Module II: Physical Geography

1.Geomorphology

- Cycle of erosion

❖ **Penck Model of Cycle of Erosion**

➢ **Walter Penck was a German**. His work appeared a little obscure, nevertheless, the arguments which he put forward were based on logic. His work was neglected for a long time.

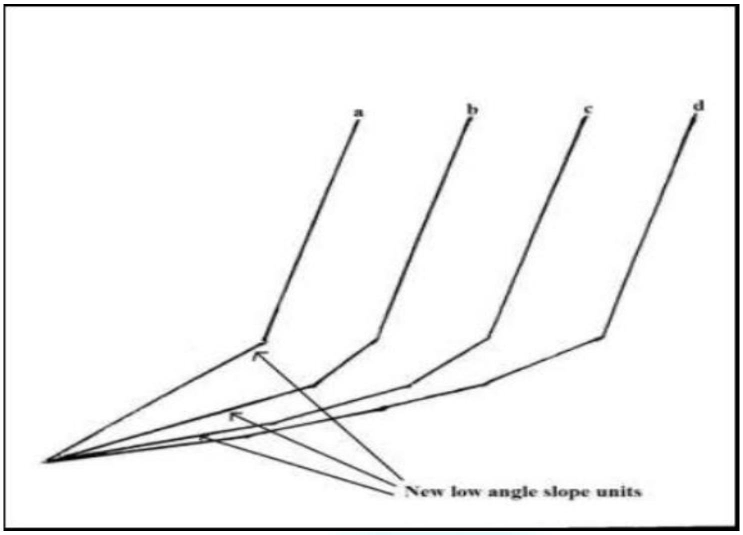
➢ He offered an alternative model where the landscape would simultaneously be eroded with the process of its upliftment. **The rates of denudation would vary and ultimately it would result in a low featureless plain called 'Endrumpf'**. He attempted to establish a relationship between the tectonic history of the region and the nature of the slope **(Spark, 1986).**

➢ Penck in his model took a straight steep slope unit bordering a river valley. **He assumed equal weathering over the entire slope**.

➢ The weathered material would fall under the force of **gravity and reach the lowest part of the slope.**

➢ The material lying at the lowest level would not be removed further owing to the fact that there is no gradient below it. In such a situation there would be a **parallel retreat of the slope.**

➢ The unit **AB** due to weathering and its removal would retreat to position **CD**. In the next stage the profile would shift further from **CD to EF**. All the weathered material will not be removed for some must remain at the foot of the unit to provide a slope of transport down to the non eroding river (Small, **1978).** The subsequent stages would see the retreat of the main slope unit to the position **XY**. There is marked reduction in the length of the slope unit as it retreats from the position **AB to XY.**



- At each successive stage it leaves behind basal fragments which combine to give a uniform slope covered with a uniform thick layer of detritus extending from the original slope unit down to the river.
- It is observed that a steep slope retreats upslope, maintains its gradient and gives rise to basal slope of lesser gradient. **Now, two slopes have emerged- the upper slope and lower basal slope.**
- Now the basal slope undergoes weathering and its material is reduced to finer particles.
- **The weathered material is removed from the basal slope but again the lowest particle is not removed as there is no gradient below it.**
- Therefore, a new slope unit of gentler angle is added below the basal slope. Over a period of time a lot of new slope units of gentler gradient than the next unit above will be formed at the foot of the slope and undergo migration upslope. **The overall result will be the development of basal concavity (Small, 1978).**
- The **original slope will eventually be destroyed**, the relief will be lowered, and the slope angle will decline. Thus it is observed

in his model that flattening of slope takes place from below upwards. **Penck's model of slope evolution is essentially deductive.** He has elaborated upon the development of slopes under conditions of accelerated and decelerated rates of erosion. **According to Penck slope forms and the way they are altered are determined by the rate of the river flowing at the base of the slope.**

- **Thus the rate of river erosion forms the overriding factor determining the form of the slope.**

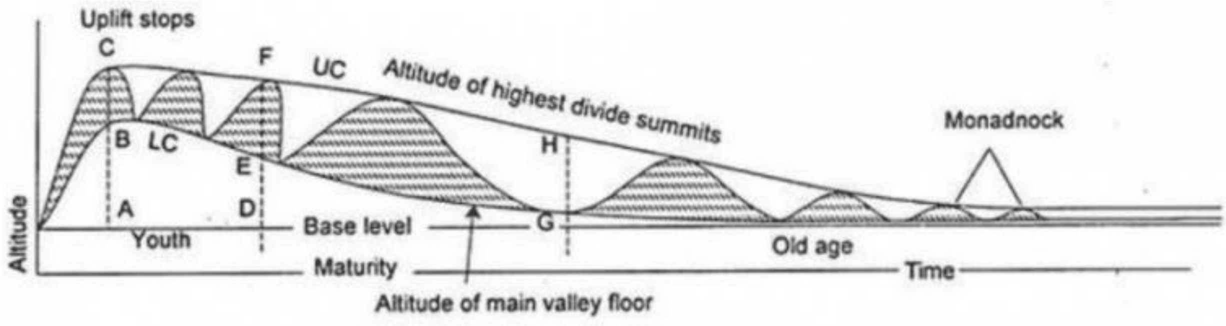
❖ <u>**Davis Model of Cycle of Erosion**</u>

- Davis postulated his concept of **'geographical cycle'** popularly known as **'cycle of erosion' in 1899** to present a genetic classification and systematic description of landforms. Later through a number of papers and articles modified his work several times.
- **Davis envisaged that all the landforms of the world pass through evolutionary sequence during which denudation processes act upon them to fashion different landforms in different stages of its evolution.**
- Change in landform with the passage of time formed the cornerstone of his cyclic concept. The landform would change from 'initial' to 'ultimate form'.
- The crest (hill tops) will not remain stable for a long period of time, rather their height and slope will decline with the passage of time. His cycle of landform development was thus dynamic in nature. **Davis argued that all physical landforms can be analyzed in terms of the three variables- structure, process and stage**.
- Davis 'geographical cycle' has been defined in the following manner

- ➔ **“Geographical cycle is a period of time during which an uplifted landmass undergoes its transformation by the process of land-sculpture ending into low featureless plain or peneplain (Davis called peneplain).”**

- ➢ Davis used the terminology of **youth, mature and old age** to mark different phases of evolution of landforms.
- ➢ He drew an analogy between **landscape and living beings** and therefore compared the life cycle of living beings with the life cycle of landforms.
- ➢ He argued every landform undergoes sequential changes through the process of evolution where it passes through **youth, maturity and old age.**
- ➢ In other words there is **no fixed time duration for youth, maturity or old age** because the **time duration for each stage will depend on many factors.**
- ➢ Assumptions made by Davis
  - ➔ Landforms are the evolved products of the interactions of **endogenetic (diastrophic) forces** originating from within the earth and the external or exogenetic forces originating from the atmosphere (**denudational processes, agents of weathering and erosion-rivers, wind, groundwater, sea waves, glaciers and periglacial processes**).
  - ➔ The evolution of landforms takes place in an orderly manner in such a way that a systematic sequence of landforms is developed through time in response to an environmental change.
  - ➔ **Streams erode their valleys rapidly downward until the graded condition is achieved**.
  - ➔ There is a short-period rapid rate of upliftment in land mass. It may be pointed out that Davis also described slower rates of upliftment if so desired.

➔ **Erosion does not start until the upliftment is complete**



Graphical presentation of geographical cycle presented by W.M. Davis.

➔ **<u>Stages of the cycle</u>**

★ **The cycle of erosion begins with the upliftment of landmass**. There is a rapid rate of short-period upliftment of landmass of homogeneous structure.

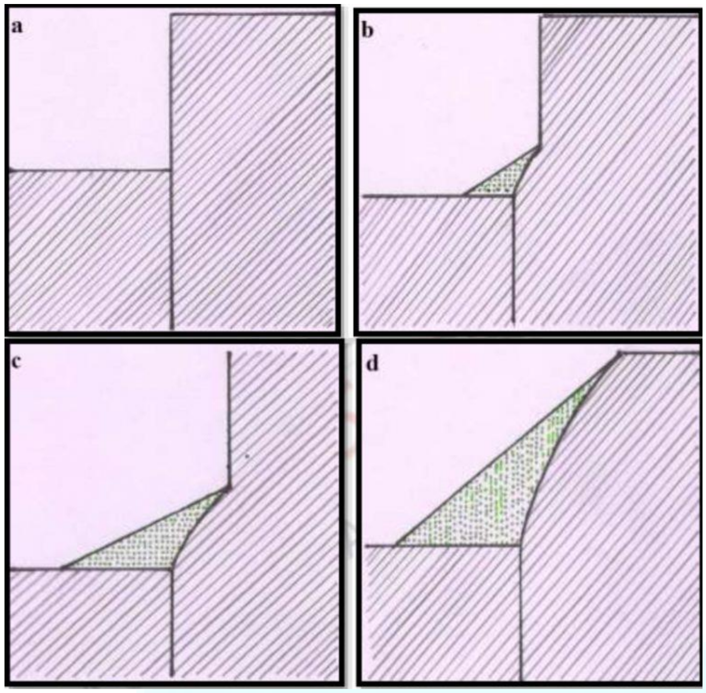
★ This phase of upliftment is not included in the cyclic time as this phase is, in fact, the preparatory stage of the cycle of erosion.

★ The above figure represents the model of geographical cycle wherein **UC (upper curve) and LC (lower curve)** denote the hill-tops or crests of water divides (absolute reliefs from mean sea level) and valley floors (lowest reliefs from mean sea level) respectively.

★ The horizontal line denotes time whereas the vertical axis depicts altitude from sea level. **AC** represents maximum absolute relief whereas **BC** denotes initial average relief. Initial relief is defined as the difference between the upper curve (summits of water divides) and lower curve (valley floors) of a landmass. In other words, relief is defined as the difference between the highest and the lowest points of a landmass. **ADG** line denotes base level which represents sea level. No river can erode its valley beyond base level (below sea level).

★ Thus, base level represents the limit of maximum vertical erosion (valley deepening) by the rivers. **The upliftment of the landmass stops after point C as the phase of upliftment is complete.**

- Slope development and theories
  - ❖ Evolution of slope is concerned with the change of slope forms with the passage of time.
  - ❖ **Models of slope evolution investigate the processes and mechanisms that operate to produce a particular slope form**.
  - ❖ **The second half of the nineteenth century saw some noteworthy work in this direction.**
  - ❖ <u>**Alan Wood's view on slope evolution**</u>
    - ➢ **Wood (1942)** began his evolution of slope taking cliff as the initial form which emerged either due to erosion or earth movements.
    - ➢ The process of weathering would push back the cliff (free face). In other words, weathering causes the free face to retreat parallel to itself.
    - ➢ Weathered material would collect at the foot of the face (scarp); the scree accumulates and slowly buries the lower parts of the free face thus reducing its height.
    - ➢ Wood regarded the foot of the scarp as the local base level for the weathering process. He assumed an ideal case of accumulated talus which is not subjected to weathering and has the same volume as parent rock.
    - ➢ The scree provides protection to the base of the rock face from weathering. The talus continues to grow and finally, it completely buries the free face (Fig). The retreating face above leaves behind protrusion under the screen.



- ➢ The surface of the scree which accumulates at a constant angle is termed as the constant slope **(wood, 1942)**.
- ➢ Beneath the screen will lie buried the convex slope. While this is an ideal case but in nature, such a process would be highly complex as there are various factors that affect the evolution of slopes.
- ➢ In nature, the volume of the screen will never be the same as the parent rock rather the volume would be more than parent rock because of the presence of interstitial space. **This will cause the upward growth of scree faster than ideal case as a result the buried face will become steeper while still retaining the convex form.**
- ➢ Similarly, if the removal of the screen takes place due to the washing out of the fine materials it will have an effect in the opposite direction. **The rate of growth of the screen will be slowed down and the slope of the buried face will become gentler.** It can also be added that the production of more coarse debris will lead to the rapid growth of screen as compared to the rock producing finer debris.

- As stated earlier the lower part of the constant slope which is formed by accumulated screen in nature will be weathered and carried by rain wash away from the foot of the hill slope, resulting in the gradual reduction of the slope and assuming a concave upward form known as waning slope.
- The recession of the hill continues till the free face disappears and the constant slope keeps extending upwards. The upper part will then result in a waxing slope. The upper convex, lower concave, and middle rectilinear slope form will develop. Gradually the rectilinear slope owing to the extension of waxing slope from above and waning slope from below will disappear. Finally, the relief gradually declines due to wasting.
- **Wood** was of the opinion that the manner in which the slopes evolve is not the same for all as a lot depends on climate, structure, and conditions observed at the slope base

❖ **<u>Strahler's View on Slope Development</u>**

- The work of Strahler is statistical in nature. His work is based on the data collected from fieldwork in parts of **California. Strahler (1950) collected data** "with a view to determining
  1. If differences in underlying rock types are associated with differences in slope angle.
  2. If differences in directional exposure to sunlight and other meteorological factors produce differences in slope angles, and
  3. If slopes decline in angle when left to weathering and erosion processes and not accompanied by basal erosion and removal".
- He conducted measurements of maximum angles attained by slope and carefully identified the area and ensured it should have uniformity in terms of **climate, vegetation, relief, and tectonic history**. Lithological factors, however, were not the same.

- He calculated the mean maximum slope angle for the study area, then assessed the deviation of slope from the mean slope by comparing the data of slope collected at different points in the study area.
- **Strahler** argued that if a large number of slopes show very little variation from the mean slope it means that the slopes have developed at approximately the same angle for the reason that this is the angle allowing the steady and efficient removal of the slope debris by slumping, creep and wash. Such slopes are in a delicate state of equilibrium **(Small,1978).**
- **According to Strahler (1950) "under the equilibrium, slopes maintain an equilibrium angle proportional to the channel gradient of the drainage system and are so adjusted as to permit a steady state to be maintained by the process of erosion and transportation under prevailing conditions of climate, vegetation, soils, bedrock, and initial relief".**
- Thus one can infer that the equilibrium slopes are governed by different slope controlling factors and change in any of the factors can cause readjustment of the equilibrium angle.
- Strahler during the course of his field observation also studied the relationship between valley side slopes and the stream gradient and noted that with the reduction of landmass there is a reduction in stream gradient and slopes. They gradually regrade towards the maintenance of equilibrium.
- He confirmed the correlation between slope angle and channel gradient (slope adjusts in proportion to the debris obtained from the valley side slopes) where the valley side slope is steep it will have a steep channel slope and where it is gentle it will have a gentle channel slope. However, there are exceptions to this rule in that the side slopes do not steepen with an increase of channel gradient very near the head of streams **(Sparks,1986).**

- ➢ Strahler also noted that a bare slope would contribute a greater amount of load than a vegetated slope at a given angle. This will result in a steeper channel gradient beneath the bare slope than that below vegetated. This example displays how both the angle of the stream channel and valley side slope modify with the change in controlling factor **(i.e.vegetation cover).**
- ➢ Through careful measurements of slopes, Strahler discovered that where the river was closer to the foot of the slope it formed a steeper slope because of the removal of debris. But when the stream was away from the slopes they were protected from the basal cutting and had lower angles

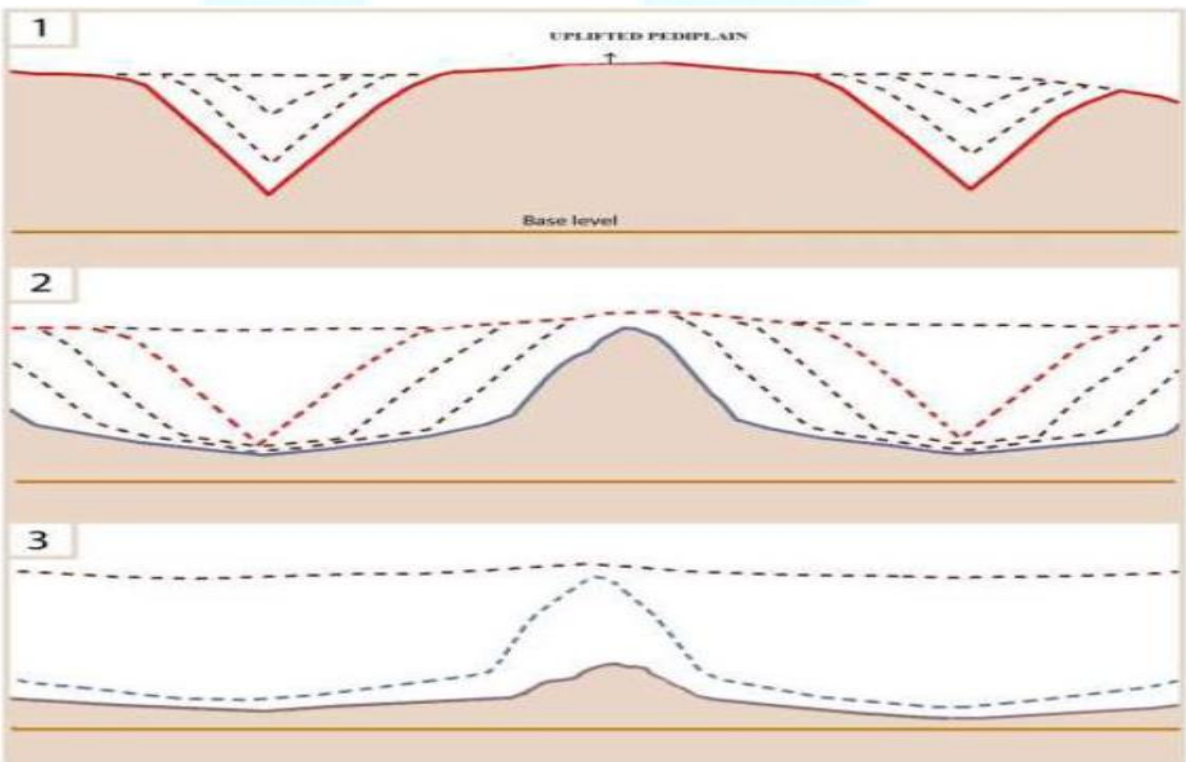
❖ **L.C. King Model of Slope Development**

- ➢ King's work on a cycle of erosion is based on his observation of the **African landscape.**
- ➢ He held that subtropical and semi-humid climates should be regarded as 'normal' instead of humid temperate on which much of the discussion of slope evolution is based.
- ➢ **His river cycle bears close similarity with Davis' cycle of slope evolution.**
- ➢ King made a closer examination of the African landscape and stated that it is made up of two important elements one is the gentle concave slope that is found in the valley bottoms and borders the streams or old watercourse.
- ➢ They are Pediments which over a period of time slowly extend their area and see the adjoining uplands retreat. **Pediments according to King (1953)** are normally covered with detritus but pediments themselves are essentially cut rock surfaces.
- ➢ The pediment is the fundamental landform to which epigene landscapes tend to be reduced. **He termed the entire process of pediment formation as pedimentation**.

- The second element is the steep slopes that bound upland blocks. He called it **'scarps'.** The scarps here have originated by the process of erosion only and maintain steep slopes of **15 to 30 degrees.** There is no reduction in their steepness when they are wasted back by weathering or rain wash.
- **This is the process of Parallel Retreat which King called 'scarp retreat'.**
- **<u>King's cycle of Pediplanation</u>**
  - King's landscape cycle discusses the process of pediplanation which shapes the erosion surface. **Different stages of his cycle are discussed below:**
    1. Youth
       - The cycle of pediplanation begins with the upliftment of an earlier formed pediplain.
       - The streams carry out rapid **downward erosion**. As the cycle draws near the end of youth the earlier fast down cutting slows down and witnesses the emergence of pediments in the valley bottoms.
       - These pediments become wider because of the reduction of upland areas by scarp retreat. In the late youthful stage most interfluves will be converted into inselbergs, many will be rounded off like domes.
    2. Maturity
       - In the mature stage the process of weathering causes a reduction in the number of Inselbergs.
       - There will be widening of pediments of adjoining valleys which would eventually coalesce.
       - The few remaining inselbergs preserve the vestiges of the former pediplain **(Small, 1978)**. **The relief which during the youth saw an increase will now show a decline or may remain constant in maturity.**

3. Old age
    - ★ Old age will see very few residual hills as **relief has mostly been destroyed.**
    - ★ The whole landscape will now be dominated by gently sloping pediments; the **'multi-concave'** surface is the ultimate form of the cycle **(Small, 1978).**

- ➢ King did not restrict the application of his concept to the **African landscape** only but he extended this to other non-arid climates of the world to explain the process of landform evolution operating under most of the climatic conditions.
- ➢ Thus, king's landscape cycle involves two processes of **'sedimentation'** and **'scarp retreat'**. **It is the operation of these two processes which lead to the formation of erosion surfaces.**



- Morphometric elements and parameters
    - ❖ Morphometric analysis is a **quantitative measurement and mathematical analysis of landforms.**

- It plays a significant role in understanding the geo-hydrological characteristics of a drainage basin in relation to the terrain feature and its flow patterns.
- It also helps to estimate the incidence of infiltration and runoff, and other related hydrological character of a watershed like erosion and sediment transport which has a strong implication for natural resource conservation.
- This study has attempted to quantify the morphometric characteristics of **Guna- Tana** watershed for proper implementation of soil and water conservation practices.
- In morphometric analysis **linear aspect** (basin length, stream order, steam length, mean stream length, bifurcation ratio, mean bifurcation ratio),
- **Aerial aspect** (basin area, drainage density, basin shape, drainage texture, circulatory ratio, stream frequency, elongated ratio) and
- **Relief aspect** (basin relief, relief ratio, ruggedness number, gradient ratio, basin slope and relative relief) of a watershed is computed to derive the general character of the watershed
- **<u>Morphometric parameters</u>**
  - **Linear aspect**

S.No	Parameter	Formula
1	Area (A)	Area of the watershed
2	Perimeter (P)	The perimeter is the total length of the watershed boundary.
3	Length (Lb)	Maximum length of the watershed

4	Stream Order (Nu)	Hierarchical rank
5	Stream Length(Lu)	Length of the stream
6	Stream length ratio (Rl)	Rl=Lu/Lu−1
7	Mean Stream Length Ratio (Lsm)	Lsm=Lu/Nu
8	Bifurcation ratio (Rb)	Rb=Nu/N(u+1)

➢ **Aerial aspect**

S.No	Parameter	Formula
1	Drainage density (Dd)	Dd = Lu / A
2	Stream frequency (Fs)	Fs = Nu / A
3	Texture Ratio	T=Nu/P
4	Elongation ratio (Re)	Re=1.128√A/L
5	Form factor (Ff)	$Ff=A/Lb^2$
6	Circularity index (Rc)	$Rc=4\pi A/P^2$
7	Length of overflow (Lg)	Lg=1/2/2d
8	Constant of Channel maintenance (Ccm)	C=1/Dd
9	Drainage texture (T)	T=Dd×Fs
10	Compactness coefficient (Cc)	Cc+0.282P/√A 0.5

➢ **Relief aspect**

S. No	Parameter	Formula
1	Basin relief (R)	R=H−h
2	Relief ratio (Rr)	Rr=R/L
3	Ruggedness number (Rn)	Rn=R×Dd
4	Gradient ratio (Gr)	Gr=(H-h)/L
5	Melton ruggedness ratio (MRn)	MRn=(H-h)/$A^{0.5}$
6	Slope (Sb)	Sb=H−h/L
7	Relative relief (Rhp)	Rhp=H/P×100
8	Shape Factor (Rf)	Rf=Lb^2/A
9	Leminscate(K)	K=Lb2/4×A

- Drainage basin compositions
  - A basin is a d**epression, or dip, in the Earth's surface. Basins are shaped like bowls, with sides higher than the bottom.**
  - They can be oval or circular in shape, similar to a sink or tub you might have in your own bathroom.
  - Some are filled with water. Others are empty.
  - Basins are formed by forces above the ground **(like erosion) or below the ground (like earthquakes).**
  - They can be created over **thousands of years or almost overnight.**
  - The major types of basins are river drainage basins, structural basins, and ocean basins.
    - **River Drainage Basins**
      - A river drainage basin is an area drained by a river and all of its tributaries.

- ➔ A river basin is made up of many different **watersheds.**
- ➔ **A watershed is a small version of a river basin**. Every stream and tributary has its own watershed, which drains to a larger stream or wetland
- ➔ These **streams, ponds, wetlands, and lakes are part of a river basin.**
- ➔ The **Mississippi River basin** in the U.S., for instance, is made up of six major watersheds: the **Missouri, Upper Mississippi, Ohio, Tennessee, Lower Mississippi, and Arkansas-Red-White Rivers**
- ➔ **Every river is part of a network of watersheds that make up a river system's entire drainage basin.**
- ➔ All the water in the drainage basin flows downhill toward bigger rivers.

➢ Structural Basins

- ➔ Structural basins are formed by **tectonic activity. Tectonic activity is the movement of large pieces of the Earth's crust, called tectonic plates.**
- ➔ Tectonic activity is responsible for such phenomena as earthquakes and volcanoes. **The natural processes of weathering and erosion also contribute to forming structural basins.**
- ➔ structural basins form as tectonic plates shift. Rocks and other material on the floor of the basin are forced downward, while material on the sides of the basin are pushed up.
- ➔ This process happens over thousands of years. If a basin is shaped like a **bowl, a structural basin is shaped like a series of smaller bowls, stacked inside each other.**
- ➔ **Structural basins are usually found in dry regions.**
- ➔ Some structural basins are known as **endorheic basins. Endorheic basins have internal drainage systems.**

- ➔ This means they don't have enough water to drain to a stream, lake, or ocean. **The water that trickles into these types of basins evaporates or seeps into the ground.**
- ➔ <u>**Lake basins**</u>
  - ★ A lake basin is another type of structural basin.
  - ★ Lake basins often form in valleys blocked by rocks or other debris left by a **landslide, lava flow, or glacier.**
  - ★ The debris acts as a **dam, trapping water and forming a lake.**
  - ★ Lake basins may also be carved out by **glaciers—huge masses of ice—as they move down valleys or across the land.** When the glaciers move, the basins they create remain
- ➔ <u>**Sedimentary basins**</u>
  - ★ Sedimentary basins are a type of structural basin that **aren't shaped like typical basins, sometimes forming long troughs**.
  - ★ Sedimentary basins have been filled with **layers of rock and organic material over millions of years.** Material that fills up the basin is called sediment fill.
  - ★ **Sedimentary basins are key sources of petroleum and other fossil fuels**

➢ Ocean Basins

- ➔ Ocean basins are the **largest depressions on Earth.**
- ➔ Ocean basins make up more than **70 percent of the total land on Earth.**
- ➔ Edges of the continents, called **continental shelves, form the sides of ocean basins.**
- ➔ There are five major ocean basins, coordinating with the major oceans of the world:
  1. **the Pacific basin,**

2. **the Atlantic basin,**
3. **the Indian basin,**
4. **the Arctic basin,**
5. **the Southern basin**

➔ Tectonic activity constantly changes ocean basins.

➔ **Seafloor spreading** and **subduction** are the most important types of tectonic activity that shape ocean basins.

➔ **Seafloor spreading**

★ Seafloor spreading happens **along the boundaries of tectonic plates that are moving apart from each other.**

★ These areas are called mid-ocean ridges. **New seafloor is created at the bottom, or rift, of a mid-ocean ridge.**

★ Ocean basins that have mid-ocean ridges are expanding. **The Atlantic basin, for instance, is expanding because of seafloor spreading.**

➔ **Subduction**

★ Subduction happens along the **boundaries of tectonic plates that are crashing into each other.**

★ In these subduction zones, the heavier plate moves underneath, or subducts, the lighter one.

★ Ocean basins that experience subduction, such as the **Pacific basin**, are shrinking.

- Drainage classifications

❖ **Drainage:**

➢ **The flow of water through well-defined channels is known as 'drainage'** and the **network of such channels is called a 'drainage system'.**

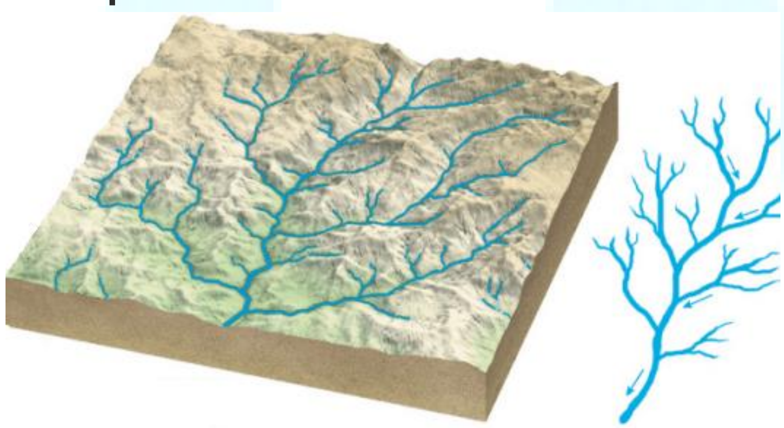
❖ **Drainage Pattern**

➢ It refers to the system of flow of surface water mainly through the forms of rivers and basins.

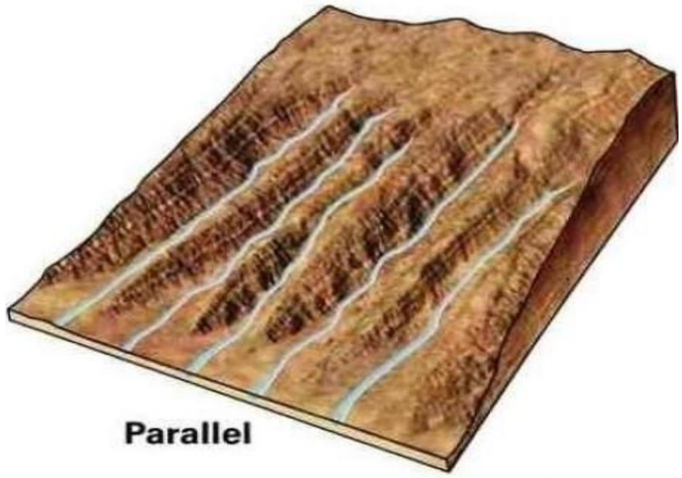
- ➢ **The drainage system depends upon factors such as slope of land, geological structure, amount of volume of water and velocity of water**.

❖ **Types of Drainage Patterns**

- ➢ **Dendritic Drainage Pattern**
  - ➔ It is the most common form and resembles the branching pattern of **tree roots.**
  - ➔ **The dendritic pattern develops where the river channel follows the slope of the terrain.**
  - ➔ The pattern develops in areas where the rock beneath the **stream has no particular structure and can be eroded equally easily in all directions.**
  - ➔ E.g. The rivers of the northern plains; **Indus, Ganga and Brahmaputra.**

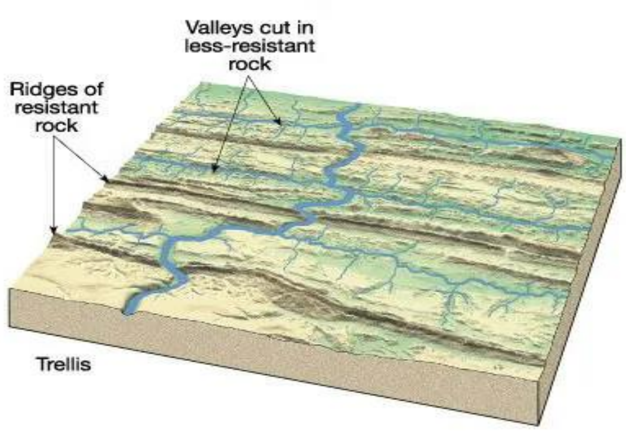


- ➢ **Parallel drainage pattern**
  - ➔ It develops in regions of **parallel, elongated landforms where there is a pronounced slope to the surface**.
  - ➔ Tributary streams tend to stretch out in a parallel-like fashion following the slope of the surface.
  - ➔ E.g. The rivers originating in the Western Ghats; **Godavari, Kaveri, Krishna, and Tungabhadra**



➢ Trellis Drainage Pattern

- ➔ **Trellis drainage develops in folded topography where hard and soft rocks exist parallel to each other.**
- ➔ Down-turned folds called synclines form valleys in which reside the main channel of the stream.
- ➔ Such a pattern is formed when the primary tributaries of main rivers flow parallel to each other and secondary tributaries join them at right angles.
- ➔ E.g. The rivers in the upper part of the Himalayan region; **Indus, Ganga and Brahmaputra.**

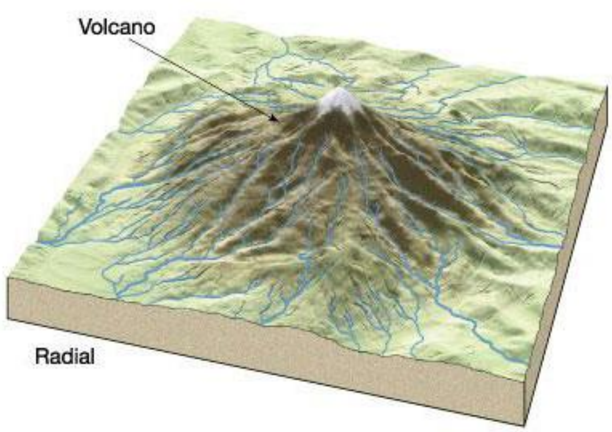


➢ Rectangular Drainage Pattern

- The rectangular drainage pattern is found in regions that have undergone faulting.
- **It develops on a strongly joined rocky terrain**.
- Streams follow the path of least resistance and thus are concentrated in places where exposed rock is the weakest.
- **The tributary streams make sharp bends and enter the main stream at high angles.**
- E.g. Streams found in the Vindhya mountain range; Chambal, Betwa and Ken.

Radial Drainage Pattern

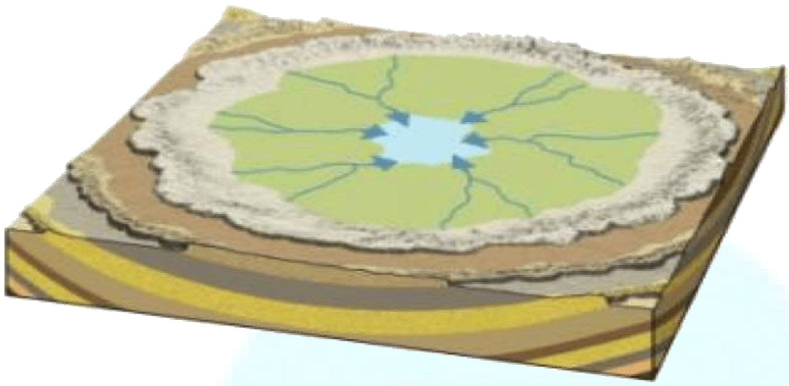
- The radial drainage pattern develops around a central elevated point and is common to conically shaped features such as volcanoes.
- When the rivers originate from a hill and flow in all directions, the drainage pattern is known as 'radial'.
- E.g. The rivers originate from the **Amarkantak range; Narmada and Son (tributary of Ganga).**



Centripetal Drainage Pattern

- It is just the opposite of the radial as streams flow toward a central depression.

➔ During wetter portions of the year, these streams feed ephemeral lakes, which evaporate away during dry periods.
➔ Sometimes, salt flats are also created in these dry lake beds as salt dissolved in the lake water precipitates out of solution and is left behind when the water evaporates away.
➔ E.g. **Loktak lake in Manipur.**



- Morphogenetic regions
  - ❖ Morphogenetic region is a theoretical **concept** propounded by various **geomorphologists to relate landforms and geomorphic processes with climate.**
  - ❖ This as a concept was first proposed by German geographer J**ulius Budel in 1945.**
  - ❖ This concept asserts that under certain sets of climatic circumstances, different sets of geomorphic processes predominate and produce distinct topographic features.
  - ❖ This theory is based on the assumption that **rock type resistant to erosion is dependent on the climatic conditions to which it is subjected.**
  - ❖ Now, it becomes clear by analyzing different factors that these landform features result from the interaction of rock type, physical processes and more predominantly climatic phenomena
  - ❖ morphogenetic regions are large areas with distinct geomorphic processes **(like weathering, frost action, mass movements and**

wind action) which operates and tends towards state of morphoclimatic equilibrium

- It is an area where landforms are shaped by similar processes more particularly by climate. **In this, the distinctive morphogenesis of an area is investigated.**
- According to **Chorley et al (1984)**, **''the extent to which different climatic regimes are potentially capable of exerting direct and indirect influences on geomorphic processes and thereby of generating different 'morphogenetic' landform assemblages''.**
- According to **Peltier (1950, p. 217)** morphogenetic regions are those geomorphic areas that are characterized by climatic regimes **"within which the intensity and relative significance of the various geomorphic processes are ... essentially uniform."**
- They are defined broadly in terms of temperature versus rainfall, and nine types of such regions were identified by him. Peltier also defined the main geomorphic agents, showing climatic fields of weaker or stronger action.
- **The morphogenetic concept does not directly identify those features of the landscape which replicate factors other than process and climate.**
- Thus, landforms whose origin is largely **tectonic, lithological, structural, volcanic** are **not considered under morphogenetic** classification, **but are discussed under the general heading of morphostructure**
- Morphogenetic processes that form the landform from earth materials are classified into two types- **endogenetic and exogenetic**.
- **The endogenic processes** are energy forces which act within the crust of the earth and it includes crustal or non-isostatic warping within the mantle causing **earthquake, folding, faulting, metamorphism etc**

- **The exogenetic processes** means phenomena which acts outside of the earth's crust and it covers **erosion and weathering and other surface processes under climatic influence**

- Application of geomorphology

- **Geomorphology and Hydrology**
  - Water used by human beings is available from different sources—**streams, lakes and rivers on the surface of the earth or groundwater**.
  - Different stratigraphic and lithological zones present different conditions of surface and groundwater.
  - Limestone terrains vary widely and the ability to yield water depends on the type of rock. Permeability in limestones may be primary or secondary.
  - Primary permeability depends upon the presence of initial interconnecting voids in the calcareous sediments from which the rock was formed.
  - Secondary (or acquired) permeability occurs because of earth movements such as faulting, folding, warping, and due to solution or corrosion mechanism.
  - This secondary permeability varies notably with respect to the topography of a region, being greatest beneath and adjacent to topographic lows or valleys. Much of the groundwater in **karst terrain** is confined to solution channels.
  - Groundwater potential in glaciated regions can be determined on the basis of the geomorphic history of the area, characteristics of glacial deposits and landform.
  - Outwash plains, valley trains and intertill gravels are likely to yield large volumes of water.
  - Most tills are poor sources of water because of the clay in them, but they contain local strata of sand and gravel which may hold and supply enough water for domestic needs.

- ➢ Buried pre-glacial and interglacial valleys could be good sources of groundwater. Their presence (or absence) may be detected by studying the pre glacial topography and geomorphic history of the area.
- ➢ Buried valleys are located by constructing bedrock topography maps of glaciated areas.

❖ **<u>Geomorphology and Mineral Exploration</u>**

- ➢ Mineral deposits are associated with geological structure. Landscape characteristics of the specific localities could indicate such geological structures.
  - ➔ **Surface Expression of Ore Bodies**
    - ★ Some ore bodies have obvious surface expressions as topographic forms, as outcrops of ore, gossan, or residual minerals, or structural features such as faults, fractures and zones of breccia.
    - ★ Lead-zinc lodes could be marked by a conspicuous ridge as in the case of **Broken Hill, Australia.**
    - ★ **Quartz** veins could stand out prominently as they are much more resistant to erosion than the silicified surroundings, as in **Chihuahua, Mexico**
  - ➔ **Weathering Residues**
    - ★ Many economically important minerals are the weathering residues of present or ancient geomorphic cycles and geomorphology can be of use in searching for such minerals.
    - ★ Iron ore, clay minerals, caliche, bauxite and some ores of manganese and nickel may be such weathering residues. Weathering and erosion are constantly at work on the rocks of earth’s surface, and the products of rock weathering may be of economical value
  - ➔ **Placer Deposits**

- ★ Placer deposits are mixtures of heavy metals which are aggregates of materials derived through chemical weathering or erosion of metallic formation.
- ★ Placer concentration of minerals results from definite geomorphic processes and, found in specific topographical positions, may have a distinctive topographic expression. The type of rock forming the bedrock floor may influence the deposition of placers.
- ★ Residual placers or **'seam diggings'** are residues from the weathering of quartz stringers or veins, are usually of limited amount, and grade down into lodes.
- ★ Colluvial placers are produced by creeping down slope of residual materials and are thus transitional between residual placers and alluvial placers.
- ★ Gold placers of this type have been found in **California, Australia, New Zealand,** and elsewhere.
- ★ Diamonds in the Vaal and Orange River districts of **South Africa,**

➔ **Oil Exploration**

- ★ Many oil fields have been discovered because of their striking topographic expression. Mineral oil is considered to have been formed by the decay and decomposition of organic matter.
- ★ After formation, this oil gets trapped in rocks under structural traps or stratigraphic traps. Sedimentary strata are folded into anticlines and synclines allowing the permeable and impermeable strata to get closer, and the mineral oil are well-preserved within the upper permeable and the lower impermeable beds.
- ★ Generally mineral oil is found in the porous and permeable rock structures with lower layers of impermeable rocks.

Sandstone and limestone provide ideal locations of mineral oil as they are porous and permeable.

- ★ **The shale below acts as the impermeable bed**. In regions of heavy tropical forests, where topography cannot be seen through the forest, tonal differences may indicate an anticlinal or domal structure.
- ★ More subtle evidence of geologic structures favorable to oil accumulation is being made use of today in the search for oil.
- ★ Drainage analysis of a terrain shown on aerial photography is one such technique. A sophisticated perception of drainage anomalies of an area is required, and a geomorphologist would most likely possess the requisite knowledge.
- ★ Drainage analysis is particularly useful in regions where rocks have low dips and the topographic relief is slight.

❖ Geomorphology and Engineering Works

➢ Road Construction

- ➔ The most feasible highway routes would be best determined by the topographic features of the area.
- ➔ Knowledge of the geologic structure, lithological and stratigraphic characteristics, the strength of the surficial deposits, geomorphic history of the area, among other things is of importance in road engineering
- ➔ A route over a **karst plain** necessitates repeated cut and fill otherwise the road will be flooded after heavy rains as sinkholes fill with surface runoff.
- ➔ Bridge abutments in a karst region should be so designed that they will not be weakened by enlarged solutional cavities which are likely to be present.

- ➔ An appreciation of the relationships of soils to varying topographic conditions and type of parent material becomes essential in modern highway construction.
- ➔ Knowledge of soil profiles, which to a large degree reflect the influence of geomorphic conditions and history, is basic.
- ➔ Poor highway performance characterizes silty-clay subgrades with a high water table, and best performance is found on granular materials with a low water table.

➢ **Dam Site Selection**

- ➔ Selecting sites for the construction of dams would be greatly helped by a synthesis of knowledge concerning geomorphology, lithology, and geologic structure of terrains.
- ➔ Five main requirements of good reservoir sites depend on geologic conditions, according to Kirk Brya
  1. A water-tight basin of adequate size
  2. A narrow outlet of the basin with a foundation that will permit economical construction of a dam
  3. Opportunity to build an adequate and safe spillway to carry surplus waters
  4. Availability of materials needed for dam construction (this is particularly true of earthen dams)
  5. Assurance that the life of the reservoir will not be too short as a result of excessive deposition of mud and silt.
- ➔ Limestone terrain, for instance, may prove a difficult one for constructing a dam.
- ➔ The bedrock surface may be irregular because of differential solution and, unless a true picture of the subsurface is understood, it could lead to avoidable expenditure.
- ➔ A construction in a valley is desirable from the standpoint of the size of the dam that will have to be built, but it may not always be a good dam site

- ➔ In glaciated areas, where buried bedrock valleys containing sand and gravel fills are **common, surficial topography may not give an adequate picture of subsurface conditions.**
- ➢ **Locating Sand and Gravel Pits**
  - ➔ Sand and gravel have many engineering as well as commercial and industrial uses.
  - ➔ Selection of suitable sites for sand and gravel pits will entail evaluation of such geologic factors as variation in grade sizes, lithologic composition, degree of weathering, amount of overburden, and continuity of the deposits.
  - ➔ **Sand and gravel may be found as a floodplain, river terrace, alluvial fan and cone, talus, wind-blown, residual, and glacial deposits of various types.**
  - ➔ All have distinctive topographic relationships and expressions and varying inherent qualities and possibilities of development.
  - ➔ Floodplain deposits are likely to contain high proportions of silt and sand and show many variable and heterogeneous lateral and vertical gradations.
  - ➔ Alluvial fan and cone gravels are angular in shape as well as a variable in size, especially near their apices. Talus materials, in addition to being angular, are too large to be suitable for most uses and are limited in extent.

❖ **Geomorphology and Military Geology**

- ➢ Thornbury points out the importance of geomorphology in the context of war.
- ➢ **"World War I** largely stabilized trench warfare, and the information that was most useful was more geologic than geomorphic in nature (Brooks, 1921).
- ➢ Information about the kind of rock that would be encountered in digging trenches, in mining and countermining, and the

possibilities of water supply and supplies of other geologic materials was most utilized.

- **Topography did play a role in maneuvering and planning routes of attack, but it can hardly be said that the Allies utilized basic geomorphic knowledge to any great extent.**

❖ **Geomorphology and Urbanization**

- Geomorphological knowledge applied to urban development has become important enough to grow into a separate branch, namely, urban geomorphology.
- This branch of geomorphology is concerned with **"the study of landforms and their related processes, materials and hazards, ways that are beneficial to planning, development, and management of urbanized areas where urban growth is expected,"** according to **R.U. Cooke**
- A city or town depends on its stability, safety, basic needs, and, later, its expansion on geomorphological features: **lithological and topographical features, hydrological conditions, and geomorphic features**
- An urban geomorphologist begins work even before urban development through field survey, terrain classification, identification, and selection of alternative sites for settlements.
- During and after urban development, an urban geomorphologist would be concerned with studying the impact of natural events on the urban community and that of urban development on the environment.

❖ **Geomorphology and Hazard Management**

- Events, natural or man-induced, exceeding a tolerable level or of an unexpected nature may be called hazards. A geomorphic hazard, says Chorley, may be defined as "any change, natural or man-made, that may affect the geomorphic stability of a landform to the adversity of living things".

- ➢ These hazards may arise from long-term factors such as faulting, folding, warping, uplifting, subsidence caused by earth movements, or changes in vegetation cover and hydrologic regime caused by climatic change. More immediate and sudden hazards are **volcanic eruptions, earthquakes, landslides, avalanches, floods, etc.**
- ➢ Geomorphic knowledge can be of use in **identifying and predicting such hazards and in assessing their effects and proper management.**
- ➢ Regular measurement of seismic events and earth tremors by seismic methods; regular measurement of the ground surface, mainly tilt measurement by tilt metres; constant measurement of the temperature of crater lakes, hot springs, geysers, fumaroles; monitoring of gasses coming out of craters, hot springs, geysers; monitoring of changes in the configuration of dormant or extinct volcanoes by lasers; measurement of local gravity and magnetic fields and their trends, etc., help in making predictions of possible eruptions in the areas having past case histories of volcanism. The path of lava flow can be better predicted on the basis of a detailed analysis of topography and identification of possible eruption points.
- ➢ Earthquakes may be **natural or man-induced geomorphic hazards.** The geomorphic knowledge of the stability of terrain and probable impacts of man-made structures (such as dams and reservoirs) on crustal stability is of paramount importance in identifying weaker zones that are likely to be affected by seismic events.
- ➢ Similarly, the geomorphic study of the nature of hill slopes and their associated lithologies enable us to know the stability or instability of the hill slopes.

- **This knowledge would help in identifying and mapping unstable hill slopes unsuitable for human settlements and road construction.**

- **Geomorphology and Regional Planning**
  - Applied geomorphology has a place in regional planning. Balanced growth of a country's economy requires a careful understanding of what each region offers in terms of resources, natural and human.
  - Detailed information on topography, soils, hydrology, lithology, and terrain characteristics are of obvious interest to enlightened regional planners who may then devise development projects best suited for the region
- Mapping of landforms viz. slope elements which affect and/or modify human activity.
- Interpretation of Aerial Photographs and Satellite Images
- Remote Sensing