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Component-I (B) Description of Module

Items	Description of Module
Subject Name	**Geography**
Paper Name	**Geomorphology**
Module Name/Title	**Interruptions of the Cycle of Erosion (Tectonics, Climatic and Base Level Changes)**
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Objectives	
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Interruptions of the Cycle of Erosion (Tectonics, Climatic and Base Level Changes)

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The objectives of present module are as follows:

1. Fluvial system

Fluvial system may be divides into following three zones:

Zone 1 primarily watershed basin and from here the sediments are collected (primarily the zone of sediment collection).
Zone 2 is the primarily involved in transformation of sediments from zone 1 to zone 2. So this is transportation zone.
Zone 3 is where these sediments finally sink and gets deposited so this id primarily zone of deposition.

In all the zones the interacting processes and the landforms found in different zones creates complex landscape structures. The **fluvial system** is influenced by various variables like time, initial relief, geological structures, climate, type and density of vegetation, relief or volume of system above base level, Hydrology within zone 1 and 3, drainage network, hillslope morphology, sediment characteristics that is channel and valley morphology and channel characteritics of depositional system morphology.

2. Cycle of Erosion

American Geographer **William Morris Davis** (1850-1934) was the first goemorphologist who proposed the model of the cycle of erosion. He develop a model showing sequential changes in landform through time. On the lines of Charles Darwin, Davis tried to study evolution of the landforms as an organic form passing through the stages of Youth, Maturity and Old.

3. Davisian cycle of erosion

Davis gave the most complete and ideal cycle erosion in the most simple and persuasive way, naming each stage after the stages of human life- Youth, maturity and Old.

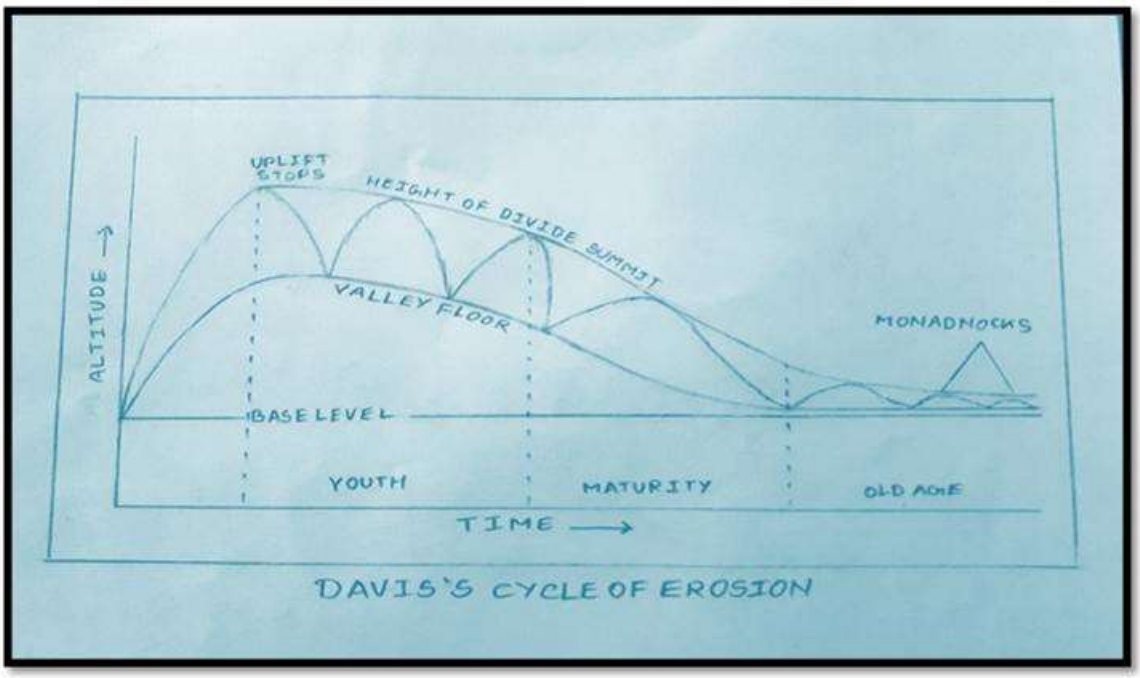

Fig. 1 Davis Cycle of Erosion

3.1 For simplicity he made following assumptions:

(i) uniform lithology or mass of land

(ii) considerable mass of land available what was, in effect, a stable mass, which has rapidly uplifted from beneath the earth's surface due to earth movements. ***For detail kindly refer module number 17 on Models of Slope Development.***

3.2 Stages in the ideal cycle of erosion:

(i) Youth

It comprises region of broad and poorly defined water divides and consequent streams. The region has numerous trunk rivers and few large tributaries, which has direction of flow, velocity and erosional capabilities. These streams from infancy are aggressive and capable of **head ward cutting**. They would rapidly cut downwards together with the vertical incision of the whole drainage network in due course of time form deep "V" shaped valleys of 30°. On these slopes slumping would be slow compared to the speed of the incision. The stream course is mostly irregular marked by falls and rapids.

(ii) Maturity

At this stage the region achieves maximum relief. The area spreads over well-integrated drainage network with maximum association with its bedrock and geological structure. There is **deepening of the "V" shaped valley**. The intricate complex network of tributaries and streams gives way to more organized well-integrated network of drainage and the streams are gentler and their velocity reduced. The base level will have reduced importance and the drainage network will have maximum relationship with the geological structure. This primarily involves removal of previously accumulated sediments from the bedrock and rejuvenation of the existing rock pediment. Lateral cutting is predominant leading to extensive floodplains, which do not generally exceed to the width of the meander belts. The valley floor is generally **graded** and the relief in general shows progressive decrease.

(iii) Old

By this stage there is **gradual reduction of the river gradient and velocity**. The valley slopes ad the sides are massively degraded and is mostly **broad, gently sloping**, broad floodplains. Sometimes the widths of the associated meander belt are surmounted by slowly lowering rounded divide. The base level will have thick soil cover and the whole surface will be closer to the base level. The integration of the drainage, which progressed throught the maturity, is complete. There are visible topographical residual like **monadnocks** with general outcrops over the peneplain in the later old age. Fig. 2.

Peneplain can be renewed through various upliftment processes, which causes it to redissect. A new set of landforms is formed as a result. In this process different stages of the cycle are superimposed on another.

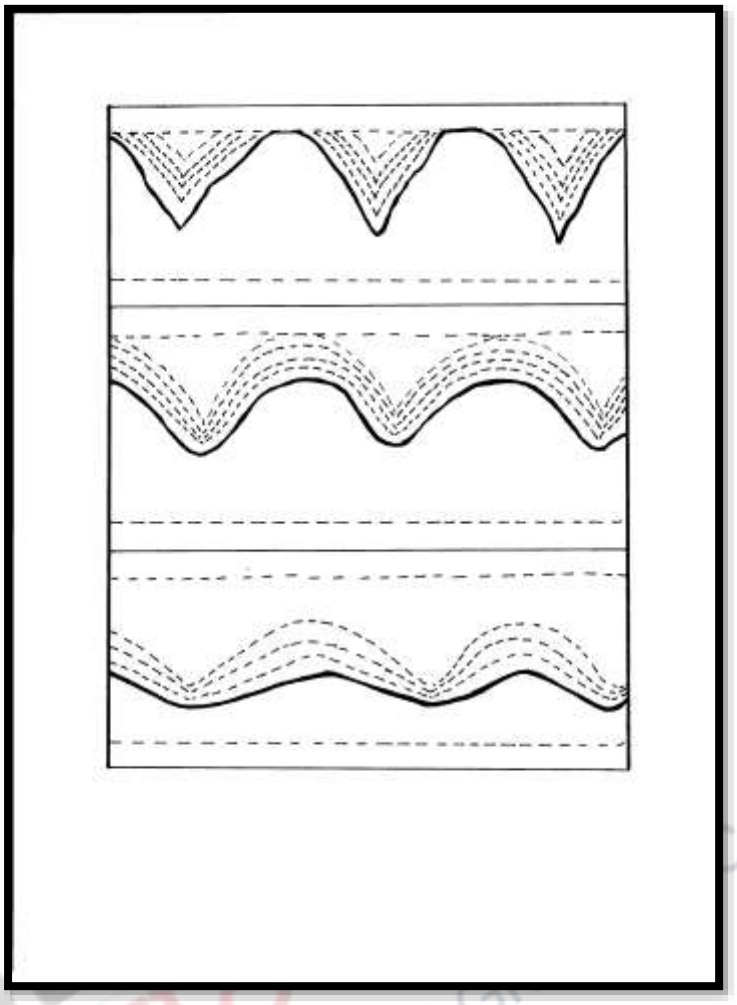

Fig.:2. Youth, Mature and Old Stage

4. Rejuvenation

There are numerous incidences where the normal cycle of erosion have been interrupted a number of times due to various reasons. **Multicyclic evolution** of the land form is more common as compared to the monocyclic. In such cases where the youthful stage of the cycle is superimposed on the old stage is termed as rejuvenation. It is therefore very rare that the landform development in a cycle is ever complete. The ultimate level to which, but not down to which the river can lower its valley due to fluvial erosion is called base level. **The ultimate base level is sea level**. The baselevel can vary according to the surface it is flowing on. Any change in the base level can change the local character of the landform. It is very unlikely that the base level will not be interrupted in during its course of erosional cycle.
There are various reasons due to which rejuvenation happens or there is interruption in the cycle of erosion.

4.1 Base level Change: The change in the base level can be termed as positive if there is a rise and negative if there is a fall. Which may lead to accelerate alluviation and renewed erosion. A complete **peneplanation** may take around from 10 to 50 million year. How early or late it happens depends on the importance of the local isostatic compensatory uplift. It is unlikely that any one erosional cycle will run its course uninterrupted by base level changes induced by either tectonic or **eustatic** causes.

Positive movement of the base level associated with accelerated alluviation or **aggradation.** It involves the submergence of the lower or the old stage of the river

cycle. The result is the aggradation work done by the stream, which results in the formation of buildup of the **floodplains** which is the result of the backfilling of the upper valley and have effects on the stream gradient. It also forms deltaic outbuildings. All these features gives it an appearance of an old stage of valley. **Mississippi river** is an example of such river system. There may be other causes of aggradation which included uplift of the source area, increase in the debris supply when a certain tributary flush its water in the main stream, due to change in the climatic conditions and due to various response of the basin due to vide range of complex changes superimposed on the drainage system.

Negative movement associated with renewed erosion. It involves rejuvenation of the landforms bringing youthful characteristics in the older stage. It may have steeper slopes, headward cutting with waves of incision and planation. It first affects the outcrops of the softer rocks and then work on the harder outcrops. It is marked by steeper slopes, terrace edges, nick points on the river courses. The river course produces a kind of valley in valley features also called **multicyclic or polycyclic** features. Because of the negative movement rise in baselevel, the peneplain gets dissected. Sometimes the resistnt outcropped rocks gets preserved and acts like summit peneplain remanant. In the lower terrains too we can observe less resistant outcrop on partial peneplains. Sometimes the marine erosional surfaces are confused with the stripped plains, pediplains or **exhumed** peneplain.

4.1.1 Dynamic rejuvenation: These are the changes brought in the cycle of erosion due to **eperiogenic movements (tectonic movements).** It may include upliftment of the land mass accompanied by tilting and warping, Lowering of the outlets and the volcanic activity.

(i) Upliftment of landmass: such movement can be caused by **local orogenic movements**. When the river is in its old stage nearing its old stage and the landmass on which it flows uplifts, the cycle gets interrupted and rejuvenates. The process of the rejuvenation can change a peneplained landscape, which has attained the profile of equilibrium and were aggrading to revive their erosional power and engage in the process of valley deepening. Sometimes on the **preexisting peneplain** "V" shaped valley, which is typical of a youthful stage, may appear and the existing cycle would not only retard but a **new cycle of erosion will began**. We may see remnant of the old cycle in the early stages of the new cycle of erosion especially near hill and plateau-tops and on the broader interfluves. By the stage of late youth, the old peneplain will be visible as summit heights, but by early maturity, the renewed onset of effective divide wasting will cause the peneplain to disappear altogether on the landscape. Most peneplains in the British Isles take the form of '**hill-top surfaces'**, and are so fragmented that they are by no means easy to identify, let alone interpret accurately. Their existence however is more readily inferred from an analysis of detailed topographical maps.

(iii) Tilting of land and warping: Tilting of the land, warping or faulting of the river basin will **steepen the gradient** of the stream that leads to the increased down cutting with more transporting power than the required. When there is a seaward tilt, its effects are noticed along the entire course of the stream as it is rejuvenated and is reflected in the deepening of the valley especially in the stream where the direction of the course is parallel to the direction of the tilting. When the tilt is at the right angle to the direction of the river course will respond to the rejuvenation only after the joining stream deepens its valleyso as to leave the tributary out of adjustment, even if the effect is only felt at the mouth of the course.

(iii) Lowering of the outlet: The mouth of the river or where the river drains is the outlet. As the outlet is lowered the river rejuvenates and its velocity increases. **Higher velocity leads to higher degree of erosion and downcutting.** If the outlet of the river is a lake then the level of the lake is its local base level. If this base level suddenly gets lowered then the outlet gets rejuvenated (at the mouth). The river suddenly joins the lake descending abruptly leading to down cutting, which is typical of youthful stage.

DID YOU KNOW?

Niagara fall is an example of the lowering of the outlet, where the water falls from Niagara and is drained into Lake Erie. It is the condition with the river course having youthful stage at its mouth near the lake and old stage and topography at the higher side of the valley.

Niagara fall.
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(iv) Volcanic Activity: Volcanic activity can cause accidental flow of lava in the valley which may interrupt the normal cycle of erosion. Blocked by lava the river will tray to erode the obsticle by intensifying the erosive activity. If the lava flow engulfs the entire valley then an all new cycle begins on the volacanic surface.

4.1.2 Eustatic Rejuvenation: Processes which results in the world wide lowering of the sea levels and is not related to the local changes happening to the base level. The eustatic changes can be produced by a decrease in ocean basin capacity as a result of the formation of the mid oceanic ridges. There can be two kinds of eustatic rejuvenation.

(i) Diastrophic eustatism: when the change in the sea level is due to the **change in the capacity of the ocean basin**. According to the Baulig (1935) who is modern proponent of diastrophic eustatism. He recognized glacio-eustism but gave more importance to **diastrophic eustatism** stating that there is evidence of the world wide lowering of the sea level during the ***Peliocene and Pleistocene***, which was of far greater magnitude than possible changes made by glacio eustatism. According to him it was the result of **epeirogenic movement** associated with orogenic movement, and not independently orogenic alone. ***For detail kindly refer module number 4 on Earth Movments.***

(ii) Glacio eustatism: when there is change in the sea level as a result of the withdrawal of water in the ocean which was earlier accumulated in the form of ice

sheets and glaciers. During the glacial period the sea water gets stored and locked up and as a result the sea level falls. Fall in the sea level leads to upliftment of the land.

4.1.3 Climatic interruptions to the cycle of erosion: The interruptions to the cycle, which has already been discussed, is either caused by structural or the earth movements or by eustatic changes of sea level caused either by glacial accumulation or through diastrophic movements. Many times streams that shows characteristics of youthful stage starts by eroding vast volume of unconsolidated glacial debris. Such a heavily loaded stream when spreads in the lower levels they start to deposite this sediments. Over a period of time the stream has lesser load. So the river requires less energy to transport the load and more energy is used for vertical erosion. This may have involved neither upliftment by diastrophic movement, nor eustatic lowering of the sea level. Such interruption is called **static rejuvenation**. Static rejuvenation of the river course involves increase in the discharge of the river, which is caused without any upliftment of the base level, nor lowering of the sea level, but because of the **climatic changes.** According to Davis, the climatic changes have tremendous effect on the normal cycle of erosion, and in certain circumstances climatic effects on erosion would totally change the course that is outlined in the 'normal' cycle.

Increase in the precipitation is usually reason for the increase in the volume with out having increase in the load. The stream in such situation is able to carry load over more gentle slopes. As a result of the decrease in the load as compared to runoff and subsequent rise in the stream volume also through acquiring the new drainage because of diversion or derangement. This kind of rejuvenation was common during post –glacial times, when the river valleys comprised of large volumes of glacial outwash.

It is debatable that only increased rainfall is the only reason of increased stream volume. Many times rejuvenation also occurs due to **capturing of one drainage system** by another, this is also called **river capture**, diverting water from captured river to captor river. Ohio valley is an example of this version, as before heading to southeast Indiana and and south west Ohio, Ohio valley had much shorter stream but later including that of Kanawha, Monongehela and Allegheny.

Denudational work in any region is greatly influenced by the climatic regimeof the region. Climatic conditions like glacial and arid climate greatly influences and modifies the normal cycle. Davis termed these imposed modifications as **'climatic accidents'**. But it is very difficult to find any remnant of the cycle of glacial erosion, since on the present landscape there is only one i.e., the Quaternary glaciations –which have left any mark. It occupied a period of only one half million years. Glacial erosion can show there effects on the upland area or the youthful stage of the cycle, which is indicated in Davisia's view of irregular profiles with basin steps. But its old age glaciated landform is difficult to recognize. But its effect on the heavily glaciated lowland such as the Laurentian and ***fenno-Scandian shields*** can be easily regard as **glacial paneplains**. But it is also a known fact that these old paneplain surface were produced under a very different climatic condition of a very geological time scale. This has been preserved over a long period of time under layers of deposits. This was exhumed by present day erosion slightly modified by the Quaternary ice-sheets.

When arid climatic conditions are totally different from glacial and so are the desert landscapes. Desert landscape appears after several periods of the desert cycle run in their full course for a considerably long period of time, over the surface of the earth. It must be noted that the areas which were arid and semi arid today were not necessarily arid in the past, they could be humid and even humid temperate climate. 'Desert' erosion was particularly active in ***permotriassic times***, In the British isles region. It may have escaped submergence by the **'Chalk sea'.** But as envisaged by Davis the arid and semi-arid cycle is more normal than the humid conditions over a

long period of time on the surface of the earth. Davis therefore also realized the need to form a separate cycle of desert erosion.

5. Rejuvenated landforms

5.1 Uplifted Peneplain: Due to various reasons the level of the peneplain gets uplifted higher than the present base level. This makes peneplain come to the second cycle of the erosion. Various factors can give evidence of such upliftment like peneplain's accordance with the summit areas and the inter stream levels, topographical unconformities, truncation of rocks of varying resistance, presence of the rocks with varying resistance to erosion, presence of layers with weathered rock debris and evidence of remnants of former alluvium.

5.2 Knick points: Sometimes in the long profile of the river there is a break due to fall or lowering of the base level. Rejuvenation causes the renewal of the down cutting along the long profile of a valley. When this valley intersects with the long profile of the other valley, knick points are formed. It is the starting point in the formation of the river terrace.

5.3 River Terraces: When the river starts cutting downwards and reaches a new base level river terraces are formed. They represents valley floor abandoned by the rivers. As the streams get rejuvenated it abandons the old valley and starts cutting the new valley's base level. Its is like cutting second valley inside the first valley and develops a second valley flat inside and below the first one. Sometimes terraces may appear at entire range of different heights on either or one side of the valley. Such valleys are called paired(with same height), unpaired with different heights.

5.4 Spurs and Benches: When after rejuvenation vallies have deeper cutting and whivh kead to the formation of terraces. When the tributaries streams joint he main river, a series of spurs are created which actually represents the valley floor of the old system.

Figure: Interlocking spurs in the Pentlands

5.5 Incised Meanders: Meandering of steam over the flood plains is rejuvenation. It can cut **gorges and canyon** into old meander because of the extra erosional capacity while still retaing the meandering form. These are called incised meanders.