OPEN ACCESS Freely available online

Journal of Geology & Geophysics

Research Article

Integrated 3-D Reservoir Evaluation and Sequence/Seismic Stratigraphic Interpretation of "Topa" and "Obi" Fields, Niger Delta, South-South, Nigeria

Hilal Al -Zeidi[1], Hamdan Ali[1*], Obichukwu Paul Tochukwu[1], Njoku Ikechukwu[1], Onyekuru Samuel[1], Selemo Alexander[1], Nwigbo Ukamaka , Osung Wilson E[2], Osahon Usen[1]

[1]Department of Geology, Federal University of Technology Owerri, Imo State, Nigeria;[2]Department of Petroleum Engineering and Geosciences, PTI Effurun Delta State, Nigeria

ABSTRACT

The inter-fingering and complexity of the subsurface seismic-reflection configurations, motives and patterns in the 'obi' and "topa" fields, niger delta have no doubt indicated high possibilities of bypassed petroleum reserves within the fields. Integrated workflow is utilized in this research and aimed at unravelling the potentials as well as predicting the hydrocarbon availabilities in most of the bypassed reservoirs within "topa" and "obi" fields. The data used include: 3d seismic data; well data, and biostratigraphic data. This data set were applied in the study for reservoirs delineations and identifications encompassing structural fault interpretations, depth structural maps, direct hydrocarbon indicators, petrophysical evaluations, 3d reservoir modeling and seismic stratigraphic analysis. Also, amplitude extraction such as semblance volume, enhanced structural smoothing as well as root means square (rms) attributes were generated. The semblance volumes were used to ascertain both lateral and vertical extent of the structural geometries while the enhanced structural smoothing were used to accurately interpret the faults, the rms amplitude was used to interpret the seismic reflectivities such as the bright spots and the flat spots were there no direct hydrocarbon indicators. Also, petrophysicalevaluations were carried out and the results indicated good effective porosities in all the studied reservoirs with an average of 35% within net-to gross sand reservoirs of at least 75% average. The determined acoustic impedance log was spasmodically skewed with chronostratigraphic packages within genetic units. Results show that "obi" field has a more complex structure when compared to "topa" field. Seismic stratigraphy of "topa" field revealed a sub-parallel to slightly divergent reflection configuration indicating a possible increase in sediment deposition by virtue of the accommodation space created by earlier subsidence or faults. Topa field is mostly stratigraphically dependent with slide structural impacts. Two bright spots were observed in "obi" field suggesting the presence of hydrocarbon as well as having good lateral extensions with faults forming closures. However, "obi" and "topa" fields vary both stratigraphically and structurally as revealed with the aid of seismic attributes. A demonstration of typical accumulation of oil in one of the studied field is shown using obi c_6000 reservoir and this indicates 691 ft of oil column height, hydrodynamic oil drive of 85 ft water within a 776 ft vertical relief of the reservoir. However, these vary from one reservoir to another.

Keywords: Reservoirs; Fault; Hydrocarbon; Seismic amplitudes; Structure

INTRODUCTION

In view of the present global challenges particularly in the Niger Delta region of Nigeria, relating to the uncertainty of how producible and recoverable some bypassed reservoirs are; it is paramount to critically assess the petroleum accumulations from the perspective of applied integrated approach such as seismic/sequence stratigraphic studies, seismic interpretations of faults and horizons, petro physical evaluation studies, amplitude extractions and 3D static modeling of the reserves. Thus far, many workflows have been demonstrated by various researchers [1-4]. Such works flows and their findings are detailed in the literature review section of this piece of research work. There is every necessity deeming it fit to use an encompassing approach in order to reduce uncertainties

Correspondence to: Hamdan A, Department of Geology, Federal University of Technology Owerri, Imo State, Nigeria, Email: sabinusibeneme@futo.edu.ng

Received: January 23, 2021; **Accepted:** February 06, 2021; **Published:** February 14, 2021

Citation: Hamdan A, Tochukwu OP, Ikechukwu N, Samuel O, Alexander S, Ukamaka N, et al. (2021) Integrated 3-D Reservoir Evaluation And Sequence/Seismic Stratigraphic Interpretation Of "Topa" And "Obi" Fields, Niger Delta, South-South, Nigeria. J Geol Geophys. S2:003.

and as well to improve the confidence of risking and investing in the Nigerian oil sector for the betterment of our economy.

It is of importance to realize that a sustainable economy requires the best of qualitative research input to trigger a better output that will enhance the growth of the country's GDP. Oil and gas is the lifeblood of the nation's revenues, economy and national survival. It accounts for about 40% of the Gross Domestic Product and 70% of government revenues [5,6].

At present, exploration and productions activities are shifting to the "offshore fields" but whereas "marginal onshore fields" are still producing till date. This could be opined from the immense struggle for the control of oil resources by the ruling class security challenges, high rate of crude theft, and sabotage in the country as many international oil companies including Shell and Chevron Corp are shifting their efforts as Africa's largest producer from land-based operations to offshore fields where these vices are lower [7,8].The increased security challenges also bring costs that are more than 40 percent higher, according to estimates from Nigeria's National oil company. Some also emanated from claims of inadequate proofs from previous research findings. Apart from security challenges, energy companies in Nigeria are refocusing on deep-water production" because of declining onshore reserves [9].

Hence, this piece of research work utilized integrated workflow in unraveling the certainties and potentials in the interpretations and predictions of hydrocarbon availabilities in most of the bypassed reservoirs within the Niger Delta fields. Two case studies were used in this piece of research work.

Objectives

To unravel the potentials as well as to predict hydrocarbon availabilities in most bypassed reservoirs within the study area using integrated approach which encompasses seismic interpretation, sequence/seismic stratigraphy, seismic amplitude extraction, seismic attributes analysis, petro physical evaluations and 3D static modeling workflows.

Location of the study area

The base maps of the two fields of study are shown in Figure 1. Both fields are located in the Niger Delta region of Nigeria. Southern part of Nigeria on Long. 4 -9°E and Lat 4 – 9°N. The "Obi" field is located in the coastal swamp depo- belt while the "Topa" field is located in the offshore depo-belt of the Niger delta [10,11]. Many wells have been drilled in the "Obi" field while 5 famer wells have so far been drilled in the "Topa" field. The locations of the fields may be related to both structural and stratigraphic in order to ascertain the hydrocarbon accumulations were studied.

Geology setting of the study area

The evolution of the delta is controlled by pre- and synsedimentary tectonics (Figure 2) as described. The base marine origin of the delta which is the Akata Formation is composed of thick shale sequences (potential source rock), turbidite sand (potential reservoirs in deep water), and minor amounts of clay and silt (Figure 3). Akata Formation is formed during the lowstands (when terrestrial organic matter and clays were transported to deep water by low energy and oxygen deficiency in the Paleocene- through the Recent [12,13]. The entire delta is underlain by this Formation, and is typically over-pressured. The Akata Formation is overlain by the major petroleum-bearing unit of the Eocene-Recent Agbada Formation which consists of paralicsiliciclastics. The clastics accumulated in delta-front, delta-topset, and fluvio-deltaic environments. Shale and sandstone beds were deposited in equal proportions in the lower Agbada Formation; however, the upper portion is mostly sand with only minor shale interbeds. The third, Benin Formation overlain the Agbada Formation is a continental, latest Eocene to Recent deposit of alluvial and upper coastal plain sands.

MATERIALS AND METHODS

Materials used for the study

- Check shot data
- Well data (gamma ray log, SP log, resistivity log, calliper log, neutron log density log, sonic log)
- Bio stratigraphic data (sequence boundaries and maximum flooding surfaces)
- Seismic data (3D) seismic volumes

Methodology

The checkshot data from the two fields were quality checked as (Q.C) to remove inconsistences in the data such as spikes and devoid of data at some intervals which were compensated with despiking and appropriate polynomiant equations. A typical of the check shot data is as shown in Table 1.

The check shot data were used for the initial display and overlay of the various well logs in the seismic volume before conducting the well to seismic tie.

The neutron logs were used to evaluate the different types of hydrocarbons in the sand reservoirs. Sonic logs were introduced in the wells to seismic relationship (i.e. well to seismic tie). These were used to calculate the interval velocities in the formations [14,15]. At different intervals, velocities were complemented with the densities of various rocks to determine the acoustic impedance of the various layers followed by the computations of the reflection coefficients. Synthetic seismograms were performed by the convolvement of the reflectivity functions and the extracted wavelet.

Sequence boundaries (SB's) and maximum flooding surfaces (MFS's) were used to designate the key surfaces.

These key surfaces were used to constrain the stratigraphic correlations chrono-stratigraphically (Table 2). Precisely in this study genetic stratigraphic correlations were used as the strata units are bounded at the tops and bases by maximum flooding surfaces representing time packages of different events.

The chronostratigraphic correlations were then used to identify the different reservoir levels and as a compared by the markers (MFS's).

The interpretations of 3D seismic data in both fields ("Obi" and "Topa") involved structural (faults) mapping and identification of the reservoir sands. Then, extraction of amplitude such as semblance volume and enhanced structural smoothing as well as root means square (RMS) attributes were generated (Table 3).The semblance volumes were used to ascertain both the lateral and vertical extent of the structural geometries while the enhanced structural smoothing were used to better mapped the faults in the two fields [16,17]. Furtherance to the interpretation, the RMS amplitude was used to interpret the seismic reflectivites such as the bright spots and the flat spots and their interpretative connotations.

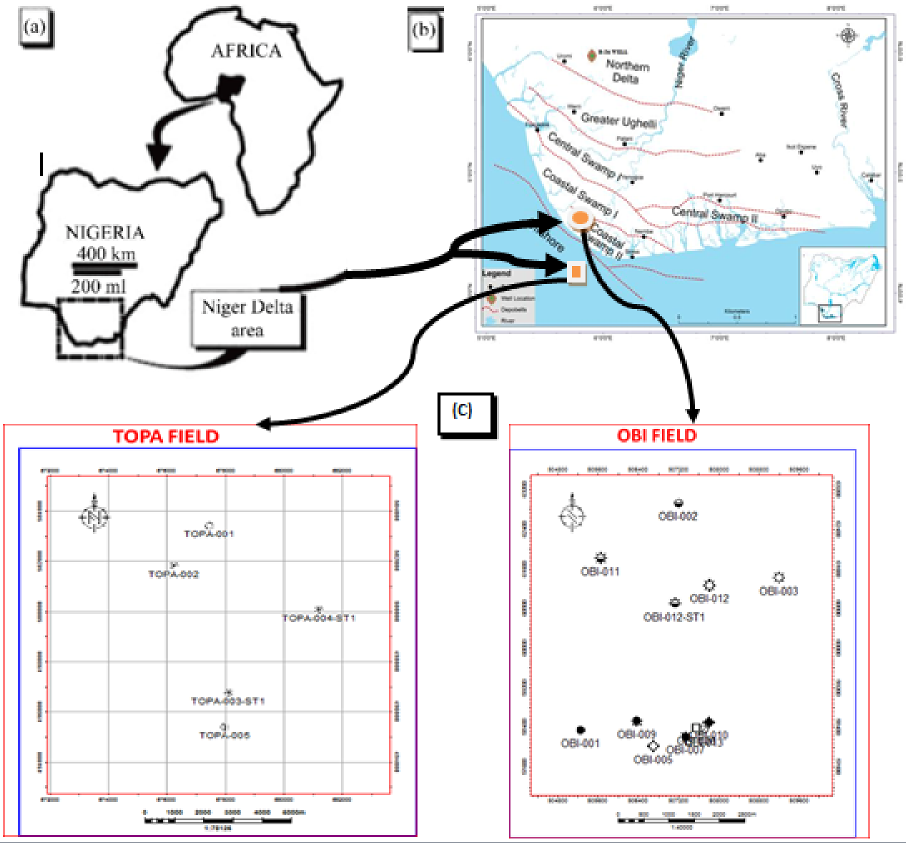

Figure 1: Map of Niger Delta depobelts showing the locations of topa and obi Fields.

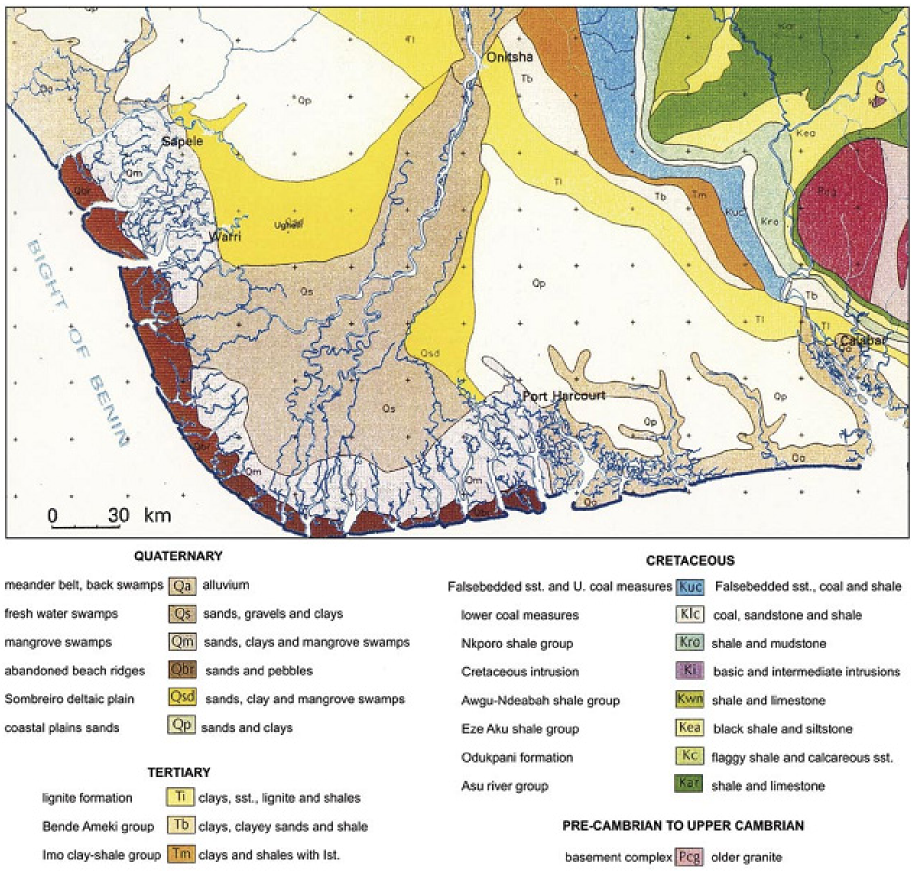

Figure 2: Geological map of the Niger Delta and surroundings.

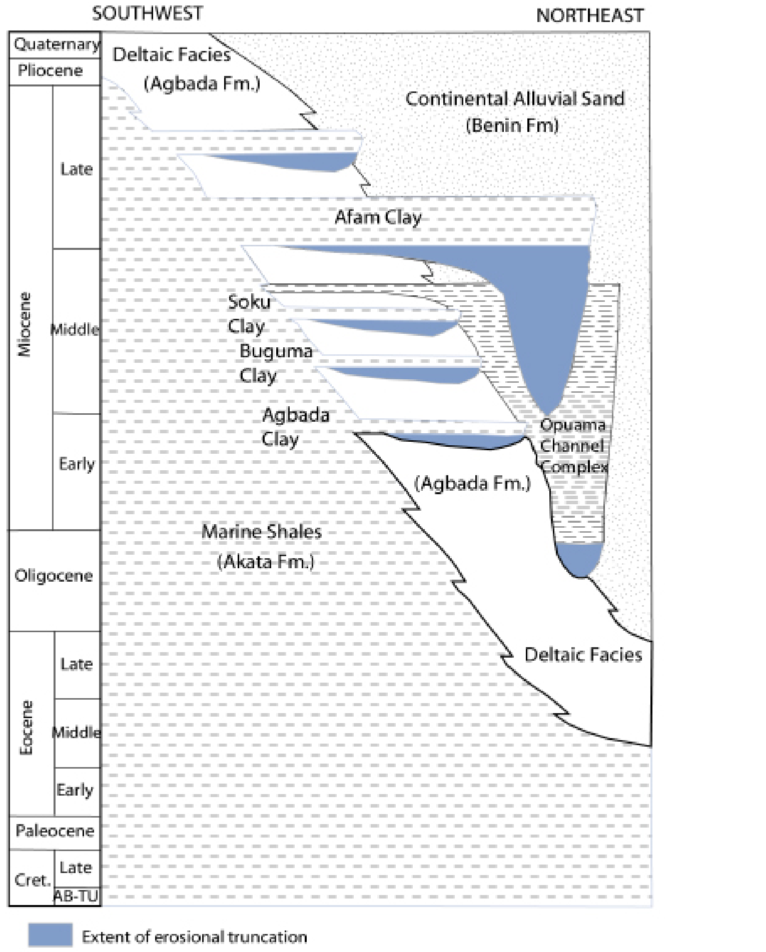

Figure 7. Stratigraphic column showing the three formations of the Niger Delta. Modified from Shannon and Naylor (1989) and Doust and Omatsola (1990).

Figure 1: Map of Niger Delta depobelts showing the locations of topa and obi Fields.

Table 1: Check shot data of "OBI" Well _1 and well_ 12.

Well Obi 1		Well 0bi_ 12							
MD (ft)	TI ME	MD (ft)	TIME	MD (ft)	TI ME	MD (ft)	TI ME	MD (ft)	TI ME
0	0	0		7283.8	1968.5	8324.2	2174.8	9270.9	2369.1
3998.8	1179.8	1945	586.8	7348.7	1982	8376.6	2184.6	9323.6	2379.8
5033.8	1456.2	6022 .3	1682.1	7412.3	1997.5	8429.3	2194.4	9376.2	2386.6
5593.8	1587	6101.2	1700.3	7474.S	2010.9	8481.9	2204	9428.9	2397.2
6153.8	1716	6180	1720.4	7535.7	2024.1	8534.S	2211.7	9481.6	2407.8
6803.8	1862.8	6258.S	1735.4	7596	2031.3	8587	2223.2	9521	2417.1
7173.8	1940.4	6336.8	1754.8	7655.8	2040.4	8639.3	2232.6	9573.7	2425.7
7653.8	2037.2	6414 .4	1766.9	7715.4	2051.4	8691.8	2244	9626.3	2436.2
8153.8	2138.6	6491.3	1779.1	7774	2062 .3	8744.4	2255.3	9679	2444.7
8653.8	2239.6	6567.5	1795.2	7831.5	2071.1	8797.1	2266.5	9731.7	2451.2
9233.8	2353.6	6717.4	1829.4	7887.7	2079.8	8849.7	2279.7		
9553.8	2414.6	6790.9	1847.5	7942.5	2088.4	8902.4	2294.7		
10053.8	2511.6	6863.8	1863.S	8009.7	2104.4	8955	2305.8		
10453.8	2581.4	6936.2	1879.5	8063	2114.7	9007.7	2316.8		
10903.8	2661.4	7008.1	1893.4	8115.6	2126.9	9060.3	2327.7		
11363.8	2743.2	7079.3	1917.3	8167.7	2139	9113	2336.7		
		7149	1937.1	8219.7	2153	9165.6	2345.6		
		7217.2	1952.8	8271.8	2164.9	9218.3	2356.4		

Table 2: Bio stratigraphic data of "Obi" Field.

WELL IDENTIFIER	SURFACE	X	Y	Z	MD	TWT AUTO
OBI-001	MFS_9.5Ma	505309.3	58312.35	-8126.03	8175.27	2276.09
OBI-001	SB1	505307.5	58311.27	-8339.61	8388.87	2321.25
OBI-001	MFS_10.4Ma	505268.8	58372.54	-10967.8	11018.52	2817.61
OBI-002	MFS_9.5Ma	506971.2	59518.99	-8090.6	8923.09	1205.93
OBI-002	MFS_10.4Ma	507130.3	61492.9	-10556.2	12087.81	1705.56
OBI-003	MFS_9.5Ma	508652.3	59428.4	-8431.97	9552.82	703.84
OBI-003	SB1	508678.3	59576.01	-8616.7	9790.72	744.85
OBI-003	MFS_10.4Ma	509134.8	61291.73	-10813.1	12624.02	1170.4
OBI-005	MFS_9.5Ma	506776.8	58045.76	-8113.47	8161.6	
OBI-005	SB1	506766.7	58044.89	-8322.29	8370.67	
OBI-006	MFS_9.5Ma	507633.5	58410.89	-8060.11	8109.64	
OBI-007	MFS_9.5Ma	507338.4	58177.39	-8530.11	8585.26	
OBI-009	MFS_9.5Ma	506375.9	58552.49	-8380.28	8428.43	1656.96
OBI-012	MFS_9.5Ma	507324.3	60354.34	-8349.78	9124.1	
OBI-012-ST1	MFS_9.5Ma	506038.3	58754.75	-7781.87	8107.36	1637.1

Table 3: Biostratigraphy data used for "Topa" field.

Well Identifier	Surface	X	Y	Z	MD	TWT AUTO
TOPA-001	MFS 5Ma	677281.1	503187.2	-6441.7	6521.17	5510.16
TOPA-001	MFS 6.0Ma	677279.4	503188.8	-7162	7241.52	5726.33
TOPA-001	MFS 7.4Ma	677278.8	503190.7	-7709	7788.56	5884.75
TOPA-001	SB 1	677278.3	503192.1	-7998.29	8077.89	5964.91
TOPA-001	MFS 9.5Ma	677278	503194.2	-8397.4	8477.06	6076.01
TOPA-001	MFS 11.5	677276.9	503197.2	-8775.6	8855.41	6180.32
TOPA-001	SB	677275.6	503202.2	-9213.14	9293.28	6288.57
TOPA-001	MFS 15.0	677274	503208.2	-9592.13	9672.83	6386.08
TOPA-001	MFS 17.4	677267.4	503223.4	-10616.8	10698.99	6628.06
TOPA-002	MFS 5Ma	676242.9	501805.8	-6188.67	6270.42	5787.78
TOPA-002	MFS 6.0Ma	676243.6	501806.6	-6921.59	7003.35	6340.49
TOPA-002	MFS 7.4Ma	676243.1	501806.6	-7366.57	7448.34	6676.06
TOPA-002	MFS 9.5Ma	676243.5	501807.6	-8078.35	8160.13	7212.82
TOPA-002	MFS 11.5	676244.1	501809.3	-8523.45	8605.27	7548.48
TOPA-002	MFS 15.0	676244.4	501811.3	-9232.97	9314.82	8083.54
TOPA-002	MFS 17.4	676244.1	501822.9	-10491.2	10573.75	9032.36
TOPA-003-ST1	MFS 9.5Ma	678108.4	496798.9	-7331.37	7411.37	
TOPA-003-ST1	MFS 11.5	678108.4	496798.9	-7483.41	7563.41	
TOPA-003-ST1	MFS 15.0	678108.4	496798.9	-8488.19	8568.19	
TOPA-004-ST1	MFS 11.5	681190.9	500114	-8069.53	8149.53	
TOPA-004-ST1	SB	681190.9	500114	-8629.21	8709.21	
TOPA-004-ST1	MFS 15.0	681190.9	500114	-8968.55	9048.55	
TOPA-004-ST1	MFS 17.4	681190.9	500114	-10303.9	10383.86	
TOPA-005	MFS 9.5Ma	678178.7	494801.6	-7130.85	7249.61	5791.46
TOPA-005	MFS 11.5	678161.3	494837.6	-7337.98	7494.65	5850.38
TOPA-005	MFS 15.0	678073.5	495021.6	-8349.37	8707.6	6122.62
TOPA-005	MFS 17.4	677981.1	495320.5	-9982.15	10640.02	6536.94

However, where the seismic reflectors are pronounced and significant enough to denote possible hydrocarbon occurrence, the seismic volume was directly used at such instances to defined reflectors.

Then, the assessment of the bright spots and flat spots were integrated in the interpreted depth maps to better define the hydrocarbon occurrences.

RESULTS AND DISCUSSION

Correlation transect line of the study fields

The stratigraphic relationships and correlations of both fields were carried our using the open–ends correlation transects lines as shown in Figure 4. The proximity of the drilled wells played a major role by first correlating wells that are drilled closer to each other. However, structural connotations as may be found in the course of the stratigraphic correlations were taken into consideration to complement the seismic data. It is paramount to note that detailed stratigraphic correlation is easier in "Obi" field because of the numerous wells drilled in the field though; the understanding of the stratigraphy requires additional knowledge of the structural implications as the "Obi" field is complexly faulted compared with the "Topa" field.

Semblance map

The Time slice at 2252Ms shows that "Obi" field is complexly faulted and structurally dependent with varying throws (Figure 5) however, "Topa" field is strati graphically influenced having northeast-southwest trending tributaries with minor channels trending. These however indicate that shoreline migrations and fluctuations of the two fields have entirely different geologies with different reservoir types and as such care must be taken to study each. Apart from the structure geometries of the fields, indicates why facies may vary in a particular reservoir in both fields. However, the obi field witnessed different regimes of faults and as such may show evidences of missing sections and short sections due to Faulted Out (FO) and Fault Cut (FC) or partly faulted.

Well to seismic ties for topa and obi fields

Considering the completeness of the well and the depth of penetration, the well to seismic tie was carried out using "Topa for "Topa" field. This involved convolving the reflectivity function i.e. the reflection coefficient and the extracted wavelet. The tie achieved a high correlation coefficient of over 65% and as such reliable for reservoir studies. The details of the acoustic impedance, reflection coefficient, extracted wavelet and complex match of the RC-1 with the wavelet are shown in Figure 6 and similar process was also carried out for the "Obi" field (Figure 7). Further interpretation then proceeded with seismic and the well logs in logs in both fields as the time and depth relationships have been established.

Stratigraphic correlation of "topa" field

The stratigraphic correlation of the "Topa" field is as shown in Figure 8. This shows that the stratigraphic distributions were ascertained chronostratigraphically within genetic packages. The different genetic units displayed the actual fluctuations of the shorelines as represented with their sequences resulting to different reservoir qualities. The hydrocarbon distributions were interpreted within the units using the resistivity logs, dentistry logs and neutron logs. The sequence descriptions were denoted with colour legends as insert (bottom right) of the Figure 8. The lateral distribution at a field – wide coverage was established by integrating the log scale interpretations in the seismic volume using the synthesis seismogram. At the seismic scale, different reflectivities of the attributes were used to compare the interpretations done at log scale.

Seismic stratigraphy of "topa" field

The seismic stratigraphy of "Topa" field inter-passed different depositional energies which transcended to diverse depositional environments. The shallower part of the field being the braided fluvialtile terrestrial Benin Formation clearly delineated its facies with sharp contrast variation where a major flooding surface delineated the base of Benin Formation. This however, fluctuated in depositional trends and energies which resulted to sub-parallel to slightly divergent reflection configuration (Figure 9) resulting to influx of sediment deposition by virtue of the accommodation space created by possibly earlier subsidence and the at deeper levels, the agbada facies were faults. This was also truncated, scooped and eroded at some points causing channel reservoirs within the retrogadational trends as correlative conformities of the earlier progradational barriers that were deposited. Deeper in the field, the depositional trends fluctuated within the holo-marine setting resulting to contorted reflection configuration.

Petrophysical evaluation of obi" field

The Petro physical evaluations were carried our using obi 001 in Figure 10. These were used to further understand the reservoir qualities as may be seen in the genetic stratigraphic correlation packages as well as the seismic attributes. These petro physical evaluations involved net-to-Gross (NTG), total porosity (PHIT), effective porosity (PHE), water saturation (SW), hydrocarbon situation (SH), permeability and volume of shale (VSH). A typical assessment of the above at various reservoirs levels are shown in Figure 11. The fluids as distributed in the reservoirs and the various reservoir motif types can now be looked at closely to understand why a particular type of reservoir may behave in a certain manner while studying their lateral stratigraphic distributions as may be seen in the correlations.

Stratigraphic correlation of the "obi" field

The "Obi" fields correlations were also chronostratigraphically constrained within genetic units (Figure 11). The points of maximum transgression and regressions are seen as maximum flooding surfaces (MFS's). These are clay-rich zones and fauna abundance zones, which delineates the marker shale's. The reservoir units and geometries of the motifs are defined within the fluctuations (rise and fall) of the shoreline and are represented in the correlations. The hydrocarbon bearing reservoirs varies within the same reservoir because of strata differences and as such explains the depoenviornment fluctuations within the field. Typical of the hydrocarbon bearing reservoir in this field is the Obi-C600. The thickness of the stratigraphic layers varies laterally with no significant pinched-out unit(s) here; most reservoirs are predominantly of the LST's. However, there exist TST and HST reservoirs.

Seismic stratigraphy reflection configuration of "obi" field

In "Obi" field, the sediments as can be interpreted in the refection configurations and patterns complemented by the faults are as follows: the sediment here (delta front facies) are constantly reworked by the influence of tidal, wave and fluvial actions causing different sub-depo environments. The most landward and being succeeded by fault episodes which created the accommodation space that favored southward basinal shift of the lithoral and sublithoral marine sediment depositional settings. These were shallower than the onset of the divergent reflection configurations (Figure 12) that re-directed and changed the depositional trends by the regimes of other faults causing more depositions in the northern part of the field and thicker reservoir units.

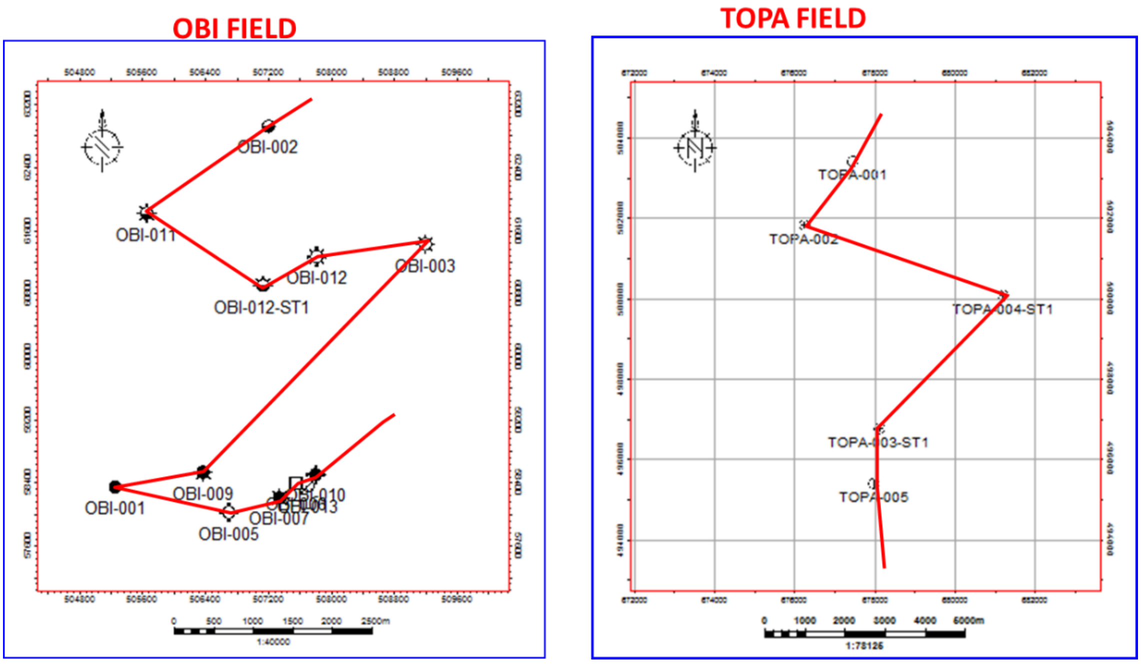

Figure 4: Correlation transect lines taken in the studied fields using open –ends method.

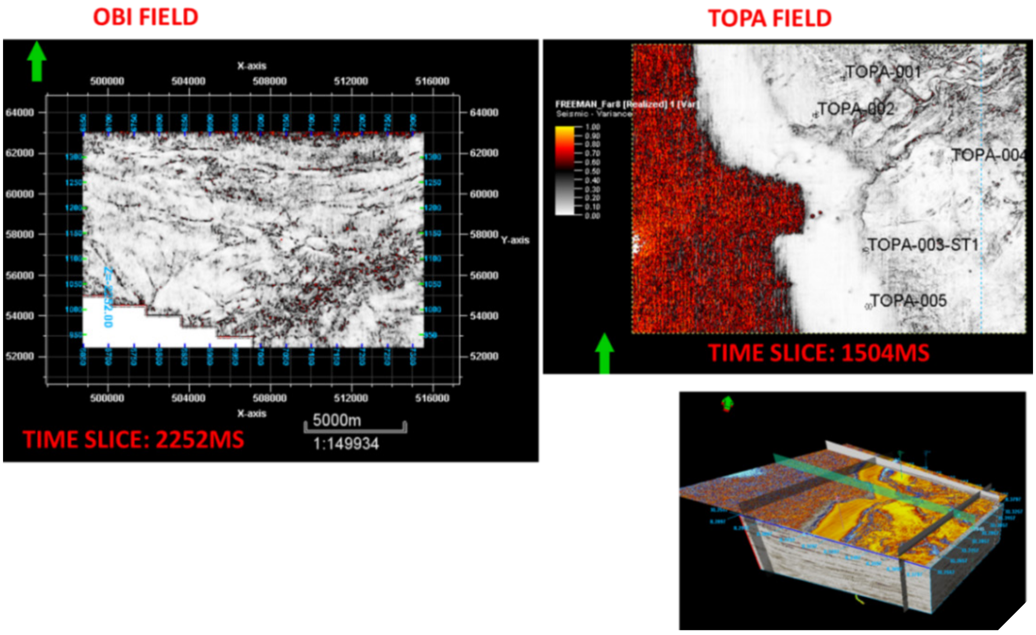

Figure 5: Semblance map extraction of obi &topa Fields at time slice 2252 milliseconds and 1504 milliseconds respectively.

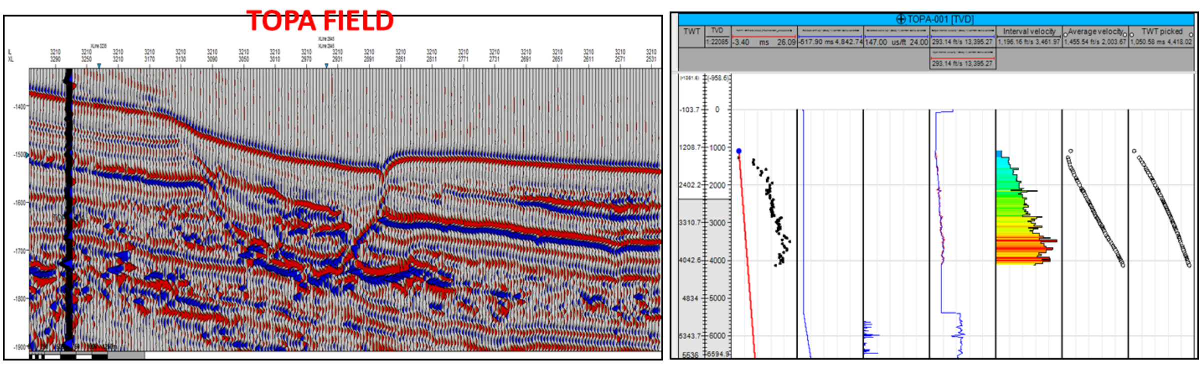

Figure 6: Typical well to seismic tie carried out in one of the study fields.

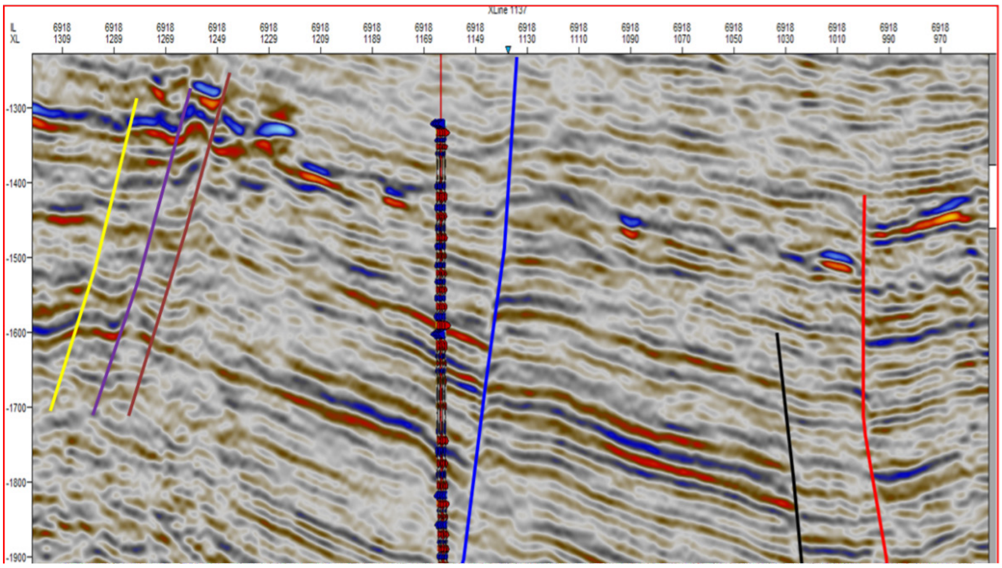

Figure 7: Typical well to seismic tie carried out in one of the study fields.

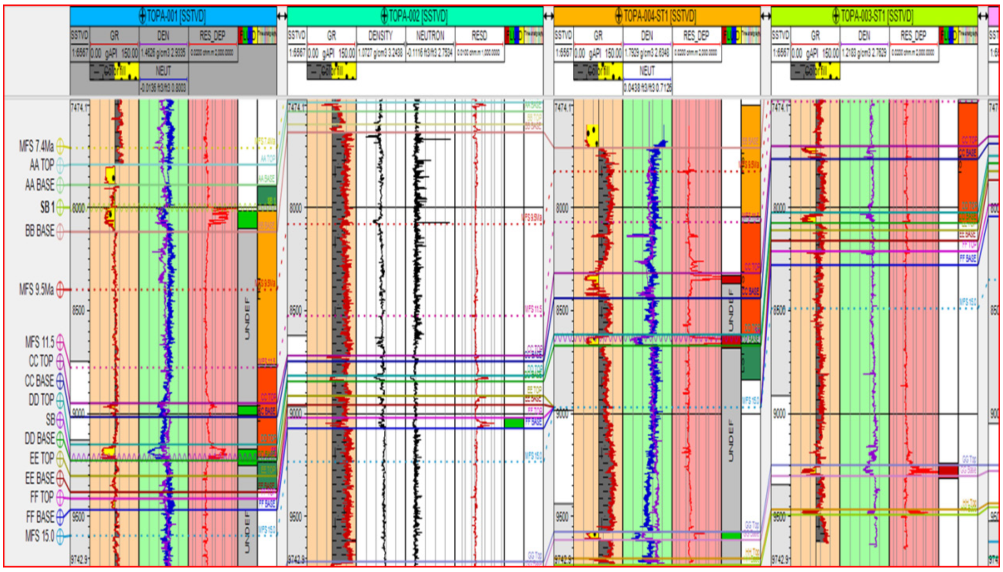

Figure 8: Stratigraphic correlation of "topa" field constrained within chronostratigraphic packages.

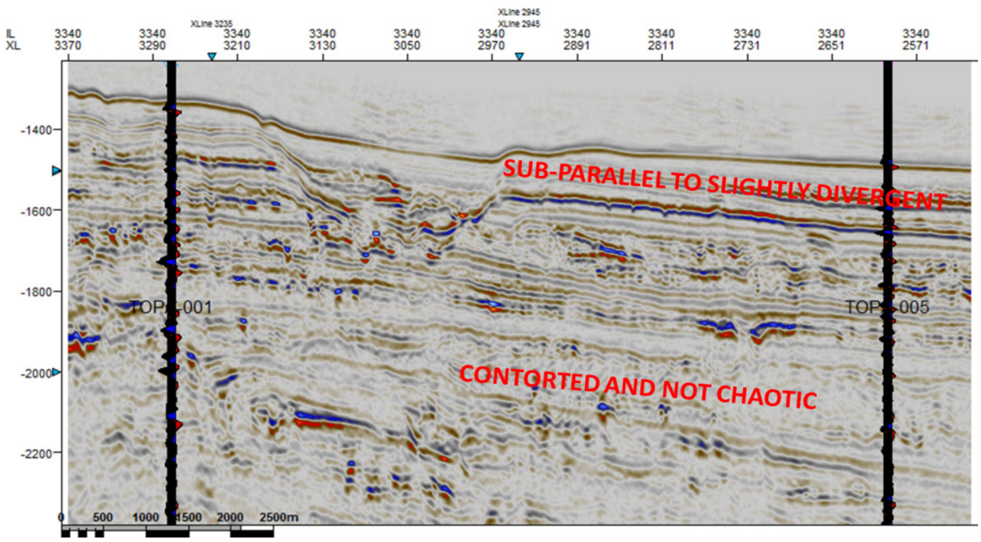

Figure 9: Seismic Stratigraphic reflection configuration of "topa" field showing diverse reflection patterns.

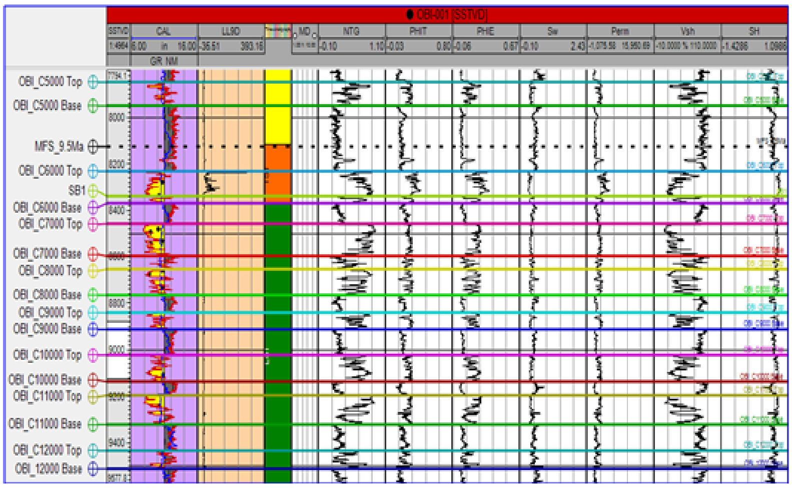

Figure 10: Typical petrophysical evaluation of the "obi" field using obi-001 well within chronostratigraphic package.

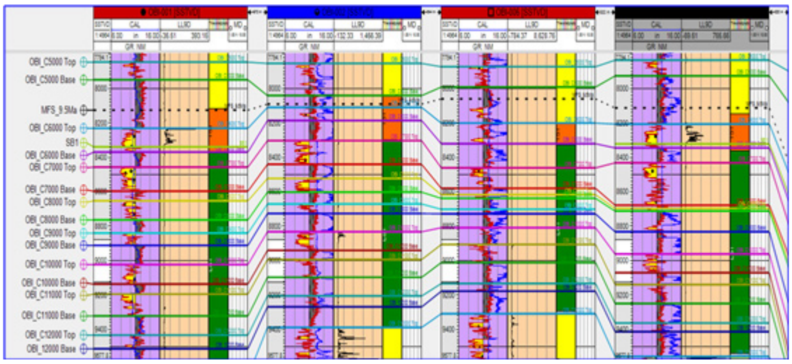

Figure 11: Typical petrophysical evaluation of the "obi" field using obi-001 well within chronostratigraphic package.

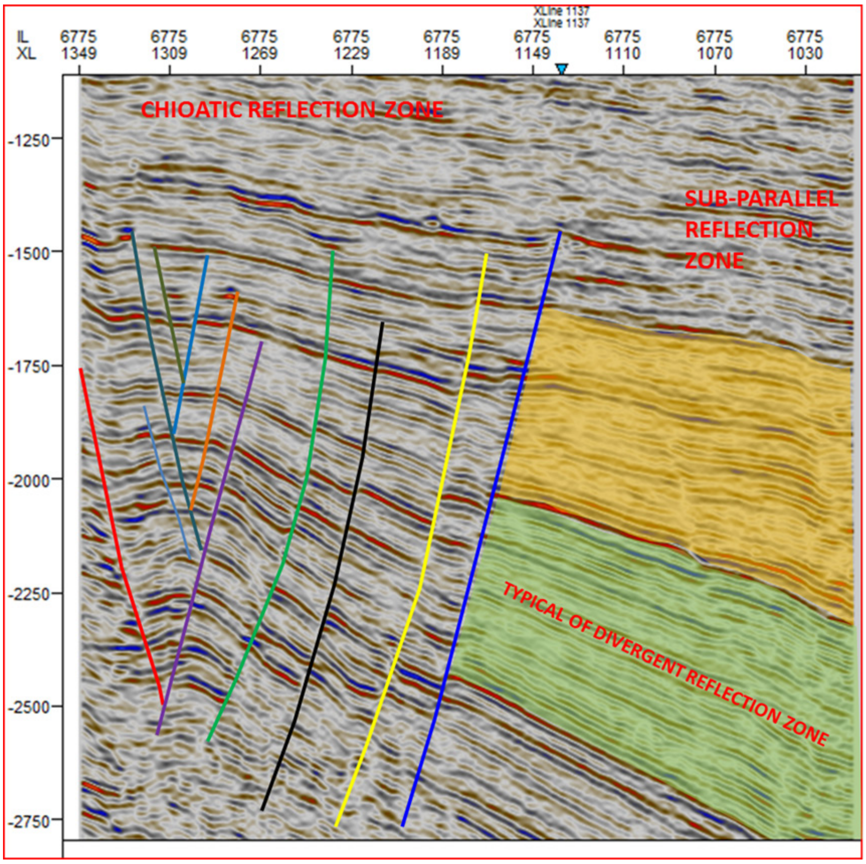

Figure 12: Seismic stratigraphic reflection configuration of "obi" field.

Amplitude extraction on "obi" field

RMS attribute reveals a flat spot in one of the reservoirs (Figure13). However, it is obvious that at this reservoir level, different fluids with different specific gravities occurred and as such will require the resistivity logs to be integrated with the density and neutron logs for proper delineations.

Also, two different bright spots occurred in Figures 14 and 15 and as such suggest likely hydrocarbon occurrences. Three different bright reflective observed in the 'obi' field and. The three different reflectivity's are structurally dependent, though may have some strati graphically influenced parts if looked at the map scale. Most importantly, how laterally extensive are these reservoirs? How are these bright reflectors (RMS) conforming to the reservoir closures at the map scale? These questions justifies why the accumulation may worth to pursue or not. However, a major input in the reserve estimation is the area of hydrocarbon accumulation at map scale and as such will determine if commercially or not commercially viable.

Typical of hydrocarbon occurrence in the "Obi" field interpreted as structurally dependent reservoir is as shown in Figure 15 using a deeper prospect. The structural style as indicated with the bright spot is a good example of roll-over anticline with accumulation within the hanging wall of the fault block.

Typical reservoir and hydrocarbon accumulation interpretation at map scale in "obi" field

It a typical interpreted depth map showing accumulation of oil and water is as shown in Figure 16. This however indicates the driving buoyancy mechanism of the water and the disparities of the specific gravities of these fluids as oil assumed the crestal part of the reservoir. A representation of the reservoir structural style and closure indicates that in reservoir Obi C_6000 has oil column height of 601 ft with a reservoir capacity of 776 ft while 81 ft is occupied by water towards the structural saddle spill point.

Interpretations of bright reflectors in "topa" field

Here, no amplitude extractions were done, in the sense that the bright reflectors are significant and prominent to be observed. The reasons being contrast variations as may be attributed to different compositions of the kerogen that formed the hydrocarbon.

A seismic pacing was carried out within the inclines on several points to ascertain the lateral continuously of the bright spot as well as any stratigraphic or structural connotations. However, the bright spot as interpreted in the seismic section is bounded by a fault (Figure 17).

The continuity of the same reservoir was achieved by tracking other in-lines and as such the reservoir covered a wide range of expanse. The extent of the reservoir coverage with evidences of the bright spot is shown in Figures 18 and 19.

3D Stratigraphic model of "topa" field

Different strata packages that have been discussed earlier using seismic stratigraphy were incorporated in a 3 D model using the Topa field as an example. The inlines and crosslines were represented as I and J directions of the model. These I and J directions were used to ascertain the inner geometry and configurations of the reservoir architecture as possible check for any truncations of the faults (which may be the bounding/sealing structure) as well as the lateral and vertical extent of the reservoir. Reservoir sands nomenclature at different depth levels were represented in the 3D model as C 6000 B 4000 and C13, 000.

A better view of how laterally continuous of these reservoirs can be observed. It is evident that stratal thinning and thickening towards any axis depends on the influence of the prevailed faults causing accommodation space, sediment supply rate and the infills of sediments in the created accommodation space. However, the outer geometry of the stratal thickness variation and the inner geometry (Figure 20) clearly explained variations in the accommodation space created by the faults and the vertical relief of the reservoirs regarding hydrocarbons accumulation as may be ascertained with the least structural closure and the culmination of the reservoir.

The anticlinal geometry of the reservoirs is shown in Figure 21. This however shows all possible interpreted reservoirs and clues to the possible hydrocarbon trend migration as buoyancy and hydro-dynamic forces are considered. The interpreted overlying shales are considered as possible overlying seals. It is imperative to recall that in the internal geometries fluctuated and may cause missing stratigraphy by virtue of limited lateral extent and fluctuations of lithofacies and depofacies characteristics.

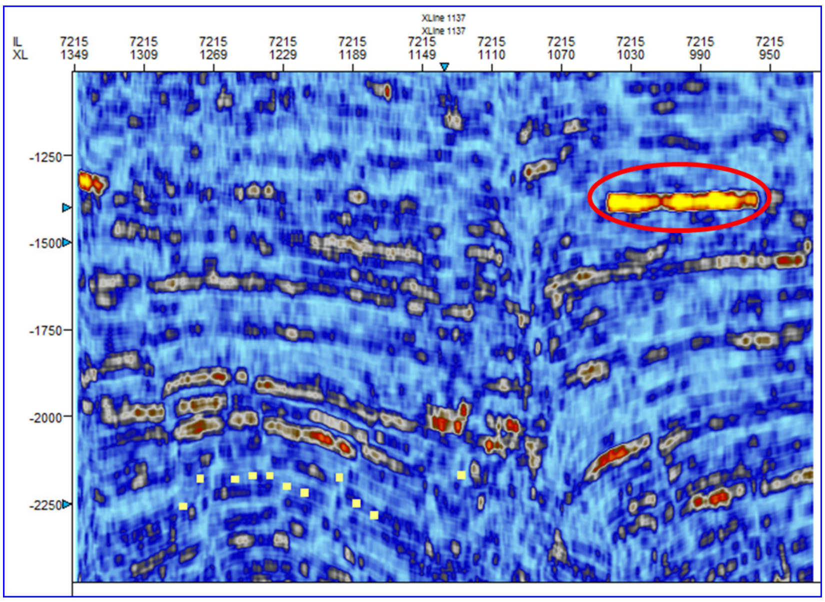

Figure 13: Typical interpreted flat spot in "obi" field using rms amplitude at inline 7215.

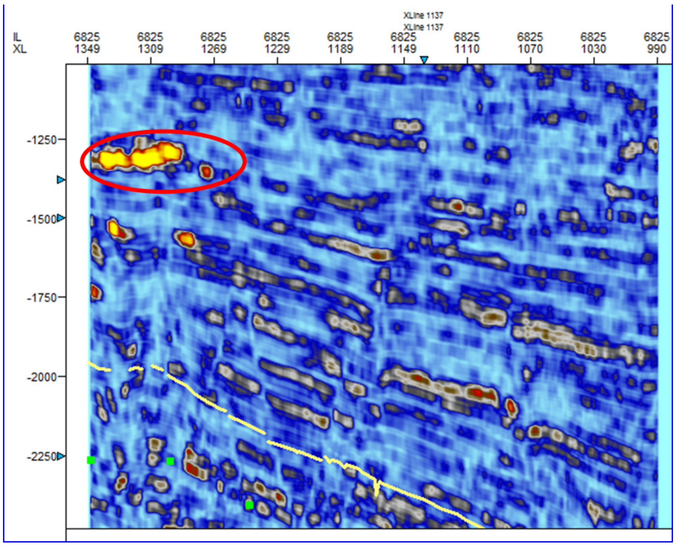

Figure 14: Typical interpreted bright spot in "obi" field (how laterally continuous? stratigraphic or structural is the reservoir?) at inline 6825.

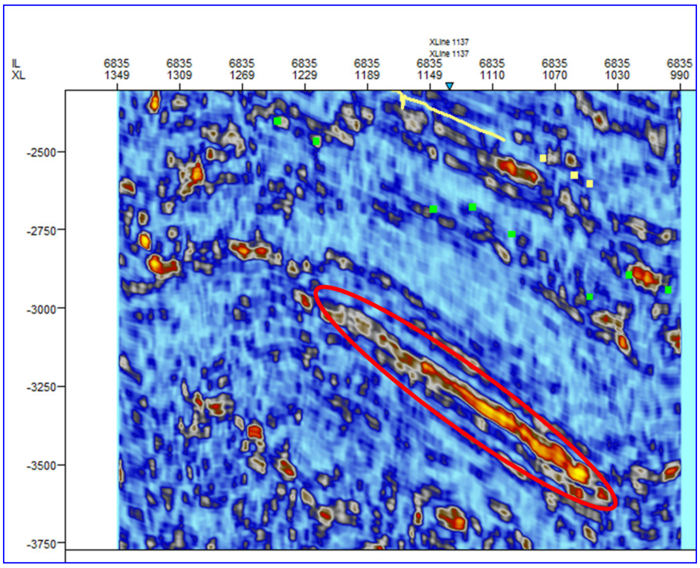

Figure 15: Typical interpreted Bright Spot in the "Obi" Field (Good example of structural dependent reservoir) at inline 6835.

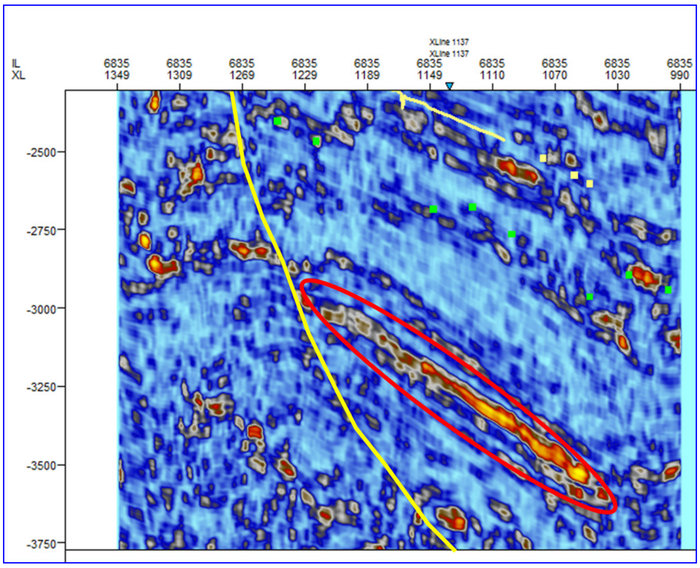

Figure 16: Bright Spot in "Obi" Field (Good example of structural dependent reservoir) with interpreted fault at inline 6835.

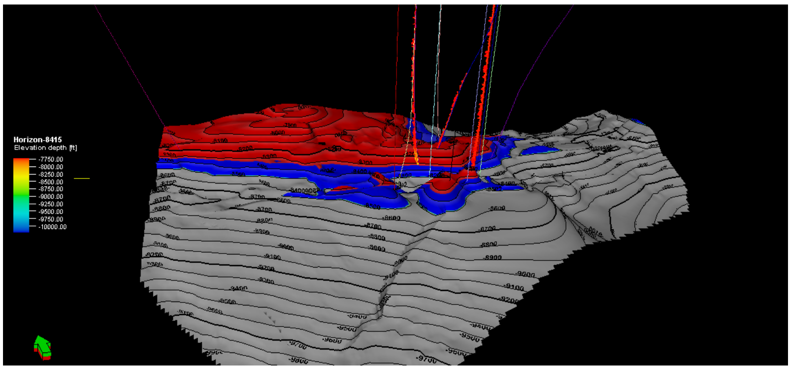

Figure 17: Typical interpreted Depth Map showing Oil and Water accumulation in “Obi” Field using reservoir Obi C_6000.

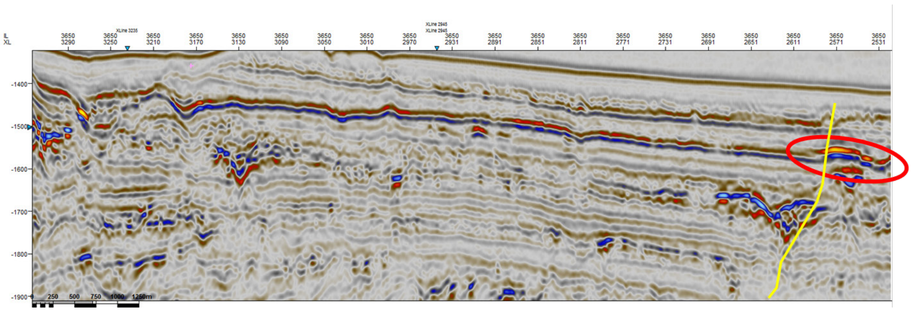

Figure 18: Typical interpreted Bright Spot (Point of emanation) in “Topa” Field (good example of structural dependent reservoir) with interpreted fault. Using different inlines at 3550, 2270,2740 and 3650ms.

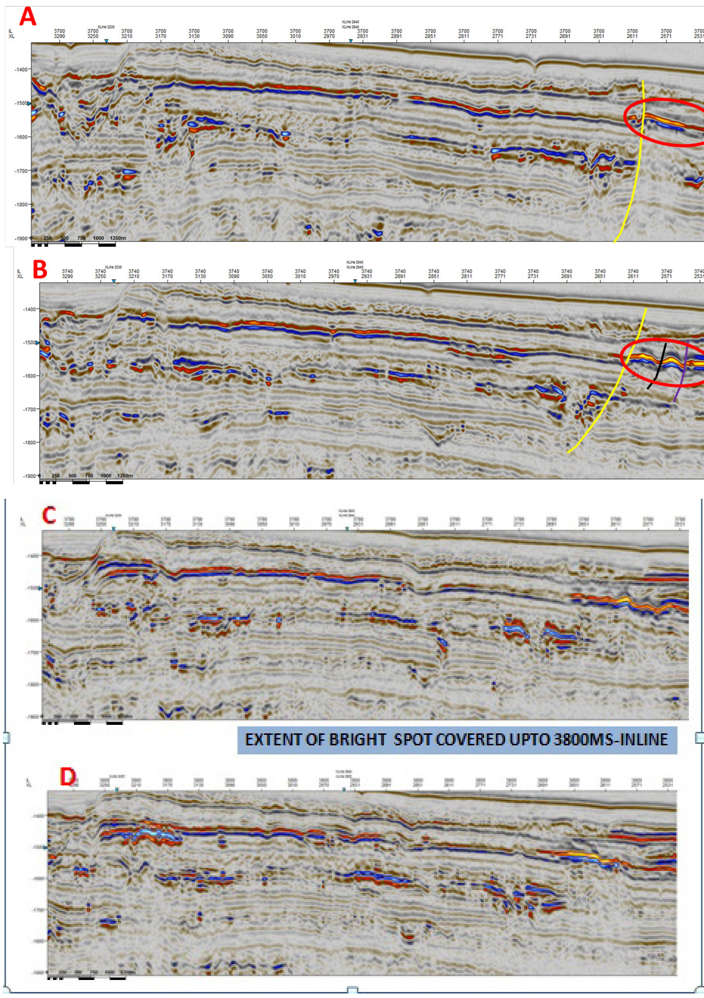

Figure 19: Typical interpreted Bright Spot in ‘Topa’ Field (good example of structural dependent reservoir) with interpreted fault. Showing lateral continuities in (a) Inline 3700ms and (b) Inline 3740ms (c) Inline 3780ms and (d) 3800ms.

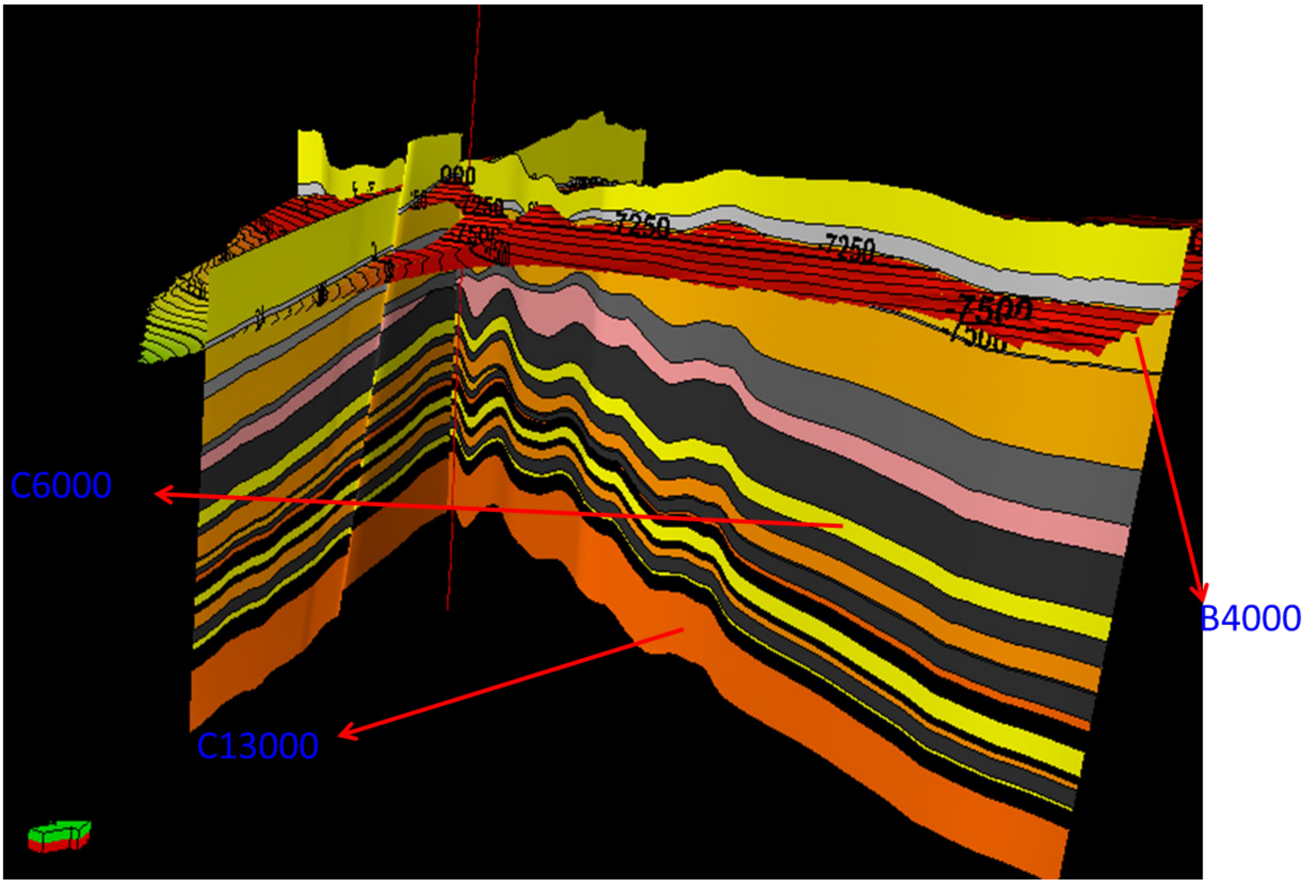

Figure 20: 3D stratigraphic model of "TOPA" Field.

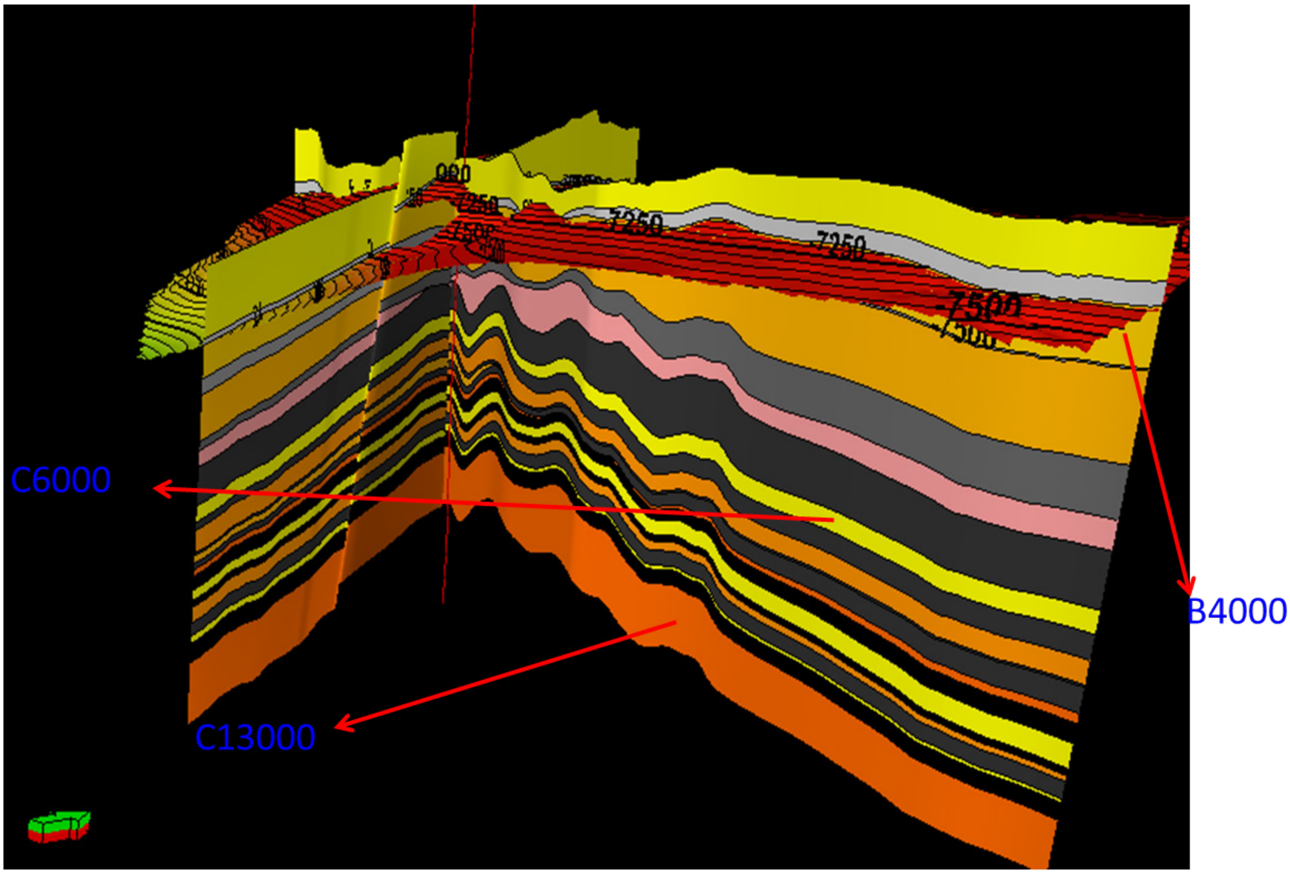

Figure 21: 3-D Model showing anticlinal geometry of Topa Field.

CONCLUSION

A critical examination of any reservoir requires integrated approach to improve the level of certainty in the presentations of predicted results. The approach utilized in this study involved seismic interpretations of fault, horizons, petrophysical evaluations, sequence and seismic stratigraphy, and root Mean Square amplitude extraction. The two fields "Obi" and "Topa" vary both stratigraphically and structurally. The "Obi" field is complexly faulted and virtually structurally dependent reservoirs in most areas. However, the "Topa" field is mainly stratigraphic but exhibits small varying magnitude of throws of some faults in some areas making the reservoirs in such areas partly structurally dependent.

It is noteworthy in this study that integrated approach is imperative in reservoir studies to ascertain high level certainty in predictions. Also, it's demonstrated from this research that not all fields requires amplitude extractions before an earliest attempt on hydrocarbon predictions can be made.

However, an important aspect of amplitude extraction in reservoir delineation must ascertain how laterally continuous is the amplitude and whether the amplitude is conforming to the reservoir structure.

A typical hydrocarbon accumulation in one of the fields is demonstrated with reservoir sand Obi C_6000 of the Obi Field which could hold up to 691 ft oil column height. The sizes of the reservoirs depends on the accommodation space created by the faults, fluid charged level, crestal point of the reservoir, spill points (saddle or fault) and any other provable possible prevailed event.

REFERENCES

1. Adeboye YB, Ubani CE, Nwalor JU. Evaluation of Reservoir production performance using 3-D seismic mapping and well logs analysis. J Sci Eng Res. 2018;5:1-10.
2. Akpabio EE, Akpan NS. Governance and oil politics in Nigeria's Niger Delta, the question of distributive equity. J Hum Ecol. 2010;30:111-121.
3. Alao PA, Olabode SO, Opeloye SA. Integration of seismic and petrophysics to characterize reservoirs in "ALA" oil field. Niger Delta Hindawi Publishing Corporation the Scientific World. 2013;10:15.
4. Bloomberg. Shell to Chevron Move Offshore as Nigerian Risks Mount. 2013.
5. Doust H, Omatsola E. Niger Delta, in Edwards JD, Santogrossi PA. Divergent/passive Margin Basins, AAPG Memoir 48. Am Assoc Pet Geol. 1990;239-248.
6. Eghweree OC. Oil politics and development in Nigeria. J Energy Technol Policy. 2014;4.
7. Ejedawe JE. Patterns of incidence of oil reserves in Niger Delta Basin. Am Assoc Pet Geol. 1981;65:1574-1585.
8. Evamy BD, Haremboure J, Kamerling P, Knaap WA, Molloy FA, Rowlands PH. Hydrocarbon habitat of Tertiary Niger Delta. Am Assoc Pet Geol. 1978;62:277-298.
9. Ikelegbe A. The Economy of Conflict in the Oil Rich Niger Delta Region of Nigeria. Nord J Afr Stud. 2005;14:208–234.
10. Knox GJ, Omatsola ME. Development of the Cenozoic Niger Delta in terms of the escalator regression model. [In: Proceedings of the KNGMG Symposium, Coastal Lowlands, Geology and Geotechnology. Kluwer Academic Publishers. 1987;181-202.
11. Okorie IPC, Ebeniro JO, Ehirim CN. Anisotropy and empirical relations for the estimation of anisotropy parameters in Niger Delta Depobelts.Int J Geo sci. 2015;07:345-352.
12. Reijers TJA. Stratigraphy and sedimentology of the Niger Delta. Geologos. 2011;17:133-162.
13. Rotimi OJ, Ameloko AA, Adeoye OT. Applications Of 3-D structural interpretation and seismic attribute analysis to hydrocarbon prospecting Over X – Field, Niger-Delta. Int J Basic Appl Sci. 2010;10.
14. Shannon PM, Naylor N. Petroleum Basin Studies: London, Graham and Trotman Limited. 1989;153-169.
15. Sonibare O, Alimi H, Jarvie D, Ehinola O. Origin and occurrence of crude oil in the Niger delta, Nigeria. J Pet Sci Engineering. 2008;61:99-107.
16. Stacher P. Present understanding of the Niger Delta Hydrocarbon Habitat. Geol Deltas. 1995;257–268.
17. Titilayo S. Oil theft in Niger Delta: why does it occur, what are its economic and social impacts and what may be done to reduce it? Science and Policy Research Unit, University of Sussex, United Kingdom. 2014.