Sequence Stratigraphy of Niger Delta – A New look at "Ake and Eta" Fields Onshore, Western Niger Delta

Magbagbeola, O. A[1]., Olayinka, A. I[2].
[1]The Chevron Nigeria Limited, [2]University of Ibadan, Nigeria

ABSTRACT

Complex stratigraphy and volumetric partitioning have always been major hurdles in effective reservoir management of Niger Delta fields. This is more important in matured fields like Ake and Eta where the need to maintain pressure support in producing reservoirs can be challenged by stratigraphic compartmentalization. This inadvertently also lead to large amount of stranded and bypassed oil/gas. Assigning depositional sequences to their correct chronostratigraphic units is thus crucial in advancing a comprehensive field development plan. Sequence stratigraphy identifies expansive heterogeneities and predicts facies distributions of specific depositional patterns in varying positions of a sequence. This study was designed to help define predictable characters within sequences for accurate reservoir modeling by reducing miscorrelation across chronostratigraphic surfaces.Result of this study subdivided the areas entire stratigraphy into Six Major Third Order sequences based on age. The earliest was the levee channel complex of mid slope, followed by retrogradation and capped by the regional 18.0Ma MFS. Progradational transitional deposits of incised valley fills, tidal and shoreface units then followed. The final basin filling phase was dominated by coastal shelf sediments pervasively cut by submarine canyons. This study also demonstrated that the various producing units of the fields are not simple reservoirs with infinite connectivity.

Keywords: Stratigraphy, Sequence, Reservoir Management, Canyon, Chronostratigraphic.

INTRODUCTION

The study interval of Ake and Eta Fields are Oligocene to Miocene sediments. Its depositional sequences comprise a complex mix of deepwater slope, coastal, estuary, shoreface, fluvial, shelf and lagoonal setting deposits. Syndepositional slumping and faulting have contributed to reservoir heterogeneity, volumetric division and field compartmentalization. This study attempts reconstruction of structural and different orders of stratigraphic interpretation of entire deposits forboth fields. It also reclassifies their depositional environments thusproviding alternative interpretation of various sequences of both fields by examining their detailed stratigraphic heterogeneities. This will invariably help in developing efficient reservoir management strategies and field development plan.

STUDY AREA

The study area is located in the distal Onshore part of Central Swamp Depobelt of Niger Delta (Figure 1). Both fields straddle a major estuary in OML-49.The modern Niger delta is a mixed wave, tide and fluvial-deltaic system. It is reworked by wave action along an arcuate coast with barrier islands, back-barrier lagoons, and chenier ridges. Incised into this coastline are numerous tide-dominated coastal estuaries filled with sediment since the Holocene sea level Highstand. The modern delta front and the continental slope are characterized by localized slumps and canyons that bypass sediments into deeper waters. Although details of deltaic features are difficult to decipher within reservoir intervals of Niger Delta deposits, the modern distribution of distributary channels, estuary fills, shoreface, back-barrier lagoonal sediments, and delta plain deposits are assumed to be a good analogue (Magbagbeola and Willis 2007).

DATA AND METHODOLOGY

Core, biostratigraphic, gamma ray, resistivity, density and neutron logs suites, from 94 Ake wells and 49 Eta wells with 2650 Km2seismic data were used for the study. Detailed structural, sequence stratigraphic analysis and description of the entire Late Oligocene to Middle Eocene sections of both Fields was undertaken using mixed approach of Allen (1995) and Posamentier and Allen (2000). This involvedobservation of well cores, logs, 3D seismic and biostratigraphy to interpret facies stacking pattern,geometry and architecture. Faults and horizons were interpreted along dip, strike and time slices in progressively smaller grid intervals. The entire

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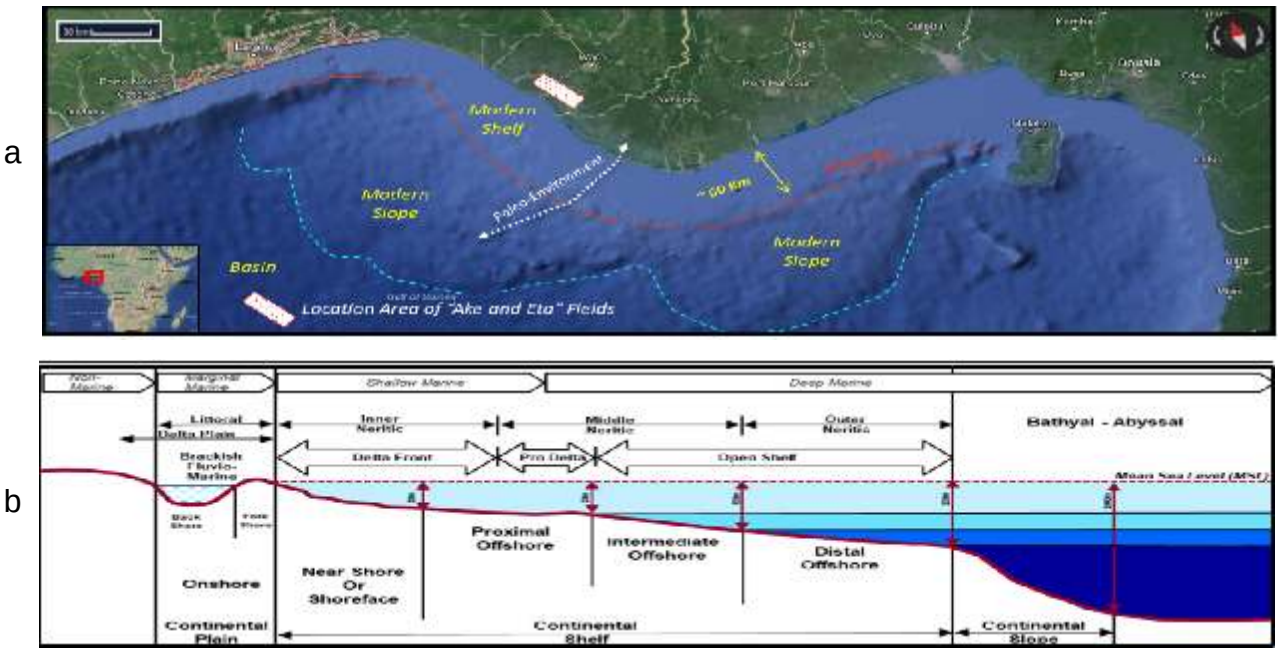

Figure 1: (a) Nigerdelta depositional environment. (b) Current bathymetry range with location of Study Area (modified after Allen,1965).

geosection was partitioned using age and broaddepositional environment. To properly illustrate the key aspects of each depositional sequence, a series of maps and cross sections were constructed for making geologic interpretations. Wireline-log crosssections illustrate the regional lithologic and biostratigraphic markers that have been tied to the seismic data. These show important stratigraphic relationships and regional variabilities, in both dip and strike orientations. For each sequence, several representative seismic profiles with time-based logs are shown to illustrate key seismic facies and stratal relationships. From the integration of all these data, geologic facies maps were generated.

RESULT AND INTERPRETATION

Stratigraphic InterpretationSix 3rd Order stratigraphic sequences have been identified in Ake and Eta Fields based on biostratigraphic data, well logs stacking patterns and truncation of underlying continuous reflections by apparently younger seismic events (Figures 2 and 3). Sequence Boundaries (SB) that separate depositional packages were interpreted as stratigraphic discontinuities. Erosion surfaces at the base of sequences were taken to represent basinward shifts of systems tracts. These depositional sequences are main unconformities within the basin and the boundaries associated with them are erosional boundaries. This definition of SB is comparable with that of standard Exxon nomenclature (Posamentier et. al., 1988; Mitchum and Van Wagoner, 1991).

Sequence 1 (32.47Ma – 29.40Ma)

A Highstand System Track (HST) from Maximum Flooding Surface (MFS) aged 32.47Ma to Sequence Boundary 29.40Ma in Late Oligocene. Its depositional environment is Upper Slope (Figures 2, 3 and4). The 32.47Ma MFS is mostly flat with 1.60 average dip typicaloffflooding events (Figure 5a). The 29.40Ma SB (Figure 5b) however has more relief with three major depressions at the southern part of thestudy area (labelled A, BandC). Thissequence on the Upper Slope is a major sediment bypass zone, itslargely muddy with few siltystringers(Figures 6a). Thickness seems to be better generally downdip of the major faults with local closures probably forming smaller sub-basins or major axis of sediment delivery systemsonto the slope environment. This interpretation is essentially different from an earlier submission byIbie (1997); he suggested this intervalto be part of a Basin Floor Fan complex. It is however reclassified in this study to be Late Lowstand Prograding Complex of Mid-Upper slope depositional environment (Figure 4). Stacking pattern analysis of well log indicates a mostly fining upward log motif typical of very muddy sediment bypassed zones (Figure 6a), likely to be Bathyal depositional environment (Figurea 1 and 4). Seismic event matched to this sequence is positive reflection around Ake-01 and 02 (Figure 6b). The 32.47Ma MFS is widely reported in the western Niger delta basin. The 29.40Ma is equally a significant Sequence Boundary that is well identified in many deepwater sub-basins of Niger delta. When the deepwater system sediment starved, they have minimal variable thickness; these features are typical of processes related to the stages of sediment

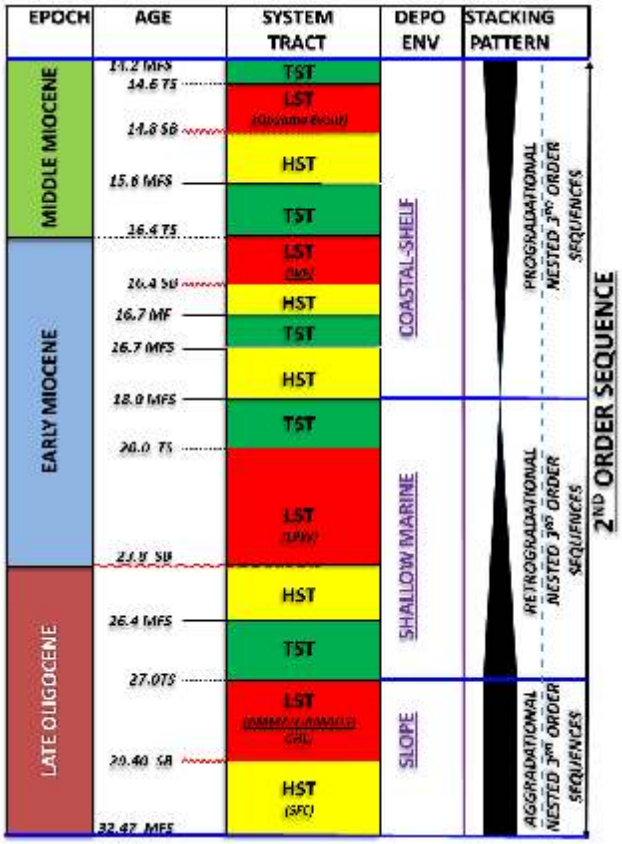

Figure 2: Cartoon representation of overall stratigraphy of Ake and Eta Fields indicating partitioning into six Major 3rdOrder sequences with additional higher frequency nested 4th and 5thorder sequences.

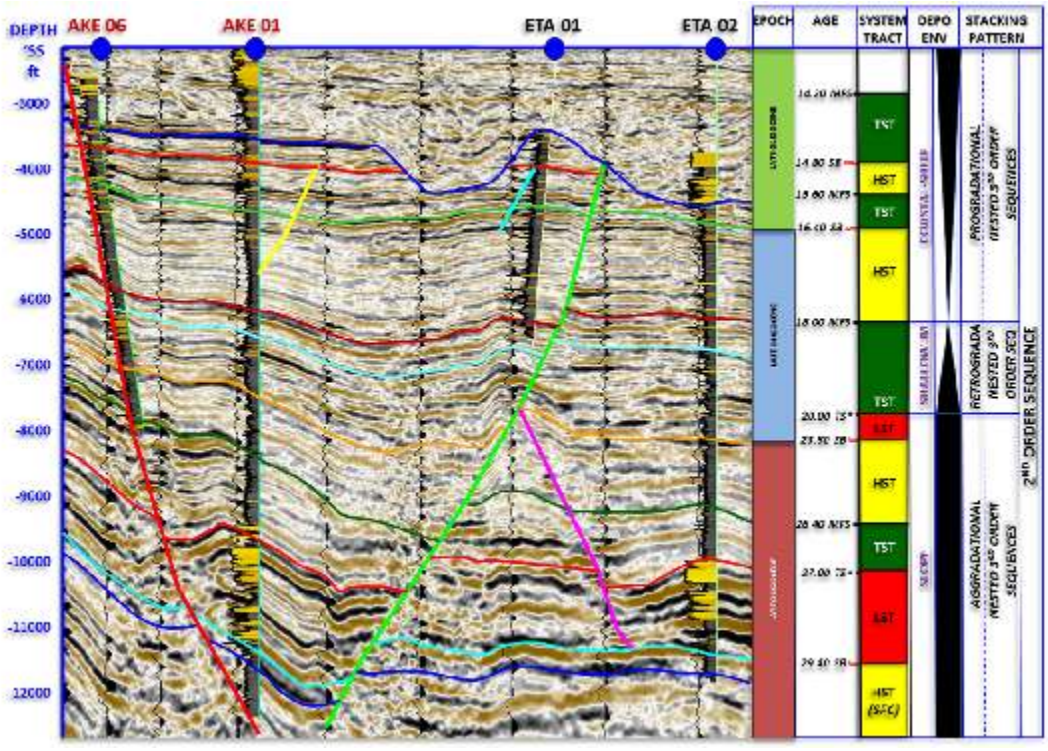

Figure 3: Entire reinterpreted and reclassified stratigraphic and structural evaluation of Ake and Eta Fields.

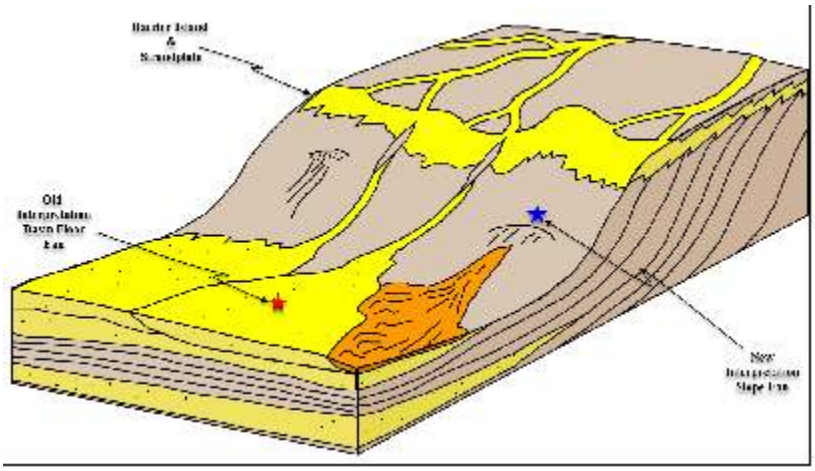

Figure 4: Sequence 1 depositional environment showing re-designation from Basin Floor Fan to Slope Fan anda major sediment bypass zone (modified from Catuneanu, 2006).

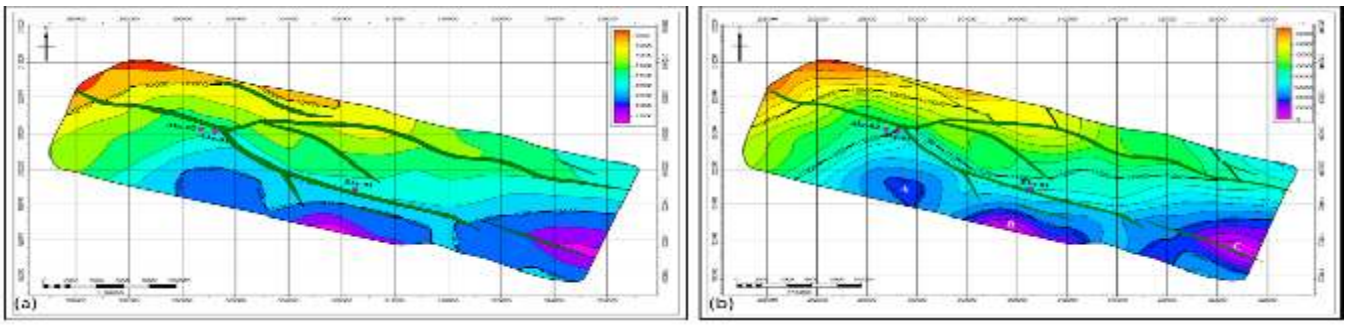

Figure 5: Sequence 1 elevation map showing the structural grains (a) 32.47 MFS. (b) 29.40 SB.

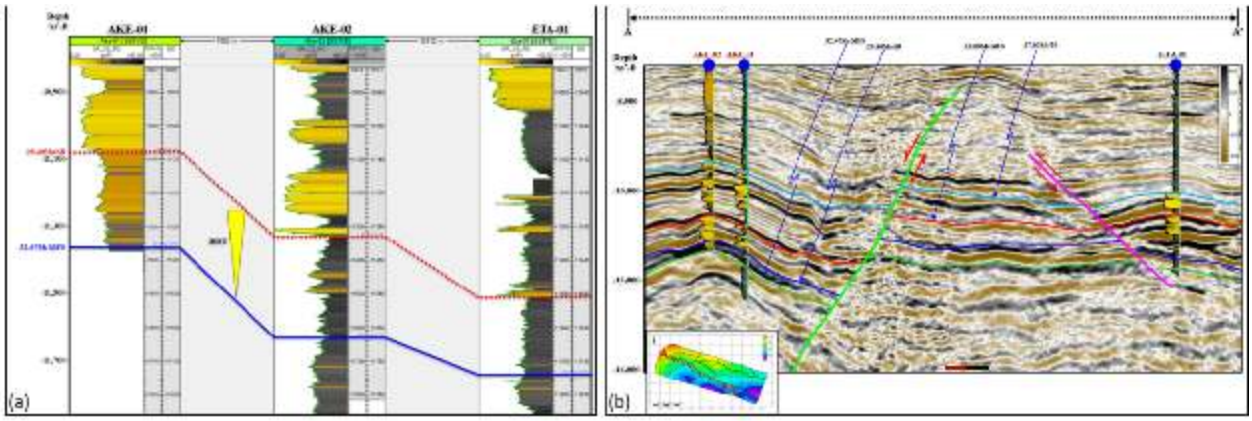

Figure 6: Sequence 1 Sections (a) 32.47 Ma MFS - 29.40 Ma SB HST Structural cross section showing general fining upward log motif. (b) Corresponding seismic section across A-A'.

starvation around the upper slope during Late regressions (Catuneanu et. al., 2011).

Sequence 2 (29.40Ma – 23.80Ma)

Sequence floored by the 29.4Ma SB and capped by the famous 23.8Ma Oligocene-Miocene boundary. This 23.8Ma surface tops an HST while below it is the last major flooding event of Oligocene represented by a Transgressive System Tract (Figures 2 and 3). The LST is bounded below by the 29.4Ma SB and topped by a 27.0Ma Transgressive Surface (TS). The TS is the first significant flooding event above the 29.40Ma SB. This stratigraphic surface marks the transition from slope environment to shallower water. The LST (29.40Ma TS-27.00Ma SB) is a slightly sandier Prograding Complex towards the end of Oligocene Lowstand; The thickest part is around Ake 1 and 2; it appears to follow an almost North- South trend (in black dotted polygon) (Figure 7a).

Figures 7b show nick point of erosive canyon heads on the 23.8Ma SB with inferred paleo shelf edge indicated by the dashed yellow line A – A'. Log motif for this LST can be divided into two zones around a 28.0Ma Major Condensed Section (MCS). The 29.4Ma SB to this 28.0Ma MCS is an overall 4th order aggradational depositional environment (Figure 8a). Figure 8b is a stratigraphic cross-section flattened on the 27.00Ma TS across this interval. Once again, the earlier interpretation for this section of Ake and Eta stratigraphy by Ibie (1997) was a Basin Floor Fan. It is however reclassified in this study to be Late Lowstand Prograding Complex of Mid-Upper slope depositional environment. Individual channel complexes representing these deposits are likely to be amalgamated/semi-amalgamatedchannel complexes, they typically have high Net-to-Gross, but poorer vertical reservoir connectivity (Sullivan et. al., 2003).The amalgamated channel LST is overlain by the

nested 4th and 5th order sequences within this HST. Depositional environment for this Systems Tract is interpreted to be Upper Bathyal – Outer Neritic water depth. This is contrary to Ibie (1997) study that suggested their depositional environment to be Lower Bathyal. The base of this Systems Tract is the 26.4 Ma MFS over which the HST sediments prograded and aggraded. This unit is topedby the eroded 23.8 Ma SB unconformity surface.

Sequence 3 (23.80Ma – 16.70Ma)

it is bounded below by the Oligocene-Miocene 23.8Ma SB and capped by the 16.60Ma MFS. Between these surfaces are the corresponding LST, TST and HST (Figure2 and 3). The underlying LST is a Lowstand Prograding Wedge (LPW) deposit floored by the 23.8Ma SB and capped by 20.0Ma TS, a resistivity spike and sonic boom at the 20Ma TS interface in some well logs indicate possible presence of cemented carbonates typical of

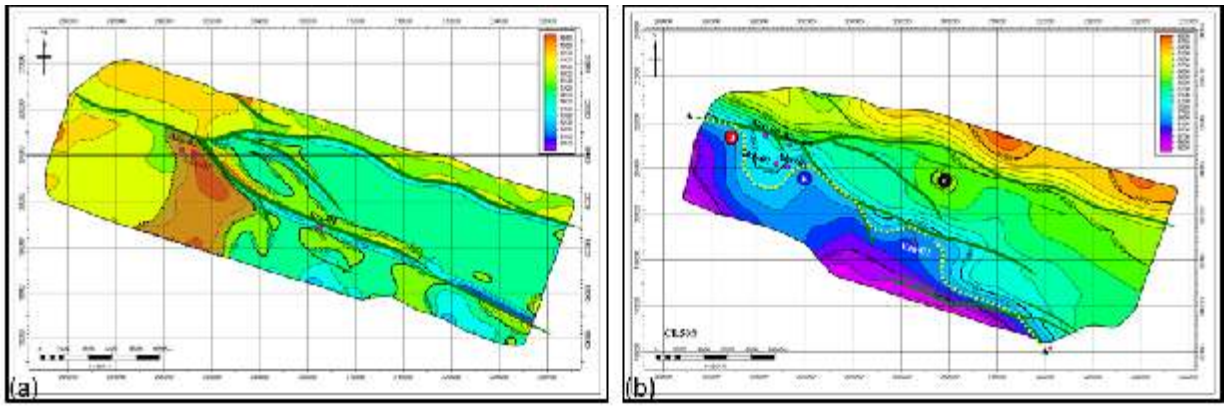

Figure 7: Sequence 2 maps (a) Isopach of 27.0Ma TS- 29.4Ma SB LST (b) 23.80 Ma SB Elevation.

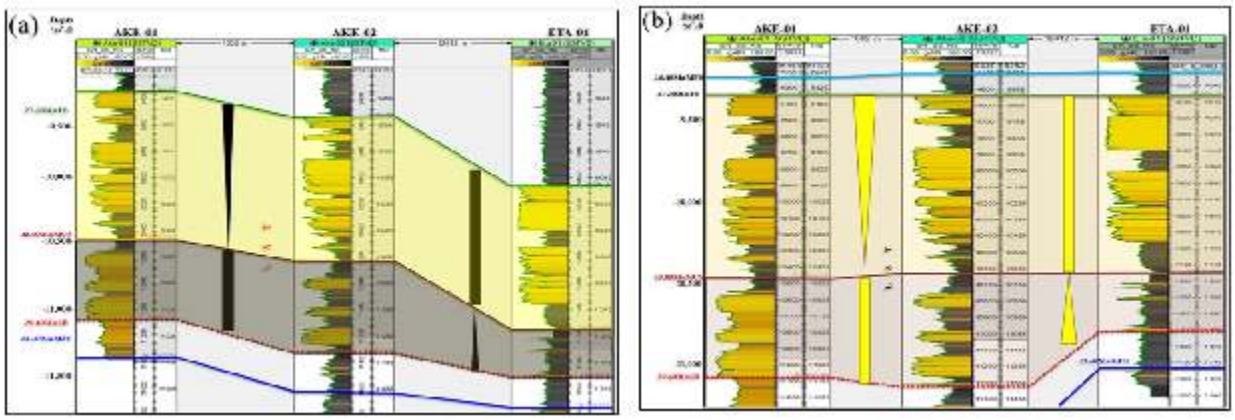

Figure 8: Cross section of 29.40 Ma SB - 27.40 Ma TS LST (a) Structural cross section (b) Stratigraphic cross section flattened on the 27.0Ma TS.

27.00Ma TS- 26.4Ma MFS Transgressive Systems Tract (TST). This Tract is capped by the 26.4Ma MFS, it consists of Retrogradational marine shaleslikelydeposited in Outer Neritic to UpperBathyal. The last significant System Tract in Sequence 2 is the HST between the 26.4Ma MFS and the 23.8Ma SB.There are

Transgressive Surfaces. ThisLST is a stack of 100ft coarsening upward gamma ray pattern (Figures 9a and9b). These sub unitswere interpreted to be higher frequency (4th order)parasequences and mostly cappedby a finning upward logmotif before the TS.Some of the identified higher frequency sequences are 22.9Ma MFS,

22.0Ma SB, 21.3Ma MFS and 20.52Ma SB (Figure9b).Inferred depositional environment for this System Tract is Outer Neritic to Upper Bathyal, this once again differs from the general Slope Fan Ibie(1997) classified this interval as (Figures 1 and4).The overlying TST of 18.0Ma MFS – 20.0Ma TS is relatively thin and capped by the widely recognised regional 2nd order 18.0Ma MFS. itssurface marks the overall turnaround from Retrogradational 3rd order Sequence to a Progradational one (Figure2). It equally signifies change from the previous Shallow Marine environment to a Coastal Shelf one (Figure3). Its Overall well log motif is aggradational to finning upwards stacking pattern.The 18.0Ma MFS – 20.0Ma TS was topped by the 1st Coastal Shelf HST which in turn marked the onset of 2nd order Progradation in the basin. This HST was capped by the 16.7Ma SB. A northeast-southwest trending canyon runs from the central part of Ake field to the southern area of the field withapaleo-shelf position indicated in dotted pink line (Figure 10a and 10b). The 16.7Ma SB to 18.0Ma MFS HST is a Progradational System Tract,itwas interpreted be one of the 4th order sequences (Figure10b). The predominant seismic reflection character tied to this HST was the semi-continuousevent while discontinuous oneswere observed in the canyon fill (Figure11a). These Highstand deposits are likely to be mud prone shoreline marine units even though the overall stacking pattern is a weakly coarsening upward one (Figure11b). Inferred depositional environment for this HST is Outer – Inner NeriticBathymetry (Figures 1 and4). Once again, this interpretation is different from Ibie (1997) which classified them Slope Fan deposits.

Sequence 4 (16.70Ma – 16.40Ma)

Made up of anLST and an overlying HST (Figure 2). The LST is floored by the 16.7Ma SB and capped by an almost indistinguishable 16.60Ma TS/MFS. The upper boundary of the overlying HST is the famous 16.40Ma SB. Average sedimentation rate for this sequence is ~0.95ft/Ky. The structural and stratigraphic imprint of the northeast-southwest trending canyon from the underlying HST is prominent on the isopach map of the sequence (Figure 12a). The 16.60Ma MFS – 16.7Ma SB LST is of diverse depositional environments ranging from shoreface to lower deltaic plain, tidally influenceddeposits, shelf/upper slope and submarine canyon (Figure 12b).

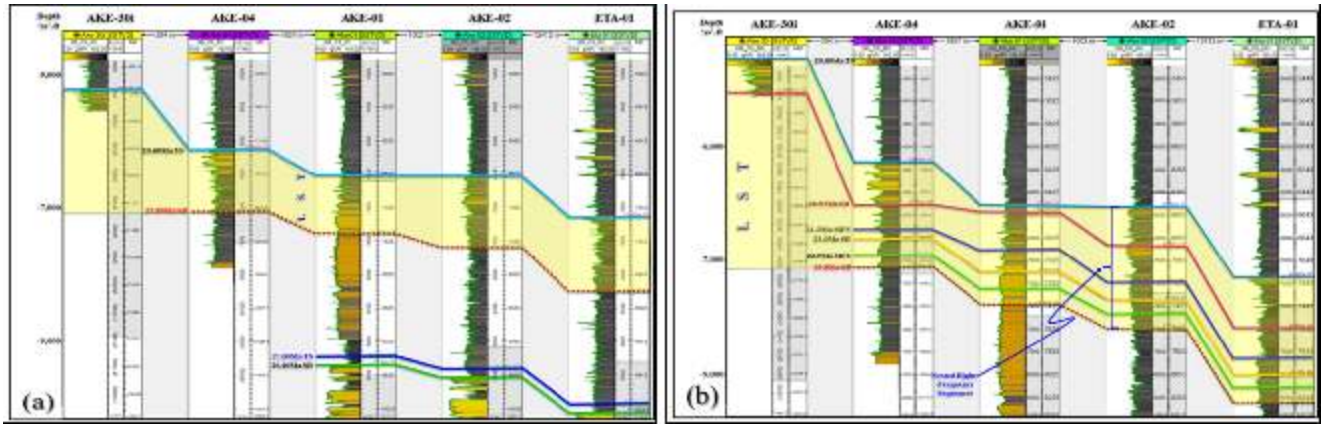

Figure 9: 20.00Ma TS - 23.80Ma SB LST (a) Structural well log cross section (b) Structuralwell log cross section with additional identified 4th order sequences between the two bounding surfaces.

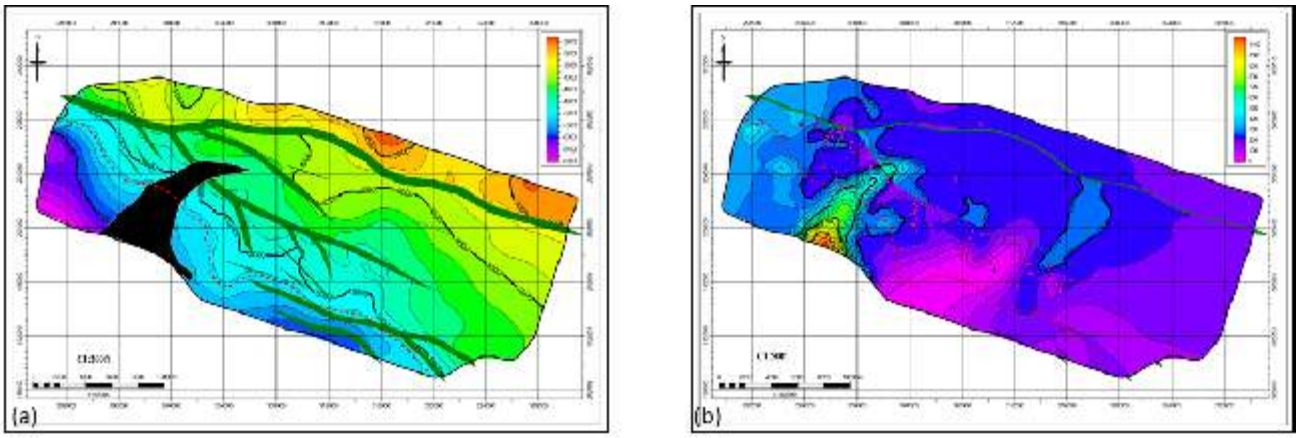

Figure 10: Sequence 3. (a) 16.7Ma SB showing canyon. (b)16.7Ma SB - 18.0Ma MFS (HST) Isopach.

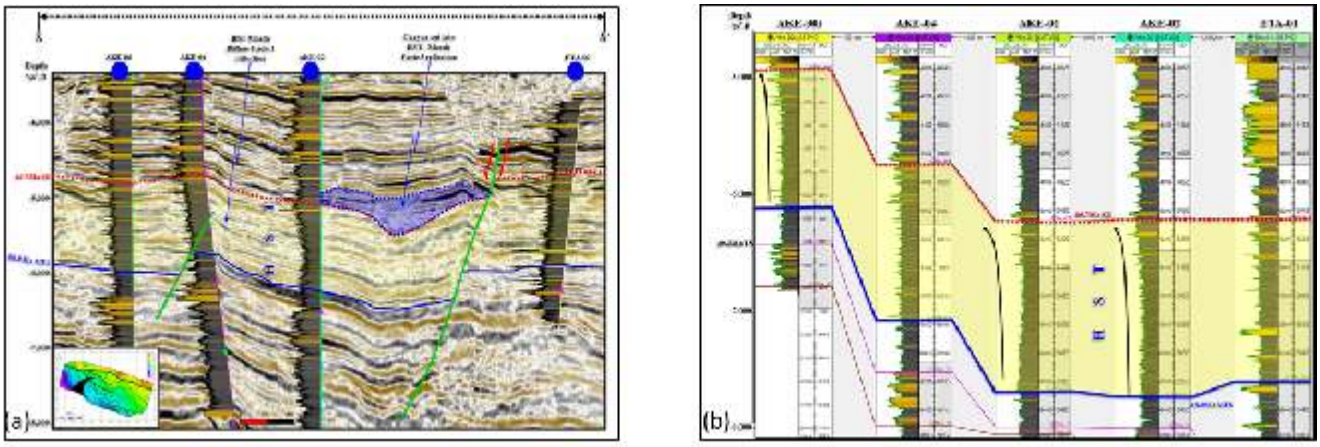

Figure 11: 16.70Ma SB-18.00Ma MFS HST (a)Seismic structural section (b)Well structural cross section.

Figure 13a is a seismic structural cross section showing the canyon axis within Ake Field. A particular thickening of the Lowstand deposit is evident towards the northwestern part of Ake Field; this was interpreted to be features of the shelf Margin and tidally influenced deltas (Figure 12b). Sand distribution in this LST was mainly controlled by stratigraphic features and faulting. Outline of a southwest Lowstand Prograding Wedge is represented by the red dotted line in Figure 12b. Likewise, at the western part of Ake Field, a shelf margin tide dominated delta was Prograding northwest much earlier in the 16.60Ma-16.7Ma Lowstand (Figure 12b). The rest of the study area was partitioned into shoreface and tidally influenced deposits (Figure 12b). Figure 13b is a stratigraphic section datumed on the 16.60Ma MFS; it indicates that the interval is a complex mix of fining

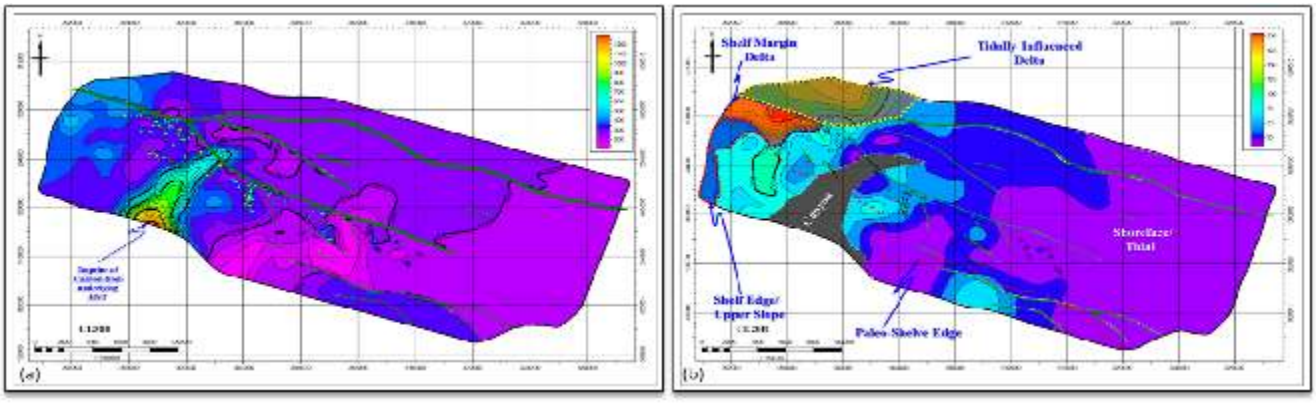

Figure 12: Sequence 4Isopach (a) 16.4Ma SB - 16.7Ma SB showing imprint of canyon from underlying HST (b)16.6Ma SB - 16.7Ma MFS LST showing the diverse depositional environments.

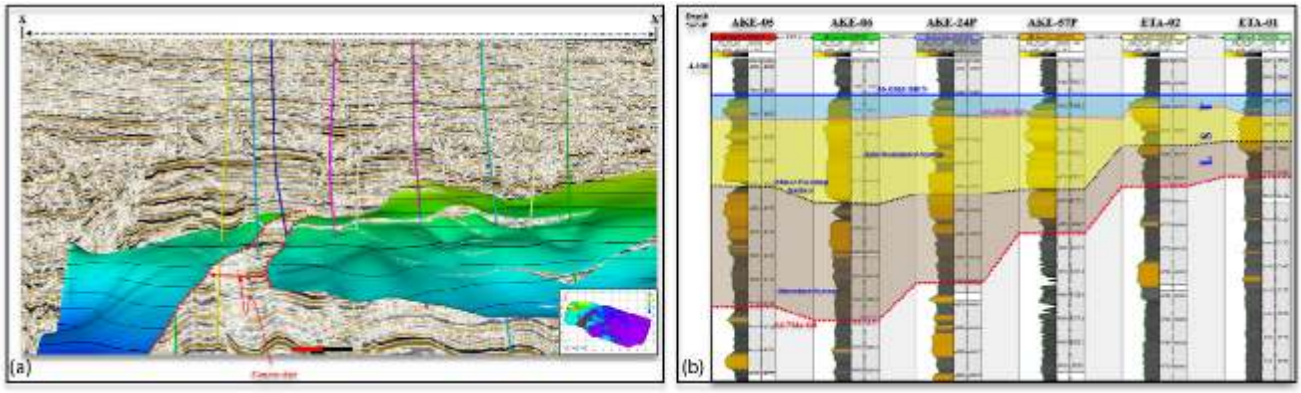

Figure 13: Sequence 4 Structural sections (a) X-X' (Strike) Showing the axis of the Canyon cutting into the earlier HST (b) 16.60 Ma MFS - 16.70 Ma SB LST showing the diverse depositional environments.

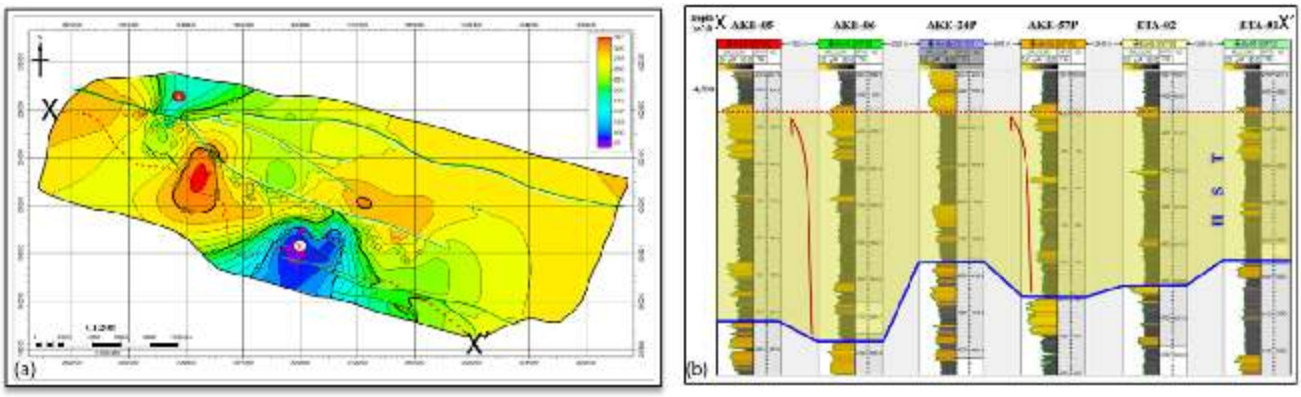

Figure 14: 16.4Ma – 16.60Ma HST (a) Showing areas of low thickness values X related to the IVF of the overlying Sequence (b)Stratigraphic section showing overall coarsening upward log motif.

upwards shoreface sands with sharp based tidal dominated channel fill deposits. On top of this is a thin Transgressive lag before the 16.60Ma MFS (Figure 13b). 16.4Ma – 16.60Ma HST tops the 16.40Ma – 16.7Ma LST and marks the end of Sequence 4. This HST is Progradational across both fieldswith 55ft average thickness (Figure 14a). Two areas of low thickness are marked as X and Y on the map. X was related to the IVF of the overlying 16.4Ma SB while Y was likely due to lower sediment supply to that part of Eta Field. Log motif for this HST is an overall upward coarsening stacking pattern; Figure 14b is a cross section hungon the 16.40Ma SB demonstrating this progradational deposition. There appears to be a significant sea level change in this HST with extended sea level rise being shale intervals while the sandy members are likely to be pulses of channel sand delivery to the basin. Inferred depositional environment for this HST is marginal to a full marine with some Fluvial (confined flow) inputs. Some Tidal Bars were observed in core sections.

Sequence 5 (16.70Ma – 16.40Ma)

Sequence 5 has three distinct Systems Tracts; An LST (16.40Ma TS -16.40Ma SB) followed by, a TST (15.6Ma MFS - 16.40Ma TS) and finally, an HST (15.6Ma MFS - 14.8Ma SB). The 14.80Ma SB is the base of the multi Epoch Opuama canyon system that is widespread in other Onshore fields of Niger delta. The 16.40Ma Transgressive Surface marks the transition from Early – Middle Miocene in the basin (Figure 2 and 3). Figure 15a shows pervasive carving of this sequence by the Opuama canyon system (areas with white background). This sequence is overallProgradational comprising diverse stack of shelf edge, coastal plain, estuarine, fluvial, tidal and Incised Valley Fills all alternating with silty units and marine shales. The 16.40Ma TS – 16.4Ma SB LST is bounded by three erosional events; the 16.40Ma Type 1 SB recognized as an Incised Valley Fill (IVF), above this is a Transgressive Surface of Erosion. The lastis the ubiquitous Opuama canyon event that has eroded into the entire Lowstand deposit. Figure 15b is a northwest-southeast trending seismic line of section showing the erosive relationship between the SB and Opuama canyon.

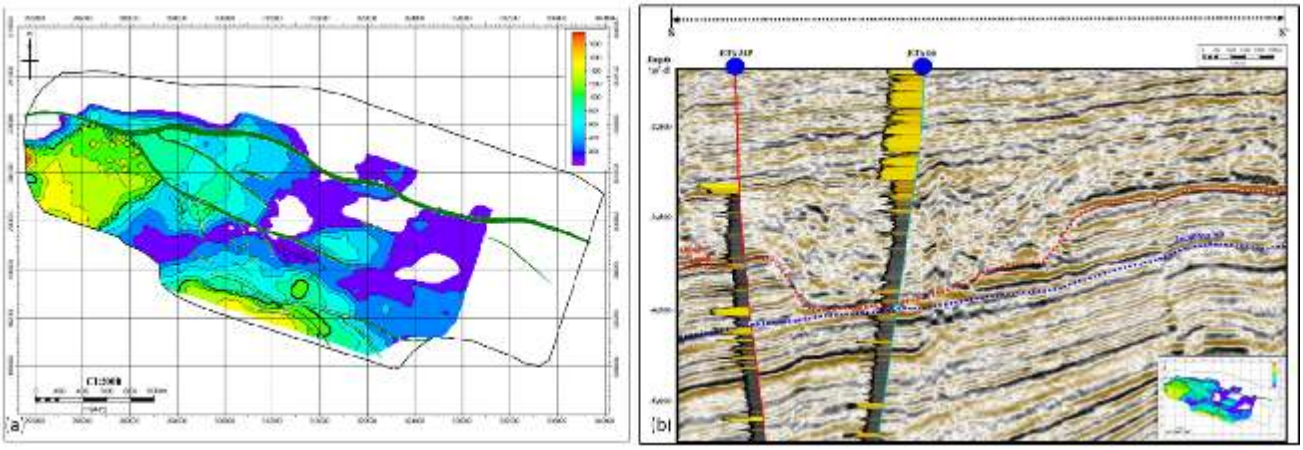

Figure 15: Sequence 5 (a) Isopach showing imprint of carving of the sequence by Opuama canyon (b)Seismic Cross Section X-X' (Dip) showing Opuama canyon cutting into Sequence 5.

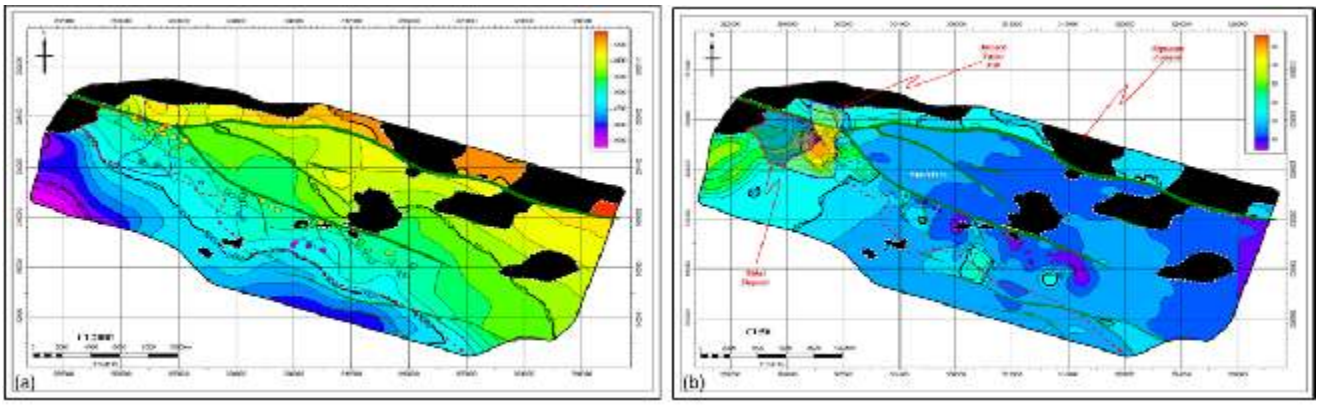

Figure 16: Sequence 5 (a) 16.40 Ma SB Elevation map showing areas (black background) of Opuama Canyon incision into the LST (b)Sequence 16.4Ma TS - 16.4Ma SB (LST) Isopach showing the diverse depositional environments.

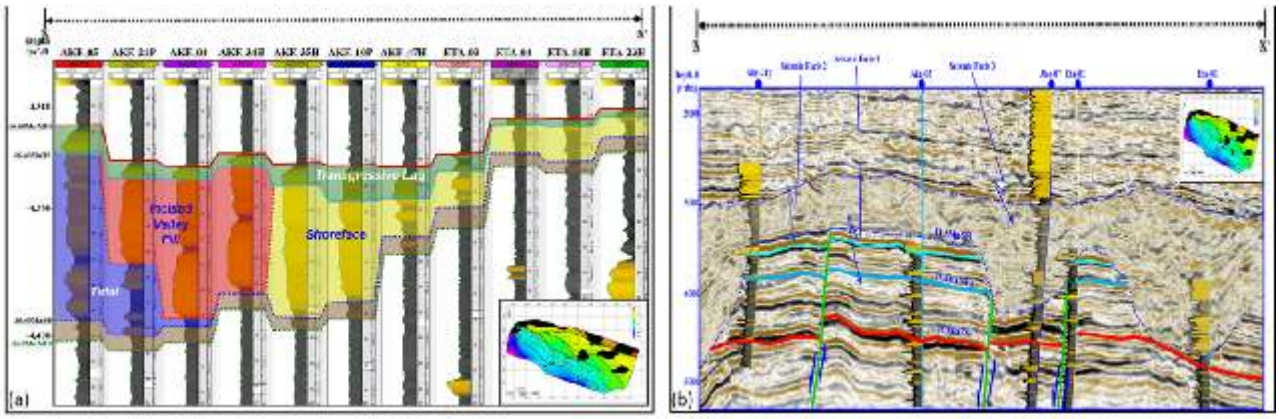

Figure 17: 16.4Ma – 16.60Ma HST(a) Structural cross section of 16.40Ma TS - 16.40Ma SB LST showing diverse stratigraphic units of the LST(b)Seismic cross section X-X' (Strike) showing the Seismic facies observed in Sequence 5. Blue line indicates outline of the Opuama Canyon cutting into Sequence 5.

This erosive SBcreated (IVF) at the end of a Late Lowstand sea level changecut into deposits of shorefaceand tidal units of previous HST (Figure 16a). This has partitioned the stratigraphic unit into three main distinct sedimentary units of estuarine/fluvial, shoreface and IVF deposits (Figure 16b). Figure 17a is structural cross section across this LST. The diverse stratigraphic complexity currentlypartitions these reservoir units during production because individual sub units are not in communication. Approximate area extent of the IVFis indicated by the blue dotted line in Figure 16b. Dotted red line equally shows the paleo-shoreline at the 16.40Ma SB while the thicker red polygon highlights the tidal deposit of the LST. The outline of the IVF was defined by the relatively thick isopach values (shown in blue dotted line), Incised valleys are relative sea-level Lowstand surfaces, eroded during falling sea level and filled during the subsequent rise (Sangree, 2007). Their origin may be fluvial, wave or tidal- estuary (Sangree, 2007). Log motif for the tidal deposit is blocky gamma ray signature with characteristic silty streak, the previous Highstand shelf deposits were identified by their usual high gamma ray values. Incised Valley Fills have sharp based unit, a minor flooding surface almost at the middle of the interval and a weakly upward coarsening Fluvial unit at the top. The shoreface typically have a weak upward coarsening gamma ray signature (Figure 17a). All these units are capped by the 16.40Ma Transgressive Surface that effectively marked the end of the LST. This Transgressive Surface is calcareous and cemented with characteristic resistivity spike and sonic boom. IVF are formed by fluvial systems that extend their channels basinward and erode into underlying strata in response to a relative fall in sea level. The timing of the incision of the Incised Valley will often be at the early stage of the Tract and capped by a Transgressive Surface while filling of the incision may occur during the following LST. The TST that overlies this LST is a relatively thin one; its lower limit is defined by the 16.40Ma TS while its upper boundary is the 15.6Ma MFS. The 15.6Ma MFS is a wide regional flooding event in Onshore Niger delta with Opuama canyon carving ~35% of its surface in a purely erosive relationship. The TST defined by this TS – MFS ranges in thickness from ~261-618 ft. Seismic facies across this

sequence (including the overlying HST) is diverse. The relatively continuous bright amplitude seismic facie is easily correlated across both fields, this transited to some of the transparent to semi-continuous reflection events, both facies have been pervasively eroded by the chaotic discontinuous seismic facies inferred to be the Opuama canyon system (Figure 17b). Log motif for the 16.4Ma TS -16.4Ma MFS TST is defined by high gamma ray values interpreted to be full open marine shale; they are however interspersed with some higher frequency sand Parasequence (Figure 18a).The last System Tract of

Sequence 6 (14.80Ma - 14.20Ma)

Last 3rd order sequence studied in Ake and Eta fields, it caps all stratigraphy in the area and is made up of two System Tracts; a 2nd order LST also referred to as the Opuama event and an HST. The LST is floored by the 14.8Ma Type1 SB and capped by the 14.2Ma MFS (Figure 2 and Figure 3); it appears that the intervening Transgressive Surface and the overlying TST were not preserved.Elevation across the 14.8Ma SB averages of 2,390ft (Figure 19a). Three main tributaries labelled L, M and N are NE – SW trending probably indicate direction

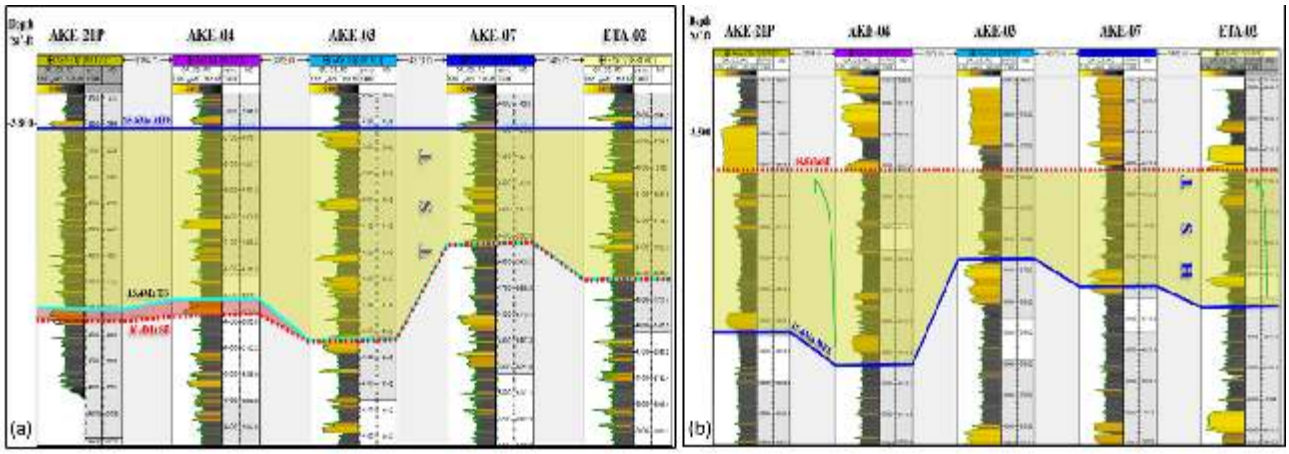

Figure 18: Stratigraphic cross section (a) 15.6Ma MFS - 16.4Ma TS TST showing overall high gamma ray log motif interspersed with some high-frequency sandy units (b)14.80Ma MFS - 15.60Ma MFS HST showing overall Progradational gamma ray log motif.

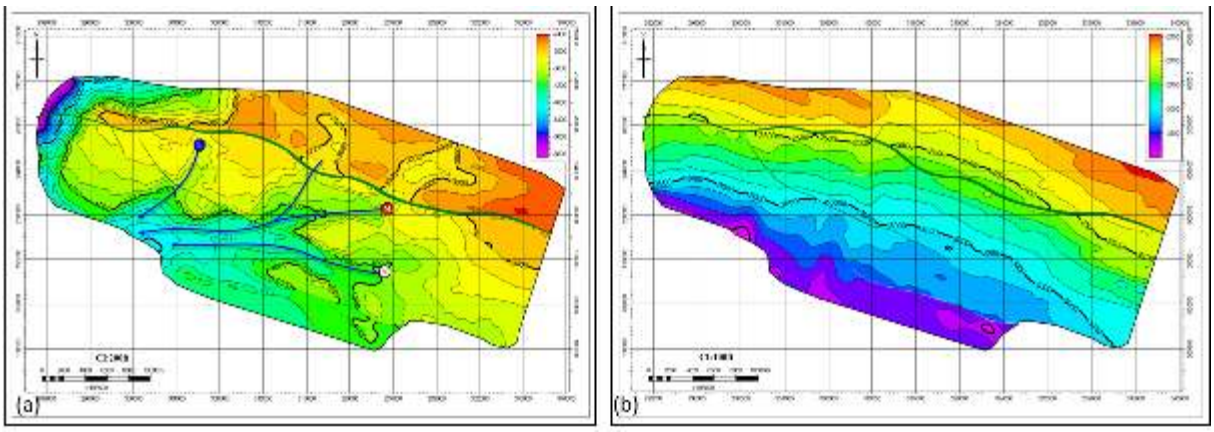

Figure 19: Sequence 6 (a) 14.80 Ma SB Elevation map showing the main tributaries of Opuama canyon (b)14.20 Ma MFS Elevation map indicating relatively flat topography of the flooding event.

Sequence 5 is the Progradational 14.8Ma SB – 15.6Ma MFS Highstand System Tract (Figure 18b) and is capped by the Opuama canyon event. The imprint of overlying pervasive Opuama canyon is widespread which has eroded 52% of this Systems Tract. This HST has an overall coarsening upward stacking pattern with some intervening higher frequency silty sand Parasequence. This HST is the upper Systems Tract of stratigraphic Sequence 5 and is capped by the 14.8Ma SB.

and axis of the regional structural weakness of underlying sediment. This canyon like the Avon and Mahin is likely to be zone of weakness along transform faults from the Mid-Atlantic Ridge during initiation of Early Cretaceous separation of South American from the African continent. The Opuama canyon LST was capped by the 14.2Ma MFS with very low regional dip (Figure 19b). Thickness across this LST averages 840ft tvd with the highest thickness observed at the northwestern part of Ake Field, which is

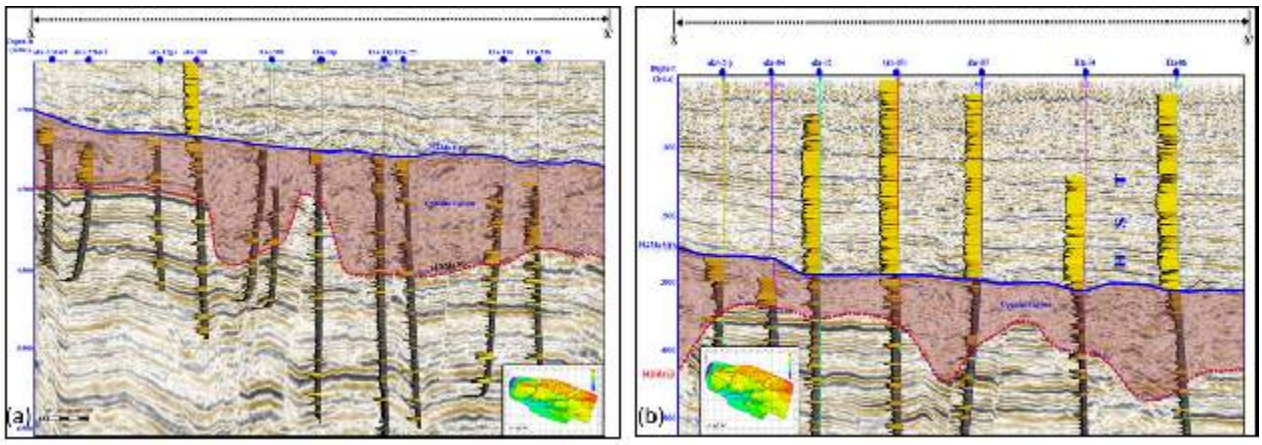

Figure 20: Seismic Cross Section X-X' (a)Showing the erosive relationship between 14.8Ma SB and overall Sequence 6. Most shallow sections of Eta Field were eroded by the canyon(b)Showing Sequence 6. An HST approximately coincident

very proximal to the main axis of Opuama channel. This canyon is not only widespread at Onshore locations in Niger delta, it's extent has also been widely documented in the shallow and Shelf fields; It is likely to be a main sediment delivery network to the Nigerian deepwater petroleum system. This canyon system has eroded most shallow stratigraphy of Eta Field (Figures20a and 20b). Log motif across this LST varies widely with stratigraphic section the individual wells intersect.

Most well through this stratigraphic interval have sharp based low gamma ray log signature indicative of sandy intervals as observed in Ake-21p, Ake-01 and Ake-07. Ake- 02 in Figures 20a and 21 however, shows that the base of this LST could equally be shaly as indicated by high gamma ray values. Predominant seismic reflection event across this LST is the unmistakable chaotic and diffuse seismic character that mostly approximate the Opuama canyon morphology and geometry. Overall, the LST is a very muddy/shalyinterval with some thin sand/silty stringers that are not correlatable even at short distances. The 14.2Ma MFS is characterized by the high gamma ray values typical of shaly Maximum Flooding Surfaces. A previous study suggested that the Opuama canyon Complex was forced into its position by underlying growth faulting activities. Tertiary faulting due to preexisting Cretaceous structural gradient sustained the development of Opuama canyon. Proposed specific circumstances around the development of Opuama

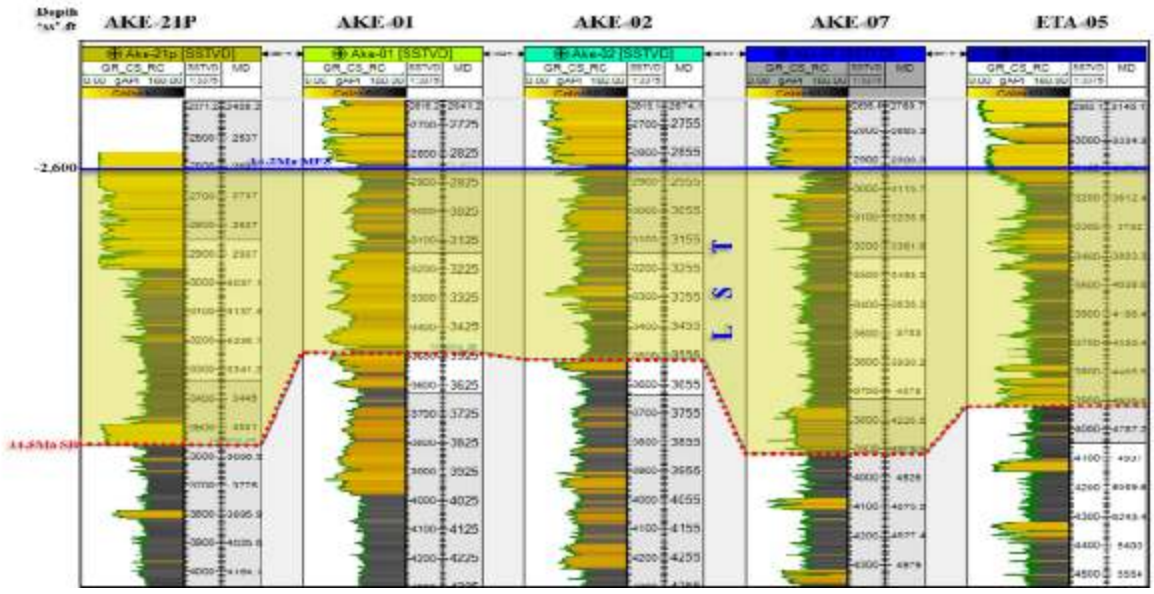

Figure 21: Stratigraphic cross section of 14.20Ma MFS - 14.80Ma MFS LST (Datumed on the 14.8Ma SB) showing diverse sequence gamma ray log motif. The base of Sequence is sandy in Ake-21p, Ake-01, Ake-07 and Eta-05. It is shaly in Ake-02.

Canyon Complex are that the canyon formed during a Late Oligocene-aged drop in sea level. Finally, Canyon fill was presumably accomplished later by slumping and progradation (Wiggins et. al., 2001). The Last System Tract of the entire study interval is the HST above the 14.2Ma MFS. This tract is Progradational and roughly coincident with the Benin Formation in the area. Predominant seismic reflection events across this HST are the parallel to sub-parallel low amplitude reflection events (Figure 20b), some of the bright amplitude seismic reflection streaks observed in seismic across this interval are likely to be trapped shallow gas pockets that have been known to constitute moderate to high hazard during drilling operations. Well log motif across the interval is mostly blocky low gamma ray values diagnostic of Benin sand (Figure 20b). The average thickness of this HST is about 2,600ft tvd. These sands though massive have some thin laminated silty sand and shale interbedded in them.

CONCLUSION

Detailed study of the entire section of Ake and Eta fields reveals that structure and stratigraphy exert significant influence on evolved geology observed in the area. The two fields were at shelf margin for the most part of their geological evolution; this important transitional environment was further complicated by the ubiquitous presence of Incised Valley Fills and different episodes of canyon evolution the most prominent one of which is the Opuama canyon. Furthermore, fluvial mouth bars, distributary channels, tidal channels as well as gravitational slumping of unstable shelf edge introduced additional complexity to the stratigraphy of the area. Extensional growth faulting that was widespread in Onshore Niger delta fields further subdivided depositional packages in the two fields into complexly challenging reservoir units with likely differing hydrocarbon phase and distribution. Accommodation in Ake and Eta fields were largely controlled by both changes in eustasy and tectonism, this indeed determined sediment delivered via sediment gravity flows to the Paleo Slope and as a result, depositional stacking patterns of the two fields. The earliest depositional package identified in the study area are amalgamated levee channel complex that are Lower to Mid Slope deposits; they are also aggradational. This gradually gave way to a prolonged 3rd order Retrogradation with significant marine influence, this also marked the transition from Late Oligocene to Early Miocene. There was a turn around to a Progradation after the 18.0Ma MFS. By now, the various transitional deposits of Incised Valley Fills, Tidal and Shoreface units were widespread in the stratigraphy of the still evolving basin of the Central Swamp Depobelt. The final deposits of the fields are the overall coarsening upward pattern observed as the basin was gradually getting filed. The most distinguishing feature of this period is the Opuama canyon that has carved into previous deposits in the basin. Result of this study is fundamentally different from the earlier work that lumped all the units together as deepwater deposits. This radical reclassification is expected to help enhance reservoir modeling and characterization efforts with consequent improved efficient hydrocarbon recovery in both fields. A key lesson from this study is the importance of using all available data to produce a complete stratigraphic framework of an area for optimum hydrocarbon recovery.

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