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Research Article

PETROLEUM VIABILITY AND PETROPHYSICAL STUDIES OF WELLS IN NIGER DELTA, NIGERIA

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ABSTRACT

This research work identifies the petroleum reservoirs that are capable of holding significant amount of petroleum in the wells, which will result from the consideration of porosity, hydrocarbon saturation and other petrophysical parameters. The aims and objectivity of this research work is to use geophysical borehole log data to determine the reservoir of the various stages in the wells, correlate the wells in the field, determine the economically viability of the wells and to determine the different lithology encountered at various depth in the wells.

INTRODUCTION

The quest for optimum method of hydrocarbon production has been an issue which many oil and gas companies are interested in. Alvarado and Manrique (2010) have stated that the effort of industries to increase production by the use of large capital investments to enhance oil recovery sometimes proves futile. This hitch needs to be proffered with a sustainable solution. One of the major ways of resolving this issue is through hydrocarbon reservoir properties modeling.

Most of the factors that determine the reservoir conditions are often too dynamic that over a short geologic time span must have been severally altered and must therefore be revisited for quantification. This shows that reservoirs must be regularly revisited with new technical devices, and also the geologic conditions must be rechecked due to the reservoir's heterogeneity in order to evaluate the possible range of uncertainty existing within the reservoirs.

This research work is therefore presented as an intensive integrated reservoir modeling approach to the study area. A thorough reservoirs characterization is therefore required approach based on the interpretation of the acquired three-dimensional seismic data set and wireline logs, to support the geologic model of the reservoirs..

STUDY AREA:

The study area is situated within the western margin of the Niger-Delta. The Niger-Delta is situated in the Gulf of Guinea between longitudes 5°E and 8°E and latitudes 3°N and 6°N.

Due to confidentiality purpose, more details about the location of the study area were not provided.

Aims and Objectives of the Study Area:

The aims and objectivity of this research work is to use geophysical borehole log data to determine the reservoir of the various stages in the wells, correlate the wells in the field, determine the economically viability of the wells and to determine the different lithology encountered at various depth in the wells

REVIEW OF GENERAL GEOLOGY OF THE NIGER DELTA BASIN:

The Niger Delta region is situated in Southern Nigeria between latitudes 4° and 7° N, and longitudes 4° and 9° E. It occupies an area limited by the Benin flank, the Anambra basin, the Calabar flank and the present coast line. It extends in an East-West direction from Southwest Cameroon to the Okitipupa Ridge. Its apex is situated southeast of the confluent of the Niger and Benue Rivers. It is bounded in the South by the Gulf of Guinea and in the North by the older Cretaceous tectonic elements such as the Anambra basin, Abakaliki uplift, and the Afikpo syncline .

The Niger Delta is a province of intense research and exploration studies.

Selly (1976) interpreted the environments of the sand bodies using a combination of log shapes and detrital mineral components. He used gamma ray log shapes to identify facies of the deltaic, fluvial, marine and deep-sea environments.The hydrocarbon properties in the Niger Delta were discussed by Evamy et al., (1978).

Ekweozor and Okoye (1980) evaluated the petroleum source bed of the Niger Delta, supporting the conclusion of Weber and Daukoru (1975) that the source rocks are the shales of the Akata Formation.

Ejedawe and Coker (1984) discussed the evolution of oil generative window and occurrence of oil and gas in the Niger Delta. They concluded that during the active subsidence phase, oil was generated initially at a temperature of 284–2950⁰F and a depth of 9,840–17,060 ft (3,000–5,201 m). However, after subsidence there was vertical upward movement of the oil generative window through 2,625–5,250 ft (800–1,600 m) accompanied by a temperature change of 41–910⁰F. This caused the maturation of the source rocks at progressively shallower depths and lower temperatures.

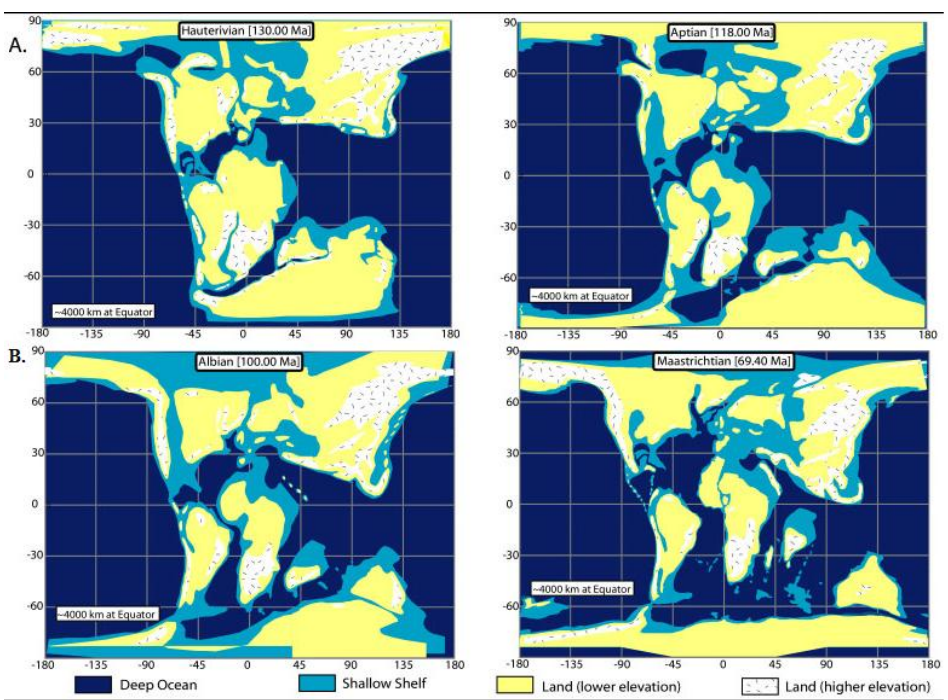

Figure 1: Paleogeography map showing the opening of the South Atlantic, and development of the region around Niger Delta. A. Cretaceous paleogeography {130.0 to 69.4 ma}. B. Cenozoic paleogeography, 50.3 ma to present, (Plots generated with PGIS software).

METHODOLOGY AND DATA SOURCE

Different types of methods of study are applied to wireline logs interpretation is within the available materials that have been adopted for the evaluation of reservoir sand that were evaluated in this research work. Basically, a log is a downhole record made during or after the drilling of a well, It measure directly or indirectly, the records of the measurable physical properties of the geologic formations penetrated by a well and its fluid content. It provides essential information and interpretation of the subsurface geology of the area penetrated by the borehole, thus facilitating correlation between different areas But nowadays provide information on the nature of the strata penetrated, the shape of the structure, physical data on the rocks, the depths at which these rocks are encountered, the porosity and permeability of the rock units, types of fluids contained in the rocks, their temperature, depths of the fluid interfaces etc.

RESULTS AND DISCUSSION

The total number of four reservoir sand bodies were identified and all of the four reservoir sand bodies falling within the parallic Agbada formation. They are labeled as reservoir sand bodies A,B,C, and D, according to their stratigraphic position beginning from the bottom to the top.

The alphabetic terms used are to distinguish from one sandbody to the other and which are separated from each other by certain thickness of shale beds. However, the sandbodies are described from the base sandbody A to the top sandbody D and their genetic mechanisms are interpreted. In order to interprete the depositional environment of different reservoir sands encountered in well X1 and well X2, the modified model of electrofacies classification for deltaic environment from gamma ray logs and schematic representation of log patterns of variety of depositional environment in which sand-shale sequence are developed.

Description of Reservoir Sand bodies And Stratigraphic Position:

SANDBODY C:

sand body C has thickness variation of 10m in well Xl and 8m in well X2. It has e shallowest top at 3809m in well Xl and the deepest top at 4070m in well X2. Shallowest base of the sand occurs at 3814m in well Xl and the deepest base 4074m in well X2. The shale thickness of about 7m separated sandbody C from

Overlying sandbody D in well X2 and the shale thickness of about 270m separated sand body C from overlying sand body D in well Xl.

Geometry: Sandbody C has its thickest sand development in well Xl with sand unit thickness of l0m. It has the sand unit thickness of 8m in well C2.

SANDBODY D:

Sand body D has its shallowest top sand at 3529m in well Xl and the deepest top and at 4054m in well X2. The shallowest base sand at 3533rn in well Xl and the base sand at 4057m in well X2. However, the sand body D is bounded a top by thick shale unit averaging 3500m in thickness, whose base was used as the reference datum in constructing the stratigraipic cross sections.

Geometry: The sandbody D has the sand thickness of 8m in well Xl and 6m in well X2. It is almost uniformly thick in well X2. Sand body D is the shallowest Reservoir sand unit encountered in the field of study.

SEISMIC-TO-WELL TIE:

One of the first steps in interpreting this seismic dataset was to establish the relationship between seismic reflections and stratigraphy. Accurately tying wells and seismic information is a necessary step in reservoir characterization. Well-to-seismic tie was a major task for this interpretation project. It was used to correlate the well information (logs) to the 3D seismic volume. This enabled the comparison (crossplots) of well-based and the 3D seismic data.

Seismic-to-well tie is key at any stage of the development of a field and is an essential step of the seismic interpretation workflow, bridging the gap between the time and depth domains.

A well section was created for the well to seismic tie, the sonic log, density and gamma ray log of the well superimposed on inline 6010 that it passed through, to have an accurate correlation of both the log and the section.

SEISMIC SECTION OF THE MAPPED FAULTS AND HORIZONS:

The exact horizons for the tops of the reservoirs were picked and this ensures that the interpretation process is consistent. The field is considered to have complex structures (classification, according to Doust and Omatsola, 1990.) and located in the distal delta.

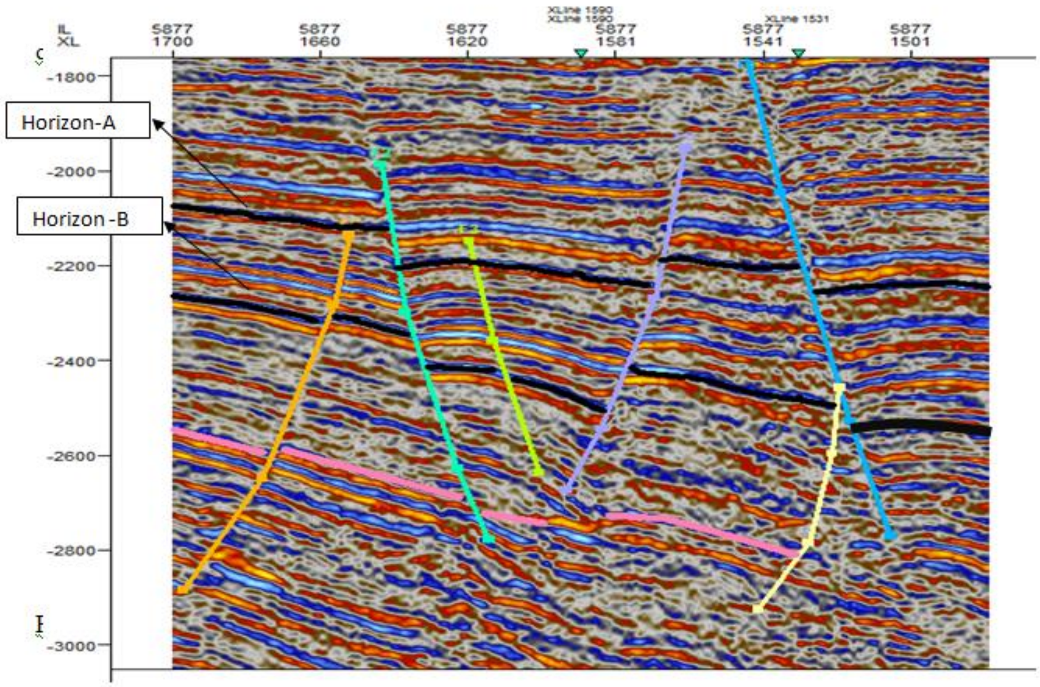

Figure 2: Inline 5877 depicting faults F1-F6 (Left-Right) and the two mapped horizons (Black).

FAULT INTERPRETATION RESULT

The study area is a complex south-east dipping anticlinal structure, parallel synthetic and antithetic faults. Six faults were mapped with series of colours. Within the major fault blocks numerous subsidiary faults, both synthetic and antithetic, have been recognized but some additional small scale faults which may be present cannot be confidently mapped, especially at the deeper levels, due to relatively poor data quality.

Within the central area of the base map, there is considerable well control therefore, the fault positions are considered to be accurate at the mapped reservoir levels to the base of the B sands.

TIME AND DEPTH STRUCTURAL MAP INTERPRETATION:

Time structural contour maps were produced for the two horizons defined on top of sand bodies, namely, Horizon A and B. Both types of structural contour maps show similar structural relationship. This linear relationship was also corroborated by the linear curve observed from the plot of depth against time using the check shot data for the wells.

Well S	Sand Top Sub Sea (M)	Sand Bottom Sub Sea (M)	Average Depth (M)	Thickness (M)
Well X1	3809	3819	3814	10
Well X2	4069	4080	4047	11

Table 1: Distribution of Thickness of Sandbody C

Well S	Sand Top Sub Sea (M)	Sand Bottom Sub Sea (M)	Average Depth (M)	Thickness (M)
Well X1	3529	3237	3533	8
Well X2	4054	4060	4057	6

Table 1: Distribution of Thickness of Sandbody D

Depositional Environment of Sandbody C:

The gamma ray log signature of sandbody C indicates that, the sand body C, appear to be clean and well sorted sand. Sandbody C, is serrated funne! shape and irregular. When this sand body C compared with the electrofacies classification for deltaic environments from gamma ray logs(Adapted by Schlumberger 1985), it favors the interpretation of sandbody C, as a stream mouth bar at the top part of the reservoir sandbody and distributary channel at the base part of the reservoir sand body C. Sand body C is separated from sand body D by a thick shale.

Depositional Environment of Sandbody D:

The gamma ray log signature of sandbody D has sharp upper and lower contacts with the shale at both portions. The sandbody is well sorted and clean at its upper and lower portions. The gamma ray log signature is smooth at its curve in upper portion and shape is serrated at the base portion. When the gamma ray log signature compare with the adapted signatures by schiumberger 1985, it shows a stream mouth bar deltaic environment.

Geological Properties and Hydrocarbon Occurrences:

Sandbody A has the minimum porosity value of 27.11% in Well X2 and the maximum porosity value of 32.82% in Well Xl. Sandbody A has low resistivity, Value of 1.20 -m in Well Xl and the high resistivity value of 20 0 -m in Well X2. The bulk volume of water of 31.42% in Well Xl and the bulk volume of water of 20.99%

in Well X2. As indicated by the resistivity log value, it is hydrocarbonbearing in Well X2; while it is water bearing in Well X1.

In sandbody B, the porosity values varies between 28.13% in Well X2 and 33.27% in Well Xl. As shown by resistivity logs, sand bocly B has resistivity value of 20 0-rn in Well Xl and 30 0-m in Well X2 while the bulk volume of water in Well Xl is 30.67% and in Well X2 is 22.97%. This indicates that, Well Xl and Well X2 are hydrocarbon bearing zones.

Sandbody C has high formation factor value of 14.625 in Wet Xl and low formation factor value of 6.607 in Well X2. The porosity range from 22.99% in Well Xl to 33.27% in Well X2. Well Xl and Well X2 have resistivity values of 95 0-rn and 100 0-rn respectively. The bulk vollume of water value of 7.46% in Well Xl and bulk volume of water value of 32.93% in Well X2. With an indication of very high resistivity values in Well Xl and Well X2 within the sand body C may shows that sand body C is gas-bearing zone.

Sand body D has formation factor value of 15.347 in Well Xl and formation factor value of 10.697 in Well X2. The resistivity value in Well Xl is 1.6 0-rn, which was very low when compared it with the resistivity value of 60 0-rn in Well X2. This indicates that, Sandbody D is an hydrocarbon bearing zone in Well X2 and water bearing zone in Well Xl.

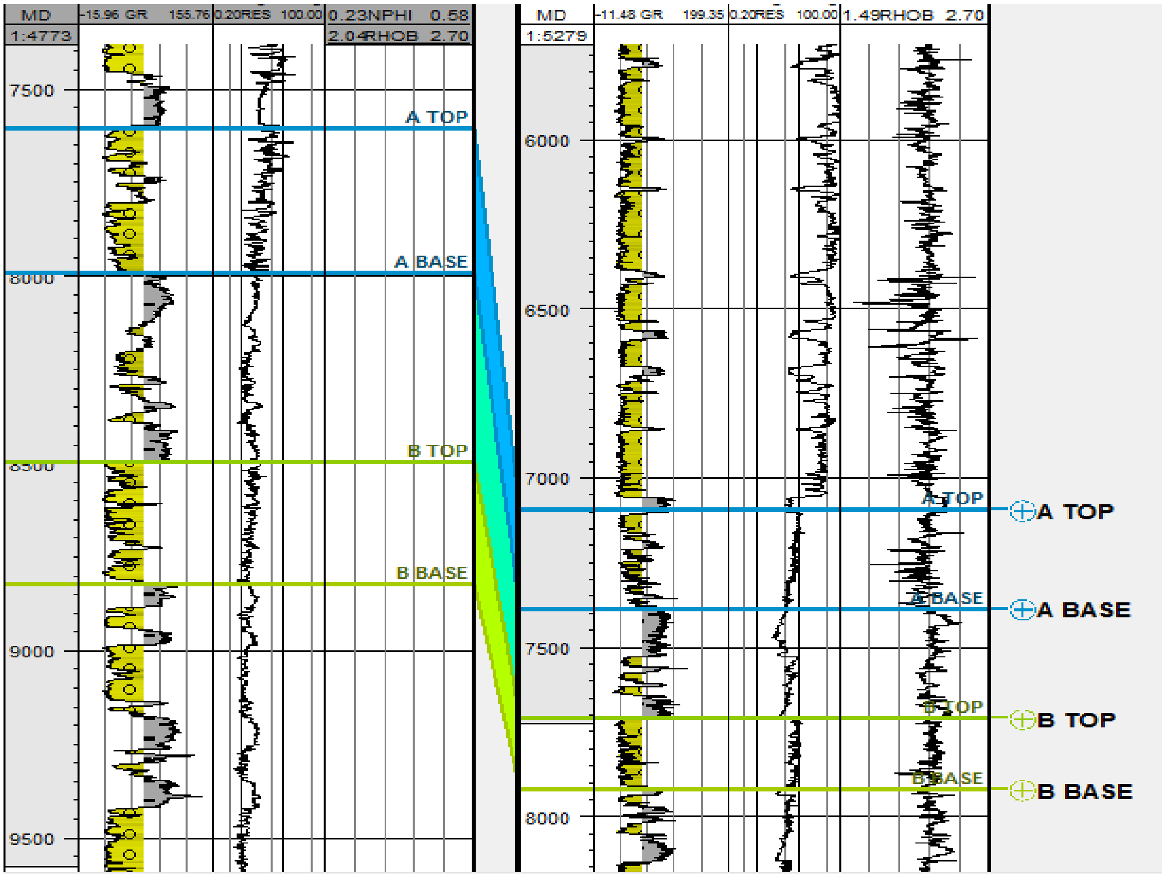

Figure 3: Well log correlation panel of Well X1 and X2

Most of the reservoir sands show similarity in geometry and the lithological interpretation shows that, the reservoir sands are dominantly sand with thin thickness of shale separated the sandbodies A,B,C, and except where there is high thickness of shale separated the sandbody C from sandbody D.

Porosity depends on the degree of uniformity of grain size, the shape of the grains, the method of deposition, the manner of packing and the effects of completion during or after deposition. In this research work the sandstone reservoir evaluated are modifications of primary porosity, which are due to principally to the interlocking of grains through compaction, contact solution, re -deposition and cementation. The reservoir sands exhibit a porosity range of 22.48% to 33.27%, which has been considered very good for hydrocarbon production in the Niger Delta region.

Vertically, from the top reservoir sand D to the last bottom reservoir sand A, there is a gradational decrease in values of porosity as depth of burial of sand increased..

It was shown from the result obtained that well X2 contain high volume of hydrocarbon more than well Xl. For further drilling of new wells in X-field, it is highly recommended that, the diamond drilling bits should be used because of thickness of shales before the hydrocarbon reservoir sands.

Similarly, area of reservoir sands with high porosity and good permeability but indicates few hydrocarbon accumulation or non-hydrocarbon accumulation in this research work can still be further evaluated with other sophisticated geophysical data such as cores and ditch cuttings and seismic data.

However, correlation of reservoir sands in X-field with the closely related or nearby field to determine the continuity of viable hydrocarbon bearing reservoir sands could also be done to facilitate or aid significant oil exploration in the nearby oil fields.

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