"Heaven's Light is Our Guide"

Rajshahi University of Engineering & Technology

Dept. of Civil Engineering

Course No: CE 2203

Course Name: Geology and Geomorphology

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2018

Q.1(a) What are the characteristics of a mature stream?

(b) Discuss the methods of transportation work of rivers.

(c) Write short notes on : (i) Alluvial rivers
(ii) Bed-rock channels.

Answers

a) Characteristics of mature streams:

i) Flood plain with natural levees

ii) Meanders with abandoned meander scrolls, cut offs and oxbow lakes.

iii) Width of valley equal to or greater than width of meander belt.

iv) No rapid or falls

v) Slow moving currents of muddy water

vi) Subdued valley walls, with deep soil cover and few rock outcroops

vii) No lakes except oxbow lakes.

b) Methods of transportation work of riveros:

Riveros transport their load in four different ways eg.

i) By traction: The haviero and large rock fragments like gravel, pebbles etc are forced by the flow of water to roll on the floor of the channel. These fragments can be seen rolling, slipping and bumping. This is known as traction.

ii) By saltation: The fragments of the rocks move onward by jumping continuously. This is called saltation.

iii) By suspension: When the rock fragments fall in the stream, their weight is reduced by the buoyancy of water. Usually the relative density of rock particles is 2.5. Their weight in the ~~rivero~~ water is reduced by 2/5. The reduced weight of the fragments keeps them in suspension. The suspended rock particles are clay or silt. 90% of the load in the Mississippi rivers is found in suspension.

iv) By Solution: Some parts of rock fragments are dissolved in the stream water.

c) i) Alluvial rivers: Alluvial river develope in the regions of sedimentation or alluviation i.e. where thick deposits of sediments of mostly fluvial origin have taken place.

These rivers are two types

a) stable channels

b) Unstable channels.

ii) Bed-rock channels: Bedrock channels are also called erosional channels and simply rock channels as they have been developed on well consolidated rocks, popularly called as bed rocks. They occurs wherever potential rates of removal exceed sediment supply (i.e. erosive power or erosion rates are very high, streams are underloaded as sediment supply through erosion of banks and beds falls short of transporting capacity of the streams); in high mountain areas with steep slopes, glaciated hardrock regions and in areas undergoing active tectonic uplift.

Q.2 (a) Write down the conditions under which the river capture occurs

(b) List the fundamental objectives of a river system over time.

(c) Define the terms : (i) Drainage density (ii) Bifurcation ratio (iii) Cut off ratio (iv) Tortuosity

Answers

2.a) The process of river capture depends on channel gradient, depth of river valley, volume of water, velocity and discharge, lithological characteristics and geological structures, stage of cycle of erosion or the stage of river development.

River capture occurs under the following conditions-

1. Steep channel gradient
2. Relatively narrow valley so that water may not spread in the otherwise wide and flat valleys.
3. Higher volume of water so that velocity and discharge may be sufficiently high.
4. Soft rocks so that the river may resort to rapid rate of headward erosion

5. Deeper valley than the valleys of other neighbouring rivers.

6. Low sediment load so that the river may resort to active erosion.

2.b) Fundamental objectives of river system over time:

1) River is directly responsible in the development of the major landforms of the earth surface.

2) It is indirectly related to many other geomorphological process in fluvially dominated landscapes.

3) River is used for drinking, irrigation, navigation, fishing, power generation, floatation of timber, recreation etc.

4) It is very useful to human being.

5) Protect natural low flows.

6) Protect or restore a proportion of moderate flows, freshes and high flows.

7) Maintain or restore the natural inundation patterns and distribution of flood waters supporting natural wetland and floodplain ecosystems.

2.c) i) Drainage density : Drainage density refers to total stream lengths per unit area. R.E. Horton (1945) defined drainage density as a ratio of total length of all stream segments in a given drainage basin to the total area of that basin and thus it can be derived as follows

$$D_d = \frac{L_k}{A_k}$$

where, L_k = total lengths of all stream segments of a basin

A_k = total area of the basin

ii) Bifurcation ratio : Bifurcation ratio(R_b) which is related to the branching pattern of the drainage network, is defined as a ratio of the number of streams of a given order (N_u) to the number of streams of the next higher order (N_{u+1}) and is expressed in terms of the following equation.

$$R_b = \frac{N_u}{N_{u+1}}$$

where, N_u = number of streams of a given order.

N_{u+1} = number of streams of the next higher order

(iii) Cut off ratio :

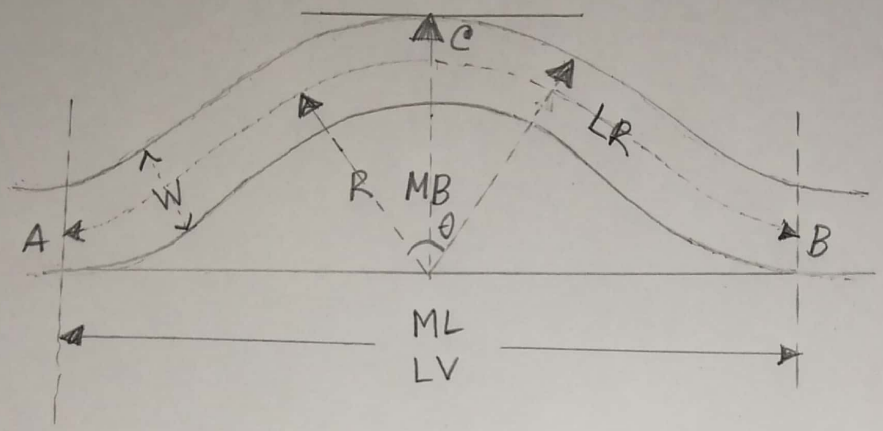

Fig: Cut off Ratio

For flow around a bend, the ratio of length of the bend to that of the chord viz. ACB / AB in Fig. when a cut off occurs is called the cut off ratio. This ratio varies according to the type of the cutoff and characteristics of the rivers. A cutoff does not therefore necessarily occur for any fixed value of the ratio but is possible if the conditions are favorable. It may occurs for cutoff ratios varying between 1.7 to 3.0 in the case of rivers in which a cutoff results due to development of a side channel.

(iv) Tortuosity: Sinuosity of a stream is defined as the ratio of thalweg length to the valley length. Joglekar defines tortuosity as

$$\text{Tortuosity} = \frac{\text{Thalweg length} - \text{valley length}}{\text{valley length}} \times 100$$

$$\text{Sinuosity} = \frac{\text{Thalweg length}}{\text{Valley length}}$$

Q.3 (a) Write short notes on (i) Natural levee (ii) Deformed meanders.

(b) Define the followings: (i) Rejuvenation (ii) Anastomosing channel pattern (iii) Thalweg (iv) Braiding index.

(c) Enumerate the differences between the braided and meandering channels.

Answer

3. a) i) Natural levee: A natural levee is a narrow ridge of alluvium deposited at the side of the channel. They are highest near the river and slope gradually away from it. During flood period the whole plain, from one valley wall, to the other, is under water and the water current is most rapid along the deep line of river channel. Silt bearing water spreads out and mingles with shallow flood waters on either side. It quickly loses its velocity and much of the silt and sand settle along year and as a result a slightly higher ground is formed known as natural levee on both sides of the river.

ii) Deformed meanders: Meanders of regular shape forming one after another in succession are not very common in rivers. Interference in the natural processes developing regular meanders is often caused by natural constraints which lead to deformed meanders. Such constraints could be of varied types.

i) Local accelerated erosion of banks composed of pockets or local stretches of sand or highly erodible alluvium.

2) Resistance to bank caving due to the presence of compacted silts or clays, which have acquired a greater degree of consolidation than that of the sorrounding alluvium.

3) Resistance to bank caving due to revetment, or erodible materials such as a rock, kanker, etc.

3. b) i) Rejuvenation: Rejuvenation simply means sudden and phenomenal increase in the erosive power of the streams and consequent accelerated rate of downcutting (valley incision) caused by steeping of channel gradient either due to negative change (fall) in sea level or upliftment of land mass in a river course. Rejuvenation may be effected either at the mouth of the river or in the middle course or in the headwaters of the river.

ii) Anastomosing channel pattern: Anastomosing channel pattern is a special type of braided pattern. Both are characterized by multiplicity of channels i.e. multithread pattern. These two patterns are distinguished on the basis of stability of bars and islands and channelways as in braided pattern sand

bars and islands change their positions and divided channelways also register frequent shifting. On the other hand, an anastomosing pattern is one where there are many channels but they are stable and retain their identities with changing discharge and time.

iii) Thalweg: A thalweg or talweg is the line of lowest elevation within a valley or water course. In hydrological and fluvial landforms the thalweg is a line drawn to join the lowest points along the entire length of a stream bed or valley in its downward slope, defining its deepest channel. The thalweg thus marks the natural direction of a watercourse.

iv) Braiding index: The braided stream channel contains bars and islands, and the degree of braiding can be expressed by the percentage of reach length that is divided by one or more islands or bars.

$$\text{Braiding Index} = BI = \frac{2(\text{sum of the length of islands or bars})}{\text{lengths of the reach.}}$$

3.c) Difference between the braided and meandering channels are given below:

Braided channel	Meandering channel
i) Braided river has multiple channels.	i) Meandering river has a single channel.
ii) For a given discharge, a braided channel has steeper slope.	ii) For a given discharge a meandering channel has comperatively flatter slope.
iii) A braided channel generally has coarser material	iii) A meandering channel generally has finer materials
iv) A braided channel is broader and shallower than a meandering channel	iv) A meandering channel is comperatively less broad and less shallow than a braided channel.
v) A braided channel is characterised by frequent bank erosion, and thus is more unstable than a meandering channel.	v) A meandering channel is more stable than a braided one.

Q.4 (a) Write short notes on : (i) Loop cut-offs (ii) Chute cutoffs
(b) Discuss the characteristics of braided pattern.
(c) Discuss the different ways in which rivers transport their load.

Answer

4.a) (i) Loop cut-offs : Loop or neck cutoffs occur when progressive bank erosion at the ~~bank~~ neck of acute bends are more common.

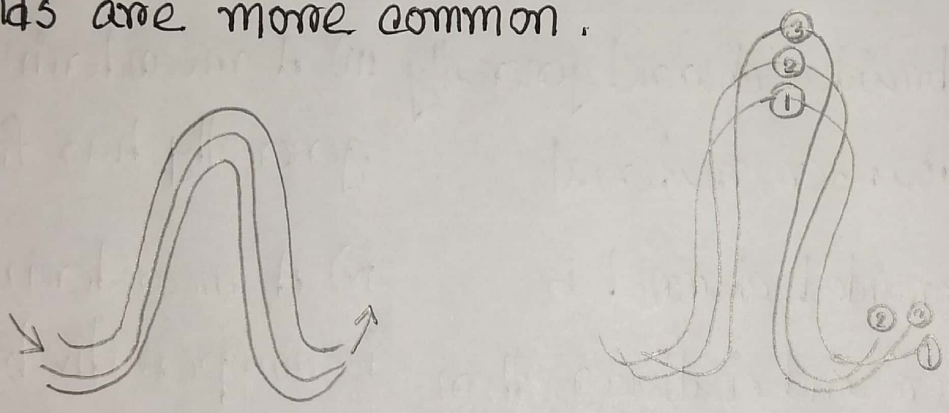

Fig: Progressive Bank Erosion in Acute Bends leading to a Cutoff.

A river increases its curvature by ~~ending~~ eroding the concave banks, until either, the velocity of the stream is so reduced that the banks cease to be further eroded or, the arms of the loop with a very narrow neck cut into one another and a cut-off occurs.

ii) Chute cutoffs : A chute cutoff normally across the base of a flat meander and is less common than neck cutoff.

Fig: Development of a chute cutoff.

3. b) Characteristics of Braided Pattern :-

(a) Aggradation: Since braided pattern emerges when bed load transport is heavy, braiding of channels is often associated with tendency for aggradation. Braiding channels however, need not always experience aggradation. For instance, Brahmaputra river upstream of Gauhati is having intensely braided pattern but is not having an aggrading trend.

(b) Channel Alignment: Heavy bed load, generating a wide and shallow cross-section, was seen to be the basic reason for formation of braiding pattern. Associated characteristics were found to be steeper slope, coarser bed materials and higher velocities. All these factors being unfavourable for meander formation, the alignment of braided channels is more or less straight, subject to constraint of valley boundaries.

(c) Movement of Islands: Islands in braided rivers get eroded on their upstream faces and build up on the downstream faces. The islands therefore appear to be unstable and moving downstream

(d) Bank Erosion: Islands in some of the braided rivers have a tendency to movement of islands, the channel along the bank gets squeezed causing increase in discharge concentration, thus leading to local bank erosion.

4.c) Rivers transport their load in four different ways. e.g.

1. By traction: The haviers and large rock fragments like gravel, pebbles, etc., are forced by the flow of water to roll on the floor of the channel. These fragments can be seen rolling, slipping and bumping. This is known as traction.

2. By saltation: The fragments of the rocks move onward by jumping continuously. This is called saltation.

3. By suspension: When the rock fragments fall in the stream, their weight is reduced by the buoyancy of water. Usually the relative density of rock particles is 2.5. Their weight in the water is reduced by 2/5. The reduced weight of the fragments keeps them in suspension.

4. By solution: Some parts of the rock fragments are dissolved in the stream water. The dissolved substances of the underground water also enter the stream water later on.

2017

Q.1) (a) Define geomorphology and provide three example applications as to how it influences human interaction through living on earth's surface.

(b) Discuss the variation of various morphological parameters of a river basin as it flows in the downstream direction. Explain these variations in the context of Bangladesh.

(c) List the five factors that control landscape characteristics and evolution over time, provide an example of each.

Answer

1.a) Geomorphology: Geomorphology is the study of landforms, which deals with the formation and history of landforms, rivers, mountains, glaciers etc and its knowledge is used more and more for avoiding environmental degradation, mitigating natural disasters as floods, planning of drainage system. The knowledge of geomorphology is also

important and its features are so broaded which include the geography, geology, engineering and planning.

Three examples applications as to how geomorphology influences human interaction through living on earth's surface:

Geomorphology has vast features and types such as process geomorphology, fluvial geomorphology, tectonic, structural, climatic, applied, regional geomorphology etc.

1) Tectonic geomorphology deals with the effect of tectonic movements on landforms. So, this type analyses on the matters that are related to earth quack or other disasters and finds out the dangerous zones of disasters. This helps people to be aware and take least steps to minimize harms caused by natural disasters and change their life style.

ii) Climatic geomorphology is that type of geomorphology which is the study of dominant influence of climate on landforms. In the hilly areas, climatic change like heavy rains often causes land slides killing people and hampering resources. Climatic geomorphology can analysis and minimize these problems caused by landforms and change human lifestyle by suggesting effective agricultural, building equipments etc.

iii) Applied geomorphology is the use of the knowledge of geomorphology for flood prevention, enviromental impact mitigation etc. Bangladesh and many other countries flood is very common phenomenon in almost every year. So, this type of geomorphology is important for predicting dangerous of floods, percentage of hamper, prevention of difficulties etc. and thus helps people to stay safe, take precautionary steps etc. Therefore, influences human interaction living there.

1.b) River basin is the portion of land drained by a river and its tributaries. It's any area of land where precipitation collects and drains off into a common outlet, such as into a river, bay or other body of water. The quantity of water always flows from higher landforms to the lower landforms. Where quantity of water in a river varies almost from moment to moment. The flow of water depends on moment, the time duration, the amount of precipitation, the local hydrological conditions etc. Depending on climatic time duration these are of various types.

1) Ephemeral: These are the rivers which carry water only during and immediately after a rain are known as ephemeral

2) Intermittent or non perennial: These are the type of rivers which flow during a part of the year such as, during the wet season of the humid tropics.

3. The Perennial : Rivers that flow all the year round are called perennial.

4. Wadis : It is an extreme case of flow, in the hot desert region a channel remains dry for months or even years but after a sudden thunderstorm the rivers start to flow. The peculiarity is that the flow stands for only an hour or two.

In the context of Bangladesh as we can see, no deserts are the parts of this country. So, there is no wadi in Bangladesh. But the other three types of rivers are available in Bangladesh depending on characteristics and similarly with them. For example—

1) Kumar → Ephemeral or temporal flow

2) The old Brahmaputra → Intermittent or seasonal flow.

3) The mighty Jamuna → Perennial or continuous flow.

1.c) 1) Climate: It controls the nature of river flow i.e. whether its perennial, non-perennial, ephemeral or intermittent. Climate influences the nature of velocity and the erosive power of river largely depends on velocity. So, over time, the velocity if be doubled, the erosive power increases four times and thus controls the landscape characteristics and evolution.

2) Nature of bedrock: It is common that the river erodes mostly those areas where bed rocks are soft or of poor resistance to erosion. Over time the softer soluble materials becomes more easy to erode and changes landscapes.

3) Time: River is a youth stage does more erosion than deposition and viseversa. Thus the time stage of a youth or old river is a very important controlling factor of landscape evolution.

4) Nature of river current: River with greater whirling currents imparts more erosions and supplies greater loads of transportation and deposition over time.

5) Human interferences: Since human civilization, man utilizes the river in many ways to control its hazards, i.e, constructing dams, canals, embankment etc. These human interferences impacted greatly and as a result of these nondesirable erosion and deposition occurs side by side and increases over time.

Q.2) a) Write down the conditions when river capture occurs.

b) Describe stream ordering suggested by Horton

c) Describe the process of valley lengthening.

Answer

2.a) has been done before in 2018 (2(a))

2.b) According to Horton ordering of stream begins from the finger-tip tributaries, which do not have their own feeders, rather they independent in terms of supply of water. Such finger-tip streams are designated as 1st order streams. Two streams of first order, when join together, form 2nd order stream just below their junction. Similarly, two streams of 2nd order meet to make the stream of ~~just~~ 3rd order and this process continues till the trunk stream is given the highest order. Simultaneously, 2nd order streams may have other 1st order streams and 3rd order streams may have additional 1st order and 2nd order streams and so on. Thus, according to Horton's scheme when two streams of same order meet, they form the next higher order and each stream ~~order increases only~~ can receive tributaries of lower orders than its own order. In other words, the stream order increases only when two streams of same order join together.

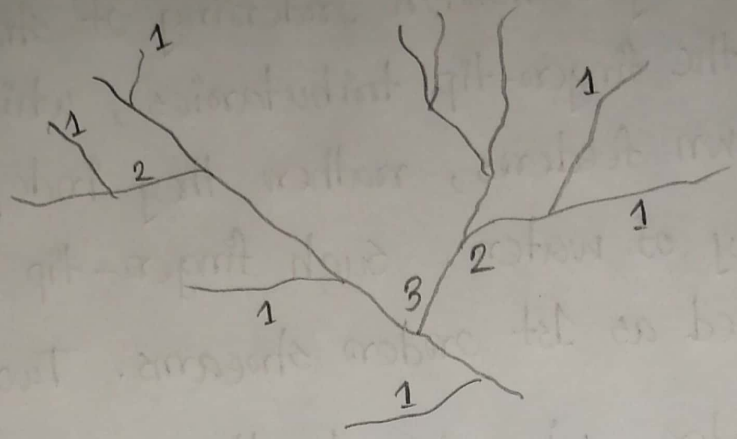

Fig: Horton Orders

~~2.c)~~ Horton's scheme of stream ordering is difficult, tedious and time-consuming as it involves classification and reclassification of streams several times.

2.c) The valley lengthening is known as the development in length of a river. Valley lengthening depends upon the followings:

i) Head Erosion: A stream begins to cutback. This increases the area of the stream where it diverts towards itself the water of springs, rills etc. This activity is called head erosion. This head erosion work continues till a hard rock interferences. Head erosion increases the length of

a stream.

ii) River meandering: It increases the length of a river. A stream creates many meanders in its course by erosion or deposition of sediment at various places. This makes the river flow in a zig-zag course. This is known as river meandering. It also increases the length of the stream.

iii) Mouth expansion: A stream deposits sediment at its mouth where it meets the sea. It makes the mouth extend towards the sea. The river Nile in Egypt has extended its mouth hundreds of km away to the sea.

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Q.3) (a) Write short notes on : (i) Alluvial Channel and (ii) Bedrock Channel

(b) Define the followings : (i) Rejuvenation (ii) Anastomosing channel pattern (iii) Sinuosity and (iv) Braiding index.

(c) Enumerate the difference between the braided and meandering channels.

Answer

3.a) has been written before in 2018 (1(c))

3. b) (i), (ii) and (iii) has been written before in 2018 (3(b))

iii) Sinuosity : Sinuosity of a stream is defined as the ratio of thalweg length to the valley length.

$$\text{Sinuosity} = \frac{\text{Thalweg length}}{\text{Valley length}}$$

3. c) has been written before in 2018 (3(c))

Q.4) (a) What is alluvial fan? Write down the geographical importance of alluvial fans.

(b) Describe the following types of multiple channels with neat sketches (i) Braided channel and (ii) Distributary channel.

(c) Discuss the different ways in which rivers transport their load.

Answer

4.a) Alluvial fan: Most important depositional features of the piedmont are the alluvial fans. In the upper reach of a river in the mountainous region, the slopes are steep and the flow has a high velocity. Sediment concentration is therefore also high. At the foothills the river descends into the plains where the slope suddenly becomes flat and the velocity drops. As a result, the capacity of flow to carry sediment reduces appreciably. The sediment then deposits and causes bed aggradation. When

the bed is raised, the river shifts laterally. By this process a cone shaped delta is built by the river which presents the shape of a fan. This formation is known by the term alluvial fan.

Geographical Importance of Alluvial Fan:

The following describes the geographical importance of alluvial fans:

1. Cities develop near the peripheries of alluvial fans. Many such towns can be seen in the upper Rhone valley.

2. Water is available for irrigation from these fans. Various branches of the stream in the fans provide water for irrigation.

3. The water of the fans goes to the lower layers by seepage. Water can be pumped up from these layers even when there is no water available on the surface of the fans.

4. Fertile soil is available in these fans in the semi arid fans. There is a series of alluvial fans from apex to the periphery. Agriculture is developed in these fans.

4.b) (i) Braided channel : A braided stream can be defined as one which flows in two or more channels around alluvial islands. A braided pattern develops after local deposition of coarser material which cannot be transported under local conditions existing in the reach. The coarse material becomes the nucleus of a bar and subsequently grows into an island made up of coarse as well as fine material. A distinctive characteristic of braiding pattern is multiple channels. The braided stream channel contains bars and islands, and the degree of braiding can be expressed by the percentage of reach length that is divided by one or more islands or bars. If the value is more than 1.5 then the channel is referred as

the braided channel.

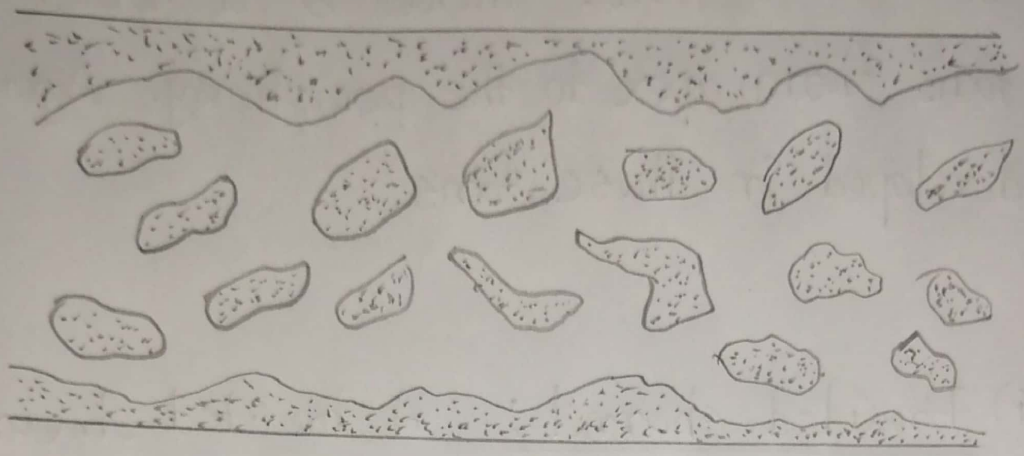

Fig: Braided Channel.

ii) Distributary channel: There are two types of multichannel streams; one is the interlaced multichannel stream separated by island at ~~two~~ low stages giving an appearance of a hair braid. The other kind of multi channel stream is distributary type in which several separate channels branch out of the parent stream as in case of a river building an alluvial fan or debris cone. Distributary type multichannel stream is also formed in building up of delta where all these different channels

finally disappear at sea end schematically shows the braided pattern as distinct form distributary channels.

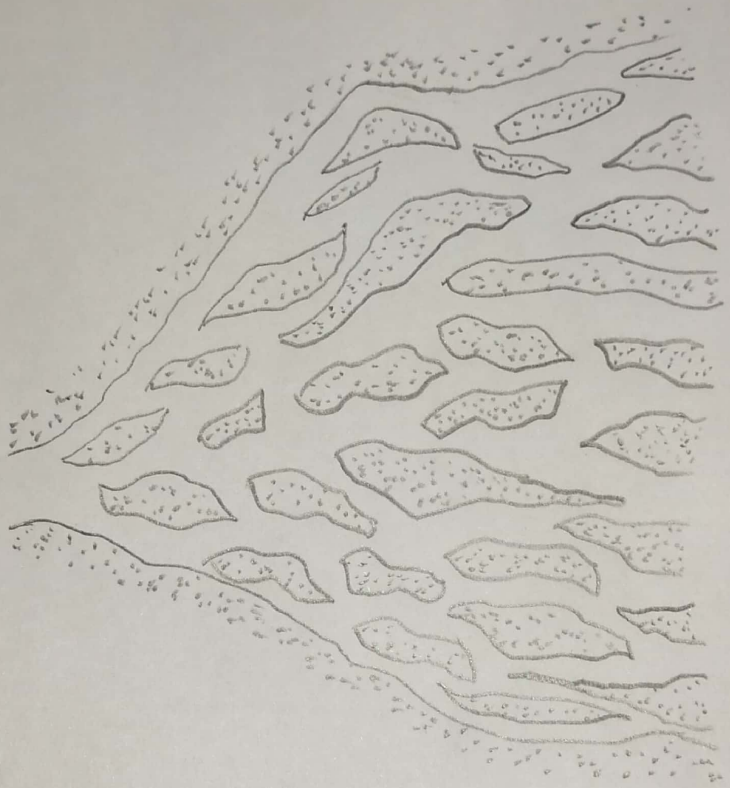

Fig: Distributary channel.

4. c) Has been written before in 2018 (4 (c))