International Journal of
Science Inventions Today
www.ijsit.com
ISSN 2319-5436
Research Article

BIOSTRATIGRAPHIC STUDY OF X- WELL IN THE ALPHA FIELD OF THE NIGER DELTA, NIGERIA

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ABSTRACT

An integrated approach has been employed in the biostratigraphic study of X-Well in the Alpha field of the Niger Delta. Detailed biostratigraphic and sequence stratigraphic studies were undertaken with the aim of deducing key candidate surfaces (MFS and SB), depositional sequences and corresponding system tracts,as well as correlating them for enhanced understanding of the stratigraphic framework and petroleum potential of the area. The ouputs were based on integration of results obtained from biostratigraphic/ biofacies and composite gamma log motifs that were created with the data using petrel software. Well log shapes, faunal abundance/diversities and paleobathymetry of X well revealed non-marine to bathyal paleoenviroment characterized by phases of delta progradation and retrogadation. Litostratigraphic analysis obtained from the logs and sedimentologic suites coupled with biofacies indices indicate the presence of two major units, which correspond to the sandy Benin and the Paralic Agbada Formations. The integrated analysis reveals that the sediments penetrated the P800 to P900 and F9900 foraminifera microzones corresponding to mostly Pliocene and Late Miocene ages. The key surfaces were defined based on foraminiferal peak abundances and diversities with high gamma ray and low restivity log signatures. Marker shales, characterized by Bolivina 46 were encountered and accordingly used in dating the key bounding surfaces with the aid of of Niger Delta Zonation chart. The alternation of high stand systems tract and trangresive system tract sand and shales, respectively, seen in the study well provide a union of reservoir and seal rock that is considerd essential for hydrocarbon accumulation and stratigraphic trapping.

INTRODUCTION

In the ever-changing economic and political climate, petroleum explorationists and field development geologists are being required to find more oil and develop older reserves. In concondant to this demand comes the array of new computing, drilling and surface engineering technologies. Therefore, it is a welcome challenge that geologists should look inward and rediscover how they can add more value to the exploration and production (E&P) business. This had led biostratigraphers, usually niche service providers, to evolve new techniques and approaches, challenging old ones and aligning the science with the business needs. Biostratigraphy is the study of rock strata using fossils. Although William Smith's principle of faunal and floral succession was to be the cornerstone for all subsequent work in biostratigraphy, a closer look at fossil successions was needed.

In the late 1800's Polish micropaleotologist, Jozef Gryzbowski realized that rock samples contained fossils that he could recognize from well to well. In addition, he could predict hydrocarbon reservoirs and even identify structural features, such as faults and folds. The refinement of sequence stratigraphy by the Exxon Group led to an increased demand for biostratigraphy, because high-resolution biostratigraphy was a key component of this development. All these pave the way for applied biostratigraphy in exploration and production.

AIM AND OBJECTIVE OF STUDY

The aim of this project is to carry out a biostratigraphic study of X-well in "Alpha field" of the Niger Delta.

Study objectives are to:

- Identify major regional markers
- Identify the p-zones and f-zones in the field area
- Age determination
- Identify and classify the depositional environments and the key surface.

GEOLOGICAL HISTORY

The Niger Delta clastic wedge formed along a failed arm of triple junction system (aulacogen) that originally developed during break-up of the South American and African plates in the late Jurassic. The two arms that followed the southern western and southeastern coast of Nigeria and Cameroon developed into the passive continental margin of West African, whereas the third failed arm formed the Benue Trough. Other depocenters along the African Atlantic coast also contributed to deltaic build-ups (figure 1). Syn-rift sediments accumulated during the Cretaceous to Tertiary, with the oldest dated sediments of Albian age.

Thickest successions of syn-rift marine and marginal marine clastics and carbonates were deposited in a series of transgressive and regressive phases (Doust and omatsola, 1989). The syn-rift phase end with basin inversion in the Santonian (Late Cretaceous). Renewed subsidence occurred as the continents separated and the sea transgressed the Benue Trough. The Niger Delta clastic wedge continued to prograde during middle Cretaceous time into a depocenter located above the collapsed continental margin at the site of the triple junction. Sediment supply was mainly along drainage systems that followed two failed rift arms, the Benue and Bida Basins. Sediment progradation was interrupted by episodic transgressions during Late Cretaceous time.

METHODOLOGY

(a) Database:

The data base made available for this study contains data for one well in Alpha field known as X well. The data includes; biofacies, biostratigraphic, top and base, depth of zones etc.

(b) Workflow:

Participate 1;

Plot litho log on petrel , Identify the parasequence sets , Identify the systems tracts on the log associated with the parasequence set, tie the systems tract to the environment of deposition. Export the MFS alongside the identified hydrocarbon levels and use them to generate a synthetic. Use the synthetic to identify the appropriate loop on the seismic and interprete. After interpreting fault and horizon; then depth convertion using the TZ, export the interpretation (fault and horizon and depth grid) and load into petrel to create a static model

(c) Deliverables:

Identify the major regional markers

Identify the P-zones and F-zones in the area, Identify and classify the depositional environments. Highlight maximum flooding surfaces and sequence boundaries

(d) The Biofacies Data:

This contained in this data were the sample depth, environment code, faunal diversity and abundance. This was used to create a plot of the faunal diversity and abundance. The plot was used in deducing the maximum flooding surfaces, sequence boundaries and the various systems tracts. When derived, they cannot be confirmed as accurate without tallying it against results from other data.

(e) The Bio stratigraphic data:

This contained the top depth and the base depth of the various zone types of their corresponding zone codes. This was used to determine the various market beds. From results gotten only one marker bed was available and that is the Bolivina 46. Also the biostratigraphic data was used in deducing the age and studies also showed that it was solely Pliocene in age.

(f) The Tops and Bases Data:

The was used in determine the depth and extent of the sand beds and invariably the reservoir beds. This data result was also tallied with the biofacies data to give a more accurate judgment of the parasequences; e.g; from the plot, any MFS deduced that fell within a sand lithology was definitely not an MFS and thereby deleted from the list of "MFSes" because it is a fact that maximum flooding surfaces are characterized by high deposition of faunal abundance and diversity. This invariably means an MFS is marked by high abundance and diversity of organic matter. This has to fall within shale. So you can see that based on the characteristics of each parasequence; the sand top and base data thereby becomes extremely useful in our final deduction.

(g) The ASCII log data:

All the above deductions get their final confirmation using the ASCII log data. The ASCII log data was used to plot a gamma ray log section using petrel. This was then used to pinpoint the shale areas, the sand areas and the area of likely hydrocarbon accumulation. It is pertinent to note that the Gamma ray log is also known as the shale log based on the fact that shale produces high radioactivity with the exception of radioactive sands.

RESULTS AND INTERPRETATION

Based on the data and the litholog that was created using the petrel software; Ten sand bodies were deduced as indicated below:

Sand body (1) ;3320ft—3359ft, **Sand body (2)**;3870ft-3883ft, **Sand body 3**; 4106ft —413311

Sand body 4; 448411-- 4560 ft ,**Sand body 5**; 4798ft—4813ft, **Sand body 6**; 488411—494411, **Sand body 7**; 657011— 6720ft, **Sand body 8**; 675011— 6782ft, **Sand body 9**; 6862ft — 6945ft, **Sand body 10;** 7228ft —755411

Hydrocarbon was identified at the following depths; 448011 to 457011 (011).

488011 to 494011 (Oil and Gas), 656011 to 664011 (Gas).

With the aid of the resistivity log potential hydrocarbon zones were deduced at the following depths; 6490ft to 655011 and 714011 to 717011. Both proved to be viable because the reservoir sands were found to be juxtaposed between shale which would act as a seal preventing escape of the hydrocarbon.

(i) Regional marker: The only major regional marker was the Bolivina 46.

(ii) Age: The presence of Bolivma 46 was indicative of Pliocene age. But using the diagnostic forams (Amphistegina) present and the F-zone in addition the age could be rightly said to be extending from Late Pliocene to Late Miocene in age. This inference was made using the Niger delta chronostraigraphic chart as a guide.

(iii) Depobelt: Based on the charts, it can be inferred that the penetration was restricted to the offshore depobelt. It can be seen that the well penetrated Benin formation consisting of continental sandstone with fluvial channels, marsh/swamps in an upper delta plain environment and part of the Agbada formation consisting of transitional sandstone and shale. The well also penetrated the F9700 to F9900 of forarniniferal zone as seen on the Biostratigraphic charts.

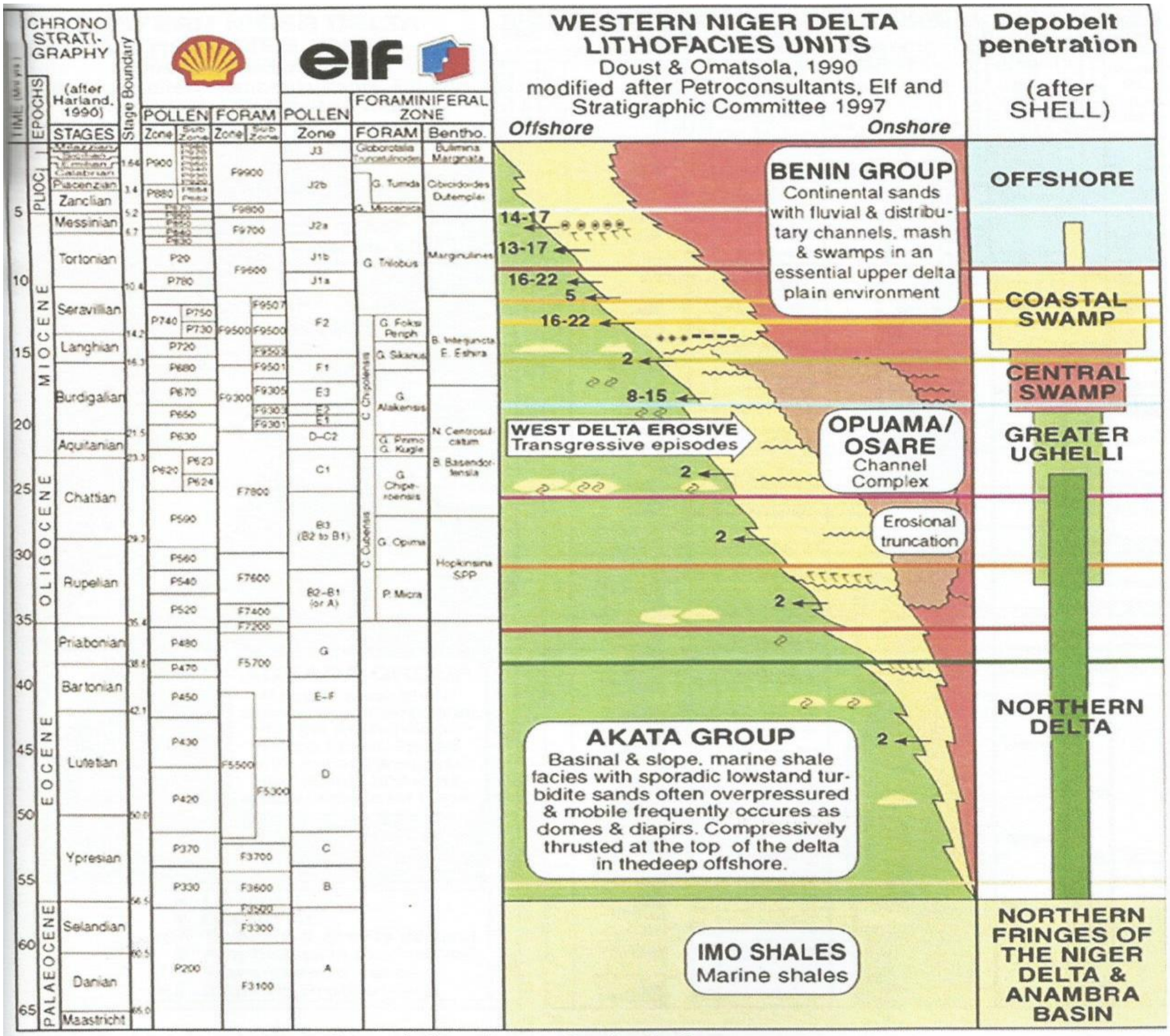

Figure 1: The Western Niger Delta Chronological chart

Based on the charts, it can also be inferred that the penetration was restricted to the offshore depobelt.

(iv) Key surfaces: The maximum flooding surfaces MFS and the sequence boundaries SB were worked out by creating plots based on the foram abundance and diversity and were as follows;

Maximum Flooding surfaces **MFS**; 2400ft— 2500ft, MFS; 3600ft — 3650ft. **MFS**; 8500ft — 8550ft, Sequence Boundaries, **SB**; 3300ff — 3400ft. **SB**; 4950ft — 5000ft, **SB**; 7550ft

(iv) Age of key surfaces: The maximum flooding surfaces MFS and the sequence boundaries SB were worked out by creating plots based on the foram abundance and diversity and were as follows; The Position of the P-zones , F-zones and diagnostic forams were used to work out ages based on the Niger delta chronostratigraphic chart.

(v) **Maximum Flooding surfaces MFS 1**: Depth; 2400ff — 2500ff**,** Age; 3.4 million years (Late Pliocene), **MFS 2;** Depth; 3600ft — 3650ff**,** Age; 3.9 million years (Early Pliocene), **MFS 3**; Depth; 8500ft—8550ft**,** Age; 6.0 million years (Late Miocene)

(vi) Sequence Boundaries SB 1: Depth; 3300ff — 3400ff, Age; 3.7 million years (Early Pliocene), **SB 2;** Depth; 4950ff — 5000ff, Age; 4.1 million years (Early Pliocene), **SB3**; Depth;7550fi Age; 5.6 million years (Late Miocene), They are depicted in the chart **below.**

(vii) Sequences encountered within the Well: 8900ff — 8450ff = **fining upwards,** 8450ff — 7600ff = **coarsening upwards**. 7600ff — 6650ff = f**ining upwards** .6550ff — 4950ff = **coarsening upwards**. 4950ff — 3900ff **fining upwards**. 3900ff — 3350ff **coarsening upward.** 3350ft — 2450ff = **fining upwards**. 2450ff — 1500ff **coarsening upwards**

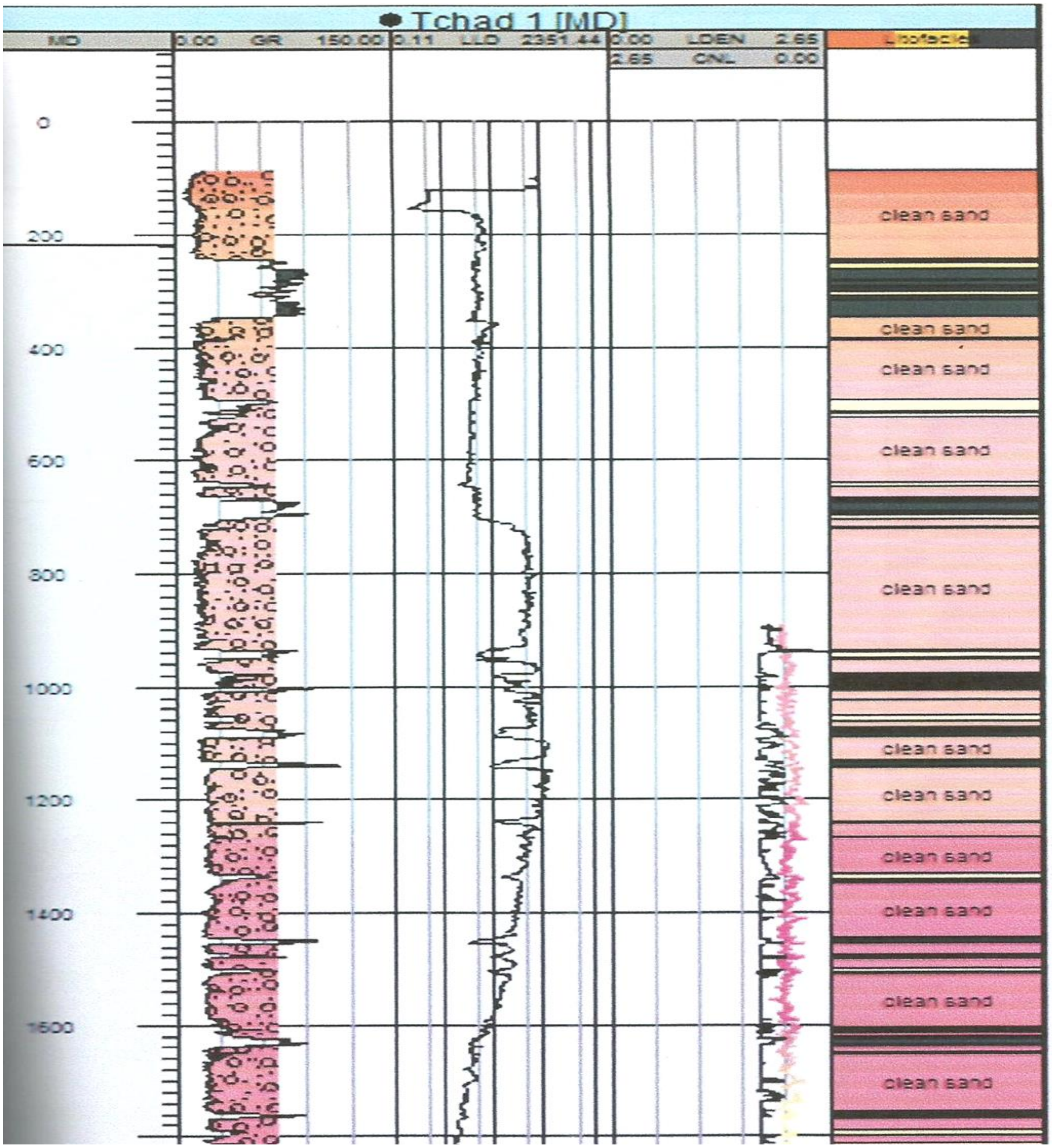

Figure 2: Log section for the well (0-9000ft)

(viii) Economic significances of parasequences: Changes in sea level cause large lateral shifts in the depositional patterns of sea floor sediments. This lateral shifts in the deposition create alternative layers of good reservoir quality rock (porous and permeaeable sands) and poorer quality mudstone capable of providing reservoir "seal" to prevent leakage of any accumulated hydrocarbons that may have migrated into the sandstone. Sequence boundaries make good reservoir rocks, for example multifluvial sandstones within incised valleys formed as result of sea-level drop. Also The alternation of high stand systems tract and transgressive systems tract sand and shales\ respectively, seen in the study well provide a union of reservoir and seal rock that is considered essential for hydrocarbon accumulation and stratigraphic trapping.

(viiii) Sequence Interpretation: Reading from strata bugs plot, it can be interpreted that from 8750ff, there was a transgression and rise in sea level which culminated in a maximum flooding surface at about 8550 ft. Above 8550ft, there was a drop in sea level and regression which culminated in a sequence boundary at about 7560ft. There was another transgression and sea level rise although it resulted in a flooding surface, it was not a maximum flooding surface. This interpretation is based on the litholog at that depth which was quite close to sandstone and also using the total foram count and diversity. This does not suggest a maximum flooding surface, but possibly a marine flooding surface. After the flooding episode, there was a continual regression and drop in sea- level up till 4950 ft where there was a sequence boundary.

After 4950 ft, another transgression occurred which culminated in a maximum flooding surface at 3550 ft. Then, there was a sea level drop giving rise to a sequence boundary at 3350 ft. This episode was followed by another sea level rise and another maximum flooding surface at 2400ft. Then, there was a drop in sea level which continued to the top depth of 1500ft.

CONCLUSION

Sequence stratigraphic framework and depositional setting of X well in this study reveals the penetration of the Benin and part of the Agbada Formations. Integrated analysis reveals that sediments of the study well penetrated the F9700 to F9700 foraminiferal microzones corresponding to the Late Pliocene to Late Miocene times situated within the same rnicrostructure.

Key candidate surfaces were recognized based on the basis of foraminiferal peak abundance and diversities with high gamma ray and low resistivity log

X Well unraveled three MFS (6.0Ma,3.9Ma, and 3.4Ma) with three corresponding SB (5 .6Ma, 4. l Ma and 3 .7ma). A1l the surfaces encountered within the analysis interval of the wells were used in dividing the stratigraphic succession into depositional sequences and their corresponding systems tracts.

The MFS and the SB further aided the subdivision of the sediments into their respective genetic sequences bounded by transgressive systems tracts. The coarsening-upward trend is interpreted to indicate a steady upward increase in sand content and energy of the depositional system while the fining upward trend shows a reduced energy environment.

The alternation of high stand systems tract and transgressive systems tract sand shales respectively seen in the studied well, provides a union of reservoir and seal rocks that is essential for hydrocarbon accumulation and sratigraphic trapping.

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