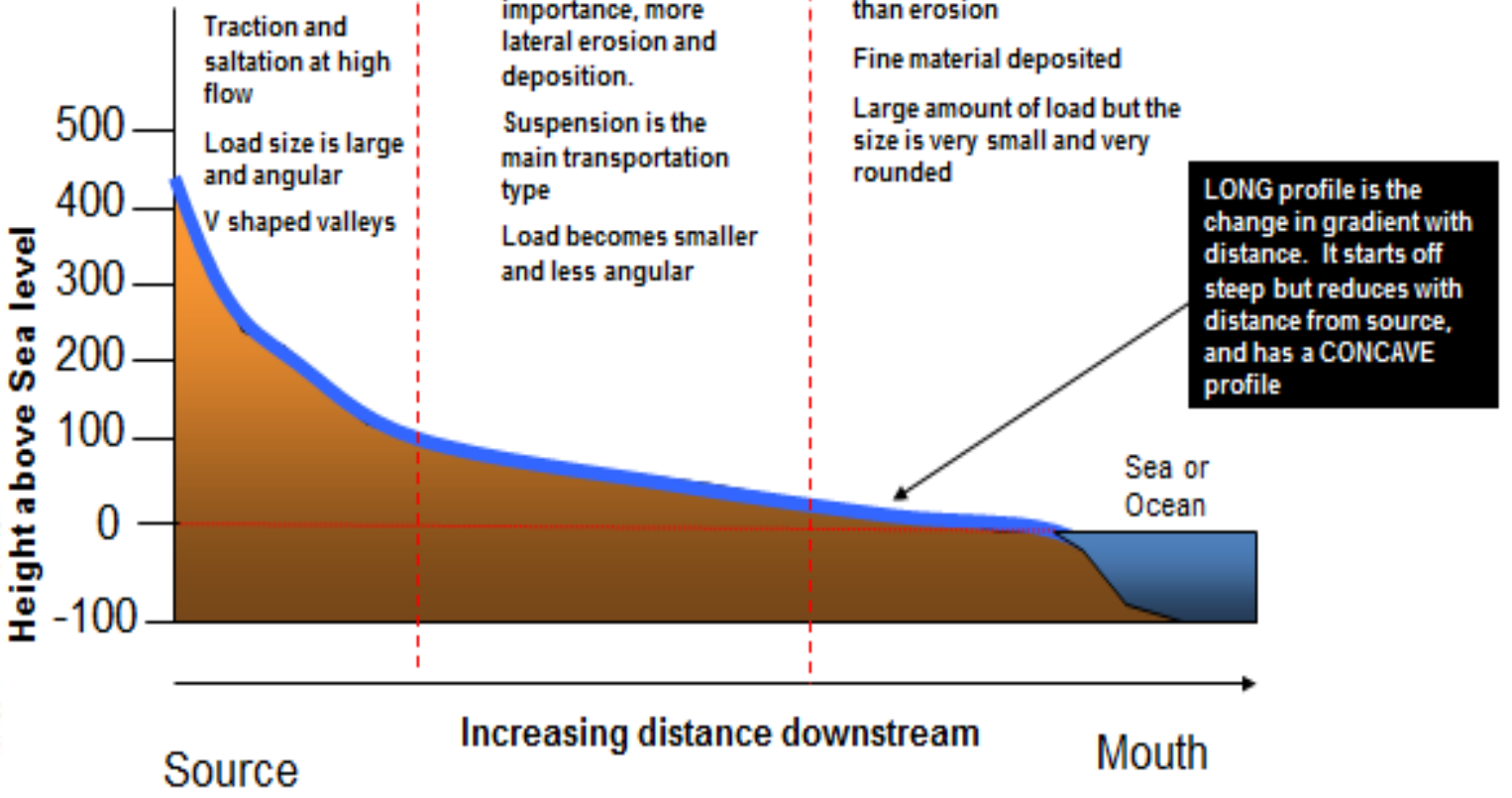


VALLEY PROFILE



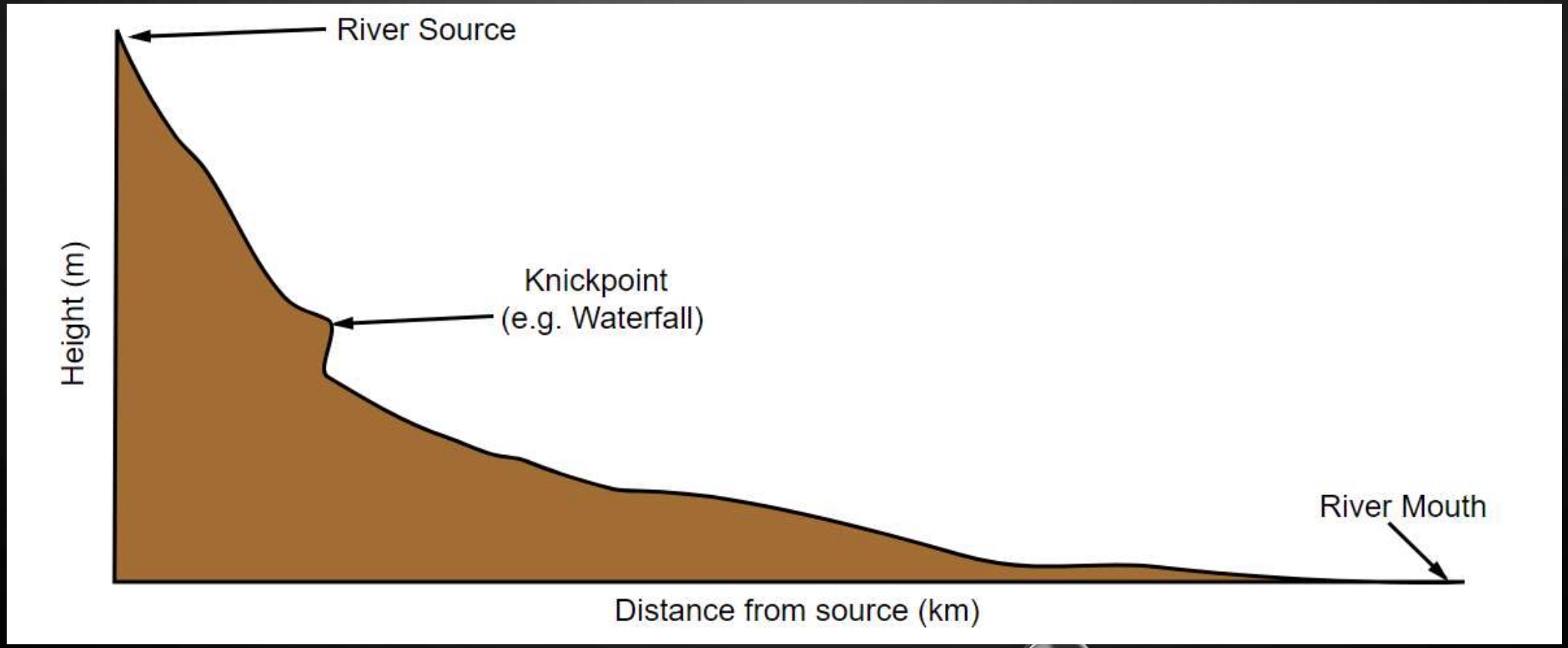
Long and cross profiles on a TYPICAL river

	UPPER VALLEY	MIDDLE REACHES	LOWER REACHES
Cross profiles			
Characteristics & processes	Vertical erosion with Hydraulic action, abrasion & attrition dominant processes Traction and saltation at high flow Load size is large and angular V shaped valleys	Channel is deeper and wider Vertical erosion decreasing in importance, more lateral erosion and deposition. Suspension is the main transportation type Load becomes smaller and less angular	Channel is at its widest and deepest, and may be tidal Deposition more important than erosion Fine material deposited Large amount of load but the size is very small and very rounded



- Longitudinal or long profile – Curve depicting the course of a stream from its head to its mouth. It gives an idea about *type of work*(erosion or deposition) a stream is likely to perform in a particular region. The main tendency of every river is to *achieve a straight longitudinal profile*. So generally older the stream flatter will be the profile
- Transverse or cross profile – Profile taken along the cross section of stream

Longitudinal Profile



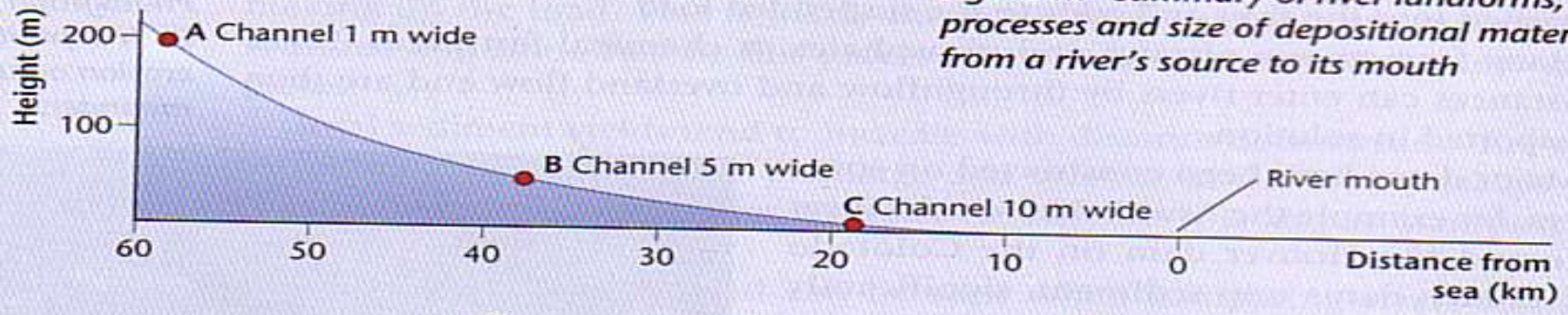


Figure 1.7 Summary of river landforms, processes and size of depositional material, from a river's source to its mouth

A

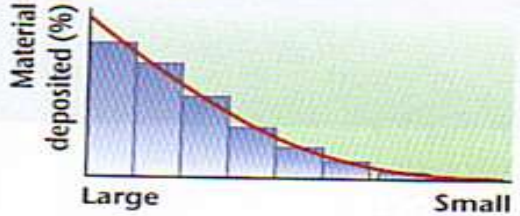
Landforms
Small waterfalls, rapids, potholes, large boulders, uneven steep river bed

Processes
Erosion
Hydraulic and attrition, mostly vertical

Transportation
Mostly large boulders (bedload). Some in suspension and little in solution

Deposition
Limited to the large bedload

Size of material



B

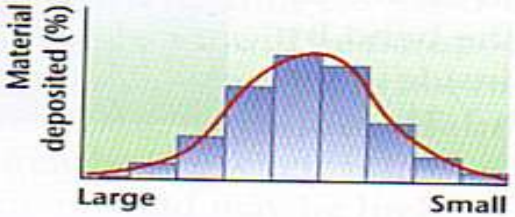
Landforms
Rapids, small meanders, small floodplain

Processes
Erosion
Mostly attrition with a little hydraulic, less vertical erosion, lateral erosion begins

Transportation
Smaller sized bedload moved by traction, suspension load increased. Little in solution

Deposition
Coarser material builds up, deposition on slip-off slopes, floodplain built up in times of flood

Size of material



C

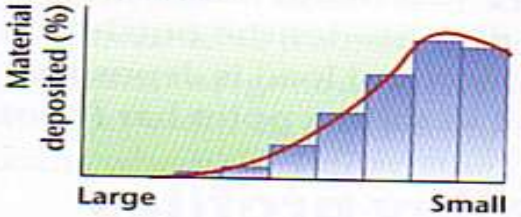
Landforms
Larger meanders, levées, floodplain

Processes
Erosion
Erosion reduced – some lateral erosion on outside bends of meanders

Transportation
Smaller sized bedload of pebbles, gravel and sand form the load. Most transported by suspension

Deposition
Mostly fine particles. Forms slip-off slopes, levées and floodplains

Size of material



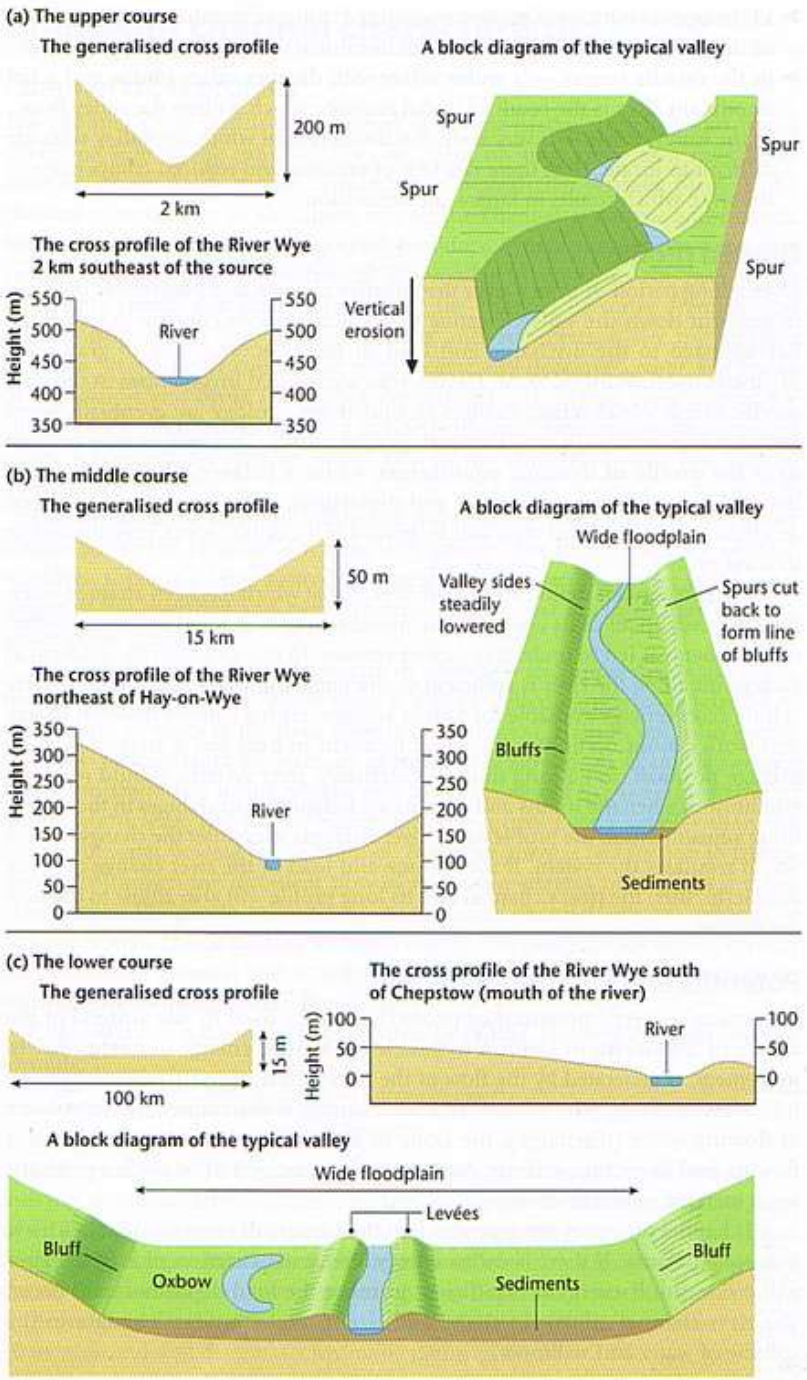
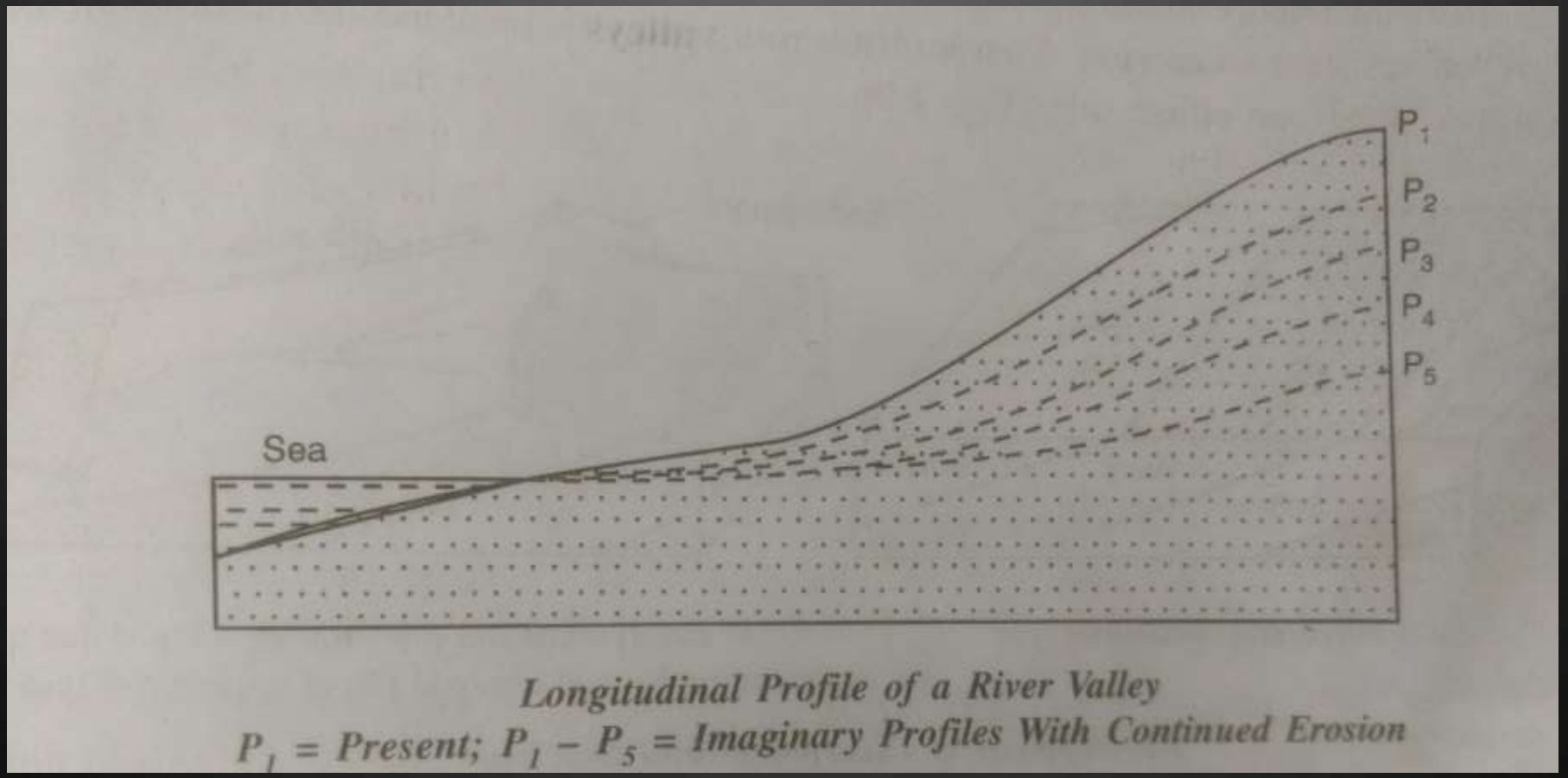


Figure 1.8
Valley cross p
characteristi



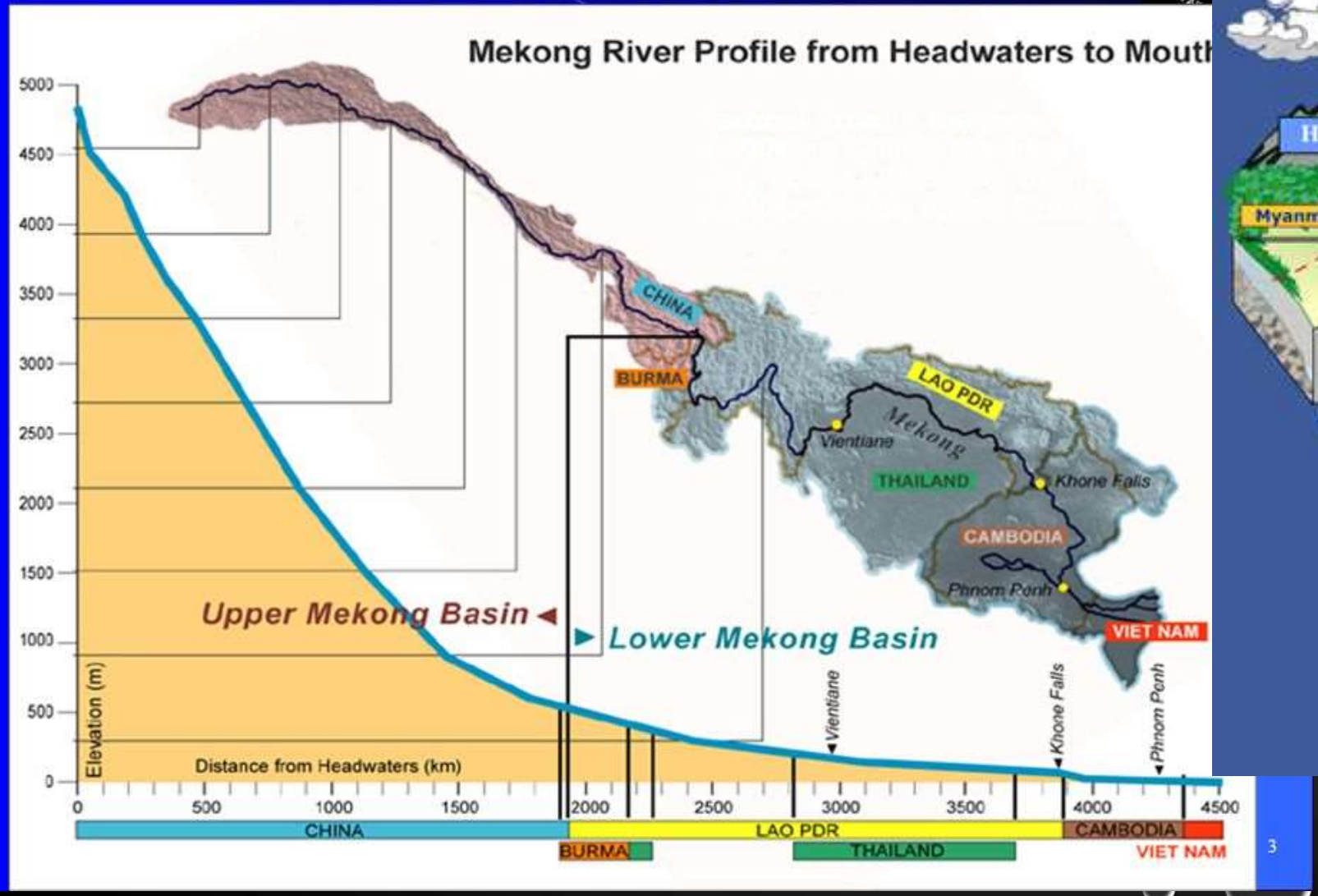
Longitudinal Profile of a River Valley

P_1 = Present; $P_1 - P_5$ = Imaginary Profiles With Continued Erosion

Profile changing w.r.t. time

MEKONG RIVER

Longitudinal river profile of the Mekong River from source to delta



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