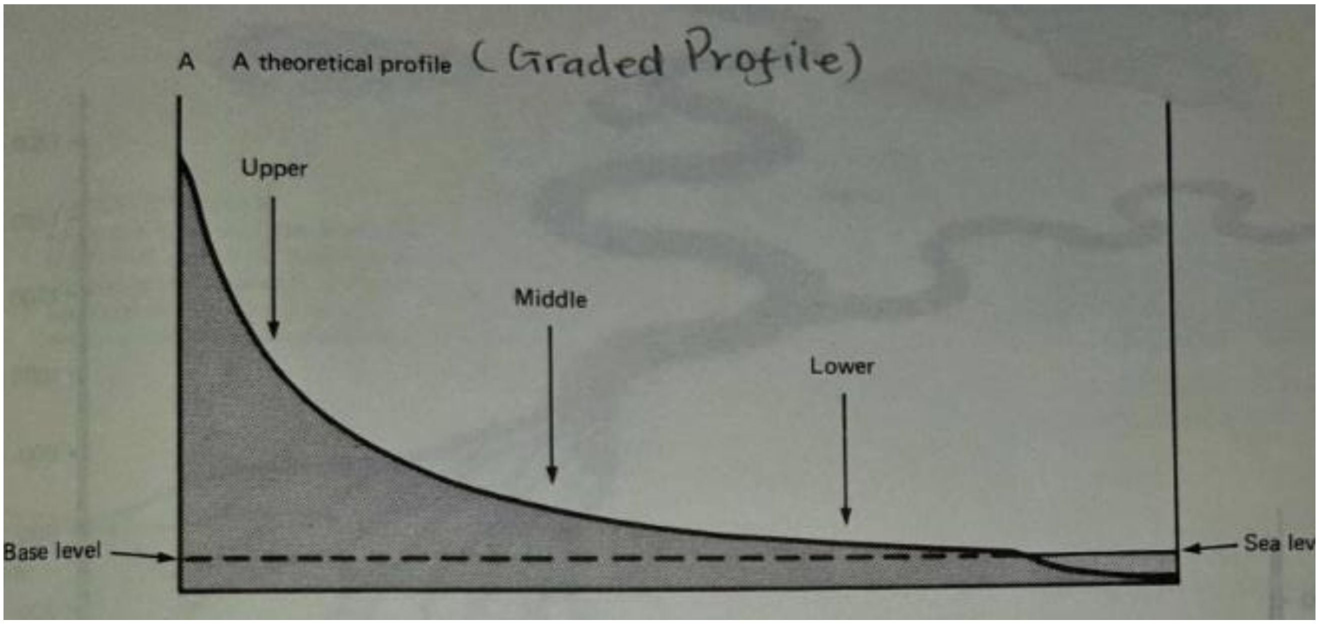
S6 GEOGRAPHY.

THE LONG PROFILE OF A RIVER

This refers to the slope along the river's bed from its source to the mouth. A river aims at attaining the equilibrium or **a graded profile** from the source to mouth where erosion and deposition are balanced.



The graded profile is steep near the source due to the fact that erosion is less than average because of small water volumes.

In the middle, the curve is so pronounced that it's concave in shape. This is due to the higher water volume resulting from the incoming tributaries that enable the river to erode either vertically or laterally.

In the lower course, the river is carrying a lot of heavy load and drops the load at the bed. The deposited material protects the bed from vertical erosion, this contributes to the observed gentle gradient.

Along the graded profile the river has just enough energy to transport its load. When a river has more energy without full load at that point of its course, it will immediately begin to erode so as to create balance within its energy and the load being transported.

Erosion decreases downstream because of the load resulting into a gentle slope. This process through which a river removes irregularities along its course is known as **degradation**.

On the other hand, when a river has more load than its energy can allow it to carry, deposition of the excess load will occur so that the river remains with enough load for it to transport at its energy level.

The process where a river deposits materials infilling the depressions is known as **aggradation.**

Degradation and aggradation result into a smooth curved slope of a graded profile of a river from its source to mouth. Along this slope, deposition and erosion are exactly balanced.

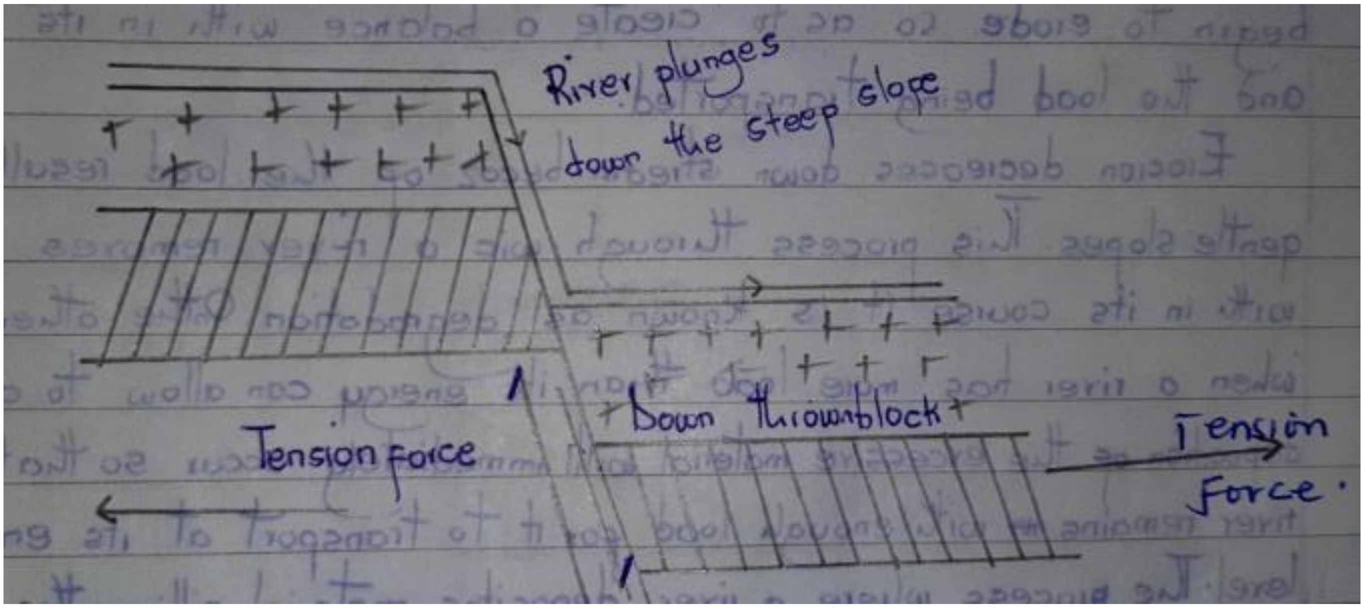
Question

Explain how a river attains a graded profile.

Criticism of a Graded Profile

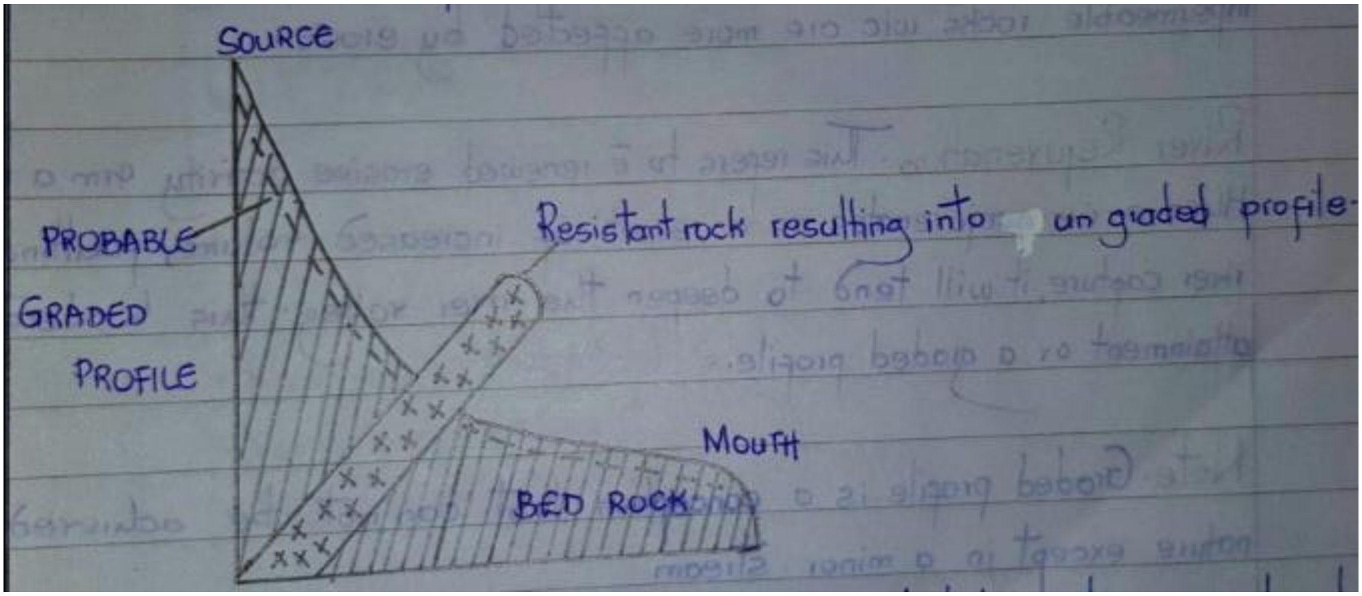
The concept of graded profile has been based on gradient and velocity of river. Other important factors have been neglected. These factors that interrupt a river from attaining graded profile include;

1. Earth movements such as faulting result into vertical displacement of the channel bed rocks and therefore hindering a river from obtaining a graded profile. For example, Karuma falls on R. Nile.



2. **Discharge/water volume.**
   The volume of water in a river may increase due to the tributaries joining a river, river capture or due to increase in rainfall. Increase in water volume renews the river's erosive activity which deepens the river channel hence failure to attain the graded profile.

3. **Presence of a hard rock across a river's channel.**
   Hard rocks across a river valley result into irregularities along a river valley preventing the formation of graded profile and many times water falls are formed for example Itanda falls, Ssezibwa falls.



4. **Presence of a lake across the river's course.**
   A lake acts as a local base level. The sediments that are carried by a river may be deposited on the Lake floor. Again , as the river flows out of the lake at the lower end, it cuts down the valley so as the level is lowered. Such interruptions hinder a river from attaining a graded profile for example R. Nile as it flows out of L. Victoria.

5. **Braidation**
   This is the splitting of a single river into distributaries which re- unite downstream. The distributaries of a divided stream are less effective than the original river. Where the division takes place, the river develops a steep gradient, hence ungraded profile for example R. Semliki, R. Rufigi , R. Ngaila etc

6. **Man's activities**
   Man through activities such as damming of rivers and tapping water for a variety of uses including irrigation may hinder a river from attaining a graded profile as it reduces the amount of water in the river for example R. Nile ,R. Mubuku , R. Tana .

7. **Nature of rocks(lithological variation)**
   If a river flows over alternating permeable and impermeable rocks, it will tend to develop ungraded profile. Permeable rocks are less affected by erosion and they will form a steeper gradient than impermeable rocks which are more vulnerable to erosion.

8. **River rejuvenation**
   This refers to renewed erosive activity of a river. Whenever a river rejuvenates due to increased volume , faulting or river capture, it will tend to deepen the river valley and this hinders the attainment of a graded profile.
   NOTE: The concept of a graded profile cannot be achieved in nature except in minor streams.

Questions

1.(a) Explain the processes by which rivers try to attain a graded profile.

(b) What factors interrupt the attainment of a graded profile.

THE CROSS PROFILE OF A RIVER

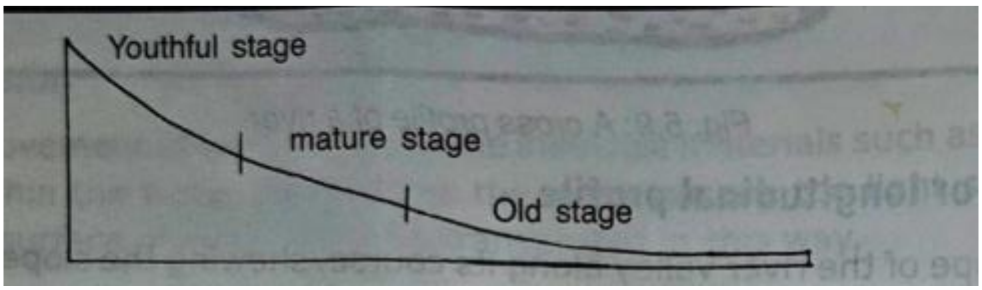
This is the transverse profile of a river valley from one bank to another. A cross profile is illustrated by the valley's width and its characterized by being narrow or V- shaped due to vertical erosion and U-shaped in the middle due to lateral erosion on the sides. Flattened and wide valley in the old stage due to deposition.

Features Along The River Profile .

As rivers flow from the source to the mouth, they adjust their courses i.e deepening and widening due to vertical erosion and lateral erosion respectively. In the lower stage adjustments are due deposition while in the upper stage its mainly due to erosion (vertical erosion resulting from abrasion and hydraulic action)

There are **three** major stages or sections along the river profile .

1. Youthful stage/upper stage/ torrent stage/Juvenile stage
2. Middle stage/mature stage/valley stage
3. Old/senile/lower/plain stage/ flood plain stage



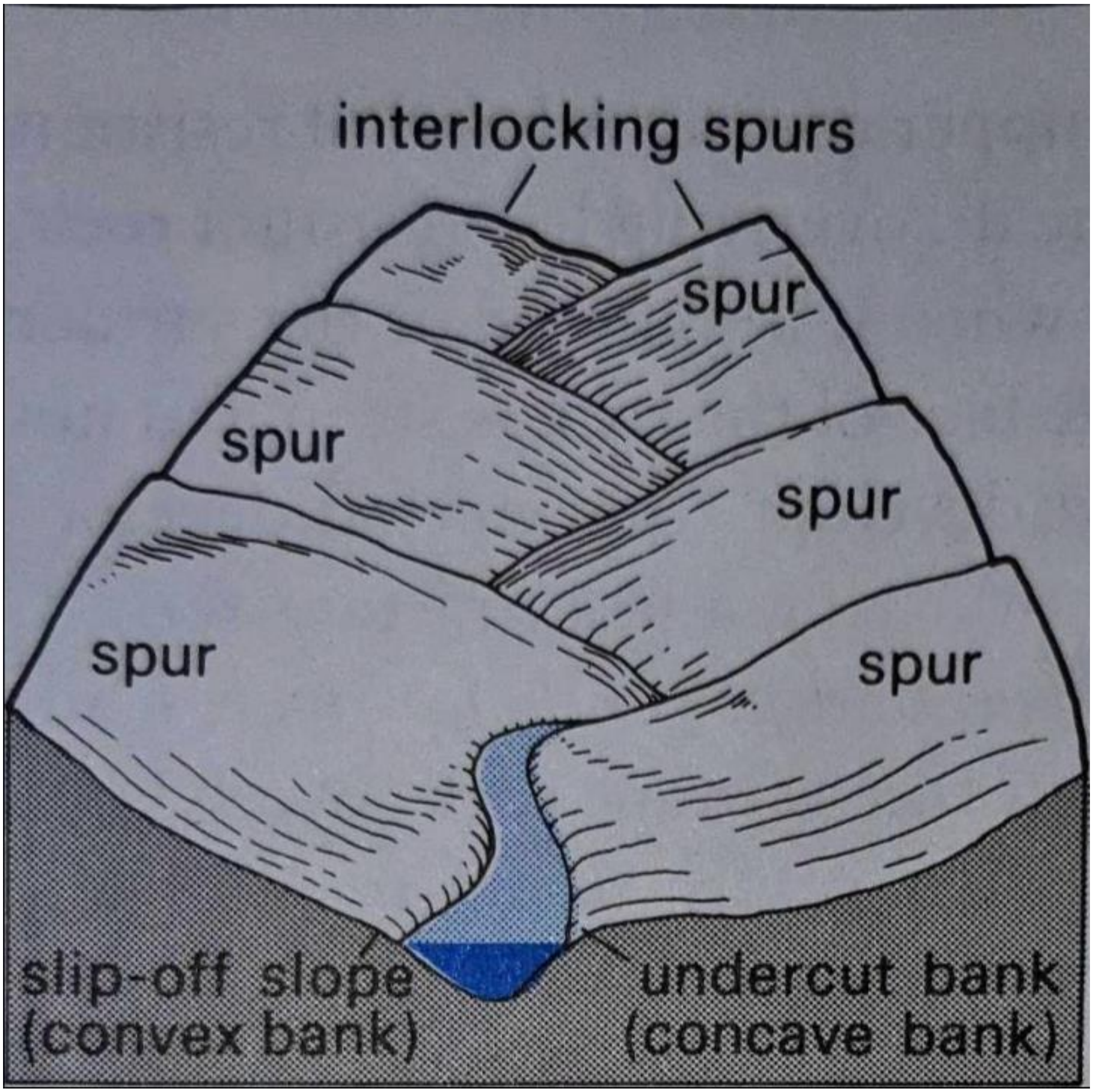
YOUTHFUL/UPPER STAGE

This is characterized by;

- A very steep gradient
- High velocity
- Vertical erision
- Narrow valley/V-shaped valley
- Low deposition/limited deposition
- Low water volume

Features Of The Upper Stage Of a River

1. **Interlocking spurs;**
Along steep slopes, rivers tend to go round obstacles of hard rocks while vertically eroding the valleys to develop a winding course. The bends become more pronounced, eventually causing projections of highlands, called **spurs**, from opposite sides of the river to **interlock**, hence forming the **interlocking spurs**. Examples can be seen on R. Nyamwamba on Mt. Rwenzori, R. Manafwa on Mt. Elgon , R. Tana on Mt. Kenya etc

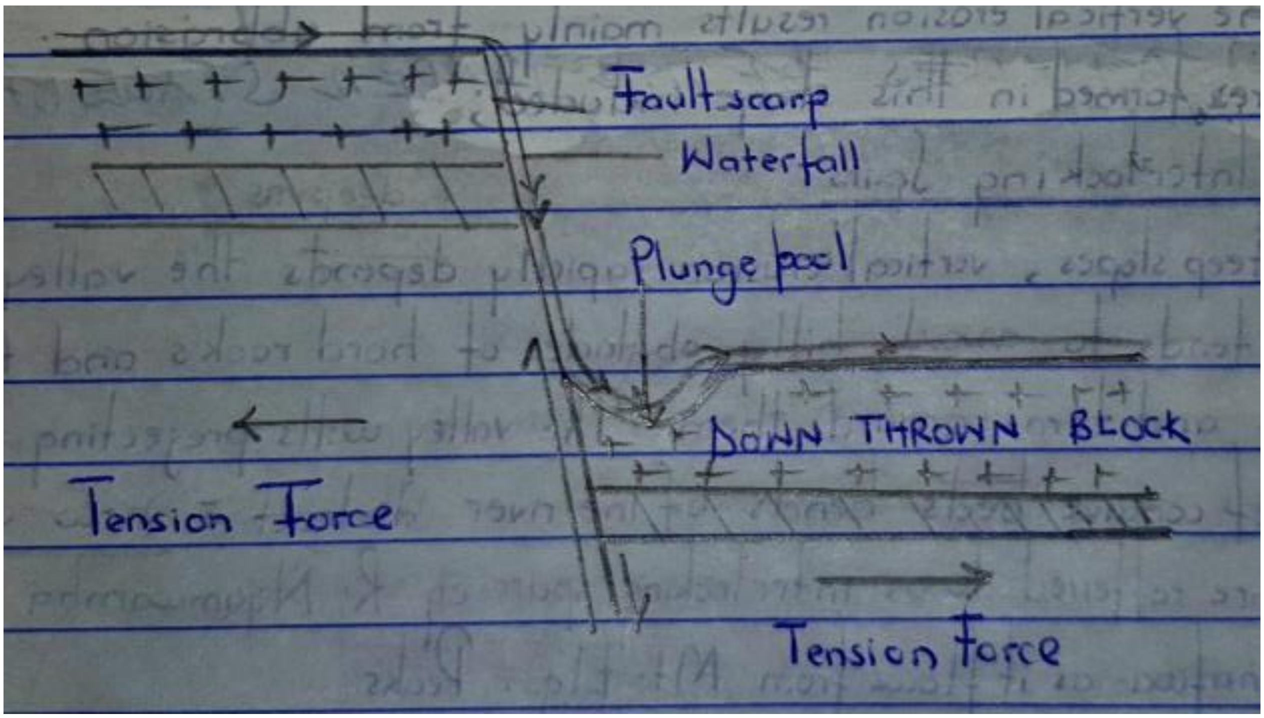


2. **Waterfalls;**

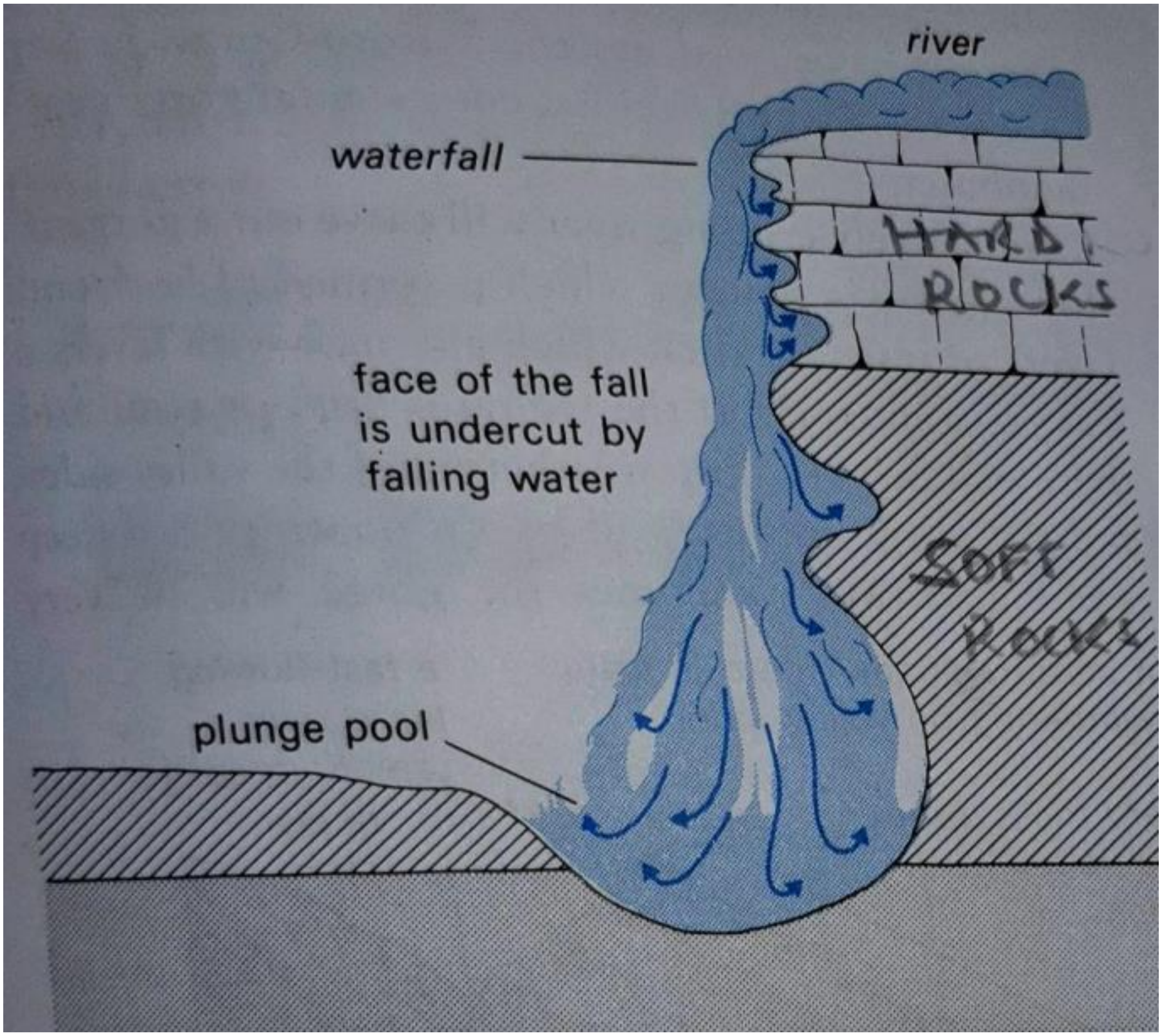
   This is a sudden vertical or steep fall of water that occurs at a sharp break in the river channel bed. Water falls develop due to ;

   a) **Earth movements**

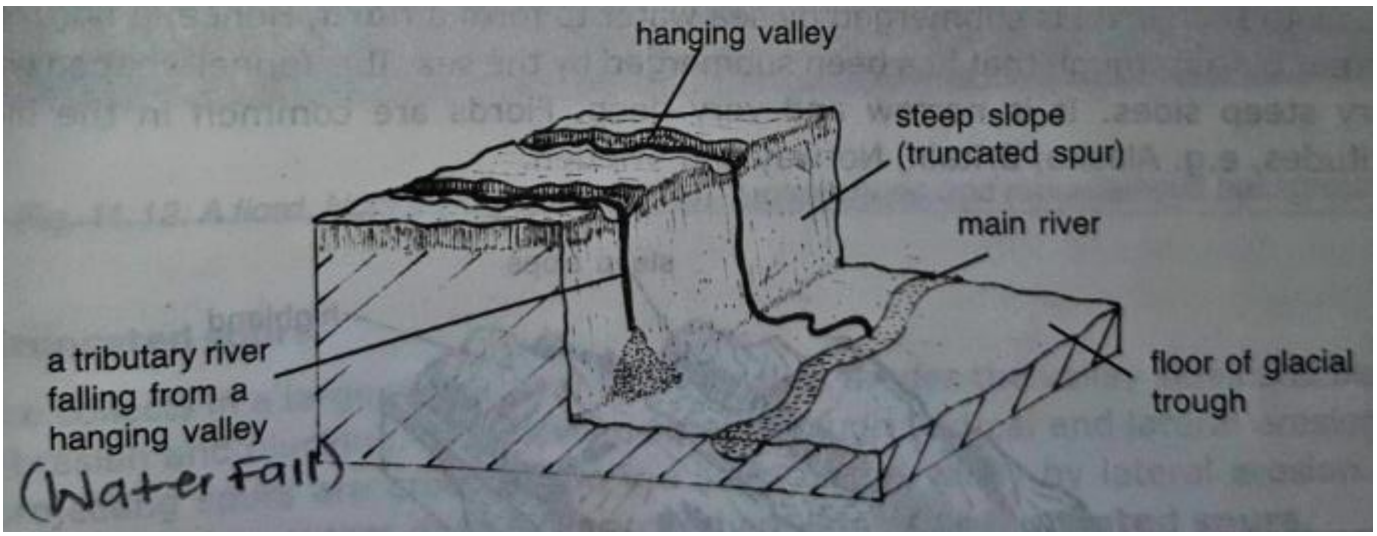
Earth movements have resulted into formation of water falls especially in rift valley areas of East Africa where the crustal blocks have been displaced by faulting through tension or compression forces creating steeper gradient i.e a long steep escarpments where a river drops downwards for example Kabalega falls on Victoria Nile in Uganda as it crosses Butiaba scarp, Webuye falls in Kenya on R. Nzoia as it descends along the Nandi escarpment , Karuma falls on R. Nile etc.



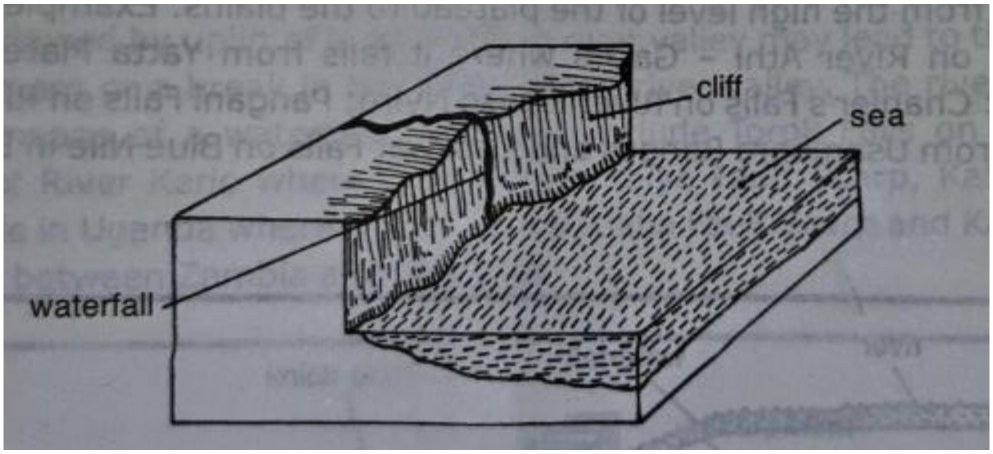
b) Waterfalls are formed due to differential erosion in areas of alternating hard and soft rocks.
When a layer of a hard rock lies across a river course, the soft rocks on a downstream side are eroded faster than the hard rocks upstream. The river bed is thus steepened where it comes across a hard rock and a waterfall develops for example Bujagali falls on R. Nile Sezibwa falls on R. Sezibwa , Thika falls on R. Tana, Fourteen falls on R. Athi.


river
waterfall
HARD ROCKS
face of the fall
is undercut by
falling water
SOFT ROCKS
plunge pool

c) Waterfalls develop where the tributary from the hanging valley joins the U-shaped valley (trough) in the glaciated uplands. The U – shaped valley (main valley) is deepened by glacial erosion more than its tributary valley (hanging valley) . In this case, the tributary valley lies at a higher level than the main valley and if a stream flows in the hanging valley, it will join the main valley by means of a waterfall.
Examples ; Bujuku falls on Mt. Rwenzori due to Speke glaciers joining Bujuku valley.



d) Waterfalls occur where a river enters the sea at a cliff line.
Waterfalls may form near the mouth of a river if wave action undercuts inland the cliff face or where the sea- level has fallen for example Lobe falls in Cameroon .



e) Waterfalls are formed where there is a sharp well defined plateau edge i.e When a river is flowing from a higher level plain to a low level plain for example Victoria falls on R. Zamberzi, Livingstone falls on R. Congo, Pangani falls on R. Pangani, Lugadi falls where the Athi-Galana rivers fall from Yatta plateau to the coastal plain.

f) Waterfalls may be formed at a point of rejuvenation where a sharp knick point develops due to renewed erosive activity that deepens the valley downstream. For example Charlotte falls in Sierra leone.

g) Waterfalls are formed by land slides/ lava barrier across the river. When the water flows over edge of barrier, a waterfall develops e.g Lily falls in Madagascar.

Questions

1.(a) Account for the formation of waterfall.

(b)Explain economic importance of waterfalls.

3. Rapids

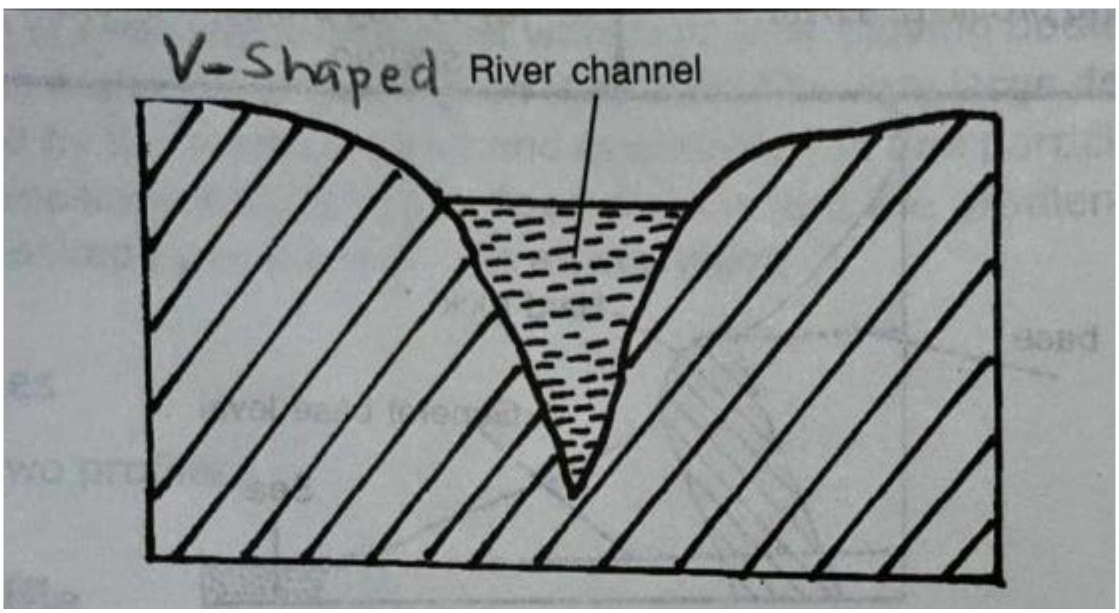
These are sections of rough, broken, fast flowing water in a river channel where the bed is steep and rocky. Rapids develop where the gradient of the river bed increases without a sudden break of slope. It also forms where the river flows over a series of gently dipping bands of harder rocks. Rapids are associated with increased erosive power.

N.B: Rapids are common in the upper stage but can form in any stage of the river.
Examples of rivers with rapids include R. Nile, R. Ngaila, R. Ewaso Nyiro in Kenya.

4. **V – shaped / Narrow Valley**

This is a deep , narrow and steep sided river valley formed through vertical abrasion/erosion . vertical erosion is more pronounced than lateral erosion leading to valley deepening. The valley is wider at the top and narrow at the bottom.

V- shaped valley's can be seen in the upper stages of R. Manafwa, R. Nyamwamba, Tana etc.

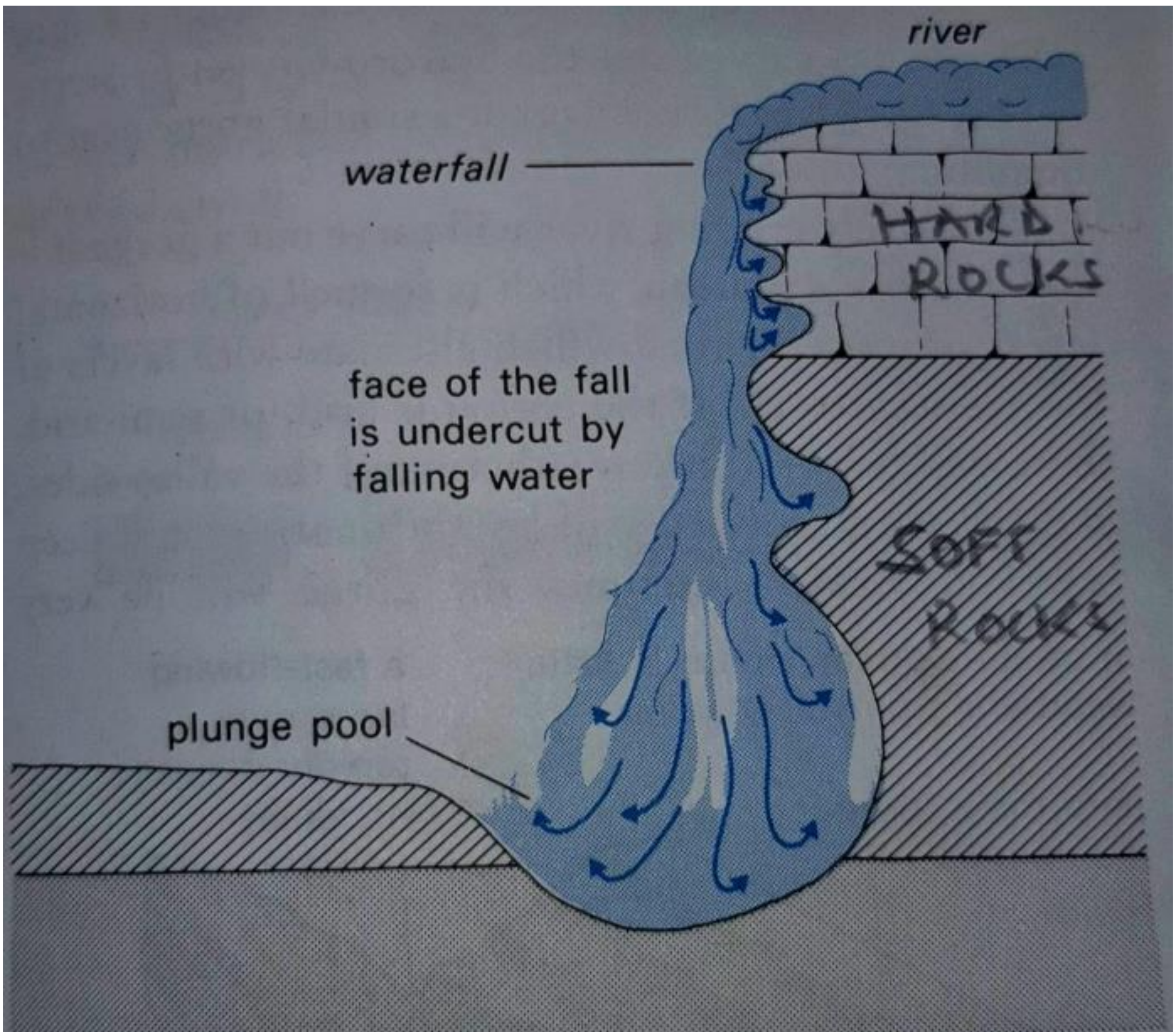


5. **Pot Hole**

These are small circular depressions formed by the action of pebbles dragged (abrasion) against an irregular bed of a fast flowing river in the upper stage. For example along R. Nyamwamba, R. Manafa, R. Mubuku in Uganda, R. Athi in Kenya.

6. **Plung Pool**

These are large, deep , circular depressions formed at the base of a water fall where the soft rocks under lie the hard rock in the river channel. They are formed by the under cutting force of the falling water through hydraulic action and abrasion by the falling rocks which enlarge and deepen the depression . Examples can be seen at the base of the Sezibwa falls in Buikwe district, at the base of Bujagali falls on R. Nile in Jinja , at the bottom of Sippi falls in Kapchorwa, eastern Uganda .

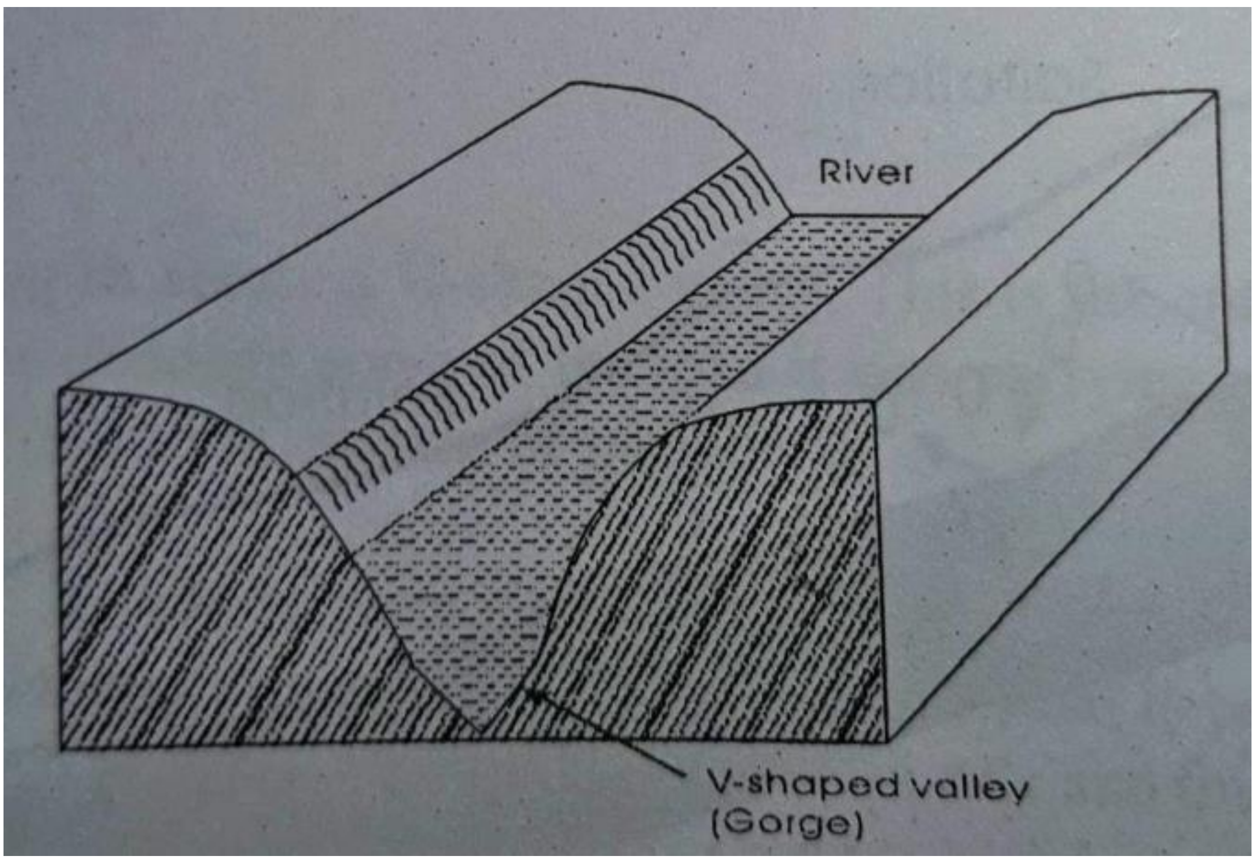


7. Gorge

A gorge is a deep, narrow river valley with steep sides. Gorges are formed when a river flows over an area of soft rocks excavating out a very deep and narrow valley by vertical erosion through abrasion and hydraulic action. A gorge can be seen at Murchison falls along R. Nile, Maruba gorge on R. Ikiwe in Kenya.

A gorge can be formed when a river incises into a landscape due to a fall in the base level e.g Manambolo gorge in Madagascar.

A gorge can also form across a land scape which is being uplifted as the river tries to maintain its course. E.g a gorge along the Great Ruaha river in Tanzania . Other examples include Chebloch gorge on River Kerio in Kenya.



THE MATURE/MIDDLE STAGE/VALLEY STAGE AND THE RELATED LANDFORMS.

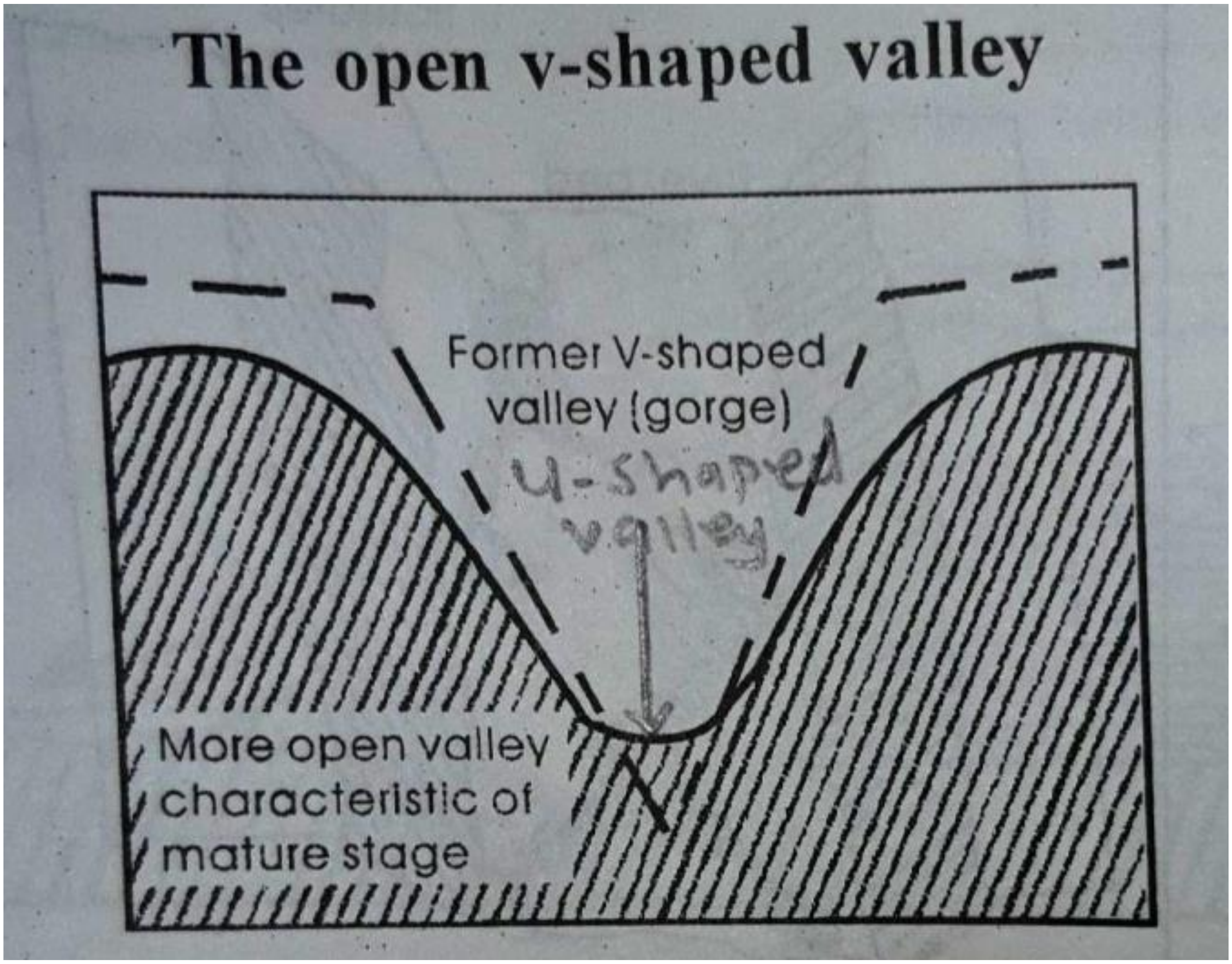
The mature stage of a river is the middle section of the river profile and it is characterised by ;-

- Gentle slopes/ moderate gradient
- Moderate water speed
- U- shaped valley
- Deposition and erosion
- River meanders
- Lateral erosion being more pronounced than vertical erosion.
- Increased water volume due to many tributaries joining the main river.

Land Forms Of The Middle Stage

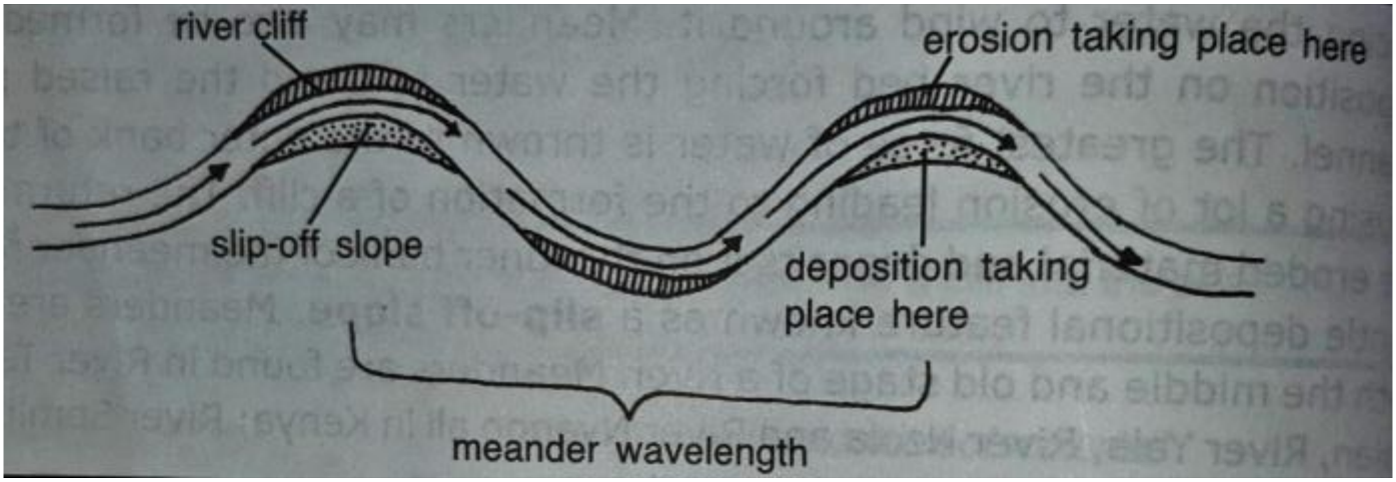
1. **U – shaped Valley**

This is an open V – shaped valley formed through lateral erosion that widens the V – shape of the former valley. U – shaped valleys can also result from the in filling of the former V - shaped valley with deposits and sediments. Examples can be seen on , Nyando , Rwizi , R. Nzoia.



2. **Cliff /Bluff**

These are steep slopes along the rivers bank. They are formed due to the under cutting (Lateral erosion) of the concave bend of the river.



3. **Slipoff Slope**

This is a gently sloping side along the river formed through deposition along the convex bend of the river examples can be seen on R. Nyando, Nzoia , R. Ngaila, R. Yala in Kenya , R. Rwizi , R. semliki in Uganda, R. Kilimbero in Tanzania.

(As illustrated in the diagram above).

4. Meanders ; (Refer to lower stage for details)

THE LOWER/OLD /SENILE/FLOOD PLAIN STAGE OF A RIVER

This is the last stage of a river/ river profile mainly found towards the rivers mouth. The main work of the river in this stage is **deposition**. Lateral erosion continues to erode the river's banks but vertical erosion is almost at an end.

The lower course of a river is characterized by ;

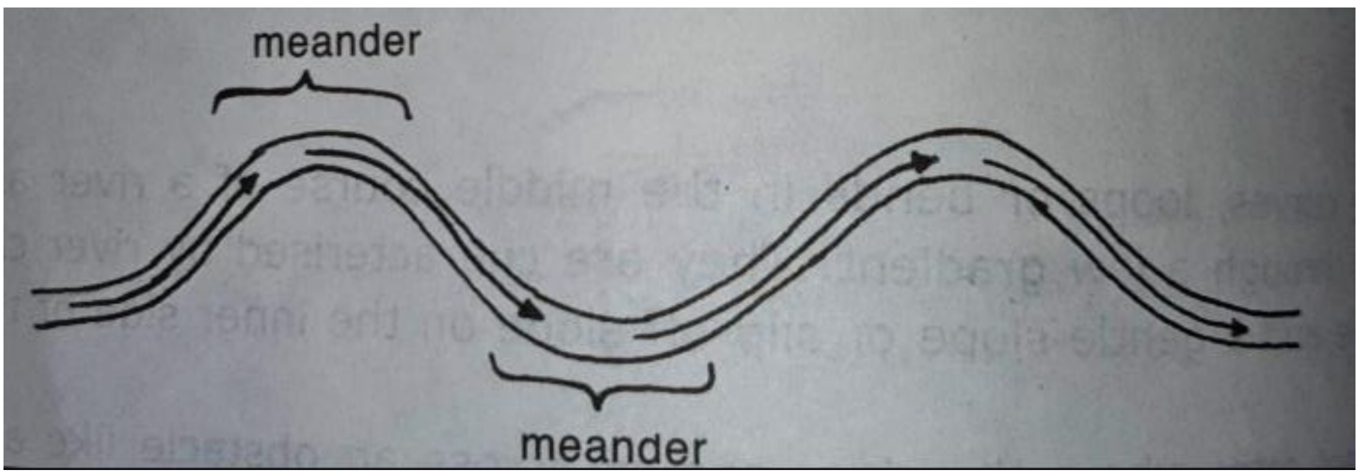
- Very gentle gradient.
- Sluggish flow of the river due to low gradient/low speed of the river.
- Dominant deposition due to reduced river's energy.
- River flows in a very wide valley due to lateral erosion.
- Large water volumes due to the addition of more tributaries.
- A lot of load partly due to the addition of more tributaries.

- Flooding due to increased water volumes.
- It has pronounced deposition features such as flood plains, levees, braided channels, deferred tributaries, ox- bow lakes, meanders and meander scars etc

Features Of The Lower Course Of a River Valley

1. **River Meander**

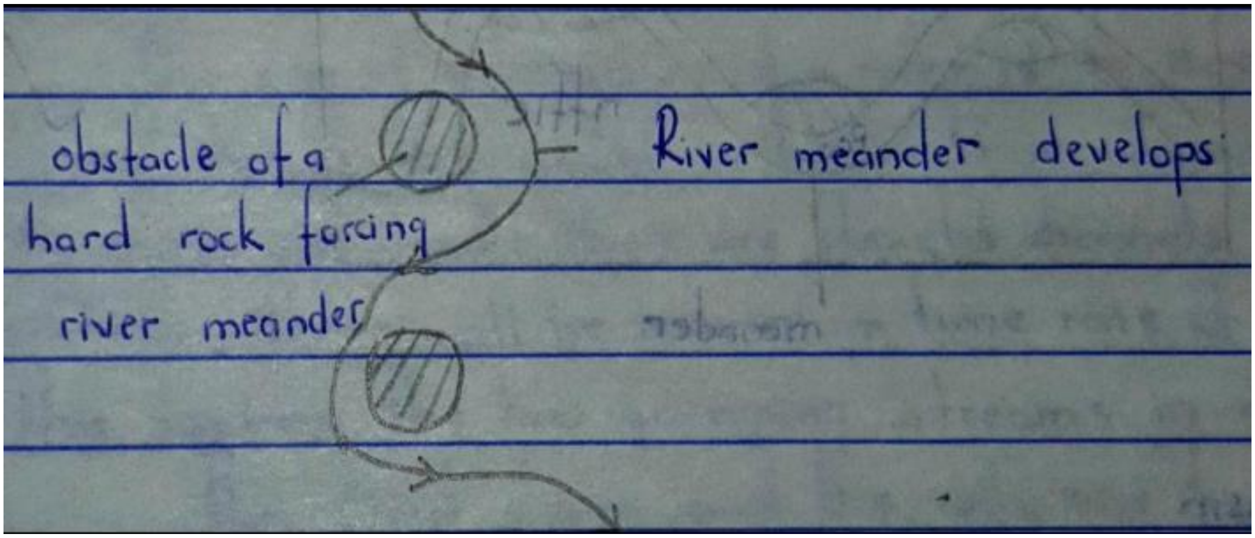
A meander is curved bend along a river channel where the river flows sluggishly. They are formed due to alternating under cutting (lateral erosion) and deposition at the concave and convex bends of the river channel respectively.



Theories Of River Meanders

(i) Presence of an obstacle (a hard rock)

It is suggested that whenever a stream encounters an obstacle such as a hard rock along its course, the river is forced to wind around it while eroding and depositing on the outer bank and inner bank respectively creating a bend that turns into a meander.



Criticism

Studies carried out in different climatic regions revealed that rivers tend to develop snake like curves. It was therefore concluded that if obstacles are possible for river meandering, then they must be of the same shape to produce similar curves. However, obstacles cannot be the same every where and on this basis, the theory was rejected as a satisfactory explanation for river meandering.

(ii) Siltatation

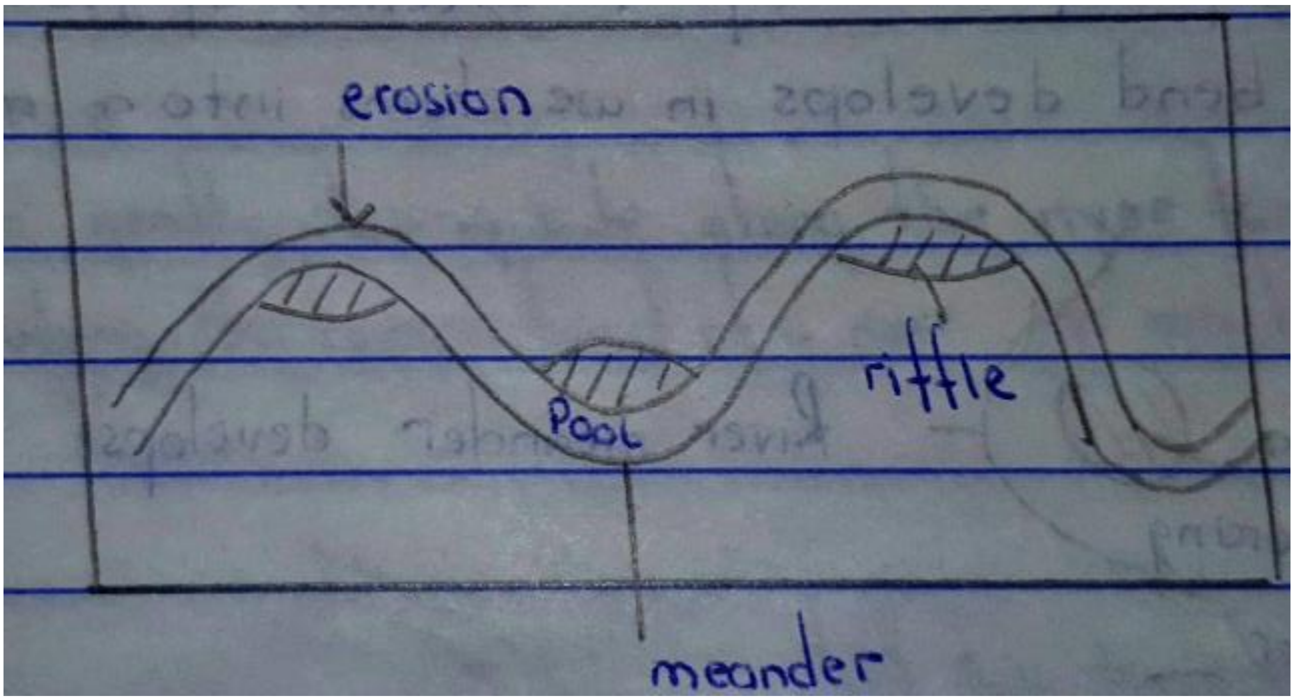
Too much deposition along the river channel bed results into reduction in the river's gradient (i.e forming a gentle slope) This forces the river to meander in order to look for alternative steeper gradient to its mouth.

Criticisms

This idea was disapproved when it was discovered that even in their upper stage, rivers meander especially in the rugged and steep topography.

(iii) Riffle and Pool theory

When a stream flows along a straight course it modifies it through erosion and deposition creating hollows and riffles respectively. Once the riffles and the pools are fully developed , the river will start to experience side to side swings. As the swinging water hits the banks of the streams, lateral erosion takes place creating bends along the channel . The bends are eventually enlarged into meanders.



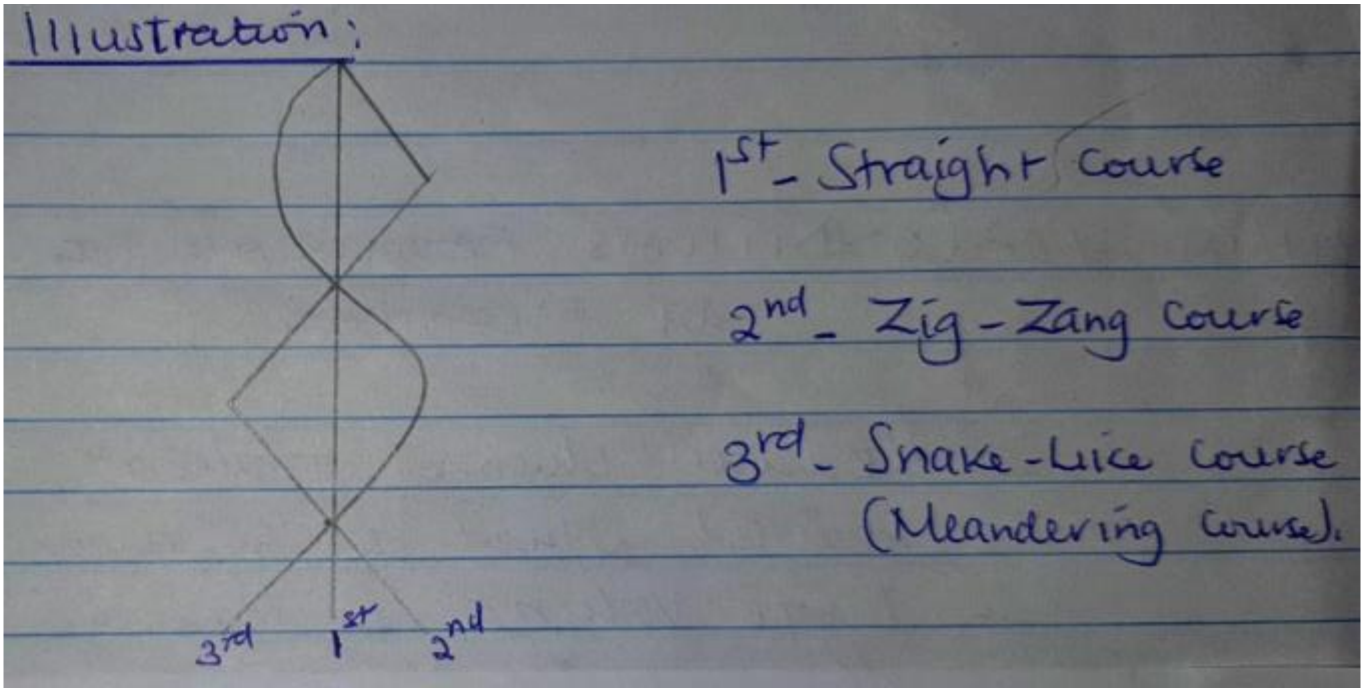
Criticism

However experiments with artificial streams like in the bathrooms where no erosion or deposition takes place reveal that water does not follow a straight-line when moving.

(iv) The minimum time rate of energy expenditure

According to this theory, it is suggested that while in motion , rivers tend to minimize the time rate of energy expenditure through lengthening the course from the source to the mouth by adapting a winding or the sinuous course.

Once in motion, a river has **three** alternative courses from its source to mouth as illustrated below.



The 1st choice is for a river to develop a straight course from the source to the mouth. But the channel AB provides the shortest distance from the source to the mouth and therefore given the available energy a river system has, a straight path will result into the maximum rate of energy expenditure. This disagrees with the behavior of all streams in motion.

The second alternative of a river is to develop a zig zag channel (2nd choice). This would be longer than channel number one. But between the source and the mouth , there are straight channels and along these sections there will be maximum rate of energy expenditure. This disobeys the law governing streams in motion.

The third choice and the only one is for the river to adapt a sinuous course (a snake like curve) so as to minimize the expenditure rate of the available energy. In a lengthened meandering course, a river is able to efficiently utilize the energy.

(v) Gentle slope/ Reduced gradient

The reduced gradient along a river's channel leads to reduced river's speed and energy. This encourages deposition along the river channel. The deposited material accumulates and the river is forced to meander as it tries to avoid it.

(vi) Meanders develop along streams due to friction checks between the flowing stream water and the channel bed rocks.

Summary of conditions favouring the development of meanders

- Reduced channel gradient
- Reduced speed of the river
- Large volume of load to be deposited
- Large water volume to effect lateral erosion
- Wide river valley
- Softer rocks along the outside banks of the river

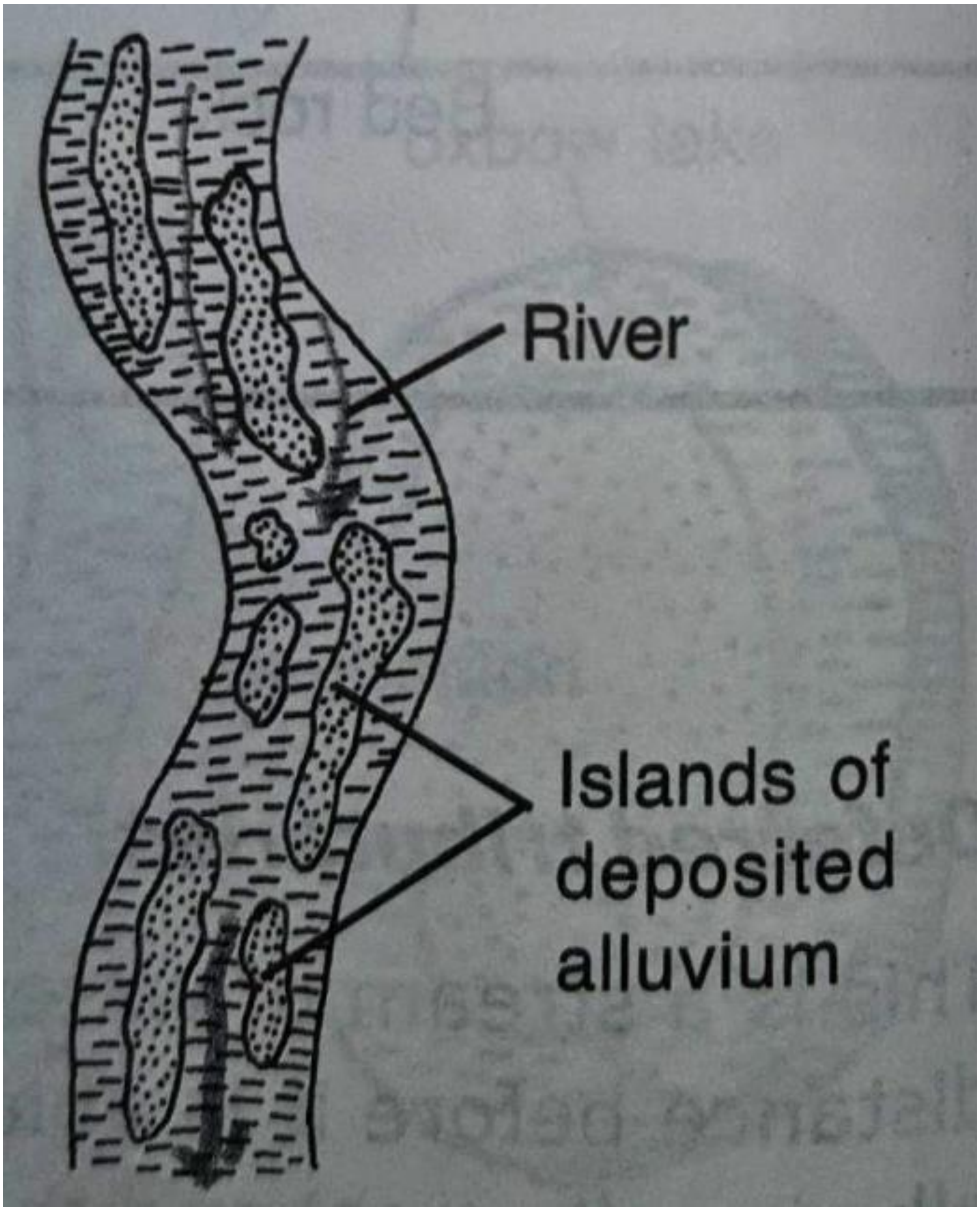
Examples of meanders can be seen on River Nzoia, R. Nyando, R. Yala , R. Ngaila in Kenya , R. Rwizi, R. Semliki in Uganda, R. Rufigi, R. Kilombero in Tanzania

Questions

1. Account for river. meandering in East Africa.
2. With reference to specific examples in East Africa explain the conditions which have led to the development of the following features along a river profile.
   (i) River meander
   (ii) Plunge pool
   (iii) Flood plain

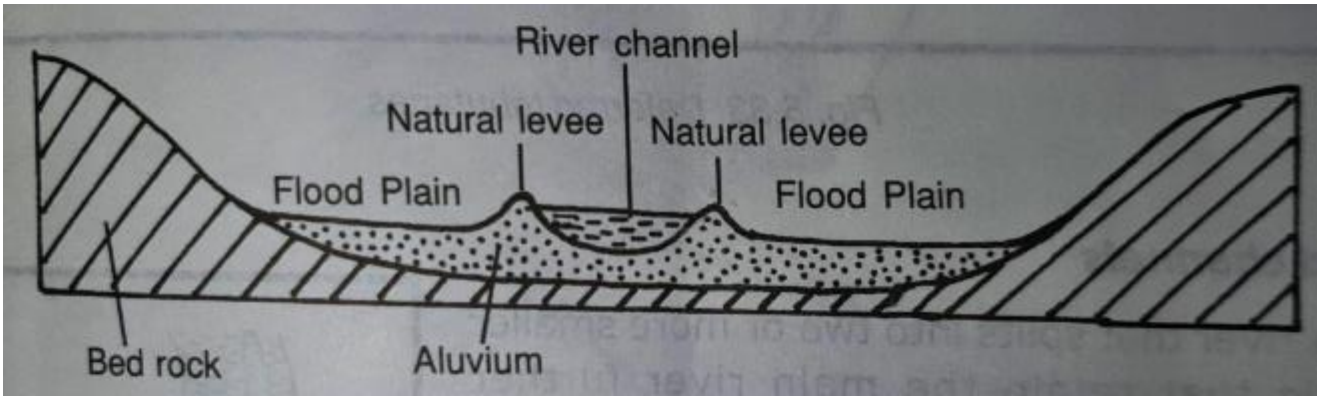
2. **Braided Channel**

   A braided channel is an extremely wide, shallow channel in which the river splits into numerous interconnecting channels separated by sand banks and alluvial deposits. Braided channels are as a result of deposition of coarse material e.g boulders, sand, gravel on a river bed that forces the River to split . Braided channels can be seen on R. Nzoia, R. Nyando, R. Ngaila in Kenya., R. Rwizi in Uganda.



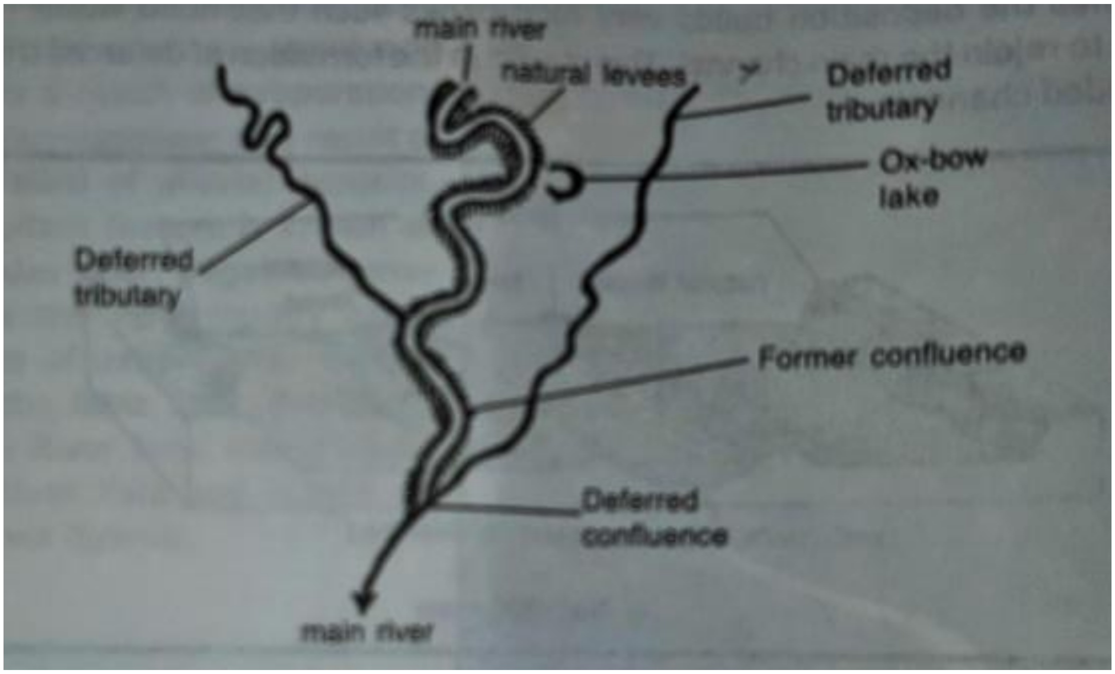
3. **Flood Plain**

This is a wide lowland surface or gently sloping plain of alluvial material, adjacent to the river channel over which water spills and flows during floods. They are formed when river floods successively deposit material that builds up around the meandering river channel to form a platform. Examples include R. Rwizi, R. Nyando, R. Ngaila, R. Nzoia, Doho plains on R. Manafwa. Kano plains on rivers Nyando , Yala and Ngaila in Kenya.



4. **Levees**
   These are ridge like features on the river banks of the channels. They are formed through successive flooding and immediate deposition of sediments at the rivers bank. Examples can be seen on a R. Rwizi , R Nzoia , R. Ngaila, R. Yala, R. Nyando.
   NB. illustration : As in the above diagram.

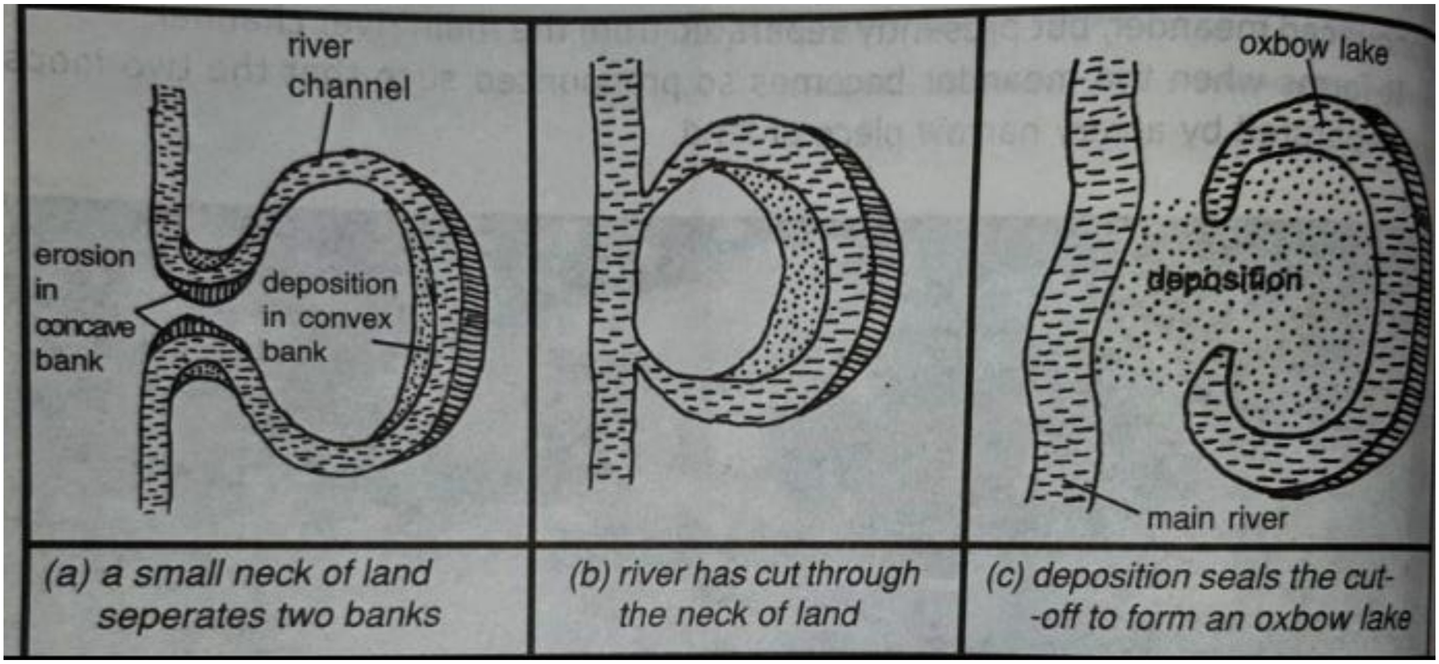
5. **Deferred Tributary Or Channel**
   This is a tributary that is forced to flow alongside the main stream for a longer distance before being able to rejoin the main river. Along the main river, levees build across the original confluence forcing the tributary to flow along side the main river until it comes at a point with low levees or no levees and then rejoins it at a **deferred confluence** or **deferred junction.**



6. **Ox-bow lake and meander scar**

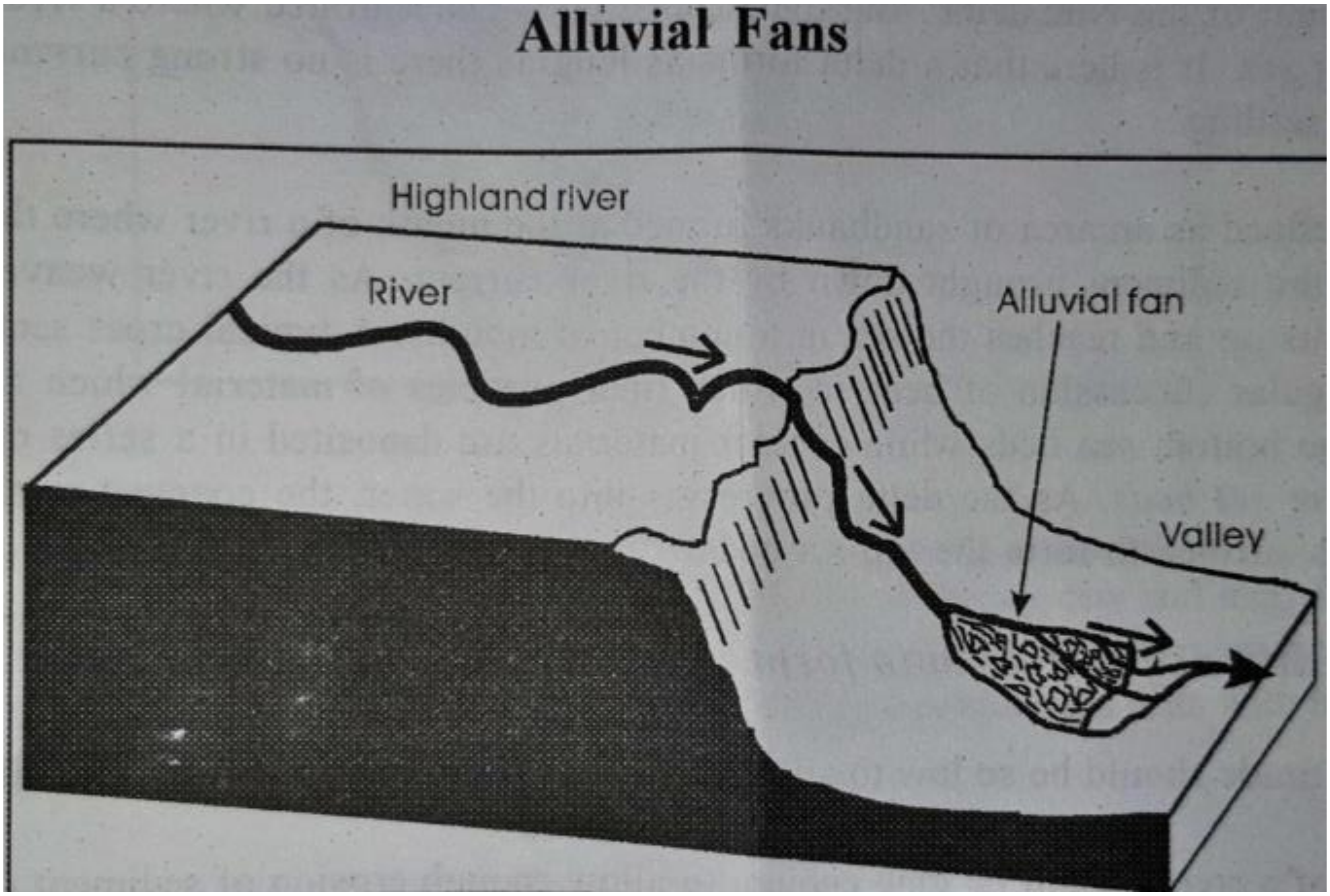
An ox- bow lake is a horse shoe shaped deserted section of a once very sharp meander , now separated from the main stream. Ox – bow lakes are formed on the river flood plains through lateral erosion and deposition on the concave and convex banks of the meander respectively.

Increased discharge forces the river to cut through the narrow neck (swan's neck) of the meander. The cut ends of the meander are sealed off by deposition and the meander now becomes an **ox- bow lake** if filled up with water or a **meander scar** if the deposited alluvium displaces the water for example L. Kanyaboli on R. Yala , R. Nzoia, L. Bilisa , L. Shakababo, L. Gambi on R. Tana , R. Semliki.



7. **Alluvial Fan/Dry Delta**

   This is a fan shaped deposit of fairly coarse material laid down by a stream at a point where it suddenly enters a wide plain from a higher land through a narrow valley. A sharp increase in the channel width, decrease in gradient cause a marked reduction in the stream energy resulting into sudden deposition that spreads out to form a fan. More deposition forces a river to split into distributaries. Fans are similar to deltas and at times they are refered to as **dry land deltas**. Examples can be seen at Lume fan on the semliki river plain , Lumemo fan on R. Kilombero plain in Tanzania, Ombei on the Kano plains in Kenya.



8. Delta

This is a large , flat , low lying plain of alluvial deposits formed at the river's mouth (i.e sea or lake). Delta formation depends on the amount of sediments deposited relative to the amount removed by waves. Rivers with relatively large load and low speed near the mouth, form deltas. Deltas also form due to the coagulation of fresh water fine particles with the salty water in the sea. Successively deposited material builds up above the sea level forming a low platform called a **delta**. Deposited material interferes with the river's smooth flow forcing it to split into **distributaries**.

Conditions favouring the formation of a delta

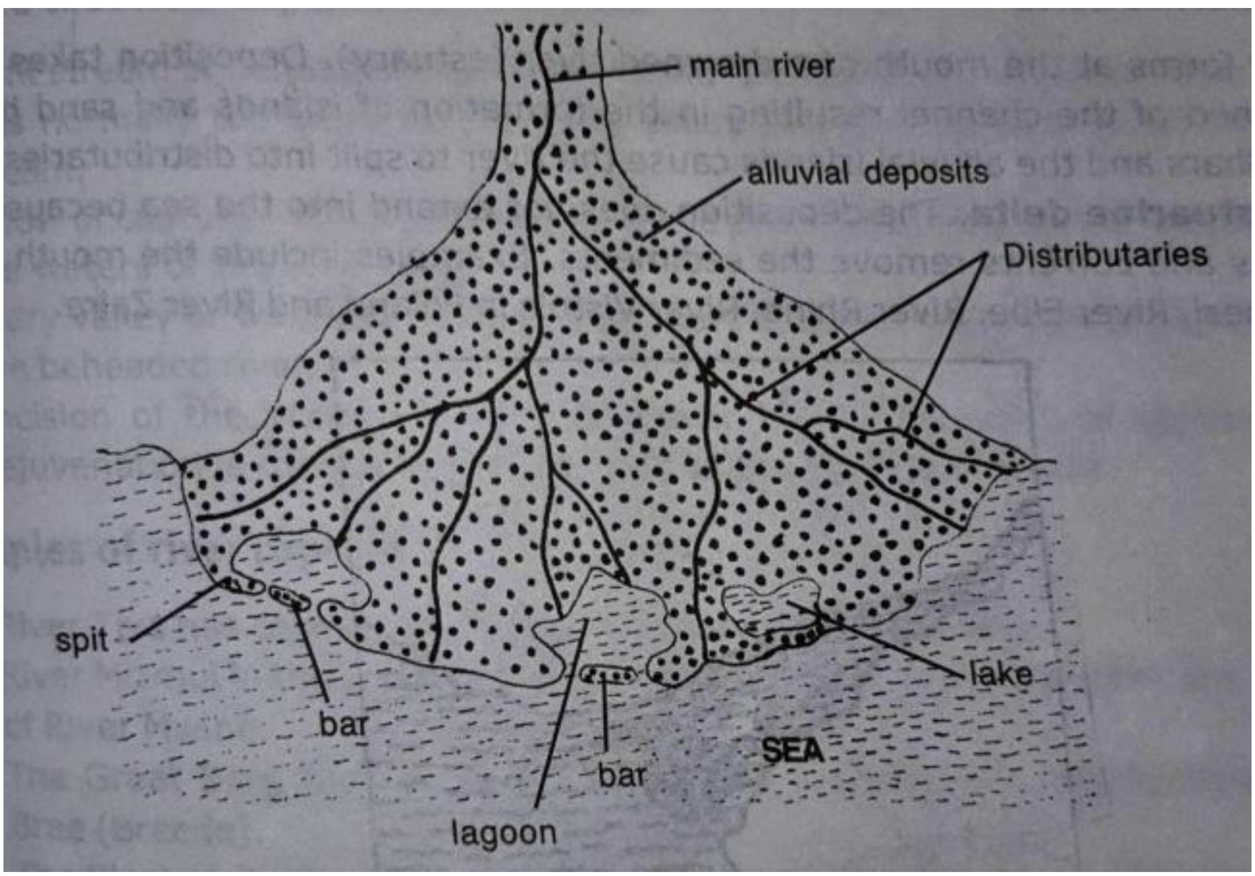
- Large quantities of sediments carried and deposited by a river.
- Large catchment area in which active erosion takes place to produce large deposits.
- Limited strength of marine waves to remove the deposited material. This allows the deposited material to accumulate .
- The gradient must be so low and gentle to allow deposition and accumulation of materials at the river's mouth.
- The sea or lake that is being joined by the river must be shallow for easy building up of the delta.
- River velocity must be low to allow deposition to occur at the mouth.
- The river's channel should be free of obstacles such as swamps, lakes etc. These act as filters and thus, reduce the quantity of sediments to be deposited at the river's mouth.
- Presence of saline water in the lake or sea into which the river flows to accelerate coagulation of deposited materials.

TYPES OF DELTAS

1. **Arcuate delta**

   This is a triangular shaped delta consisting of both coarse and fine materials such as gravel and sand . It has a convex, rounded sea ward extension due to the smoothening effect of the strong sea currents.

   Arcuate deltas are formed due to heavy and successive deposition at the river's mouth, causing the river to subdivide into numerous distributaries. The distributaries are prevented from extending into the sea by the strong sea currents. Examples include Sondu delta in Kenya , Rufiji delta in Tanzania, Nile delta , Niger delta etc



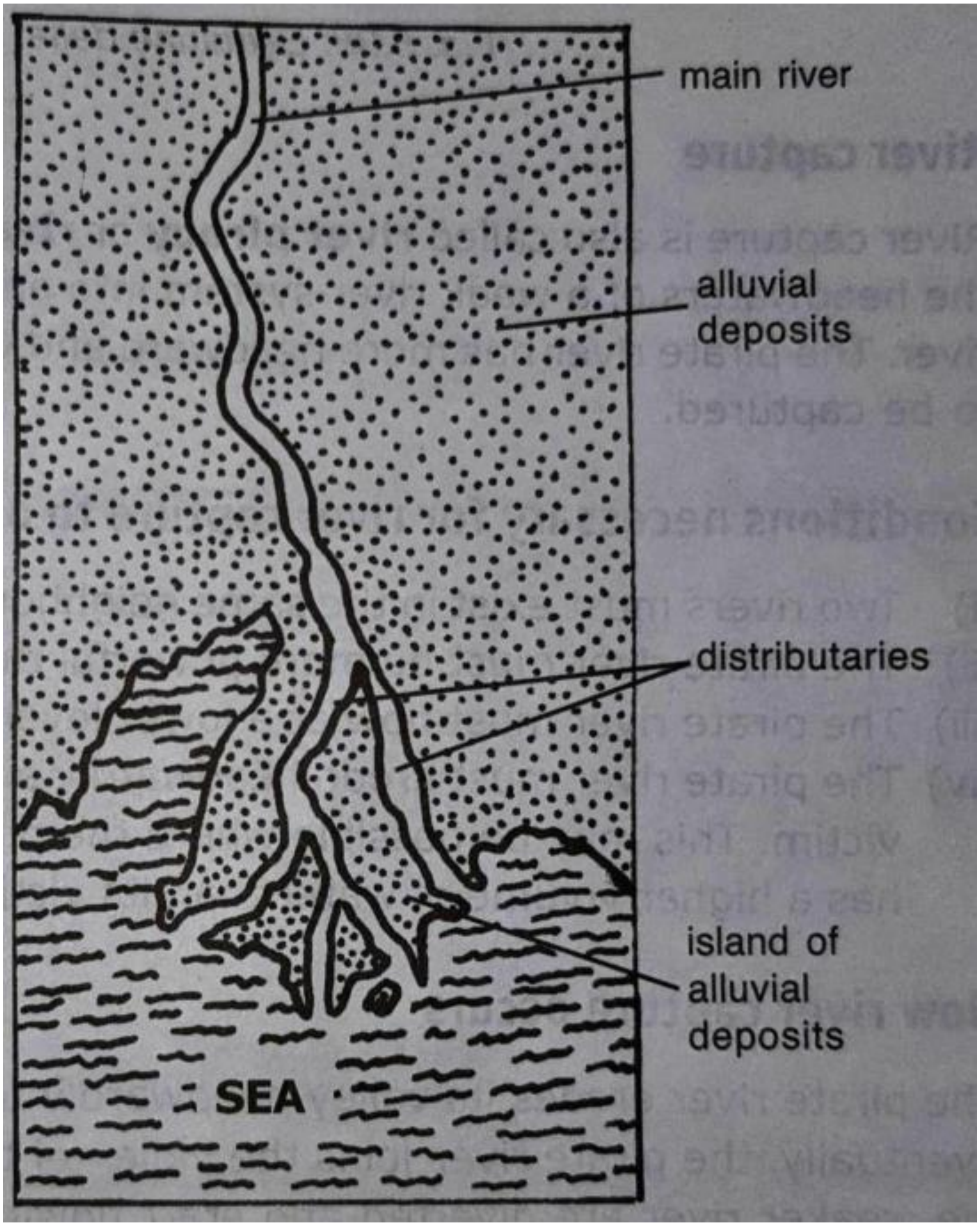
2. **Bird's Foot Delta**

   It is a delta with a few long distributaries projecting into the sea bed. Its finger like projections are bordered by levees and take a pattern of the bird's foot .

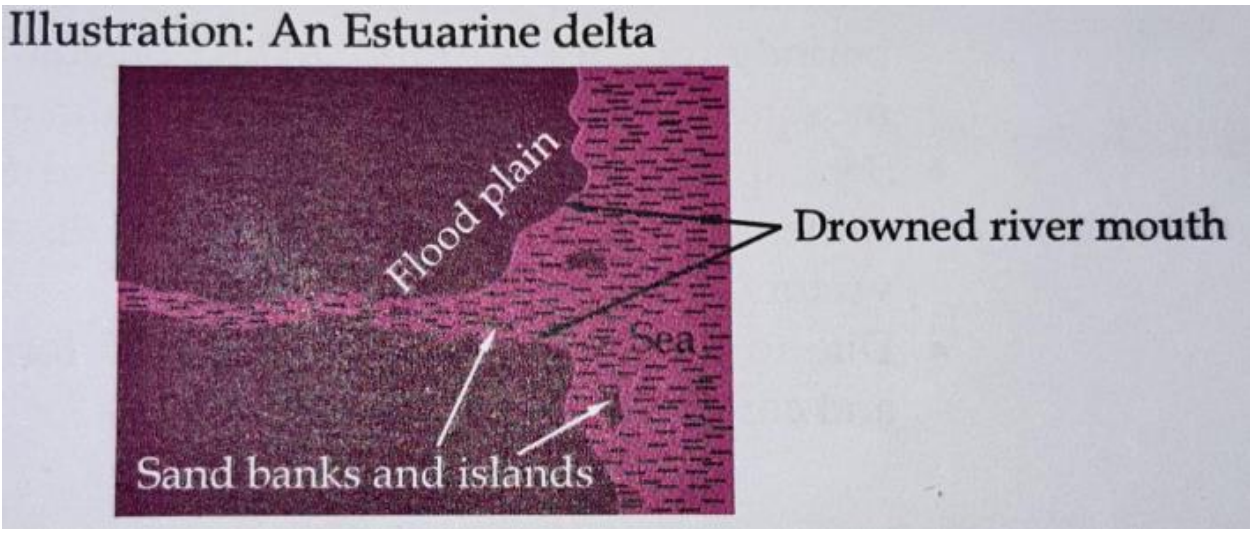
   They are formed by rivers carrying large quantities of fine material into the sea where wave energy is low to allow accumulation to take place.

   Also, the saline sea water may encourage the formation of the bird's foot delta since the less dense water of the distributaries is able to float on the denser sea water depositing deep into the sea to form the long projections.

   Examples include; R. Nyando delta in Kenya , R. Omo as it enters L. Turkana.


main river
alluvial
deposits
distributaries
island of
alluvial
deposits
SEA

3. **Estuarine Delta**
   This forms at the mouth of a drowned or submerged river. Deposition of material occurs in the submerged river mouth resulting into formation of islands and sand bars that cause the river to split into numerous distributaries forming an **estuarine delta**. Examples include R. Rufigi.



4. **Lacustrine Delta**
   This is an inland delta formed where the velocity of a river is checked on entering an inland water body or a flat land such as a swamp. An inland delta may form at a point before the river reaches its mouth. Example R. Nile where it joins L. Albert , R. Omo on L. Turkana.

Similarities And Differences Between Alluvial Fans And Deltas

Similarities

- Both are funnel shaped ie having an apex at the source.
- Both are formed due to river deposition.
- Both form where there is a considerable reduction in the gradient .
- They are associated with distributaries resulting from deposition.
- Both are formed where the river speed has reduced.
- Both form on rivers with large quantities of load.

Differences

- Deltas are associated with lagoons, bars while alluvial fans are not.
- Alluvial fans have a steeper gradient compared to deltas.
- Deltas are formed at the river mouth while alluvial fans develop on land far away from the mouth or sea.
- Deltas are formed in the old stage while alluvial fans can form anywhere along the course of the river i.e middle stage or upper stage.
- Deltas have more distinct distributaries than alluvial fans.
- Deltas are associated with the growth of swampy vegetation while alluvial fans are not.
- Delta formation is attributed to the absence of tidal currents, presence of sheltered bays, low depth, absence of obstructions upstream, differences in salinity . However such conditions don't apply to the alluvial fans formation .
- Delta's are mainly composed of fine sediments while alluvial fans are mainly composed of coarse sediments.

Importance of deltas

Positive

The swampy vegetation associated with deltas can be harvested for the craft industry e.g making mats etc

Deltas are at times composed of important minerals e.g oil in the Niger delta, Rufigi delta in Tanzania.

Deltas support the growth of mangrove forests which are important for building , fishing equipment such as the floaters e.g Rufigi delta.

Deltas are tourist attractions which earns foreign exchange for example Nile delta, Omo delta , Rufigi delta etc

Delta facilitate research and study purpose .

Delta's contain fertile alluvial soils suitable for farming e.g Nile Delta.

Delta lagoons contain silt that supports the growth of planktons which is food for fish , supporting the fishing industry.

Delta's attract dense settlement e.g Cairo city of the Nile Delta.

Negative

Deltas are good breeding places for mosquitoes and snails which cause malaria and bilharzia to man respectively.

The saline conditions associated with deltas reduce their productivity in terms of farming.

Too much deposition at the delta may hinder navigation.

Deltas are flat low lying plains that are subjected to flooding causing destruction of infrastructure, crop fields and settlement.

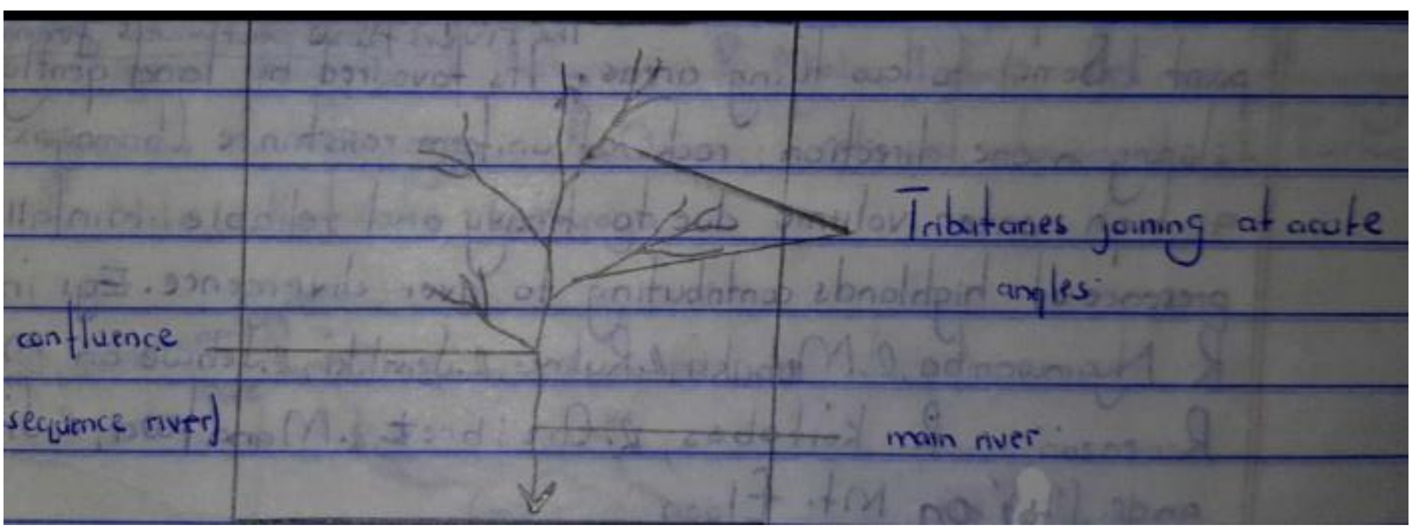
Questions

1. Examine the conditions that favour the formation of depositional land forms along a river.
2. (a) Examine the formation of deltas.
   (b)Explain the importance of deltas to man
3. Describe the land forms associated with flood plains along the river profile.
4. Describe the depositional landforms in the old stage of a river.
5. Compare deltas and alluvial fans in East Africa.

DRAINAGE PATTERNS

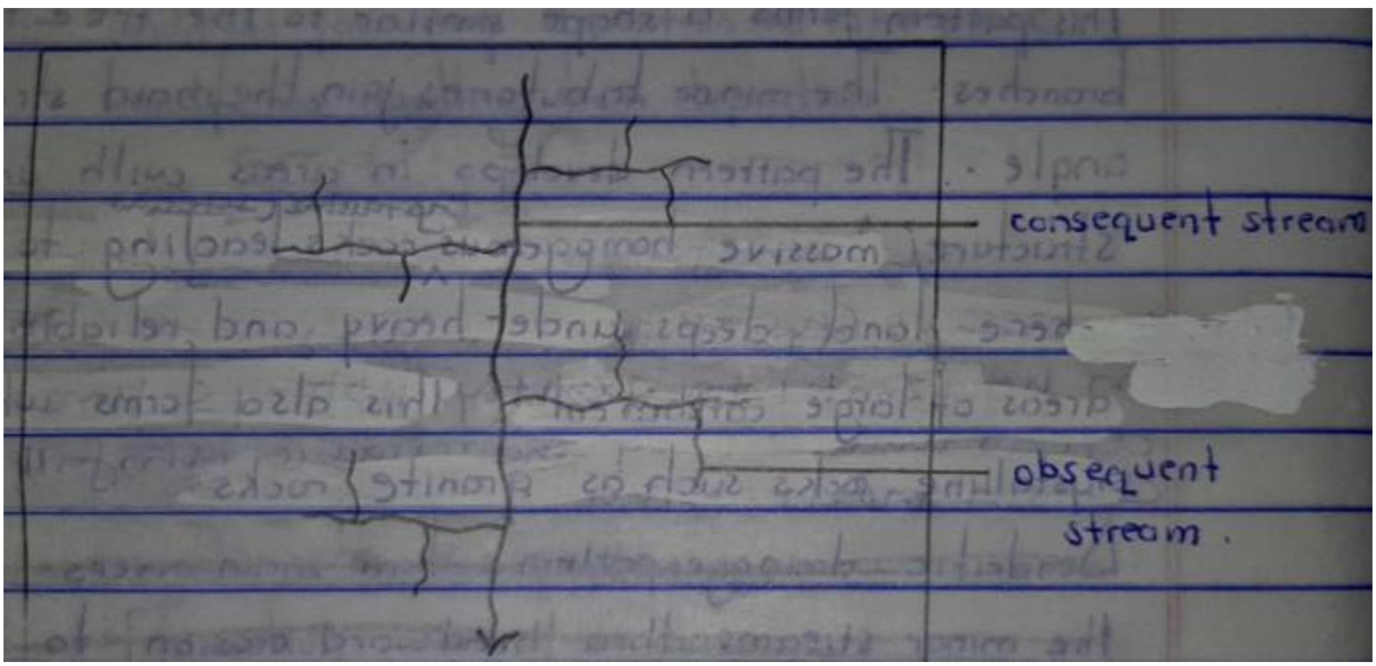
A drainage pattern refers to the layout/plan made by rivers and their tributaries on the landsdcape. Drainage patterns differ mainly according to the slope of the land, rock structure and differences in rock hardness. The main drainage patterns include; -

1. **Dendritic patterns**
   This pattern forms a shape similar to the tree trunk and its branches. The minor tributaries join the main stream at an acute angle. The pattern develops in areas with uniform rock hardness and structure (homogenous rocks) leading to uniform erosion, and on massive crystalline rocks such as granite . It also develops on horizontal to gently dipping sedimentary strata , in areas under heavy and reliable rainfall and a large catch ment area for example R. Rufigi, upper section of R. Nzoia, Victoria Nile, R. Ruvuma , R.Aswa , R. Namatala.



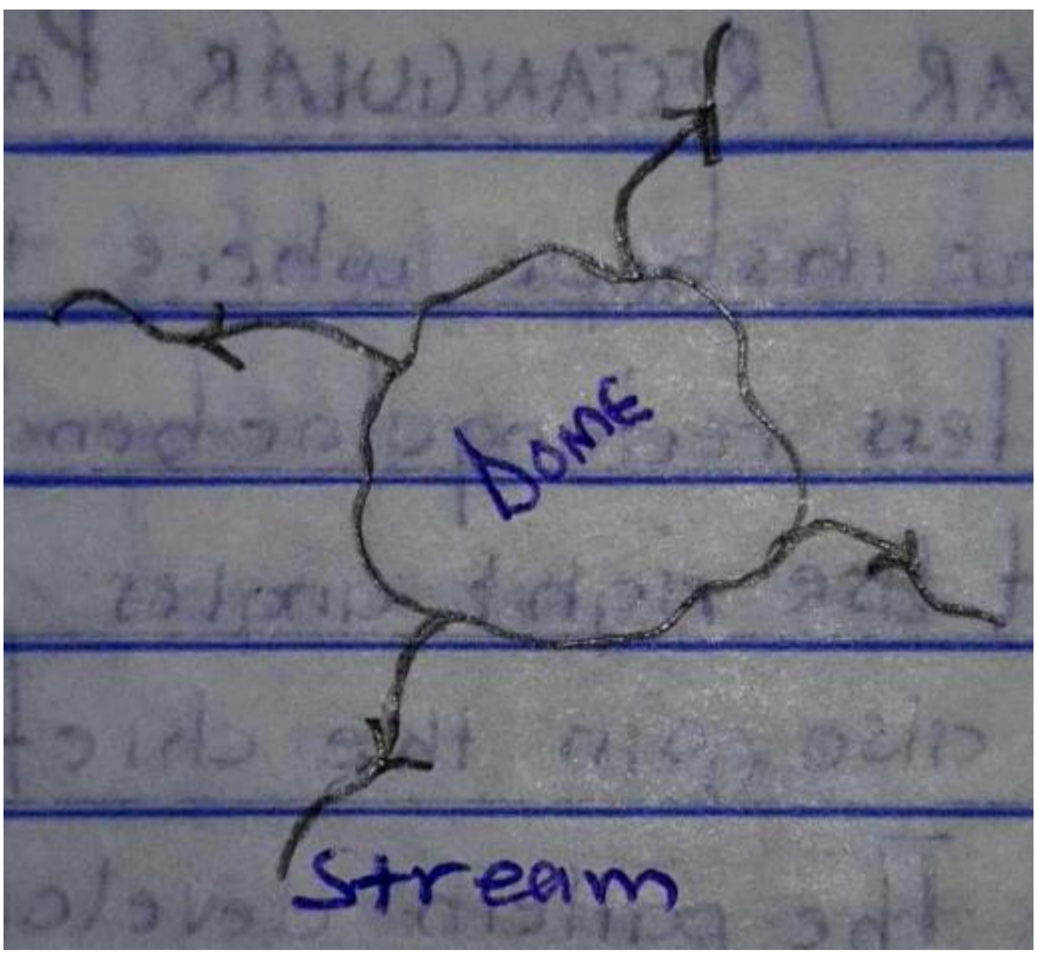
2. **TRELLIS/RECTILINEAR/RECTANGULAR PATTERN**

This is rectilinear in shape where the main stream takes sharp, more or less rectangular bends with tributaries joining it at almost right angles.
The minor tributaries also join the chief tributaries at more or less right angles. The pattern develops in areas that have been faulted, areas of alternating hard and soft rocks (heterogenous) , areas of heavy and reliable rainfall and large catchment areas.
Trellis pattern may also develop due to river capture where powerful rivers may drain water from others leading to abrupt change of drainage hence angularity. Examples include R. Tochi in Northern Uganda, R. Mayanja, Wasswa – Kato in central Uganda (Mityana – Mubende), R.Galana , and R. Athi in Kenya.



3. **Radial drainage pattern**

This is a pattern where rivers diverge from a common high point (Dome) to low lying areas. The rivers flow outwards forming a pattern like the spokes of a bicycle wheel . Its favoured by land gently sloping in one direction, rocks of uniform resistance (homogenous) , a high water volume due to heavy and reliable rainfall and presence of highlands contributing to river divergence. Examples include; R. Nyamwamba , R. Mubuku, R. Rukoki, R. Semliki, R. Sebwe on Mt. Rwenzori , R. Koitobos, R. Chelbrot, R. Manafwa , R. Sironko and R. Sippi on Mt. Elgon.



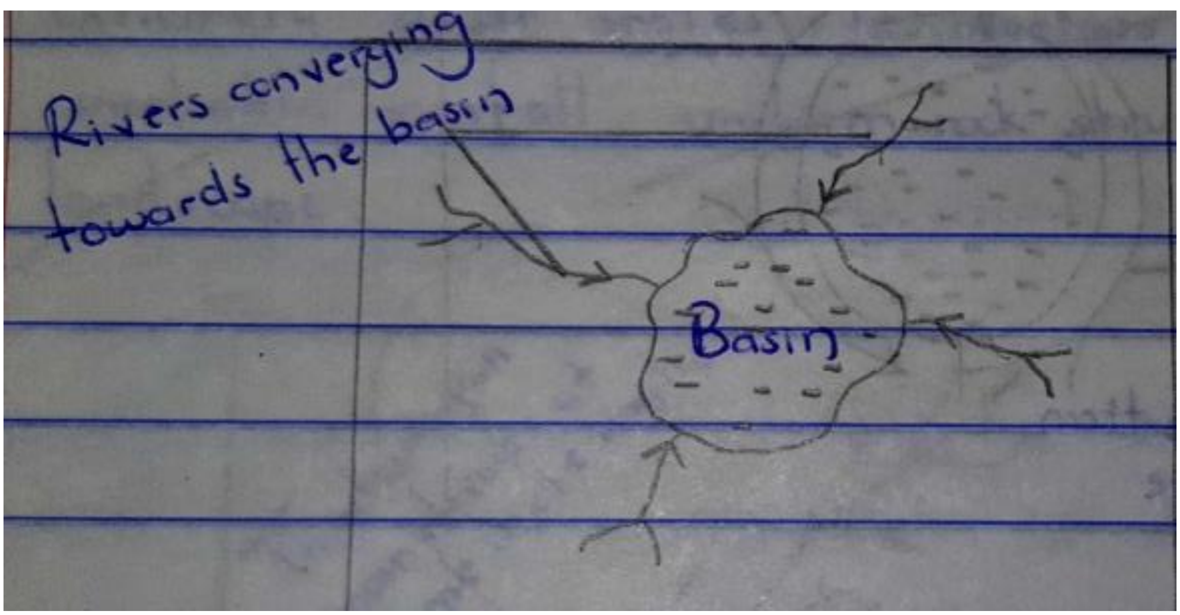
Questions.

Examine the conditions and processes responsible for the development of the following drainage patterns.

(i) Dendritic (ii) Radial (iii) Trellis

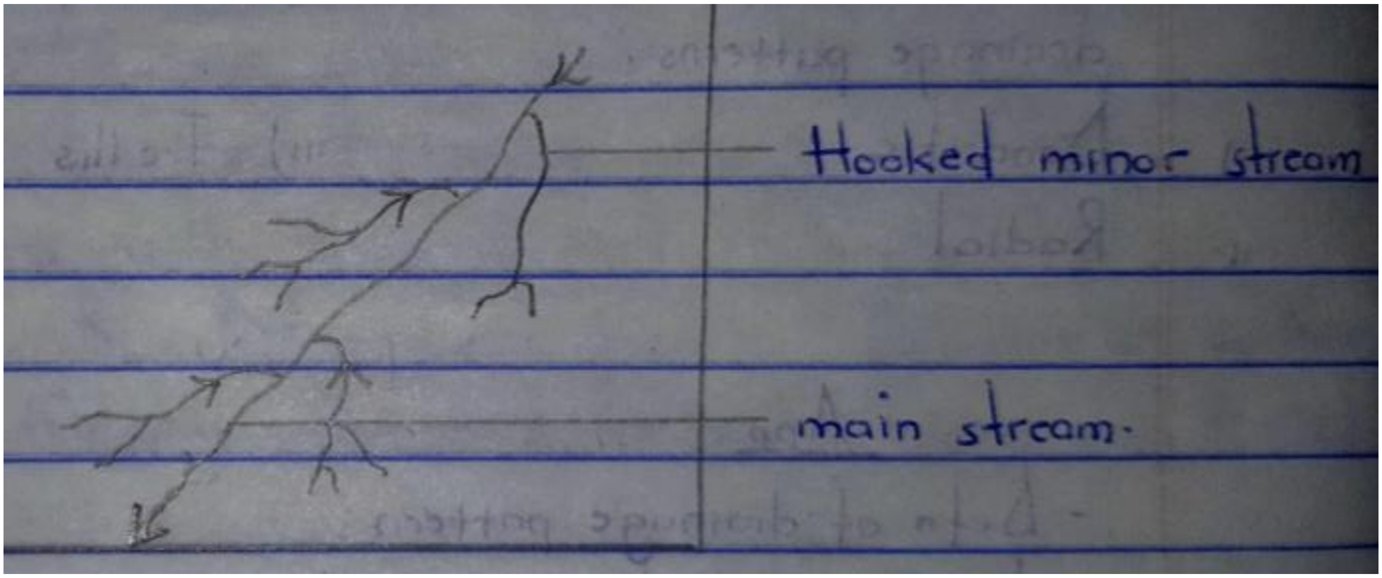
4. **Centripetal drainage pattern**

This is an arrangement where rivers flow from different directions and converge at a central point or basin such as a lake or swamp. This pattern occurs in basin areas and is controlled by the slope, heavy and reliable rainfall, relatively uniform structure gently sloping landscape towards the basin for example R. Nzoia, R. Katonga, R. Kagera towards L. Victoria, R.omo , Turkwel towards L. Turkana , R. Nile, Kafu to L. Kyoga, R. Molo , R. Loboi , R. Pekera flowing towards L. Baringo.



5. **Hooked/barbed drainage pattern**

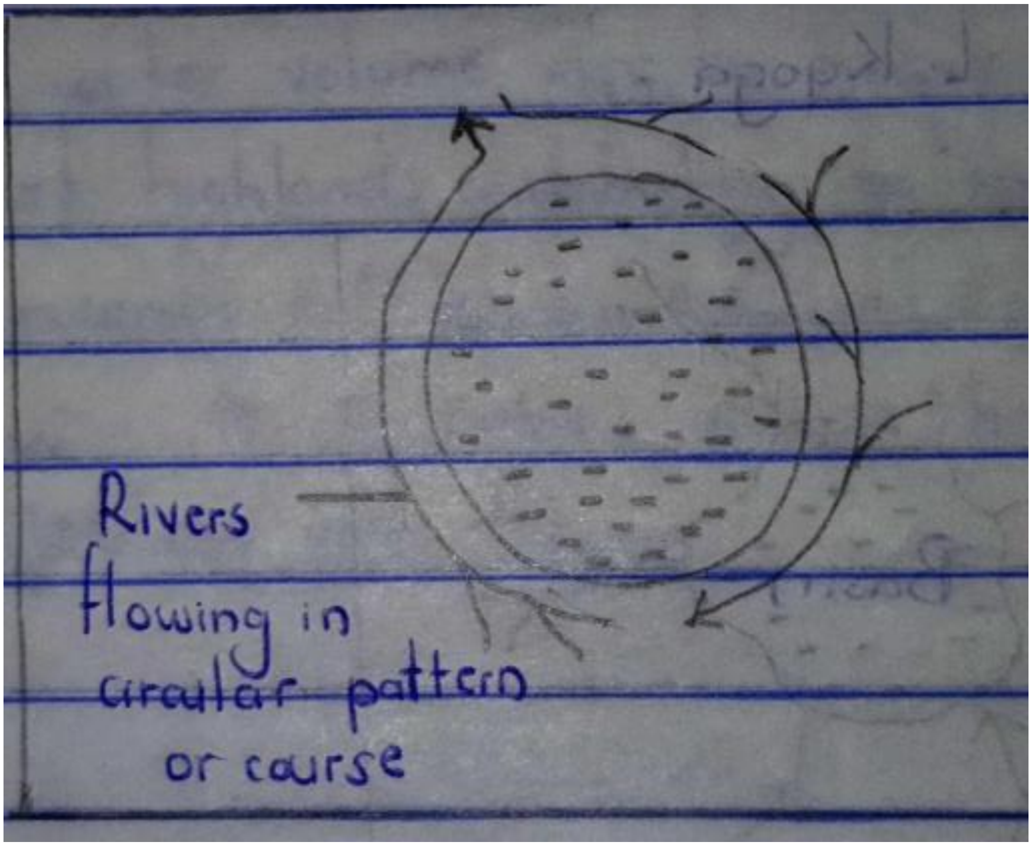
In this pattern tributaries flow in opposite direction to the main river before joining it in a hook shaped bend, at acute angles. It occurs in western Uganda as a result of drainage reversal for example R. Rwizi , Kagera , Kafu , Katonga .



6. **Annular drainage pattern**

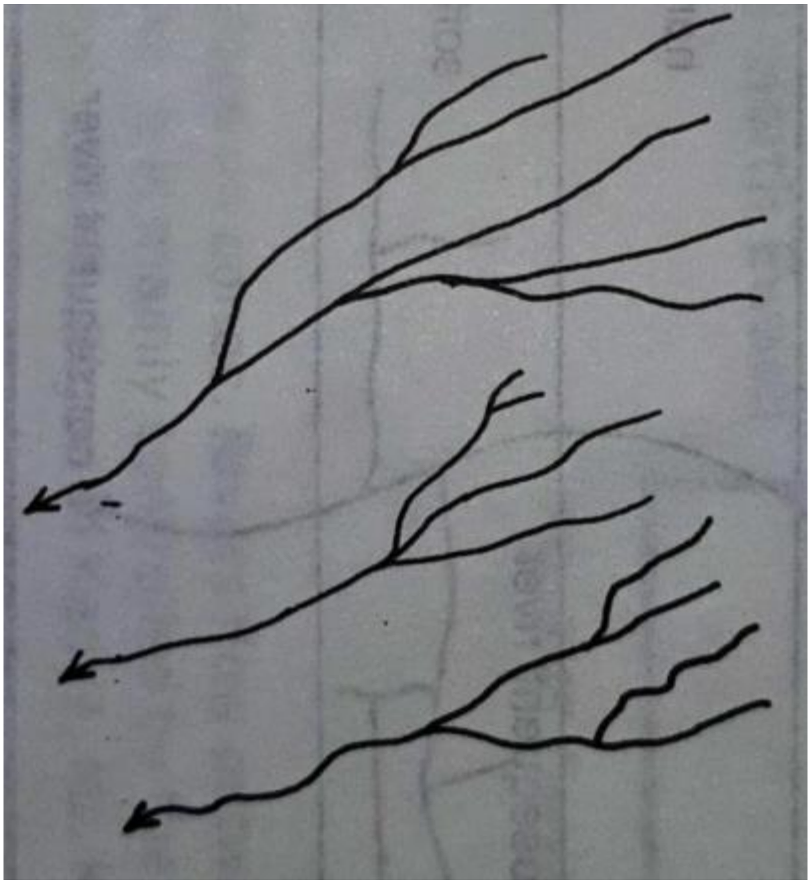
This is a type of drainage pattern where the main river and its tributaries are arranged in a series of curves around the basin or dome. Tributaries join the main river at sharp angles.

Annular pattern development is favoured by presence of a dome or basin with alternating hard and soft rocks, heavy and reliable rain fall. Examples can be seen around Ngorongoro caldera in Tanzania , Bukigai hill in Bududa ,Eastern Uganda and L. Bosumtwi with rivers Banko and Buonim in Ghana.



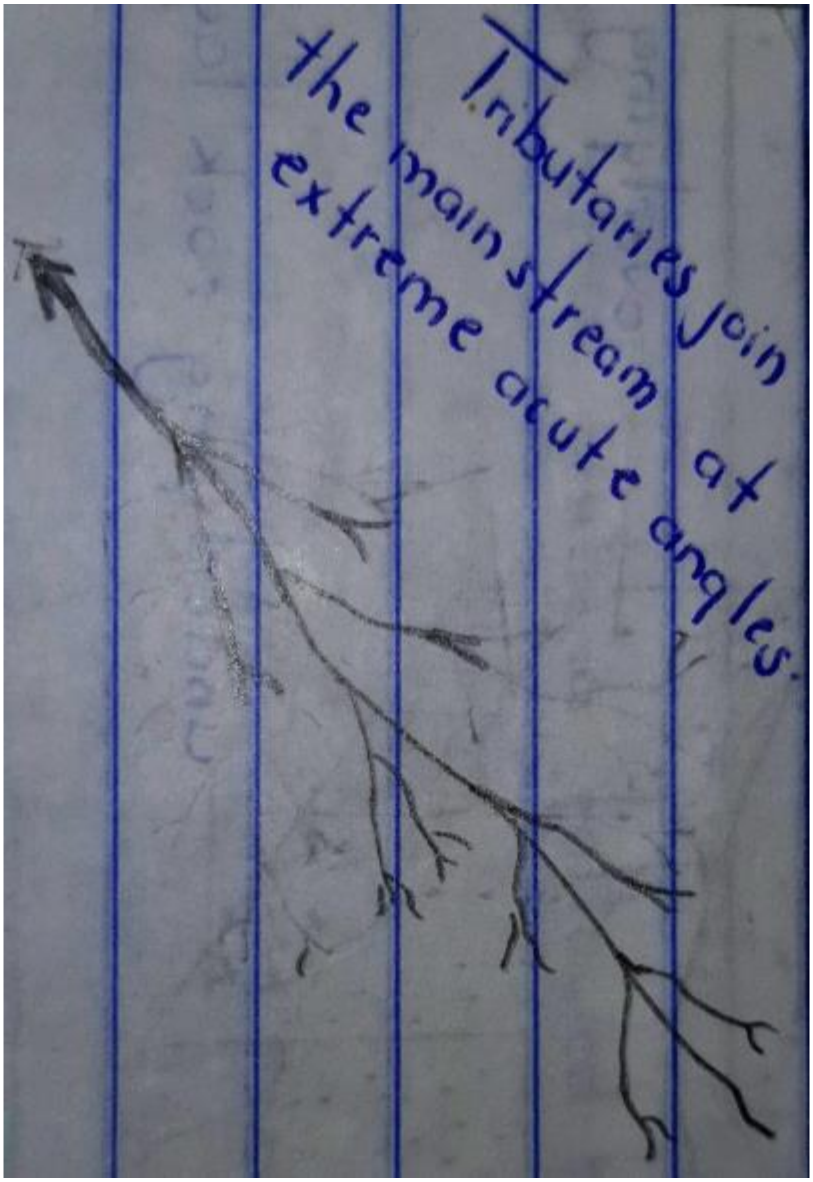
7. **Parallel drainage pattern**

   In this pattern , the main rivers and tributaries flow parallel to each other for long distances. The pattern developes on escarpments, in areas with alternating hard and soft rocks and on slopes dipping towards the same direction. For example R. Nkusi and R. Hoima are parallel to each other due to Butiaba escarpement, R. Athi & Ruiru flowing parallel to each in Kenya, Sondu and Nyando along the Mau ranges display a parallel drainage pattern .



8. Pinnate drainage pattern

This is a feather like pattern, consisting of a single main stream with short tributaries joining it at extreme acute angles. Its development is favoured by heavy and reliable rainfall, very gently dipping slopes and rocks of uniform resistance to erosion.


Tributaries join
the main stream at
extreme acute angles.

ACCORDANT & DISCORDANT DRAINAGE

Accordant drainage is where rivers show a direct relationship with a rock structure on which they are flowing.

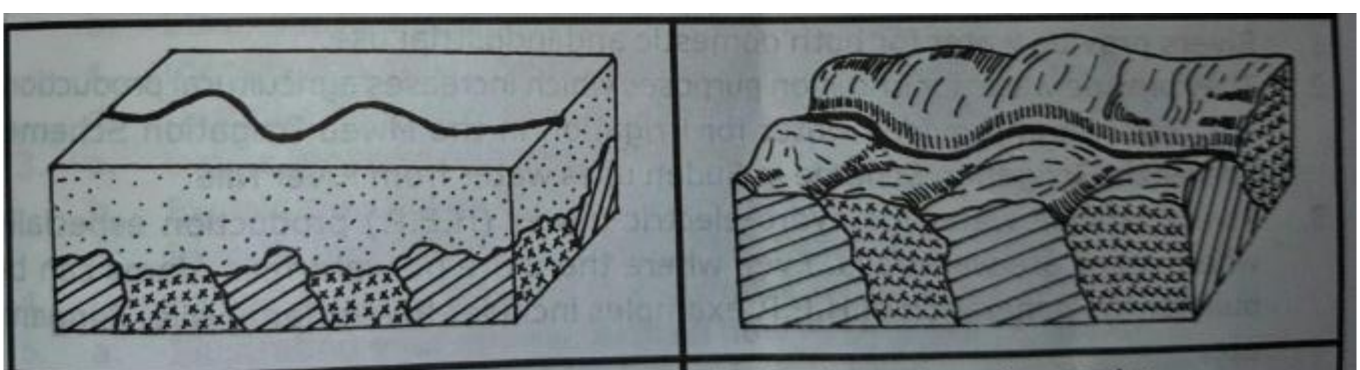
In East Africa , most of the rivers are accordant i.e their flow is determined by rock structure for example the faulted landscape of Mt. Rwenzori i.e R. Nyamwamba , (Annular , trellis, Radial centripetal, dendritic patterns, parallel , all show an accordant drainage)

On the other hand , drainage patterns without relationships with underlying rock structure are termed as **discordant**. Discordant drainage patterns are divided into two;

(i) Superimposed drainage

It refers to a river valley or part of river valley that originally developed on a layer of rocks that has now been removed by erosion. The erosion cuts through the surface layer of rocks on to the underlying rocks, exposing them to the surface. In this case, the river gets superimposed on to completely new types of rocks but maintains its original direction of flow.

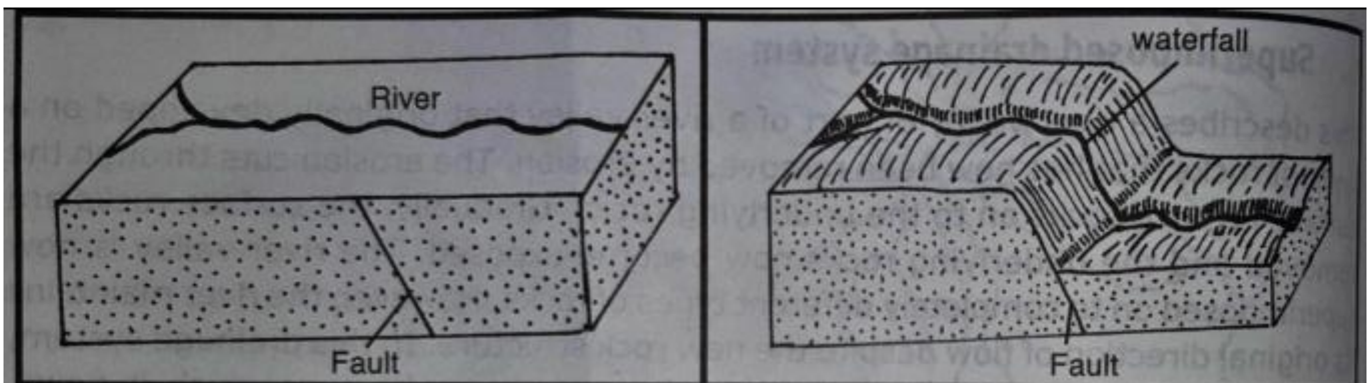
In this drainage system , the super imposed river valley is younger in age than the existing rocks over which it flows. Examples; superimposed gorge of the Nile at Sabaloka in Sudan.



(a) layers of rocks before erosion | (b) Rock structure after erosion

(ii) Antecedent drainage

The antecedent drainage pattern on the other hand, describes a river valley that was in existence before the present form of land scape. The river valley develops on a landscape which later undergoes local uplift due to faulting. As uplift occurs, the river maintains its direction of flow by eroding vertically at a rate faster than that at which land is uplifted. The under cutting by the stream leads to formation of deep, narrow gorges. The antecedent river valleys therefore are older in age than the rock structure over which they are flowing (discordant).They are common areas of recent earth movements for example R.Pangani, Kilombero which were down faulted along the Ushungwa escarpment. R. Malewa as it flows into Lake Naivasha, the Great Ruaha river in Tanzania , R. Birira at Mitano gorge in Uganda.



(a) landscape before uplift (b) landscape after faulting followed by uplift

FACTORS INFLUENCING DEVELOPMENT OF DRAINAGE PATTERNS.

1. **Rock structure/Nature of Rocks**

   Rock structure involves aspects of rock hardness, rock homogenity or heterogenity , rock stratification, rock jointing/faulting, the rock mineral composition, rock dipping etc. These aspects influence drainage pattern development in the following ways;

   Existence of hard and homogeneous crystalline rocks such as granite has led to the development of dendritic and radial patterns. Uniform rocks enable the rivers to erode uniformly creating a variety of tributaries.

   Heterogeneous rocks, with alternating hard and soft rocks lying almost at right angles to the general slope, encourage differential stream erosion to take place leading to the formation of trellis or rectangular pattern. Annular pattern forms where the soft and hard rocks lie in a circular form around the depression or dome. In cases of hard and soft rocks lie side by side , a parallel drainage pattern develops, where rivers flow by the side of each other for example R. Nkusi and R. Hoima.

   Jointed or faulted rocks have encouraged the development of trellis or rectangular drainage patterns where the main stream and its tributaries tend to follow rock joints or faultlines in the rock as seen on River Tana, Athi in Kenya , Mayanja , Kato – Wasswa in Uganda.

   Presence of impervious rocks structure in a catchment area encourages adequate drainage, causing a lot of run off in form of minor streams and main stream leading to development of dendritic drainage pattern as evidenced by R. Apwac and its tributaries in Kalongo, Northern Uganda.

   Steeply dipping rocks like on a dome shaped upland, encourage the development radial drainage patterns where the streams erode uniformly and downwards. For example on Mt. Suswa with rivers Ruiru, Ewaso –

Nyiro in Kenya , on Mt. Rwenzori with Mubuku river , Nyamwamba river, R. Rukoki etc.

Gently dipping rocks towards a central basin, with rivers flowing from the rims of the catchment area towards a common point, swamp or lake, encourage the development of centripetal drainage pattern. For example Lake Victoria with the Kagera, Katonga draining into it, R. Kafu draining into L. Kyoga.

2. **Relief/Nature of slope**

Highlands with steep slopes favour the development of radial drainage pattern. In most cases, the highland summits are water catchment areas for the streams and the steep slopes accelerate the downward movement of water, thus erosion of rocks to create channels along which the rivers flow to form dendritic drainage patterns. For example on Mt. Rwenzori with Nyamwamba, Mubuku, Chalanga rivers, Mt. Elgon with Sippi, Manafwa, Namatala, Chelbrot rivers.

Steep slopes such as escarpments existing between two drainage basins with force the rivers to flow parallel to each other forming a parallel drainage pattern . For example R. Hoima and R. Nkusi due to Butiaba escarpment.

Uplands/highland encourage the development of annular drainage pattern as they make the rivers to erode in a circular pattern.

Gently sloping landscape leads to the formation of dendritic drainage pattern. The gentle slopes enable the river develop several tributaries that flow in the direction of the slope. For example R. Rufigi , R. Malagarasi.

Presence of hills separated by wide valleys lead to the development of trellis drainage pattern. Tributaries tend to avoid the hilly areas and follow the easily eroded wide valleys, joining the main stream at right angles, hence forming a trellis pattern. For example R. Mayanja, Kato – Wasswa in Mubende , Uganda.

Lowlying areas, depressions or basins are associated with the centripetal drainage pattern development as the low lying landscape allows several streams to drain into it for example L. Victoria with rivers Katonga, Kagera.

Basins or depression also lead to the development of annular drainage pattern where streams erode in a circular pattern around the depression/basin for example L. Ngorongoro.

3. **Tectonism**

This has led to development of drainage patterns through processes of warping , faulting and vulcanicity .

Warping has led to the development of centripetal and barbed or hooked drainage patterns. Down warping in central Uganda formed depressions such as Victoria and Kyoga basins, which later encouraged several rivers from various directions to flow into them, forming centripetal drainage pattern. While the upwarped western Uganda and eastern rift valley shoulders forced rivers to divert their directions of flow forming a hooked/barbed drainage pattern. For example R. Kagera, R. Kafu, R. Katonga.

Faulting led to the formation of joints and faultlines that influenced the flow of rivers and their tributaries forming trellis and parallel drainage patterns.

4. **River capture**

River capture involves diversion of waters of a weaker neighbouring stream to a valley of a stronger stream. This leads to the development of trellis pattern, dendritic and barbed drainage patterns. For example when lower Tiva captured upper Tiva river in Kenya , a dendritic pattern formed.

5. **Climate**
   Reliable and relatively heavy rainfall in the catchment area or drainage basin is required for the evolution and continued existence of the main streams and its tributaries . This may result into formation of several drainage patterns such as dendritic , annular, rectangular etc. All drainage patterns require rain fall for their development .

Question.

1. Explain the influence of tectonic movements on the drainage system of East Africa.
2. Distinguish between super imposed and antiscendent drainage pattern.
3. To what extent has nature of rocks affected the development of drainage patterns in East Africa.

RIVER REJUVENATION

This is the renewal of the erosive power/activity of a river as a result of increased energy. Rejuvenation usually occurs in the middle or old stage of a river. A rejuvenated river flows very fast with high energy . The energy enables erosion of the bed to take place.

Causes Of River Rejuvenation

Rejuvenation may be caused by the following factors;-

1. **Increase in the river's water volume or discharge;**
   An increase in the river's water volume can result from;
   (i) Heavy rainfall;
   Prolonged heavy rainfall in the catchment areas increases the volume of water in a river channel leading to increased energy of a river, enabling it to renew its erosive activity resulting into rejuvenation.

(ii) River capture/piracy

When a river captures an adjacent weaker river or stream, the volume of water in the pirate river channel increases leading to increased energy to carry out erosion hence rejuvenation

(iii) Deglaciation

Melting of ice from gacial areas such as mountain tops of Rwenzori, Kilimanjaro and Kenya releases melt water into rivers, increasing their water volumes resulting into increased energy and therefore renewed erosive activity.

NB : This type of rejuvenation resulting from an increase in the river's discharge is termed as **static – rejuvenation.**

2. **A fall in the base – level/fall in sea level.**

   A base level refers to the lowest point to which a river can erode its channel and this is usually the sea or local lake. A fall in sea level creates a sharp break along the river's channel at a point close to the coast, resulting into steepening of the river's gradient. This increases the speed at which the river flows and its erosive activity.

   Afall in base level/fall is sea level can be caused by;-

   (i) Glaciation

   This occurs due to an extreme drop in temperatures (to freezing point) where water is removed from seas and locked up in form of ice caps and ice sheets. This results into a fall in sea level and lowering of the base level of the river. A steep gradient is created close to the coast which increases the river's speed and its ability to erode the channel.

   (ii) Earth movements such as ;

(a) regional uplift of land along the river's channel in relation to the sea, causes a gradual steepening of the river's gradient . This increases the river's speed and its ability to erode in order to reach the new base level.
(b) subsidence of the sea bed results into a fall in sea level, creating a steep gradient over which the river flows. This increases the river's speed, forcing it to erode vertically to reach the new base level.

NB : The type of rejuvenation resulting from a change in base level is termed as **dynamic rejuvenation.**

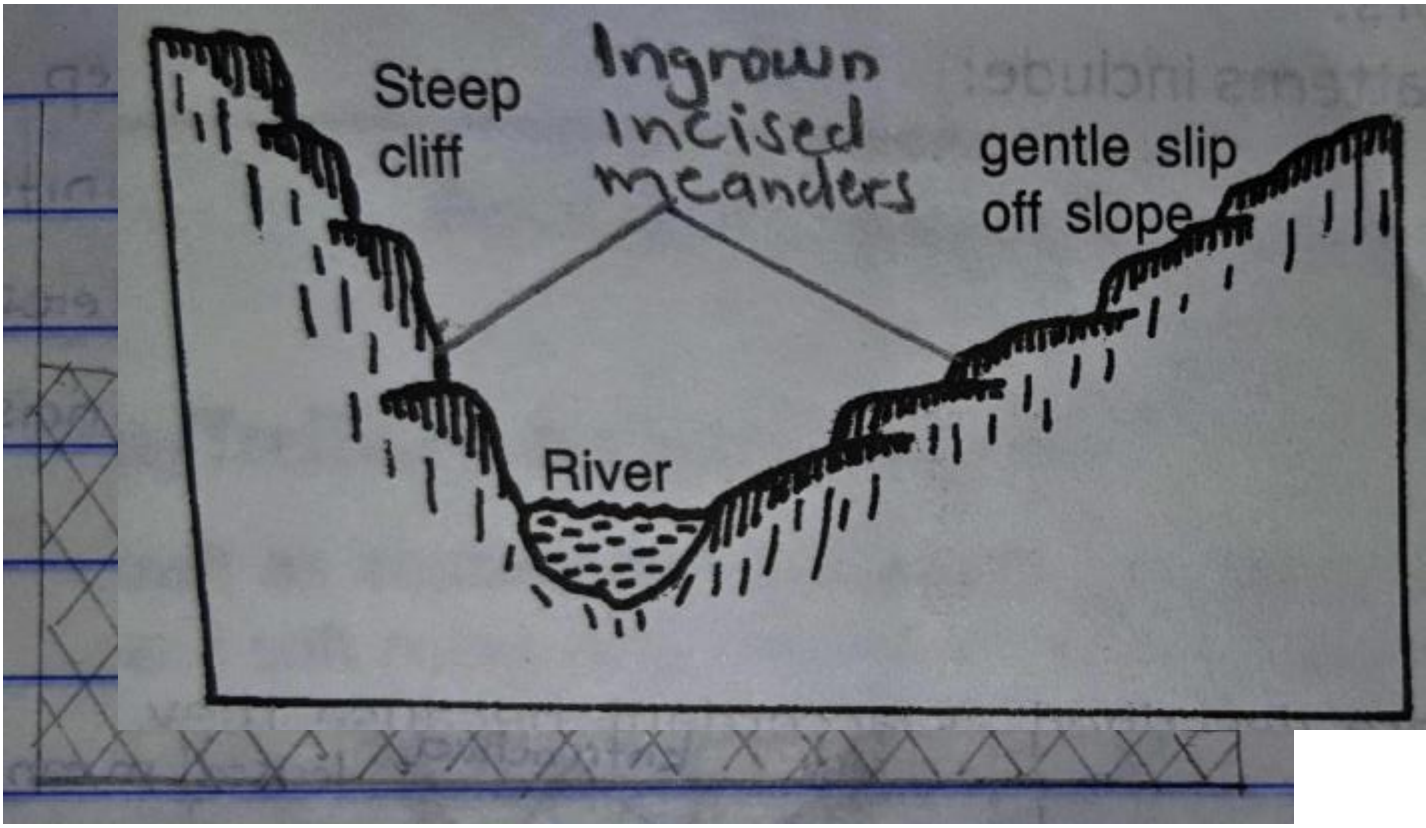
3. **Nature of basement rocks**
   Where a river flows over alternating soft and hard rocks, it will erode the softer rocks faster than the hard rocks to create a steeper gradient over which the river flows at a high speed resulting into a renewed erosive activity .

4. **Amount of load transported**
   If a river experiences a reduction in its load, its energy increases and starts eroding its bed, thus rejuvenation

Effects of river rejuvenation

i) Knick Point/Rejuvenation Head

This is a sharp break of slope along a river's course marking where rejuvenation started from. A knick point is a result of renewed down cutting and its associated with waterfalls and rapid formation . A knick point is a point where the river changes from the old valley to the new one. Knick points can be seen at Kabalega falls on R. Nile in Uganda, along R. Mwachi in Kenya.



ii) Incisedmeander

These are curved bend of a river that have been cut deeply into the bed rock as the renew its erosive power. Incised meanders usually result from vertical erosion of an already meandering river e.g along R. Rwizi, Mpanga , Mwachi, Ngaila, Nyando etc.

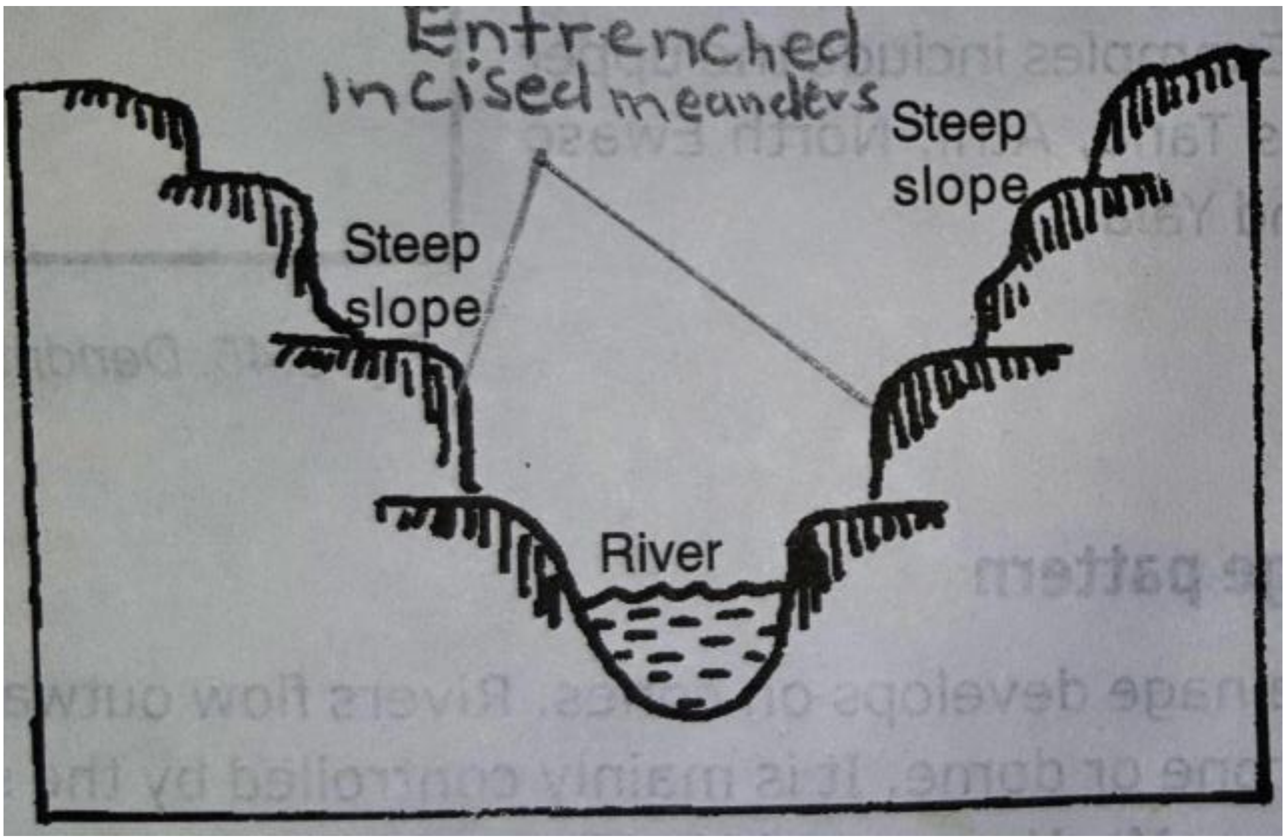
There are **two** types of incised meander and these include;-

(a) Ingrown incised meander

This has asymmetrical river profile/river valley i.e one side of the meander is steeper than the other. In grown incised meanders develop due to differential erosion over rocks of different resistance and where base level falls slowly thus meanders tend to shift laterally as they are incised for example along R. Mwachi in Kenya, R. Nkomazi in Tanzania , R. Manafa, R. Mubuku.

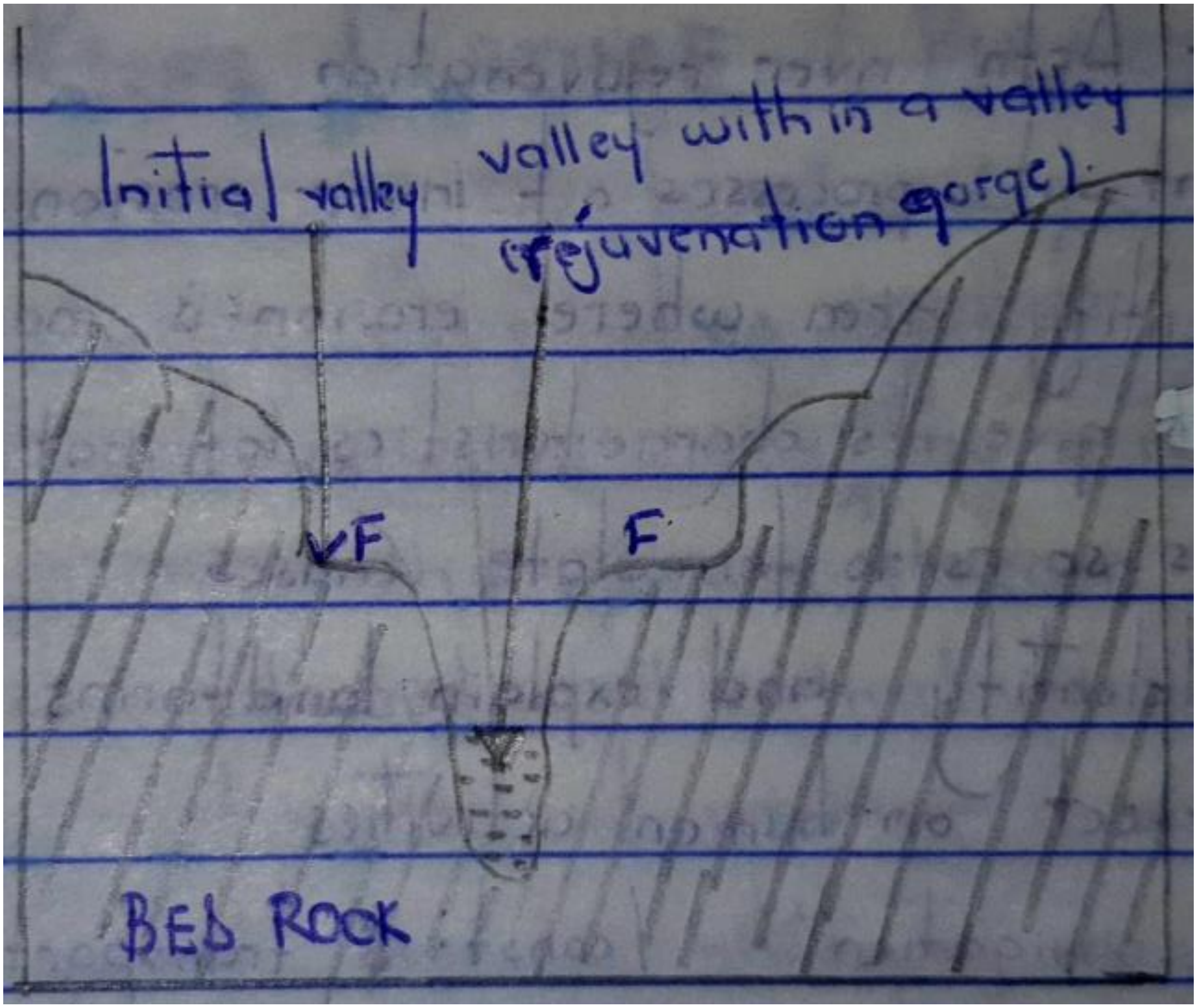
(b) Entrenched incised meander

This is a river valley with symmetrical steep sides. It develops on weaker rocks that are eroded faster and uniformly. It can also be formed where base level falls and rapid vertical erosion occurs along the river meanders resulting into an entrenched incised meander. Examples include; R. Mwachi, R. Chua Simba, R. Kombeni in Kenya.



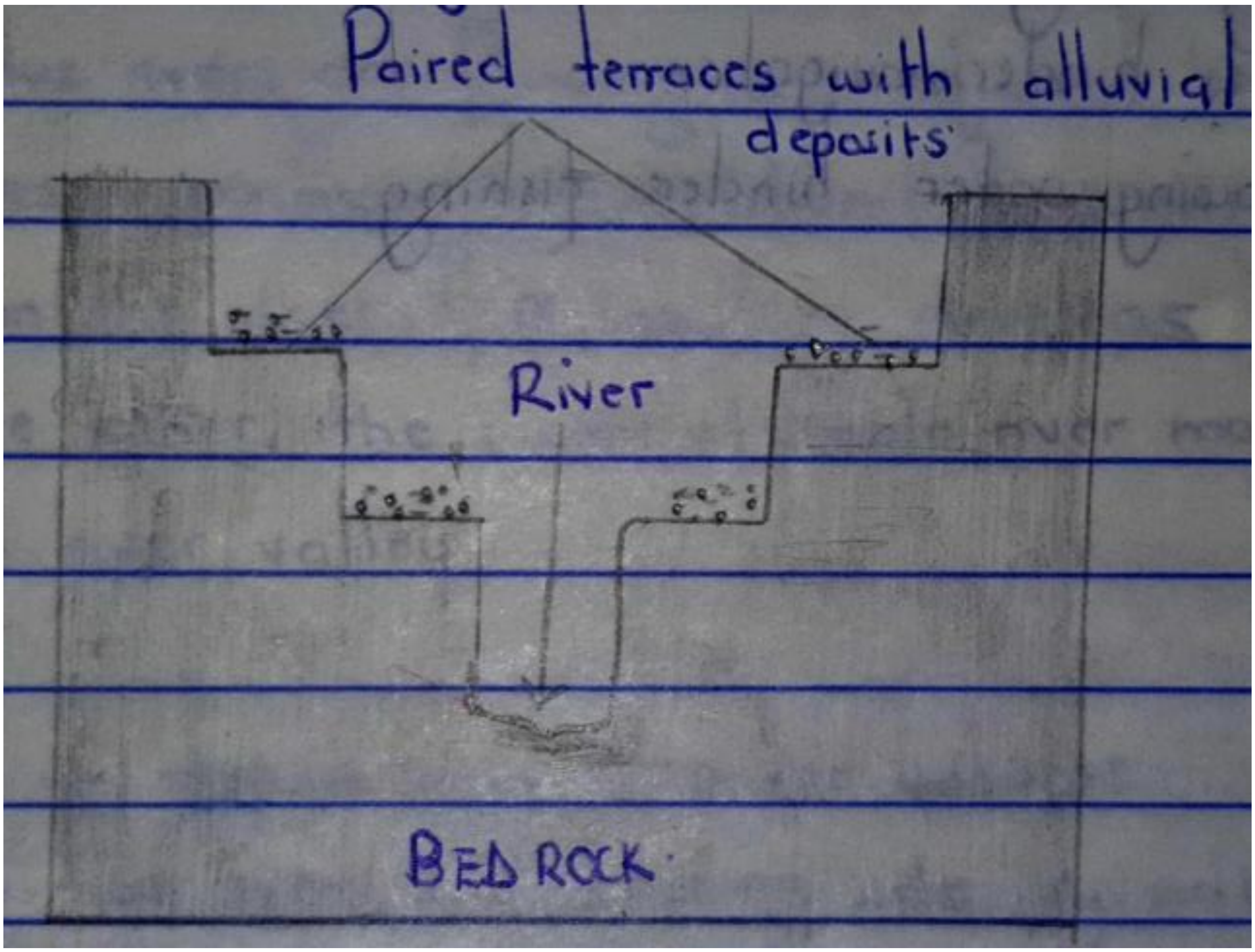
iii) A Valley With in a Valley

This is a steep sided and narrow valley which develops rapidly along a river where rejuvenation is so rapid and a fall with in base level is extremely large. As a river rejuvenates it cuts the old river bed to form a valley with in a valley (rejuvenation gorge) for example R. Rwizi, R. Nyando, R. Ngaila.



iv) **Paired River Teracces**

These are step like cuts on the sides of a river valley covered by a layer of gravel and alluvial material. When a river rejuvenates, it cuts deep into the former flood plain creating step like features or bench like features known as **terraces**. Paired river terraces occur at the same heights along the river valley on either sides . They result when base level falls successively forming a series of terraces for example along R. Nyando, R. Ngaila and R.Rwizi.



Questions

1. Examine the effect of river rejuvenation on land form evolution in East Africa.
2. Examine land forms resulting from river rejuvenation and their effect on human activities in East Africa.

RIVER CAPTURE/PIRACY

Refers to the diversion of the headwaters of a weaker river into the system of an adjacent more powerful river able to erode its valley more rapidly than itsweaker neighbor. The **pirate stream** (capturing river) through rapid head ward and vertical erosion, captures and diverts to itself the head waters of another weak stream (**misfit** or **beheaded stream**) thereby enlarging its own drainage area and diminishing that of the other (weaker stream).

Causes of River Capture

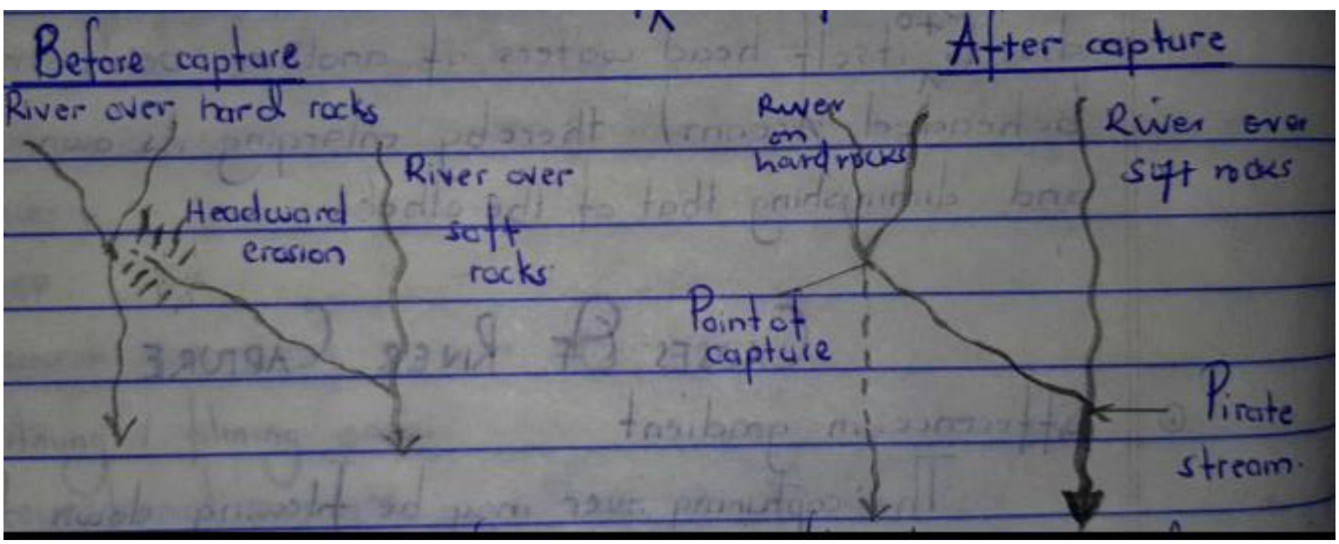
1. **Difference in gradient**
   The capturing river flowing down to a much steeper gradient than its victim will have greater erosive ability and it will certainly capture the adjacent weak river that flows down on a gentle slope by cutting across the water shed.

2. **Rejuvenation**
   If two rivers are flowing one adjacent to another and one of the rivers experiences rejuvenation, its valley bed will be eroded lower than the other. If a tributary develops from the rejuvenated river to the other, the water of the stable river may be diverted into the rejuvenated river valley.

3. **Differences in water volume**

If two rivers are flowing side by side over the homogenous rocks and one of the river has more water than the other it will have more ability to erode its valley lower than the river having less water volume. If a tributary stream develops from the more powerful stream to the weaker stream, the head water from the weaker stream will be diverted into the valley of a more powerful stream for example R. Nile captured the water of R. Tochi, R. Okole, R. Arocha in this way.

4. **Difference in rock hardness**
   When two rivers are flowing over heterogenous rocks, the one flowing over weaker /softer rocks will erode its bed faster than the one flowing over hard rocks. If a tributary develops from a river flowing over softer rocks with a deeper valley towards one flowing over hard rocks, the head water of the river flowing over hard rocks will be diverted into the valley of a river flowing over softer rocks.



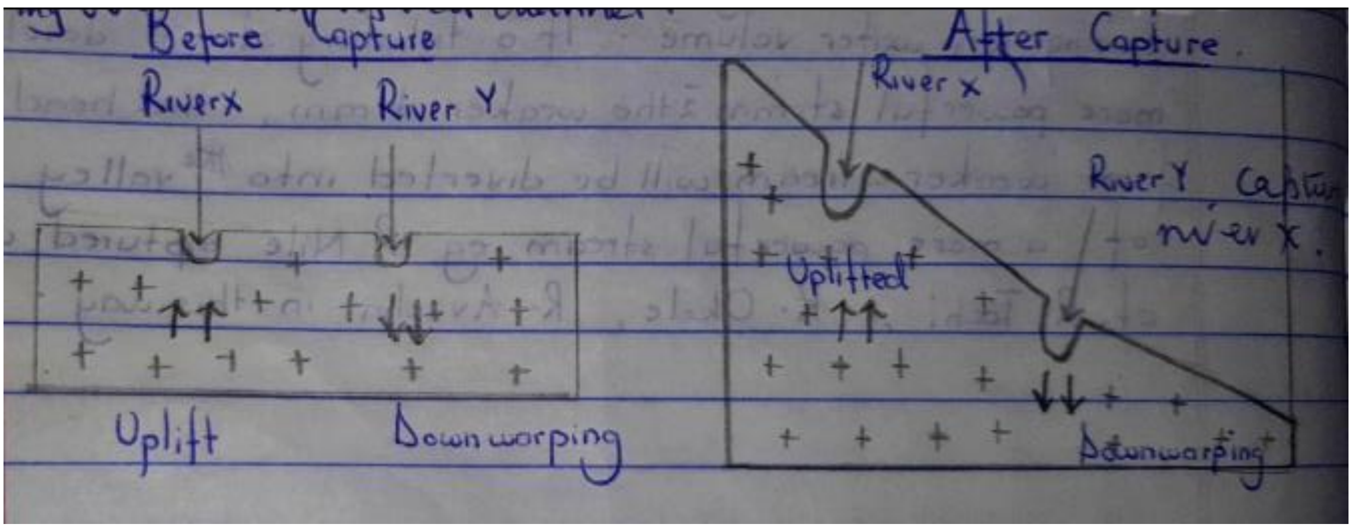
Example include R. Wasa flowing over soft rocks captured R. Nyabaroga in Fort portal (Kabarole) .

5. **Rock jointing**

Where the capturing river is flowing over well jointed rocks and its able to deepen its valley while the captured river flows over massive rocks.

6. **Earth movements**

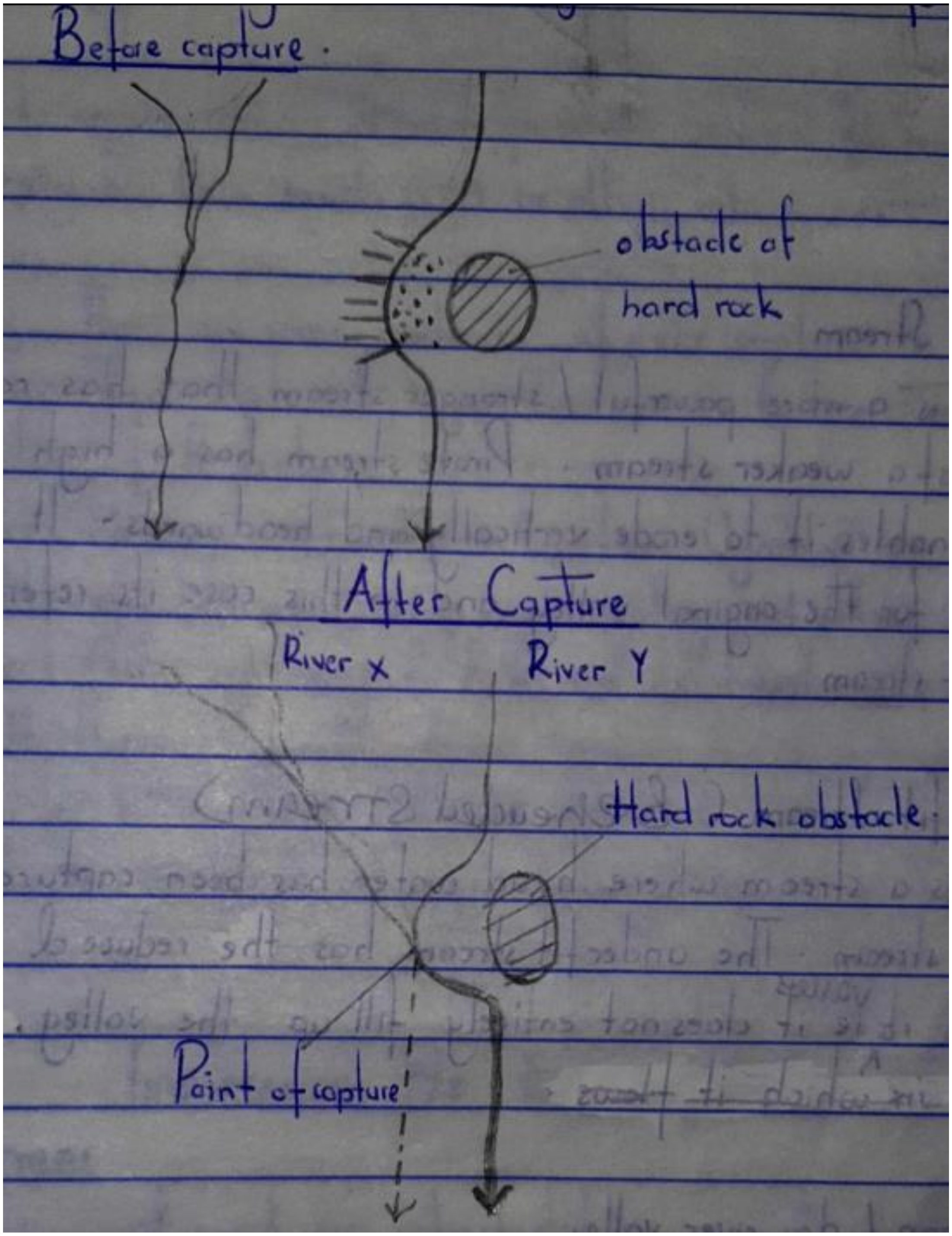
   It there are two rivers flowing adjacent to one another under similar conditions, uplifting or down warping will result into river capture. if down warping takes place along the course of one river, its bed will now be much lower than that of the adjacent uplifted river. A river flowing over a downwarped channel may extend its valley by headward erosion and capture the waters of the adjacent weaker river flowing over an uplifted channel.



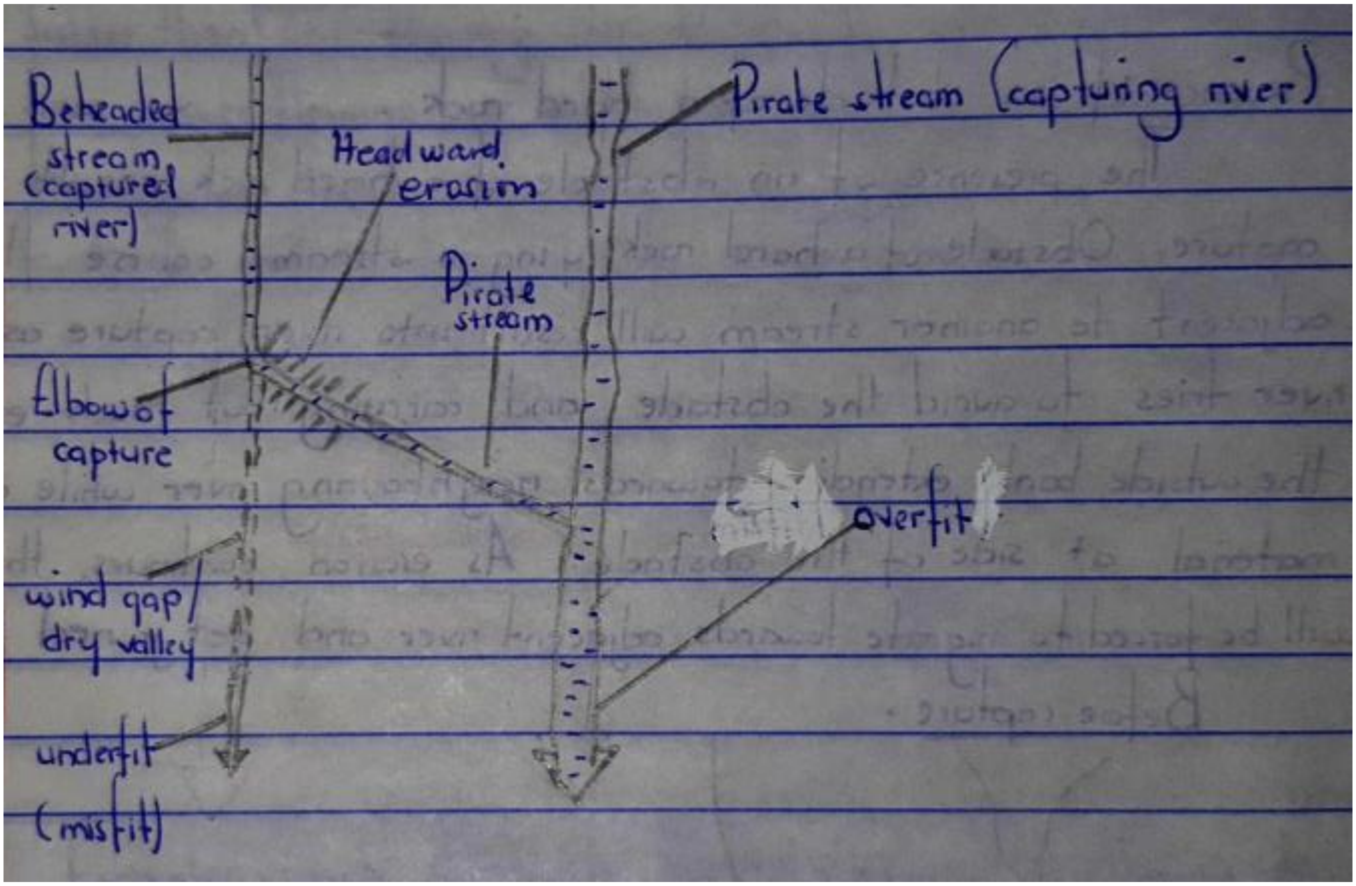
Head waters flowing from River X to River Y. for example R. Birira captured R. Rwizi due to earth movements.

7. **Presence of an obstacle of a hard rock**

The presence of an obstacle of a hard rock results into river capture. Obstacle of a hard rock lying in stream's course flowing adjacent to another stream, will result into river capture as a river tries to avoid the obstacle and carrying out much erosion on the outside bank extending towards the neighbouring river while depositing material at the side of the obstacle. As erosion continues, the course will be forced to migrate towards the adjacent river and get joined together resulting into river capture.



Features Of River Capture



1) **Pirate stream**
   This is a more powerful/stronger stream that has captured the water of a weaker stream. Pirate stream has a high water volume that enables it to erode vertically and headwards. It has higher water volume for the original valley and in this case its referred to as an **over fit stream.**

2) **Underfit stream (Beheaded stream)**
   This is a stream where head water has been captured by the pirate stream . The underfit stream has reduced water volume flowing through its valley i.e it does not entirely fill up the valley in which it flows.

3) **Wind gap/dry river valley**

This is a valley of a beheaded stream below the point of capture (elbow of capture). Its either dry or swampy due to the loss of much of its head water to the pirate stream. The floor of the valley may be occupied by alluvium.

4) **Elbow of capture/point of capture**
This is a right angled sharp bend formed at a point where the head water of the captured stream flows into the pirate stream.

5) **An incised valley/gorge/rejuvenated valley**
Undercutting of the pirate stream near the point of capture due to increased water volume, produces a steep and deep valley known as a **gorge/incised valley.**

6) **Knick point**
This is a sharp break in the slope created near the point of capture due to rejuvenation that erodes the pirates valley deeper than its victim's valley. Water from the stream flows down sharply/ steeply on this knick point resulting into a water fall.

NB: There are some evidences of river capture on East African drainage .

(i) Lower Tiva caputed upper Tiva river in Eastern Kenya , formerly a tributary of R. Galana .
(ii) Rivers flowing westwards in Western Uganda e.g R. Mpanga.
(iii) R. Ntungu occupies a very wide valley indicating it's a misfit.
(iv) Albert Nile capturing R. Kafu and its tributaries i.e Tochi and Koli.
(v) In Northern Uganda, Aswa drainage basin captured R. Agago, R. Moroto and Pager river.
(vi) R. Ruaha captured Pawaga drainage basin in Tanzania.

IMPORTANCES OF RIVERINE FEATURES TO MAN

Positives

- Clay and sand are extracted from river flood plains for constructing and pottery work for example from R. Manafwa. River deltas may also contain other valuable minerals for example oil in the Niger delta.
- The swampy vegetation around rivers is an important source of raw materials for art and craft industry e.g basket and mat making along R. Lubigi on Hoima – Kampala road.
- Rivers are used for study and research purposes for example along R. Nile .
- Form natural political boundaries in the regions.
- Rivers act as habitats for aquatic life such as fish and this promotes the fishing industry.

Rivers are associated with various unique features for example waterfalls , ox-bow lakes, meanders. These act as tourist attractions and this earns foreign exchange to the country for example Bujagali falls and Sezibwa falls in Mukono.

Waterfall points on rivers are suitable sites for generation of Hydro Electric Power which in turn promotes industrial development and provision of power used for domestic purposes. For example on R. Nile , R. Tana , R. Pangani.

River deltas and flood plains contain fertile alluvial soils that are suitable for crop growing for example on Doho scheme on the flood plains of R. Manafwa , cultivation on the lower Nile in Egypt.

Rivers are sources of water for industrial, domestic and agricultural purposes. Many rivers have been tapped for irrigation purposes for example the White Nile for irrigation on Gezira scheme in Sudan, R. Kilombero for Kilombero sugar plantation in Tanzania, R. Nile also supplies water to industries for example Nyanza textile industry , Nile breweries in Jinja ,Uganda.

Rivers act as natural transport routes for example ferries across R. Nile .

The lower parts of rivers support growth of forests (swampy vegetation) eg mangrove forests at the mouth of R. Rufigi. These are sources of timber for building and construction.

Rivers are used for recreational purposes for example boat racing, rafting along R. Nile.

Mature river valleys attract settlements for example the Kano plains in Kenya , Doho plains in Uganda.

Negatives.

They harbour disease causing vectors for example snails which cause bilharzia and mosquitoes for malaria along the flood plains of R. Manafwa, R. Rufigi, R. Rwizi etc

Some rivers flood leading to loss of lives and destruction of settlement , infrastructure and crop fields for example in lower Manafwa river , lower Nyamwamba river.

Rivers hinder construction of roads and railways Where roads and railways are constructed, high costs are met in constructing bridge for example along R. Nile.

Questions

1. Describe the features commonly associated with rivers that flow in a wide flood plain.
2. Examine processes leading to formation of River delta.
3. With the aid of diagrams and specific examples from E. Africa , account for the formation of any **three** of the following;
   (i) Plunge pool
   (ii) Braided channel
   (iii) meander
4. With reference to East Africa , write short notes on any **three** of the following;
   (i) River terrace
   (ii) Meandering
   (iii) River capture
   (iv) Radial drainage pattern
   (v) Dendritic drainage pattern