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Research Article

FIELD DEVELOPMENT PLANS USING SEISMIC RESERVOIR CHARACTERIZATION AND MODELING; A NIGER DELTA 3D CASE STUDY

Toluwalpe A.O[1], Beka Francis T[2] and Akagbosu Pius[3]

[1,2,3] *Centre of Petroleum Geosciences, Institute of Petroleum Studies, University of Port Harcourt, Nigeria*

ABSTRACT

This project is to optimize development plans using integrated seismic reservoir characterization and modeling of Obisesan Oil field, its objectives involve: Detailed well log analysis, generation of surface maps, detailed integrated 3D Reservoir Geological Modeling, project volumetric analysis and well path design; using both qualitative and quantitative approaches. In this study, the results from the well log interpretation indicate a lithologic sequence of the intercalation of sand and shale which depicts the stratigraphic sequence of Niger Delta. The fundamental petrophysical parameters of interest across the two wells (Net to gross (0.78-0.98), Porosity (0.14-0.26), permeability (2796- 10846md), and water saturation (0.20-0.39)) are within a highly prospective range. The results of the stratigraphic cross-sections drawn from well correlation show that, the horizons are laterally continuous, however, pinch-outs/wedge-outs are evident. The horizons mapped are all within the Agbada Formation where most of the hydrocarbon is believed to be trapped in the Niger Delta. Anticlinal closures and fault assisted closures regarded as good hydrocarbon prospect areas have been delineated in the structure contour maps. Apart from the structural traps delineated, other stratigraphic pays including pinch-outs, unconformities, sand lenses and channels were also suspected.

INTRODUCTION

A quantitative, detailed description of reservoir architecture (both external and internal) and petrophysical properties which integrates all available well logs, seismic and geologic information can strongly improve the economics of reservoir development and enhance production. Spatial distribution of reservoir characteristic can be determined using petrophysical analysis with different subsurface models obtained from structural and stratigraphic interpretation of seismic images to match dynamic reservoir behavior and to manage production forecast as these underpin all decisions in hydrocarbon exploration and production. In order to obtain the most accurate and detailed results, one must step through a standard workstation seismic and geologic interpretation by designing a multidisciplinary workflow that quantitatively integrates well log, petropiiysical and seismic information.

As part of the major stages involved before the generation of static models, detailed interpretation of well logs and the seismic cube is very important. This helps in taking some simple but important decisions about structures in depth and also the extraction of amplitude of the different horizons of interest which will help in identifying hydrocarbon. Closed areas are hgh1ighted on the generated depth contour map because these form possible hydrocarbon traps. Closure of contours against faults can also be investigated and the sealing capacity of the fault planes determined.

The core of the development plan is the reservoir model. The model is used to simulate production of petroleum from the accumulation using computer modeling packages. Each model commonly comprises many tens of thousands of cells. Each cell represents a portion of the reservoir. It is populated with reservoir properties such as net to gross, porosity, permeability anisotropy, pressure, and the like. Faults and other potentially impermeable barriers are woven through the array of cells Reservoir models are commonly conditioned to static data, such as a geologic description of the trap shape, the reservoir architecture, the petrophysical properties, the gas to oil ratio, and the petroleum compressibility.

AIM AND OBJECT1VES

This study aims at optimizing field development plans through the use of integrated seismic reservoir characterization and modeling approach.

Location of the Study Area: OBISESAN oilfield is an offshore field located on the Niger Delta. The new name given to the field and the wells are only valid for this project.

METHODOLOGY

(A) WIRELINE LOGGING: Wireline well logging involves continuous measurement of physical properties of rocks –formation and their fluids using devices or tools also known as sonde that can be lowered into wells. Wireline well logging is carried out from a logging truck. The truck carries the down hole measurement instrument, the electrical cables and which are needed to lower the instrument into bore hole, the instrument then receives and processes the signals.

The primary objectives of logging and formation evaluation are: identification of reservoir; of hydrocarbon in place; reservoir description like shape, thickness, porosity and permeability, well-to-well correlation; formation dip and borehole image; surface seismic well it control; production planning and corrosion monitoring.

(B) PETROPHYSICAL DATA ANALYSIS (Gross and net sand reservoir thickness): Gross reservoir thickness interval is the interval covering shale and sand within a reservoir. Net thickness of sand is the interval covering sand only within a reservoir. It is called net productive sand. The gross reservoir trickiness is determined by knowing interval covering both sand and shale within the reservoir studied using gamma ray log. Net sand thickness is determined by subtracting the interval covering the shale from gross reservoir thickness.

(C) Well log correlation: Stratigraphic correlation is the determination of the continuity and equivalence of lithologic units particularly reservoir sands or marker sealing shale across a region of the subsurface. The lithologic units are delineated in vertical succession by distinct surfaces representing changes or lithologic character.

(D) Qualitative log interpretation: This is based on the visual observation of the logs to determine zone of interest. It is basically concerned with shape, characteristics signature and physical model of the relevant well log, it involves the identification of permeable beds. Also bed thickness and depth to various fluid contacts can be determined.

(E) Gamma ray log analysis: GR log reading for impermeable formation (shale) with high content of radioactive element is usually while it is relatively low for a permeable formation (sand) with low content of radioactivity.

(F) Resistivity log analysis: Resistivity response in the hydrocarbon bearing formation is usually high while in water bearing it is low. The resistivity of the transition zone between hydrocarbon and water is between these extremes

Axis	**Min**	**Max**	**Delta**
X	423550.50	430400.50	6850.00
Y	66025.50	72425.50	6400.00
Time	-4254.00	-1702.00	2552.00
Trace	-4254.00	-1704.00	2548.00
Amplitude (data)	-19400.26	-25202.20	-4460.46

Table 1: Seismic data default properties

PRESENTATION OF THE DATA

WELL LOG RAW DATA: The well log data used for this study were in ASCII format and are graphically displayed in order aid interpretation in which the recorded logs of gamma ray count in count per seconds (cps), resistivity (deep induction log) in ohms-meter, neutron porosity in porosity unit, density log in g/cm^3 and the measured depth (MD) in feet m)

STRATIGRAPHIC SEQUENCE: The stratigraphic sequence observed in the study area is an intercalation of sand, shale and shaly sand unit' representative of the Agbada Formation. The interpreted stratigraphic sequence for the depth interval of interest falling within the depth of 270m to 4357m for well X2 and 2500m to 3l9m for well X l1, these depths were chosen based on the observed resistivity logs for the wells. The sand units that occur within this depth, their respective depth to top and bottom, net and gross thickness, porosity and other petrophysical parameters are thus presented in the Tables **2**

CORRELATION SECTION OF THE LITHOLOGIC UNITS: The correlation section of wells in OBISESAN oil field was done considering their spatial location on the field. The general stratigraphy shows that the lithology consists of sand-shale intercalation. The stratigraphic units shows a variation in thickness from one well to another. This could probably suggest non-conformity in the rate of sediment deposition and compaction. The correlated section also show a variation in the gross and net sand thickness and also confirmed the fact that hydrocarbon reservoir are restricted to sand units and not shale units for this study.

Reservoir	Top(m)	Base(m)	Thicknes(m)	Ish	Vsh(%)	Por_Des(%)	Por-Eff(%)	Sw-Ai	FY
1	3311.88	3329.51	17.63	0.20	9	0.260	0.20	0.20	10.50
2	3426.39	3450.94	24.55	0.59	24.5	0.209	0.25	0.25	14.55
3	3545.24	3574.74	29.5	0.0851	24.24	0.238	0.236	0.236	15.39
4	3798.87	3878.33	7946	0.1649	21.34	0.1997	0.2719	0.2719	21.398
5	4189.90	4326.79	136.89	0.2328	16.25	0.1497	0.3916	0.3916	59.26

Reservoir	Swirr	Sh	K	Sx0	Krw	Kw	Kro	Ko	OMI
1	0.0711	07987	1084640	0.7240	0.00084	20.225	0.7384	8364.32	0.2700
2	0.0830	0.7670	4226.63	0.7450	0.00390	10.98	0.7000	3156.00	0.3106
3	0.0850	07637	3058.75	0.7466	0.00376	9.534	06958	2235.081	0.3137
4	0.0984	0.7280	1286.04	0.7668	0.0106	5.4031	0.6527	908.31	0.3508
5	01465	0.6084	231.524	0.8168	0.0001	1.774	0.7205	150.635	0.4642

Table 2: Derived petrophysical parameters for well X2

In all, five different hydrocarbon bearing reservoirs were delineated across all the wells. In well X2, which have **reservoir l** (3311.88-3329.51)m, **reservoir 2** (3426.39-3450.94)m, **reservoir 3** (3545.24-3574.74)m, **reservoir 4** (3798.87-3878.33)m and well X11, which have **reservoir 1** (3345.4-3356.7 l)m, **reservoir 2** (3461. 85-3479.40)m and **reservoir 3** (3561 .27-3704.320) m Correlation section also **shows that reservoirs 1, 2, 3** is laterally extensive, cutting across both well X2 and well Xl1

DISCUSSION OF RESULTS

(A) WELL LOG INTERPRETATION:

The implication of the observations made, parameters estimated are presented with respect to the five reservoir sands delineated within the net of interest. Once more the sands are considered in the order of increasing depth of burial, starting from reservoir 1 across well X2 and X11, then reservoir 2 also across both well X2 and X11, reservoir 3 across well X2 and X 11, reservoir 4 and 5 along only well X2 since it's not laterally extensive.

Reservoir 1: This is the topmost reservoir within the interval of interest, it occurs at depth interval of 33l1.88m to 3329.51m at well X2 and 3345.42m to 3356.71m at well X11. Its thickness is thus varying from 17.63m in well X2 to 1 1.29m in well 11, laying net to gross of 0.9080 at well X2 and 0.78 at well X11.

Thus, its porosity values (porosity from density log) are 28% and 23% at well X2 and X11 respectively. However there is a very sharp decrease in its permeability values from well X2 to Well X11 which might be as a result of the effect of grain sizes on permeability. It is also characterized by hydrocarbon saturation of 79.87% and 74.10% with a corresponding increase in the water saturation across well X2 and X11 respectively and its oil movability index at each well is 0.27 and 0.3363 which implies the hydrocarbon content were movable during invasion since it is less than 0.7(if OMJ<0.7, for sandstone.

Reservoir 2: This is the second reservoir within the interval of interest, it occurs at depth interval of 3426.39m to 3450.94m at well X2 and 3461.83m to 3479.4m at well X11. Its thickness is thus varying from 24.55m in well X2 to 17.57m in well X11, having net to gross of 0.8368 at well X2 and 0.86 at well X11.

Thus, its porosity values (porosity from density log) are 24.5% and 22.04% at well X2 and X11 respectively. However then is a very sharp decrease in its permeability values from well X2 to Well X11 which might be as a result of the effect of grain sizes on permeability. It is also characterized by hydrocarbon saturation of 76.7% and 74.380% with a corresponding increase in the water saturation across well X2 and X11 respectively and its oil movability index at each well is 0.3106 and 0.3360 which implies the hydrocarbon content were movable during invasion since it is less than 0.7(if OM <0.7, for sandstone

Reservoir 3: This is the third reservoir within the interval of interest, it occurs at depth interval of 3545.24m to 3574.74m at well X2 and 356 i.27m to 3704.32m at well X11. Its thickness is thus varying from 29.5m in well X2 to 143.05m in well X11, having net to gross of 0.9748 at well X2 and 0.92 at well X11.

Thus, its porosity values (porosity from density log) are 24. 24% and 24.02% at well X2 and X11 respectively. However there is a very sharp decrease in its permeability values from well X2 to Well X11 which might be as a result of the effect of grain sizes on permeability. It is also characterized by hydrocarbon saturation of 76.3 7% and 76.31% with a corresponding increase in the water saturation across well X2 and X11 respectively and its oil movability index at each well is 0.3137 and 0.3148 which implies the hydrocarbon content were movable during invasion since it is less than 0.7(if OM (<0.7, for sandstone.

Reservoir 5: This is the fifth reservoir within the interval of interest, it occurs at depth interval of 41 89.9m to 4326.79m only at well X2. Its thickness is thus 136.89m in well X2 having net to gross of 88.12% at well X2

Faults and horizons mapping result: The mapped horizons corresponds to the tops of the identified reservoirs and the fault expression f these horizons shows series of listric faults cutting through it which depicts the structural pattern of the Niger Delta. Visual display of mimes, crosslines and time slice in various attribute shown in figure 1 and fig 2 respectively.

Depth structure map: Closed high on the depth maps and closure of contours against fault are of great importance to recommending where to drill. The faults are trending from east to west .

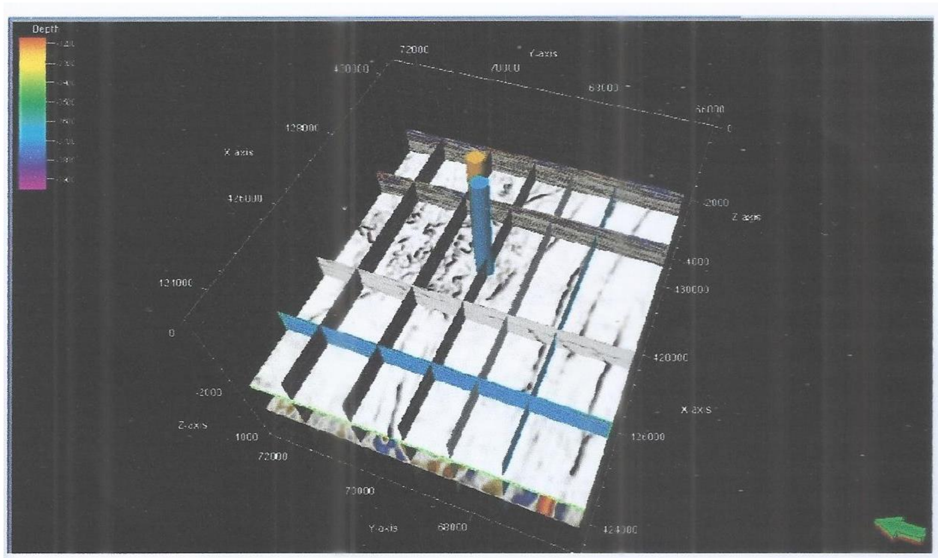

Figure 1: Arbitrary inlines, crosslines and time slice in various attribute view

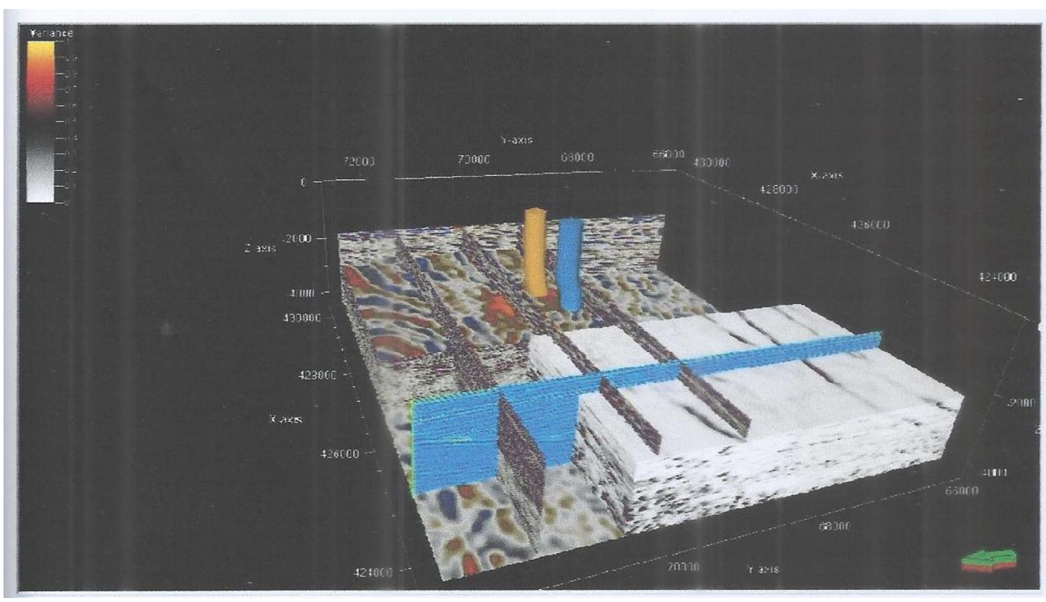

Figure 2: Arbitrary inlines, crosslines and time slice with 3D volume display

(B) SEISMIC INTERPRETATION AND MODELING:

From the generated depth structure maps for all the horizons of interest, closed high on the depth maps and closure of contours against fault are of great importance to recommending where to drill.

The results of both the structural model and the stratigraphic model revealed that there are five major faults dividing the held into six compartments and are of varying internal stratigraphic geometry which will have considerable influence on the transmissivity of fluid during production. The interpretation of the set of faults running through the reservoir will have considerable impact on its production characteristics, and in particular on the most appropriate plans for its development. Given an equal volume of hydrocarbons in place, the number of wells that will be required will be higher for reservoirs characterized by faults which isolate independent or partially independent blocks from the point of view of fluid content.

RESERVOIRS	BULK VOLUME (MMSCF)	NET VOLUME (MMSCF	HCPV	STOIIP (MMSTB)	GIIP (BSCF)	RECOVERABLE OIL (MMSTB)	RECOVERABLE GAS (BEEF)
1	25	22	0	0	156732	0	153597
2	643	538	91	76	0	30	0
3	1143	1114	179	149	0	60	0
4	594	539	89	74	0	30	0
5	1750	1543	149	124	0	50	0
Total	4155	3756	508	423	156732	170	153597

Table 3: Result of Reservoirs volumetric

Also the result of the lithologic model and the petrophysical model shows facies variation and petrophysical parameters variation across the different horizons of interest away from well control

CONCLUSION

In this study, the results from the well log interpretation indicate a lithologic sequence of the intercalation of sand and shale which depicts the stratigraphic sequence of the Niger Delta.

Also, the fundamental petrophysical parameters of interest (Net to Gross, Porosity, Permeability, Water saturation etc.) spans within a highly prospective range for well X11. The integration of seismic data with well logs was successful in defining the subsurface geometry, stratigraphy and hydrocarbon trapping potential of the field The technique proved to be useful in structural and stratigraphic mapping and in predicting lateral and vertical variations in the lithologic unit' reasonably. Hydrocarbon prospect areas were delineated in the structured maps produced. The growth faults may have acts as migratory paths for hydrocarbon from the underlying Akata formation. Thus, it is necessary to integrate all exploration and evaluation tools so as to effectively explore the study area and optimize well locations.

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