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1. Learning outcomes

After studying this module, you shall be able to:

- Know different types of river systems as classified based on their sinuosity values.
- Learn about depositional processes by which different types of deposits form in these river systems with emphasis on alluvial fan, braided-river, meandering-river and incise-valley fill deposits.
- Understand nature of sediments and sequences different river systems leave in geological record.

2. Introduction

Sediments transported and deposited by rivers in a continental setting is referred to as fluvial deposit. This includes a variety of continental settings viz. (a) Alluvial fan, where fan shaped sediment body get deposited at any slope (mountain or fault-bounded)margin at the mouth of rivers, (b) fan deltas which form at the base of mountain/fault slopes and get deposited within a marine/lacustrine basin, (c) braided rivers, which form in high gradient physiography but beyond the mountain base, (d) meandering rivers which form in low-gradient areas with gently inclined floodplain, and (e) incised valleys those form when a river incises its own floodplain or immediate substratum. Fluvial deposits of each of these settings differ from each other in terms of grain size and sand body geometry.

3. Alluvial Fan

Cones of detritus deposited at break in slope, defined either by any mountain slope or fault-bounded slope, at the edge of an alluvial plain is termed as alluvial fan. Sediments carried downslope by a feeder system get deposited at break in slope as the flow loses its energy and competence on encountering low-gradient surface. Although alluvial fan deposits are not very significant in terms of volume in geological record, they are important because fan deposition is sensitive to tectonic and climatic controls.

The longitudinal profile of an alluvial fan is concave upward, whereas its transverse profile is convex up. Sediment body of a fan is commonly wedge-shaped; thicker part of the wedge found near to the mountain front and in the axial part of the fan. The wedge gets thin away from the mountain front on all sides. Depending on the climatic zone, alluvial fans vary widely in size; large alluvial fans are described from humid climatic zones e.g. Kosi fan. In its longitudinal profile an alluvial fan can be divided into three morphological parts viz. inner fan, middle fan and outer fan (Fig. 1). Very coarse grain size, single entrenched channel and domination of debris flow over stream flow are the characters of inner fan i.e. upslope of intersection point (point which defines intersection of stream profile (water table) on the fan surface in longitudinal profile). In contrast, intermediate grain size (mostly sandy with subordinate pebbles, cobbles); multiple channels and domination of stream flow are the characters of middle fan. Gentle slope, finest grain size and lack of well-defined channels demarcate the distal fan. Fan deltas are alluvial fans that have built into a lake or the sea. While subaerial part of a fan delta is same with the proximal part of an alluvial fan, the subaqueous sediments of fan delta differ strongly from their subaerial counterparts.

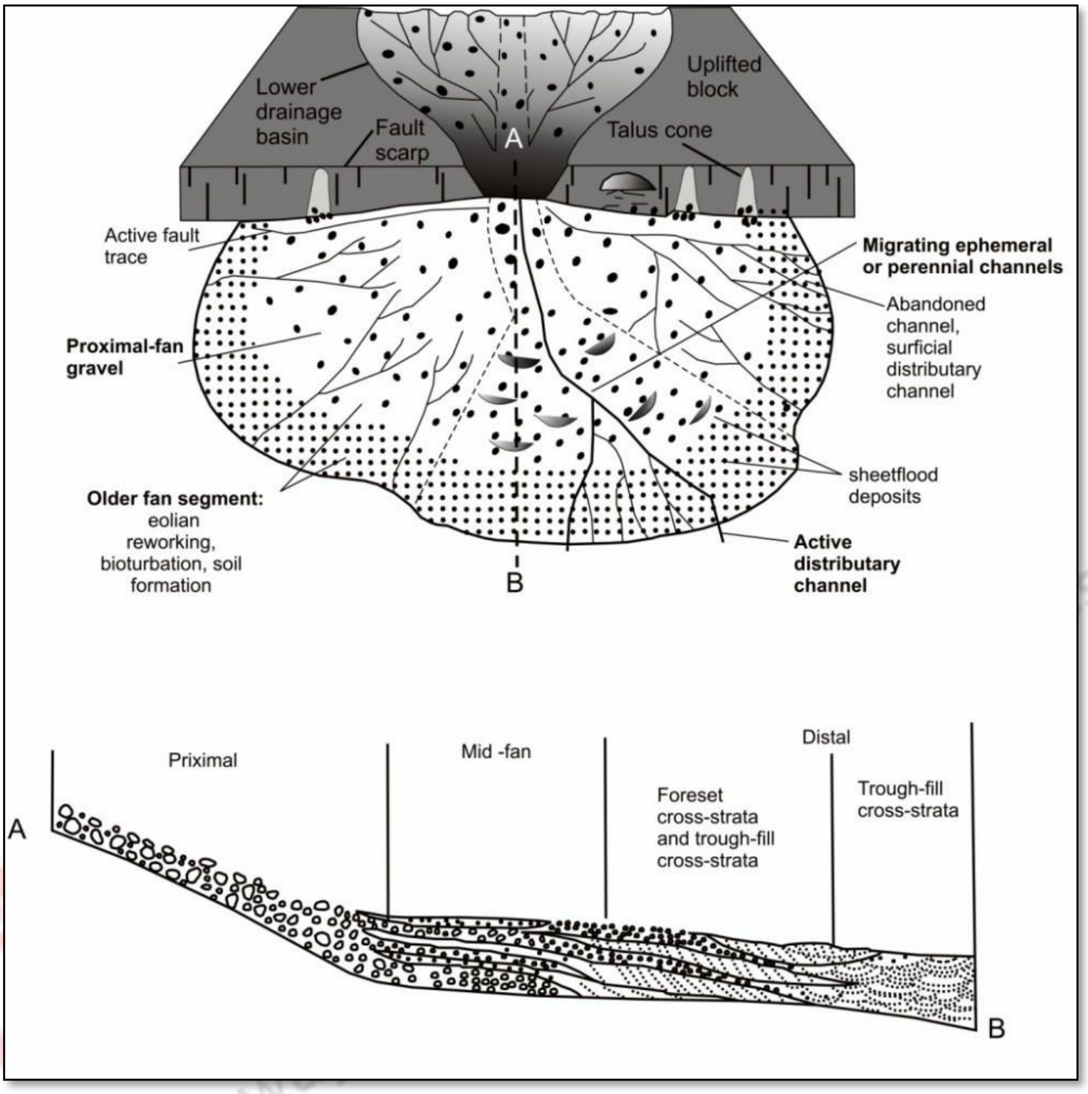

Fig. 1 Plan view and longitudinal cross-section of an alluvial fan marking different subdivisions.

Processes dominate a fan system include stream flow, debris flow, mudflow and landslide. While debris flows and mudflows are dominating processes in fans of arid or semiarid climate, fans in humid climate are dominated by stream flows. Short-lived high energy flows those inundate the fan surface at times of high energy (e.g. heavy rainstorm) and deposit pebbles, cobbles as bedload and fine pebbles, granules as suspension are referred to as 'Sheet flood' deposit. Formation of standing wave is common in such flows resulting in formation of antidune bedforms in gravel bedload. A common product of sheet flood is 'depositional couplet' constituted of coarse gravel deposited from standing wave sand its immediately overlying layer of fine gravel and sand, deposited from suspension as the wave is washed out. Imbrication of clasts is common in these deposits. In cases when little fine-grained sediment i.e. sand, silt, clay is supplied from source in the fan system, highly permeable coarse gravel lobes are formed in the fan, which are called **Sieve deposit**. High permeability of these deposits allow water to pass through these deposits holding back only coarsest of clasts. In all alluvial fan systems, a radial flow pattern can be deduced from measurement of current structures. Down-slope alluvial fans grade into other alluvial deposits, mostly braided river systems.

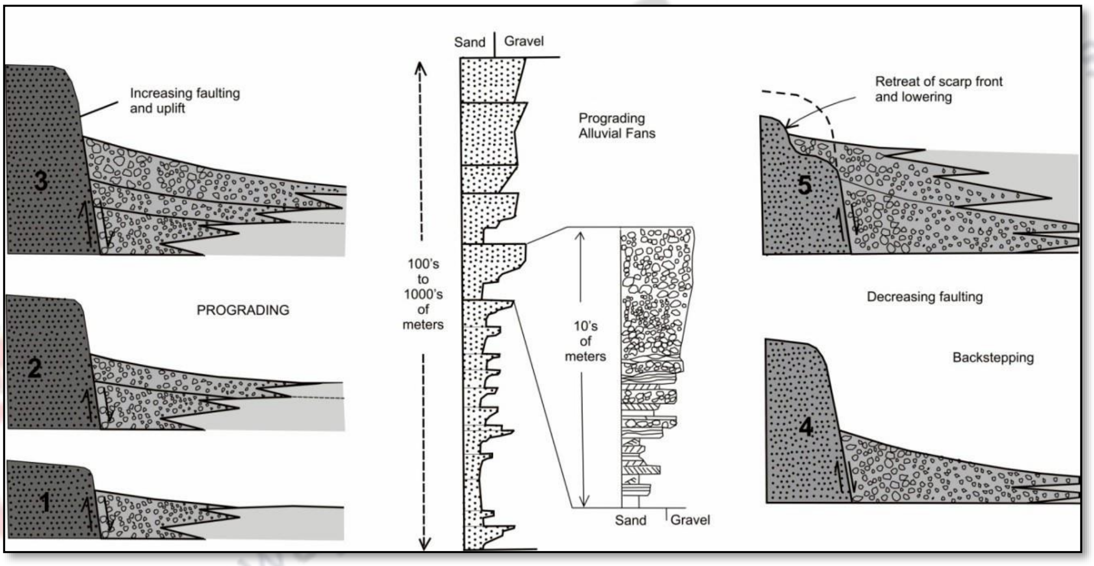

Fig. 2 Vertical sequences of alluvial fan deposits. Fan progradation and coarsening-up sequences result from active faulting (on the left) whereas tectonic quiescence and retreat of scarp result in fining-upward sequences (modified after Einsele, 2000).

Nature of an alluvial fan deposit in rock record including its long-term evolutionary character depends on a number of factors, which include relief in the hinterland, its amplification or denudation, climate (weathering), erosion in the drainage area, and base level of a fan. In general, alluvial fan sediments are coarse grained, compositionally and texturally immature and decrease in grain size down fan. Plant fossils and vertebrate remains may be found in association. Both coarsening-upward and fining-upward sequences can be found as result of alluvial fan deposition and its temporal evolution. A coarsening-upward sequence suggests fan growth in association with continuous faulting, uplift of source area and subsidence of fan system. Systematic analysis of bed thickness and clast sizes within beds of an alluvial fan deposit can provide important clues for tectonic activity in basin margin (Fig. 2). In contract, a fining-upward sequence can result when a short phase of faulting is succeeded by retreat of scarp and lowering of relief in the hinterland.

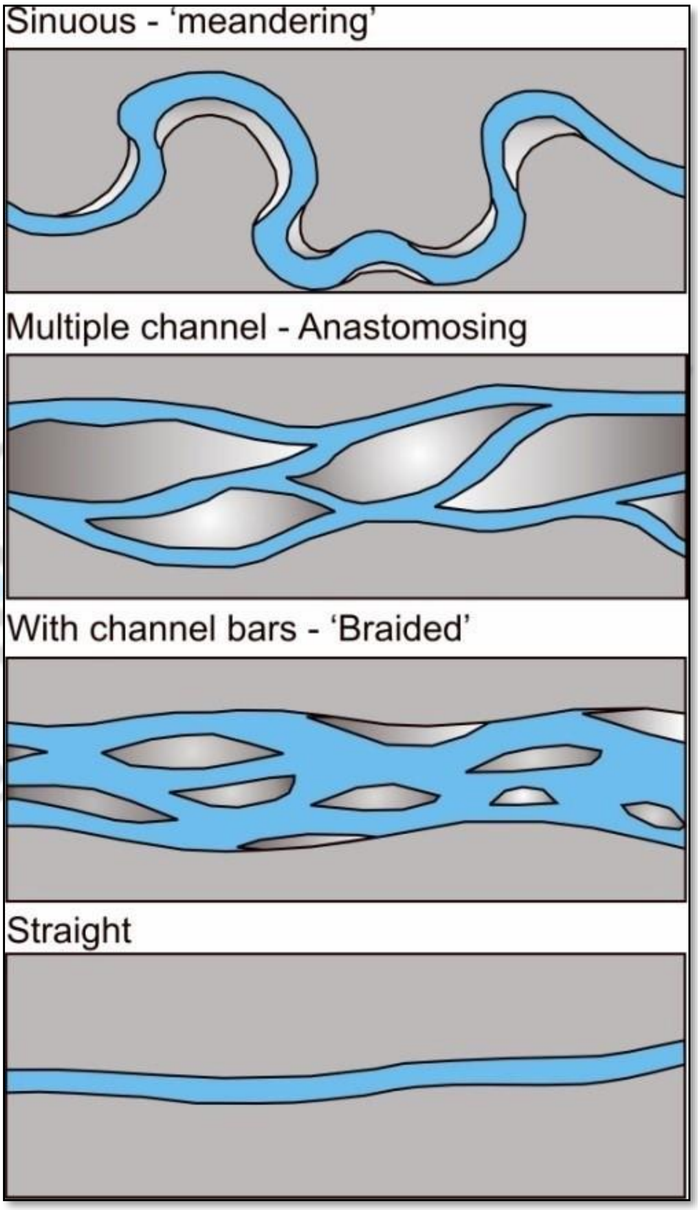

Fig. 3 Different geometry of river with varying Sinuosity Index (SI).

4. Rivers

As parts of alluvial fan, braid plain or as high-sinuosity stream, rivers transport and deposit a wide variety of sediments. This include gravels, pebbles, granules as proximal sediments, which gradually get replaced downstream by sand, silt and mud. Depending on stream power, sediment load (calibre and discharge) capacity, a river changes its geometry and nature of bedforms. Change in geometry of river is described by the parameter called 'Sinuosity' of a river. Sinuosity is defined as the ratio between the stream length and valley length of a river and according to the Sinuosity Index (SI) rivers are classified as of four major types i) braided, ii) meandering, iii) anastomosing, and iv) straight (Fig. 3).

4.1 Braided stream deposit:

Streams tend to braid (SI= 1.1 to 1.2) if i) slope is relatively high, ii) bank stability is low due to lack/deficiency of mud and low vegetation cover, iii) discharge high but unsteady/ ephemeral and iv) sediment load is essentially coarse- grained with dominance of bed load relative to suspended load. Best development of braided streams can be noticed in distal parts of alluvial fans, glacial outwash plains or high-sloping mountainous areas where streams are overloaded with coarse grained sediment and water discharge in streams is often flashy and climate driven. Extensive areas represented by gravelly/sandy bars, many times wider than the river channel,separate channels in a braided river system (Fig. 4). It is surmised that in pre-Devonian time in absence of rooted vegetation streams had dominant braided character because of lower bank stability and flashy surface runoff.

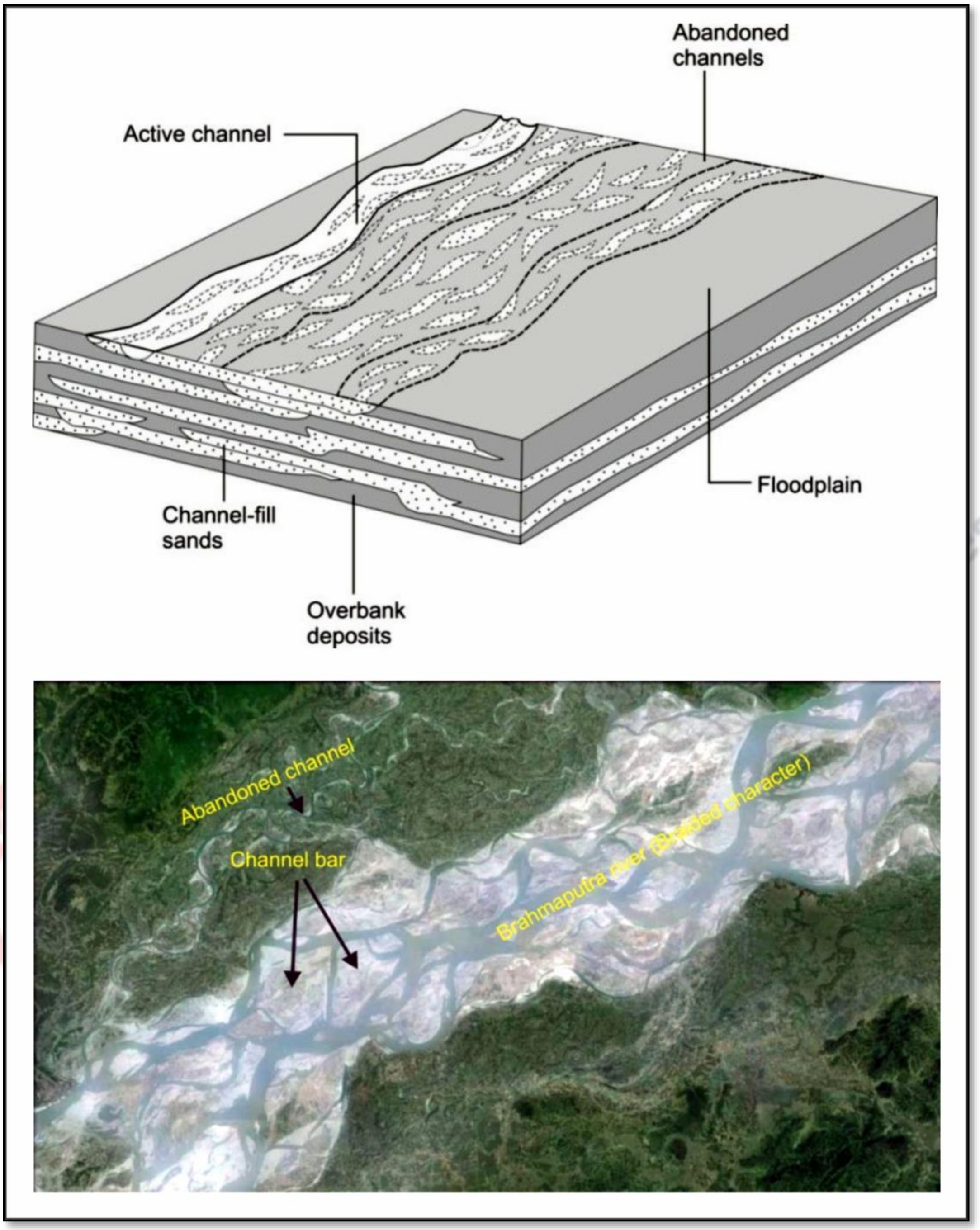

Fig. 4 Architecture of a braided river system showing channel abandonment and relocation. Below is Brahmaputra River (from Google Earth) with its braided character.

Competency failure either cause chocking/abandonment of channel or deposit coarse sediment mid channel forming mid channel bars in periods of high discharge in braided stream and thereby force water flow to divert. Repeated bar formation and channel branching give rise to a network of bar and channel in braided river system (Fig. 2). Bars in braided river are characterized as i) longitudinal bar, ii) transverse bar and iii) lateral bar depending on their orientation with respect to flow and operative depositional processes (Fig. 5). Longitudinal bar with long axis parallel to the stream flow, initiates as a small geomorphic entity with competency failure of flow and continue growing in length and height by accretion/ trapping of sediment both sideward and on downstream lee side of the bar. Deposit of longitudinal bar can be found as massive or crude horizontal laminated gravel or sand-gravel mixture. In bars constituted of gravelly material, clasts accumulate as inclined parallel layers on the downstream bar faces. In sandy braided systems transverse (with straight crest) and linguoid (with curved crest) bars, having long axes at high angle with flow direction, dominate. Unlike longitudinal bars, which grow by sediment accretion, transverse/linguoid bars are with steep downstream-directed avalanche faces. Ripples are common on surfaces of sandy bars. Sandstones with extensive development of downstream dipping cross-stratification (planar and trough cross-strata) represent deposit of transverse/linguoid bars. Bank attached very large bars developed along sides of channel in low energy condition are referred as lateral bars.

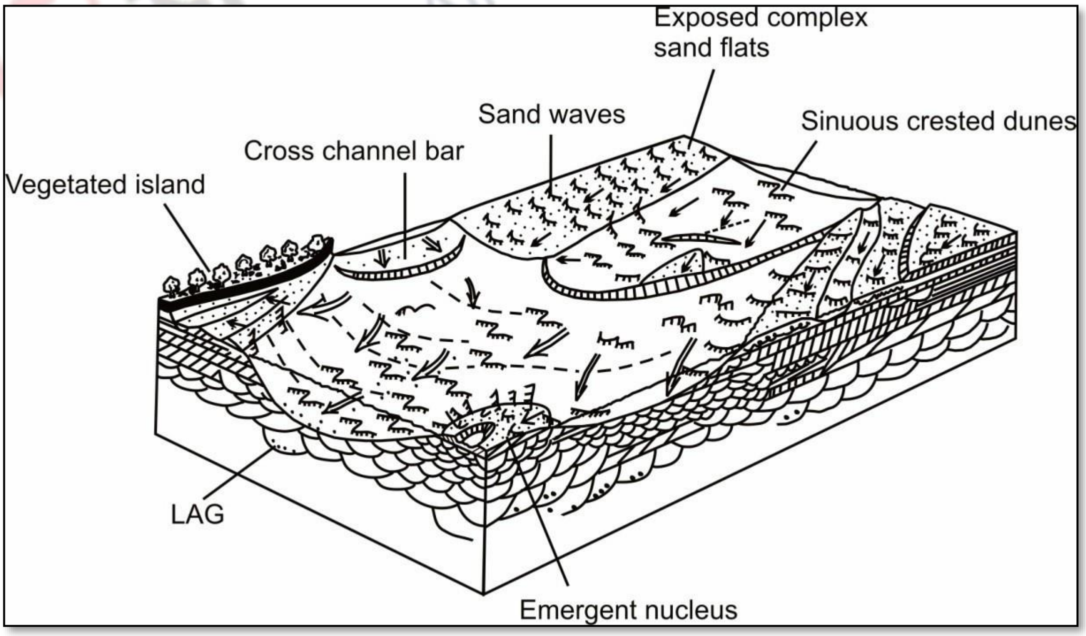

Fig. 5 Structure of bars and sand flats in a braided river system.

Braided river cuts and fills channels with coarse-grained deposits (mud is very rare) of tabular form with high to very high (1: 20 to 1:200) width/depth ratio. Deposits tend to occur as thick laterally extensive tabular or wedge shaped bodies of channel and bar complexes with high sand: shale ratio. Shales, if present, are thin, non-persistent and with lenticular geometry. A characteristic sedimentary succession of sandy braided stream deposit is a fining-up succession (Fig. 6) initiated with an erosion surface marking base of channel, which is successively overlain by cross-stratified granule/pebble/cobble representing gravelly braided bar and multistoried cross-bedded sandstone representing sandy bar. Fine sand/silt can be found at the top of the succession suggesting abandonment of the bar when it is not actively moving. Decrease in cross-set thickness upward within the fining up succession suggests decrease in flow velocity within the channel from base to top. Paleo-current determined from cross-stratifications in a braided river bar deposit may show around 600 variance either side of mean channel flow.

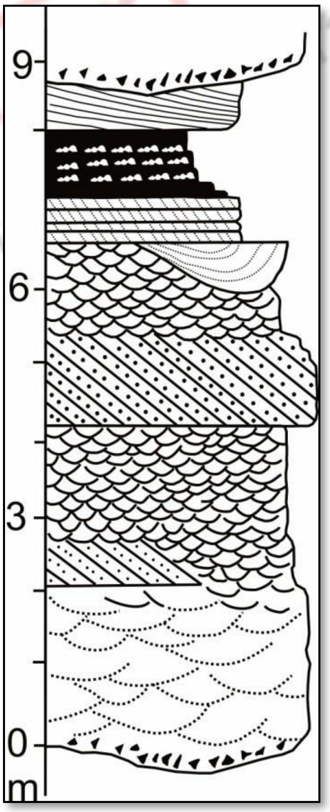

Fig. 6 Vertical succession of braided stream facies (Example from Battery Point Sandstone, Quebec; modified after Boggs, 1995).

Depending on caliber of bed load, depth of stream channel and variability in stream discharge braided rivers behave differently; while lateral accretion process dominate in some streams, others may be dominated by vertical accretion and aggradation and accordingly deposits of these streams also differ. Miall (1977) proposed four vertical profile models of braided river based on different bedload and discharge of modern braided river systems and their respective deposits. These are i) Scott-type: gravelly with minor sand wedges; very poorly developed cycles, ii) Donjek-type: sand and gravel mixture; fining-upward cycles of variable scale, iii) Platte-type: Mostly sandy with occasional gravel; presence of indistinct fining-upward cycles, and iv) Bijou-creek type: Superimposed flood sediments in form of fining-upward cycles; little topographic difference between channel and bar.

Fig. 7 Meandering character of River Ganges (Google Earth) including earlier courses.

4.2 Meandering River

High sinuosity (sinuosity index ≥ 1.5), low gradient, high bank stability in presence of higher amount of cohesive mud, dominance of suspension load over bed load and steady, perennial discharge demarcate meandering rivers from braided rivers systems. In contrast to network of channels in braided river system, meandering river system is represented by single major channel confined between its cohesive banks (Fig. 7). However, thalweg (deepest point in a stream at any point of time) will follow a sinuous path moving from side to side along the length of a meandering channel. Banks close to channel thalweg get eroded because of higher water velocity and eroded sediments get deposited on the opposite side of channel where flow is sluggish. With continued erosion on one bank and deposition of bed load in other (inner) bank meander loops form and a channel bends its course (Fig. 8).

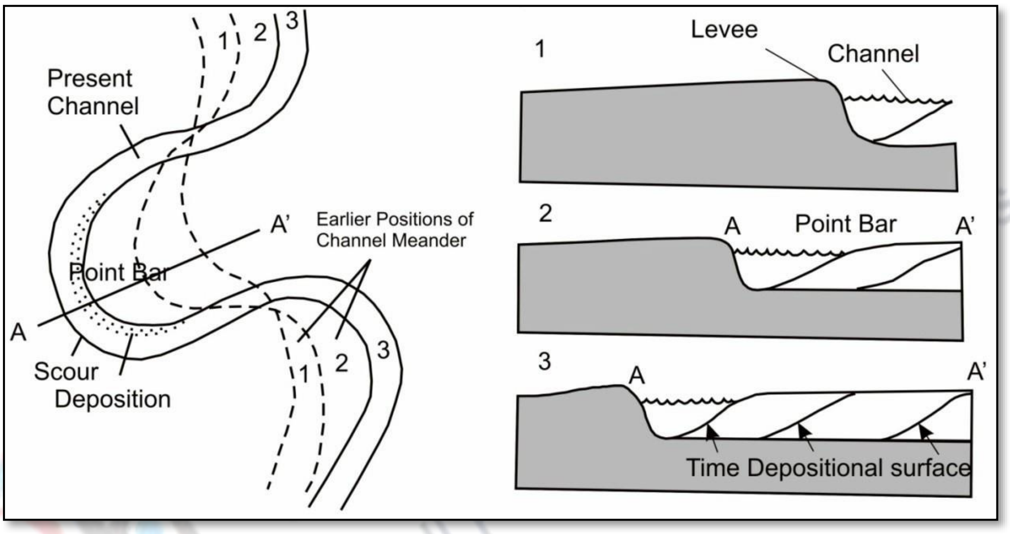

Fig. 8 Meander channel and formation of point bar. Formation of time-transgressive epsilon cross-stratification on the right.

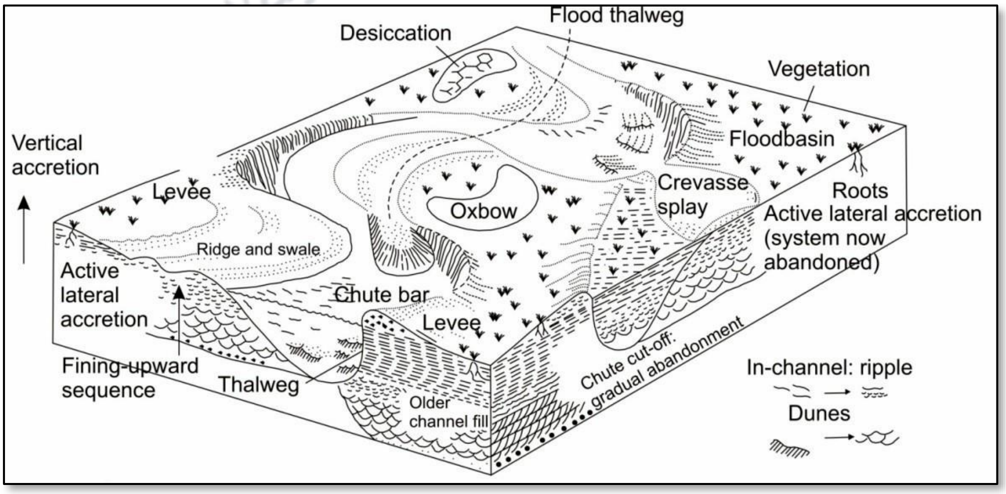

Fig. 9 Block diagram illustrating morphological elements of a meandering river system i.e. channel, levee, floodplain, oxbow lake etc.

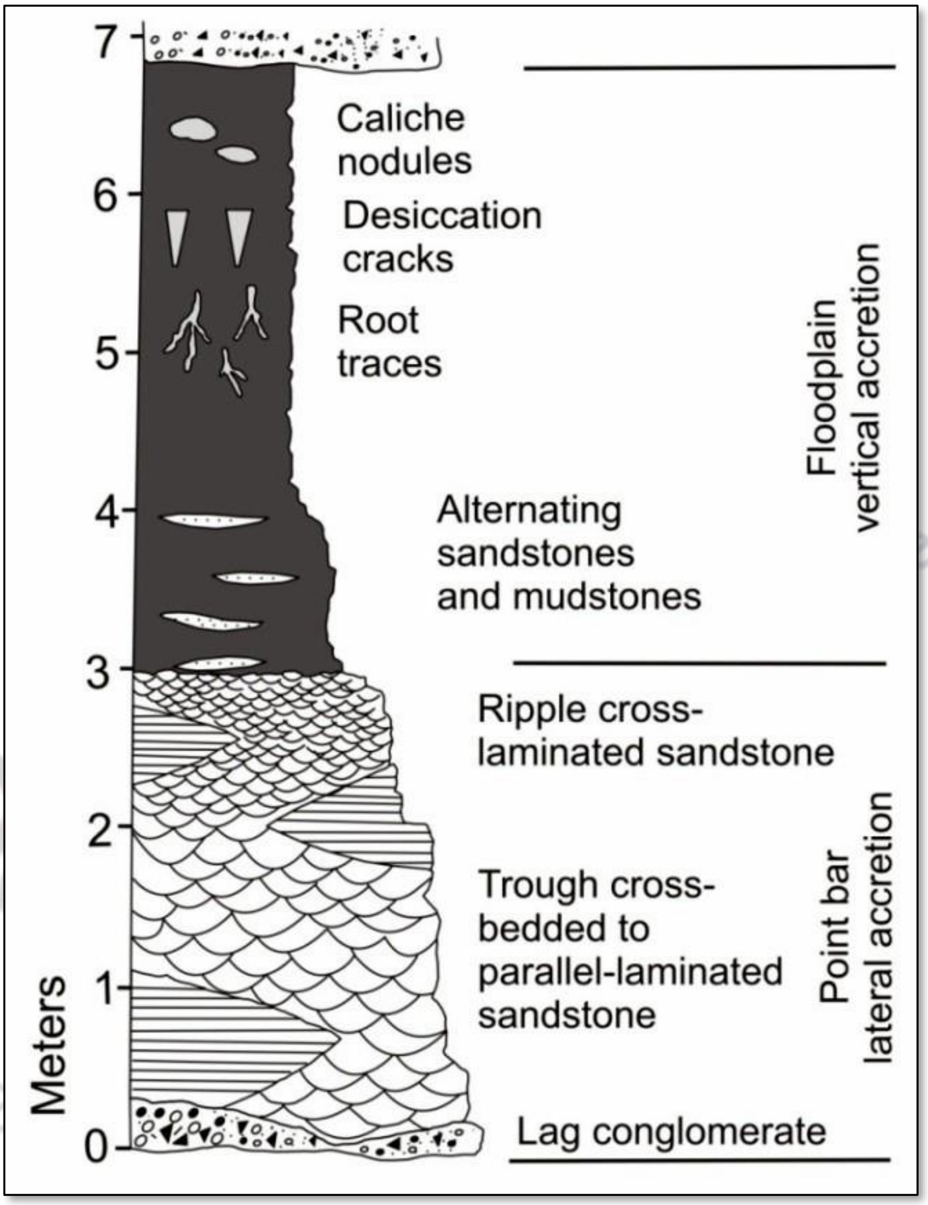

Fig. 10 Vertical succession of braided stream facies (example from Battery Point Sandstone, Quebec; modified after Boggs, 1995).

Major sub-environments in a meandering system are i) channel ii) point bars and lateral accretion surfaces, iii) chute bars, iv) channel plugs (oxbow lakes), v) Levee and crevasse splay deposits, and vi) Floodplain deposits. The sideward movement in a meandering channel through this process is referred to as 'lateral shifting' and the deposit on the inner bank is referred to as 'point bar'. History of this lateral migration often remain preserved within point bar deposits as inclined surfaces, commonly referred to as 'epsilon cross-stratification' (Fig. 8). Development of epsilon cross-stratification becomes most prominent when low discharge allow deposition of fine sediment on point bar surfaces. Deposit of a point bar is characteristically fining-upward (Fig. 10) with large-scale cross-bedded coarse sediment at the base give way to small-scale cross-bedded fine-grained sediment towards top. The channel floor commonly has a coarse lag of pebbles, which are only moved at maximum flow velocities. During average discharge periods, sand dunes move on the channel floor and ripples migrate on point bars. Essentially, sand deposition in a meandering system remain restricted within main channel with its point bars and chute bars. Abandonment of meander loops happen either a) gradually i.e. by Chute cut off depositing thick cross-laminated sand, or b) abruptly i.e. by Neck cut off (Fig. 11) or avulsion (Fig. 12) causing vertical accretion of muddy sediment above channel deposits. In addition, a meandering river may abandon single loop (oxbow lake) by cut off which gets filled with fine grain sediments forming clay plugs, or it abandons an entire meander belt, the abandoned belt being usually covered with flood plain clay.

Fig. 11 Neck-cutoff and Chute-cutoff in a meander channel (Google Earth image).

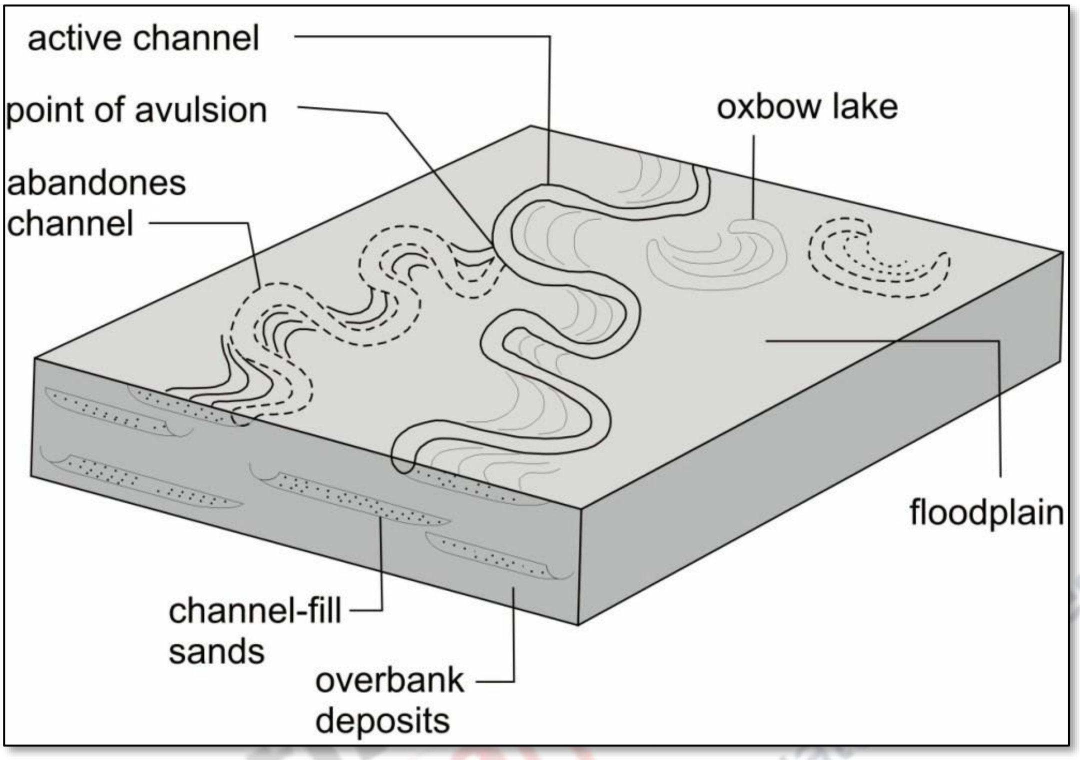

Fig. 12 Avulsion of a meander channel isolating an earlier course or cutoff to form an oxbow lake.

Fine-grained sediments get deposited in natural levees, flood plains and oxbow lakes in course of floods in meandering streams overtopping its banks. Settlement from overbank water cause vertical accretion, up building in the levee, and make it a natural energy barrier for the meandering stream. Deposit of levee is wedge shaped; coarsest and thickest near the channel and thin, fine-grained towards flood plain. Flood plain sediments are fine grained (silt and mud) and settle from suspension within flood waters that reach the flood plain crossing or breaching natural levee during flood. Breaching of levee and erosional emplacement of coarse bed load sediment and suspension sediment right on to the low-energy flood plain, often resembling graded beds of 'Bouma turbidite' sequence, is referred to as Crevasse splay deposit.

Meandering streams migrate in zones (meander belts) that are 15 to 20 times the width of the channel. The meandering stream produces sheets of sand in the form of coalescing bars, over a relatively short period of geological time. However, these sand sheets are not as continuous as those of braided stream origin. Sand: shale ratio is lower and sand bodies often assume shoestring geometry with intervention of thick and laterally extensive shale units. Because of sinuous character of a meandering river, the flow indicators normally range 900 on either side of mean stream flow direction; thereby cover near 1800 span of a compass.

4.3 Anastomosing rivers

An Anastomosing river system is a system of multiple, suspended load bearing relatively stable channels separated by islands, which are large relative to size of the channels. Anastomosed rivers appear to be favored by high rates of vertical aggradation promoted by rise in local base level, causing stabilization of channels between adjacent wetlands. There are very few examples of anastomosed rivers in the rock record. Studies in modern examples revealed that a combination of highly variable flow regime, cohesive banks and a sediment supply that marginally exceeds capacity of onward transport characterize anastomosed river system and allows the river system for slow aggradation. Fixed channel, low levee and extensive muddy flood plain are the telltale characters of an anastomosing river system. The Channel Country, Lake Eyre basin, central Australia, North Saskatchewan, western Canada are examples of some modern anastomosing systems.

5. Rivers in incised valleys

An incised valley is formed when a river cuts into its own floodplain or substratum so much that even during flood flow does not overtop the banks. Different factors which can promote valley incision are i) base level fall, ii) tectonic tilting of alluvial plain and/or iii) decrease in fluvial discharge. In course of valley incision a fluvial system, continue transporting sediment downstream beyond the confines of valley without storage of much sediment within the valley. Filling of valley starts when the base level starts rising and in response the river system changes its geometry and products. Valley fill deposits are quite complex not only because of varied fluvial geometry but also owing to marine influence in the downstream parts of a valley. An ideal valley fill sequence consists of basal lag, which grades upward into fluvial sandstone and successively overlain by estuarine sediments. While fluvial sediments dominate in proximal parts of valley, domination of estuarine products can be observed in downstream parts of the valley.

6. Facies elements and architecture of fluvial systems

Facies studies have provided wealth of data, which helped in formulation of varied facies models. From more and more availability of data, it became apparent that there are many points of similarity between fluvial deposits of all kinds. To address these commonalities between different fluvial systems and describe a modern and ancient fluvial systems in spatio-temporal framework the concept of 'Architectural element' was introduced by Allen (1983) and Miall (1985) through which fluvial deposits are subdivided into eight basic architectural elements (Fig. 12). Differing in dimension and rank, these architectural elements, as building blocks, constitute any fluvial deposit. The key concepts inbuilt in 'Architectural element' concept are i) Standardization of facies assemblages for modeling purpose, and ii) emphasis on facies geometries (architectures). Description and definition of an architectural element should include:

1. Nature of lower and upper bounding surface i.e. erosional, gradational, planar, curved, irregular etc.
2. Geometry of element: tabular, lensoidal, wedge, scoop etc.
3. Scale and extension: thickness, extension of element parallel or perpendicular to flow direction.
4. Internal constitution: litho-facies assemblage, bedding and secondary erosional surfaces, current directions, geometry and order of internal bounding surfaces etc.

It may be noted that many facies types appear in more than one element. In addition, large architectural elements may include several smaller elements e.g. CH (Channel) element may include several other elements such as sandy bedform (SB), lateral accretion (LA), Gravel bar (GB) etc. (Fig 12; Table 1 & 2).

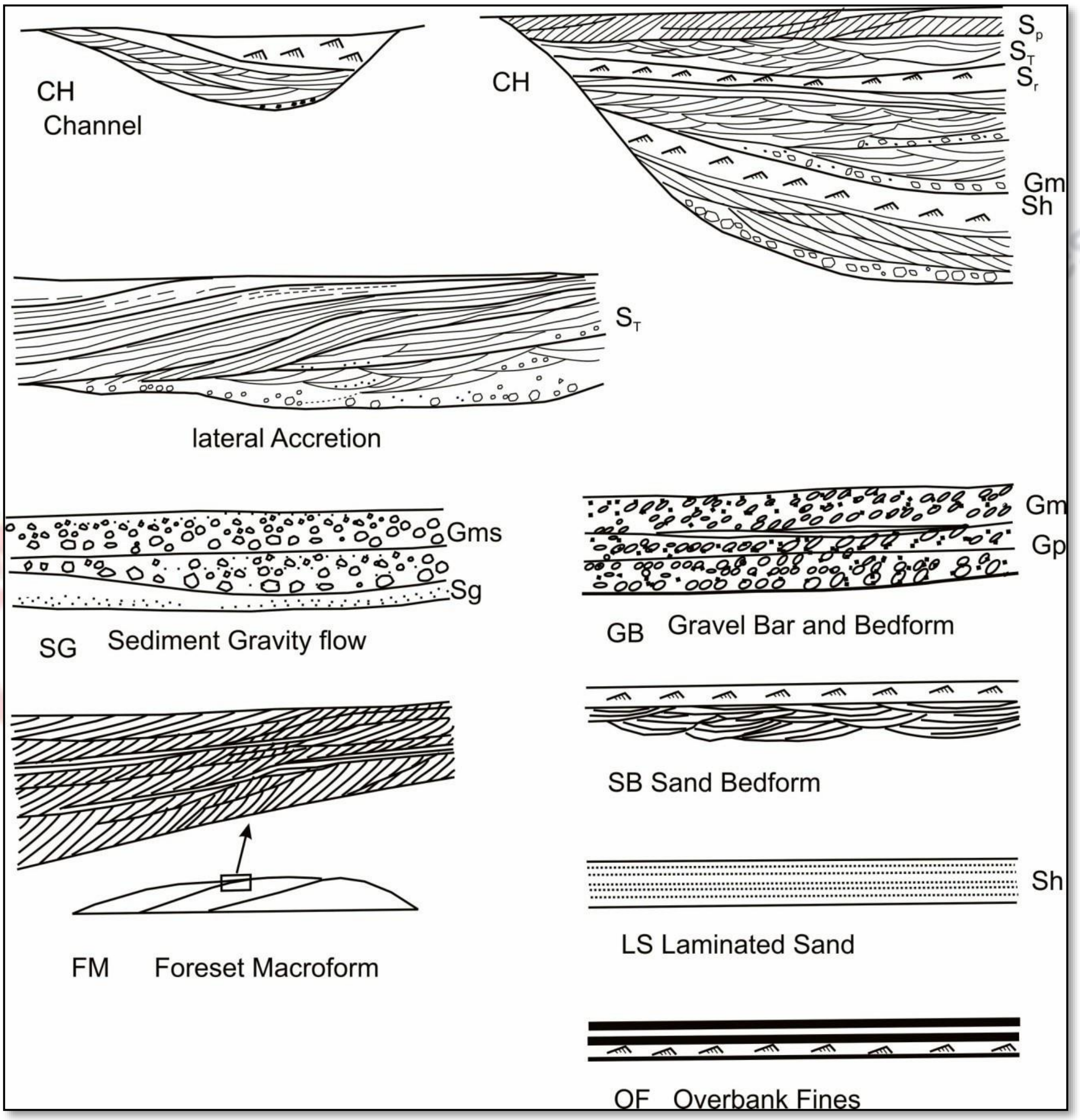

Fig. 12 Basic Architectural Elements of fluvial deposits after Miall (1985).

Table 1: Architectural elements in fluvial deposits (after Miall, 1985).

Elements	Symbol	Principal lithofacies assemblage	Geometry and relationships
Channels	**CH**	any combination	finger, lens or sheet; concave-up erosional base
Gravel bars and bed-forms	**GB**	Gm, Gp, Gt	lens, blanket; usually tabular bodies; commonly interbedded with SB
Sandy bed-forms	**SB**	St, Sp, Sh, Sl, Sr, Se, Ss	lens, sheet, blanket, wedge; occurs as channel fills, crevasses splays, minor bars
Foreset macroforms	**FM**	St, Sp, Sh, Sl, Sr, Se, Ss	lens resting on flat or channeled base, with convex-up second order internal erosion surfaces and upper bounding surface
Lateral accretion deposits	**LA**	St, Sp, Sh, Sl, Sr, Se, Ss; less commonly Gm, Gt, Gp	wedge, sheet, lobe; characterized by internal lateral accretion surfaces
Sediment gravity flows	**SG**	Gm, Gms	lobe, sheet,; typically interbedded with GB
Laminated sand sheets	**LS**	Sh, Sl; minor St, Sp, Sr	sheet, blanket
Overbank fines	**OF**	Fm, Fl	thin to thick blankets; commonly interbedded with SB; may fill abandoned channels

Definitions of facies types given in next table

Table 2: Lithofacies classification after Miall (1978).

Facies code	Lithofacies	Sedimentary Structures	Interpretation
Gm	Massive or crudely bedded gravel	Horizontal bedding , Imbrication	Longitudinal bars, Lag deposits, Sieve deposits
Gt	Gravel, stratified	Trough crossbeds	Minor channel fills
Gp	Gravel, stratified	Planar crossbeds	Linguiod bars, deltaic growths from older bar remnants
St	Sand, medium to v. coarse may be pebbly	Solitary or grouped trough cross beds	Dunes (lower flow regime)
Sp	Sand, medium to v. coarse, may be pebbly	Solitary or grouped planar crossbeds	Linguiod, transverse bars, sand waves (lower flow regime)
Sr	Sand, very fine to coarse	Ripple marks of all type	Ripples (lower flow regime)
Sh	Sand, very fine to very coarse, may be pebbly	Horizontal lamination, parting or streaming lineation	Planar bed flow (l. and u. flow regime)
Sl	Sand, fine	Low angle crossbeds	Scour fills crevasse splays, antidunes
Se	Erosional scours with intraclasts	Crude cross-bedding	Scour fills
Ss	Sand, fine to coarse	Broad, shallow scours including eta cross-stratification	Scour fills
Fl	Sand, silt, mud	Fine lamination, very small ripples	Overbank or waning flood deposits
Fsc	Silt, mud	Laminated to massive	Back swamp deposit
Fcf	Mud	Massive with fresh water molluscs	Back swamp and deposit
Fm	Mud silt	Massive, dessication crack	Overbank or drape deposits
Fr	Silt, mud	Rootlets	Seatearth
C	Coal, carbonaceous mud	Plants, mud flims	Swamp deposits
P	Carbonate	Pedogenic features	soil

7. Summary

Deposits formed by riverine processes i.e. channel flow and overbank sedimentation are referred to as fluvial deposits and two most common continental environments where stream processes dominate are i) alluvial fan and ii) River systems. Alluvial fans form by deposition of channel-borne sediments at break in slope (morphologic or tectonic), and observed in rock record along margins of sedimentary basins. Facies types in alluvial fan include matrix-supported conglomerate of debris flow origin, stratified gravel and sandstone of sheet flood origin, clast-supported conglomerate, and trough cross-stratified sandstones of channel flow origin. Dominance of channel flow is seen downslope of intersection point of fan profile i.e. in the mid and outer fan parts. Depending of climatic zone within which a fan system developed an alluvial fan inter fingers with fluvio-lacustrine or eolian facies. In case an alluvial fan directly divulges sediment within a marine system, it is referred as fan delta.

In terms of Sinuosity Index, river systems are classified as braided, meandering, anastomose and straight, amongst which most common are braided and meandering rivers. Channel-levee and overbank are principle morphological features of a river system. Deposits of channels are with scoured base and vary between lenticular (meandering) and sheet-like (braided) geometry with or without channel margin. While channel abandonment and relocation are major processes in braided river system, lateral migration and point bar formation are common in meandering river systems. Massive, stratified and cross-bedded conglomerates represent gravel bars in braided river systems, whereas trough cross-bedded sandstones, plain- and ripple cross-laminated sandstones as constituents of fining-upward succession represent sandy braided river or meandering river deposition. Thin sandstone sheets in alternation with mudstone, paleosol and/or coal represent products of flood plain and wedge-shaped, fine-grained bodies (thick near the channel and wedge out away), made up of silt and mud, occasionally with coal, represent levee deposits in a meandering river system. Paleo current data from channel deposits is unidirectional but with different amounts of dispersion; meandering channels show more dispersion in comparison to a braided channel.

Frequently Asked Questions-

Q1. Define 'Sinuosity'. How rivers are classified in terms of sinuosity?

Ans: Sinuosity of a river is defined by the ratio between stream length (l) and valley length (L). The value of this ratio is referred as 'Sinuosity Index (SI). According to sinuosity index rivers are classified as i) straight ii) braided, iii) meandering iv) anastomosing. Whereas straight channel shows SI value 1, braided rivers have SI values 1.1-1.2 and meandering rivers >1.5.

Q2. What sorts of condition promote braided character of a river? What bed geometry one would expect in a braided river deposit?

Ans: High gradient, flashy, episodic (ephemeral) discharge, domination of bed load, lack of mud and bank stability and large channel width: depth ratio are characters of braided rivers. Plugging and relocation of channel is common in braided river systems. Because of frequent relocation of channel, a braided river system is likely to result granular/ sandy bed with tabular geometry; mud is present only as discontinuous lenticles.

Q3. Enlist characteristic features, which can help in identifying a alluvial fan deposit in rock record?

Ans: An alluvial fan deposit is represented by conglomerates and sandstones predominantly immature in mineralogy; presence of mudstone is noticed only in minor volumetric proportion. yellow, reddish or brown coloration is common because of oxidizing condition. Bed geometry vary between lenticular (channel) and sheet like (within fan). Although often it becomes difficult to differentiate products of distal fan and braid-plain products, predominance of debris flow over stream flow products and presence of sieve deposit are considered as good recognizing criteria of alluvial fan deposit in rock record. However, in absence of proximal fan products in many ancient alluvial fan deposits even such recognition becomes a challenge. Radial paleo current is common indicating both current direction and depositional slope. Alluvial fan deposits commonly lack fossils except for plant fossils within flood plains and rare vertebrate fossils. Deposits of ephemeral lake, eolian dune, braided river are found in common association.

Q4. What is 'intersection point' in an alluvial fan profile? How does it control facies development in an alluvial fan system?

Ans: Intersection point refers to the intersection between fan profile and stream profile (water table). Upslope of this intersection point is referred to as the fan head (proximal fan) where water percolates down through sediment column and debris flow constitutes the dominant depositional process. Matrix-supported conglomerates result from debris flows whereas subordinate clast-supported conglomerate can also be found as products of stream flow. Downstream of intersection point stream flow dominate above debris flow and clast-supported conglomerate and cross-stratified poorly sorted sandstones dominate the mid fan products.

Q5. What is sheet flood? What are the characters of a sheet flood deposit?

Ans: Inundation of an alluvial fan surface in course of high discharge by a heavy rainstorm when loose sediments spread over the fan surface in bedload (pebbles, cobbles, boulders) and suspension (granules and fine pebbles) is called 'sheet flood'. Rapid, supercritical (upper flow regime) turbulent flows operate on the fan surface during sheet floods.

Characteristics of sheet flood deposit are:

1. Sheet geometry of beds; cms to a few meter in thickness. Poorly sorted sediments and negligible mud content.
2. Well stratified beds with common occurrence of depositional couplet i.e. couplets of coarse gravel and coarse sand, fine gravel. Occasional presence of up-slope directed antidune cross-stratification.
3. Clasts may show imbrications; waning flows result normal grading.

Q6. What is a 'point bar'? Where and how does it form? How do we identify a point bar deposit in rock record?

Ans: A meandering channel migrates laterally by erosion on its outer bank and deposition in inner bank. The deposit it forms in this process on its inner bank is referred to as 'point bar'. A point bar always forms a fining-upward deposit starting from channel lag and coarse-grained sediments at the base and fine grained deposits towards top. Together with decrease in grain size, bed forms also decline in scale upward in a point bar deposit. As point bar deposits are formed by lateral migration and sediment accretion on inner bank of channel, the lateral accretion surfaces (with inclination <150) get preserved within point bar deposits as 'epsilon cross-stratification's. Best expression of these surfaces can be seen when there are episodes of low discharge, which allow deposition of fine sediment on point bar surface. Orientation of these surfaces is always perpendicular with flow directions observed within channels.

Q7. Define terms 'levee' and 'Crevasse splay'?

Ans: Repeated deposition of sand and silt on riverbank in course of overbank floodings that raises the channel edge higher than the level of floodplain is referred to as 'levee'. Deposit of levee is wedge shaped; coarsest near the channel and fine-grained towards flood plain. ripple cross-stratification and horizontally stratified sand and mud layers are commonly observed sedimentary structures in levee deposits.

At high flow stages when levee is breached and sediment-laden water directly come on the flood plain, it is referred as crevasse splay. Coarse bedload sediment and fine-grained suspension sediment debouches suddenly in the way get deposited on the flood plain as normally graded turbidite deposit. Base of such deposit is invariably erosional.

Q8. What kind of difference in bed geometry is expected between braided and meandering river deposit and why?

Ans: Owing to frequent channel plugging, aggradation, abandonment and relocation braided rivers produce sheet-like bodies constituted of conglomerates and sandstones.

Mudstone is present only in rare cases as discontinuous stringers. Meandering streams, in contrast, migrate in zones (meander belts) that are 15 to 20 times the width of the channel and produce shoestring sand body. These sand bodies are not as continuous as those of braided stream origin. Sand: shale ratio is lower than braided river deposits and continuity of shale units divide the sand bodies as multi-tier units.

Q9. What is an incise valley? How fluvial system behave in course of formation and filling on an incise valley?

Ans: An incised valley is formed when a river cuts into its own floodplain or substratum so much that even during flood, flow does not overtop the banks. Different factors which can promote valley incision are i) base level fall, ii) tectonic tilting of alluvial plain and/or iii) decrease in fluvial discharge. In course of incision of a valley, sediment storage is minimum in the valley. Deposition in valley takes place with increase in base level and fluvial system filling an incise valley change its pattern from an early braided to late meandering character. In fact, valley fill deposits become more complex in pattern with influence of marine processes both down slope and upper parts of a valley fill.

Multiple Choice Questions-

1. Deposit of a point bar is

(a) Coarsening-upward
(b) Fining-upward
(c) With no grain size trend; aggradational

Ans: b

2. Sinuosity Index (SI) for braided rivers is

(a) 1.1-1.2
(b) 1
(c) >1.5

Ans: a

3. Raised banks of meandering rivers formed by deposition of fine sand, silt and clay during overbank flooding are called

(a) Levee
(b) Flood plain
(c) Crevasse splay

Ans: a

4. Current directions measured from a meandering river deposit would show

(a) Unimodal paleo current with low dispersion
(b) Unimodal paleo current with high dispersion
(c) Bimodal paleo current

Ans: b

5. Low inclination (<15^0) lateral accretion surfaces present within point bar deposits are referred to as

(a) Epsilon cross-stratification
(b) Trough cross-stratification
(c) Sigmoidal cross-stratification

Ans: a

6. Meandering rivers produce sandstone beds with

(a) sheet-like geometry
(b) lobe-like geometry
(c) shoe-string geometry

Ans: c

7. Tectonic tilting of a river valley will result

(a) Meandering in channel system
(b) Braiding in channel system
(c) Avulsion of channel system

Ans: c

8. Increase in base level (water table) in a fluvial system will result in

(a) Channel dominated succession
(b) Flood plain dominated succession
(c) No change in fluvial style

Ans: b

Suggested Readings:

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