

Three-Dimensional Modelling and Volumetric Analysis Using Seismic and Well Log Data at DINO Oil Field, Niger Delta Basin Nigeria

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How to cite this paper: Ugbor, C. C., Umejuru, I., & Nwokocha, C. S. (2025). Three-Dimensional Modelling and Volumetric Analysis Using Seismic and Well Log Data at DINO Oil Field, Niger Delta Basin Nigeria. *Journal of Geoscience and Environment Protection*, 13, 106-124.
<https://doi.org/10.4236/gep.2025.133006>

Received: January 5, 2025

Accepted: March 10, 2025

Published: March 13, 2025

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Abstract

The paper explores the technique of three-dimensional modelling and volumetric analysis of reservoir sands in the DINO Field onshore Niger Delta, Nigeria to enhance reservoir production capability of a hydrocarbon field. Despite advances in the application of Seismic Data Interpretation, results from that alone fails to provide detailed and trusted volumetric assessment hence a method that integrates seismic data modeling is introduced to enhance reliance on the results. An interpretation and modeling approach that integrated seismic data and well data from four wells was employed. Results of the well-to-seismic tie revealed that there is good correspondence between the seismic and the well data in matching the reservoir geometry. From the wireline log signatures, some sand horizons were identified, among which the X-reservoir sand which was the hydrocarbon bearing sands. The gross thickness of the X-reservoir ranges from 71 m to 106 m. The X-reservoir model shows a major growth fault trending East-West and an antithetic fault trending Northwest-Southeast. The positions of the four wells are on the structural highs within the model. Compartments were delineated with additional well positions identified on the model to enhance hydrocarbon recovery. The oil water contact was at the depth of 3825 m on the footwall and 3835 m on the hanging wall due to the downward displacement caused by growth fault trending in East-West direction. Estimate of the volume of hydrocarbon in place revealed that X-reservoir has approximately 2 million Stock Tank Barrel of Oil.

Keywords

Three Dimensional, Modelling, Reservoir, Seismic Data, Volumetric, Hydrocarbon, Well Log Data

1. Introduction

Hydrocarbon exploration activity started in the year 1937 in Nigeria by a company now known as Shell Petroleum Development Company (SPDC). After many years of exploration, a commercially viable deposit of crude oil was discovered in 1957 at Oloibiri now in Bayelsa State (old Rivers State) in the Niger Delta. Shell began production and exporting from Olobiri Field in 1958 at the rate of 2000 bpd. Production has since increased from this humble beginning to over 2.5 million bpd. Export of crude oil now accounts for well over 94% of total Nigeria's foreign exchange earnings (Petroconsultants Inc., 1996).

All of the Niger Delta's depobelts have been found to have hydrocarbon accumulations in high-quality sandstone reservoirs that are part of the major deltaic/paralic sequence (Agbada Formation).

In the hanging-walls of growth faults, the majority of the bigger accumulations take place in roll-over anticlines, where they may become caught in fault closures or dips. A significant amount of unrelated gas has also been found. Reserves exceeding $80 \times 10^6 \text{ m}^3$ can be found in a number of sizable fields. The hydrocarbons are present in several pay sands with comparatively short columns and nearby fault blocks that typically accumulate independently. Amajor and Agbaire (1989) had described the depositional history of the reservoir sandstones of a typical oil field in the Niger Delta (Whiteman, 1982; Weber, 1986; Xiao & Suppe, 1992).

Since the majority of "easy" to produce petroleum assets have already been produced, it is become harder and harder to develop fresh petroleum resources in the Niger Delta. The oil sector needs to use more sophisticated recovery procedures or relocate to a harsher offshore environment in order to start up new production. Development costs are quite high in hostile environments like deep water; a single well might cost millions of dollars. As a result, significant investment choices frequently have to be based on data from remote sensing (seismic data) and early appraisal wells. Additionally, there are frequently few data accessible, and the ones that are come from a wide range of sources and cover a range of scales.

The goal of this research is to overcome the difficulty of precisely interpreting the structural and stratigraphic features of reservoir sands in the intricate but oil-rich Niger Delta by utilising the potential of combining 3D seismic data, reservoir modeling, and evaluation (Abiel et al., 2004). Folami et al. (2008) had identified hydrocarbon reservoir in the Niger Delta using seismic attribute modelling. Adiola & Jackson (2018) studied the depositional environment and reservoir Studies of Niger Delta. Similarly, Allen (1989) model for hydrocarbon migration and entrapment in the Niger Delta.

The quality of the data used and knowledge of the reservoir's lithology and host rock have an impact on how well a reservoir modelling tool is applied. Within the reservoir, faulted sandstone and a network of granulation seams may serve as permeability barriers. The granulation seams' actual permeability and their density inside the host rock will then determine the effect on bulk reservoir permeability (Serra, 2004). Therefore, when using the Petrel Work Flow Tool, it is crucial to

comprehend the environment in which the reservoir is located. An essential component of the input for the simulation and productivity estimation of the reservoir is figuring out its internal features.

The three-dimensional (3D) modeling and volumetric analysis in the context of reservoir characterization and hydrocarbon production has been a subject of significant research. Several studies have aimed to enhance the reliability of volumetric assessments by integrating seismic data with well data. Here, we summarize relevant literature that aligns with the aim and results of the research on the DINO Field in the Niger Delta, Nigeria. Some authors had evaluated the volume of hydrocarbon in place by employing Seismic data interpretation alone with limited successes and some had combined with petrophysical data modelling to enhance the result. [Knox & Omatsola \(1989\)](#) employed escalaror model in characterizing the reservoir of the Niger Delta. [Randen et al. \(2000\)](#) had Investigated 3D texture attributes for automated interpretation of seismic data and Introduced robust attributes (dip, azimuth, chaotic texture, and continuity) applicable to mapping gas chimneys, fault systems, salt domes, and stratigraphic features (e.g., carbonate reefs, sand channels). [Bacon et al. \(2003\)](#) in his book discussed the process and advantages of 3-D Seismic Interpretation: [Matos et al. \(2011\)](#) and [Field et al. \(2017\)](#) employed cluster analysis for channel delineation and chert reservoir characterization by employing 3D volumetric to identify stratigraphic features and enhance understanding of reservoir characteristics and volumetrics.

These studies collectively emphasize the importance of integrating seismic data modeling and well data to enhance volumetric reliability and reservoir understanding. The DINO Field research aligns with these principles, aiming to improve hydrocarbon reservoir production capabilities through advanced 3D modeling techniques. Hydrocarbon production can be increased at a low time and cost by precisely modelling field conditions before to making large capital investments ([Shannon & Naylon, 1995](#)). A precise and high-resolution geological model of the reservoir's structure and strata is necessary for hydrocarbon identification and extraction. Realistic geological models are also required in the oil industry as input to reservoir simulation programmes which predicts the movement of rocks under various hydrocarbon scenarios from which the best recovery option and most effective development plan for a particular field can be determined ([Harilal et al., 2009](#)). Had applied 3D visualization and spectral decomposition technique to map thin sandstone reservoir in the Niger Delta Basin. [Ugbor et al. \(2022\)](#) had investigated the influence of shale on the petrophysical properties of hydrocarbon bearing reservoir sands in the Niger Delta area. They concluded that cleaner reservoirs tend to hold more hydrocarbon volumes than dirty reservoirs that had been impregnated by impurities like shales. Defining a finer properties of the reservoir becomes very important if a precise evaluation of the reservoir potential is desired.

This research therefore, optimizes the geological, geophysical and engineering routines available within the Petrel software to perform an integrated study by providing an accurate static 3-D reservoir model of the gross internal constitution

and the volume of the hydrocarbon initially in place in the DINO field, Niger Delta, Nigeria.

2. Materials and Methods

2.1. Materials/Data

Digital suites of well logs, well headers, checkshot data, seismic data, and a base map of the study area are among the data used in this investigation. The interactive “Petrel” Work Station was used to import these data. The hydrocarbon reservoirs’ well-to-seismic connection was determined using the checkshot data, which was then shown on the seismic lines they intercepted. These reflections’ horizons were monitored on the field’s inlines and crosslines.

The identification of hydrocarbon-bearing reservoirs and computing of petrophysical parameters and delineation of fluid contacts were done by employing relevant wire line log signature. These logs includes: gamma ray log (identification of lithology), density and neutron log (delineating fluid contacts), resistivity and water saturation logs (identifying pore fluid type) and volume of shale log (porosity correction).

2.2. Methodology

Petrel software was selected to model the reservoir because to its Microsoft-standard user interface and window-based 3D visualisation tools. Within Petrel, a database was made specifically for this study that outlines the many pieces of data and information required to finish the research. After that, the different types of data were imported into the primary database of the Petrel software.

2.2.1. Data Import

Petrel has great visualisation capabilities, and a statistics report sheet is appended for every loaded object. The user can import data in a variety of formats using Petrel’s data import phase. As part of a very crucial routine, a quality check of the input data, was first completed. The input data were organized at an early stage as to make it easier to categorize the different data types as the project progresses. With the Petrel panes, folders and sub-folders were then created (Petrel Courseware, 2023).

The user can import data in a variety of formats using Petrel’s data import phase. An extremely crucial stage, a quality check of the input data, was completed. Excellent visualisation tools are included in Petrel, and a statistical report sheet is appended for every input entity. Early organisation of the incoming data made it simpler to classify the various data kinds as the project developed. Sub-folders and folders were then made using the Petrel panes.

2.2.2. Data Analysis

In this phase, the data is explored, quality controlled, and inputs for facets and petrophysical modelling are prepared. Facies thickness and percentage were thoroughly examined, and data transformation on continuous attributes was done.

Among the data analysis tools are the function and histogram windows to examine the distributions of characteristics and the relationships between them. The method of analysing discrete data involves creating a variogram as well as examining the facies thickness, percentage, and calibration between continuous properties (such as sampled seismic) within each zone. Continuous data analysis is used to create variograms and define data transformations.

2.2.3. Correlation

Using electric wireline logs, correlation involves the creation of geological patterns displayed by structural and stratigraphic units that are comparable in age, time, or stratigraphic position. It is the result of applying fundamental geological concepts, which comprise logging instruments and measurements, reservoir engineering principles, qualitative and quantitative log analysis, and solid understanding of depositional processes and the deposition environment. Composite logs were used to correlate stratigraphic units within the interval in the research region based on the depth range covered by the available data.

2.2.4. Fault Analysis

By modelling fault qualities based on grid permeability or directly generating fault transmissibility multipliers, fault analysis makes this possible. These can then either utilised as input for the simulation or as a straightforward visual evaluation of the sealing potential of the faults.

2.2.5. Reservoir Modelling

In general, reservoir modelling refers to methods for creating fictitious three-dimensional depictions of the observed and predicted properties of the identified subsurface reservoir. A model's dependability is determined by its number, quality, and dispersion, and data accuracy. Using a probability distribution, geostatistical or stochastic algorithms produce samples of data interpretation sequences. In order to replicate the value at a specific place, it entails interpolating between data measurements using a random draw from a cumulative data distribution function. Models of the detected sand-rich reservoirs and the distribution of their corresponding petrophysical parameters were constructed using Petrel's built-in geostatistical techniques.

2.2.6. Structural Modelling

This is the point where the fault and the structure surface meet. These polygons lines must have Z-values associated with the surface to which they belong in order to be used to construct Key Pillars. A single fault, not several, must be represented by the polygons.

2.2.7. Create Fault Polygons

This is the point where the fault and the structure surface meet. These polygons must have Z-values associated with the surface to which they belong in order to be used to construct Key Pillars. A single fault, not several faults, must be represented by the polygon lines.

2.2.8. Fault Modelling

Utilising Petrel workflow tools, this procedure was utilised to create a structural model by constructing listric and vertical faults utilising a range of fault data. The fault model can be defined in a number of ways. It is possible to create a fault model using fault polygons, interpreted seismic lines, imported fault sticks or structural maps. By using Key Pillars, which provide the framework of the 3D model—thus the name—the dip, azimuth, length, and shape determine the fault planes. It is a line with two, three, or five representative shape points that can be vertical, linear, listric, or curved.

Faults might be linear, listric, vertical, s-shaped, vertical truncated, reverse and branched connected faults. Every fault has to be defined by Key Pillars to be included in a 3D grid. Geometrically and structurally correct fault representations within the horizon were created using the fault modelling process. The model consists of about seven primary faults which were built using the Key Pillars: five for vertical and linear and two for listric.

2.2.9. Pillar Gridding

Creating uniformly spaced rectangular grid cells is the aim of the pillar gridding technique. The 3D framework into which the horizons would be subsequently integrated was created using the Pillar grid, a method of storing XYZ positions to represent a surface. The materials of the 3D grid cells are thought to be almost identical. As a result, every grid cell contains a single type of rock with the same porosity and water saturation values. Surfaces are not represented by the three skeleton grids that are produced. Rather, they depict the position of the Pillars at the top, middle and base levels.

2.2.10. Vertical Layering

The final stage of building the structural framework is determining the layers' thickness and orientation between the horizons of the 3D grid. Together with the pillars, these layers define the grid's cells which attributes were defined during property modelling; the layering process only fine-tunes the grid's resolution and is dependent on input data. The vertical resolution of the grid is defined by setting the cell thickness, defining a number of cells, or using a fraction code; the zone division can either follow the base or the top of the zone when defining the cell thickness.

2.2.11. Determining Fluid Contacts

The Volume Calculation Process phase is where volumes are most frequently computed. The Make Contact process step requires that any hydrocarbon contacts that will be utilised in the volume calculation procedure be pre-defined. Facilitating the utilisation of contacts inside a 3D grid is the goal of this procedure. Oil/gas, oil/water, oil up to, gas down to, and so on can be used to describe any kind of interaction. These connections may differ for every zone and segment and may be represented by a 2D grid (surface) or by continuous depth levels. The user can choose to use a single contact for all zones and segments, or separate contacts for

each zone, segment, and/or segment.

2.2.12. Volume Calculation

In this study, the volume calculation was performed after the property modeling. This volume is calculated in a 3D grid format in terms of the bulk, pore and fluid components. The purpose of this calculation is to determine the economic viability of the hydrocarbon field. In conjunction with uncertainty analysis, this helps to narrow down on the most valuable future reservoir exploration target. Once one of the model's principle horizons has been thoroughly interpreted, the initial volume computation can be carried out. Early on in the grid development process, simple scenarios can be tried to assess the relative significance of various possible interpretations or depth conversion. Early uncertainty analysis can help identify where resources should be allocated to obtain the most economical research.

2.3. Geological Framework

The Niger Delta basin of Nigeria is located between latitude 4°N-6°N and longitude 4°E-9°E and covers an area of about 105,000 sq·km (Avbovbo, 1978). The sediment thickness at the basin's centre is over 10 km (Kaplan et al., 1994; Doust & Omatsola, 1990). **Figure 1** is the location map of the Niger Delta area.

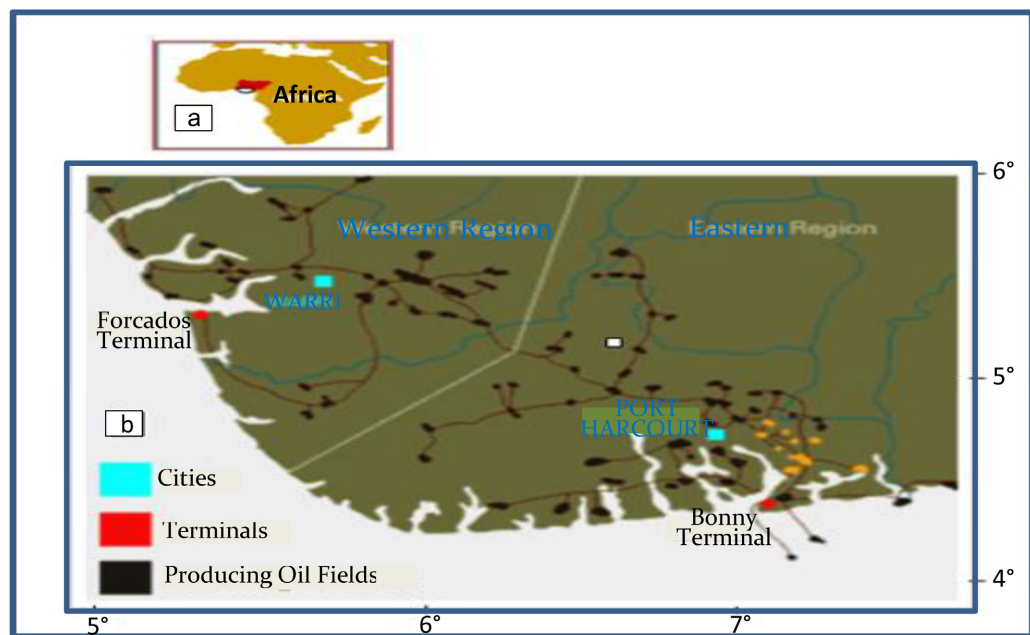


Figure 1. (a) Insert map of Africa; (b) Location map of the study area in Niger Delta.

Regional Stratigraphic Setting

The existence of three major lithostratigraphic subdivisions in the Niger Delta have been recognized from the study of well logs, biostratigraphic data and seismic section (Knox & Omatsola, 1989).

These units from descending order are mainly continental sandy deposits called

Benin Formation, regressive deposit of alternate sandstone and shale sequence called Agbada Formation and a transgressive phase deposits of exclusively marine shale called Akata Formation (Avbovbo, 1978; Burke et al., 1971; Bustin, 1988). The Petroleum System of the Niger Delta Basin is in a chart shown in Figure 2. The stratigraphic succession of Akata, Agbada and Benin Formations are clearly seen (Evamy et al., 1978).

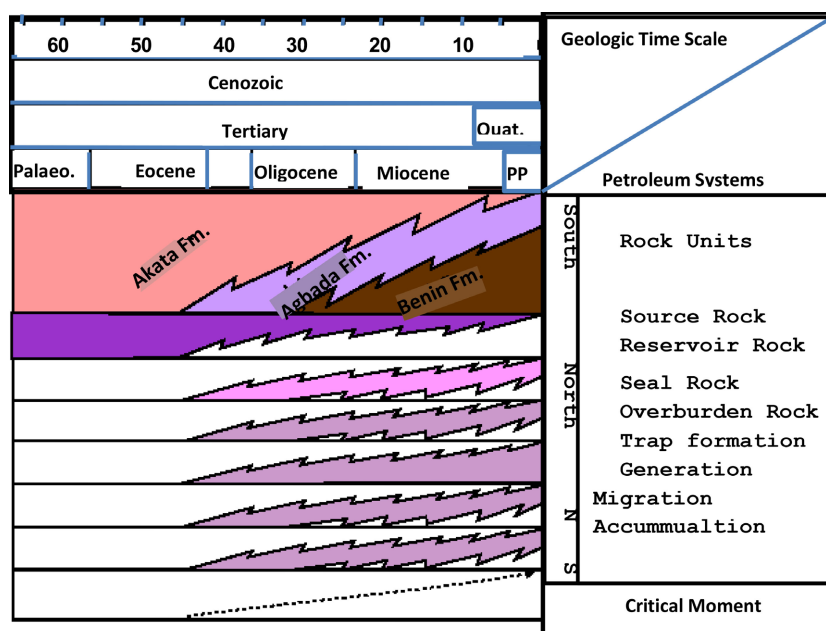


Figure 2. Events chart for the Niger Delta (Akata/Agbada) petroleum system.

3. Results

3.1. Logs and Seismic Characteristics

A log-correlation profile connecting the four wells (DINO 1, DINO 2, DINO 3 and DINO 4) across the area is shown in Figure 3. It shows the hydrocarbon bearing zones thinning progressively towards the basin. The gross reservoir thickness of DINO 1 is 106 m (3750 m to 3856 m), DINO 2 is 84 m (3826 m to 3910 m), DINO 3 is 100 m (3738 m to 3838 m) and DINO 4 is 71 m (3527 m to 3598 m). These intervals were clearly delineated as hydrocarbon bearing zones by high kick on the induction resistivity log (ILD). This distinguishes between hydrocarbon filled pores from water saturated pores in the reservoir sand. Table 1 shows the computed petrophysical parameters from X-Reservoir.

Well-to-seismic tie of X-reservoir well top from DINO 3 at the depth of 3738.25 m is shown in Figure 4(a). Figure 5 shows highly faulted structure such as synthetic, antithetic and growth faults and the associated rollover anticlines. The displacement resulting from the growth faults could cause some distortions on the correlation panel (El Moway & Marfurt, 2008). Faulting of sandstone layers created a juxtaposing of adjacent blocks thereby creating variations affecting the reservoir compartmentalization and development in the area. This created a dispar-

ity in the geometry of the adjacent blocks as seen in the hanging wall being thicker than the footwall. Fault sticks generated on the seismic time horizon. **Figure 6** shows normal faults trending in East-West directions and listric fault trending in NW-SE direction on the seismic surfaces. **Figure 7** shows the Modelled faults and 3D grid of X-reservoir showing Well positions within fault model.

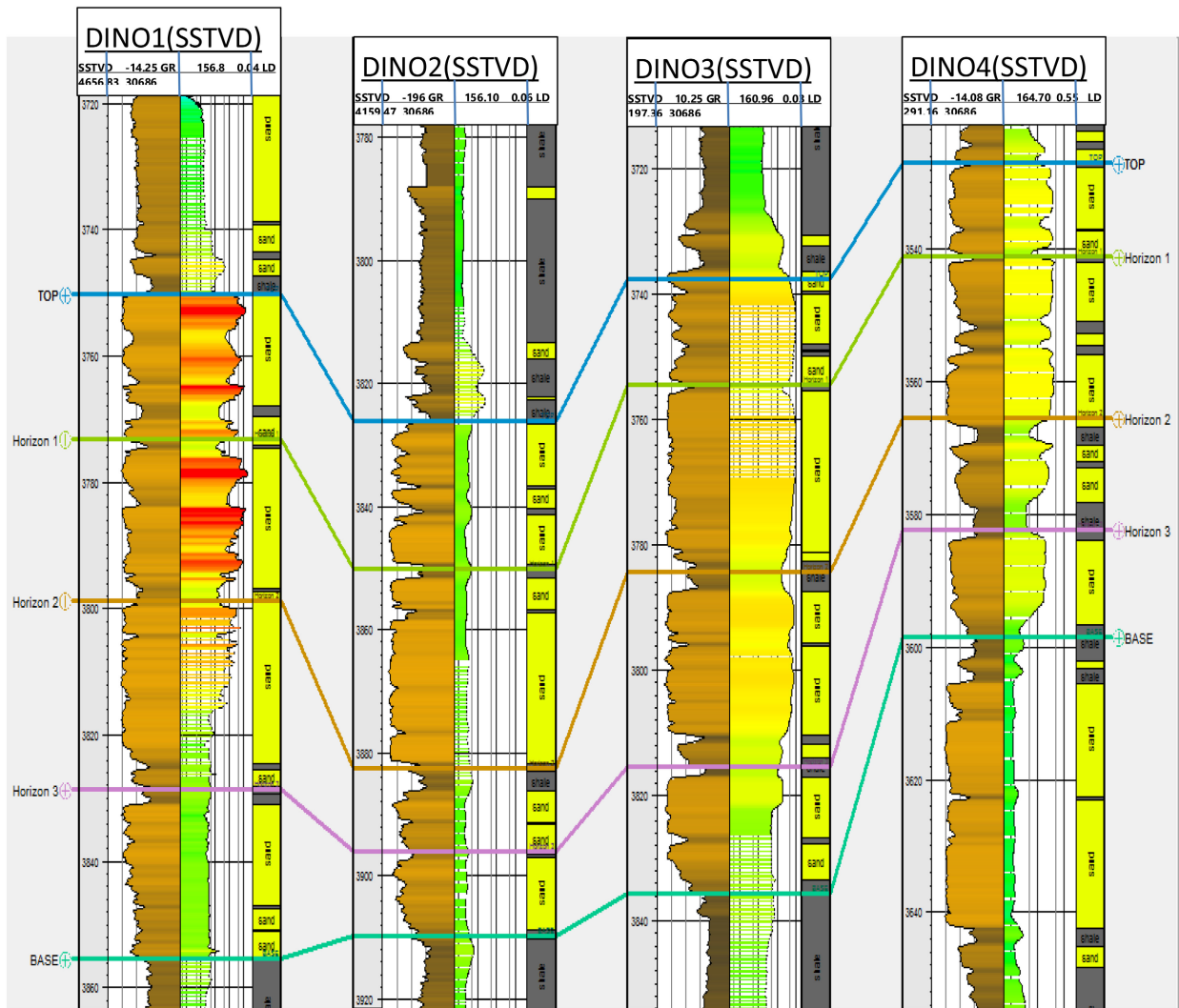
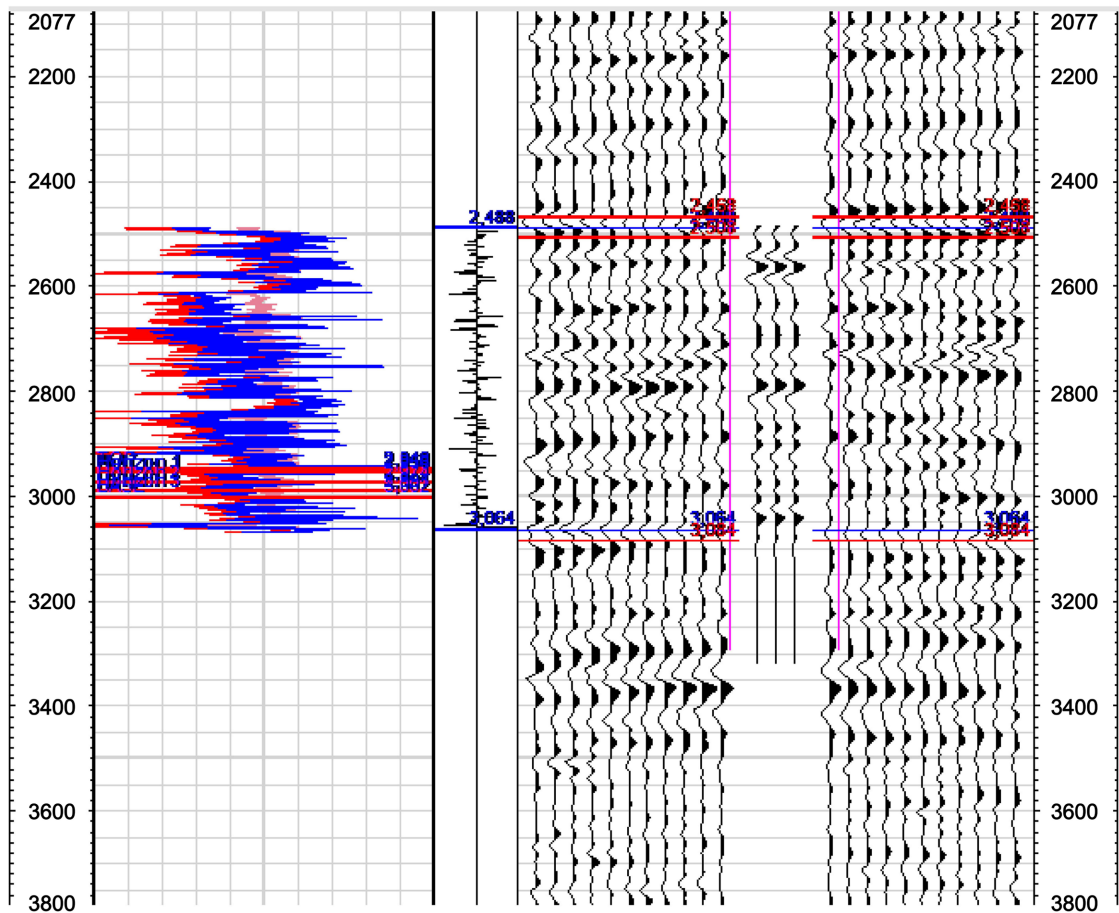


Figure 3. Log correlation profile connecting the four wells (DINO 1, DINO 2, DINO 3 and DINO 4) across the area, showing the pay sands and shale.

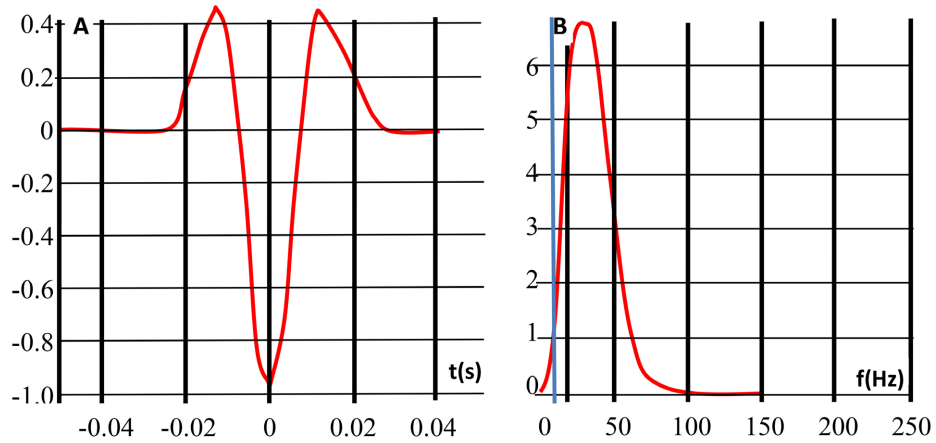
Table 1. Computed petrophysical parameters from X-Reservoir.

Well	Top (Md) (m)	Bottom (Md) (m)	Gross Thickness (m)	Net Thickness (m)	Net/Gross	Effective Porosity	Permeability	Water Saturation
DINO 1	3750	3856	106	77	0.73	0.24	1635.13	0.34
DINO 2	3826	3910	84	54	0.64	0.23	1546.15	0.34
DINO 3	3738	3838	100	50	0.50	0.19	1129.22	0.45
DINO 4	3527	3598	71	43	0.61	0.24	1679.21	0.37

Time SRD		Well: DINO3		Survey: Survey 1		ynthetic	Survey: Survey 1		Time SRD
ms		Log set: Log set 1		ic:DINOSEGY [Realize			ic:DINOSEGY [Realize		ms
2196	13405	Calc AI (kPa.s/m)		Inline	5702	5702	Inline	5702	
1.5	3	RHOB (g/cm3)		Xline	1648	1652	Xline	1657	
147	24	DT (us/ft)							



(a)



(b)

Figure 4. (a) Well-to seismic tie of X-Well Top from DINO 3; (b) Zero-phase wavelet of X-reservoir.

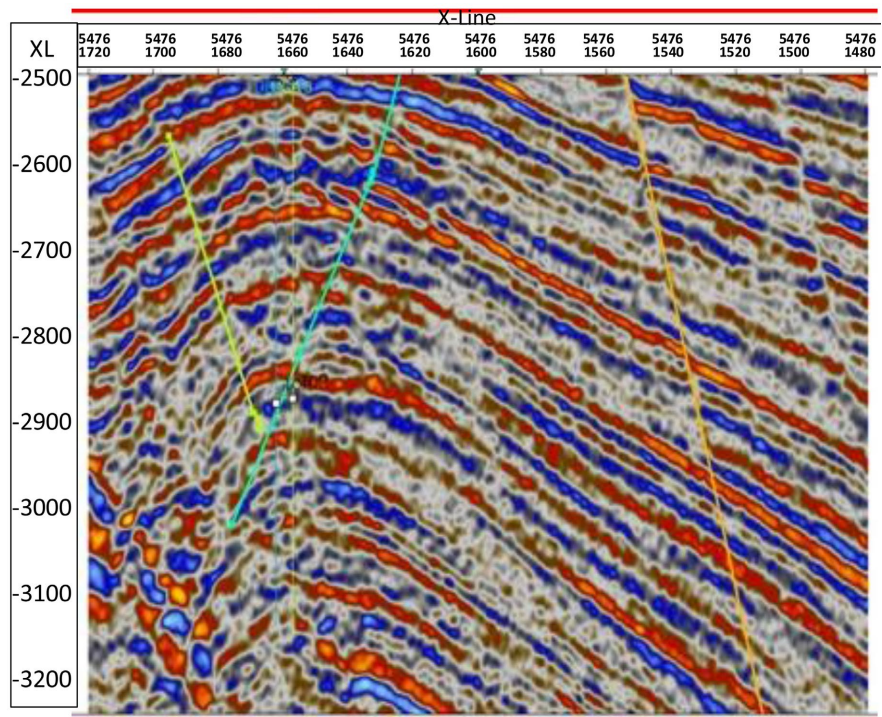


Figure 5. Fault interpretation on seismic section inline 5676.

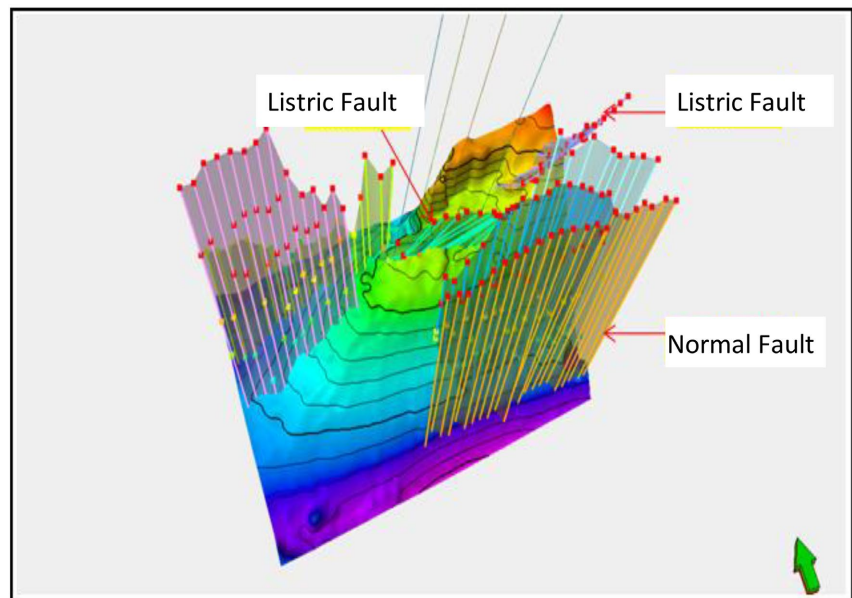


Figure 6. Interpreted faults and seismic surface in time in 3D window showing normal and listric faults forming X-reservoir anticlinal hydrocarbon traps.

3.2. Reservoir Models

The X-reservoir model is shown in **Figure 8** with a major growth fault trending East-West and an antithetic fault trending Northwest-Southeast. The positions of the four wells are on the structural highs within the model. The reservoir (**Figure 8(b)**) is separated into two blocks on the north (block a) and south (block b) with

relation to the East-West trending fault thereby compartmentalizing the reservoir. From this model, it is observed that at least one well can be drilled on block b (the foot wall) so as to increase the amount of hydrocarbon production. The reservoir was divided into four zones and several layers for better understanding of the distribution of its petrophysical properties and to correctly estimate the volume of hydrocarbon in place.

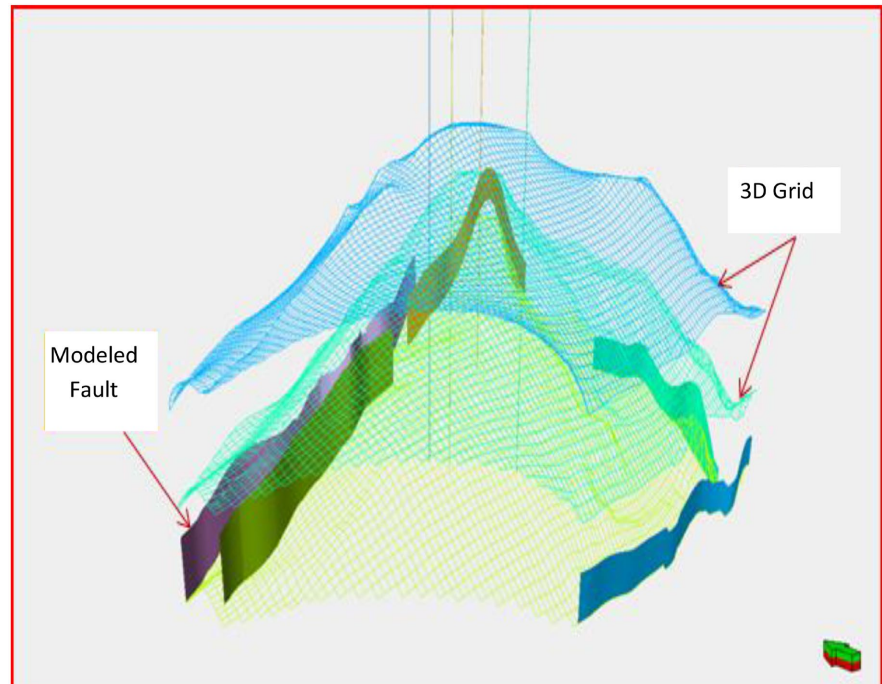
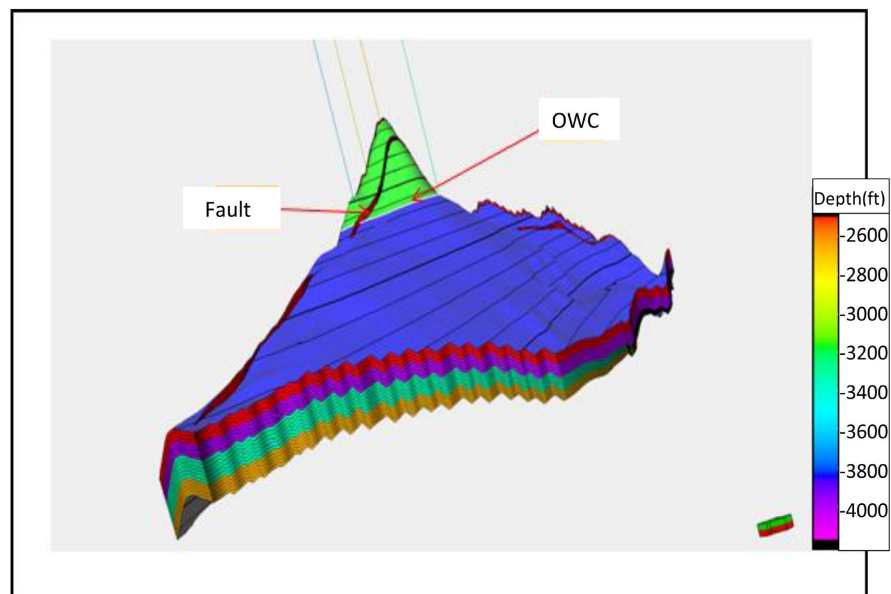


Figure 7. Modelled faults and 3D grid of X-reservoir showing Well positions within fault model.



(a)

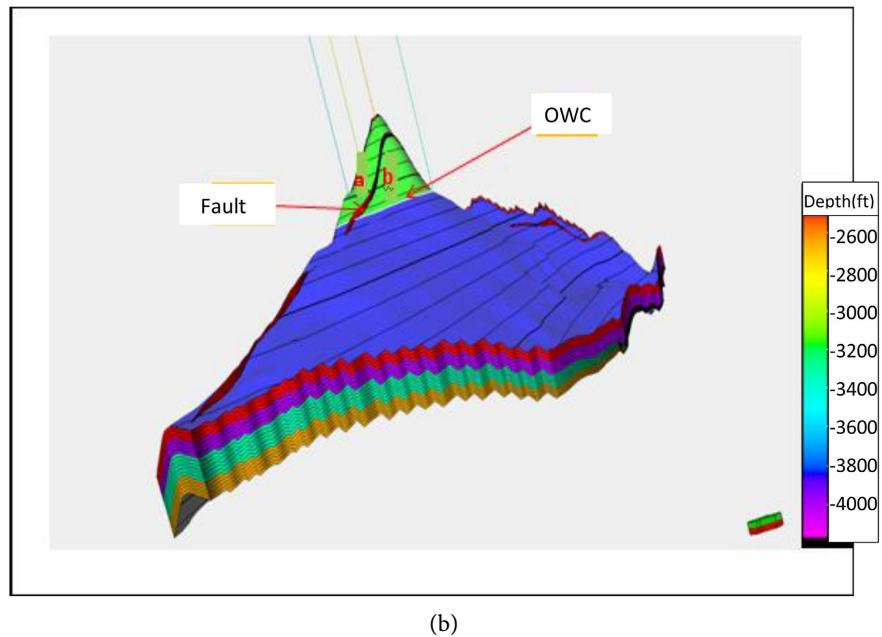


Figure 8. (a) X-reservoir model showing zones, layers and oil water contact [owc]; (b) X-reservoir model showing compartments (a) and (b).

The oil water contact at the depth of 3825 m is shown in **Figure 8** and **Figure 9**. Due to the growth fault trending in East-West direction, the depth to oil water contact is greater (i.e. about 3835 m) on the hanging wall (block a) due to downward displacement as can be clearly seen in the oil water contact map in **Figure 9**. This, if not carefully noted, could lead to wrong estimation of the depth of oil to water contact thereby constituting a major problem in hydrocarbon production.

The mean value for the upscaled log is 0.6497, showing that X-reservoir has the potential of a good reservoir.

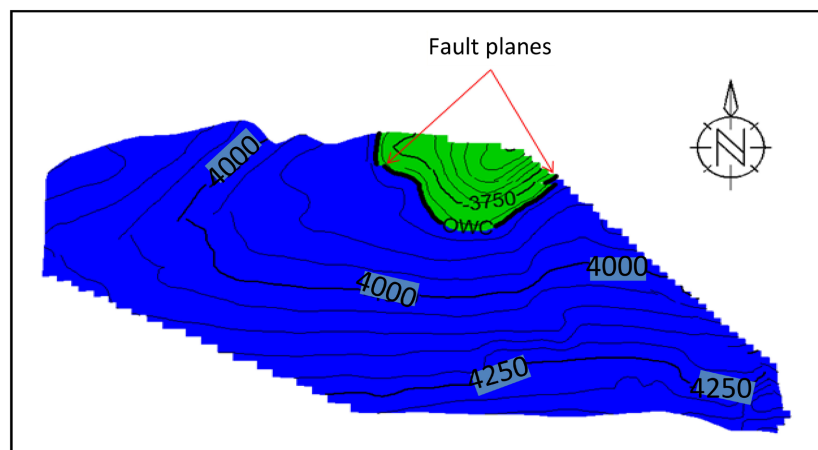


Figure 9. Map showing oil water contact [owc].

3.3. Volume Calculation

Oil volume and recovery prediction was carried out based on information from

the reliable well data available. To lower uncertainty in the volumetric estimation, more data was also taken from the seismic data and included into the geocellular model. The volume estimate of the X-reservoir, calculated using Petrel's Monte Carlo simulation, is displayed in **Figure 10** and **Table 2**. A number of equiprobable stochastic realisations were produced in order to quantitatively assess the volumetric uncertainty, and the upscaled reservoir values were used to compute each realization's OOIP (original oil in place). According to an estimate of the volume of hydrocarbons present, the X-reservoir has an estimated 2 million barrels of oil in stock tanks.

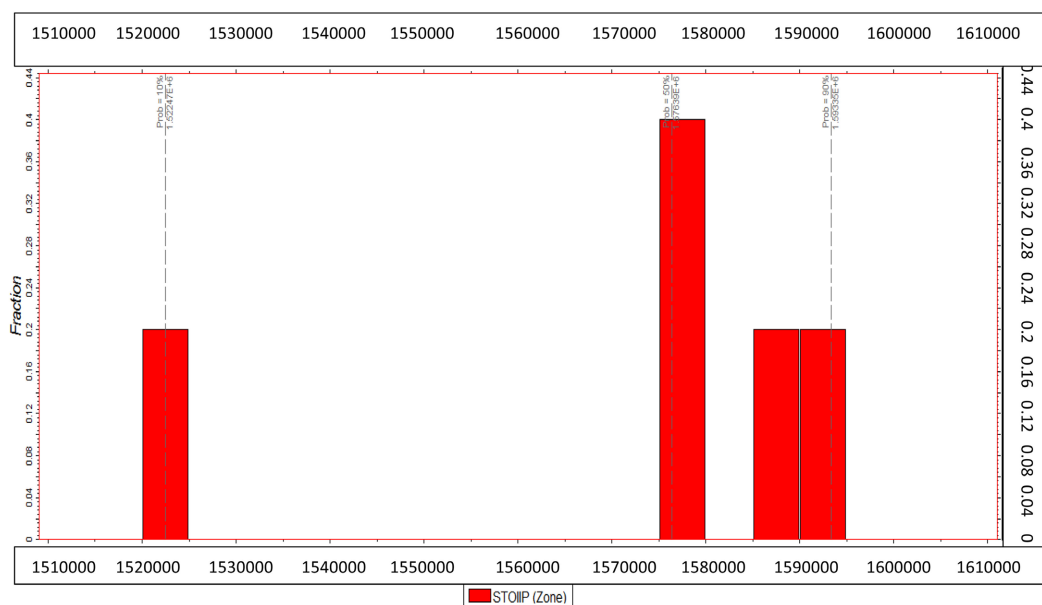


Figure 10. STOIP values of DINO reservoir with volume estimates (prob-10% = 1.52247E+6, prob-50% = 1.57639E+6 and prob-90% = 1.59335E+6).

Table 2. Volume calculation parameters using Monte Carlo simulation calculation in Petrel.

c Interval	Includes oil interval only	
Upper oil contact	OWC	
General Property		
Porosity	Poro.	
Net gross	Ntg	
Properties in gas interval		
Bg (Formation vol. factor)	1.0000	m ³ /sm ³
Rv (Vaporized oil/gas ratio)	0.0000	Sm ³ /sm ³
Recovery factor gas	1.0000	
Properties in oil interval		
Sat. water	Sw	
Sat. oil	1-Sg-sw	

Continued

Sat. gas	0.0000							
Bo (formation volume factor)	1144.0							
Rs (solution gas/oil ratio)	1.2080							
Recovery factor	1.0000							
Case	Bulk volume ($\times 10^6$ m ³)	Net volume ($\times 10^6$ m ³)	Pore volume ($\times 10^6$ m ³)	HCPV Oil ($\times 10^6$ m ³)	HCPV Gas ($\times 10^6$ m ³)	STOIIP (in oil) ($\times 10^6$ STB)	STOIIP (in gas) ($\times 10^6$ STB)	STOIIP ($\times 10^6$ STB)
Case 1	2844	1928	451	287	0	2	0	2
Totals (all results)								
Zone	653	444	104	65	0	0	0	0
Zone	832	582	139	89	0	0	0	0
Zone	751	586	115	73	0	0	0	0
Zone	607	396	92	59	0	0	0	0

4. Discussion

The integration of seismic data and well data in the three-dimensional modelling and volumetric analysis of the DINO Field in the Niger Delta has demonstrated significant benefits in improving the reliability and accuracy of hydrocarbon reservoir evaluations. The results obtained from this study align well with the aim of the research which highlights the importance of combining multiple data sources for a comprehensive reservoir characterization.

The success of the data Integration in this study aligns with the study by [Randen et al. \(2000\)](#) that emphasized the importance of using 3D texture attributes for seismic data interpretation. The DINO Field research aligns with this by employing robust attributes to enhance the reliability of volumetric assessments. Both studies highlight the necessity of integrating seismic data with well data to achieve a detailed and trusted volumetric assessment. The present study shows that the integration of well-to-seismic tie techniques significantly enhances the accuracy of matching reservoir geometry, addressing the limitations noted by previous authors.

On the reservoir characterization, the identification of the X-reservoir sand as the primary hydrocarbon-bearing formation, along with the determination of its gross thickness and structural features, aligns with the geological understanding of the Niger Delta's sandstone reservoirs described by [Matos et al. \(2011\)](#). The study's findings on the presence of growth faults and antithetic faults, as well as the positioning of wells on structural highs, corroborate the typical characteristics of hydrocarbon accumulations in the region as noted in the literature review.

The result of the volumetric analysis gave a volumetric estimation of approximately 2 million Stock Tank Barrels (STB) of oil in the X-reservoir as a critical outcome of the study. This result underscores the value of using integrated 3D modelling techniques to enhance the reliability of hydrocarbon volume calcula-

tions. It aligns with the conclusions drawn by Shannon and Naylon (1985), who emphasized the importance of precise volumetric assessments for making informed investment decisions in hydrocarbon production, particularly in challenging and costly environments like the Niger Delta.

The result of the analysis of the compartmentalization pattern of the fault in this study gave an improved identification of the structural compartments and possible locations for additional well positions to enhance hydrocarbon recovery. Thus is a significant contribution to optimizing production strategies. The detailed fault analysis, including the delineation of oil-water contacts influenced by growth faults, aligns with the prevailing understanding of the Niger Delta reservoir as comprising a complex structural and stratigraphic features. The findings are in line with the observations made by Schlumberger Information Solution (2005), which highlighted the importance of high-resolution geological models for effective hydrocarbon recovery and estimation.

The Implications of the above result for future studies shows that the method of this study which employed an integrated seismic and well data modelling not only aligns with historical and geological knowledge of the Niger Delta but also sets a precedent for future studies in similar environments. The successful application of the Petrel Work Flow Tool for reservoir simulation and productivity estimation demonstrates its potential in optimizing reservoir management and development strategies.

Future studies should continue to explore the integration of advanced geophysical and geological modelling techniques to further enhance the accuracy and reliability of hydrocarbon reservoir evaluations. The findings from this study can serve as a benchmark for improving hydrocarbon recovery and reducing uncertainties in reservoir characterization across the Niger Delta and other similar hydrocarbon-rich regions. By leveraging the strengths of both seismic and well data, researchers and industry professionals can achieve a more comprehensive understanding of subsurface formations, leading to more effective exploration and production strategies.

5. Conclusion

This research involves creating a 3D model of X-reservoir in the Niger Delta.

At various scales, well log and seismic data typically yielded trustworthy information. Overall, the stratigraphic and structural features in the area had impacted the hydrocarbon migration and accumulation in the area. While the sandstone continuity especially along the reservoir horizons across the wells show deep connectivity that allow for excellent communication of the fluids across the areas, the faults, especially the sealing ones had constituted baffles to the fluid flow. Consequently possible reservoir compartmentalization was inevitable. Fine-scale features, such the vertical distribution of lithofacies inside the wells, were identified using well log data, while relatively large-scale geologic features, like depositional facies, were identified using 3D seismic data. About 85% of the reservoir was com-

posed of pay sands, with shale intercalation, which is consistent with the Agbada Formation's geology in the Niger Delta. The X-reservoir porosity varied between 20% and 25%, permeability from 1.5 to 2 Darcys, consistent with Niger Delta values by previous research. This shows that the X-reservoir is very viable for hydrocarbon production. Essentially, only structural traps with associated fault seals by marine shales constitute the main trapping features in the study area. Compartments were delineated with possible additional well positions identified on the model as to enhance hydrocarbon recovery. The integration of the more geologic features to 3D seismic data during interpretation gave rise to a more robust and more representative volumetric estimation thereby reducing the uncertainty associated by the use of 3D seismic data alone. The volume of the hydrocarbon present yielded an estimated total of 2 million stock tank barrels of oil in the study area.

Acknowledgements

The assistance of the management of Agip Oil Nigeria Ltd for providing the data and facility used in this research.

Originality of Research

The authors hereby declare that the work presented in this paper is original and has not been presented for publication, either in part or whole by the authors to any other journal.

Conflicts of Interest

There is no potential conflict of interest was reported by the authors.

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