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Depositional History and Neo-tectonics of Rajshahi and Nawabgonj District- Miniature of Barind Tract, Bangladesh Using Sub-surface Geology

Shahtaj Karim, Dr. Mrinal Kanty Roy, Dr. Md. Sultan-UL- Islam

Abstract—Rajshahi and Nawabgonj district occupies a portion of Barind Tract. Depositional environment and neo-tectonics of the area analyzed with the help of bore log data. About 80 no of bore logs were collected from BMDA and BWDB. Subsurface geological condition, their architectural elements as well as depositional environment was derived from those lithologs. The study area divided in to four informal units named Unit-A, Unit-B, Unit-C and Unit-D. Unit-D is further subdivided into two subunits as Subunit-1 and Subunit-2. Subunit-1 is being deposited during Recent time and Subunit-2 was deposited during Pleistocene period. Below this Unit-C, Unit-B and Unit-A is found which have been deposited during Mio-Pliocene period. The subsurface litho-succession was prepared from collected lithologs and architectural element analysis helps to understand the vertical and lateral distribution pattern of the sediments. The study area is tectonically still very active and signatures of neo-tectonic activities are found inside the subsurface sedimentary deposits. The sediments of the study area were deposited mainly under fluvial environmental condition.

Index Terms— Barind Tract, Neo-tectonics, Depositional History, Bore Log.

1 INTRODUCTION

The study area occupies the whole Nawabgonj and parts of Rajshahi district, which is situated in the northwestern part of Bangladesh lies within 24^0-24^0 95′ N latitudes and 88^0 1′-88^0 95′ E longitudes (Fig. 1a). Six lithological cross-sections (Fig. 1b) and panel diagram (Fig. 4) were constructed to get subsurface geology, lithofacies, sedimentary architecture and their environments of deposition.

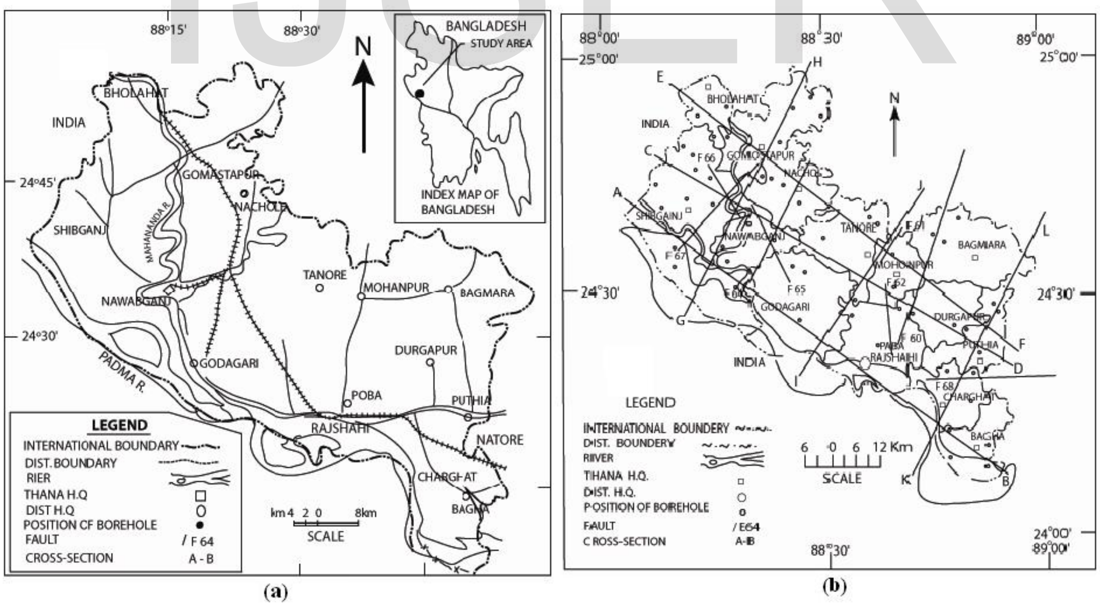

Fig. 1. Location map of the study area (a) with bore hole locations and profile of cross-sections (b).

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2 Geology of the Study Area

The study area is covered by Holocene fluvial sediments with comparatively elevated Pleistocene terrace, deposited as floodplain sediments. Subsurface stratigraphy of the study area has been establish on the basis of field observation, deep tube-well borelog data and published literature. Lithological cross-sections along northwest-southeast and northeast-southwest directions (Fig. 1b) have been constructed to provide two dimensional vertical images of the sub-surface and correlated with vertical and horizontal sedimentary sequence. On the basis of lithologic characteristics sub-surface stratigraphy of the study area is divided into four lithostratigraphic units named as Unit-A, Unit-B, Unit-C and Unit-D (Table 1) which consist mainly of coarse sand, medium sand, fine sand and clay respectively.

2.1 Unit-A

This unit contains mainly light gray to gray coarse sand which becomes brown to reddish brown at places. Sometime medium sand and little amount of gravel are also found with predominant coarse sand. Thickness of this unit ranges from 3 to 33 meters which is higher in the northwestern to central part and in the northeastern part, observed by the lithological cross-sections and panel diagram (Fig. 2, 3 and 4). Along A-B cross-section (Fig. 2a) the thickness of Unit-A is higher in the areas of Shibgonj, Nawabgonj and in Bagha. Thickness of this unit decreases from Bagha towards Charghat and Poba and suddenly it is absent throughout the whole Godagari area. Along C-D cross-section (Fig. 2b) thickness is greater in Dugrapur, Mohanpur and Shibganj areas and becomes lower toward the central part of the cross-section and totally absent in Tanore area. Similar treand is also found along E-F cross-section (Fig. 2c). Here thickness of this unit is greater along Puthia, Durgapur, Mohanpur and Bholahat areas but coarse grained sand is absent in Gomostapur, Nachole and Tanore areas. Some gravels are present here as basal deposits. Absence of coarse grained sand is mainly found in the exposed Barind areas, which are fault bounded in most of the cases. Cross-sections along the NE-SW directions (Fig. 3a, 3b, 3c) and panel diagram also support these findings.

2.2 Unit-B

Light gray to gray color medium sand is the main constituent of this unit. In some borelog medium to coarse sand or medium to fine sand are also found with very few amounts of gravels. In some areas reddish brown color deposits are also found. Thickness of deposit varies from 3 to 43 meters. Higher thickness variation of this unit is found in the northwestern to northeastern part of the study area. In the southwestern part thickness of this deposit is comparatively small. From the observation of all the cross-sections and panel diagram it has been found that the quick accumulation of this unit is found in Shibgonj, Nawabgonj, Gomgstapur, Poba and Durgapur areas but greater accumulation of this unit is found along the E-F cross-section (Fig. 2c) from Tanore to Dugrapur area. Along C-D cross-section (Fig. 2b) parts of Nawabgonj and Tanore areas, deposits of this unit are capped by fine grained clay deposits. Due to the presence of the basement controlled fault the position of this unit becomes displaced from place to place.

2.3 Unit-C

Thickness of this unit ranges from 2 to 43 meter and consist mainly of light yellow to yellow color fine sand. In some places the color of the deposit become reddish brown to brownish yellow and the grain size becomes finer too. The southwestern to central part of the area have greater accumulation of this unit. Northwestern part also shows similar distribution pattern. But in the southwestern part and south-central part of the area are characterized by very lower thickness of this unit. Thickness of the Unit-C is higher in the Tanore area and becomes lower in Godagari, Gomgstapur and Nachole areas throughout all the cross-sections (Fig. 2a, 2b, 2c and Fig. 3a, 3b, 3c) and panel diagram (Fig. 4). The distribution of this unit is almost equal throughout the rest of the areas. Lower thickness of this unit is fault bounded.

2.4 Unit-D

Depending upon the nature of the clay this unit has been subdivided into two sub-units. The thickness of this unit increases from west to east direction i.e. higher thickness of this unit exhibits in the central to eastern part and lower scale deposition found in the whole western part of the study area. This unit shows a different depositional trend from the other three lithological units. Greater thickness of this unit is found in Godagari, Poba, Tanore, parts of Nawabgonj, Gomostapur, Nachole, Tanore and Mohanpur areas along the A-B, C-D and E-F cross-sections respectively (Fig. 2a, 2b, 2c). Thickness variation of this unit is mainly due to the existence of faulting but on the other hand, this thickness variation might be caused by depositional processes due to changes of energy level.

2.4.1 Sub-unit-2

The hard and plastic clay mainly compose this sub-unit. The color of this clayey sub-unit is mainly reddish brown to brownish yellow. Blackish plastic clay and light gray stiff clay are also present here. It is hard and compact in nature with sticky and plastic behavior indicates that they are older deposited clay. Thickness of this unit ranges from 3 to 40 meter.

2.4.2 Sub-unit-1

This sub-unit mainly contains blackish or brownish gray clay with light yellow to brown color silty to sandy clay. Loamy clay is also found in this sub-unit. The presence of loamy clay and their nature indicate that this sub-unit has been deposited recently by the active channels. Thickness of this unit is 3 to 37 meter.

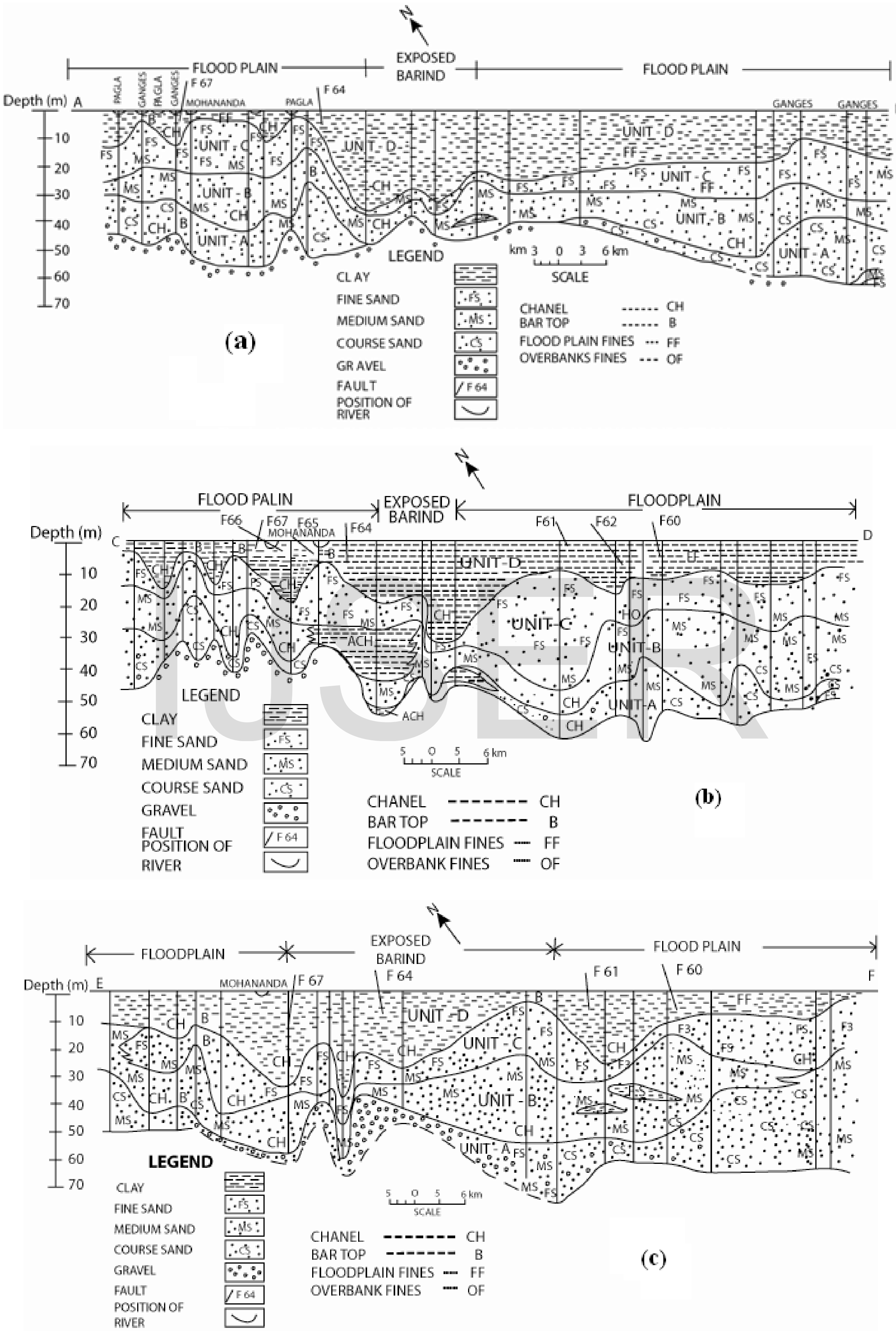

Fig. 2. Lithological cross-sections A- B (a), C-D (b) and E-F (c) along NW-SE direction.

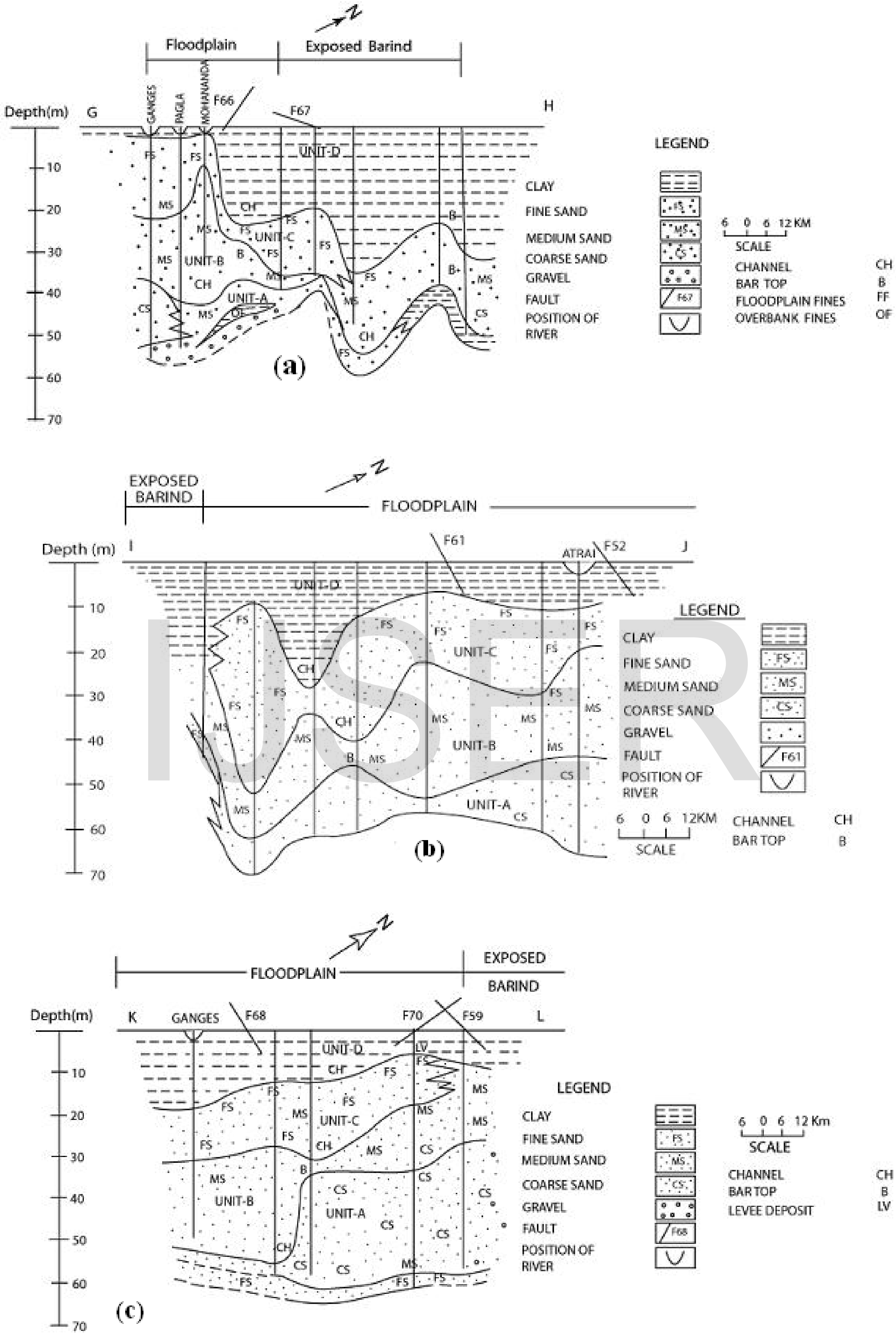

Fig. 3. Lithological cross-sections G-H (a), I-J (b) and K-L (c) along NE-SW direction.

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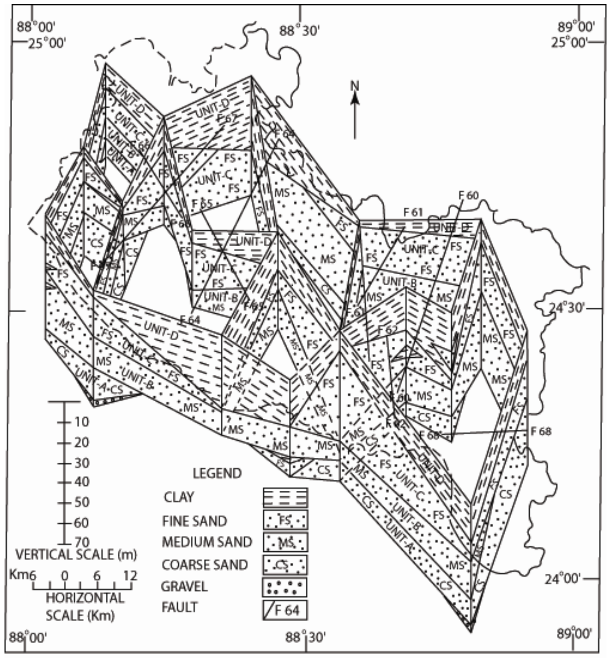

Fig. 4. Panel diagram of the study area.

TABLE 1. SUB-SURFACE STRATIGRAPHIC SUCCESSION OF THE STUDY AREA.

Unit	Sub-unit	Lithology	Thickness (m)
D	1	Blackish to brownish gray clay with light yellow to brown silty to sandy clay. Loamy clay is also present.	3-37
	2	Reddish brown to brownish yellow hard and plastic clay.	3-40
C		Light yellow to yellow fine sand with reddish to brownish yellow very fine sand.	2-43
B		Light gray to gray medium sand with gray medium to coarse sand and gray medium to fine sand with gravels.	3-43
A		Light gray to gray coarse sand with gravels.	(3-33) +

3 ARCHITECTURAL ELEMENT ANALYSIS

Architectural element analysis was carried out by both field observation and correlation of subsurface lithologs along suitable traverses. Geometry of deposition and bounding surfaces are clearly identified from subsurface lithological units and sedimentological boundaries, which helps to construct the three-dimensional mapping through the study area.

Throughout the Study area different types of architectural elements have been identified which are Channel (CH), Scour hollow (HO), Bar top (BT), Natural levee (LV) and Floodplain fines (FF). In the study area bounding surfaces from 0 to 5th order are mainly recognized. All these macroform deposits are identified mainly by their bounding surface condition and depositional geometry. The channels are recognized by concave-up erosional 5th order bounding surface with change in facies above and below the scoured surface (Fig. 2a, 2b, 2c and Fig. 3a, 3b, 3c). The largest channel has length and depth of about 15 Km and 35 m respectively. Dimension of smaller channels ranges from 1.5 Km to 3.5 km in length and 5 to 10 m depth. The depth of channels increases comparatively from place to place due to faulting. Some channels were occasionally filled with fine-grained clay deposits surrounded by coarse-grained deposits. Such deposits are termed as abundant channel (ACH) deposits. Scour hollows are also existing channel like geometry but their extent of deposition are smaller and shallower than channels. They are scooped shaped hollow with asymmetric fill and bounded with curved, concave-up 4th order bounding surfaces (Fig. 2b). The dimension of this element is 2 km in length and 5 m in depth. Bar tops are characterized by large convex-up 4th order bounding surfaces formed due to lateral accretion of deposits (Fig. 2a, 2b, 2c and Fig. 3a, 3b, 3c). The length of bars ranges from 0.5 to 1 km and height of the bar is about 3.5 to 5 m. Natural levees are also identified by 4th order narrow convex-up microform top which is bounded by flat surface floodplain element. Natural levees in the study area have the length of 1 to 1.5 km and height is about 5 to7 m. Floodplain fines are recognized by 2th and 4th order nearly horizontal bounding surfaces (Fig. 2a, 2b, 2c, 3a). These sheets like deposits are extent laterally in many kilometers.

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The floodplains of the study area are about 11 to 26 km long. The largest one is about 29 km long.

In many areas of the cross-sections two banks of the paleo-channels are not in the similar elevation. One bank is situated comparatively higher elevation than other. Existences of basement controlled faults are also found in these positions, which indicate that it may be caused due to faulting. The distributions of channels and natural levees have also changed their positions from the bottom to the top of the cross-sections. Exact vertical positions of some natural levees are indication of lateral channel shifting through time.

4 Depositional History and Neo-tectonics

4.1 Depositional History

The prominent depositional element of the area is mainly the channels which are identified by architectural element analysis within the subsurface sedimentary deposits. The widths of the paleovalleys are in the scale of 16 to 24 Km indicating that the paleovalleys are multistacked channel deposits. These types of multistacked paleochannels have been found throughout the study area along every cross-sections. In some areas within these paleochannels lense shaped very fine sand and clay deposits are also found as overbank fine deposits indicate that the development of these elements might have taken place under different depositional phases. The dimensions of those paleochannels are quite larger than the present perhaps due to the compaction of channelized bodies resulted from the tectonic activities of the area. The position of present channels and their shape, size and dimension signify this condition.

Among the surface clay deposits there are some Barind clay deposits of reddish yellow to yellowish brown color, hard and plastic in nature. This clayey unit was deposited during Pleistocene period. Below this Barind clay deposits there are some sandy deposits. They are yellowish brown color fine to coarse grained sandstone with few amount of gravel. These sandy deposits were being deposited during Mio-Pliocene period (UNDP, 1982). The subsurface sedimentary deposits of the area have been deposited under fluvial environment.

From architecture element analysis channels, bar and floodplain deposits are found along A-B cross-section (Fig. 2a). The thickness of channel sand is greater in western and eastern part and becomes thinner in the central part of the section where thickness of upper clay deposits is higher than other areas. It indicates the flood basin deposits within two channel deposits. Along C-D cross-section (Fig. 2b) channel, scour hollows, bar and floodplain deposits are found. Here thickness of channel sand is more or less greater throughout the section. Scour hollows are present within the channels. The abundant channels are filled up by finer deposits. Here the thickness of flood basin deposits is also increases between two channel deposits. Cross-section E-F (Fig. 2c) also gives the similar feature. All these depositional elements are found within the fluvial depositional architecture, suggest fluvial depositional environment of the study area.

Architecture element analysis from different cross-section shows that the channel shape deposits on the Barind clay and upper floodplain clay deposits were developed under strong hydrodynamic condition, which was further filled by clayey deposits. As the Barind clay was deposited during Pleistocene period, so it could be said that the strong hydrodynamic condition, which creates the channels within the upper clay deposits could be originated by the activity of glacial water.

Below the Pleistocene deposits channels, bars and floodplain deposits are also found within the sandy formation. The bottom sequence of all the cross-section shows undulating surface like channel deposits. All of these indicate fluvial environment. But the presence of incised valley indicates that the environment of deposition might be fluvio-estuarine with small amount of seawater transgression.

4.2 Neotectonics

Tectonically the study area is still very active which was proved by various workers. Khondoker (1987) shows that the Barind Tract was elevated as horst block at the close of Pleistocene. From aeromagnetic map of Bangladesh (Hunting, 1981) an E-W fault possibly terminates the northern extension of Barind. Nandy (1980) shows a lineament along the river Padma (Ganga) that delineates the southern extremity of the Barind surface possibly indicative of being fault controlled. All these works indicate that the study area, including Barind Tract is structurally controlled along all margins. Khan and Rahaman (1992) also show that the study area is characterized by many faults. Some of which are Pre-Gondowana while the others are generated by latter tectonic activities and formed intrabasinal horsts and graven. The faults associated with the origin of the Barind Tract are still active (Khondoker, 1987). Recent vertical movement of this area is at the rate of 0.4 to 1.1 mm/year (Haque, 1982).

Throughout the study area a number of faults have been identified (Fig. 1b) which was numbered as F60, F61, F62, F64, F66, F67 and F68 (Hunting, 1981; Fig. 1b). Along the cross-section A-B (Fig. 2a) F64 and F67 are found. In the eastern margin of F64 the thickness of clay deposits becomes much thicker than the western part. Similar features are also found around F67 where thickness of clay deposits is higher in western margin and becomes thinner along the eastern margin which indicates that the eastern margin of the F64 and the western margin of F67 are downthrown blocks of successive faults. Besides this, in the eastern part of the exposed Barind deposit, the continuation of Barind clay is found which are overlain by Recent floodplain deposits. But in the western part of the exposed Barind the continuation of Barind clay deposits is changes abruptly indicates that the subsurface deposits are affected by existing faults. Similar opinion was given by Klinski (1979). In some parts of the Barind area the boundary separating the Recent and Pleistocene sediments is sharp and quite straight may be the result of recent tectonic activites (Klinski, 1979).

Similarly along the cross-section C-D (Fig. 2b) fault number F60, F61, F62, F64, F65, F66 and F67 are present. The eastern margin of the F67 and western margin of F64 are upthrown because the thickness of clay deposits becomes increasing and decreasing in both the two areas respectively. A thick accumulation of clay is also present in the eastern part of F61. Here also the continuation of Barind clay is missing suddenly along the western margin of the cross-section, which forms the western part of the Mohananda River. The N-S Malda-Kishangonj fault with an appreciable downthrown on the western side seems to control the entire course of the Mohananda River which originates in the Darjeeling Himalayas and flows south to join the Ganges near Godagari, Rajshahi (Jahan and Ahmed, 1997).

Along cross-section E-F (Fig. 2c) eastern margin of F67 and western margin of F60 and F64 contain greater clay accumulation. The thickness of clay deposits and presence of incised valley prove the faulting activity. Western part of the exposed Barind are also characterized by absence of Barind clay deposits but in the eastern part the continuation of Barind clay are still present under the floodplain deposits. Moreover, exposed Barind of the study area are fault bounded both in the eastern and western part which have been observed along all cross-sections.

Cross-sections which were prepared along northeast to southwest direction are also shows the similar leaning (Fig. 3a, 3b, 3c) as northwest to southeast trending cross-sections (Fig. 2a, 2b, 2c). Fault activities are also found here like the previous cross-sections (e,g cross-sections AB, CD and EF) which ultimately control the subsurface depositional condition.

The shifting of the river courses is indicative of neotectonic activities in the northwestern Bangladesh (Gafoor, 1982). The evidences of river shifting are quite prominent throughout the study area. From the study of cross-sections, architectural element and position of the present river courses it has been found that the present positions of the exiting rivers were shifted slightly (about 100 to 150 meters) from their original position in the paleo-valley. In a nut shell, the whole study area and its surroundings are structurally controlled and tectonically active which affected partially the subsurface sedimentary deposits of the study area.

5 Conclusion

The study area mainly consists of clay and sand deposits. Barind clay was deposited during Pleistocene Period and sand was deposited during Mio-Pliocene Period (UNDP, 1982). Depositional environment have been delineated from architectural element analysis signifying fluvial depositional environment. Some paleo-valleys are found in the upper portion of the cross-section filled with Barind clay and floodplain clay deposits. Upper valleys might be designated as glaciated valley and lower incised valleys may indicate the fluvial environment with estuarine nature. The study area is tectonically still very active. Sudden thickness variation of surface clay deposits proved the effect of basement controlled fault mapped by (Hunting, 1981). The whole study area represents a pre-existing paleo-geographic high land area with undulation and different channel like features were developed within this uplifted high land because of channel incision. Although the study area is tectonically still very active but these movements are not sufficient for the present elevated feature of the area, it only emphasized the total surficial nature.

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- *Author name: Shahtaj Karim, Assistant Director, Geological Survey of Bangladesh,153 Pioneer Road, Segunbagicha, Dhaka-1000. E-mail: geoshimu@yahoo.com*
- *Co-Author name: Dr. Mrinal Kanty Roy and Dr. Md. Sultan-UL- Islam, Department of Geology and Mining, University of Rajshahi, Rajshahi.*