

Davis : Cycle of Erosion

M.A (Semester-I)

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Geomorphic Cycles & Davis Cycle of Erosion

Davis Model of Cycle of Erosion

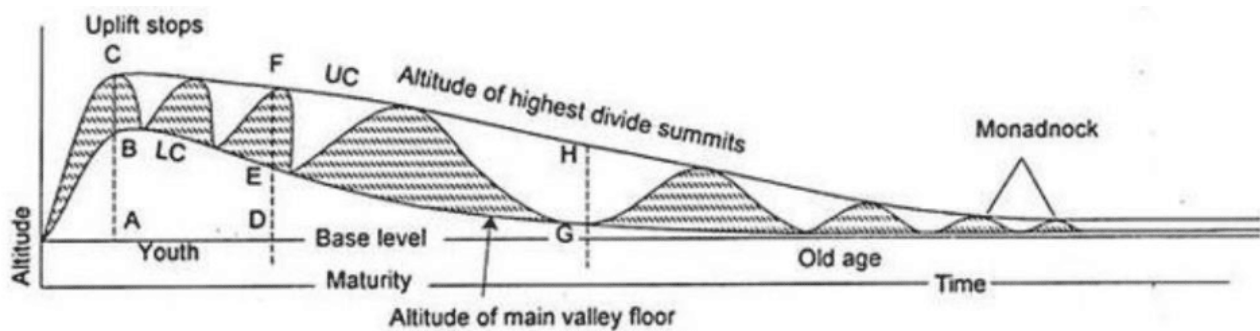
- **Davis postulated his concept of 'geographical cycle' popularly known as 'cycle of erosion' in 1899 to present a genetic classification and systematic description of landforms.** Later through a number of papers and articles modified his work several times.
- Davis envisaged that **all the landforms 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 peneplane).”**
- According to Davis three factors viz. structure, process and time play important roles in the origin and development of landforms of a particular place.
- **Trio of Davis:**
 - **Structure**— The term structure included more than what its literal meaning. It included the manner of disposition of underlying rocks, level of hardness, porosity, folds and faults etc.
 - **Process:** It includes all types of weathering river, wind and glacial erosion, mass movements etc.
 - **Stage:** It means the time duration during which the processes operate on a structure
- Davis used the terminology of **youth, mature and old age to mark different phase of evolution of landforms**. He drew analogy between landscape and living being and therefore compared the life cycle of living being 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.
- Davis talked about all these stages of life cycle in relative terms. **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. In regions of highly resistant rocks the duration of this cycle will be fairly longer compared with relatively weaker less resistant rock types.

- **The basic premises of Davisian model of 'geographical cycle' included the following 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. In other words, upliftment and erosion do not go hand in hand. This assumption of Davis became the focal point of severe attacks by the critics of the cyclic concept.



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

Stages of the cycle

- 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 vertical axis depicts altitude from sea level. AC represents maximum absolute relief whereas BC denotes initial average relief. Initial relief is defined as difference between 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.

- **Now erosion starts and the whole cycle pass through the following three stages:**
- **Youthful stage:**
 - **Erosion starts after the completion of the upliftment of the landmass.** The topsurfaces or the summits of the water divides are not affected by erosion because the rivers are small and widely spaced. Small rivers and short tributaries are engaged in head-ward erosion due to which they extend their lengths. **The process is called stream lengthening (increase in the lengths of the rivers).**
 - Because of steep slope and steep channel gradient rivers actively deepen their valleys through vertical erosion aided by pothole drilling and thus there is gradual increase in the depth of river valleys. This process is called valley deepening. The valleys become deep and narrow characterized by steep valley side slopes of convex plan.
 - **The youthful stage is characterized by rapid rate of vertical erosion and valley deepening because:**
 - The channel gradient is very steep,
 - Steep channel gradient increases the velocity and kinetic energy of the river flow,
 - Increased channel gradient and flow velocity increases the transporting capacity of the rivers,
 - Increased transporting capacity of the rivers allows them to carry big boulders of high calibre (more angular boulders) which help in valley incision

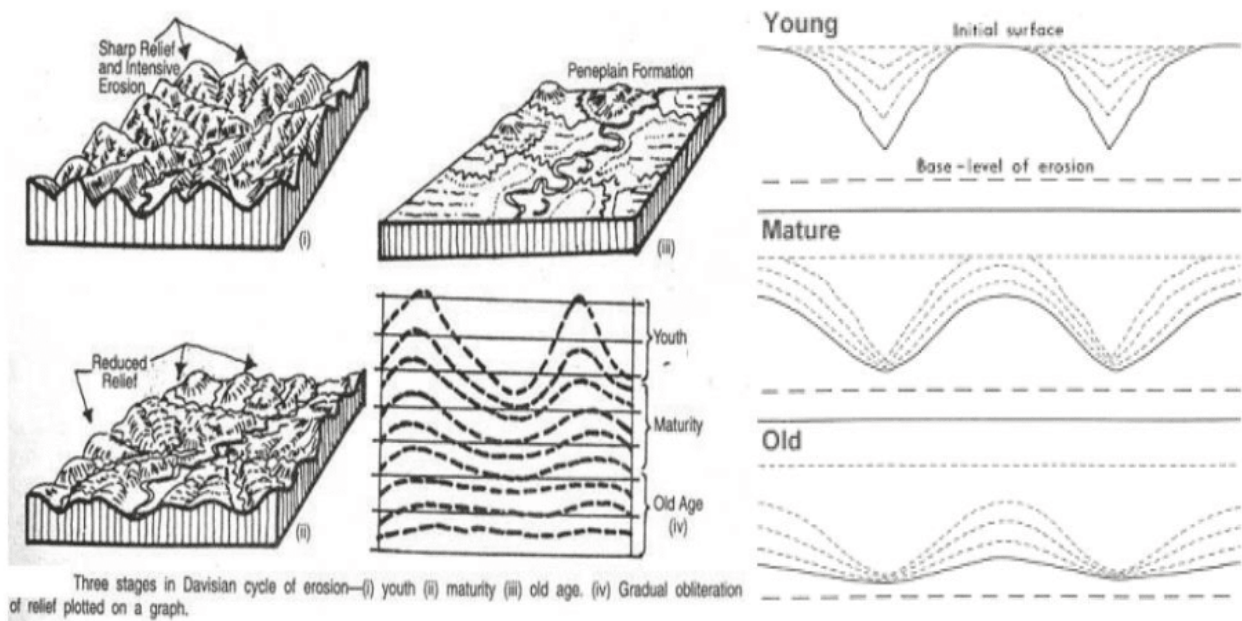
(valley deepening through vertical erosion) through pothole drilling.

- The lower curve (LC valley floor) falls rapidly because of valley deepening but the upper curve (UC summits of water divides or inter stream areas) remain almost parallel to the horizontal axis (AD, in fig.) because the summits or upper parts of the landmass are not affected by erosion. Thus, relative relief continues to increase till the end of youthful stage when ultimate maximum relief (EF, in fig) is attained.
- In nutshell, the youthful stage is characterized by the following characteristic features:
 - Absolute height remains constant (CF is parallel to the horizontal axis) because of insignificant lateral erosion.
 - Upper curve (UC) representing summits of water divides are not affected by erosion.
 - Lower curve (LC) falls rapidly because of rapid rate of valley-deepening through vertical erosion.
 - Relief (relative) continues to increase.
 - Valleys are of V shape characterized by convex valley side slopes.
 - Overall valley form is gorge or canyon.
 - Long profiles of the rivers are characterized by rapids and waterfalls which gradually diminish with the march of time and these practically disappear by the end of late youth. The main river is graded.
- **Mature stage:**
 - **The early mature stage is heralded by marked lateral erosion and well integrated drainage network. The**

graded conditions spread over larger area and most of the tributaries are graded to base level of erosion. **Vertical erosion or valley deepening is remarkably reduced.** The summits of water divides are also eroded and hence there is marked fall in upper curve (UC) i.e., there is marked lowering of absolute relief.

- Thus, absolute relief and relative relief, both decrease. The lateral erosion leads to valley widening which transforms the V-shaped valleys of youthful stage into wide valleys with uniform or rectilinear valleys sides. The marked reduction in valley deepening (vertical erosion or valley incision) is because of substantial decrease in channel gradient, flow velocity and transporting capacity of the rivers.
- **Old Stage:**
 - **Old stage is characterized by almost total absence of valley incision but lateral erosion and valley widening is still active process.** Water divides are more rapidly eroded. In fact, water divides are reduced in dimension by both, down-wasting and back-wasting. Thus, upper curve falls more rapidly, meaning thereby there is rapid rate of decrease in absolute height. **Relative or available relief also decreases sharply because of active lateral erosion but no vertical erosion. Near absence of valley deepening is due to extremely low channel gradient and remarkably reduced kinetic energy and maximum entropy.**
 - The **valleys become almost flat with concave valley side slopes.** The entire landscape is dominated by graded valley-sides and divide crests, broad, open and

gently sloping valleys having extensive flood plains, well developed meanders, residual convexo-concave **monadnocks** and extensive undulating plain of extremely low relief. Thus, **the entire landscape is transformed into peneplain**. As revealed by fig. the **duration of old stage is many times as long as youth and maturity combined together**.



Analysis of Davis cycle of erosion

- There have been diverse views expressed by different geomorphologists on the concept of '**peneplain**' put forward by Davis. **Some regarded peneplain as a theoretical landform because they considered that for Davis' cycle to run its full course it requires the landform should remain stable for a very long time.**
- This possibility was very rare in a reality where both endogenetic and exogenetic forces operate continuously and this may obstruct the smooth course of the cycle. **It is also argued that during the period when the river is eroding its valley the removal of the overlying load is compensated**

by the addition of more material to its root as per the principle of Isostatic adjustment.

- This will give a push to the overlying landform thus keeping the process of upliftment continue for an infinite time. Thus **the attainment of the peneplain stage is questioned as it contradicts the view of isostatic adjustment.**
- Most geomorphologists also believe that **Davis' idea of the sequential change of landform is the too simplistic a presentation of landform evolution. The evolution of landform, in reality, is a far more complex process.**

Criticism of Davis Model

- **Davis concept of upliftment is not acceptable.** He has described a **rapid rate of upliftment of short duration but as evidenced by plate tectonics upliftment is exceedingly a slow and long-continued process.**
- Davis' concept of the relationship between **upliftment and erosion is erroneous.** According to him, **no erosion can start unless upliftment is complete. Can erosion wait for the completion of upliftment? It is a natural process that as the land rises, erosion begins.**
- He admitted that **he deliberately excluded erosion from the phase of upliftment** because of two reasons:
 - **To make the model simple**
 - **Erosion is insignificant during the phase of upliftment.**
- The Davisian model **requires a long period of crustal stability for the completion of cycle of erosion but such an eventless long period is tectonically not possible** as is evidenced by plate tectonics according to which plates are always in motion and the crust is very often affected by

tectonic events. Davis has also offered an explanation to this objection. **According to him if crustal stability for the desired period is not possible, the cycle of erosion is interrupted and a fresh cycle of erosion may start.**

- **Walther Penck objected to the over-emphasis of time in Davis' model.** In fact, Davisian model envisages '**time-dependent series**' of landform development whereas Penck pleaded for '**time-independent series**' of landforms.
 - According to Penck **landforms do not experience progressive and sequential changes through time.** He, thus, pleaded for deletion of 'time' (stage) from Davis' 'trio' of 'structure, process and time'. According to Penck "**geomorphic forms are expressions of the phase and rate of upliftment in relation to the rate of degradation**".
- **A.N. Strahler, J.T. Hack and R.J. Chorley and several others have rejected the Davisian concept of 'historical evolution' of landforms.** They have forwarded the dynamic equilibrium theory for the explanation of landform development.
- It may be pointed out that the **non-cyclic concept of 'dynamic equilibrium'** as a valid substitute of Davis' cyclic concept of landform development and other so-called '**open system**' and **non-cyclic models** of landform development **could not arouse any enthusiasm among the modern geomorphologists.**
- Although the Davis cycle has faced a lot of criticism, **it still holds its place in the work pertaining to slope evolution owing to its wide appeal and manner of presentation.**