Drainage Development and Topographic Expression on Uniclinal and Folded Structure

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Drainage Development on Uniclinal Structure

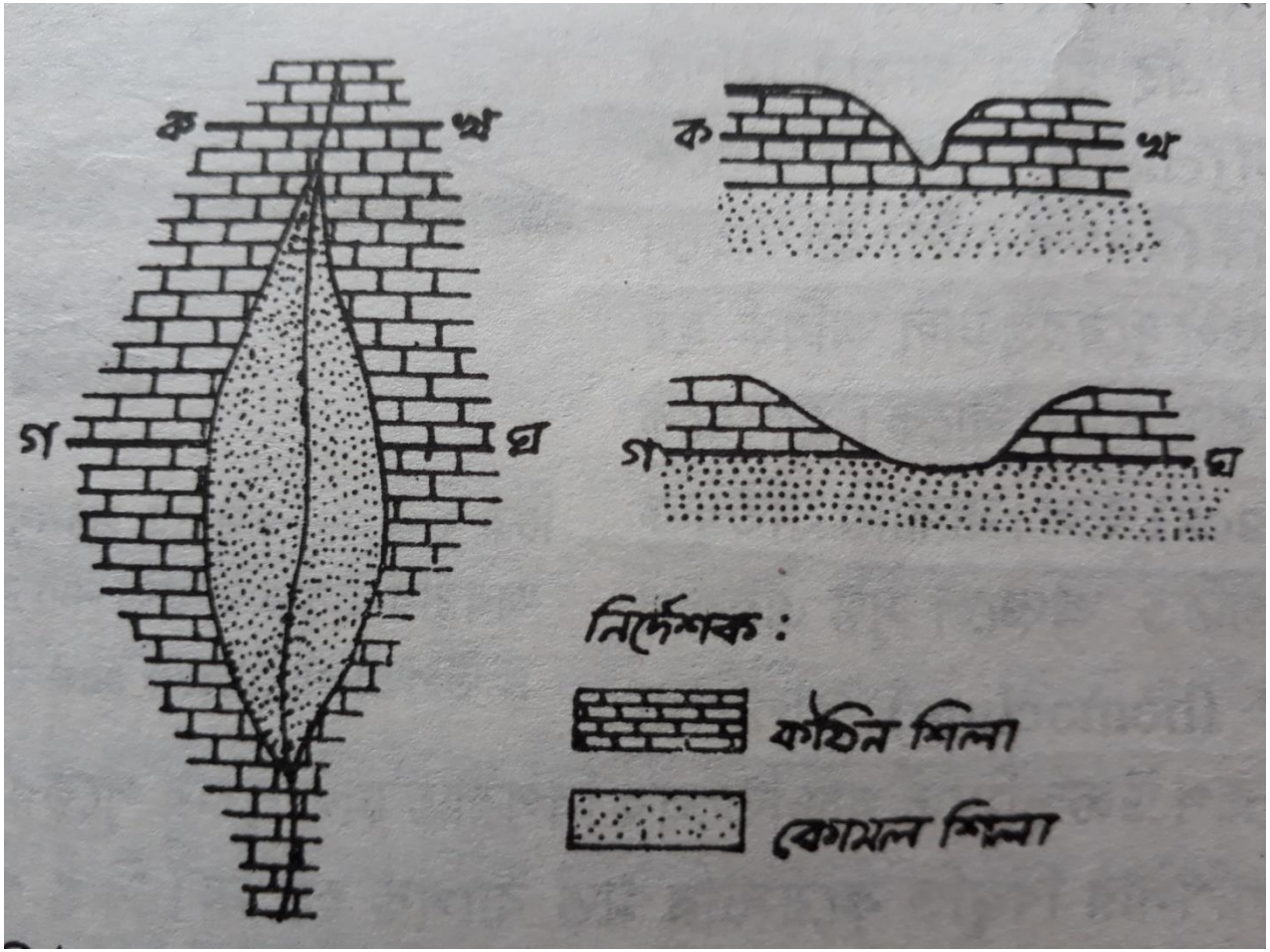
- Uniclinal or Homoclinal structures are those which represent inclined rock strata (of sedimentary) at uniform dip angle caused by general regional tilt
- These structures are formed by two main ways: either by the uplift of a sequence of off-lapping coastal plain sediments or as part of one limb of a large dome or fold

Drainage Development on Uniclinal Structure

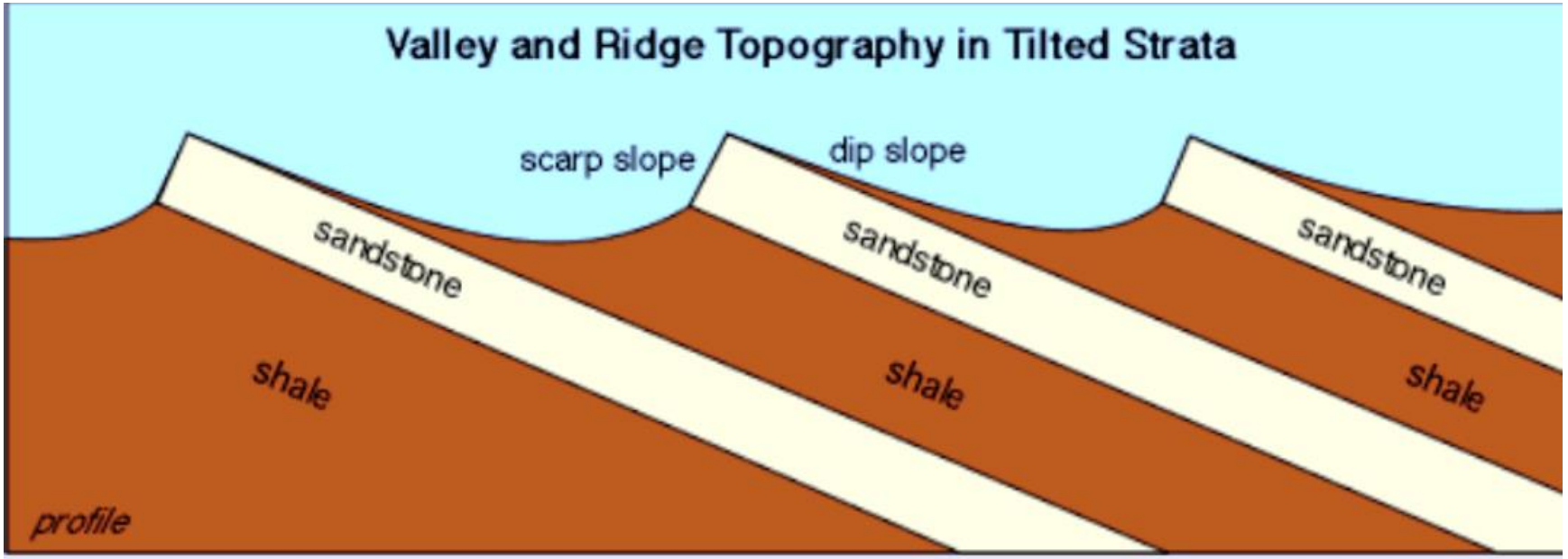
- Such structures involve both hard and soft rock and sometimes there are alternate bands of hard and soft rock
- These are subjected to differential erosion
- The differential erosion of dipping strata of varying resistance gives birth to trellised drainage pattern and a few typical topographic features like scarp and vale topography, cuesta, hogback, homoclinal ridges etc.

Drainage Development on Uniclinal Structure

- Rivers form their valleys along soft rock beds due to comparatively more erosion than the resistant rock beds giving birth to the formation **strike vales**
- The resistant rock beds are less eroded and becomes lines of asymmetrical ridges or hills known as **cuestas**
- **Cuestas** are characterised by **steeper scarp slope and gentle dip slope**



Source: Landforms: Evolution and Characteristics, S.C. Mukhopadhyay and R.K. Das



Source: Columbia.edu

Drainage Development on Uniclinal Structure

- Scarp slope: the steep slope of a ridge
- Dip slope: a dip slope is a topographic surface which slopes in the same direction and often by the same amount as the true or apparent dip of the underlying strata. Dip slopes form the back slopes of the cuestas, hogbacks and homoclinal ridges. Dip slopes are result of the differential erosion of strata of varying resistance to erosion that are dipping uniformly in one direction.
- **Shale, mudstone, marl** are less resistant while **sandstone, limestone, dolomite** are more resistant.

Drainage Development on Uniclinal Structure

- Homoclinal structure is characterized by **trellised drainage pattern**
- Homoclinal structure formed due to general tilting of sedimentary beds of **coastal plains** and retreat of sea water presents **ideal condition** for the development of trellised drainage pattern having consequent and subsequent streams
- The **consequent stream drain seaward** across resistant and weak rock beds alike but the **lateral consequent stream** develop on the **less resistant rocks**

Drainage Development on Uniclinal Structure

- Tributaries join the master consequent stream at right angles
- Dip stream: the streams flowing down the **dip slopes are called dip stream**
- Anti- dip stream: stream flowing in **anti-dip direction is called anti-dip stream**
- **Dip streams develop on resistant rocks while anti-dip streams develop on soft rocks**
- The relative **length of dip and anti-dip stream** depends on the **angle of dipping strata**

Dip and Anti Dip Stream

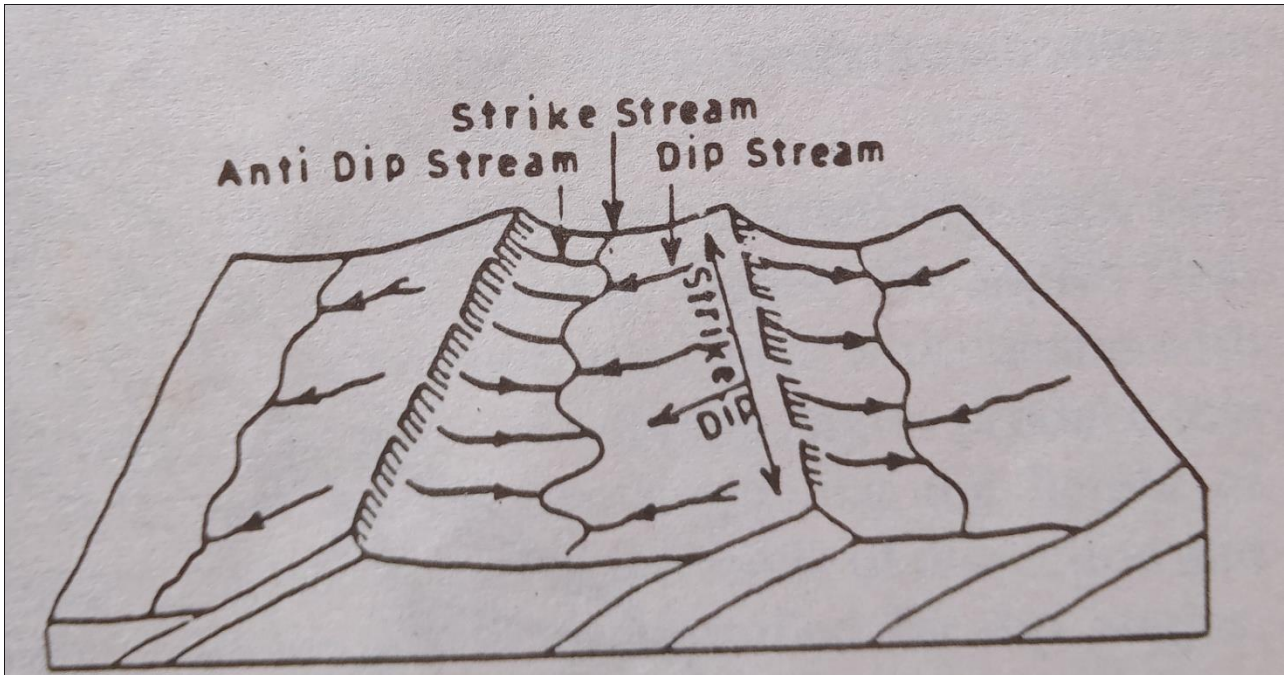


Fig. 10.1 : Development of structurally controlled streams on dipping strata, after C.D. Ollier, 1981

Source: Geomorphology, Savindra Singh

Drainage Development on Uniclinal Structure

- If the **dip angles** are relatively **gentle**, the slope lengths become **longer** and hence streams draining on dip slopes are of longer lengths than the tributaries draining in opposite slope
- The **drainage density** in dip slope and anti-dip slope is also variable
- **Anti-dip slopes** are characterized by **closely spaced stream** of relatively shorter lengths
- **Dip slopes** are characterized by **relatively low drainage density** due to relatively longer length of widely spaced dip streams

Drainage Development on Uniclinal Structure

- The structural control of tilted strata imposes a powerful asymmetry on drainage network
- *Escarpment streams* are steep, short and have high gradient
- *Dip slope streams* are likely to have more gentle gradients, larger watersheds, more tributaries, and more sustained flow.

Drainage Development on Uniclinal Structure

- Due to differential but continued erosion, the subsequent stream developed between two cuestas migrate laterally following the direction of dip slope
- The entire ridge and valley system migrates laterally as well as downward with time in a process termed homoclinal shifting (monoclinal shifting) by G.K.Gilbert, 1877.

Homoclinal Shifting

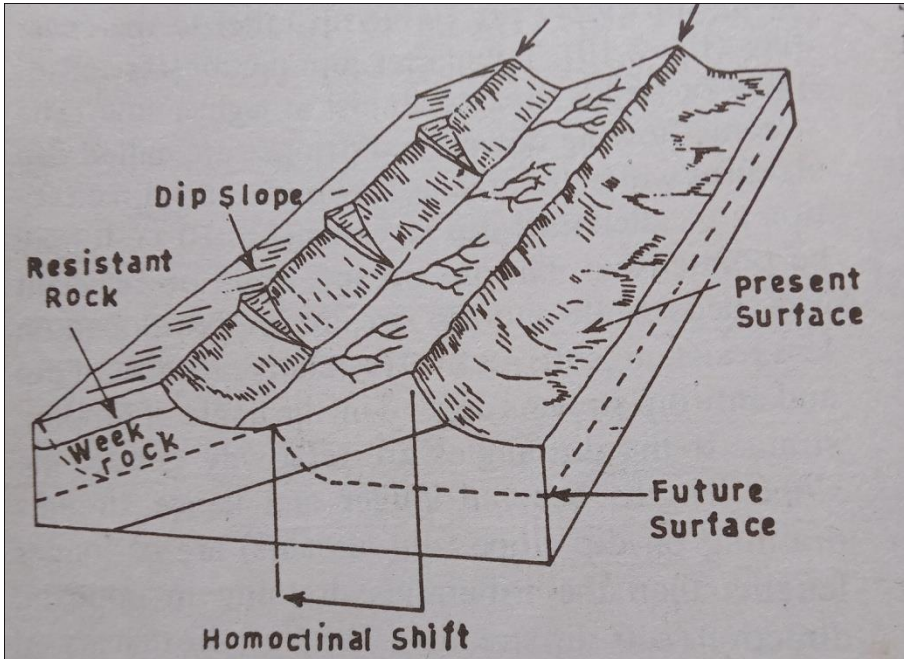
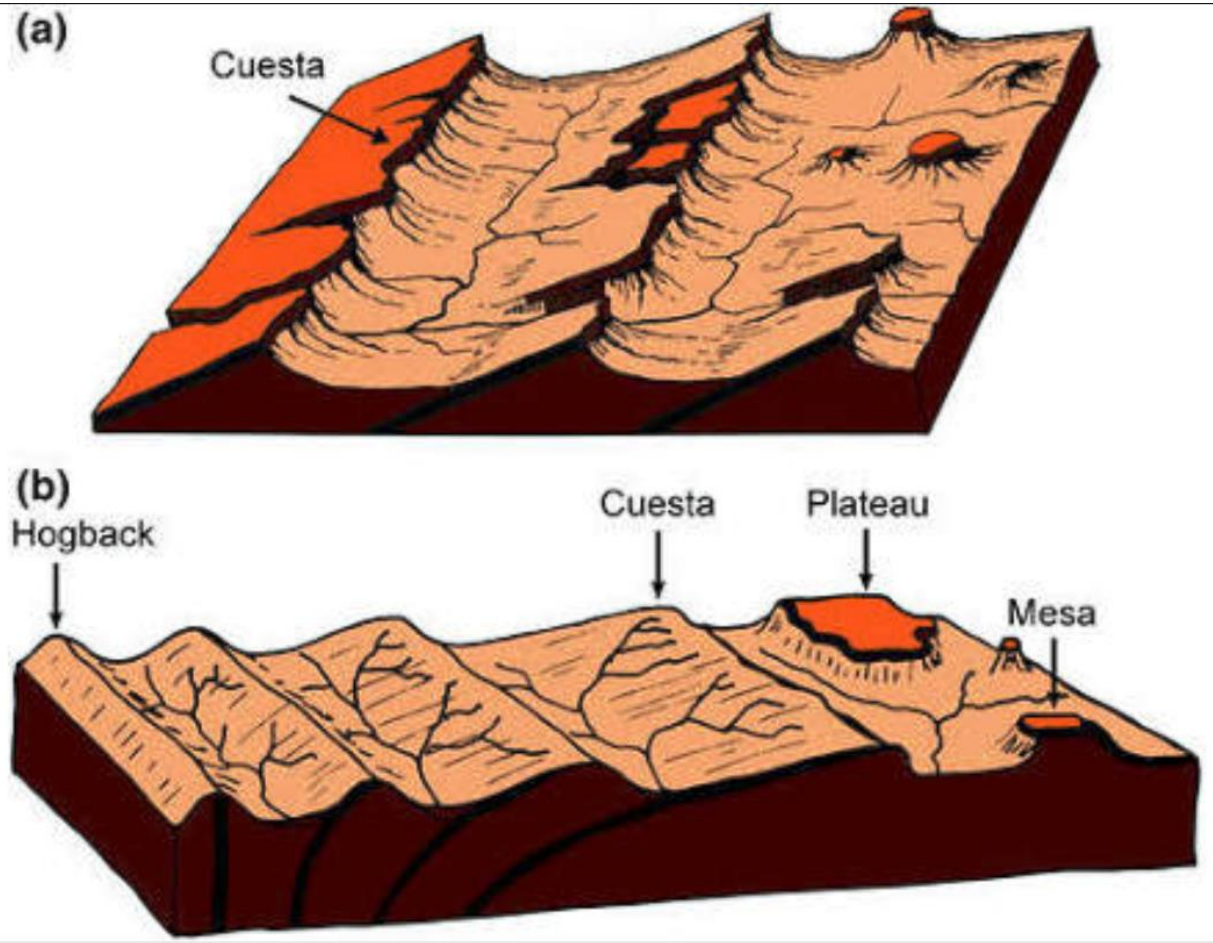


Fig. 10.2 : Development of asymmetric drainage on humoclinal strata and homoclinal shifting of ridge crests and valleys—after A.L. Bloom, 1978).

Source: Geomorphology, Savindra Singh

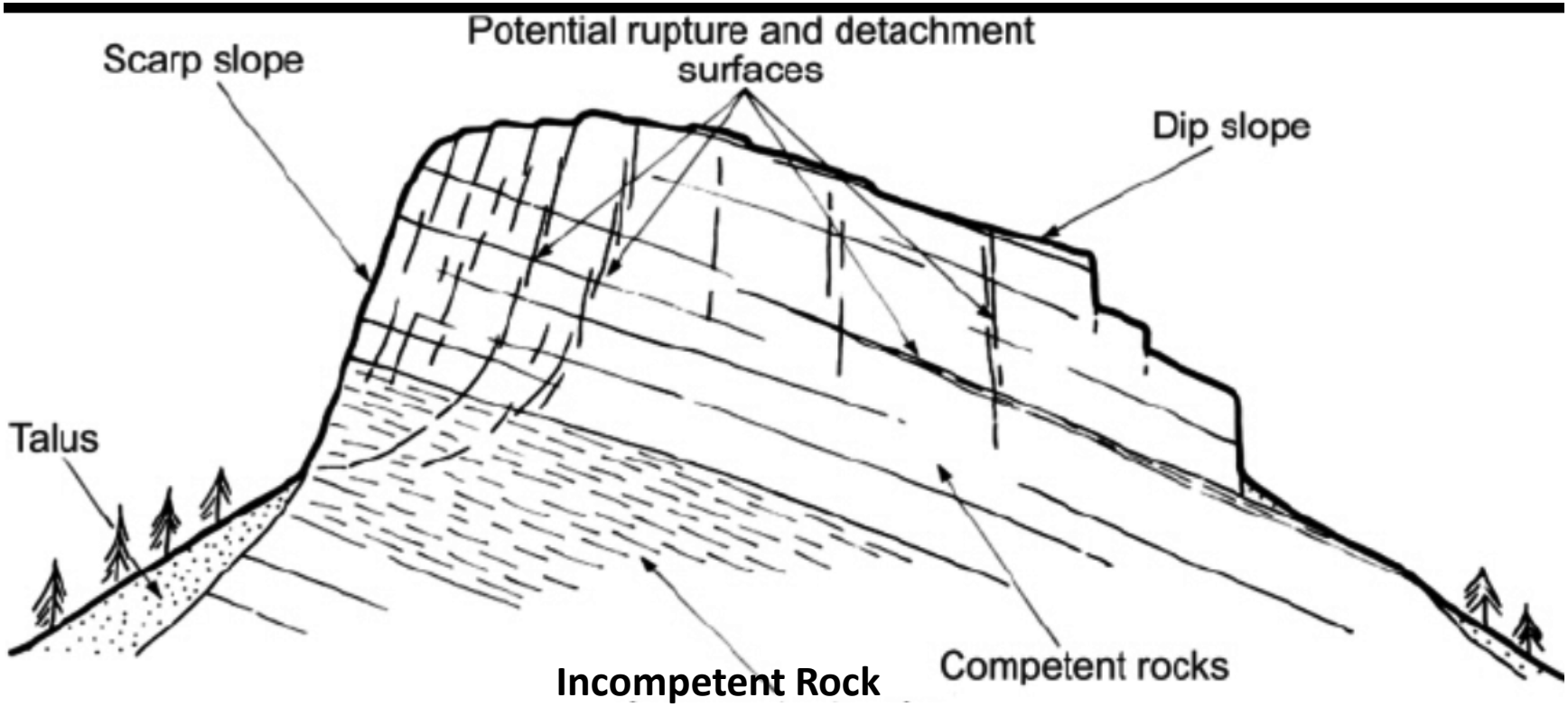


Source: Link.Springer.com

Cuesta

- **Cuesta** is the most significant landform resulting from continued erosion of uniclinal/homoclinal sedimentary structures alternated by resistant and soft rock beds
- Cuestas develop when the dip slope ranges between 10°-25°
- The morphology of cuestas vary greatly depending on local conditions
- In the simplest form they comprise a **steep scarp face , often exceeding 30°** in angle and sometimes displaying bare rock faces, and a **long and gentle dip slope** (sometimes referred to as **backslope** when the gradient of the surface does not exactly coincide with the angle of dip)

Cuesta



Source: Researchgate.net

Homoclinal Ridge

- **Homoclinal ridges: a** homoclinal ridge or strike ridge is a hill or ridge with a moderate sloping backslope. Its backslope is a dip slope that conforms with the dip of a resistant stratam or strata, called caprock. The frontslope is steeper or even cliff-like.
- **The dip slopes of homoclinal ridges range between 25°-45°**

Hogback

- When the **dip angle** of cuesta **exceed 45°,** the cuesta is characterized by symmetrical slopes on both sides and is called **hogback**
- Hogbacks are ridges having **symmetrical slopes on both sides**
- The difference between cuesta, homoclinal ridge and hogback is related to the **steepness in the dip of the resistant beds** of which they have been eroded and to their geographic extent

Scarp-and-vale Topography

- Long continued erosion results in the bevelling of previously formed cuestas in a scarpe-and-vale topography
- A landscape consisting of roughly parallel sequence of cuestas and intervening strike valleys (vales).
- It dominates most of lowland Britain where Mesozoic sediments dip gently towards the east and south east

Drainage Development on Folded Structure

- Anticline: upfolded rock strata in arch like form
- Syncline: Downfolded structure forming trough-like feature
- Limbs : two sides of fold
- Axis of fold: the plane which bisects the angle between two limbs of the anticline or the middle limb of the syncline
- Axis of anticline and axis of syncline
- Dip and strike: the inclination of rock beds with respect to horzontal plane is termed as dip while the strike of an inclined bed is the direction of any horizontal line along a bedding plane. (A. holmes and D.L. Holmes)
- Anticlinorium : A series of minor anticlines and synclines within one extensive anticline.
- Synclinorium: An extensive syncline having numerous minor anticlines and synclines.

Drainage Development on Folded Structure

- *Longitudinal master consequent* stream following slope are originated over the synclinal valley
- *Transverse consequent or lateral consequent stream* are originated on the flanks of the anticlines and join the master consequent stream as tributary stream. They develop their valleys through headward erosion of the anticlines
- With march of time crest of anticlines are breached and *subsequent streams* develop along the axes of anticlines.

Drainage Development on Folded Structure

- Initial stage: regular arrangement of anticline and syncline without any complexity
- Folded strata includes beds of resistant and weak rocks
- *Longitudinal master consequent and Transverse consequent or lateral consequent stream* are developed. These are sequent streams
- These streams start to erode their valleys
- Lateral consequent stream erode at faster rate than master consequent stream
- Lateral consequent streams extend their valleys headward erosion over the axis of the anticlinal ridges

Drainage Development on Folded Structure

- Later on stream also develop on anticlinal axis which are called *subsequent stream*
- *The subsequent stream cut their valleys at faster rates and captures the lateral consequent streams*
- *Thus a second master stream is developed on the anticlinal axis flow parallel to the synclinal master consequent stream*

Drainage Development on Folded Structure

- Mature stage: is heralded by accelerated rate of valley deepening by the subsequent stream
- The valleys developed by anticlinal stream becomes deeper than the synclinal stream
- The anticlinal stream also capture the synclinal master consequent stream
- This results in ***inversion of topography.***

Drainage Development on Folded Structure

- The vertical erosion and valley deepening by subsequent stream become less significant when the underlying resistant rock beds are exposed due to removal of soft rock beds
- Now the river instead of eroding hard rock, are subjected to *homoclinal or uniclinal shifting along the dip slope of the relatively resistant rock beds*
- *Gradually the subsequent stream reach the synclinal ridges through uniclinal shifting and ultimately form their valleys in the synclinal ridges (originally synclinal valleys)*

Drainage Development on Folded Structure

- Now the stream is similar to the original longitudinal master consequent stream developed in the original syncline but it flows at much lower elevation and is older than the original consequent stream. This stream is called ***resequent*** stream.
- Old stage: is heralded by cessation of active erosion and reliefs are subdued and most of them are obliterated

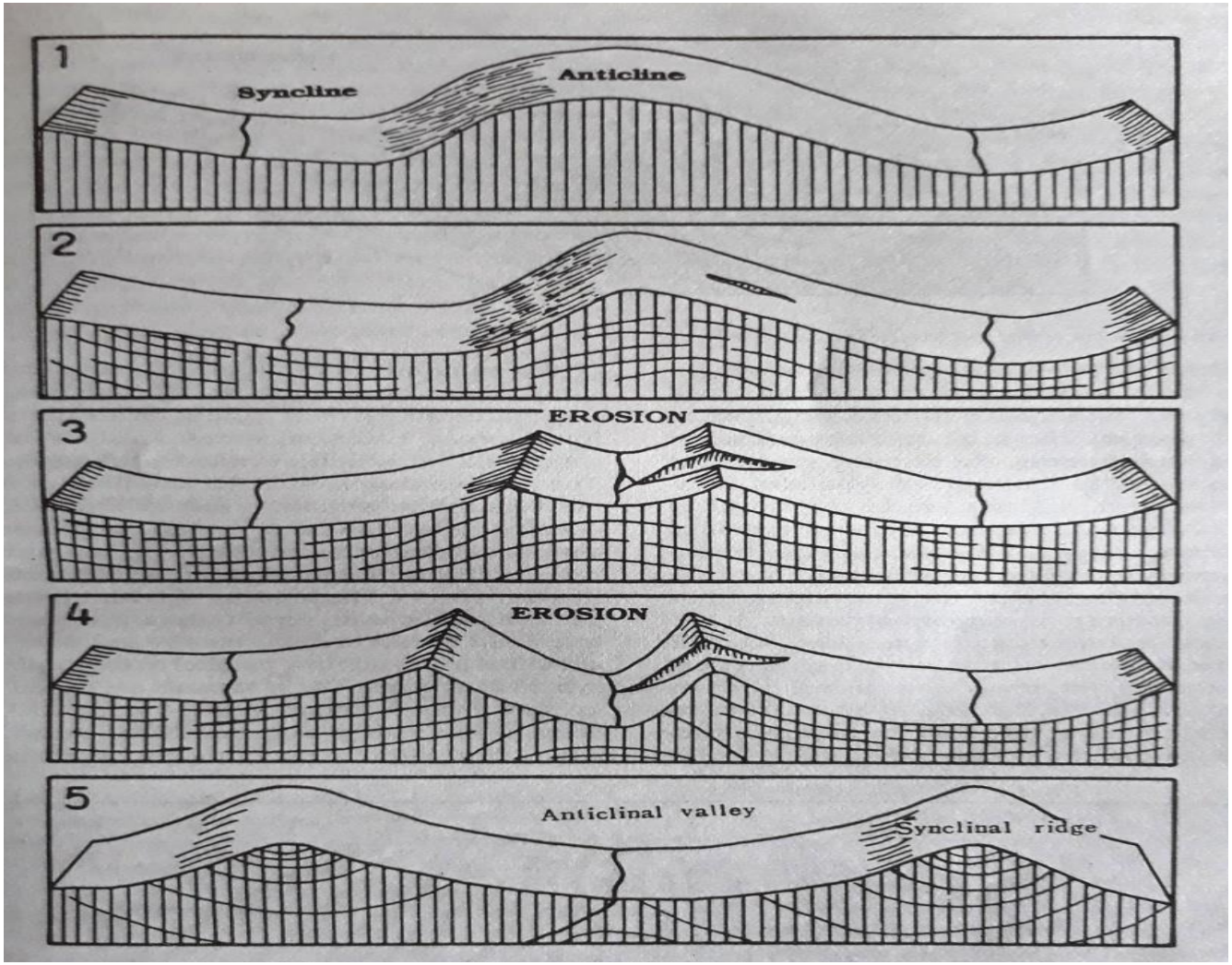
Drainage Development on Folded Structure

- The entire folded mountain region becomes featureless plain-*peneplain*
- *Streams are not adjusted to the structure as the original structural features are covered under thick deposits of alluvia*
- *If the region is again uplifted the second cycle of fluvial erosion may be initiated*

Topographic Expression of Cycle of Erosion over Folded Structure

- ***Anticlinal ridges*** are of structural origin as formed due to folding of rock strata
- ***Synclinal ridges*** are of erosional in origin and are formed due to more erosion of synclinal valleys
- ***Homoclinal ridges*** formed on the uniclinal beds of resistant rocks having uniform slopes on both sides
- ***Synclinal valleys*** are of structural origin and represent structural vallley
- ***Anticlinal valleys*** are of erosional origin as they are formed due to active downcutting of anticlinal crests by subsequent streams
- ***Homoclinal valleys*** are of erosional origin and develop between homoclinal ridges and resistant beds of anticlines

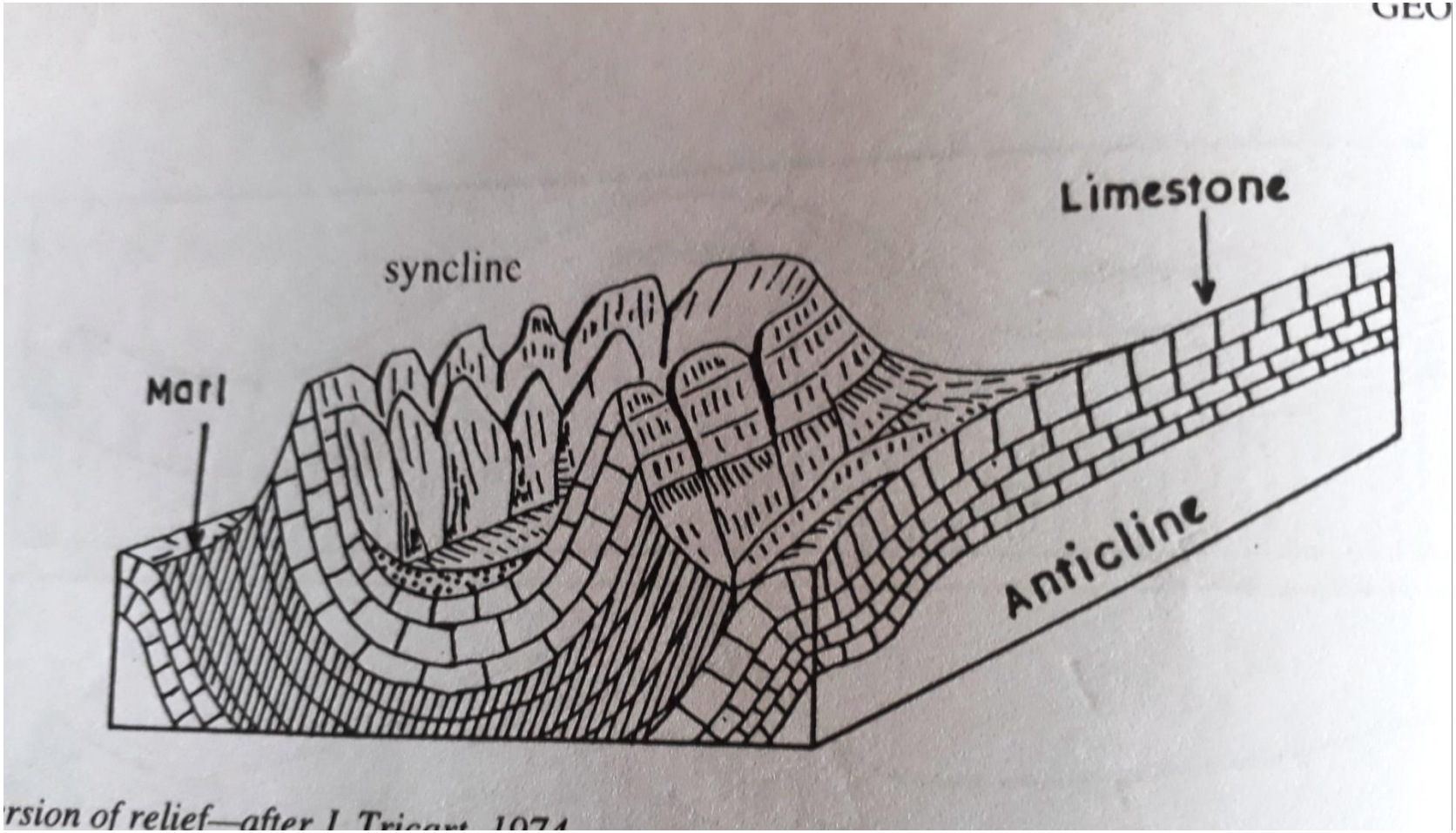
Drainage Development on Folded Structure



Source: Geomorphology, Savindra Singh

Source: Landforms: Evolution and Characteristics, S.C. Mukhopadhyay and R.K. Das

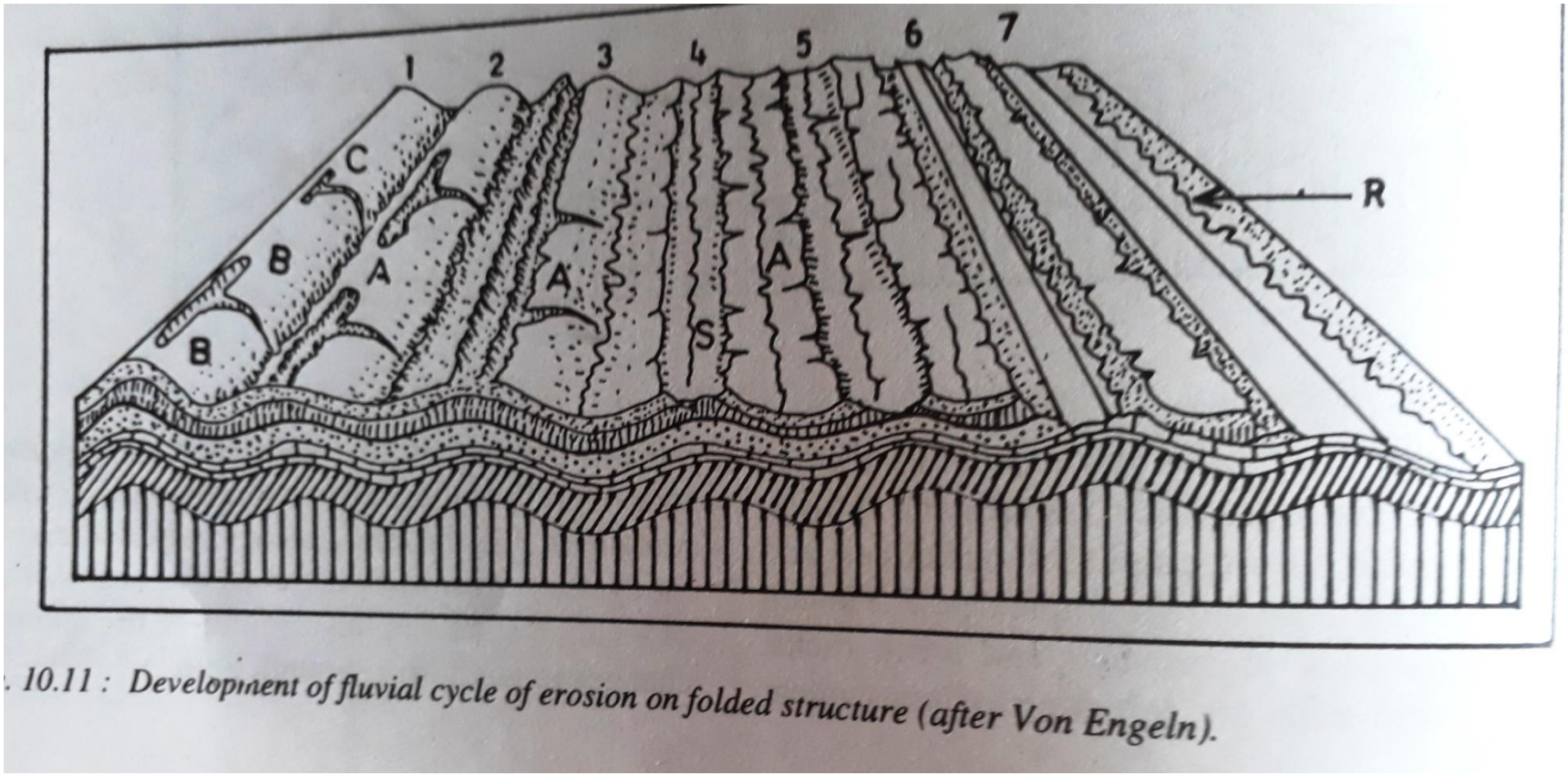
Drainage Development on Folded Structure



rsion of relief—after J. Tricart, 1974

Source:Geomorphology, Savindra Singh

Drainage Development on Folded Structure



. 10.11 : Development of fluvial cycle of erosion on folded structure (after Von Engeln).

Source: Geomorphology, Savindra Singh

Drainage Development on Folded Structure

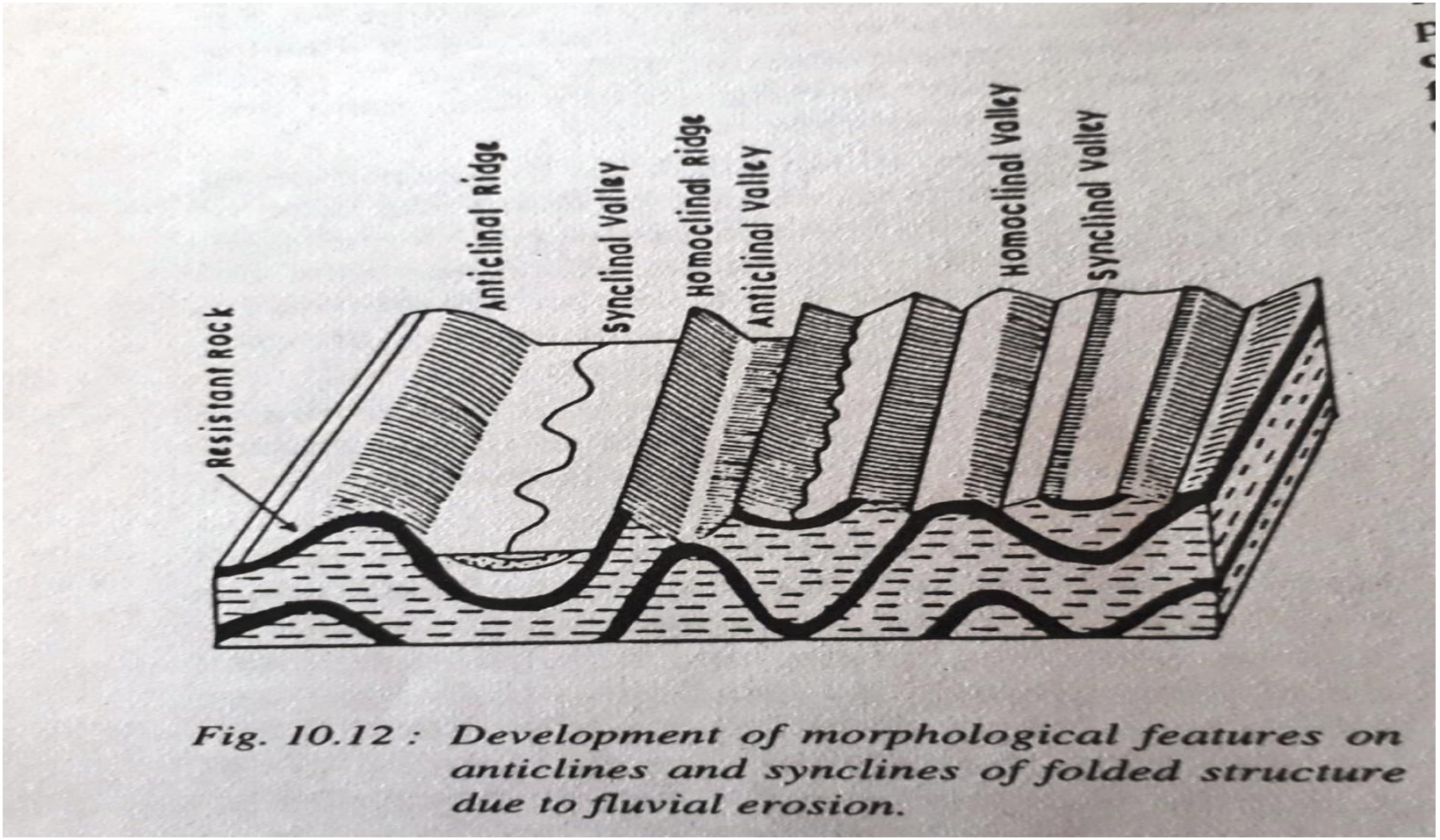
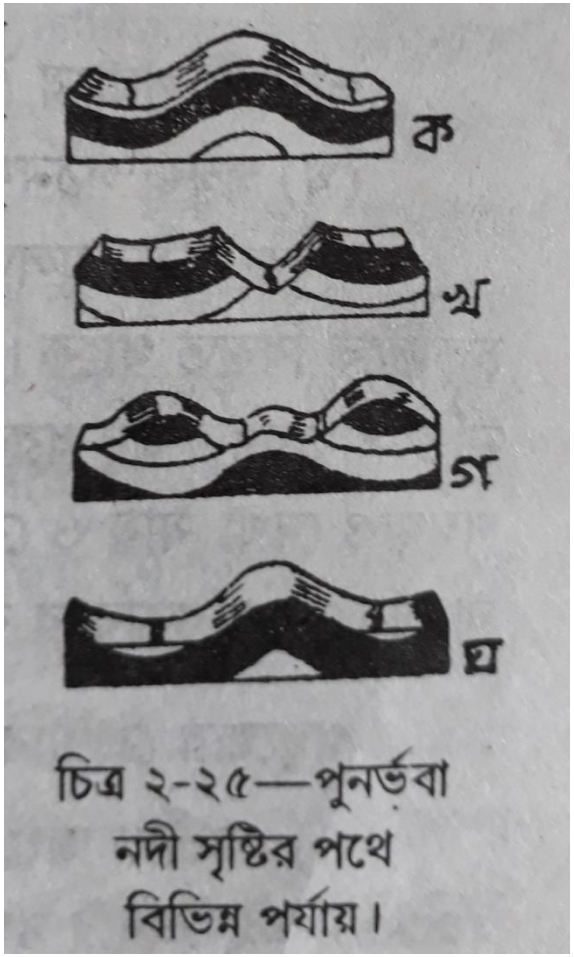


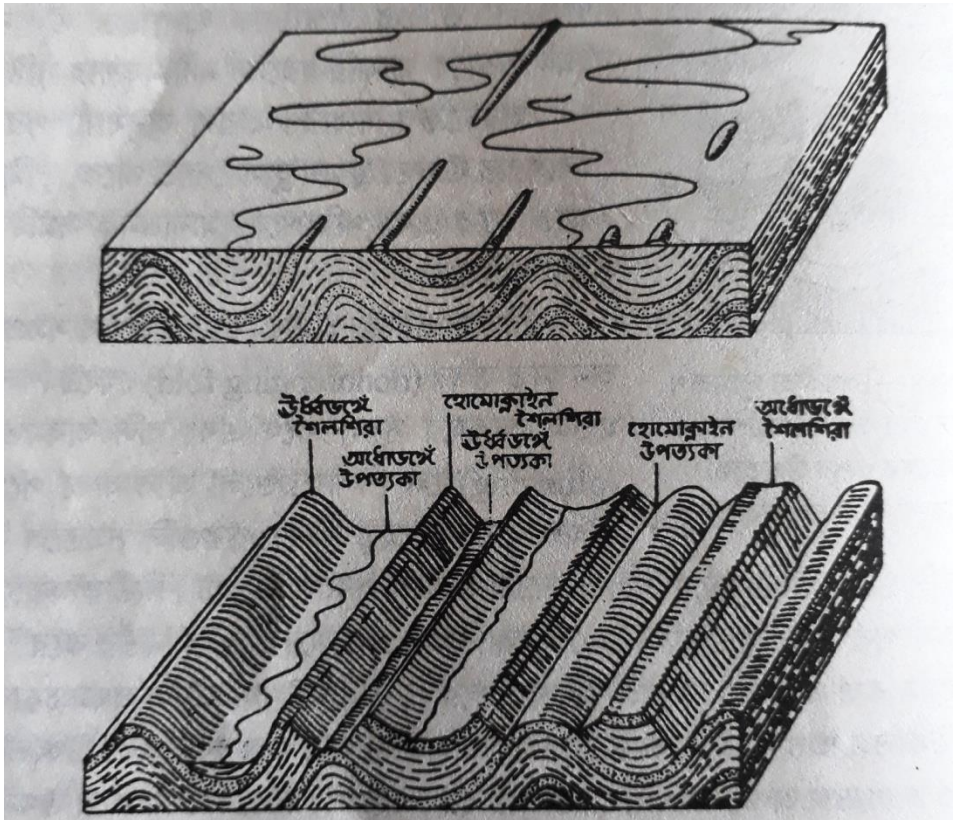
Fig. 10.12 : Development of morphological features on anticlines and synclines of folded structure due to fluvial erosion.

Source:Geomorphology, Savindra Singh



চিত্র ২-২৫—পুনর্ভবা নদী সৃষ্টির পথে বিভিন্ন পর্যায়।

Source: Landforms: Evolution and Characteristics, S.C. Mukhopadhyay and R.K. Das



২৬—সমতলীকরণের পর বলিত গঠনযুক্ত অঞ্চলে ঊর্ধ্বভঙ্গ, অধোভঙ্গ ও এদের অন্তর্ব
গঠনের সঙ্গে ভূমিরূপের সম্ভাব্য সম্পর্ক।

Source: Landforms: Evolution and Characteristics, S.C. Mukhopadhyay and R.K. Das

References

- S.C.Mukhopadhyay & R.K.Das: Bhumirup Udbhab o Prakriti (Landforms: Evolution and Characteristics), West Bengal State Book Board
- Savindra Singh: Geomorphology, Prayag Pustak Bhawan, Allahabad