

NORMAL CYCLE OF EROSION: W.M.Davis

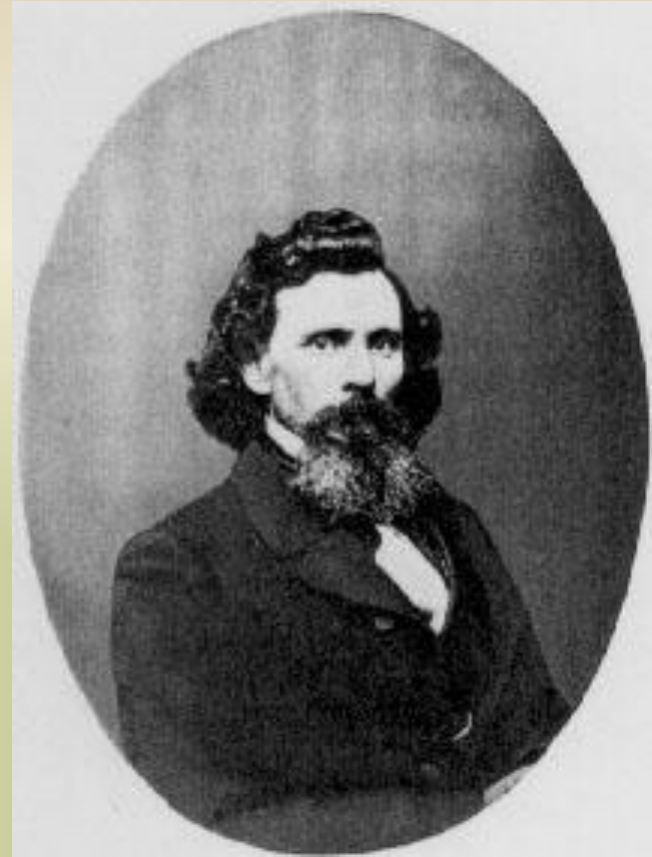
(UG HONS. 1st Year)

by

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**A HIGHLY INFLUENTIAL
MODEL OF
RELIEF/LANDFORM EVOLUTION
AND
EVENTUAL PLANATION
INTRODUCED TO
GEOMORPHOLOGY
BY
WILLIAM MORRIS DAVIS
IN
1899**



Historical Context

- Development of geology as a separate branch of science -1775 to 1830.
- **Hutton** (1726-1797) -uniformitarianism. **John Playfair** (1748-1819) publicised Hutton's theories and added further ideas.
- **Lyell** published the classic textbook, 'Principles of Geology', in 1830-1833.
- **William Smith** (1769-1839)-stratigraphical successions based on fossils
- By the middle of the Nineteenth Century, the general geological time scale based on fossils and stratigraphic mapping was established.
- Geomorphological studies were advanced by the work of **Agassiz**, who in the 1840s recognised the effects of Pleistocene glaciation in Europe and the USA.
- Later **Gilbert** and **Powell** made classical studies on arid erosion in the western USA.
- The strongest influence up to 1900 was the work of **W.H. Davis**, an American who worked both in USA and Europe and who first defined the cycle of erosion.



James Hutton by Abner Lowe



FUNDAMENTAL CONCEPT



- The arrangement of the phenomena of Erosion into an orderly sequence – Cycle – of the development of Landforms.

i.e.,

- Landscapes can be arranged in evolutionary sequences illustrative of cyclical changes.

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.

ACCORDING TO DAVIS

“LANDFORM IS A FUNCTION OF –

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

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

STRUCTURE

• *Denotes*

**LITHOLOGY, ATTITUDES
COMPOSITION, TEXTURE OF
• EARTH MATERIALS**

PROCESS

Denotes

**Exogenetic and
endogenetic processes**

STAGE

• *Denotes*

THE SUCCESSIVE PHASES OF LANDFORM EVOLUTION

LOGICAL COHERENCE

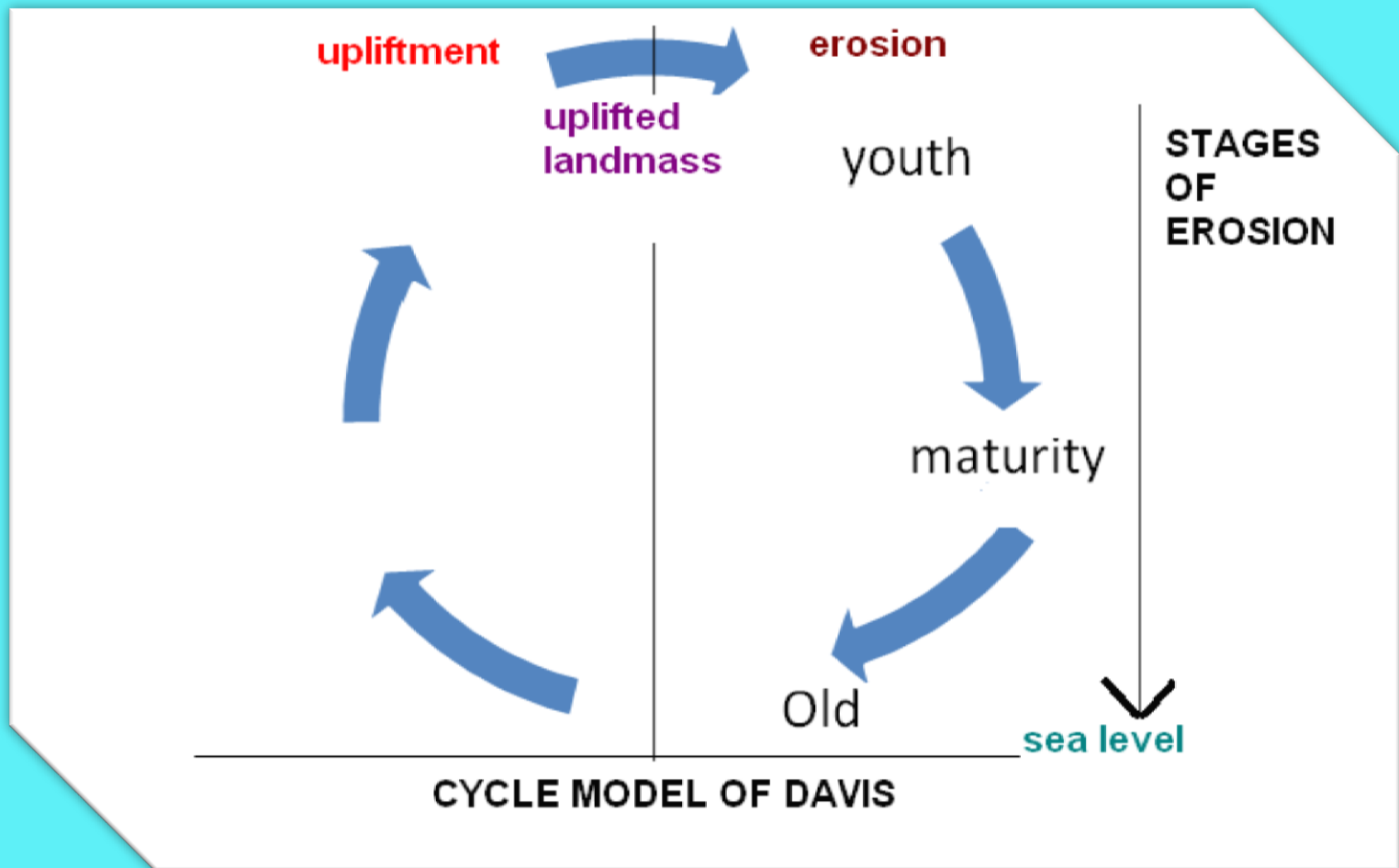
- **A LOGICAL OUTGROWTH OF ‘STAGE’ → CONCEPT OF GEOMORPHIC CYCLE**
- **W.D. THORNBURY’S DEFINITION— “The various changes in surface configuration which a landmass undergoes as the processes land sculpture act upon it”**
- **An initial surface underlain by a certain type of geologic structure, upon which geomorphic processes operate
→=sequential development of landforms**

UNDERLYING PRINCIPLE OF DAVISIAN CYCLE

- **BASE LEVEL OF EROSION**— A LEVEL BELOW WHICH STREAMS CANNOT ERODE THEIR VALLEY FLOORS.
- EXTENSION OF SEA-LEVEL BENEATH THE CONTINENTS
- A CRITICAL MINIMUM GRADIENT BELOW WHICH A STREAM CANNOT BE REDUCED
- SLOPE GENTLY UPWARDS AWAY FROM THE COAST
- DAVIS SUPPLEMENTED THE IDEA OF BASE LEVEL WITH THE CONCEPT OF 'GRADE'— THE BALANCE BETWEEN **EROSION** AND **DEPOSITION**
- **GRADATION**= **AGGRADATION** — **DEGRADATION**

CENTRAL CONCEPT

- Transformation of a recently uplifted landmass into a senile gently sloping land through sequence of erosional episode
- similarity with concept of 'entropy maximization' of 2nd law of thermodynamics
- Initial Upliftment → Potential energy = $m \cdot g \cdot h$
- COMMENCEMENT OF POTENTIAL ENERGY AND ITS DESTRUCTION THROUGH CYCLICAL PROCESS



Basic Assumptions

***HOMOGENEOUS
LITHOLOGY***

***RAPID UPLIFT &
NO EROSION
DURING UPLIFT***

***COMMENCEMENT
OF EROSION AFTER
UPLIFTMENT ENDS***

***LONG CRUSTAL
STABILITY***

***AREA SHOULD BE
HUMID TROPICS***

Influenced by —

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

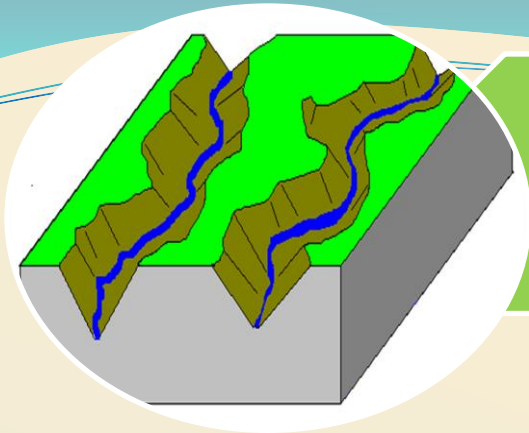
and

➤ Darwin's Evolutionary concepts

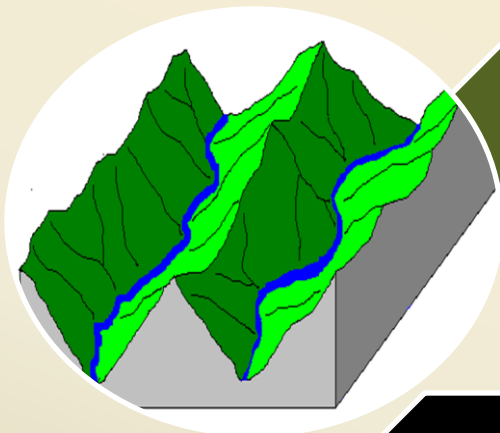
Davis referred to the whole sequence of transformation of landforms as a **cycle of erosion**

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

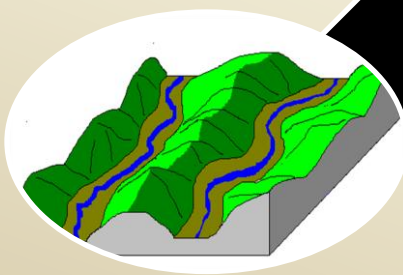
YOUTH, MATURITY, OLD AGE



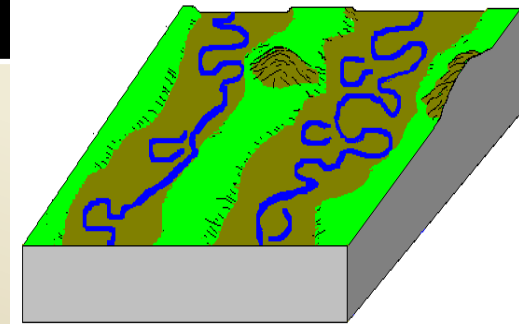
YOUTH



MATURITY



OLD

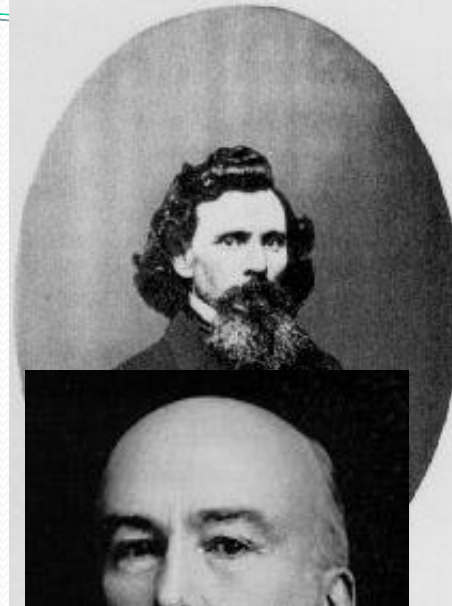
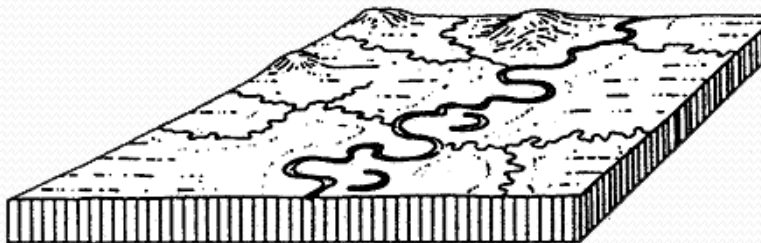
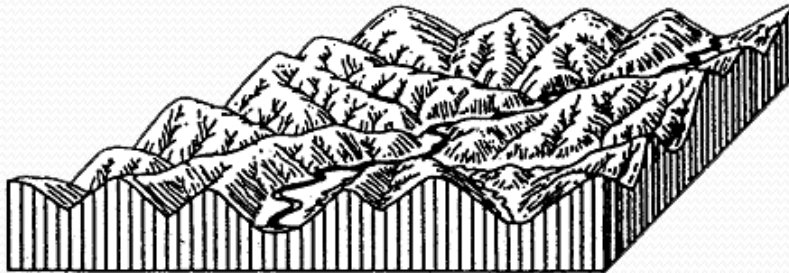
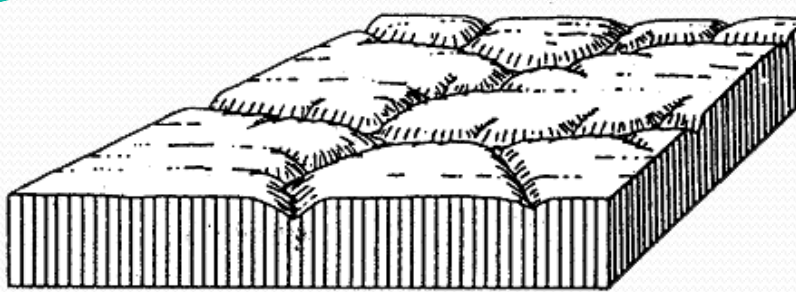


CHARACTERISTICS OF YOUNG LANDSCAPE

- **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**

The Landscape

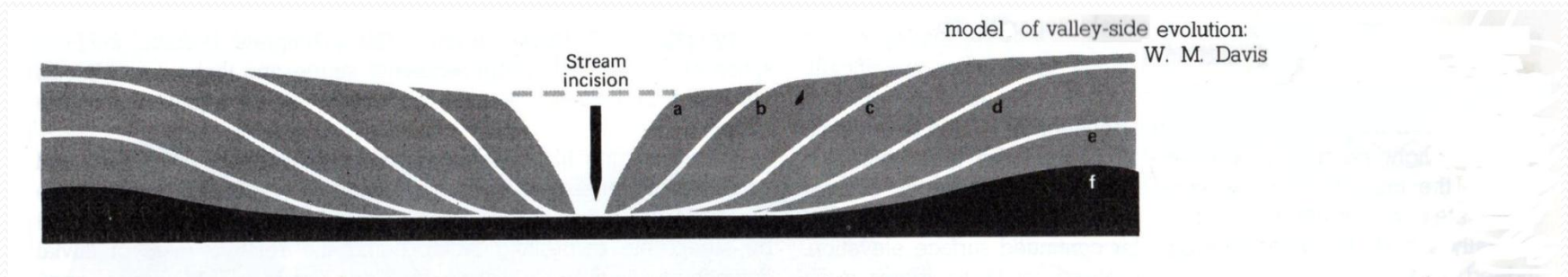
W. M. Davis



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

MODEL OF VALLEYSIDE EVOLUTION



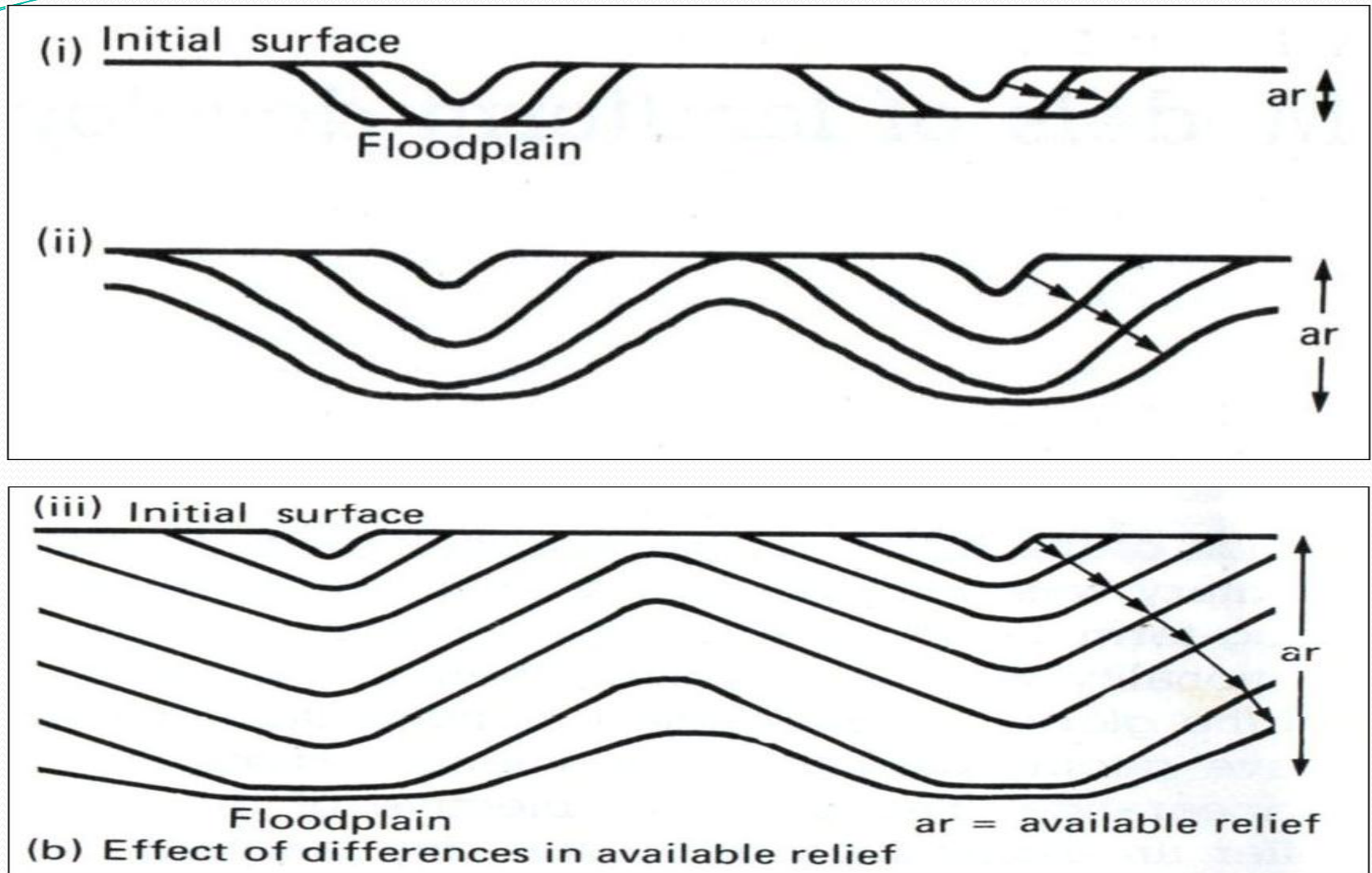
CHARACTERISTICS OF OLD LANDSCAPE

- 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 —

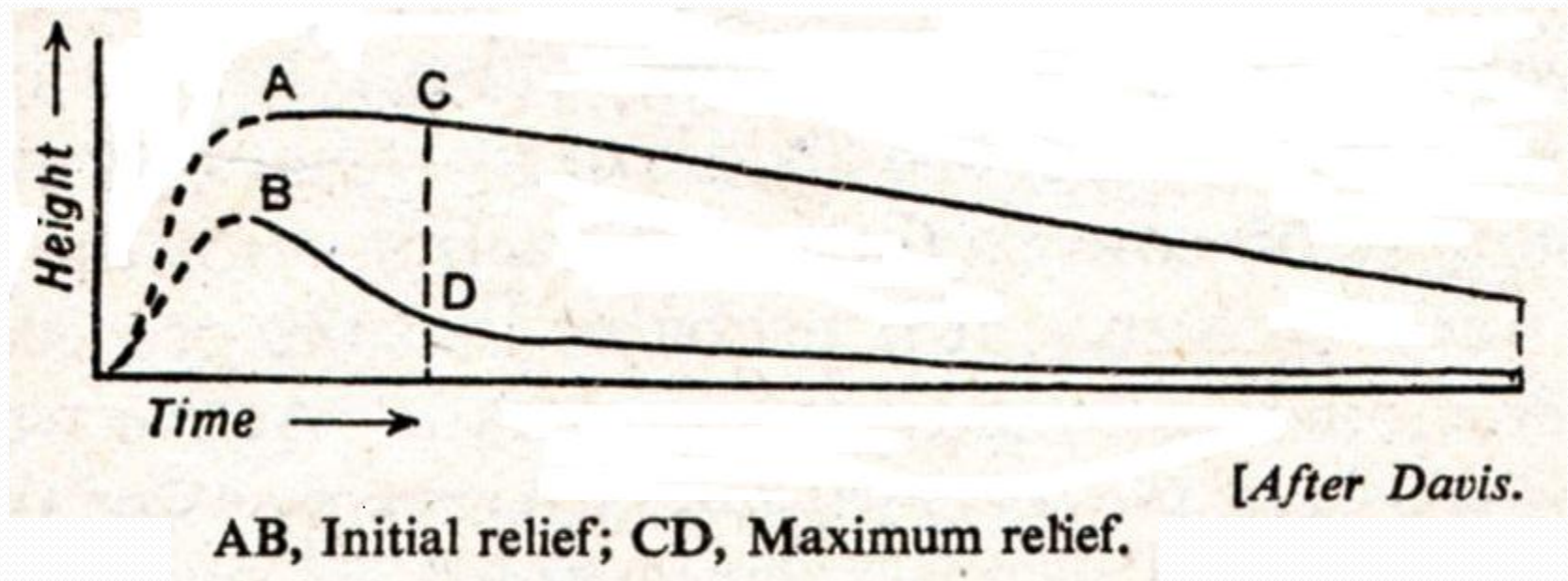
MONADNOCKS (after Mt. Monadnock in New Hampshire)

- 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**

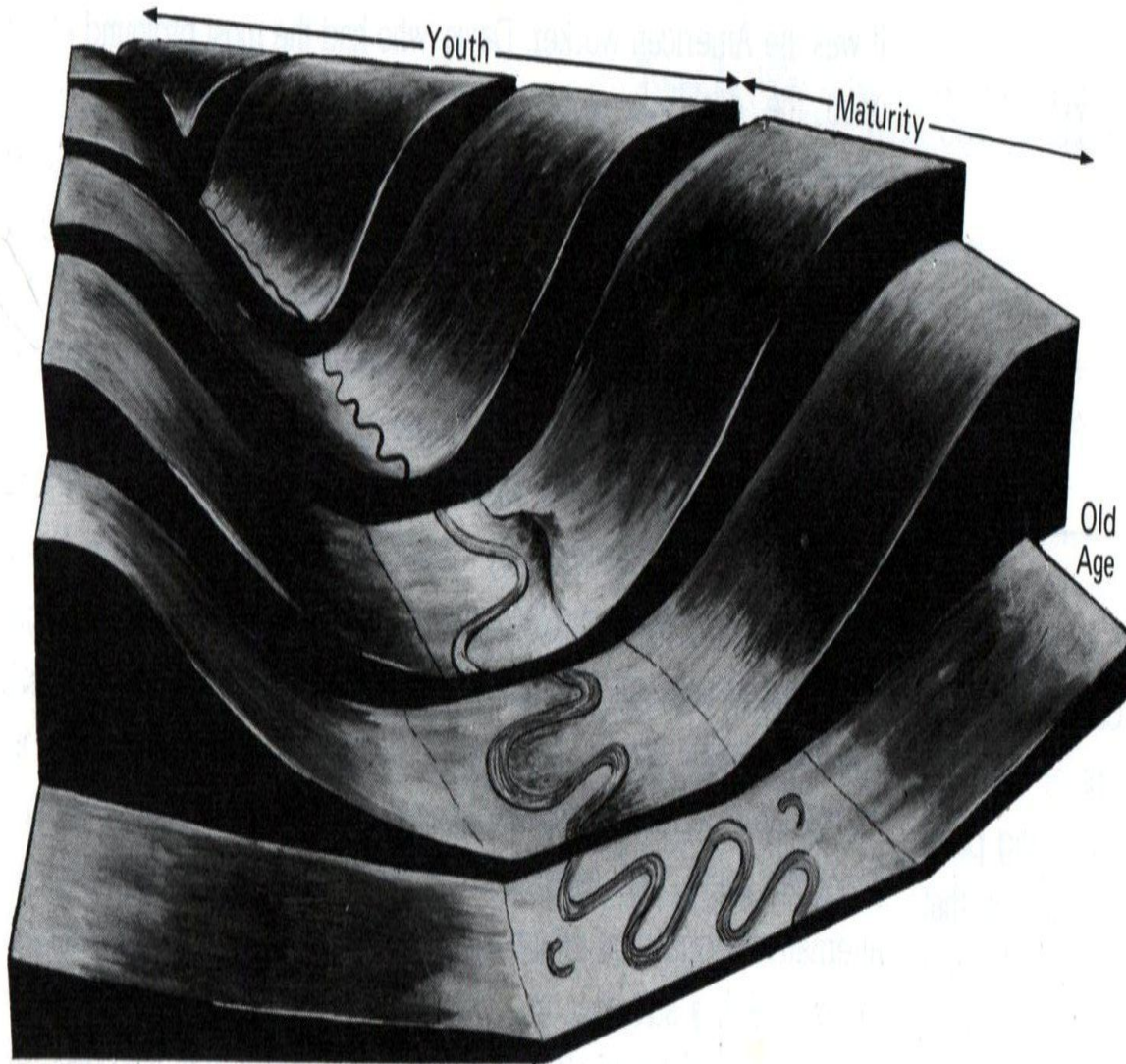
The cycle concept of W. M. Davis



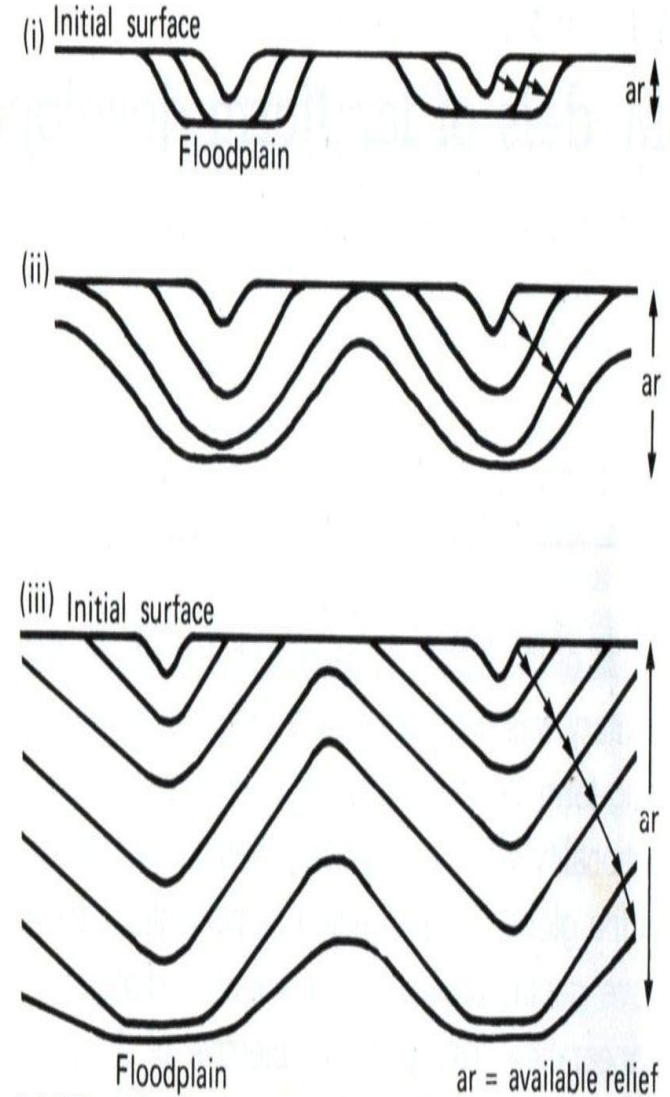
Graphical Representation of Erosion Cycle



The cycle concept of W. M. Davis. He normally described the sequence as depicted on the left although the available relief, i.e. the altitudinal difference between the initial surface and the level at which floodplains begin to form, will clearly have an important effect on landform evolution, as illustrated on the right.

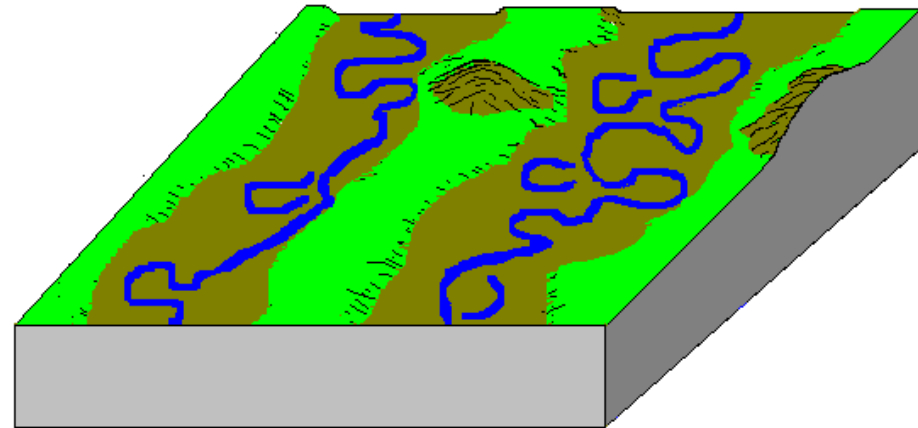
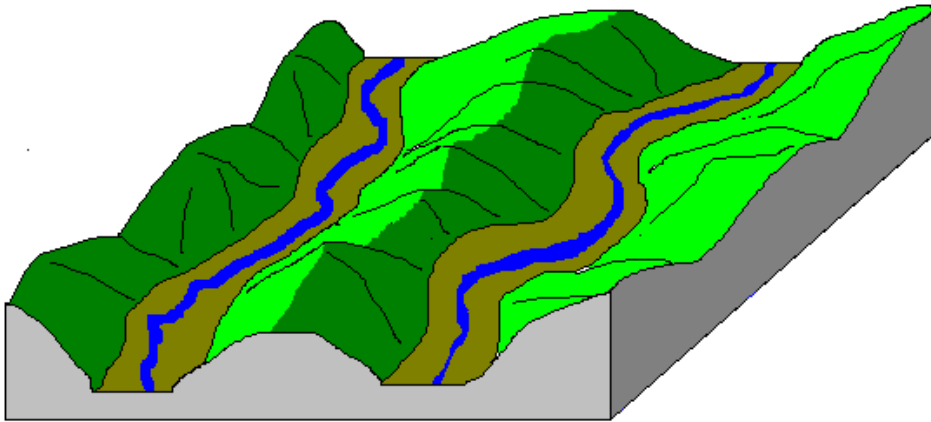
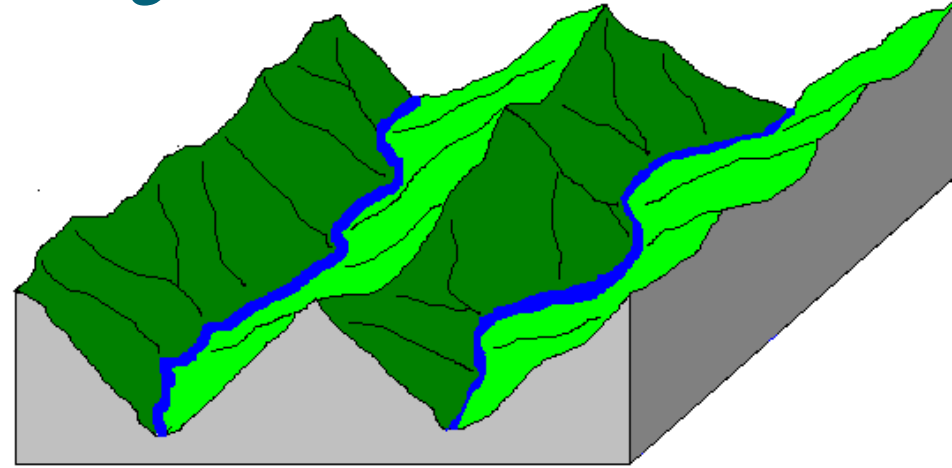
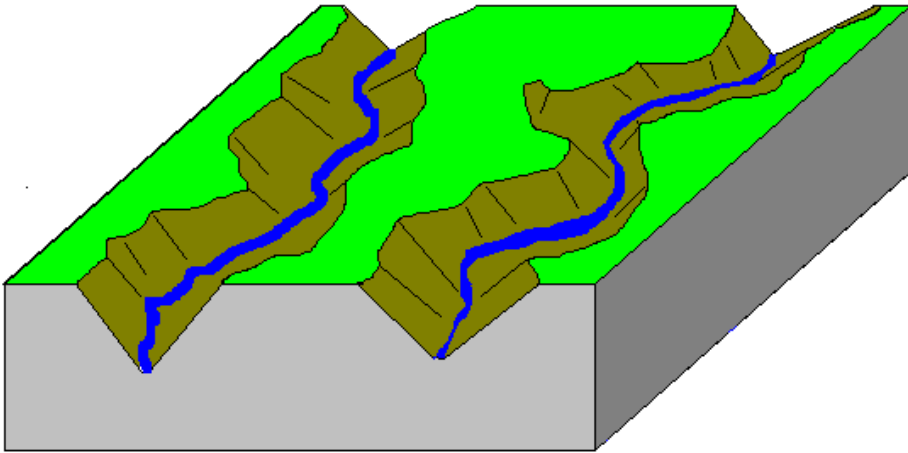


(a) Idealised cycle with moderate available relief



(b) Effect of differences in available relief

The Ideal Stream Cycle



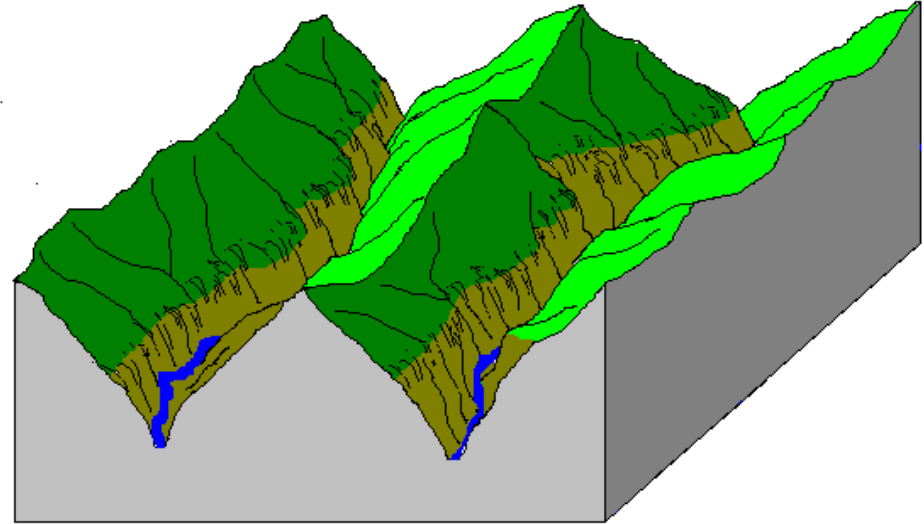
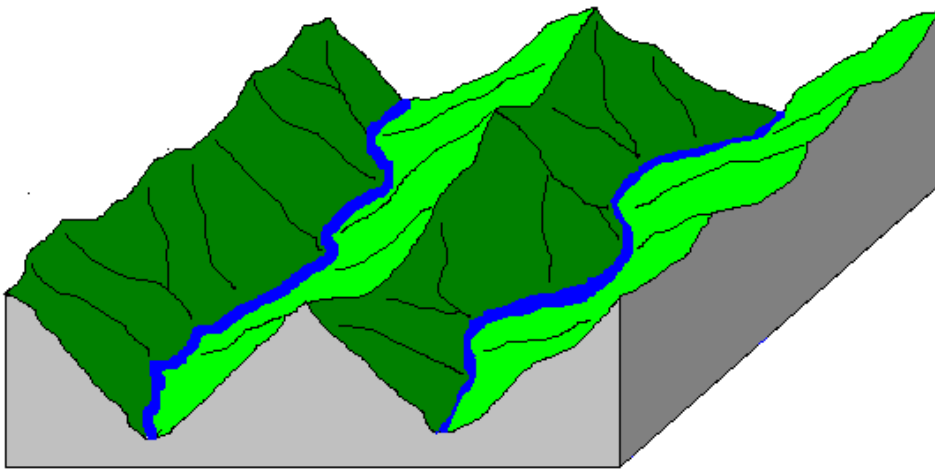
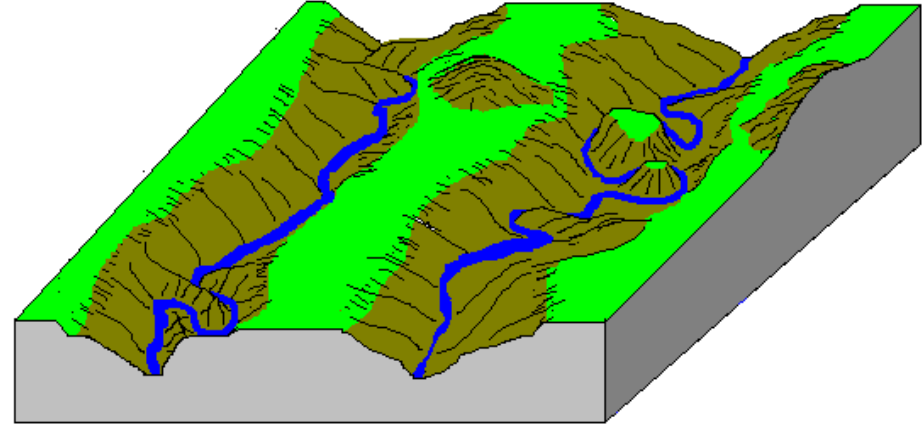
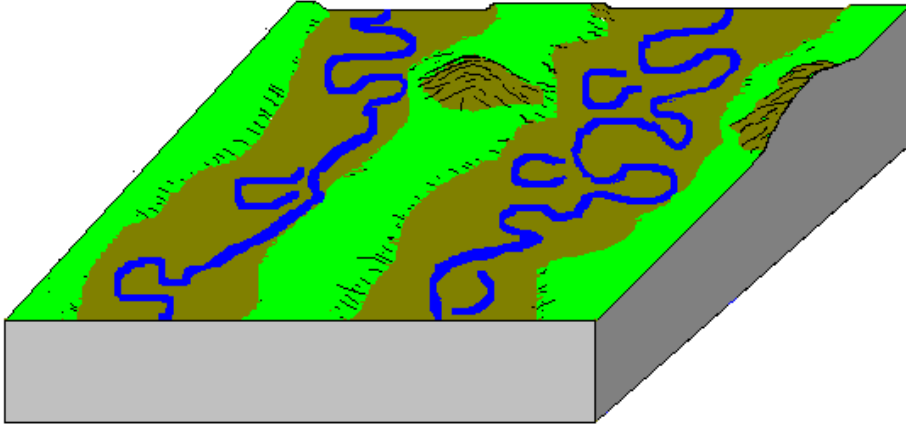
INTERRUPTIONS IN THE CYCLE

- **REJUVENATION**

Some change causes stream to speed up and cut deeper.

- **Uplift of Land**
- **Lowering of Sea Level**
- **Greater stream flow**
- **Stream valley takes on youthful characteristics but retains features of older stages as well.**
- **Can happen at any point in the cycle**
- **Leads to development of Polycyclic or Multicyclic Landscapes.**

Rejuvenation



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

References

1. An outline of Geomorphology by Wooldridge and Morgan
2. Principles of Geomorphology by W.D. Thornbury
3. The Study of Landforms by R.J. Small
4. Geomorphology by Savindra Singh
5. Geomorphology by Enayet Ahmed



Inviting Questions and
seeking clarification

Thank you