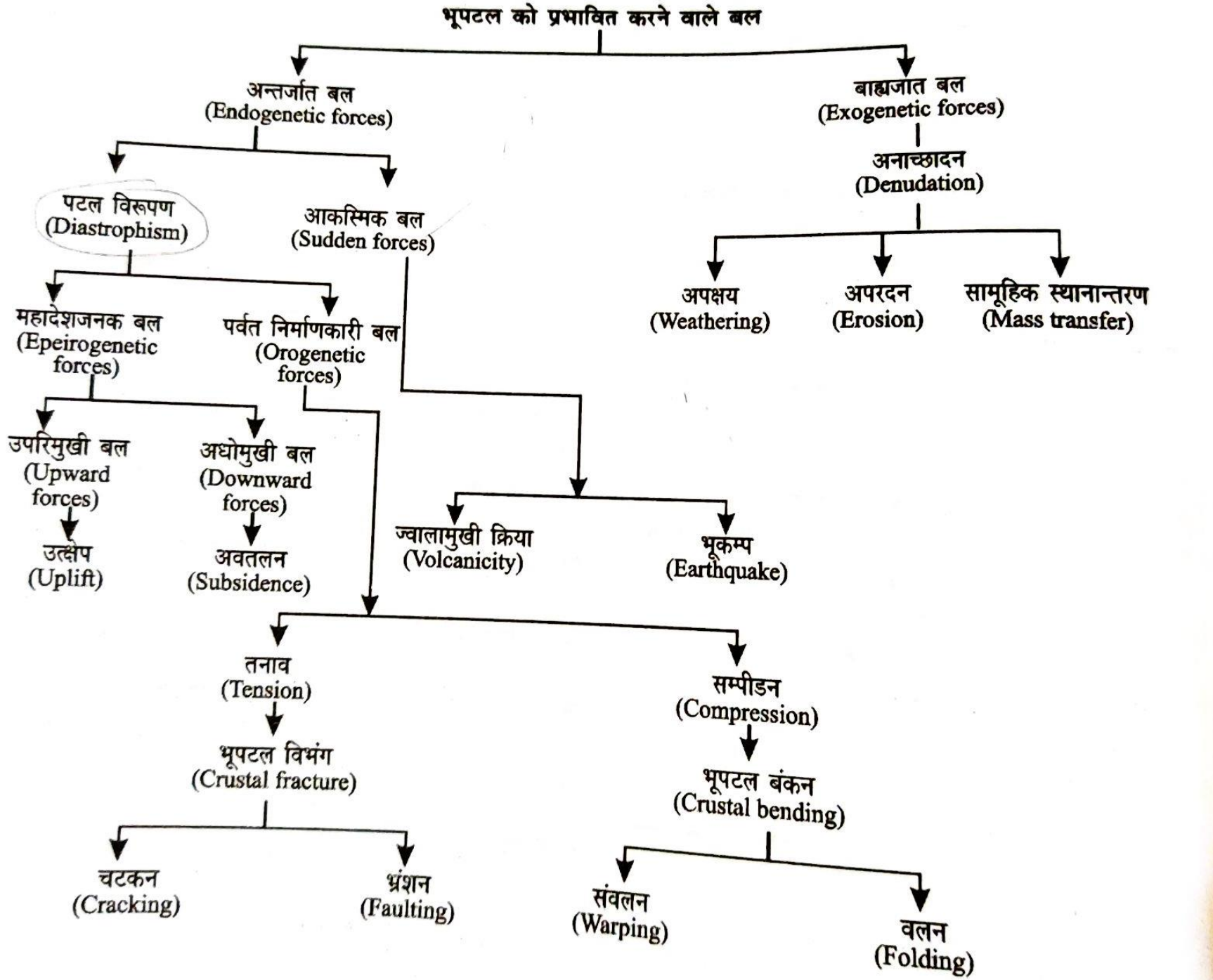
Diastrophism

Faults and Folds

Compiled by Urmi Sharma

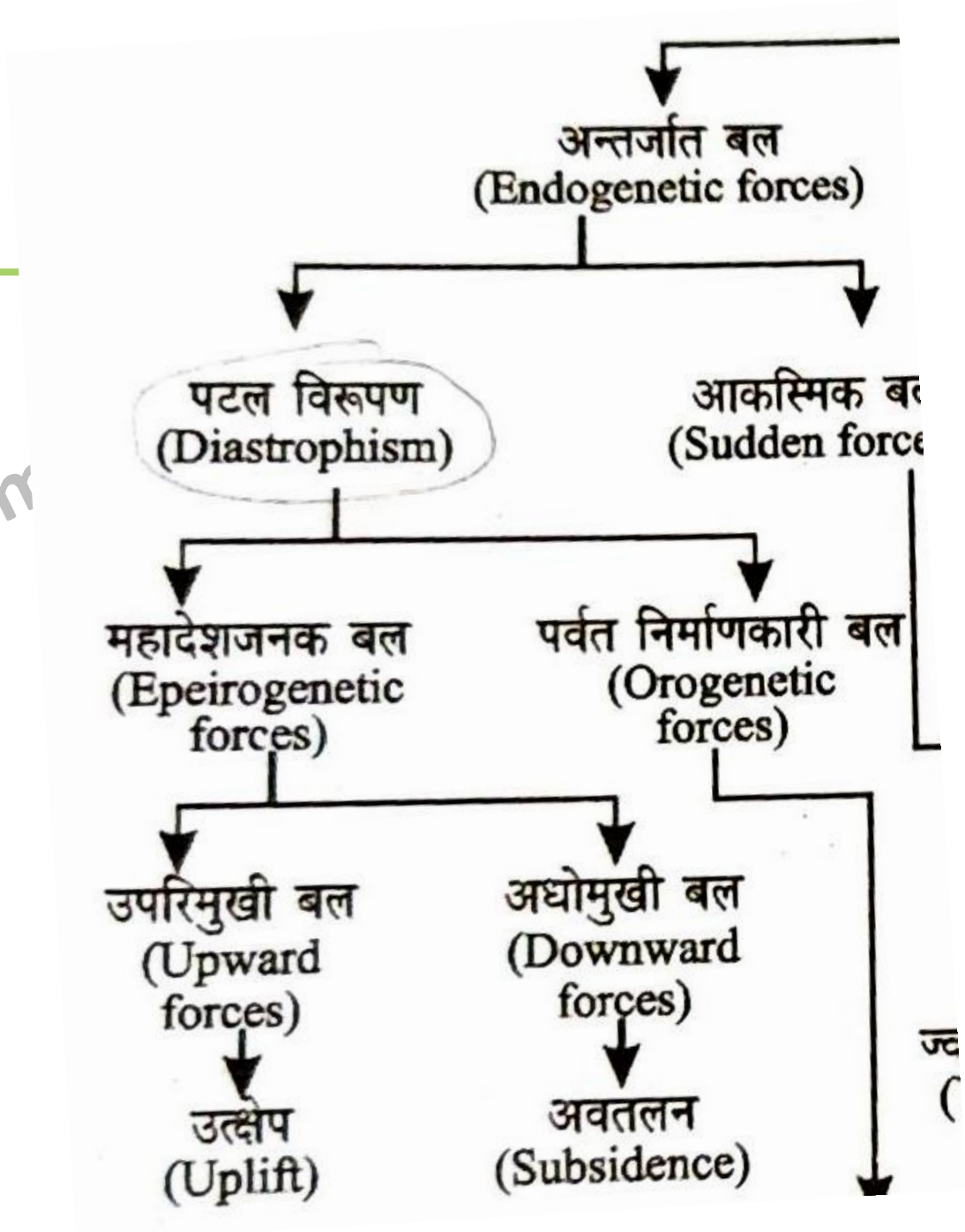
What is Diastrophism ????
पटल विरूपण ?????

- It includes all crustal movements of the earth.
- These movements can be VERTICAL or HORIZONTAL.
- The process that results into the deformation of the earth crust.


भूपटल को प्रभावित करने वाले बल
अन्तर्जात बल
(Endogenetic forces)
बाह्यजात बल
(Exogenetic forces)
पटल विरूपण
(Diastrophism)
आकस्मिक बल
(Sudden forces)
अनाच्छादन
(Denudation)
अपक्षय
(Weathering)
अपरदन
(Erosion)
सामूहिक स्थानान्तरण
(Mass transfer)
महादेशजनक बल
(Epeirogenetic forces)
पर्वत निर्माणकारी बल
(Orogenetic forces)
उपरिमुखी बल
(Upward forces)
अधोमुखी बल
(Downward forces)
उत्क्षेप
(Uplift)
अवतलन
(Subsidence)
ज्वालामुखी क्रिया
(Volcanicity)
भूकम्प
(Earthquake)
तनाव
(Tension)
सम्पीडन
(Compression)
भूपटल विभंग
(Crustal fracture)
भूपटल बंकन
(Crustal bending)
चटकन
(Cracking)
भ्रंशन
(Faulting)
संवलन
(Warping)
वलन
(Folding)

Diastrophism

1. Epeirogenetic movement
2. Orogenetic movement



Epeirogenetic movement

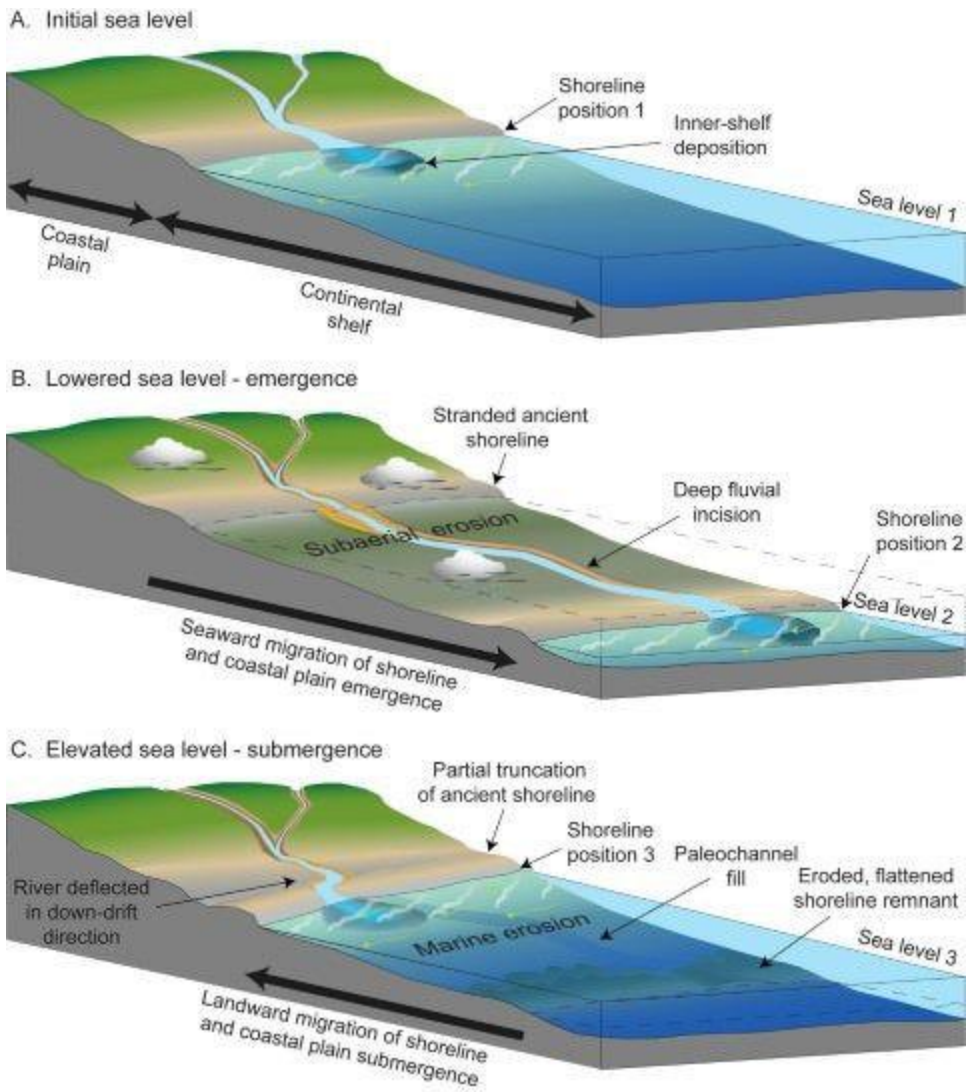
- **'Epeiros' = *Continent***
- **These movements are very <u>extensive</u>**
- **Types:**

1. ***Upward* movement** and
2. ***Downward* movement**

1. उपरिमुखी संचलन (Upward movement)—इस संचलन द्वारा स्थल भाग ऊपर की ओर उठता है। भूखण्ड का ऊपर की ओर उठना दो प्रकार से होता है।

***(a)* उत्थान** (Uplift)—महाद्वीप के आन्तरिक या स्थलीय भाग जब अपनी निकटवर्ती सतह से ऊपर उठते हैं, उसे उत्थान कहते हैं।

***(b)* उन्मज्जन** (Emergence)—महाद्वीप के तटवर्ती भाग जो पहले जलमग्न थे, यदि सागर की सतह से ऊपर उठ जाते हैं तो उसे उन्मज्जन कहते हैं। प्रायः प्रत्येक महाद्वीप पर उत्थान एवं उन्मज्जन के प्रमाण मिलते हैं—



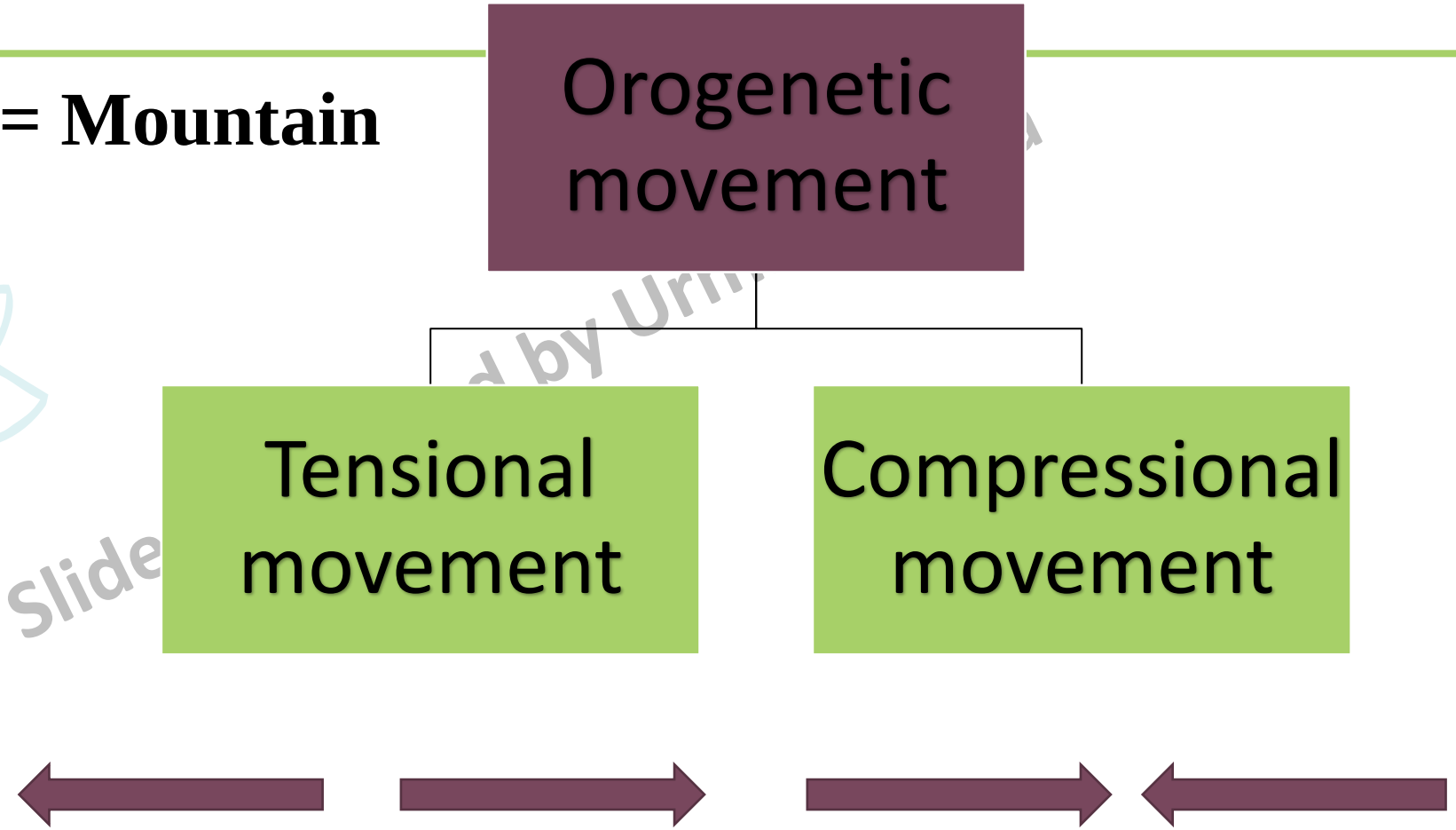
2. अधोमुखी संचलन (Downward movement)—इस संचलन से भूमि का धँसाव होता है। यह क्रिया दो प्रकार से होती है—

(a) अवतलन (Subsidence)—महाद्वीप के आन्तरिक भाग में स्थानीय अथवा प्रादेशिक स्तर पर भूमि आस-पास की सतह से नीचे धँसती है।

(b) निमज्जन (submergence)—तटवर्ती भाग में भूखण्ड के सागरतल से नीचे डूबने की क्रिया निमज्जन कहलाती है। उपरोक्त दोनों क्रियाओं के प्रमाण व्यापक रूप से पाये जाते हैं।

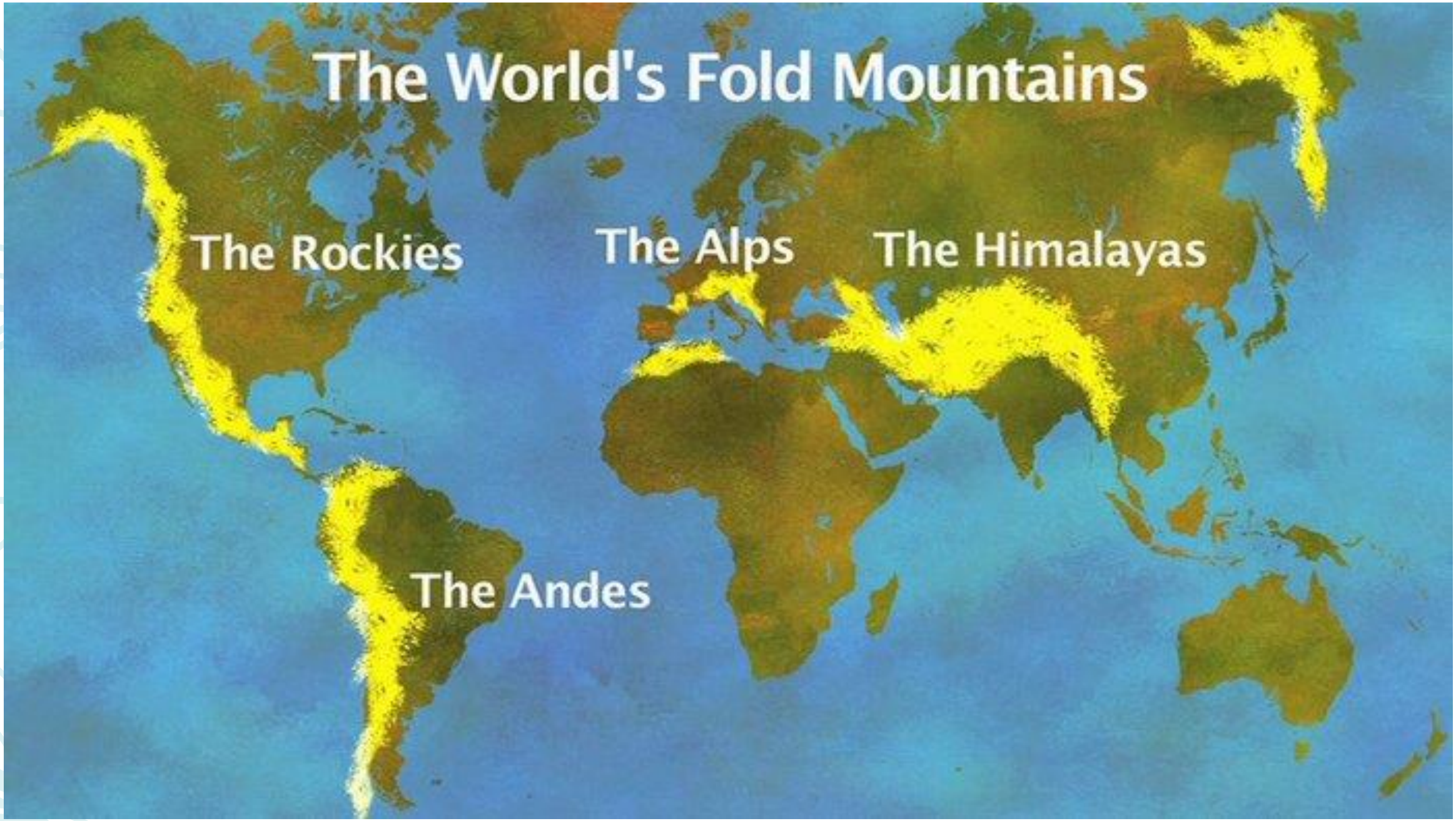
Orogenetic movement

- **'Oros' = Mountain**



Folds

- Folds are one of the most common geological structures found in rocks. When a set of horizontal layers are **subjected to compressive forces, they bend either upward or downward.** The bend noticed in rocks are called folds.
- In terms of their nature too, folds may occur as single local bends or may occur repeatedly and intricately folded to the tectonic history of the region.


The World's Fold Mountains
The Rockies
The Alps
The Himalayas
The Andes

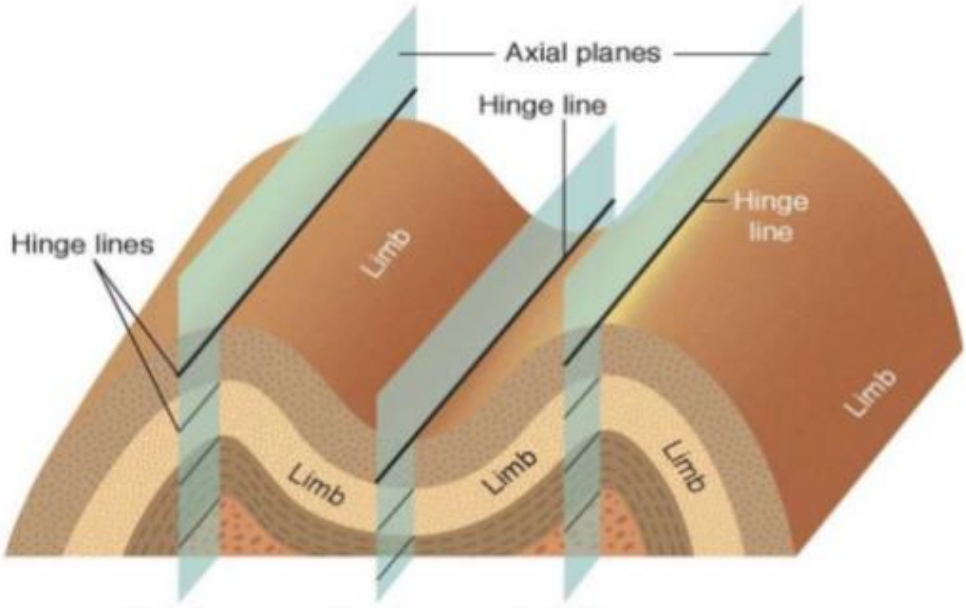
Folds...

मिलर (Miller, 1952) के अनुसार, "वलन शैल संस्तर या संरचना में एक मोड़ है।'

("A fold is a bend in rock layer or formation.")

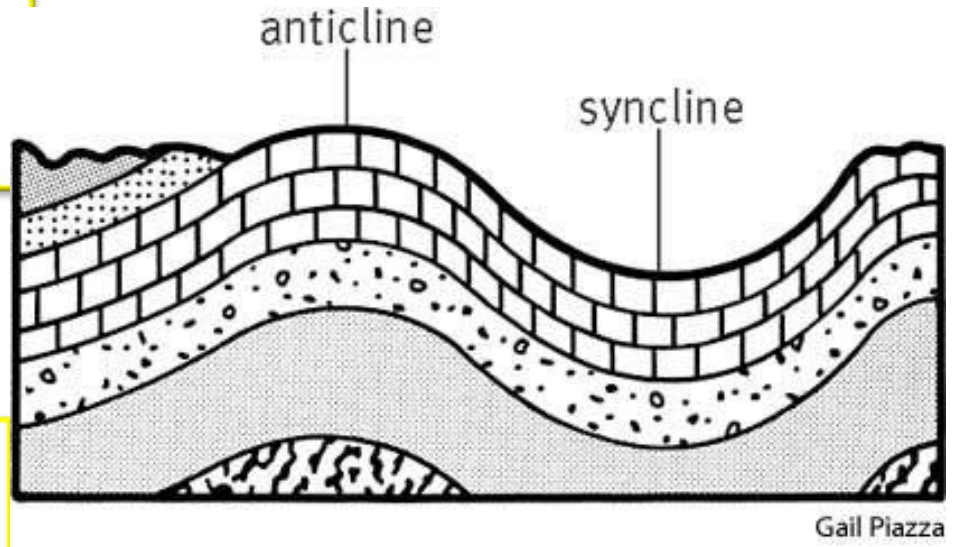
वॉरसेस्टर (Worcester, 1965) के अनुसार "वलन पद का प्रयोग लघु संरचना के लिए किया जाता है जो शैलों के स्तरों में मोड़ से उत्पन्न होता है।"

("The term fold is usually applied to smaller structures which result from the bending of layer of rocks.")



Anticline अपनति and Syncline अभिनति

- **Anticline:** When the beds are **bent upwards**, the resulting fold is called anticline. **This fold is convex upwards**. Naturally, in such a fold, the older beds occur towards the concave side.



- **Syncline** is just opposite to **anticline in its nature, i.e. when the beds are bent downwards the resulting fold is called syncline.** This fold is **convex downwards.** In this the younger beds occur towards the concave side.

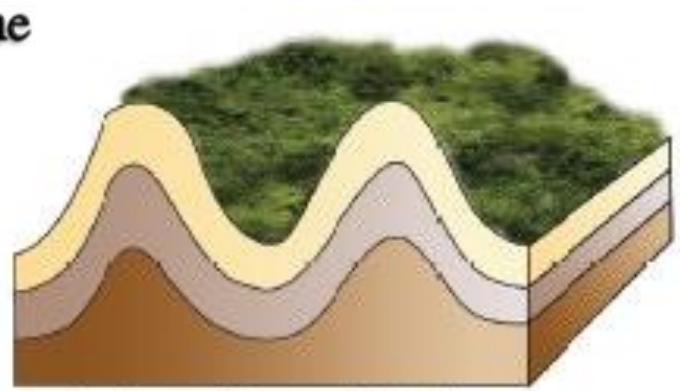
Types of FOLDS

(a) सममित वलन (Symmetrical fold)—साधारण एव खुले हुए वलन की दोनों भुजाएँ यदि समान झुकी होती हैं तो वह सममित वलन कहलाता है।

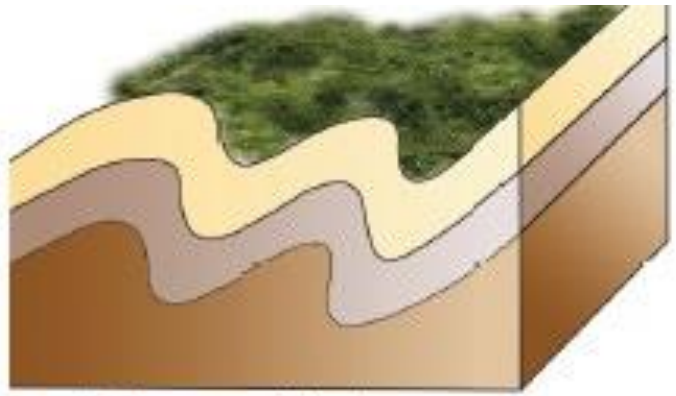
(b) असममित वलन (Assymmetrical fold)—यदि वलन की एक भुजा कम व दूसरी भुजा अधिक झुकी हो तो वह असममित वलन कहलाता है।

Symmetrical and Asymmetrical Folds

- When the axial plane divides a fold into two equal halves in such a way that **one half is the mirror image, then the fold is called as symmetrical fold**. If the compressive forces responsible for folding are not of the **same magnitude, asymmetrical folds are formed.**

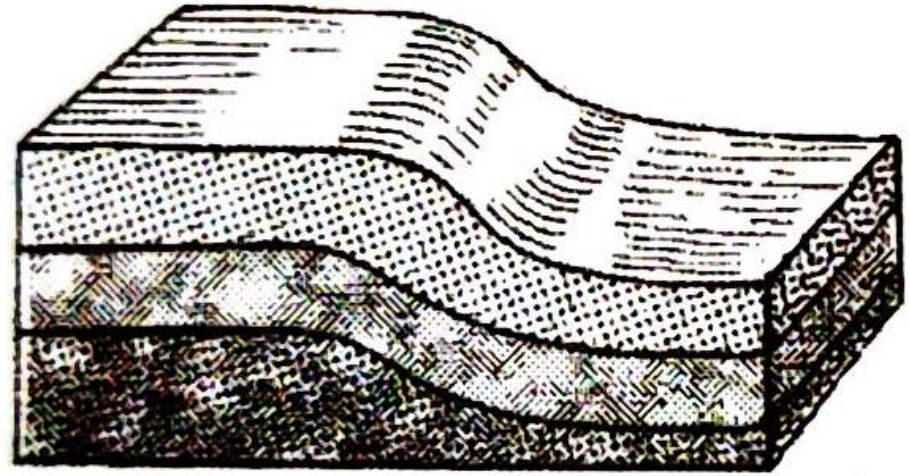


A. Open (Symmetrical)



B. Asymmetrical

(c) ***एकनति या एकदिग्नत वलन*** (Monoclinal fold)— जब वलन की एक भुजा मन्द ढाल एवं दूसरी भुजा समकोण बनाते हुए तीव्र ढाल प्रस्तुत करती है तो उसे एकदिग्नत वलन कहते हैं।

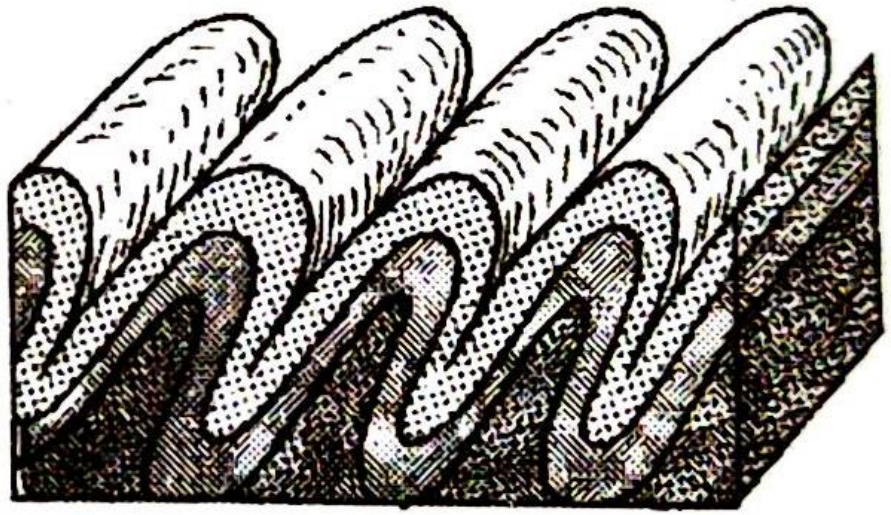


एकनतिक वलन

(d) समनत वलन (Isoclinal fold)—यदि वलन की दोनों भुजाएँ समान दिशा को झुकी हुई एवं समान्तर होती हैं तब समनत वलन निर्मित होता है।

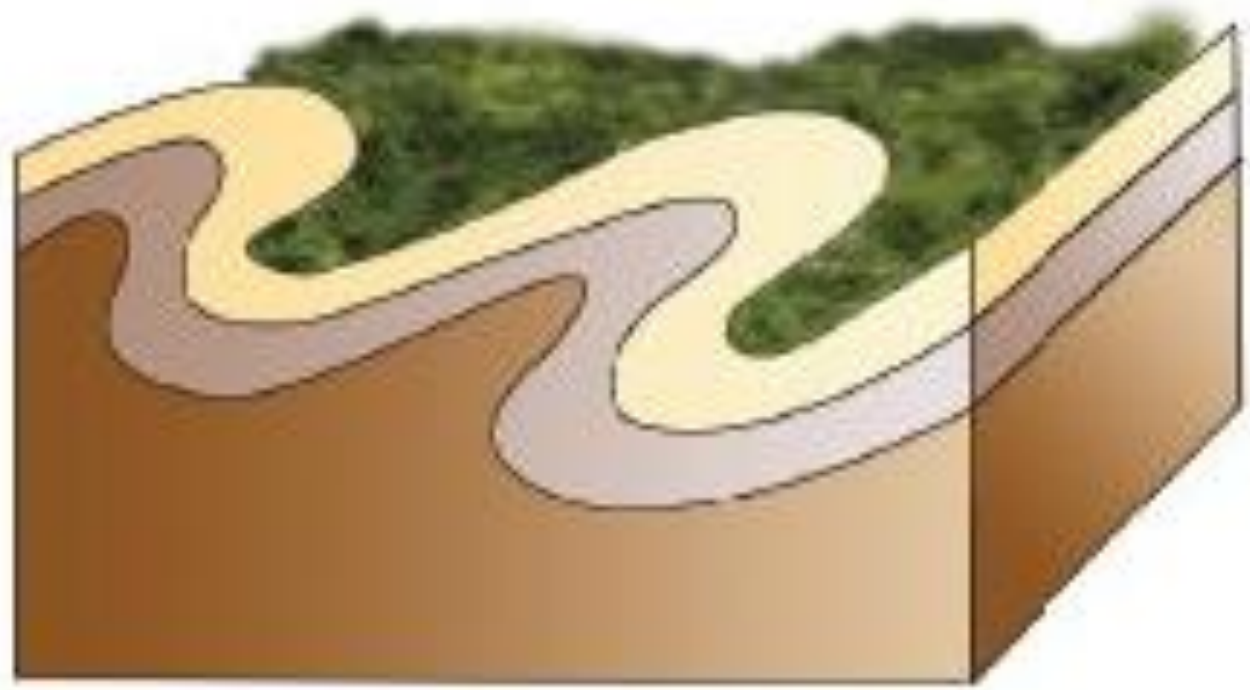
Isoclinal Folds

- Usually the **folds have inclined limbs**, i.e. the limbs will be mutually diverging or converging with reference to axial planes. But in some folds, the **limbs will be mutually parallel to a great extent**. Such folds are called isoclinals folds. These folds may be vertical inclined or horizontal.



समनतिक वलन

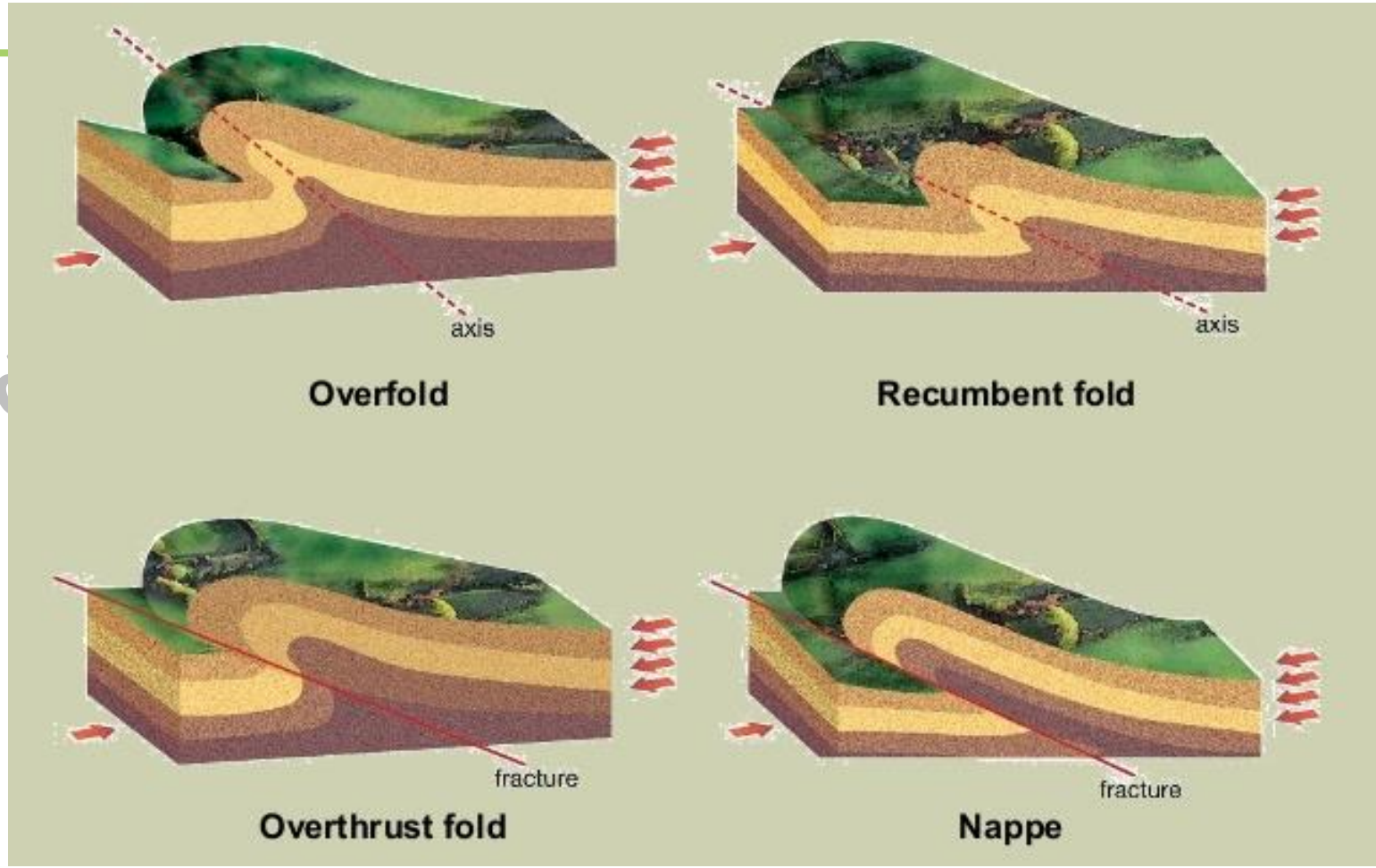
(e) परिवलन या शयान वलन (Recumbent fold)— वलन क्रिया तीव्र होने पर अधिक संपीडन के कारण वलन की दोनों भुजाएँ अत्यधिक झुक जाती हैं तथा क्षैतिज दिशा में समान्तर क्रम में स्थित होती हैं तब उसे शयान वलन कहते हैं।



D. Recumbent

Nappe ग्रीवाखण्ड

- **In geology, a nappe or thrust sheet is a large sheetlike body of rock that has been moved more than 2 km or 5 km above a thrust fault from its original position.**
- **Nappes form in compressional tectonic settings.**
- **Nappes form when a mass of rock is forced (or "thrust") over another rock mass, typically on a low angle fault plane.**
- **The resulting structure may include large-scale recumbent folds, shearing along the fault plane.**



(g) ***पंखावलन*** (Fan folding)—एक वृहत् वलन की भू-अपनति एवं भू-अभिनति में जब अनेक लघु अपनतियाँ व अभिनतियाँ बन जाती हैं तो उन्हें क्रमशः **समपनति** (anticlinorium) एवं **समभिनति** (synclinorium) कहते हैं (चित्र 8)। उनकी आकृति पंखाकार होती है। पंखावलन में दोनों भुजायें प्रतिवलित हो जाती हैं (चित्र 7)।

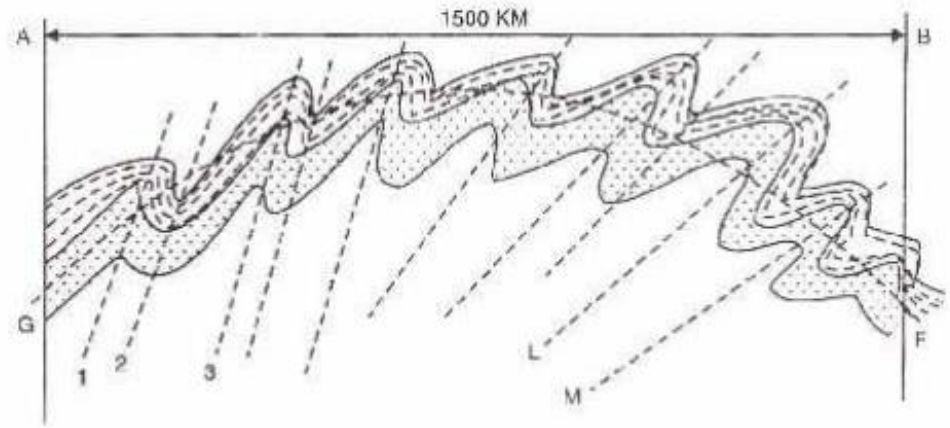
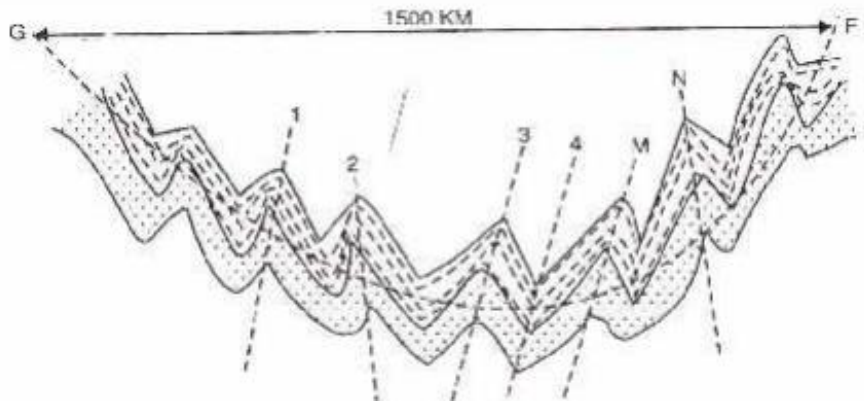


Fig. 6.23. A-B Anticlinorium

Fan Folds

- Usually in simple anticlines, the limbs dip away from one another and in simple synclines they dip towards each other. But in the case of fan folds, this trend is just the opposite, i.e. **in anticlines of fan folds, the limbs dip towards each other with reference to their axial plane.** In **synclines of this kind, the limbs dip away from each other**. As the term suggests, these folds are fan shaped.



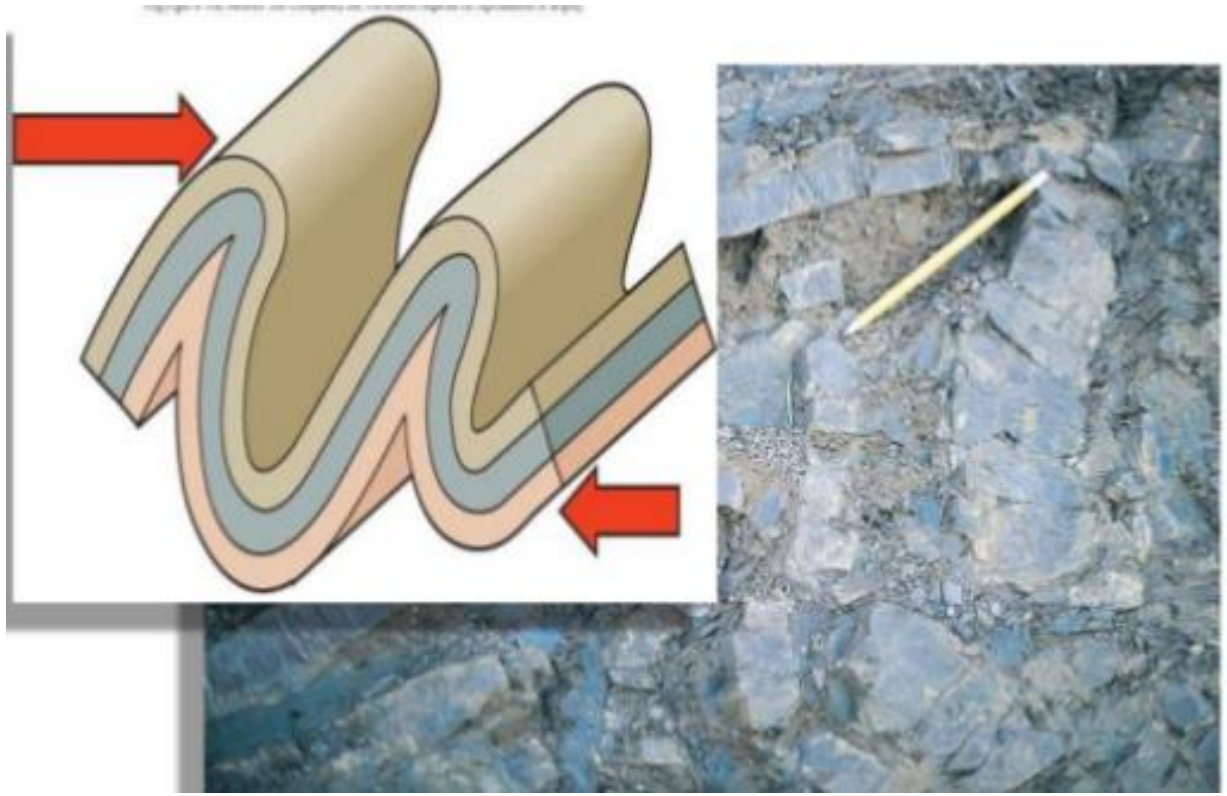
(h) खुले व बन्द वलन (Open and closed folds)— जब किसी वलन की दो भुजाओं के बीच का कोण 90° से अधिक किन्तु 180° से कम होता है तो वह खुला वलन तथा दोनों भुजाओं के बीच का कोण 90° से कम होने पर उसे बन्द वलन कहते हैं।

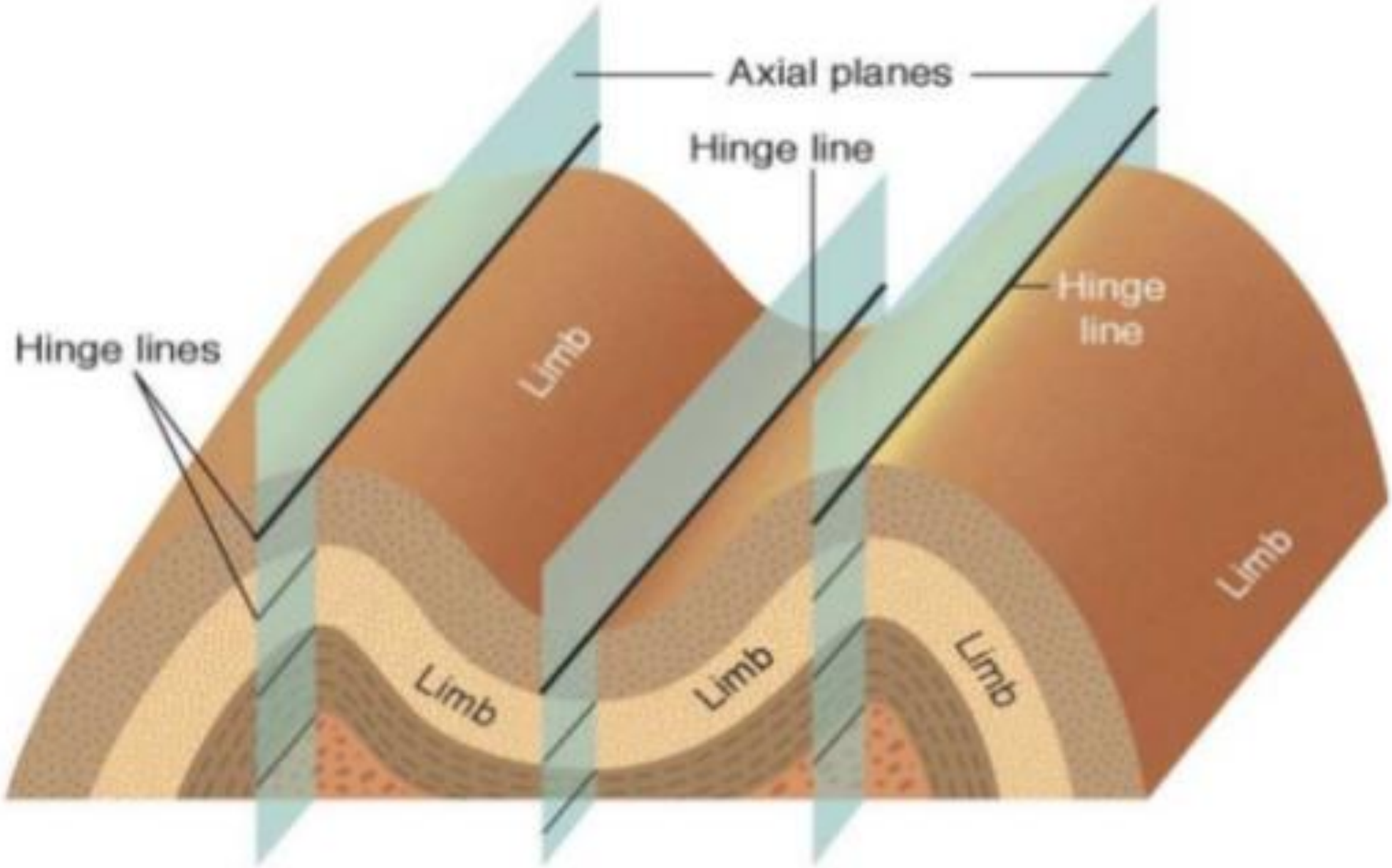
Open and Closed Folds

- Depending on the intensity of deformation, the beds of the fold may or may not have uniform thickness. **If the thickness of beds is uniform throughout the folds, it is called an open fold**. On the other hand, in a fold, **if the beds are thinner in the limb portions and thicker at crest and trough, such a fold is called closed fold.**

Overturned Fold

- Usually, in simple folds, the limbs show the order of superposition. **But when one of the limb is overturned, the order of superposition of beds in that limb will be in reverse order** and such a fold is called an **overturned fold.**




Axial planes
Hinge line
Hinge lines
Hinge line
Limb
Limb
Limb
Limb
Limb

Fault

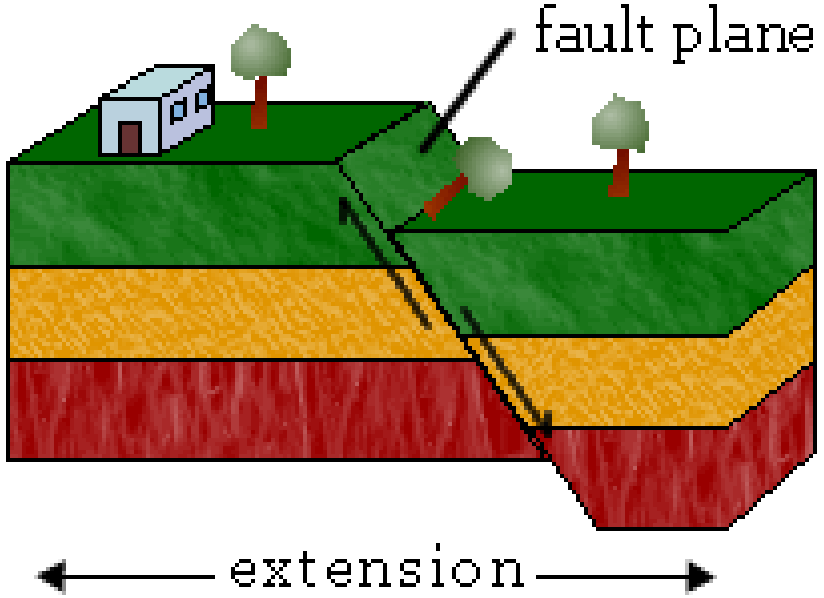
है। वॉरसेस्टर के अनुसार, "पृथ्वी के एक विभंग या विदर को भ्रंश कहते हैं जिसके सहारे एक भाग दूसरे भाग की अपेक्षा सरक जाता है।"

("A fault is a fracture or fissure in the earth along which one side has moved with reference to the other side.")

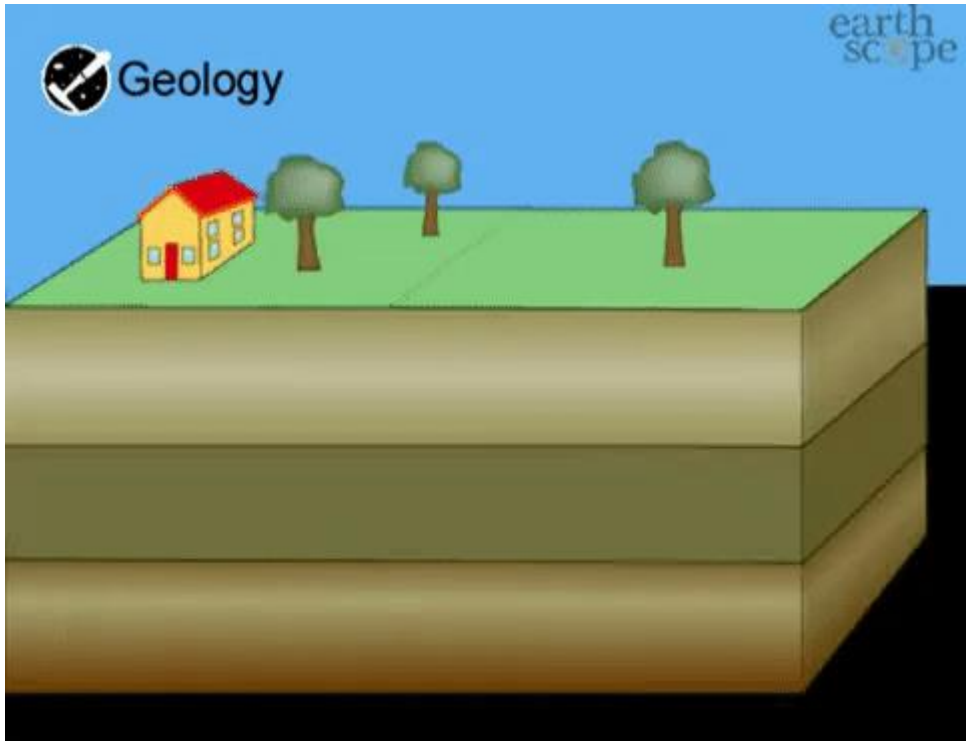
इसी प्रकार होम्स (A. Holmes) के अनुसार "एक भ्रंश विभंग सतह वह है जिसके सहारे शैलें सापेक्ष रूप से स्थानान्तरित होती हैं।"

("A fault is a fracture surface along which the rocks have been relatively displaced.")

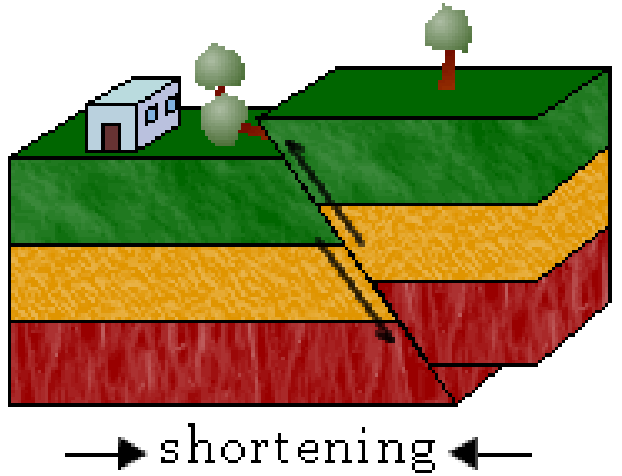
a) Normal Fault



- In a normal fault, **the block above the fault moves down relative to the block below the fault.**
- This fault motion is caused by **tensional forces** and results in **extension.**
- Other names: *normal-slip fault, tensional fault or gravity fault*



b) Reverse Fault



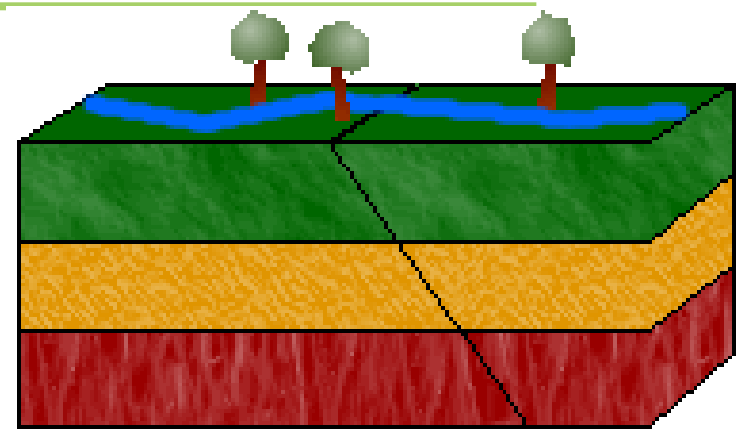
- In a reverse fault, the block above the fault **moves up relative to the block below the fault.**
- This fault motion is caused by **compressional forces and results in shortening.**
- A reverse fault is called ***a thrust fault*** if the dip of the fault plane is small.
- Other names: *thrust fault, reverse-slip fault or compressional fault*

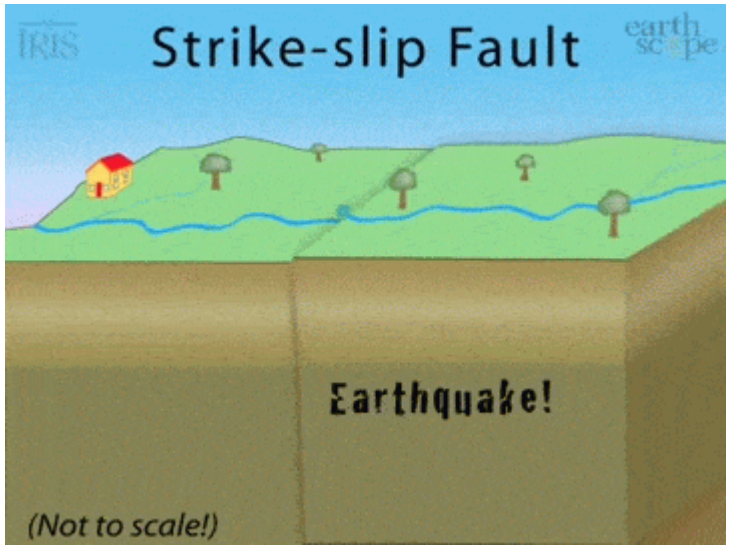
Reverse Fault

Footwall Hanging Wall

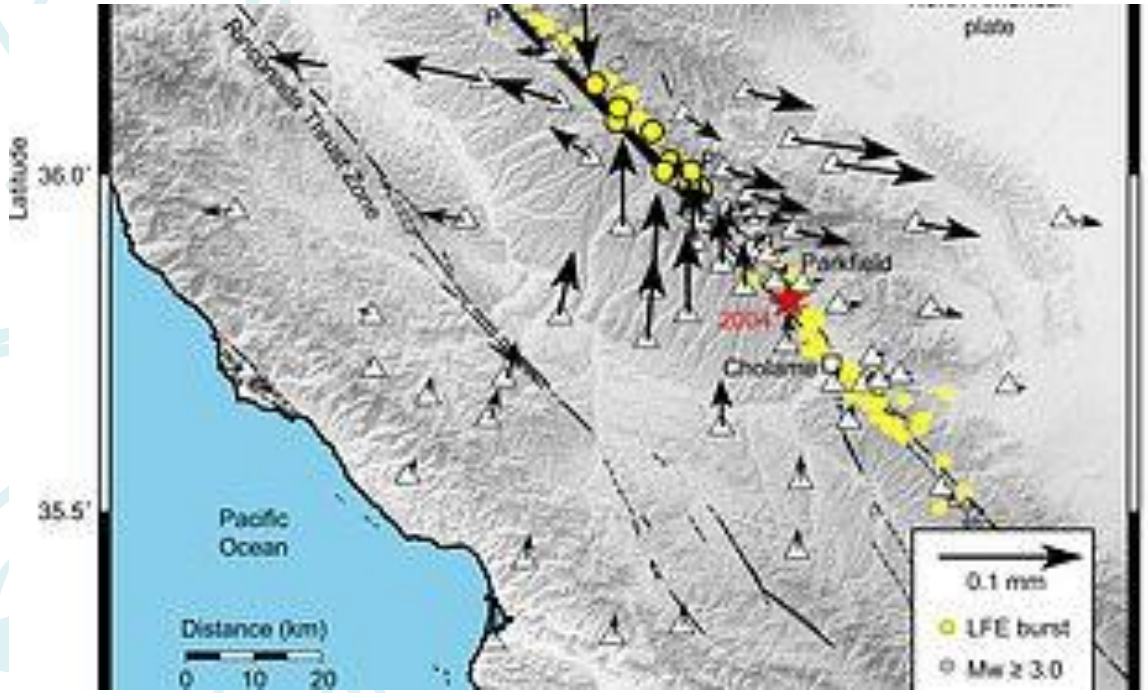
c) STRIKE-SLIP FAULT

- In a strike-slip fault, **the movement of blocks along a fault is horizontal.**
- If the block on the far side of the fault moves to the left, as shown in this animation, the fault is called **left-lateral.**
- If the block on the far side moves to the right, the fault is called **right-lateral.**
- The fault motion of a strike-slip fault is caused by **<u>shearing forces</u>**.
- This force acts in **HORIZONTAL** direction.
- Other names: *transcurrent fault*, ***lateral fault***, *tear fault or wrench fault*

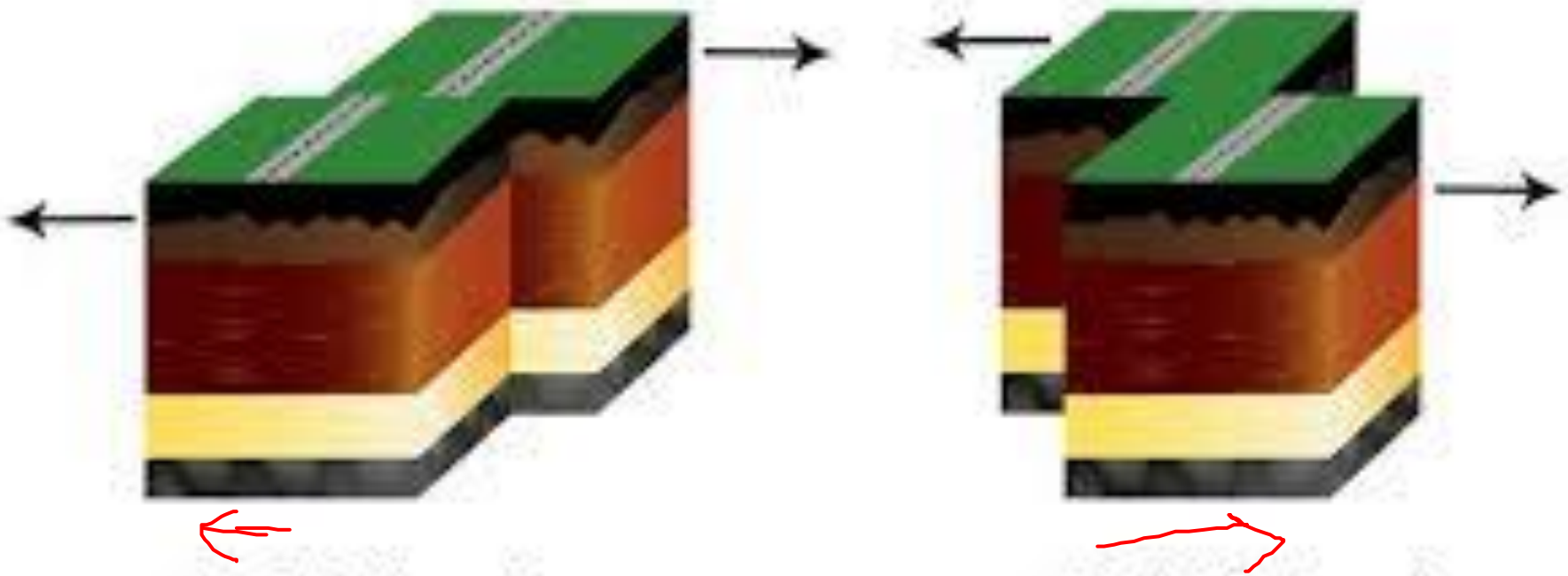




San Andreas Fault in California



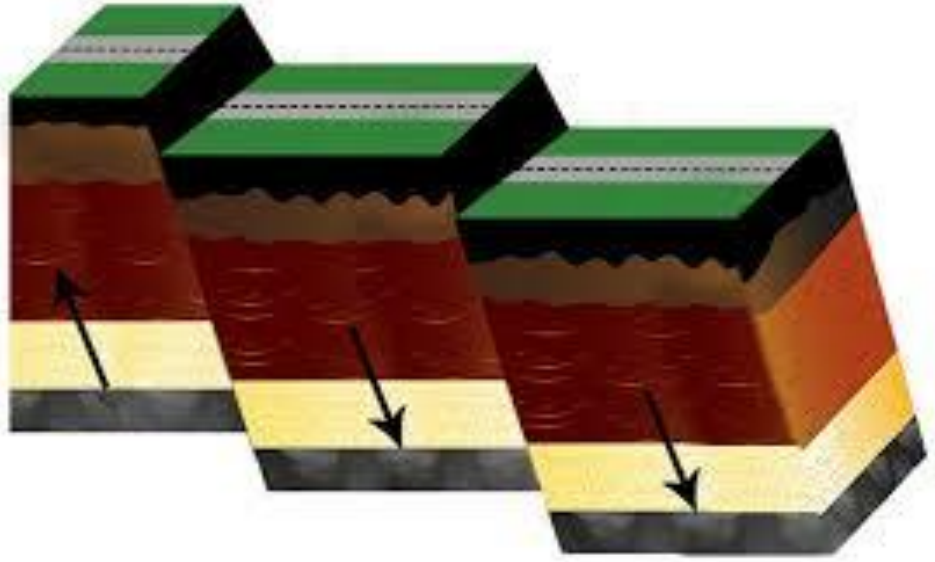
STRIKE-SLIP FAULTS



Left Lateral

Right Lateral

d) Step fault



- A **series of parallel faults** that, all **inclined in the same direction**, gives rise to a **gigantic staircase** hence these are called **step faults**.
- Each step is a fault block and its top may be horizontal or tilted.
- Aka ***Distributive fault*** or ***Compound fault***

Fault structures

1. Horst
2. Graben
3. Rift Valley

Weathering
अपक्षय

Denudation अनाच्छादन

- In geology, denudation involves the processes that cause the **wearing away of the Earth's surface** by moving *water*, *by ice*, *by wind*, *and by waves*, leading to a reduction in elevation and in relief of landforms and of landscapes.
- **Endogenous** processes such as volcanoes, earthquakes, and plate tectonics uplift and expose continental crust to the
- **Exogenous** processes of **weathering**, of **erosion**, and of mass wasting.

Definitions

- Weathering processe occur at or near the Earth's surface and produce changes to the landscape that influence surface and subsurface topography and landform development.
  - **Weathering** is the physical disintegration or chemical alteration of rocks at or near the Earth's surface.
  - **Erosion** is the physical removal and transportation of weathered material by water, wind, ice, or gravity

Weathering

- The process of disintegration and decomposition of rock in generally called weathering .

Processes involved in Weathering

1. Physical processes

2. Chemical processes

Factors controlling weathering

1. **Rock composition and structure**
2. **Slopes of the land**
3. **Climatic condition:** *Temperature variations*
4. **Vegetation**
5. **Time**

Types of weathering

1. Physical weathering
2. Chemical weathering
3. Biological weathering

I. **Mechanical (physical) weathering** is the physical disintegration and reduction in the size of the rocks without changing their chemical composition.

- Examples: exfoliation, frost wedging, salt wedging, temperature changes, and abrasion

II. **Chemical weathering** decomposes, dissolves, alters, or weakens the rock through chemical processes to form residual materials.

- Examples: carbonation, hydration, hydrolosis, oxidation, and solution

III. **Biological weathering** is the disintegration or decay of rocks and minerals caused by chemical or physical agents of organisms.

- Examples: organic activity from lichen and algae, rock disintegration by plant or root growth, burrowing and tunneling organisms, and acid secretion

Physical weathering

1. ***Block*** disintegration due to **Temperature** change
2. ***Granular*** disintegration due to **Temperature** change
3. ***Shattering*** due to rain water and Temperature
4. ***Block*** disintegration due to **Frost**
5. ***Exfoliation*** due to **Temperature** and **Wind**
6. Disintegration due to **Pressure** release

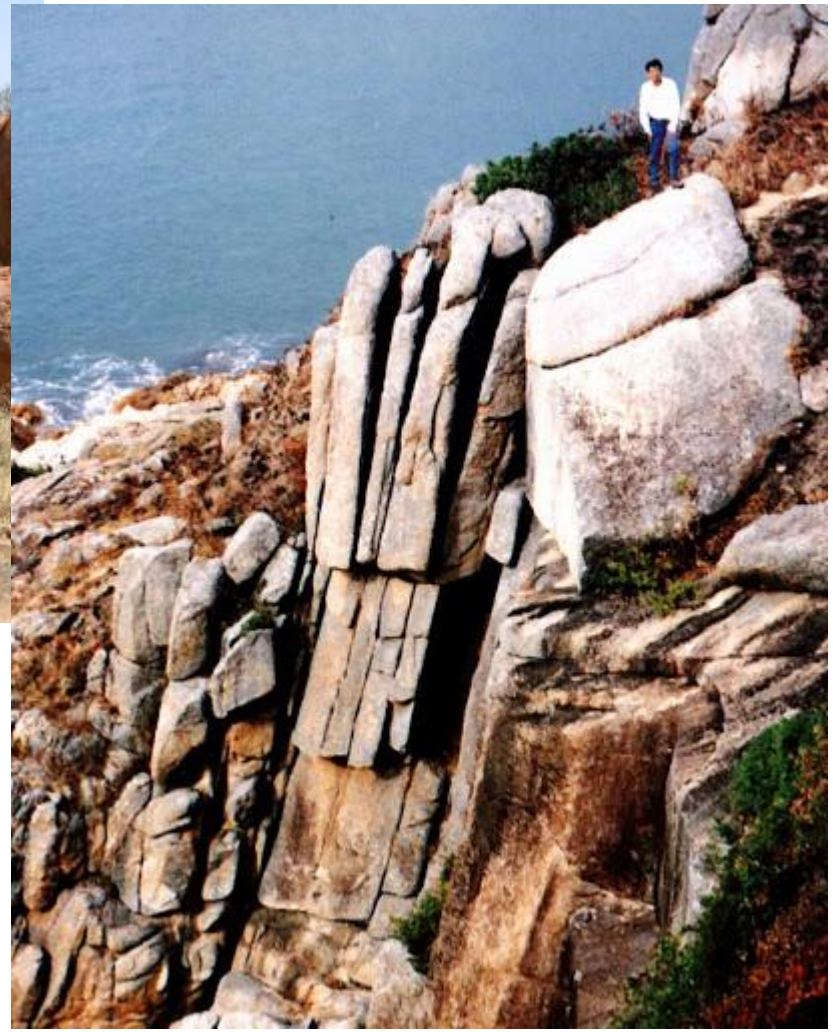
1. ***Block*** disintegration due to **Temperature** change

- Crystalline igneous rocks
- Due to differential temperature
- Expansion and Contraction in rocks occur

Granular disintegration due to **Temperature** change

- Hot deserts
- Mixed composition of rocks
- Temperature difference of day and night
- Differential rates of Expansion and Contraction in rocks occur

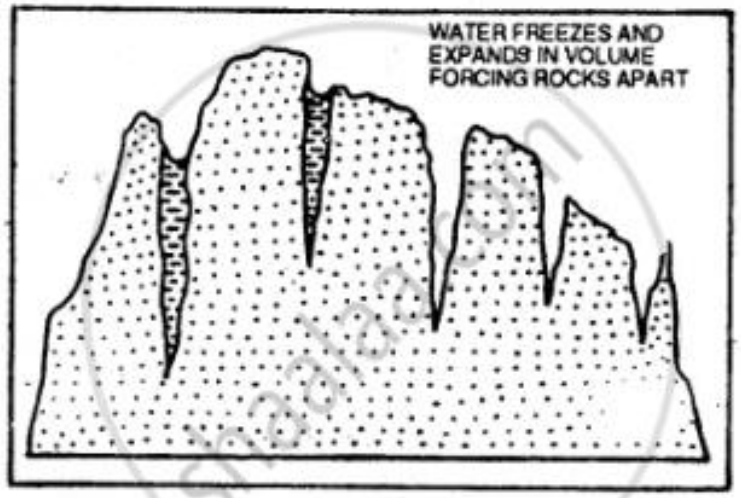
Block **disintegration**



Granular **disintegration**

Shattering due to rain water and Temperature

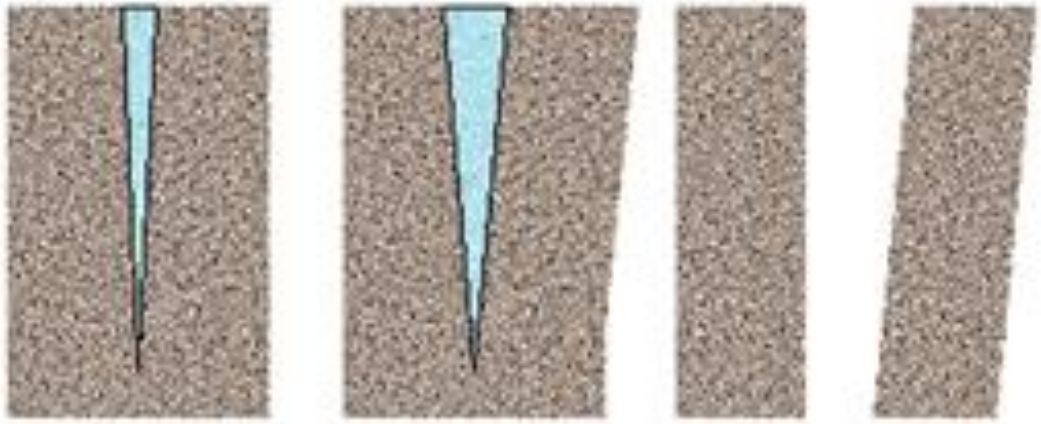
- Hot regions hot rocks in daytime
- Rain water on rocks
- Rocks disintegrates



Frost action cause weathering

Frost action cause weathering

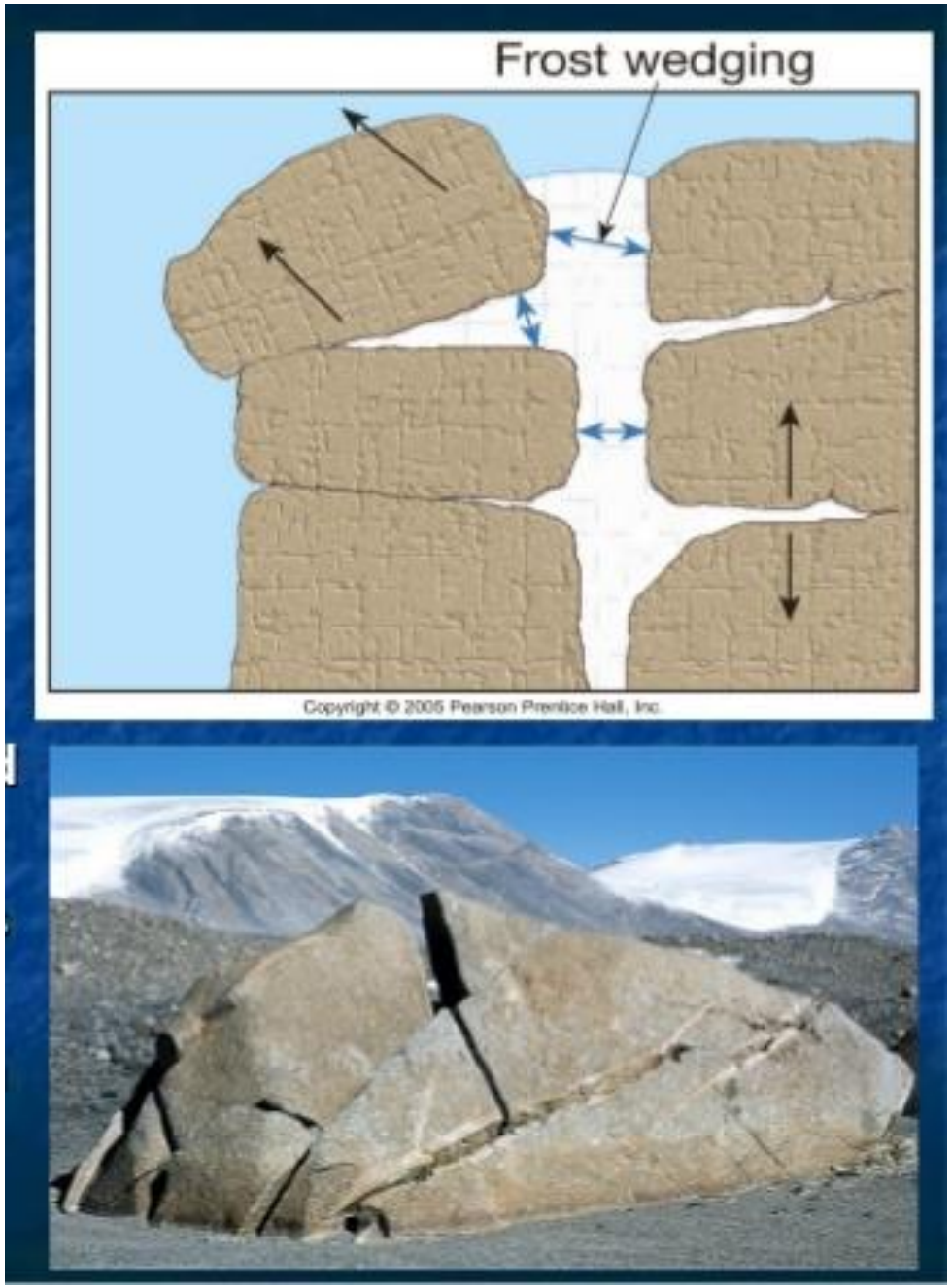
Frost Wedging



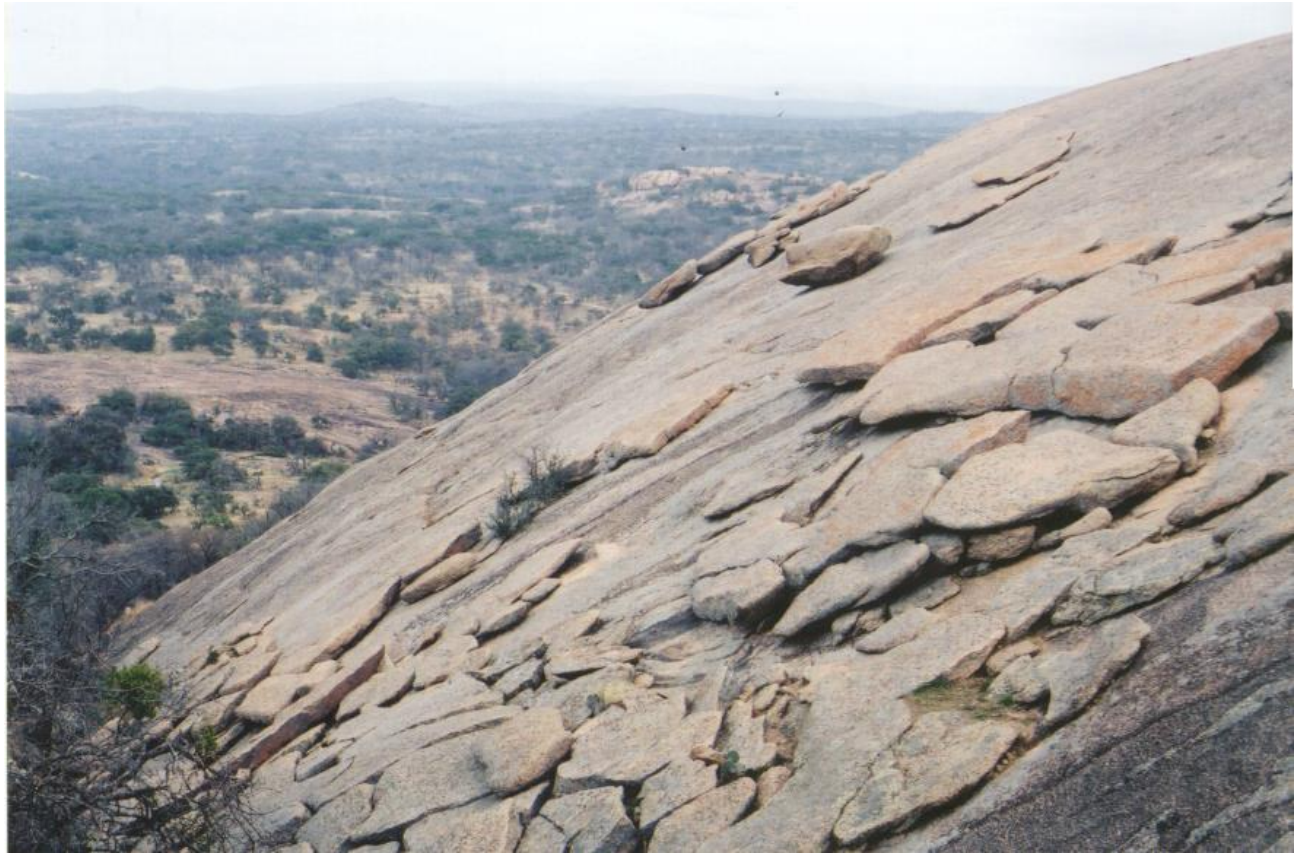
Water-filled crack

Freezes to ice

Breaks Rock



Exfoliation



- In Monsoonal and semi-monsoonal regions
- Semi- arid deserts
- Crystalline rocks

Chemical weathering

1. Hydrolysis: rain water dissolves carbonic elements of rocks
2. Hydration:
3. Desilication: removal of silica from rocks
4. Oxidation: oxides are formed
5. Carbonation: carbonates are formed

Hydrolysis

When rocks sit in water for extended periods of time they begin to break down and have a clay-like texture.

Hydration

Oxidation

Red color of rocks due to presence of Iron and reaction with oxygen present on air and moisture

Biological weathering

1. Weathering due to **Animals**
2. Weathering due to **Vegetation**
3. Weathering due to **Man**

Theory of Isostasy

Airy and Pratt views

Compiled by Urmi Sharma

Introduction

- Regions on earth are balancing themselves
- Regions: Plain, Plateau, Mountains
- The ***process of formation of landforms*** are result of two processes: **Endogenetic** forces and **Exogenetic** processes
- Even after these process all the features on the surface of the Earth are in BALANCE.
- This state of Balance on earth surface is known as ISOSTASY

"परिभ्रमण करती हुई पृथ्वी के ऊपर स्थित ऊँचे क्षेत्रों (पर्वत, पठार आदि) तथा निम्न बेसिनों के मध्य भौतिक अथवा यान्त्रिक स्थिरता की दशा ही सन्तुलन है।"

("Isostasy simply means a mechanical stability between the upstanding parts and lowlying basins on a rotating earth.")

होम्स (Holmes) के मत में "समस्थिति सन्तुलन की वह दशा है जो भूपटल के ऊपर विस्तृत विभिन्न ऊँचाई वाले विशाल पर्वतमालाओं, पठारों तथा मैदानों के मध्य पाई जाती है।"

("Isostasy is the corresponding state of balance which exists between extensive blocks of the earth's crust, which rise to different levels and appear at the surface as mountain ranges, widespread plateaus of plains.")

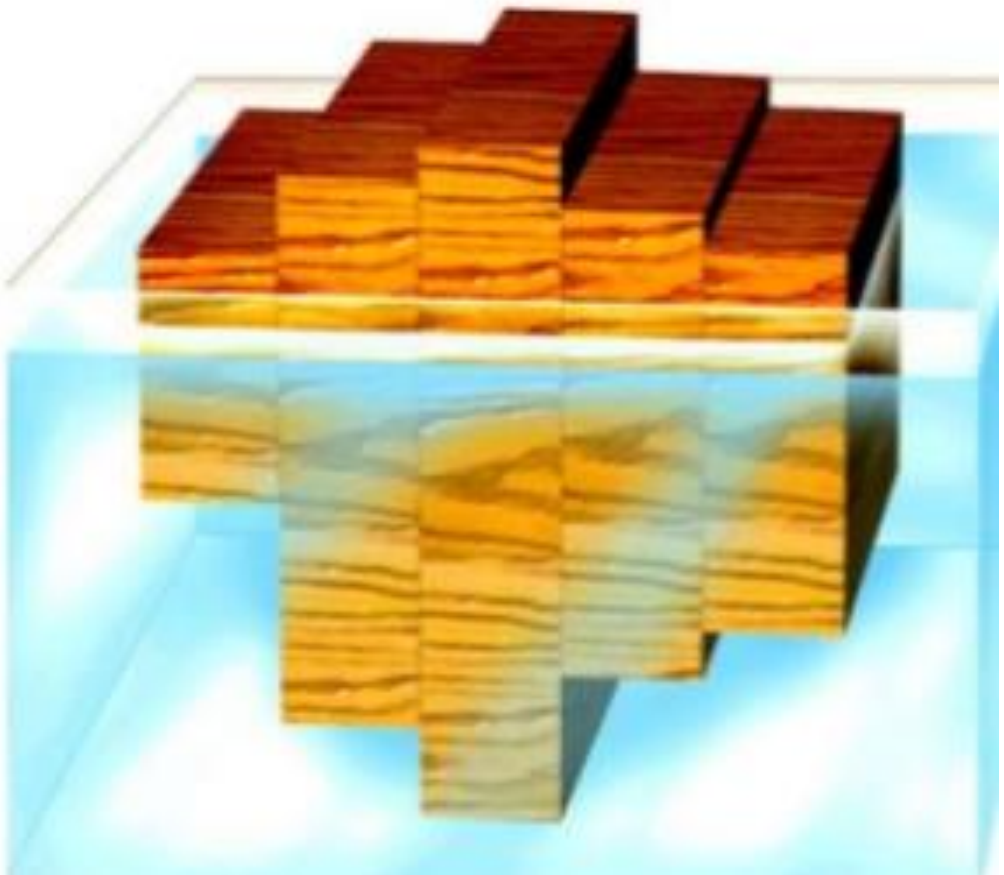
स्टीयर्स (Steers) ने समस्थिति की व्याख्या सरल शब्दों में करते हुए बताया है कि "पृथ्वी के धरातल पर जहाँ कहीं भी सन्तुलन विद्यमान है, समान धरातलीय क्षेत्रों के नीचे पदार्थ की मात्रा समान होगी।"

("Wherever equilibrium exists on the earth's surface, equal mass must underlie equal surface areas.")

- **Isostasy** (Greek *ísos* "equal", *stasis* "standstill")
- Term used in geology to refer to the state of gravitational equilibrium between the earth's lithosphere and asthenosphere.

➢Isostasy: a state of gravitational equilibrium in which an area of crust "floats" in a balanced way on the denser rock of the mantle below.

➢The elevation of any part of the Earth's crust is a function of the THICKNESS and DENSITY of the crust.



ISOSTASIOS means "**IN EQUIPOISE WITH, EQUIVALENT TO**"

The term *isostasy* was proposed in 1889 by the American geologist C. Dutton, but the first idea of mass balancing of the Earth's upper layer goes back to Leonardo da Vinci.

The term means that the Earth's topographic mass is balanced (mass conservation) in one way or another, so that at a certain depth the pressure is hydrostatic.

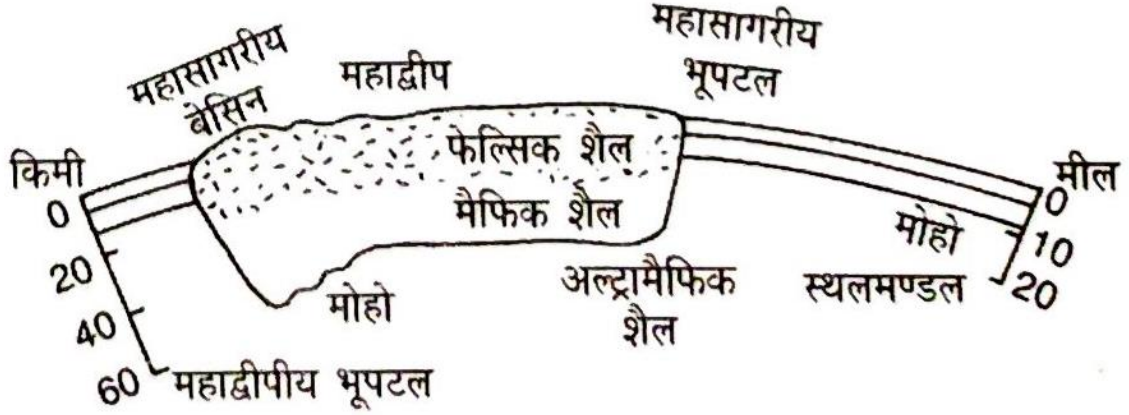
Isostasy is an alternative view of Archimedes' principle of hydrostatic equilibrium

Why ship not sink?

SHIPS FLOAT:

The weight of a floating body is equal to that of the volume of water that it displaces - Archimedes Principle

समस्थिति की संकल्पना **प्लवनशीलता** (buoyancy) के सिद्धान्त पर आधारित है जिसे **आर्किमिडीज** (Archimedes) ने प्रस्तुत किया था। प्लवनशीलता तरल माध्यम में किसी वस्तु के तैरने का वह गुण (योग्यता) है जिसके द्वारा वह अपने **द्रव्यमान** (mass) के बराबर द्रव के द्रव्यमान को हटाता है।



चित्र 1. पृथ्वी के भूपटल तथा ऊपरी मैन्टल का आदर्श पार्श्व चित्र।

किसी महाद्वीप का सागर तल से ऊँचा उठा हुआ कोई भाग उपरोक्त विधि द्वारा ही सहारा प्राप्त करता है। उदाहरणार्थ, माउण्ट एवरेस्ट के भूभाग की कल्पना कीजिए, जो विश्व में सर्वोच्च (8848 मी०) है। माउण्ट एवरेस्ट तथा इसकी निकटवर्ती पर्वत शिखरें पृथ्वी के भीतर स्थित पदार्थों की यान्त्रिक शक्ति के कारण अपने स्थान पर नहीं टिकी हैं। अपितु महाद्वीप की सतह का ऊपरी (पर्वतीय) भाग समुद्रतल के ऊपर इसलिए तैरता है क्योंकि स्थल का वह भाग अपने द्रव्यमान के बराबर राशि को हटाकर लचीले **दुर्बलतामण्डल** (asthenosphere) में गहराई तक प्रविष्ट है। इस प्रकार महाद्वीप के पर्वतों के ऊँचे भागों के नीचे का पदार्थ उन्हें धरातल पर सन्तुलित करता है। निचले भागों की जड़ें उथली होती हैं। जल में तैरते हुए यान की भाँति समस्त महाद्वीप समस्थितिक सन्तुलन (isostatic equilibrium) की स्थिति में होता है (चित्र 1)। स्पष्ट है कि धरातल के ऊपर स्थित ऊँचे पर्वतों को सन्तुलित रहने के लिये उनकी 'सिआल'

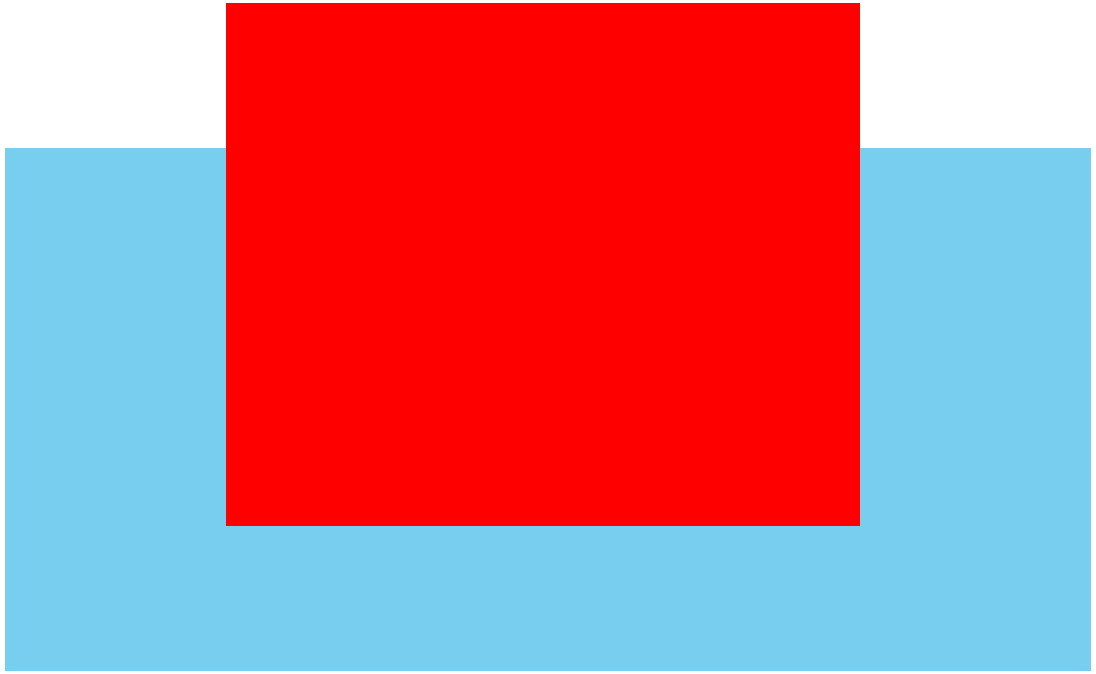
THEORY OF ISOSTASY, IS A FUNDAMENTAL CONCEPT IN EARTH SCIENCES BASED ON THE OPPOSING INFLUENCE OF TWO MAIN FORCES

BUOYANCY AND GRAVITY

IT IS THE STATE OF GRAVITATIONAL EQUILIBRIUM BETWEEN EARTH'S CRUST AND MANTLE, SUCH THAT –

THE CRUST FLOATS AT AN ELEVATION THAT DEPENDS ON ITS THICKNESS AND DENSITY.

IT IS THE IDEA THAT THE LIGHTER CRUST MUST BE FLOATING ON DENSER UNDERLYING MANTLE.



IDEAL THEORETICAL BALANCE OF ALL LARGE PORTIONS OF EARTH'S LITHOSPHERE AS THOUGH THEY WERE FLOATING ON THE DENSER UNDERLYING LAYER, THE ASTHENOSPHERE.

ASTHENOSPHERE, IS A SECTION OF THE UPPER MANTLE COMPOSED OF WEAK, PLASTIC ROCK.

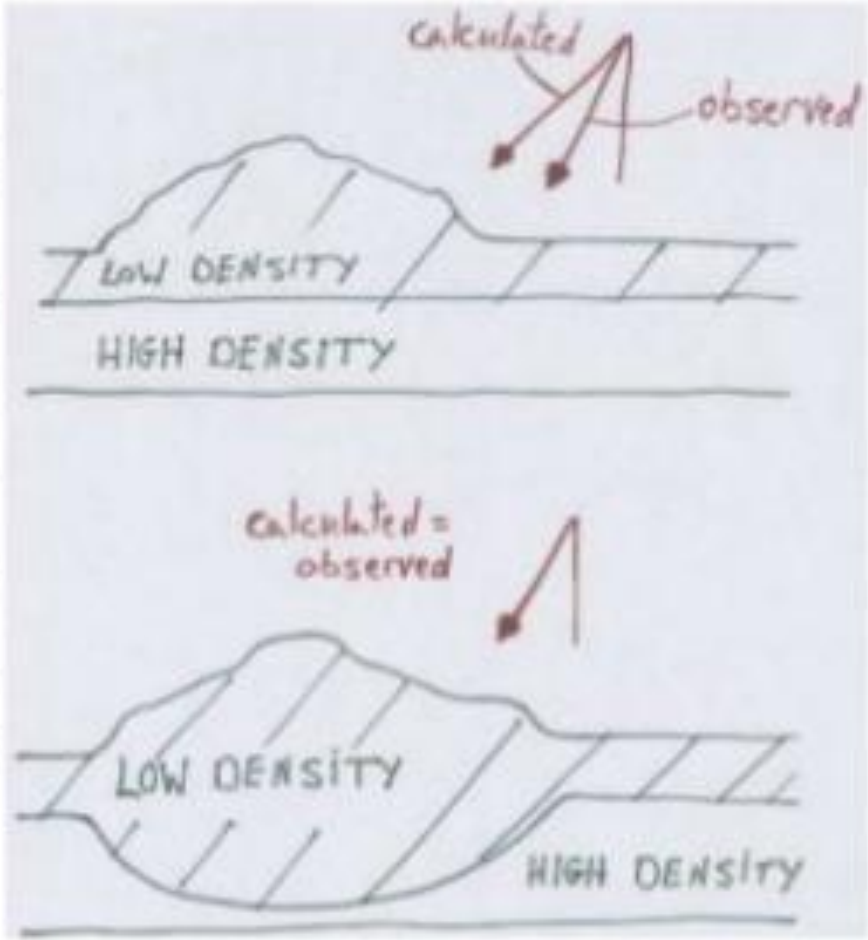
ISOSTASY CONTROLS THE REGIONAL ELEVATIONS OF CONTINENTS AND OCEAN FLOORS

IN ACCORDANCE WITH THE DENSITIES OF THEIR UNDERLYING ROCKS.

Development of Doctrine

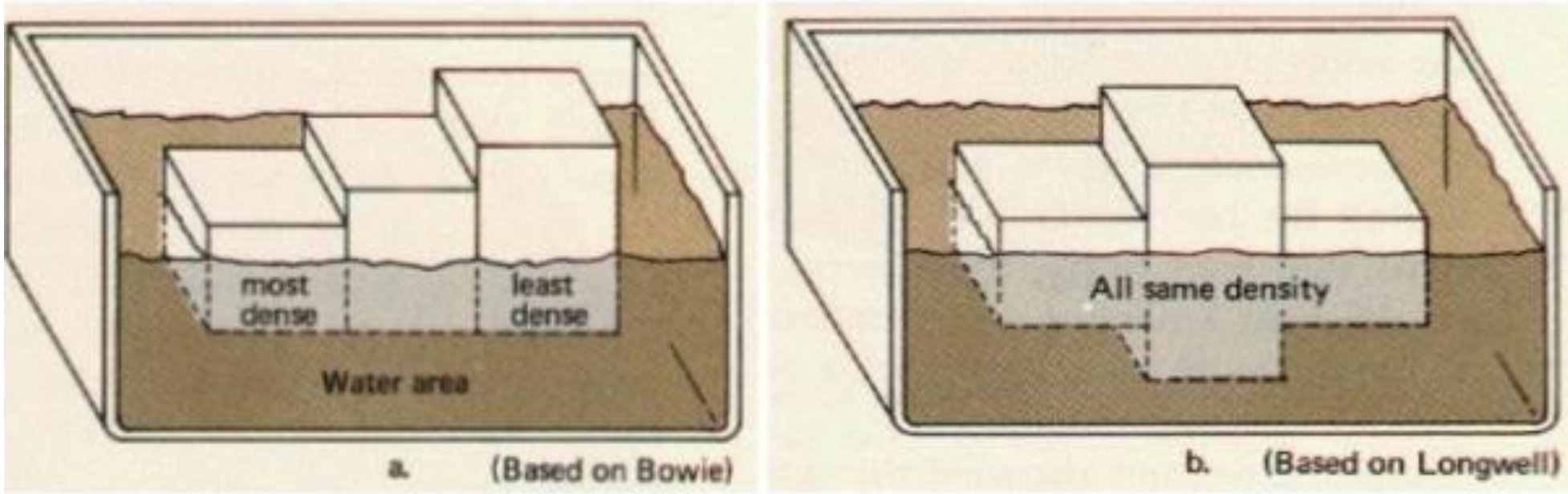
- Pierre Bougher 1735. Survey of Andes Mountains
- He identified Gravitational Anomalies with Andes' low gravitational pull as compared to its total mass.
- G. Everest 1859: Himalaya's Gravitational Anomalies during a triangulation survey in the region
- Deflection of Plumb bob during calculation of Latitudes by astronomical method of Kalyan and Kalyanpur places near Himalayas.

The deflection of plumb bob near mountain chains is less than expected. Calculations show that the actual deflection may be explained if the excess mass is canceled by an equal mass deficiency at greater depth.



A plumb-bib

The Concept of Isostasy



These figures show how either thickness differences or density differences determine how high the wood blocks will float.

- Isostasy used to denote the ideal state of balance b/w different parts of the earth crust due to difference of densities of two crustal material lithosphere and asthenosphere.

- This state of balance tends to maintain the certain level known as level of compensation.

Pratt's Model (1859)

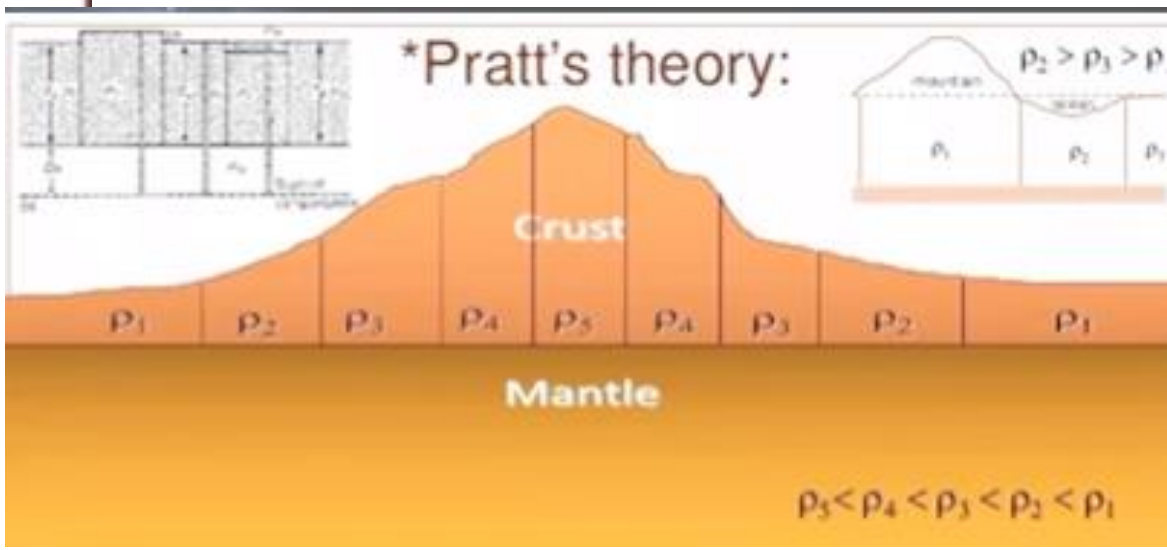
UNIFORM DEPTH WITH VARYING DENSITY'

ALL BLOCKS FLOAT AT THE SAME DEPTH, BUT HAVE DIFFERING DENSITY

HIGHER ELEVATIONS INDICATE LESS DENSE ROCKS

HIGHER GROUND IS WHERE THE LITHOSPHERE IS THICKER HAVING DIFFERENT DENSITIES

Inverse relation between DENSITY and HEIGHT/ ELEVATION

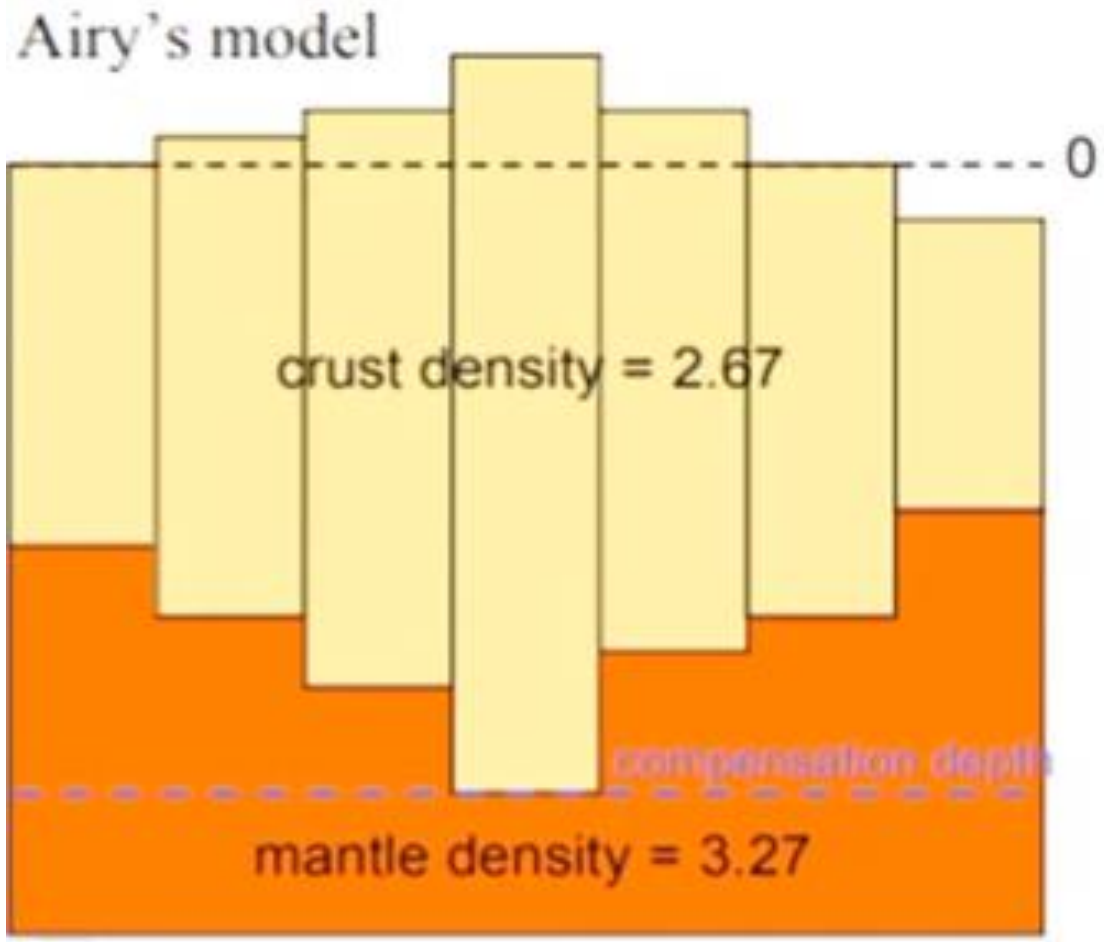


Airy's Model (1854)

ALL BLOCKS HAVE THE SAME DENSITY BUT DIFFERENT THICKNESSES

THICKER BLOCKS HAVE HIGHER ELEVATION AND MUCH THICKER ROOTS

HIGHER GROUND IS WHERE THE LITHOSPHERE IS THICKER

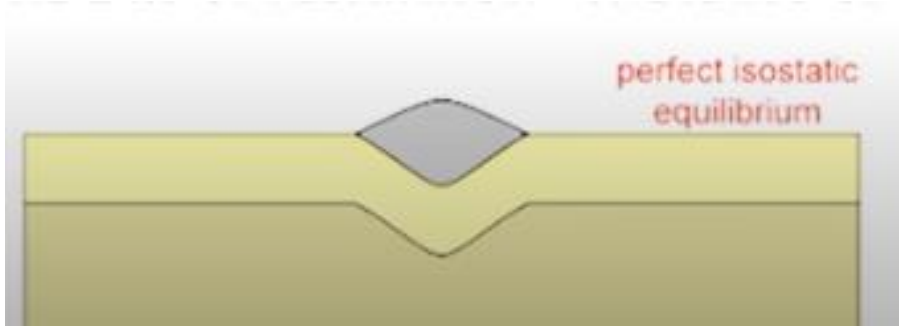


UNIFORM DENSITY WITH VARYING DEPTH

Principle of Buoyancy

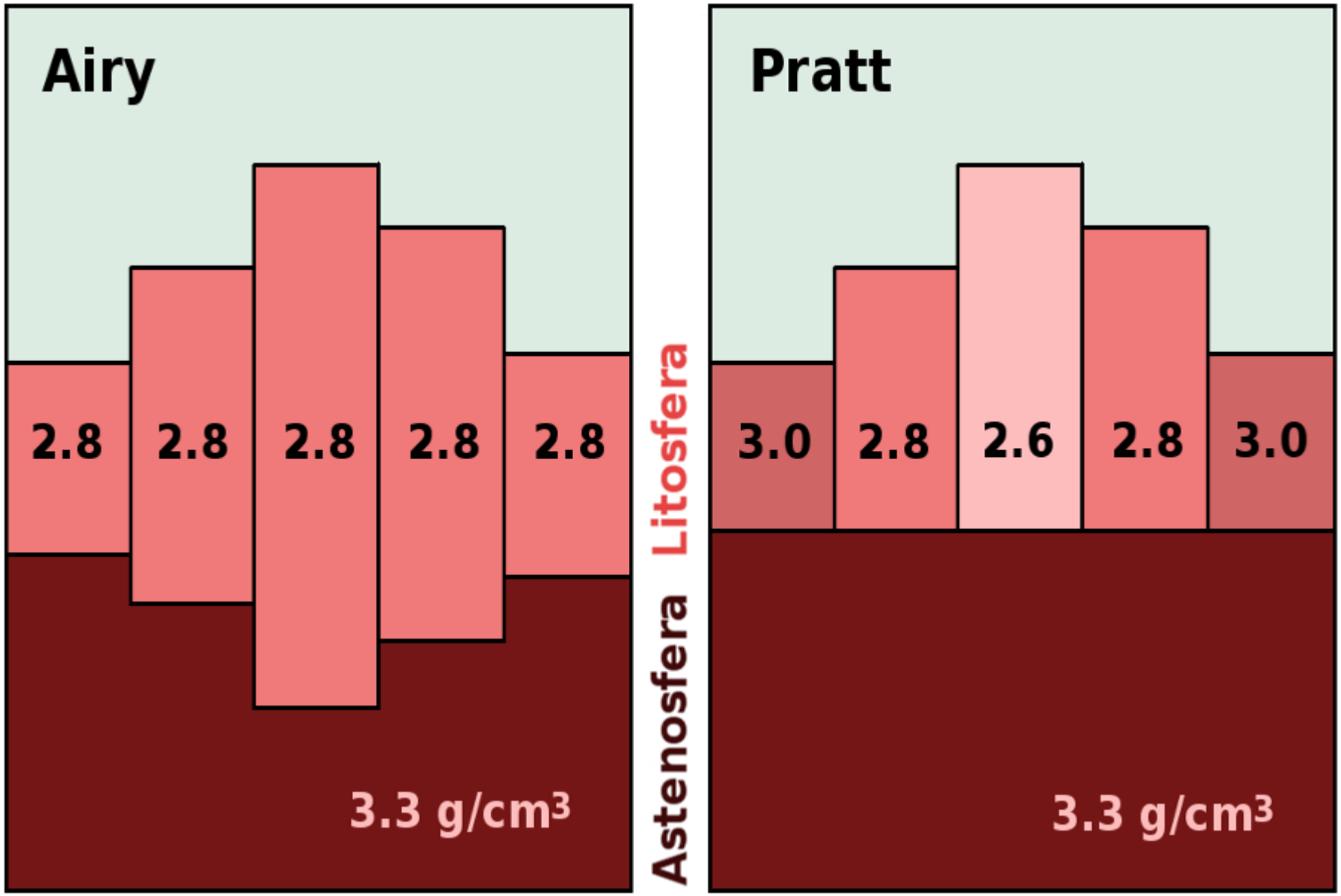
IN OTHER WORDS, THE HIMALAYAS ARE FLOATING IN THE DENSER MAGMA WITH THEIR MAXIMUM PORTION SUNK IN THE MAGMA

IN THE SAME WAY AS A BOAT FLOATS IN WATER WITH ITS MAXIMUM PART SUNK IN THE WATER.



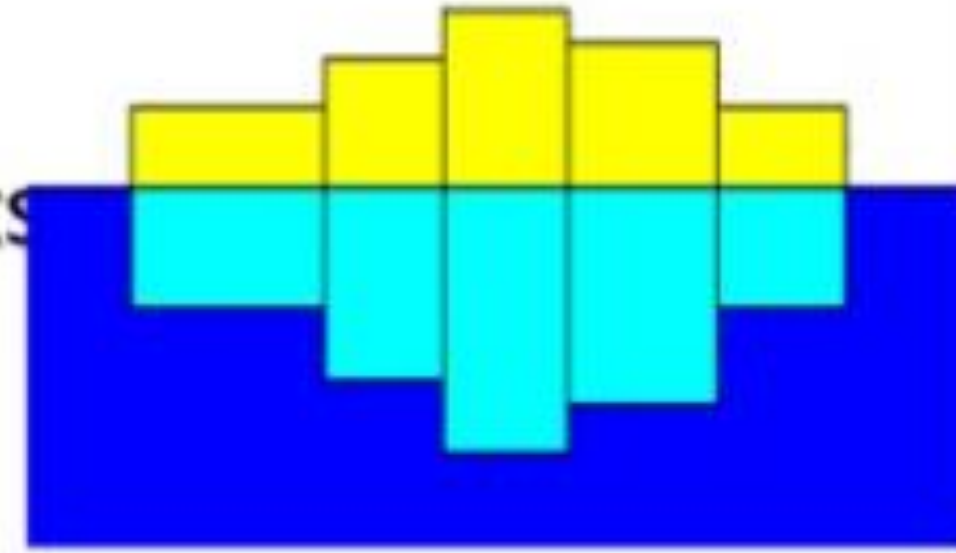
THIS CONCEPT IN FACT INVOLVES THE PRINCIPLE TO FLOATION.

THE LAW OF FLOATATION - THE RATIO OF FREEBOARD TO DRAUGHT IS 1 TO 9



Bigger the Column lesser the density, smaller the column, greater the density

- Isostasy is the vertical movement of the crust to attain “buoyancy” in the mantle.



- The height a block of wood floats in water depends on it’s density and thickness.

- The “height” of the earth’s crust also depends on it’s density and thickness.

APPLICATIONS

The principle of isostasy suggests that the earth's crust should adjust to any changes in mass that occur at the earth's surface (we call these "isostatic adjustments"). There are basically two types of responses:

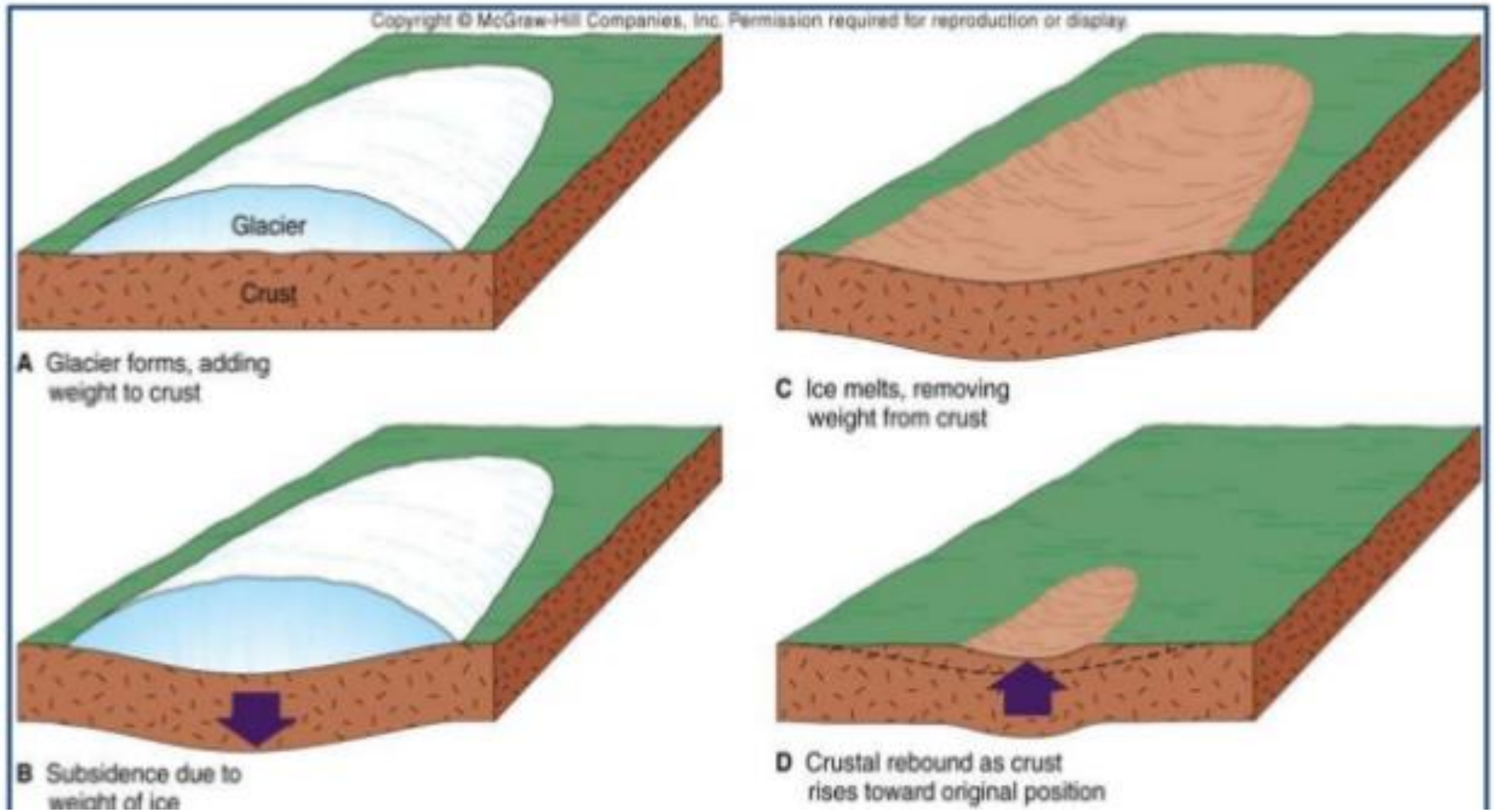
1. SUBSIDENCE
   a. Definition: the slow, sinking of the earth's crust
   b. Cause: the addition of mass to the crust
   c. Example: the advance of glacial ice sheets

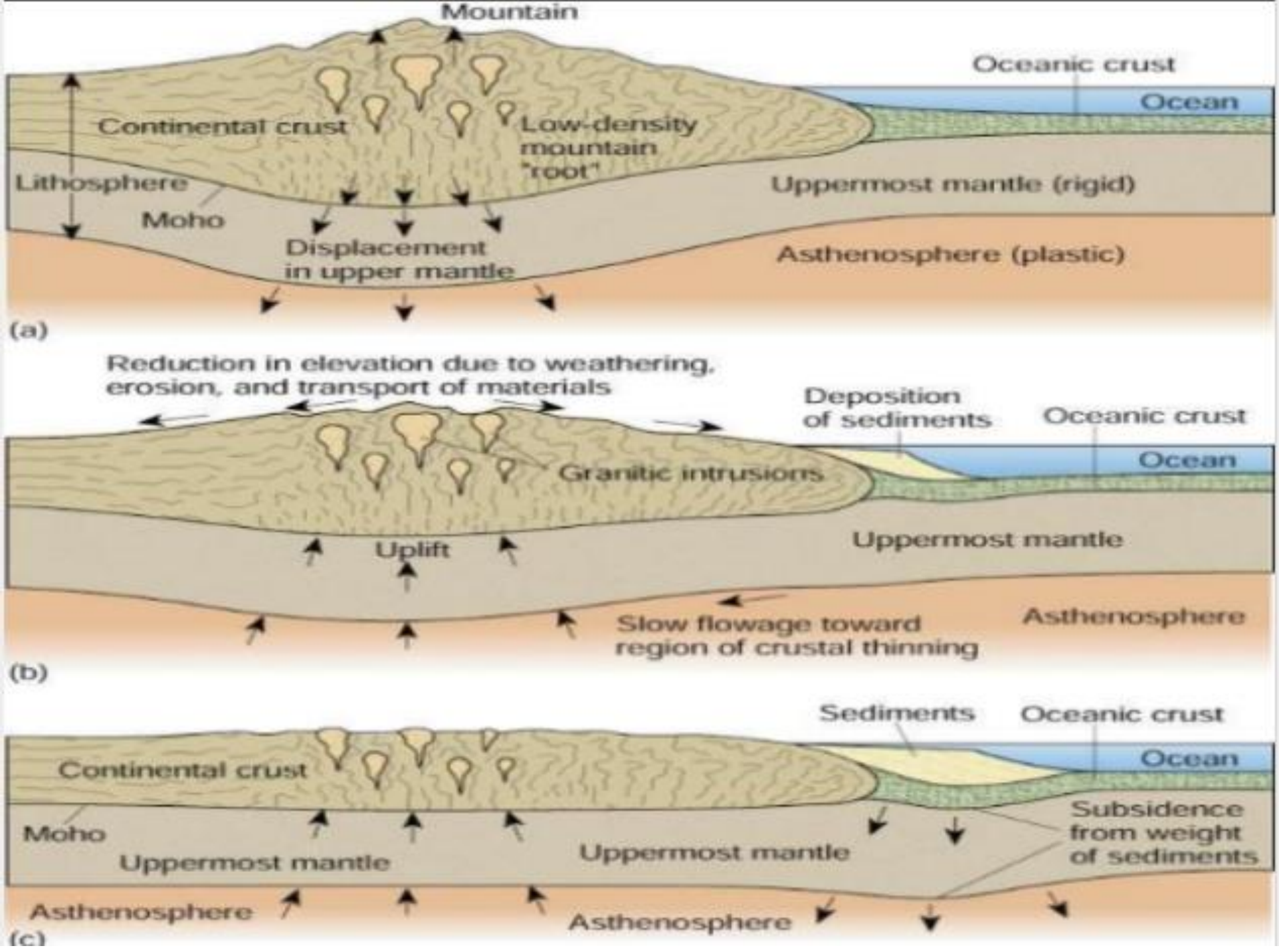
2. REBOUND
   a. Definition: the slow, vertical rise in earth's crust
   b. Cause: the removal of mass from the earth's crust
   c. Example: post-glacial rebound (Scandinavia) (U.S.)

It should also be noted that isostasy explains why continental plates cannot be subducted: the forces that drive subduction cannot overcome the "buoyancy" of these low density plates.

Subduction is a geological process that takes place at convergent boundaries of tectonic plates where one plate moves under another and is forced or sinks due to gravity into the mantle. Regions where this process occurs are known as subduction zones.

"see" isostatic adjustment today from load of glaciers on crust during last glaciation and unloading from melting (possible because response of asthenosphere is slow) *process is called post-glacial rebound*




Mountain
Oceanic crust
Ocean
Continental crust
Low-density
mountain
"root"
Lithosphere
Moho
Uppermost mantle (rigid)
Displacement
in upper mantle
Asthenosphere (plastic)
(a)
Reduction in elevation due to weathering,
erosion, and transport of materials
Deposition
of sediments
Oceanic crust
Ocean
Granitic intrusions
Uplift
Uppermost mantle
Slow flowage toward
region of crustal thinning
Asthenosphere
(b)
Sediments
Oceanic crust
Ocean
Continental crust
Moho
Uppermost mantle
Uppermost mantle
Subsidence
from weight
of sediments
Asthenosphere
Asthenosphere
(c)

Cycle of Erosion

DAVIS AND PENCK MODELS

The concept

- Denudation = Weathering + Erosion
- Relates to the **formation** and **development** of the landforms.

- Concepts related to the Landforms development:

1. ***Time Dependent Landform Concept***
2. ***Time Independent***
3. ***Process Form Concept***
4. ***Climato-genetic Concept***
5. ***Structure Form Concept***
6. ***Tectono-geomorphic Concept***

Important works

- **Concept of Uniformitarianism - *James Hutton 1785 "Present is the Key to the Past"***
- **Normal Cycle of Erosion – *William Morris Davis 1889***
- **Concept of Dynamic Equilibrium – *Gilbert***
- The concept of geographical cycle of erosion recognizes the possibility of obliteration of relief, or **planation**, during the life history of a landscape, by process of erosion.
- To explain a systematic progressive process of landform formation '**CYCLE' word is used.**
- Cycle = occurring in a sequence of orderly changes,
- **Finally reducing the landscape relief to a minimum.**
- The earth scientists have attempted to interpret geomorphological processes or forces on the basis of these cycles of erosion

WHY IS IT DESIGNATED AS 'NORMAL CYCLE OF EROSION'

NORMAL CYCLE OF EROSION

=

FLUVIAL CYCLE OF EROSION

Since fluvial action is widespread over the earth's surface in all areas excepting that of cold and hot deserts.

Major parts of the world (except the cold and hot deserts) experience fluvial actions.

Views of William Morris Davis:

- **Davis defined a geographical cycle as that sequence of changes which an uplifted block has to undergo before it gets reduced to base level or peneplane.**
- He postulated that a geographical cycle is a function of **three factors**:

1. **Structure:** Which includes ‘nature’ (hardness, permeability) and ‘attitude’ (folds, faults, joints, slopes) of rocks? (Rocks: folds, faults, joints; Type; Composition; Porosity; Permeability)
2. **Process:** Implies the **factors** or **agents** responsible for weathering and erosion.
3. **Time:** Implies the stage at which the cycle is—*youth*, *maturity or old age.*

ACCORDING TO DAVIS

"LANDFORM IS A FUNCTION OF –

- STRUCTURE (s)
- PROCESS (p) AND
- STAGE (t)"

Trios of Davis

$$L = f(s, p, t)$$

STRUCTURE

- *Denotes* **LITHOLOGY, ATTITUDES COMPOSITION, TEXTURE OF**
- **EARTH MATERIALS**

PROCESS

Denotes Exogenetic and endogenetic processes

STAGE

- *Denotes* **THE SUCCESSIVE PHASESOF LANDFORM EVOLUTION**

Cycle of Erosion is that period of time in which an uplifted landform faces erosion process and becomes a featureless plain.

Premises of Cyclic Concept

1. **Rapid rate of Upliftment**
2. **Erosion starts after the Upliftment stops**
3. **Landscape is a result of Endogenetic and Exogenetic forces.**
4. **There is a sequence in the development of the landforms: Cyclic in Nature**
5. **Gradation (Gradation of Landforms: Aggradation – Degradation) by the river continues till the landform is not completely degraded.**

Influenced by –

- Hutton's Cyclic nature of Earth's History & 'Uniformitarianism'

and

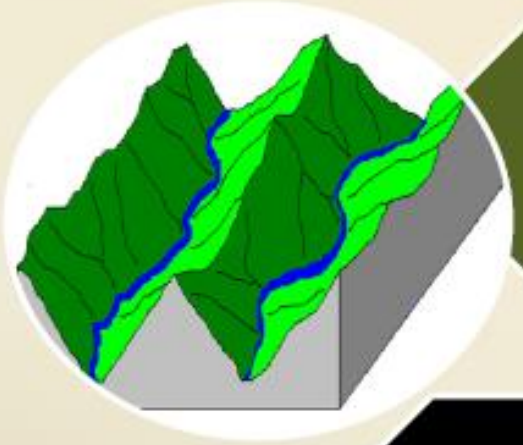
- Darwin's Evolutionary concepts

Davis referred to the whole sequence of transformation of landforms as a **cycle of erosion**

By analogy with the divisions of a lifetime he divided his evolutionary series into three stages, metaphorically described as

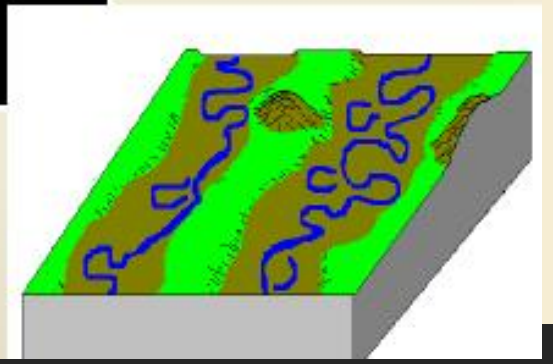
YOUTH, MATURITY, OLD AGE

YOUTH



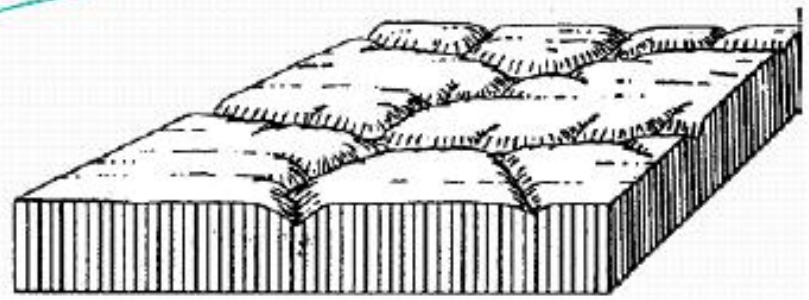
MATURITY

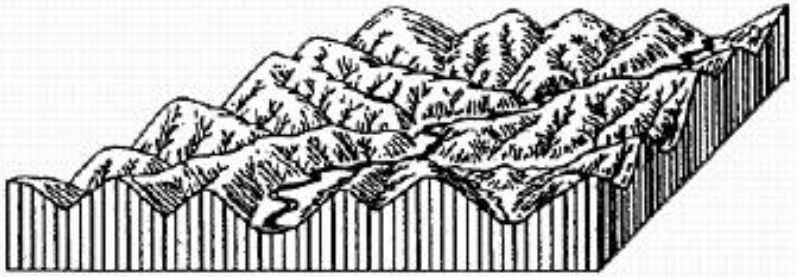
OLD

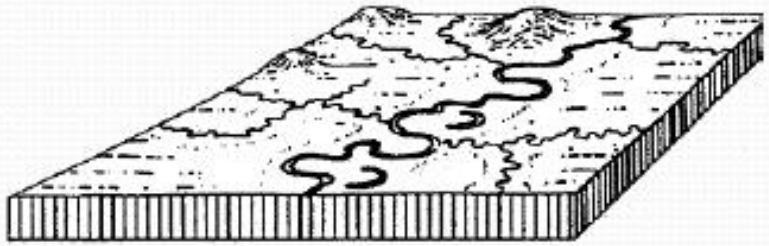


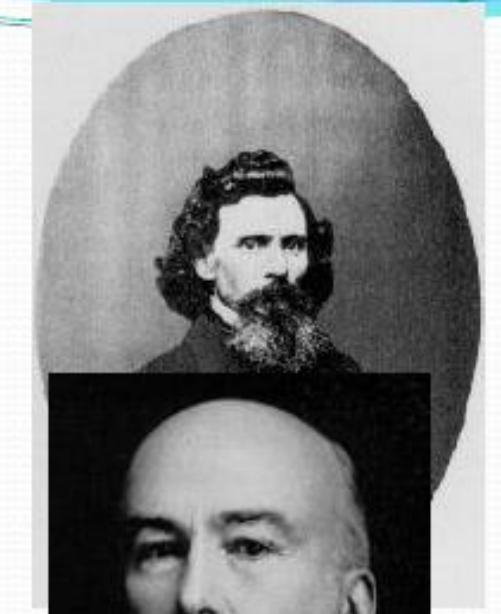
The Landscape

W. M. Davis

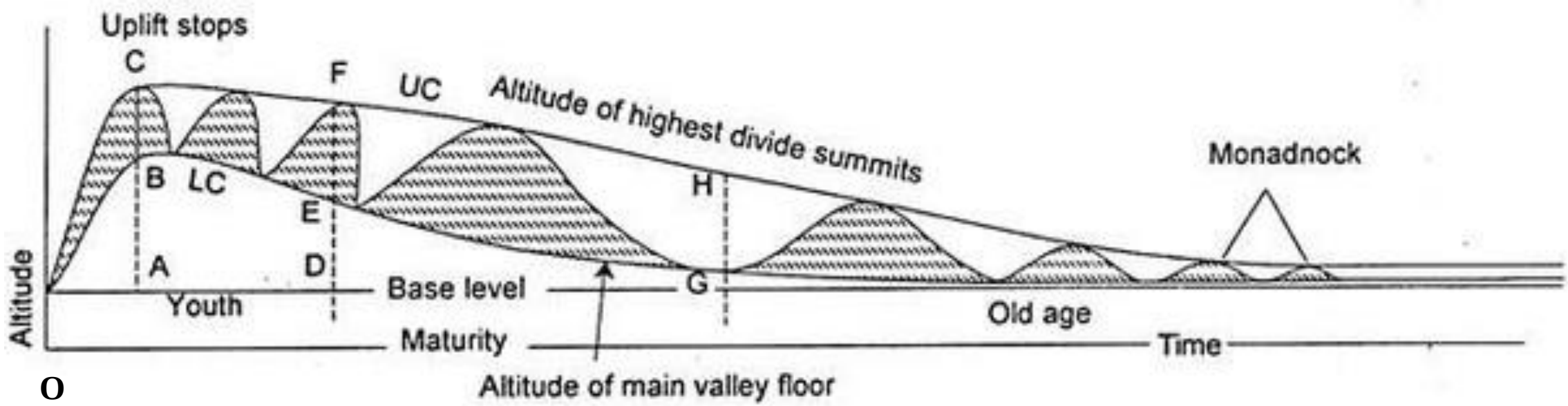








Graphical Representation of Geographical Cycle of Erosion by W.M. Davis

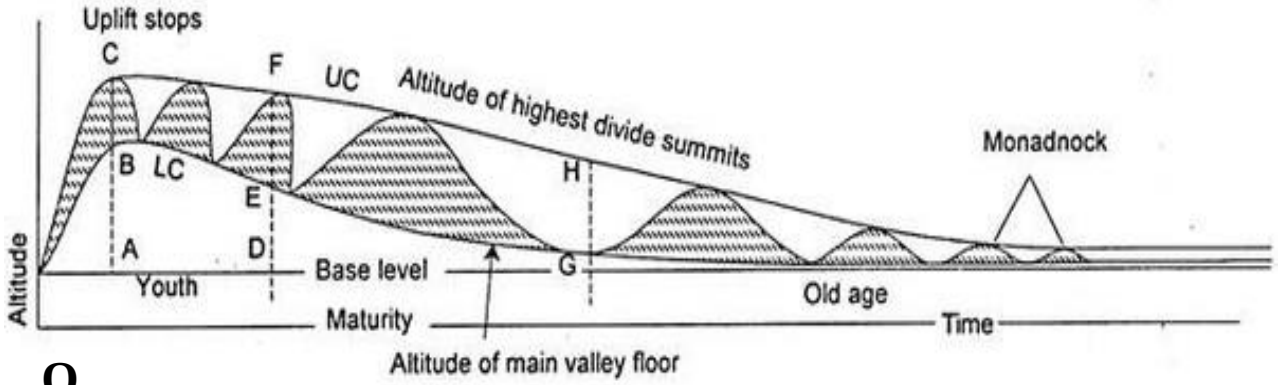


Explanation of the Graph

- **The lower curve (LC): River channel and long profile of the river**
- **It also depicts the state of erosion**
- **The upper curve (UC): Characteristic of summit of the landform**
- **BC: Initial average relief (UC – LC)**
- **EF: Ultimate Maximum Relief**

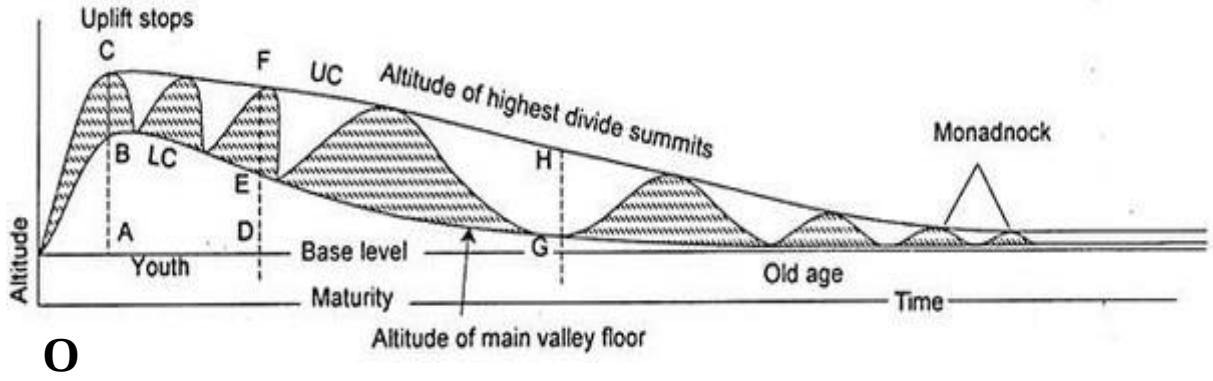
Stage I

- **Upliftment as OB and OC**
- **No erosion**
- **Altitude and relief both increases**
- **BC: Initial average relief (UC – LC)**



Stage II

- **Upliftment stops and erosion starts**
- **Erosion starts initially on LC**
- **Altitude same**
- **Relief increases**
- **Ultimate maximum relief (EF)is reached by the end of this stage**
- **BC: Initial average relief (UC – LC)**
- **Vertical erosion by the river**



O

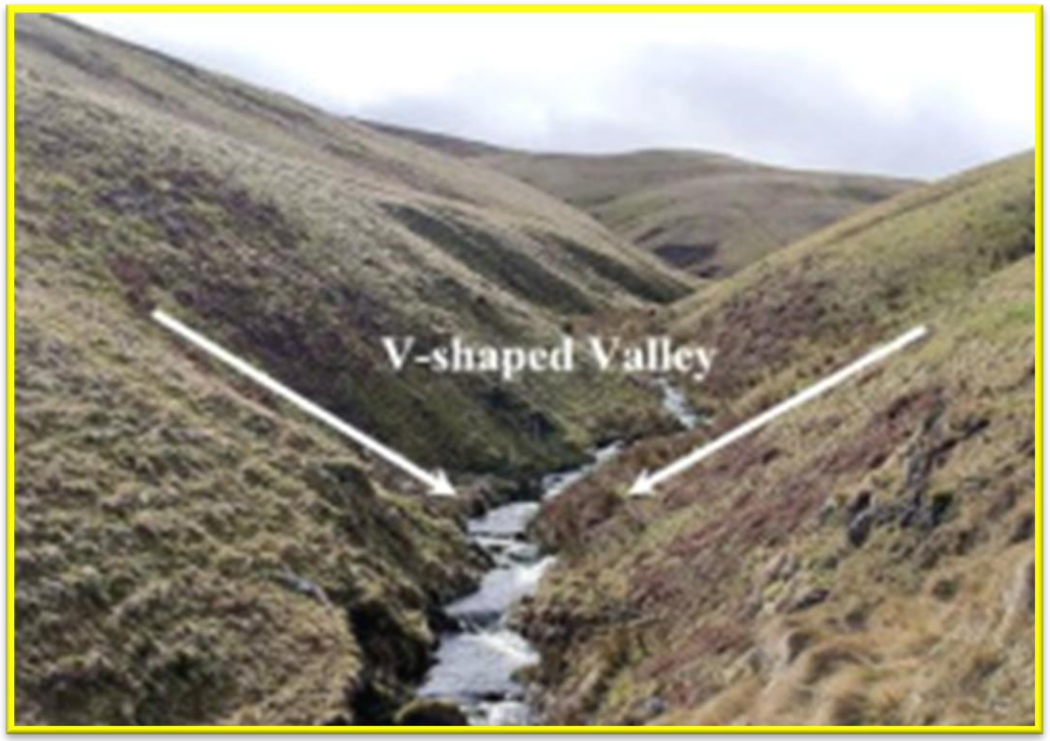
Youth stage

- The uplift is complete and has stopped.
- Immediately erosion of the uplifted block sets in.
- The streams follow initial irregularities available without adjusting to the structure.
- These are consequent streams.
- The floors of the valley suffer down cutting while the summits remain almost unaffected. Increased relief heralds the beginning of mature age, indicated by widening of the gap between lines ‘A’ and ‘B’ (Fig. 1.44).

CHARACTERISTICS OF YOUNG LANDSCAPE

- Few Consequent Streams with few Large Tributaries
- Headward Erosion by Small Tributaries and Gullies
- Development of V-shaped Valleys
- Lack of Floodplain Development
- Interstream Tracts — wide and poorly drained; development of Lakes and Swamps
- Waterfalls and Rapids exist where stream crosses resistant rock beds
- Stream Meandering may exist on flat, undissected initial surface but are closely confined
- Maximum Altitude → Maximum Potential Energy

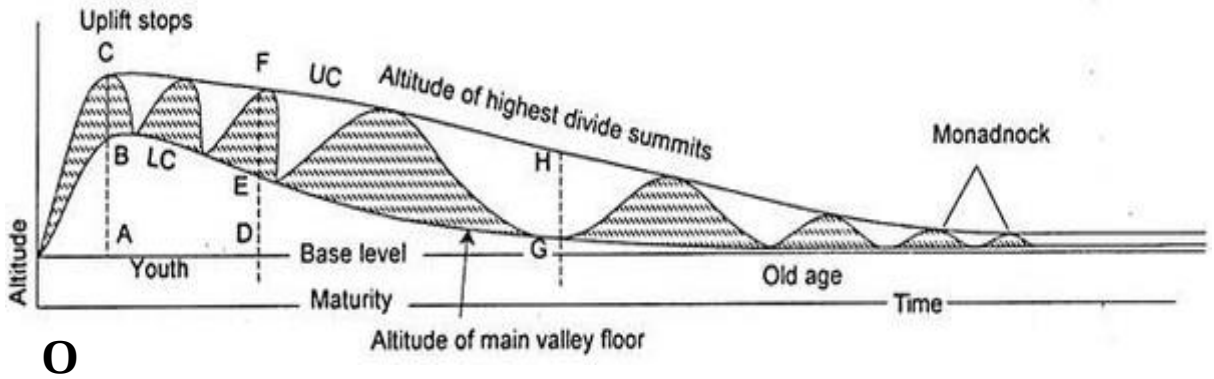
V – Shaped Valleys



Canyons

Stage III

- **Altitude starts to decrease**
- **Erosion starts on the UC**
- **River meanders are formed**



Maturity stage

- At this stage, the vertical erosion slows down and the horizontal action increases.
- A characteristic feature is the erosion of mountain tops at a faster rate than lowering of the valley floor.
- The coming closer of lines ‘A’ and ‘B’ indicates emergence of a gentle slope. The subsequent streams gain importance now.

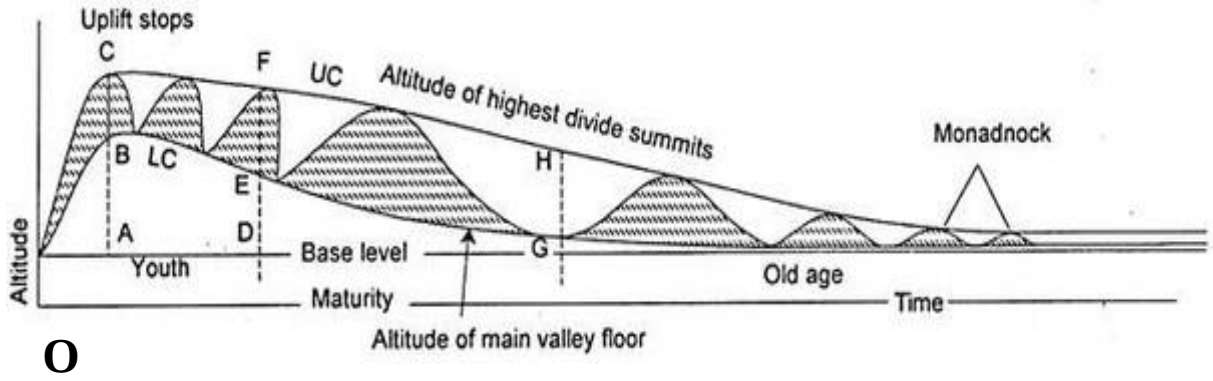
CHARACTERISTICS OF MATURE LANDSCAPE

- Valleys extend → well-integrated Drainage system
- Adjustment of streams with lithology and structure →Existence of Longitudinal Tributaries along belts of weak rock
- Stream divides sharp and ridge-like →minimum interstream uplands → Maximum Relief at early Maturity
- Attainment of Profile of Equilibrium by master Streams
- Elimination of lakes and waterfalls
- Wide Floodplains at Valley floors
- Conspicuous Meanders – free to shift positions over floodplains
- Width of the Valley floors do not exceed the width of the Meander belts
- Maximum possible Relief
- Topography consists much of Slopes of Hillsides and Valley sides

River Meanders

Stage IV

- **Altitude starts to decrease**
- **Erosion starts on the UC**
- **Landform turns into a PENEPLAIN**
- **Monadnocks remains**
- **Landform turns into a PENEPLAIN**
- **Monadnocks remains**



Old stage

- A gentle gradient, accentuated by horizontal action and deposition, reduces the erosion intensity.
- A thick layer of sediment represents the earlier erosion activity.

Relicts of mountains or monadnocks are dotting the water divides and a featureless plain—peneplane is produced.

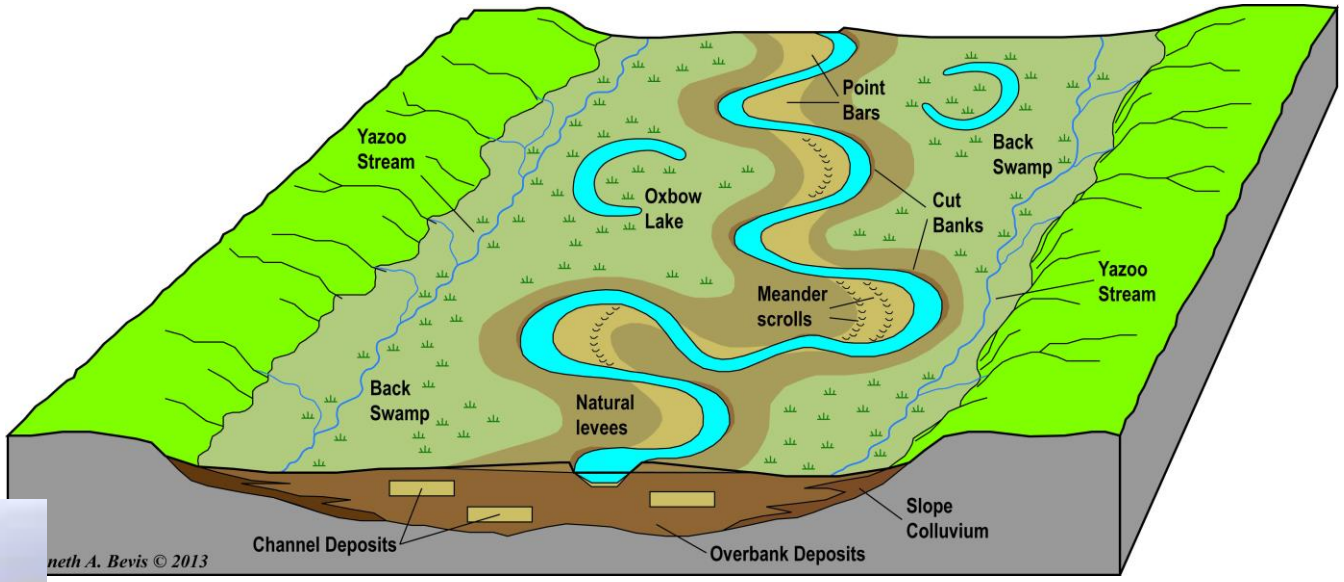
CHARACTERISTICS OF OLD LANDSCAPE

- Tributaries – less numerous than in Maturity but more than in Youth
- Valleys – extremely broad & gently sloping laterally and longitudinally
- Extensive Floodplains with broadly Meandering Streams
- Valley widths – greater than those of the Meander belts
- Stream divides reduce in heights, gently sloping → Residual hills—

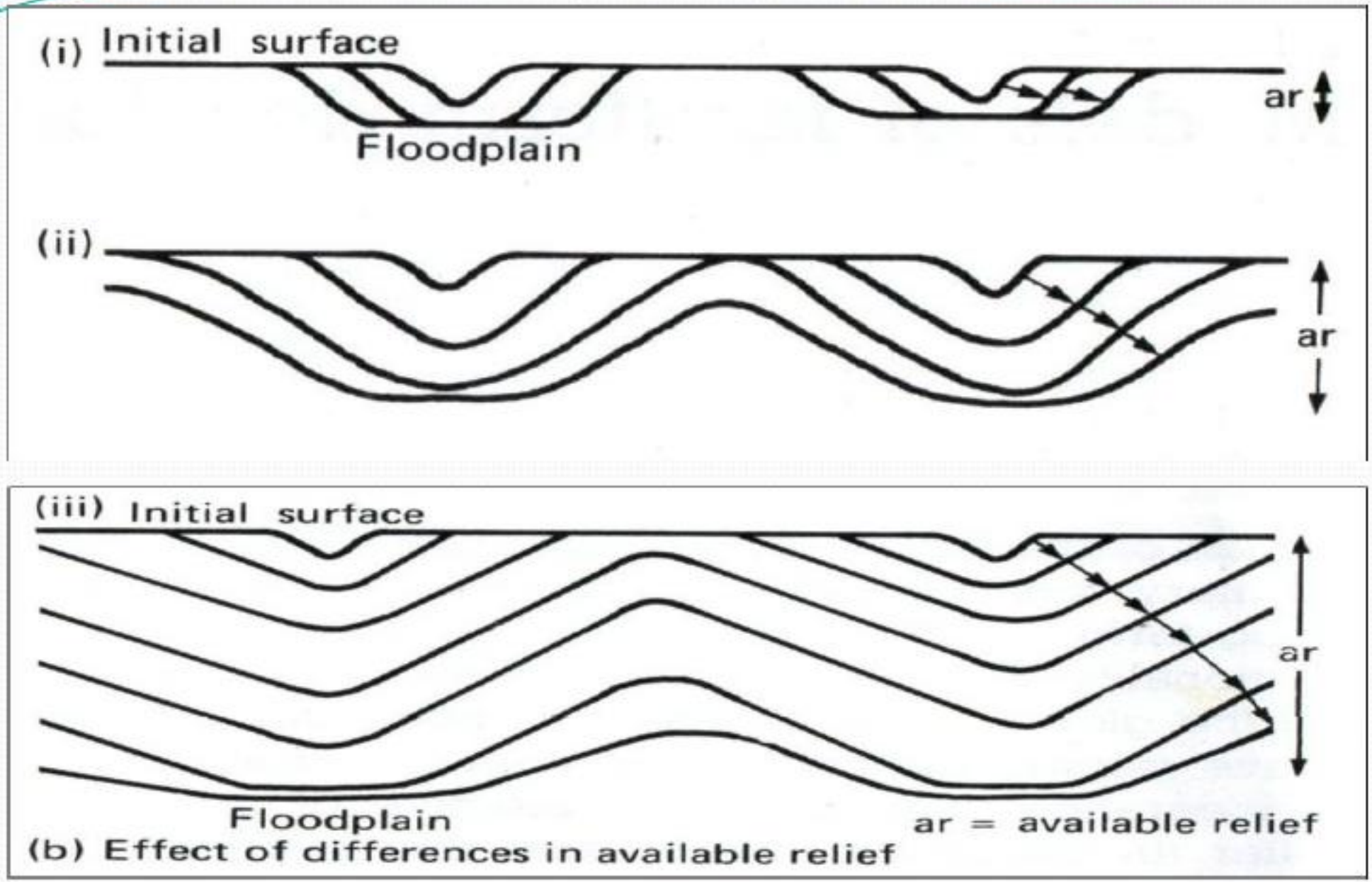
MONADNOCKS (after Mt. Monadnock in New Hampshire)

- Lakes, Swamps, Marshes on floodplains, not on interstream areas
- Mass Wasting – dominant over fluvial processes
- Extensive areas are or at near BASE LEVEL OF EROSION

Flood Plains



The cycle concept of W. M. Davis



(b) Effect of differences in available relief

CRITICAL APPRAISAL

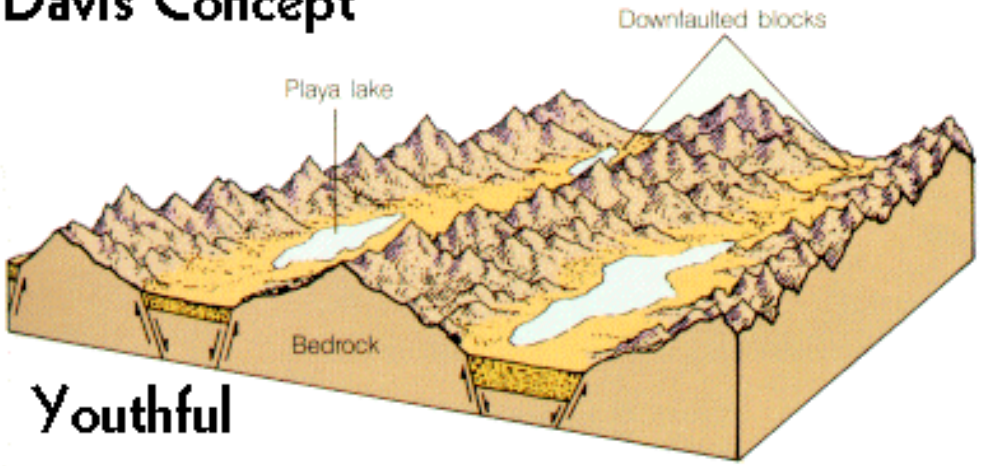
Merits

- Provides the dogma, the comprehensive theoretical arrangement of all the aspect of DENUDATION
- A Long-term view of Landscape, a geological view
- Though uplift is intermittent, accelerated, retarded at the end Denudation wins → land is worn down to low relief → peneplain
- Development of Drainage Basin is well explained
- Analogy with human geography
- Realistic Analogy with living being

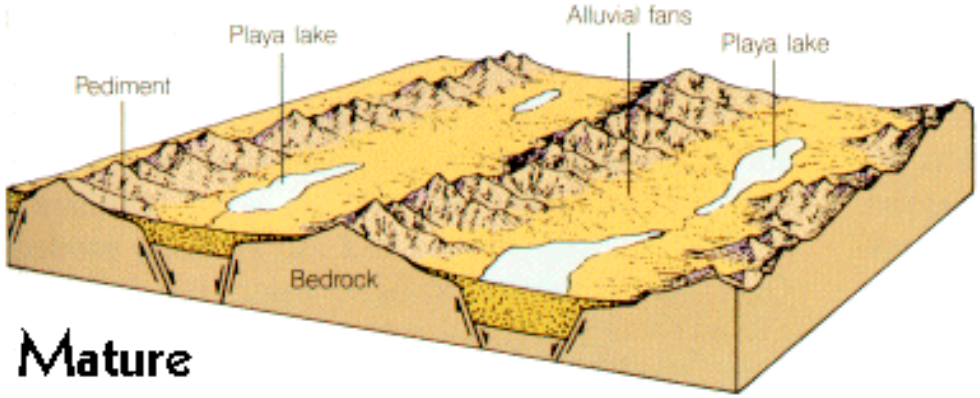
Limitations

- Rapid Uplift– not observed
- Slow period of Erosion can be disrupted by dynamic endogenesis & Climate changes
- Upliftment and Denudation are divided into separate episodes – which is unrealistic
- Long stability of landmass is not possible
- Rock structure may not be homogeneous
- Application of entropy maximisation not possible in open system, i.e, landform

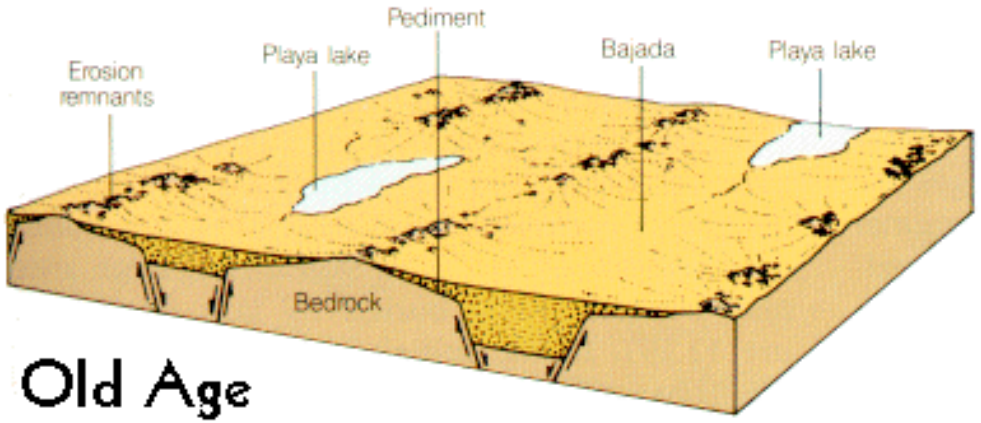
Davis Concept



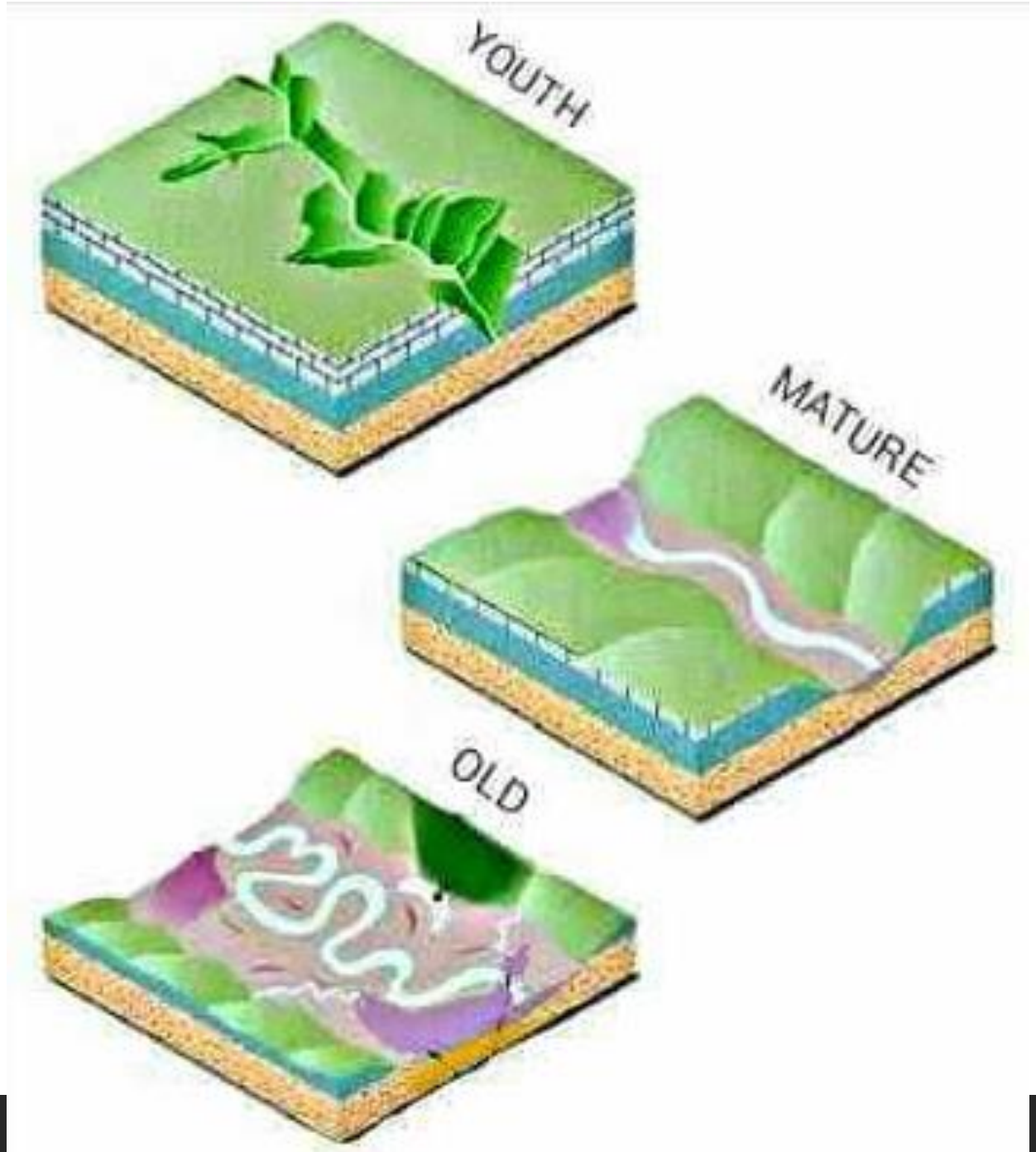
Youthful



Mature



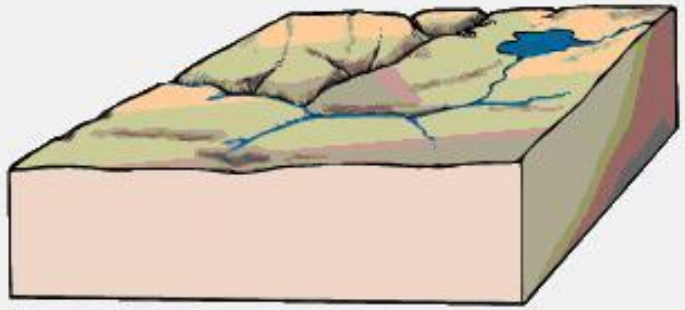
Old Age



Youth

Mature

Old

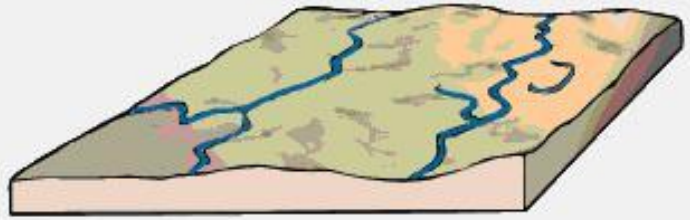


A Youth

V-shaped valleys, few or no floodplains, extensive interfluves, many falls and rapids plus some lakes and swamps; incising watercourses

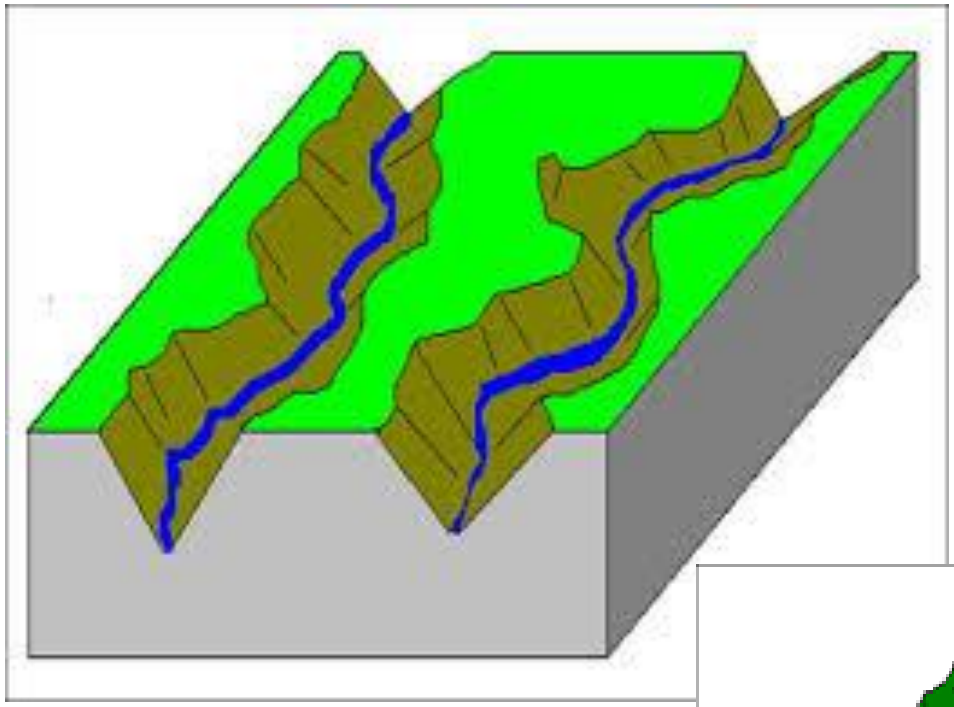
B Maturity

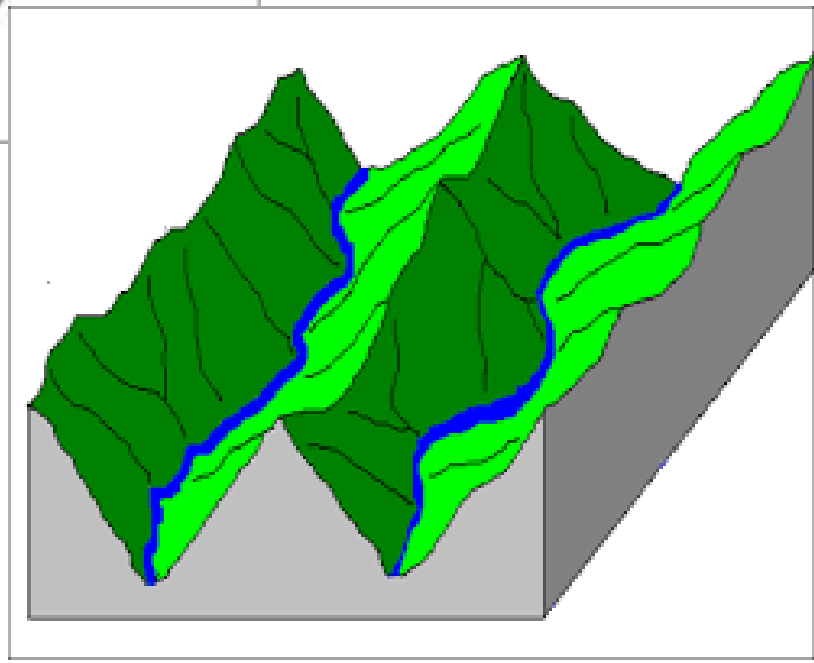
well-drained terrain, all in slopes except floodplains; trunk and some tributary streams meander; maximum relief



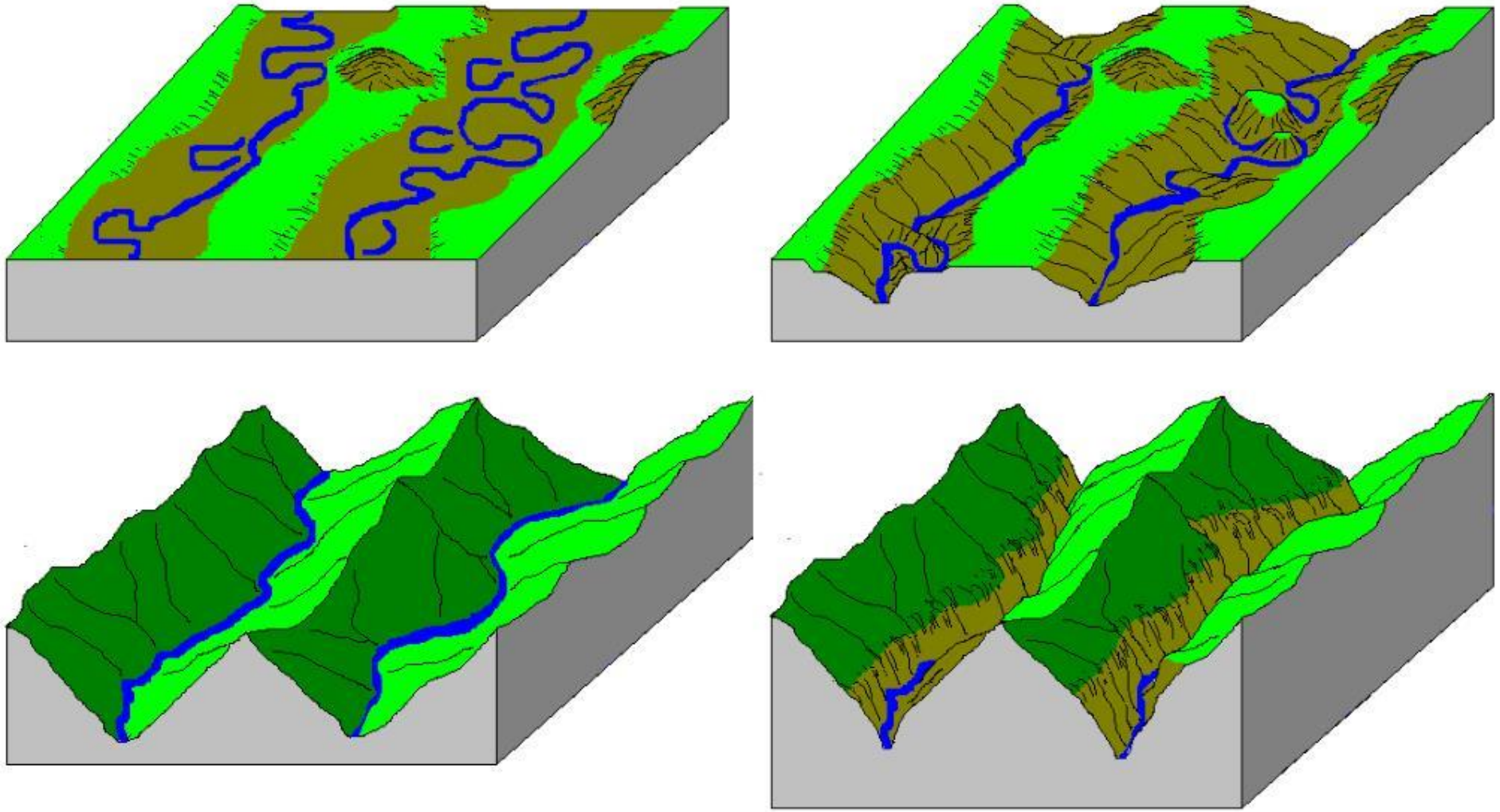
C Old Age

broad, open valleys with widely meandering streams, indistinct divides, erosion remnants of resistant lithologies, surface near erosional base level





Reiuvenation



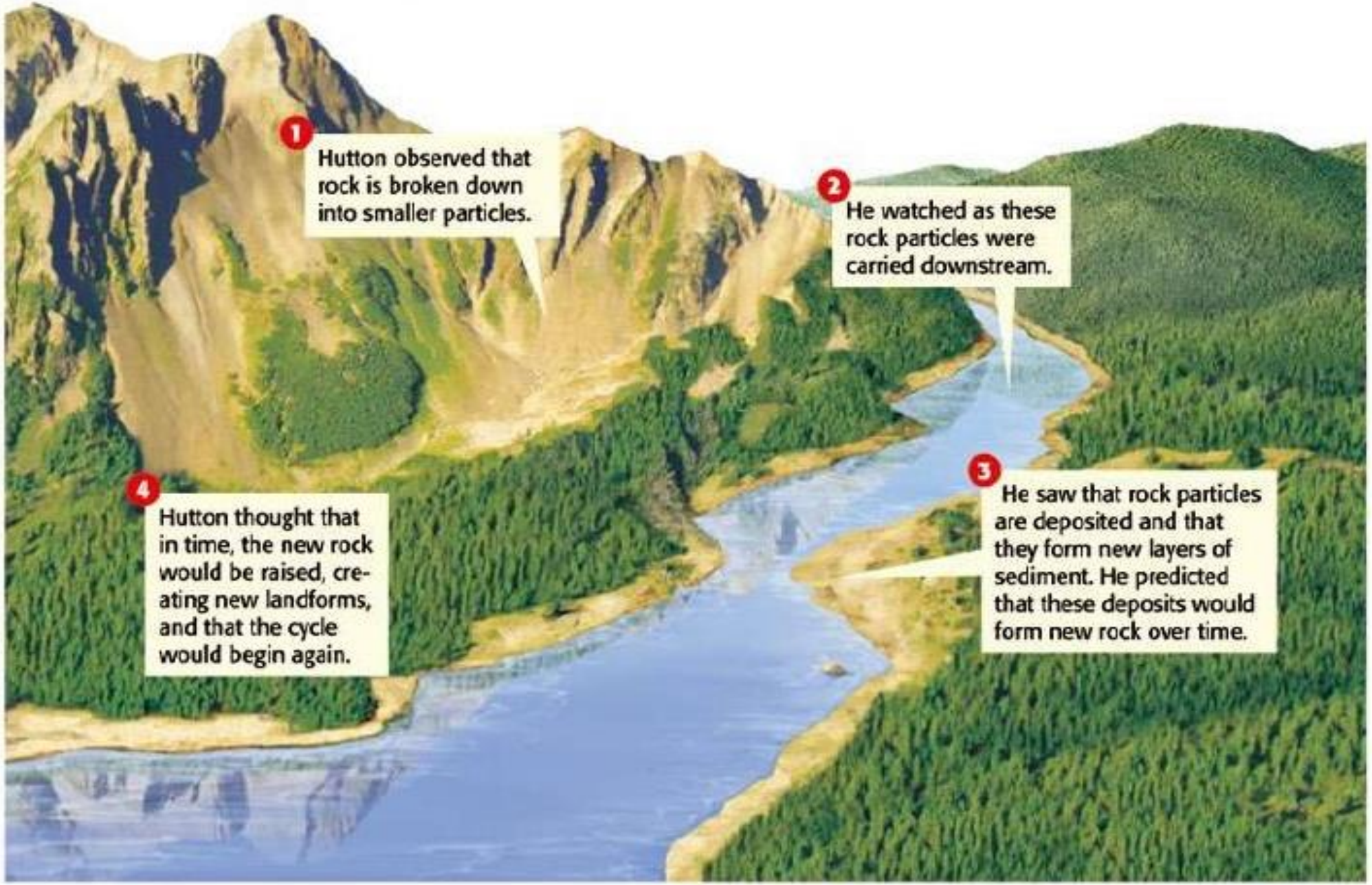
Positive Aspects:

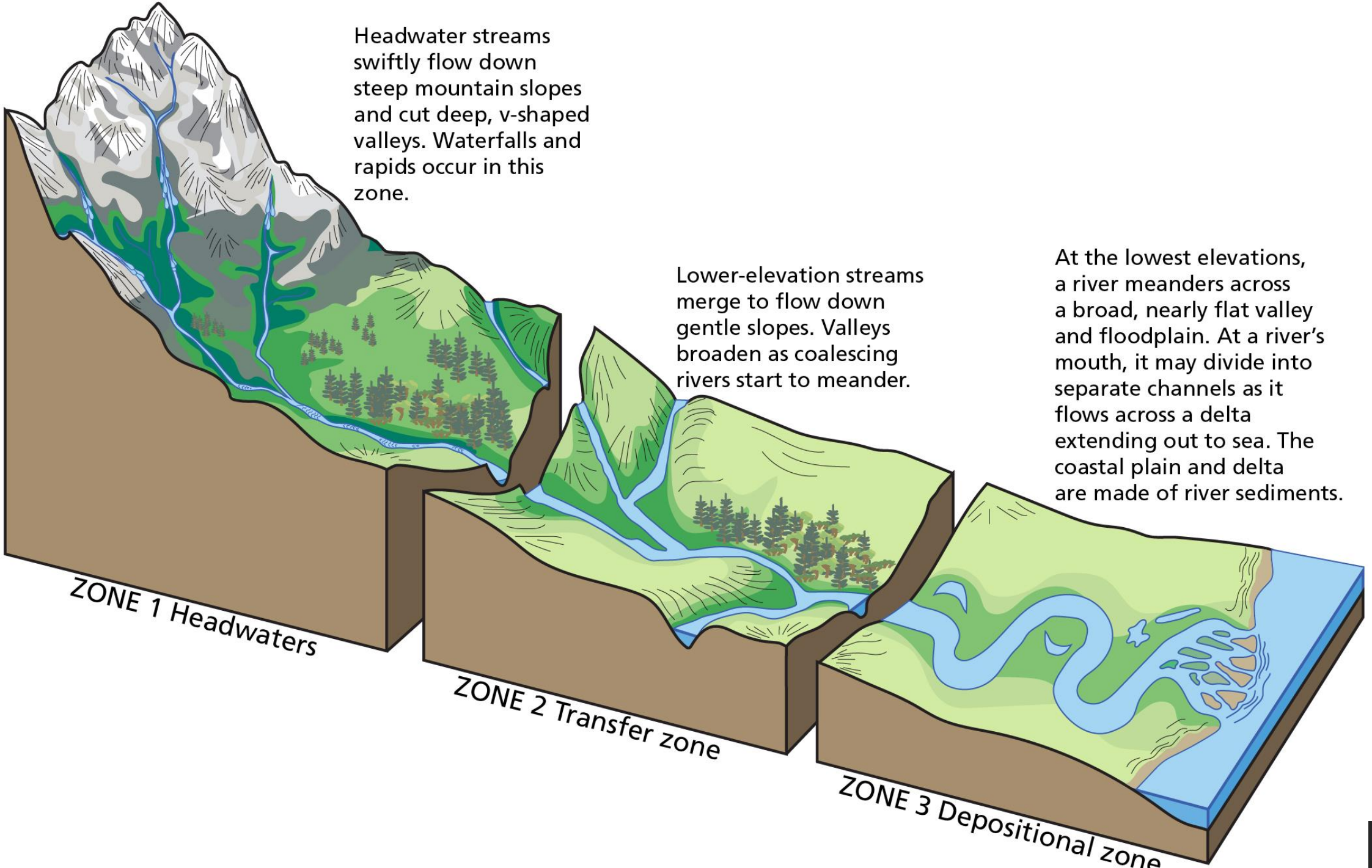
1. The Davisian cycle affords a genetic classification and nomenclature of landscape, as compared to a morphological one and provides the means of expressing texture and the build of a landscape.
2. The consideration by Davis of change in base level as indication of the initiation of a new cycle has certain advantages. One, the base level change can be considered a unit of time compared to the geologists' stratigraphical time unit. Two, the base level changes during glaciations are accommodated.

Drawbacks

1. In a way, the geographical cycle proposed by Davis is backward looking as it considers complete suspension of uplift after the erosion has set in.
2. There are no logical grounds for the assumption that flat slopes are old and steep slopes are young. Other variables controlling the slope are nature of soil material and the bedrock, climate, vegetation and the downslope factors acting at the slope foot.
3. An ideal Davisian cycle would take millions of years to complete. What about the earth movements during the cycle?
4. Too much of generalization in the Davisian cycle presents an inadequate framework for landform interpretation.
5. There is little evidence to prove that landforms actually evolve to an end product or peneplane.

Hutton and the Principle of Uniformitarianism




Headwater streams swiftly flow down steep mountain slopes and cut deep, v-shaped valleys. Waterfalls and rapids occur in this zone.
Lower-elevation streams merge to flow down gentle slopes. Valleys broaden as coalescing rivers start to meander.
At the lowest elevations, a river meanders across a broad, nearly flat valley and floodplain. At a river's mouth, it may divide into separate channels as it flows across a delta extending out to sea. The coastal plain and delta are made of river sediments.
ZONE 1 Headwaters
ZONE 2 Transfer zone
ZONE 3 Depositional zone

Important links to check

- https://rashidfaridi.com/2012/10/18/concept-of-cycle-of-erosion/
- https://triumphias.com/blog/landforms-and-cycle-of-erosion-fluvial-landforms-and-cycle-of-erosion/
- https://www.slideserve.com/ludwig/walther-penck-1888-1923

LANDFORMS

Fluvial landscapes

Compiled by Urmi Sharma

Introduction

- Running water =

  1. Over-land flow
  2. Inter-flow

- Main source of running water over land is **RAIN**
- **"A river is a long narrow body of flowing water occupying a trench like depression or channel and moving to low land under the force of gravity." - *Strahler***

Works of river

One of the chief functions of river is to carry the LAND to the SEA.

1. **Erosional works of river**
2. **Transportation works of river**
3. **Depositional works of river**

Types of erosion

1. **Vertical erosion –**

- ✓ Downward erosion
- ✓ Valley deepening
- ✓ Down cutting by the river

2. **Horizontal erosion**

- ✓ **lateral erosion**
- ✓ **Valley widening**

3. Headward erosion

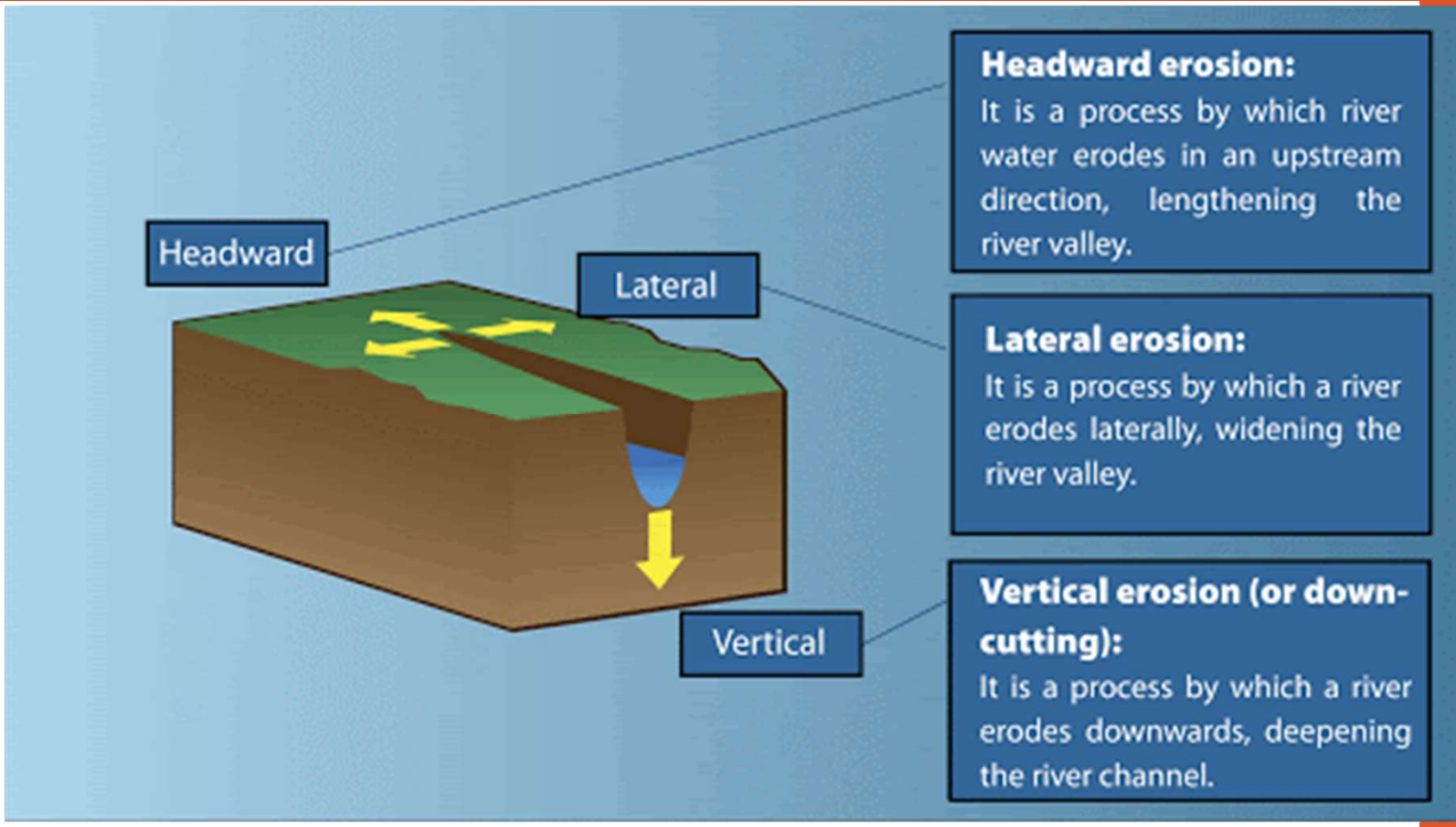
- ✓ erosion directed towards river's origin
- ✓ Narrow downs the water divides

4. Mouth ward erosion:

- ✓ near its delta

Types of erosion

1. Vertical erosion
2. Horizontal erosion
3. Headward erosion
4. Mouth ward erosion



Erosional works of river

- Cutting and removal of sediments in the course of river channel.
- Carves and shapes the landscape through which they flow
- Two forms of erosion – Physically and Chemically

1. CORROSION संक्षारण –

- ✓ water dissolves minerals from the rocks and washes them away.
- ✓ Chemical action

2. ABRASION अपघर्षण –

- ✓ wearing away of the river bed and banks by the LOAD hitting against them.
- ✓ Load = Pebbles, stones, gravel, boulders, drilling tools

3. ATTRITION सन्निघर्षण –

- ✓ wearing down of the LOAD by each other
- ✓ breaking into smaller and more rounded pieces

4. HYDRAULIC ACTION जलगति क्रिया –

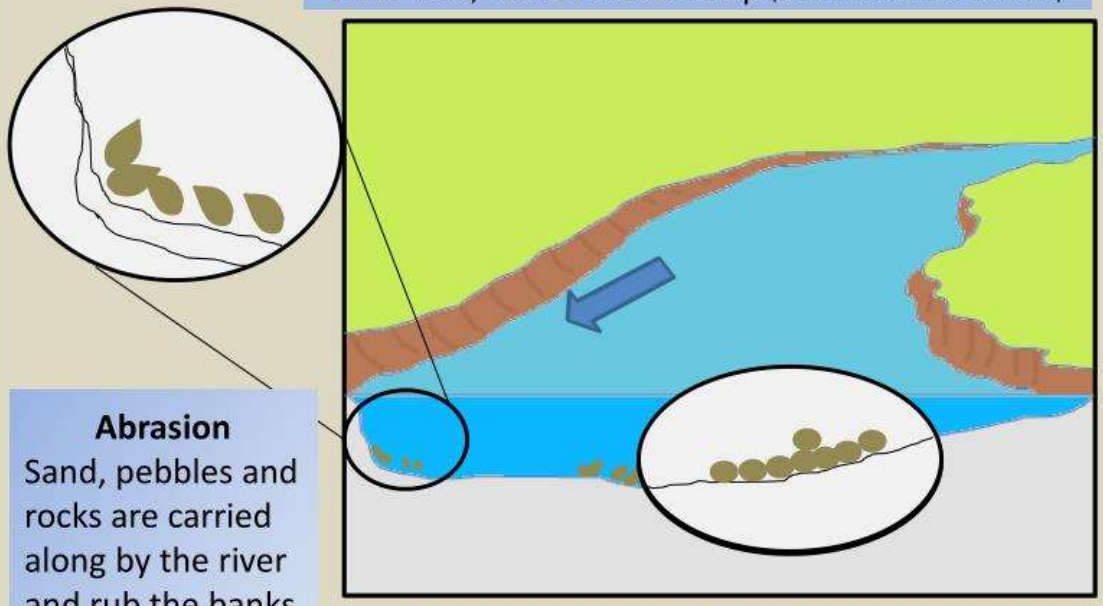
- ✓ breaking away of the river bed and banks by the sheer force of the water getting into small cracks
- ✓ Mechanical erosion by force of water

5. BANK CAVING तट गुहिकायन –

- ✓ At times of FLOOD
- ✓ When the river load is in excessive amount

River processes- Erosion

Hydraulic action
Fast-moving water is forced into cracks in the river-bed, which breaks it up (click on box to demonstrate)



Solution
Slightly acidic river water can dissolve some minerals, which weakens and breaks up the rocks that make the river channel.

Abrasion
Sand, pebbles and rocks are carried along by the river and rub the banks and bed of the channel, wearing it away.
(click on box to demonstrate)

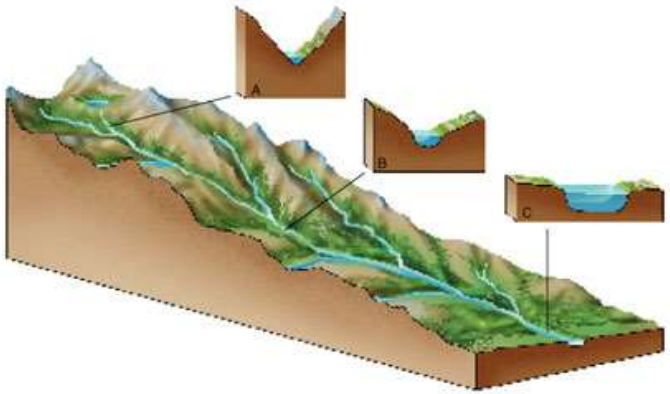
Attrition
Rocks and pebbles knock against each other in the moving water and become smoother and rounder. (click on box to demonstrate)

CORROSION

HYDRAULIC ACTION

Factors affecting erosional work of river

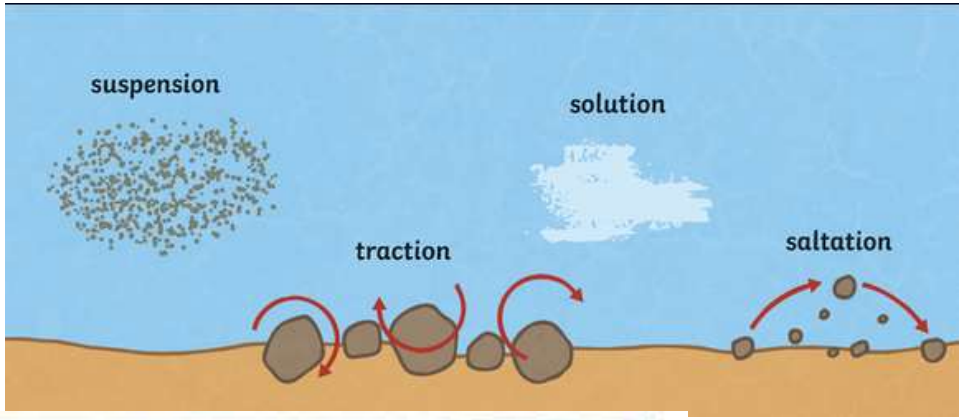
1. Slope gradient of the river
2. Velocity of the river
3. Quantity or volume of water
4. Quantity of load
5. Rock structure of the river bed

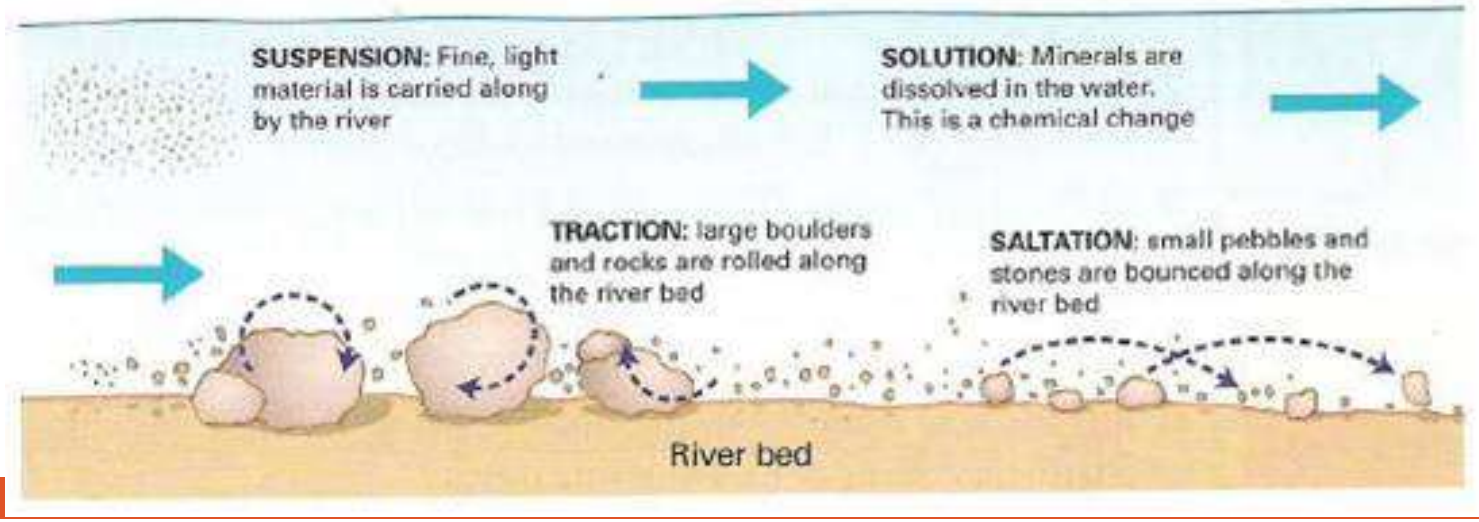


Transportation by the river

$T \alpha V$ (to the power 6)

1. Traction कर्षण: transportation of big boulders known as 'Bed load'
2. Saltation उत्परिवर्तन:
3. Suspension निलम्बन
4. In solution घुलकर





Factors affecting Deposition work of the river

1. Decrease in velocity of the river –

✓ decrease in slope

✓Water in rivers: flows in an expanded manner or when its volume decreases

✓Obstacle in the river course

2. Increase in LOAD in the river -