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FACIES ANALYSIS AND PALEOENVIRONMENTS OF THE UPPER CRETACEOUS SEDIMENTS IN SHARE – LAFIAGI AREAS, NORTHERN BIDA BASIN, NIGERIA.

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ABSTRACT

The Bida Basin is located in central Nigeria and it is perpendicular to the main axis of the Benue Trough. Due to its large areal extent and facies variation, the basin is often geographically divided into northern and southern Bida Basins. Whereas, aspects of the mineral resource and sedimentation history of the sediments in NW and SE extremes have been consistently studied, the present study area (Share-Lafiagi-Shonga areas) remains either unknown or under-reported. In the study area, fifteen vertical profiles of the Campanian-Maastrichtian sediments were studied along road cuts, erosional channels and Cliff sides with special attention focused on their internal physical and biogenic attributes. The sedimentological analysis permitted recognition of five distinct depositional facies; alluvial fan, braided channel, floodplain, tidal channel and shoreface in the lithostratigraphic units mapped.

In Unit I, the proximal alluvial fan facies were preserved as conglomeratic facies which overly non-conformably, the Pre-Cambrian weathered schists and granites. Both the matrix and grain supported subfacies are indicative of gravity induced alluvial processes. The braided channel facies comprising of conglomeratic sandstone, medium-coarse grained sandstone subfacies are wide spread and their fluvial origin is supported by unidirectional flow pattern and absence of marine biogenic features. The sequence grades into claystone facies which probably formed in localized non marine floodplains. The younger Unit II comprises of conglomerate, sandstone and claystone facies. The conglomerate facies is moderately sorted and mature showing evidence of reworking and recycling. Association of this facies with herringbone cross stratifified beds probably indicates tidal channel lag origin. The sandstone facies are commonly compositionally mature, bioturbated and contain clasts of reworked clays and clay drapes suggesting high energy tidal channels and shoreface subenvironments.

The depositional model for the Upper Cretaceous sediments in the study area is strongly dominated by alluvial processes which in places evolved into shallow marine processes and frequently incised by fluvial channels. The clay deposits of the floodplain may offer economic resource potential in the area.

KEY WORDS: Bida, Facies, Cretaceous, Fluvial, Sedimentation

INTRODUCTION

The Bida Basin (synonymous with middle Niger and Nupe Basins) is a 350km long NW – SE trending intracratonic embayment and is oriented perpendicular to the main axis of the Benue Trough of Nigeria (Fig. 1a). To the east, it is contiguous with or adjacent to the Anambra Basin. These basins were major depositional centres for transgressive and regressive sediments in the upper Cretaceous times of Nigeria. To the northwest, it is adjacent to the Sokoto basin. Due to its large areal extent and facies variation, the basin is often geographically divided into northern and southern Bida Basins.

Among the previous studies on the geology of the Bida Basin are the works of Adeleye (1973, 1974), Braide (1992a), Olaniyan and Olabaniyi (1996) and Oluyide et al. (1998) which reported aspects of the stratigraphy and sedimentology of parts of the northern Bida Basin. Jan Du Chene et al (1978) recognized the presence of Maastrichtian pollen and spores in the shales in southern Bida Basin. The origin of the oolitic ironstones in the Bida Basin had been a principal subject of several works e.g. Adeleye (1973), Ladipo et al. (1994) and Abimbola et al. (1999). In recent time, investigations have also been made on the petroleum potentials of the Bida Basin (Idowu and Enu, 1992; Braide, 1992b; Obaje et al. 2004; Akande, et al. 2005).

The stratigraphy, mineral resources and paleoenvironmental evolution of the sediments in northwest of the northern Bida Basin and southern Bida Basin have been consistently studied and published, however, no such information is available on the present investigated area (Share – Lafiagi - Shonga area) with hundreds of metres thick clastic sediments. The only effort in that direction, is, however, that of Braide (1992a) which presented facies association and tectonic implications of sediments north of the River Niger (Bida – Enagi traverse). This article covers the traverse south of the Niger River (Fig. 1b). Even though, the rocks in this region, may be lateral equivalents of those north of River Niger, their distribution, geological developments, depositional history and economic resources (main

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objectives of this study) are worth studying and indeed the documentation will help to further understand the geology of the entire basin. This approach will also help to further appreciate the lateral and time variation in facies in the entire basin and their significance. It is important to also note here that, from our experience in the southern Bida Basin (Ojo and Akande, 2006, 2009), the depositional models of Braide (1992a & b) which foreclose influence of marine processes in that basin need to be re examined.

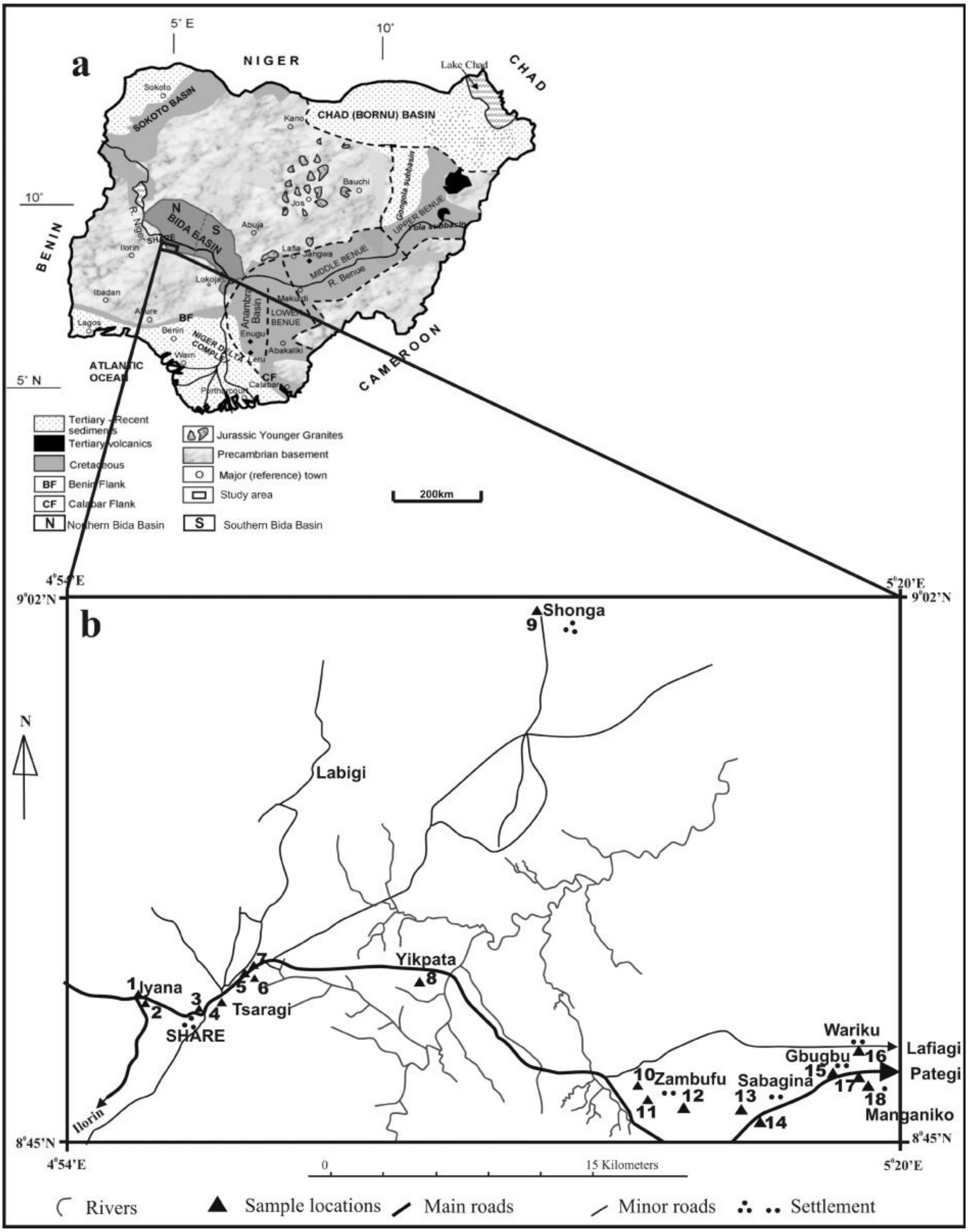


Fig. 1: (a) Geological map of Nigeria showing the position of Bida Basin (modified after Obaje et al. 2004). (b) Map of the study area (boxed area of Fig. 1a) and locations of the investigated outcrops.

Geological Setting

Consensus of opinion on the origin of the Bida Basin is that the upper Cretaceous sediments, which are essentially clastics were deposited in a rift basin associated with drifting apart of south America and Africa plates (King, 1950; Kennedy, 1965). The Bida Basin is popularly believed to be part of the tectonic evolution of the Benue Trough which perhaps, began in the Jurassic – Early Cretaceous with the opening of Gulf of Guinea about a triple junction. Interpretations of Landsat images, borehole logs as well as geophysical data across the entire Bida Basin by Kogbe et al. (1981) suggest that the basin is bounded by a system of linear faults trending NW/SE. Gravity studies also confirm central positive anomalies flanked by negative anomalies as shown for the adjacent Benue Trough and typical of rift structures (Ojo and Ajakaiye, 1989; Kogbe et al. 1983). Ojo (1984) suggested an estimate of 3.5km as the maximum thickness of the sedimentary successions in the central axis based on gravity survey. Adeniyi (1985) through ground and aeromagnetic studies also outlined the basin configuration. A recent spectral analysis of the residual total magnetic field values over several sections of the basin, reveal an average depth to the basement of ca.3.4km and sedimentary thickness of up to 4.7km in the central and southern parts of the basin (Udensi and Osazuwa, 2004). In a different model, the basin is thought to be associated with isostatic readjustments and gentle down warping or subsidence of the granitic basement complex as a result of the removal of mantle material which led to the emplacement of the Younger granite ring complexes during the Jurassic (Ojo and Ajakaiye, 1989; Whiteman, 1982).

Braide (1992b) observed that the simple rift model could not explain the processes involved when the basins are put together as related horst and graben structures originating from the original NE/SW fracture systems and therefore suggested a wrench fault tectonic model to explain the origin of the Bida Basin. By such a model, the Bida Basin could be considered as a graben resulting from the sinistral movements along the bounding Chain and Charcot fracture systems of the Benue Trough whereby the basin is developed at an angle to the major principal fault movements in which the horizontal movements translated to vertical movements leading to basement fragmentation and subsidence.

Four mappable stratigraphic horizons all of which are Campanian – Maastrichtian have been delineated and described in the northern Bida Basin (Adeleye, 1974). The formations are Bida Sandstone, Sakpe Ironstone, Enagi Siltstone and Batati Ironstone. These correlate with Lokoja Formation, Patti Formation and Agbaja Ironstone Formation in the southern Bida Basin (Ojo and Akande, 2003) (Fig. 2). Remark must be made here that stratigraphic nomenclatures in this part of the basin as at today is chaotic and uncoordinated. Therefore, in the present study area, we provisionally refer to the mappable depositional sequences as Unit I and Unit II which correlate with Bida Sandstone and Enagi siltstone of Adeleye (1976) respectively. These constitute the stratigraphic framework in this study.

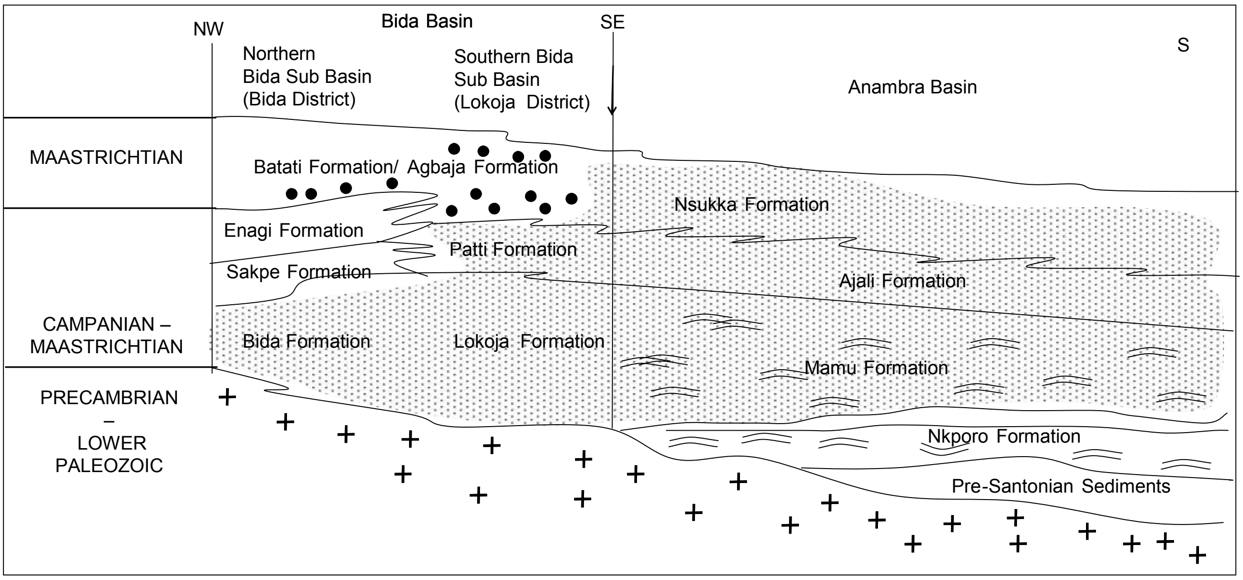


Fig. 2: Regional stratigraphic successions in the Bida Basin and their lateral equivalents in the Anambra Basin (Ojo and Akande, 2009).

Methods of Study

In this study, surface exposures of the Campanian to Maastrichtian sediments in the study area were measured and described with special attention paid to the internal features of the beds such as their texture, mineralogy and physical and biogenic sedimentary structures. Fifteen vertical profiles of the outcrop sections were studied along road cuts, erosional channels and cliff-sides. The access roads used include Share – Lafiagi – Pategi highway and Share – Shonga road (Fig. 1b). Vertical stratigraphic columns (in some cases, composite) were constructed at various locations and photographs of significant features were taken for documentation and reference purpose. The exposures are well preserved enough and suitable to permit detailed study of the facies. The paleoenvironmental interpretation was attempted based on facies association, sedimentary structures, textures and petrography.

Sedimentary Facies Description and Interpretation.

The sedimentological analysis of the sediments permitted the recognition of distinct depositional facies; alluvial fan, braided channel, floodplain, tidal channel and shoreface in the study area. The facies are distributed within two main stratigraphic units I and II.

Unit I

This comprises of the proximal alluvial facies, braided river facies and floodplain facies (Table 1).

Proximal Alluvial Fan

The proximal alluvial fan processes were preserved in the stratigraphic record as conglomerates in various part of the study area. The conglomerate facies can be distinguished into matrix-supported conglomerate and clast to matrix-supported conglomerate subfacies. The matrix-supported conglomerate subfacies also vary in terms of their composition. At Yikpata, Sabagina, Zambufu and Gbugbu, the matrix-supported conglomerates are massive, friable and poorly sorted with red, muddy to sandy matrix (Fig. 3). Their pebbles and cobbles include rounded to angular quartz, feldspars, and fragments of quartzite, schist and granite. At Yikpata and Gbugbu sections, this matrix-supported conglomerate subfacies occurs at the basal part of the sections where they overly unconformably the weathered basement complex (Figs. 3, 4 and 5). Some of the beds have irregular, scoured lower bounding surfaces. The average size of the clasts is 5cm. Cobble-size clasts constitute less than 3%. The pebbles and cobbles are mostly well rounded to sub angular quartz, schist, quartzite and in few cases granite. These clasts float within poorly sorted matrix consisting of ferruginous sand and clays. Generally, this subfacies are non-imbricated and lack any internal organization and they commonly grade upward into conglomeratic sandstone. In some other locations at Zambufu and Sabagina, it is noticed that, the conglomerates have larger fragments (cobble size) and the components are more indurated. Few imbrications and burrows are observed. The average thickness of the conglomerate beds is 3m and in most cases they show sheet like geometry with thick tabular bodies that are laterally continous for few tens of metres.

The grain to matrix-supported conglomerates subfacies in the study area are observed only at middle part of the Tsaragi and Yikpata sections (Figs. 3 and 5). This conglomerate bed appears to have less matrix and the pebbles, mostly of well rounded quartz, are well indurated. The beds with average thickness of 2 m is massive and bioturbated. Generally the conglomerates are immature.

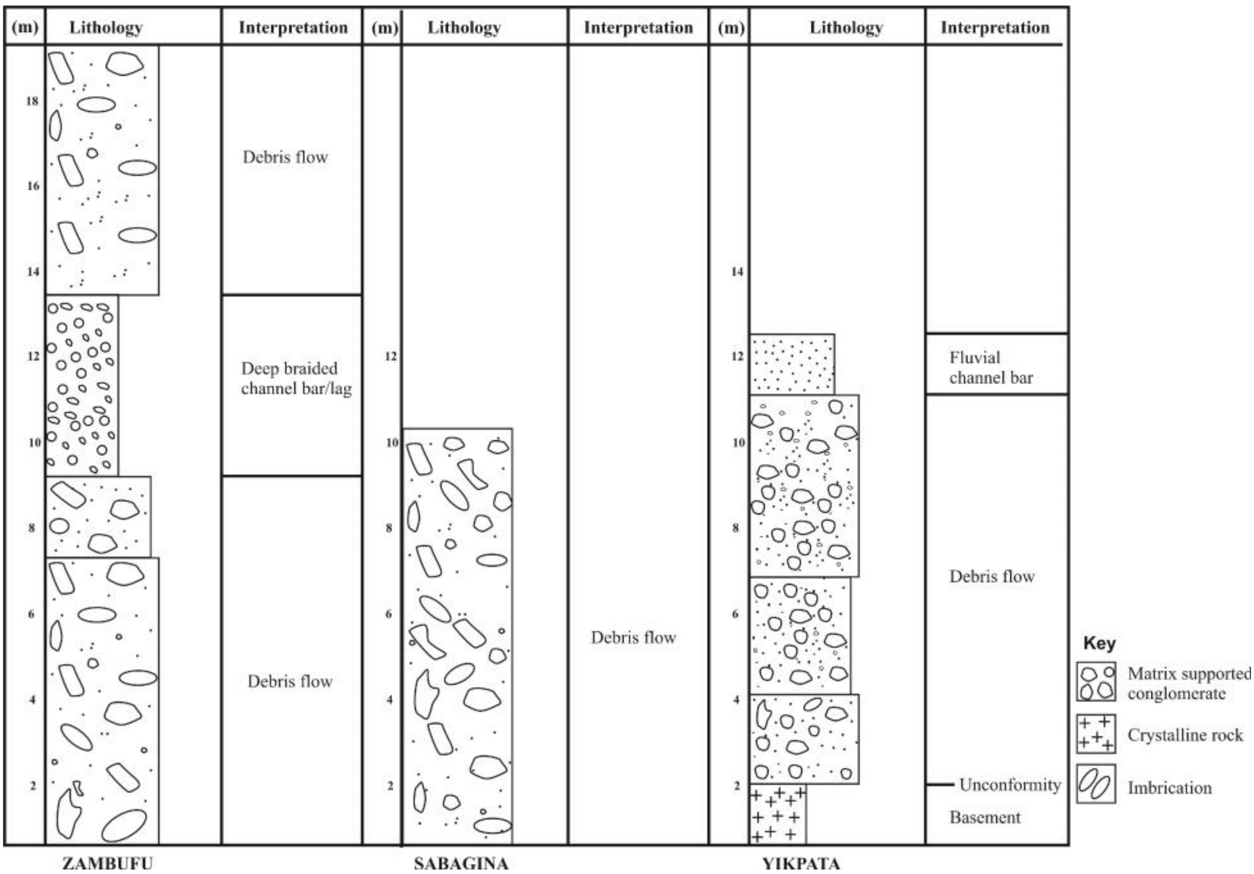
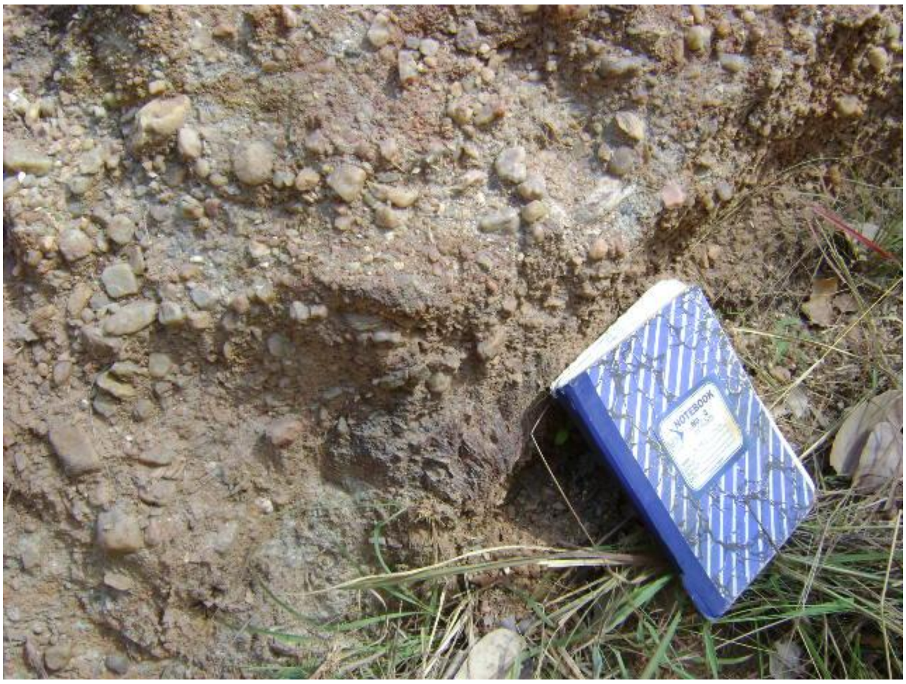


Fig. 3: Lithostratigraphic sections of the Unit I exposed at Zambufu, Sabagina and Yikpata.

Fig. 4: (a) Matrix supported conglomerate showing fining-upward trend (Debris flow), exposed at Sabagina.



(b) Non conformable contact between matrix-supported conglomerate and basement rock at Yikpata. Note the irregular erosional contact.

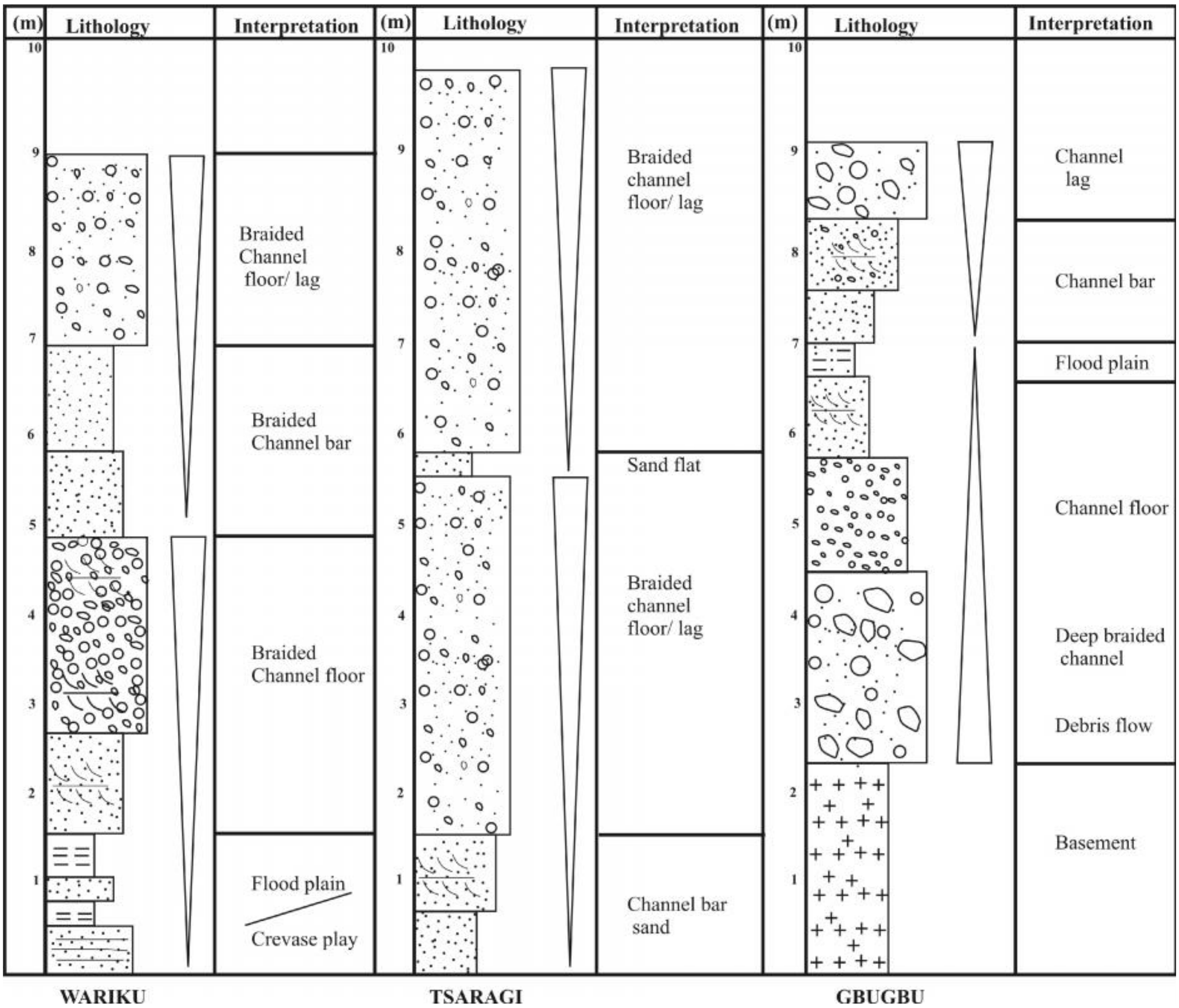


Fig. 5: Lithostratigraphic successions of the Unit I exposed at Wariku, Tsaragi and Gbugbu.

Interpretation

Both the matrix-supported and grain to matrix-supported conglomerate subfacies contain features indicative of continental environment dominated by gravity induced alluvial processes. A comparison of the sedimentary features of these conglomerate beds with well known and documented conglomerates in various parts of the world suggest that the matrix-supported conglomerates are products of cohesive debris flow deposited from dense and viscous fluids (Hampton, 1979; Collinson, 1996; El – Arabi and Abdel Motelib, 1999). Guiraud (1990) and Ojo and Akande (2003) interpreted similar conglomerates characterized by poor sorting, lack of internal organization and non imbricate clasts in the upper Benue Trough and southern Bida basin respectively as gravity-induced proximal alluvial fan deposits. This conglomerate also closely compare with the fanglomerate around Doko and Baro north of River Niger, northern Bida Basin, interpreted as deposition from rapid freezing of cohesive debris flows by Braide (1992b). The occurrence of grain to matrix-supported conglomerate towards the upper part of Tsaragi and Yikpata sections is an indication of changes in the flow system probably into streamflow. The well-rounded clasts of quartz which are significant or prominent in this conglomerate suggests possible derivation from older sedimentary rocks probably in adjacent sedimentary basins.

Braided Channel Facies

This facies, widely distributed in the sections studied comprises of conglomeratic sandstone, medium to pebbly sandstone, and fine grained sandstone subfacies. The conglomeratic sandstone subfacies is well represented in the sections exposed at Tsaragi, Gbugbu and Wariku (Figs. 5 and 6). Generally, it is friable and feldspathic. The thickness ranges from 0.50 to 3.00m averaging 2.00m. In most of the sections, they are massive and occur in repeated upward coarsening cycles, where they commonly pass upward into conglomerates. In places, the pebbly clasts form irregular bands of conglomerates lag on the erosional surfaces defining the bounding surface between it and the lower beds (Fig. 6). A variant of this is graded bedded and stratified conglomeratic sandstone with average thickness of 2.00m. This was observed at the basal part of the Tsaragi erosional channel section. In Gbugbu and Wariku, trough cross bedded, conglomeratic sandstone subfacies are well exposed. Planar cross beds were also observed in places. The trough cross bedding type occurs in most of the sections, with the sets varying in thickness from 0.40 to 1.00m. The tangential surfaces are sharp and marked by train of pebbly to cobbly clasts showing impacts of the erosion of older sets (Fig. 6). The cross beddings are generally unidirectional.

The medium to coarse sandstone subfacies is the next in terms of grain sicz to conglomeratic sandstone sub facies in the study area. They are composed mainly of sands, minor silts and pebbles. their thickness ranges from 0.30 to 1.00m. At Gbugbu and Wariku, it is frequently interbedded with claystone, both of which grade upward into conglomeratic sandstones (Fig. 6). Also, at Tsaragi, the medium to coarse grained sandstone passes upward into the conglomeratic sandstones (Fig. 5). The medium to coarse grained sandstone subfacies is commonly massive and rarely cross or parallel stratified.Such planar cross bedded sandstone occurs in Lafiagi where a small-scale low angle cross stratification is displayed. Petrographic evaluation of the sandstones shows that they are arkosic to sub-arkosic.

Fig. 6: (a) Unidirectional cross bedded sandstone subfacies (braided channel bar deposit) at Wariku.

(b) Fining-upward matrix-supported conglomerate within the alluvial fan facies at Gbugbu.

Interpretation

The sandstone facies comprising of the conglomeratic sandstone and medium to coarse grained sandstone subfacies is interpreted as braided fluvial deposits. The fluvial origin is supported by unidirectional paleocurrent pattern, shallow water traction-transport structures like trough cross bedding, planar stratification and absence of marine biogenic features (Rust and Jones, 1987; Hendrix et al. 1992, 1995; Amireh and Abed, 1999; Ojo and Akande, 2003). The frequently interbedded conglomeratic sandstone and medium to coarse grained sandstone is suggestive of development of low sinuosity fluvial channel bars, probably arising from high discharge, channel switching, and lack of point bar sedimentation (Allen, 1982; Selley, 1985; Blair, 1987). The conglomeratic sandstone lithofacies is thought to represent deep braided channel and channel lag deposits. The most plausible scenario is that the massive conglomeratic sandstone were rapidly deposited from a high velocity current whereas the graded and trough cross stratified conglomeratic sandstones developed from downstream migration of dunes of possibly straight crested bedforms in a low flow regime conditions (Miall, 1988, 1990; Amireh et al. 1994). The thinly bedded medium to coarse grained sandstone (massive to planar cross stratified) subfacies is however interpreted as mid to distal channel bars deposited in upper flow regimes (Table 1).

Table 1. Facies characteristics and interpretation

Unit	Lithofacies	Characteristics	Microfacies	Interpretation
Unit I	Ia: Matrix supported Conglomerate	Polymictic, poorly sorted, no internal organization, erosive base, high matrix, few imbrication.	Immature polymictic conglomerate.	Proximal alluvial fan (debris flow)
	Ib: Matrix-Clast supported	Less matrix, more rounded cobbles/pebbles, lack basal scour	Polymictic conglomerate	Proximal alluvial fan (cohesive debris flow)
	Ic: Massive to cross bedded, med.-pebbly sandstone.	Uni-directional paleocurrent, elongate sand body, lack of lateral migration	Arkosic sandstone	Braided river channel
	Id: Massive-Trough conglomeratic sandstone	Uni-modal paleoflow, channel scours, massive and trough cross bedding	Arkosic sandstone	Deep braided channel/channel lag
	Ie: Claystone-Siltstone	Thin bed, clay/sand, intercalation, mud crack, ripple mark and laminations	Micaceous/kaolinitic	Low energy floodplain/crevasse splay
Unit II	IIa: Horizontally-cross bedded sandstone	Wavy laminations, wave ripples, bioturbations, convolute bedding, clay clasts	Quartzarenite	Subtidal shoreface
	IIb: Cross bedded-massive sandstone	Herringbone cross bedding, clay drapes, bioturbations	Quartzarenite	Tidal channel
	IIc: Grain supported conglomerate	Well rounded quartz pebbles, no matrix	Quartzarenite	Channel Lag
	IId: Claystone	Kaolinitic, massive, mudcrack, sand/clay intercalation	Kaolinitic	Floodplain/tidal flat

Floodplain Facies

This facies is made up of claystone and siltstone and it rarely occurs in isedimentary sections of unit I. A very thin bed of the claystone occurs at Gbugbu and Wariku where it attains thickness ranging from 0.20 to 0.40 m. It is intercalated with siltstone and fine sand which may be crevasse splay deposit at Wariku. They are well laminated and kaolinitic. The colour is dominantly brown.

Interpretation

The argillceous nature of the claystone facies coupled with the thin lamination suggest a low energy depostional system within floodplain and crevasse splay environment. Lack of any marine fauna or sedimentary features suggest a non marine floodplain or crevasse splay environment adjacent to the braided channels.

Unit II

This unit directly overlies the unit I. It comprises of depositional facies that are quite distinct in term of architectural elements, lithofacies associations, microfacies, texture and sedimentary structures (Table 1). Among the facies are conglomerate, sandstone and claystone and they outcrop mainly around Share and Shonga (Fig. 1b).

Tidal Channel Lag Facies

This facies is composed of mainly clast-supported conglomerates. The thickness varies from 0.30 to 1.00 m (Fig. 7). The grains are mainly well rounded quartz of average pebble size ranging from 2.00 to 8.00cm. The matrix is almost zero and in deed, they are moderately sorted indicating compositional maturity which makes it distinct from those described in Unit I. In most cases, where they occur they are massive. At Share, the conglomerates are less than 0.40m and they fine upward into conglomeratic sandstone. At Shonga, the conglomerates are relatively thicker (Fig. 8). In both locations, *Ophiomorpha* “isp” burrows are observed.

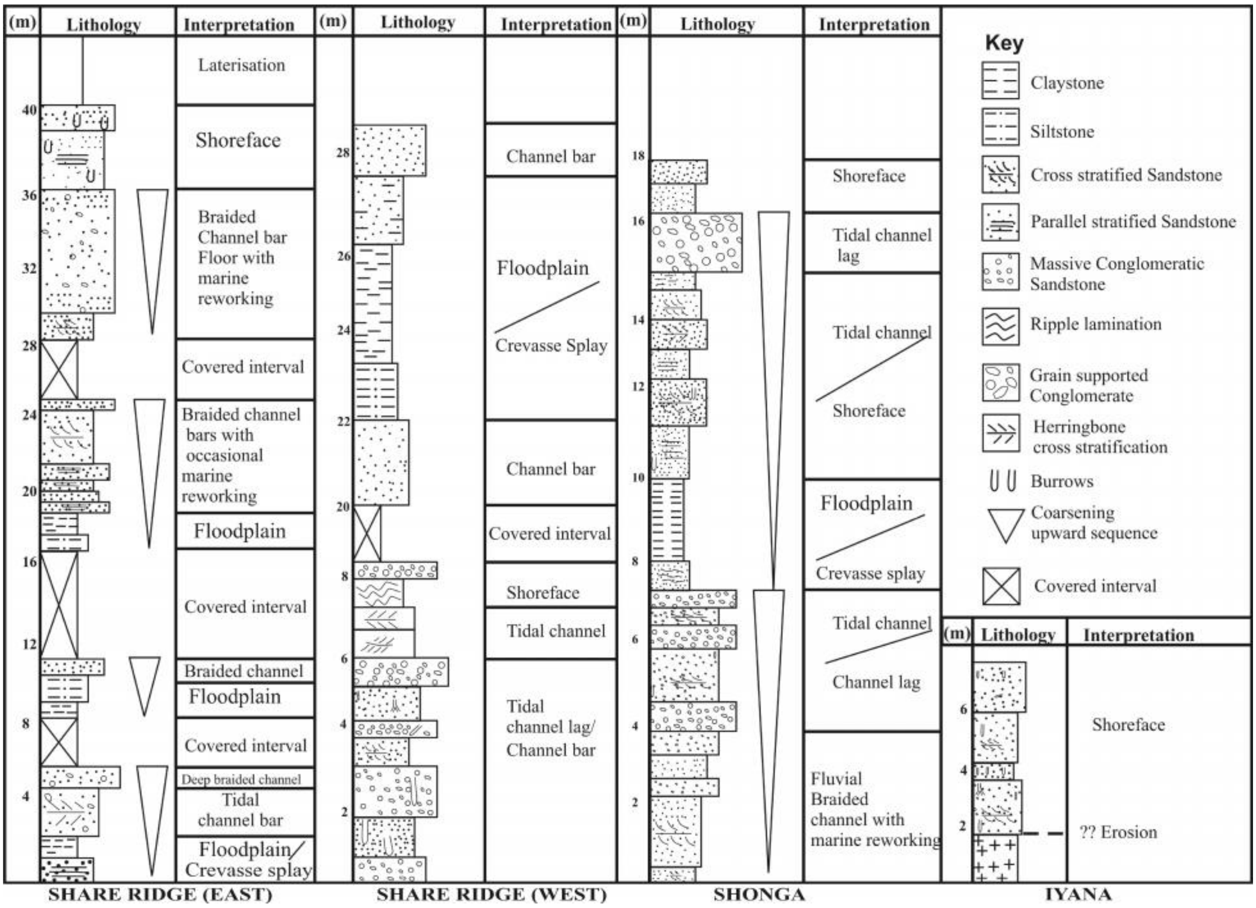


Fig. 7: Lithostratigraphic successions of the Unit II exposed at Agbona Hill, Share, Shonga and Iyana, Share.

A

B

Fig. 8: (a) Grain supported quartzose conglomerate subfacies (tidal channel lag) grades into tidal channel sandstone subfacies at Share Ridge and (b) at Shonga

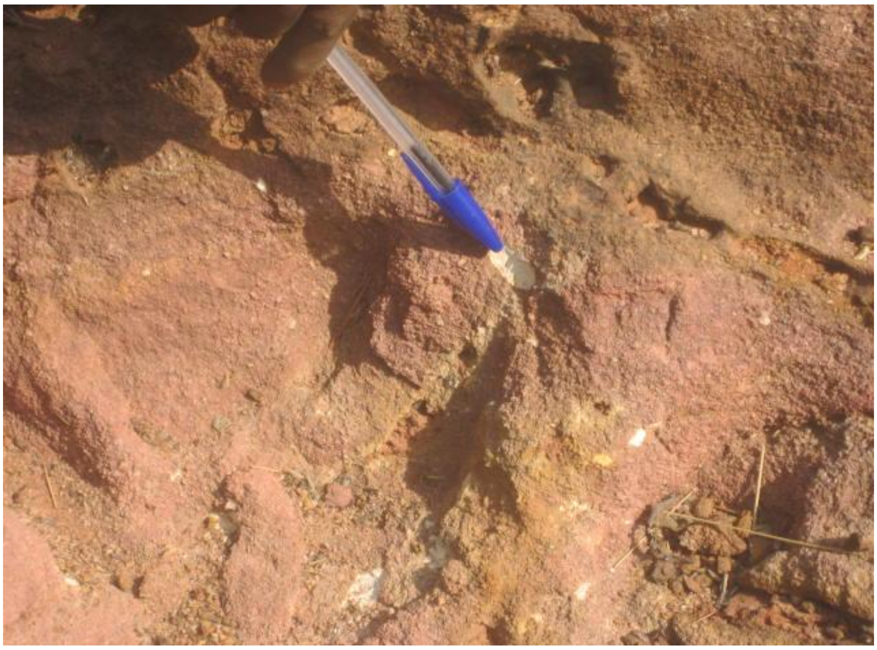
Interpretation

The conglomerate facies of Unit II shows features that are reflective of tidal channel floor deposits, probably transported mainly via bottom traction. The moderate sorting and the mineralogical maturity (lack of feldspar and other labile rock fragments) suggest some reworking or recycling of material, probably implying distal source. The presence of *Ophiomorpha* burrows in this conglomerate may indicate a near shore marine environment. The scenario envisaged here is that of a braided river evolving distally into tidal channels considering the association of this facies with hummocky and herringbone stratified sandstone in the sections (Amireh et al. 1994; Prave et al. 1996). The conglomerates are therefore interpreted as tidal channel lag deposits.

Tidal / Shoreface Facies

This facies comprises of sandstones which vary texturally and in term of sedimentary structures from pebbly to fine grained, and massive to stratified sandstone respectively. The following subfacies are recognized; conglomeratic sandstone, cross stratified medium to coarse grained sandstone and laminated fine grained sandstone. The conglomeratic sandstones are massive, burrowed and in places, the thickness attains an average of 5.00m. It is well represented in the upper parts of Share and Shonga ridge sections (Fig. 7). It grades upward into medium to coarse grained sandstones. The massive conglomeratic sandstones which are strongly bioturbated capped the upward coarsening cycles (Fig. 9a) at Iyana. At Shonga, the conglomeratic sandstone subfacies are trough cross stratified. The trough cross stratified conglomeratic sandstone has an average thickness of 1.50m. Compositionally, it contains pebbly sized quartz grains that are moderately well sorted and re worked clay pebbles (Fig. 9b).

Fig. 9: (a) Horizontally stratified, mature shoreface subfacies characterized by coarsening upward trend at Iyana, Share.



(b) Reworked clay clast and thalassinoides burrow in the massive, shoreface sandstone subfacies at Iyana, Share.

In Share, Iyana, and Shonga, the cross stratified, medium to coarse grained sandstone subfacies are exposed. They contain mainly planar cross stratification which in some cases, are small scale and bidirectional (Fig. 10). At Iyana, they are overlain by the massive, bioturbated, conglomeratic sandstone. At other localities, they are interbedded with parallel laminated and massive fine grained sandstones. The cross bedded sandstones show bounding surfaces with clay drapes. The cosets are small scale with low angles. The sands are typically reddish to pink in colour and compositionaly mature. Small clasts of reworked clays are also common (Fig. 9b). In Share, some of the medium to coarse grained sandstones display convolute beddings, herringbone and small-scale hummocky cross stratification types. *Ophiomorpha* "isp" trace fossils are common in these deposits.

The fine grained sandstone subfacies is less common in the sections. Where they occur particularly at Share and Shonga, they are commonly parallel laminated and in some cases, ripple cross laminations are preserved (Fig. 10a). Sometimes the lamination are defined by alternation of kaolinitic clay laminea and red sands. The average thickness of this subfacies is 1.00m in most localities. Sand size particles are dominated by quartz and muscovites.

A

B

Fig. 10: (a) Wave ripple laminated, subtidal sandstone facies at Shonga and (b) Herringbone cross bedded sandstone subfacies (tidal channel sands) at Shonga.

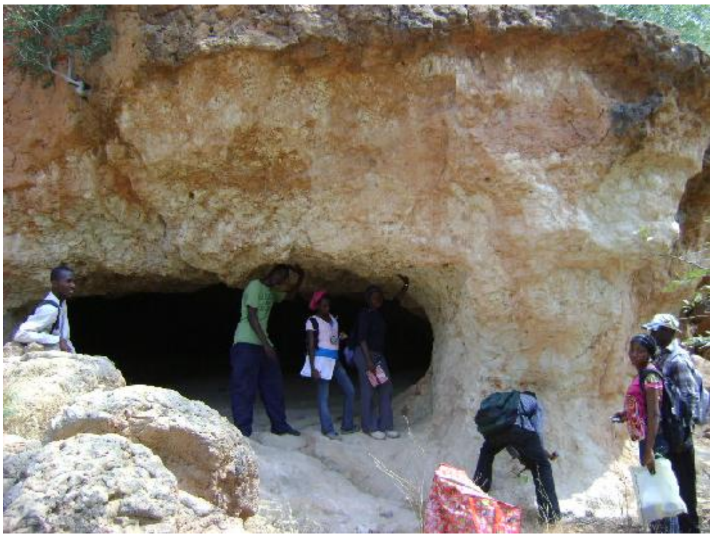
Interpretation

The characteristics of the sandstone facies in this area permit recognition of near shore high energy marine environments; tidal channels and shoreface environments (Fig.12). The herringbone cross stratified sandstone subfacies is interpreted as tidal channel facies. Klein (1970) and Amajor (1984) suggested that current direction reversals are associated with tidal processes. Clay drapes and worm burrows which are common in this subfacies have been reported as signatures of tidally influenced environments by Ladipo (1986) and Amireh and Abed (1994).

The parallel stratified to massive sandstone subfacies characterized by hummocks in places, reworked clay pebbles and *Ophiomorpha* burrows are interpreted as shoreface deposits (Walker, 1990; Taylor and Lovell, 1991). Most probably, the horizontally laminated sands may be the product of sands being transported and reworked below the fair weather wave base within upper flow regime. Generally, association of this subfacies with wavy laminations, convolute beddings, clay clasts and wave ripples suggest storm influenced, high energy shoreface domain (Castle, 2001; Dott and Buorgeois, 1982).

Floodplain Facies

The claystone in this facies is well represented in Share and Shonga ridge sections (Fig. 7). The dirty white claystone beds are massive and show shrinkage crack features. At Share ridge sections, the claystone bed is about 2m thick. It is kaolinitic and interbedded with cross stratified sandstone. The base of the claystone bed makes sharp contact with underlying cross bedded sandstone (Fig. 11). The clay has attracted the attention and activities of local miners. This may be due to its suitability as raw materials for ceramics and potteries (Ojo et al, 2011).



A

B

Fig. 11: Floodplain kaolinitic claystone interbedded with mature tidal channel sands at Share Ridge (a) artificial cave created by local mining and (b) sampling pit (about 1.5m deep).

Interpretation

The predominance of clay minerals and clay size fraction in this facies indicate settling from suspension in a low energy environment, probably the floodplain adjacent to the tidal channels.

Depositional Model

The depositional model proposed for the upper Cretaceous sediments in the study area is that of largely alluvial dominated processes which evolved trangressively later into shallow marine processes and periodically incised by fluvial channels (Fig.12). The older depositional sequence herein refer to as Unit I are characterized by well preserved, sharp based, non – imbricated to poorly imbricated, poorly sorted and matrix supported conglomerates suggesting debris flow deposit (Nilsen, 1982; Steel and Thompson, 1983). They rest in most localities, non-conformably on the pre Cambrian crystalline rock and contain various clasts or fragments of quartz, feldspar, pegmatite, gneiss and schist. The abundant fresh feldspars in the sediments, high matrix, poorly developed stratitification, and lack of internally developed structures are indicative of proximity to the high relief source area and gravity supported flows. The immature conglomerates were probably formed from sediments that are transported to and filled the down thrown grabens formed during early rift phase of the basin evolution. The adjacent, distinctly developed stream flow deposit (Wasson, 1979) characterized by channel fill structure, grain to matrix supported conglomerate facies with more well rounded quartz grains and poor feldspar content is suggestive of down fan lateral migration in the area (Fig. 12). This mid to distal facies evolved into fluvial braided channel sandstones and floodplains with their characteristic fining upward, channel switching features and lenticular geometry (Allen, 1982; Cant and Walker, 1978: Rust and Jones, 1987). Generally, the depositional Unit I is characterized by lack of marine fossil, presence of unidirectional paleocurrent feature and compositional immaturity. These are features typical of most known and described alluvial to fluvial deposits in continental settings (Guiraud, 1990; Braide, 1992; Ojo and Akande, 2003). The depositional facies assemblage of the Unit I probably represent substantial sedimentation during the syn-rift stage in lowstand system tract.

A shallow marine environment is represented by the Unit II (Fig. 12). This consists of mainly shoreface and tidal channel facies association. In this upper part, trangressive channel lag grades upward into tidal channel conditions and shoreface characterized by *Ophiomorpha* burrows, clay drapes and herringbone and hummocky cross stratifications (Prave et al. 1996; McCrory and Walker 1986; Amireh and Abed, 1994). Evidences of stream run offs such and periodic subaerial exposure are common. Based on the lithofacies association and gross sedimentological characteristics Unit II is thought to represent the trangressive phase during which tidal channels and shoreface sediments were deposited (Ojo and Akande, 2009, 2011).

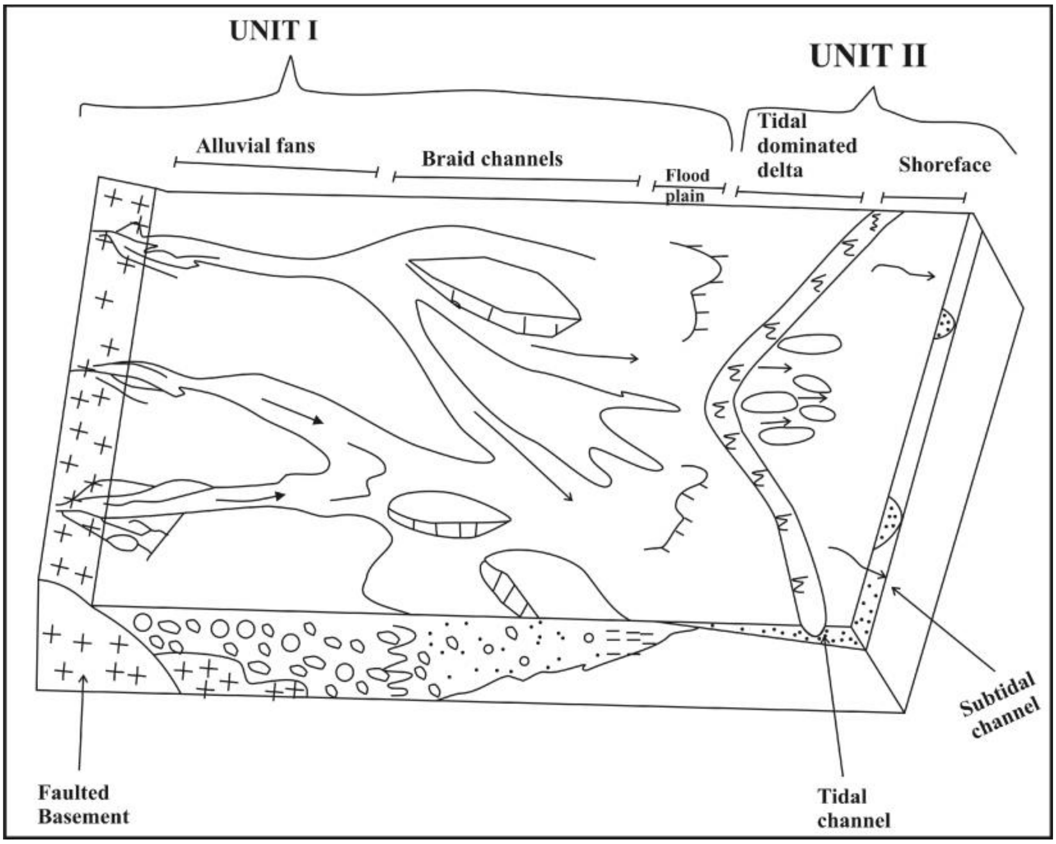


Fig. 12: Reconstructed depositional model, using block diagram for the investigated sediments.

CONCLUSIONS

1. Depositional facies provide evidence of transition from alluvial regime to shallow marine
2. Facies association of Unit I indicates deposition within low sinuosity braided channels associated with alluvial fan deposits and represent lowstand system tract
3. Facies association of Unit II indicates landward migration of the shoreline and marine incursion and it probably represents trangressive phase.

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