SEISMIC AND RESERVOIR CHARACTERIZATION OF THE OLUMO FIELD, NIGER DELTA BASIN, NIGERIA

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Abstract: *Seismic attributes have been used to characterize two reservoirs in Olumo field located onshore Niger Delta. 3-D seismic data and well logs were integrated to unravel complex field subsurface traps associated with hydrocarbons and to gain more insight on reservoir architecture. Two horizons; A001 and B00l were identified and mapped on the 3D seismic data using correlations provided in the well tops across the four wells to delineate and establish the continuity of the reservoir sand bodies.*

Key Words: Sesmic, Niger delta, Reservoir, hydrocarbons.

1. INTRODUCTION:

Reservoir characterization using seismic attribute analysis can play an essential role in the exploration and development of a field. Seismic attributes has come a long way since their introduction in the early 1970s and have become an integral part of seismic interpretation projects. Today, they are been used widely for lithological and petrophysical prediction of reservoir and various methodologies have been developed for their application to broader hydrocarbon exploration and development in decision making. A good seismic attribute is either directly sensitive to the desired geologic feature or reservoir property of interest, it contributes to the prediction of reservoir properties as well as economic potential of the field. In a world of severe economic constraints on projects, it has become essential for Oil Companies to obtain as early as possible an accurate assessment of the reservoir characteristics and the hydrocarbon volume available in the subsurface. Reservoir characterization and subsurface geological mapping are perhaps the most important tools used to explore for undiscovered hydrocarbons and to develop proven hydrocarbon reserves as the knowledge of reservoir characterization is an important factor in quantifying producible hydrocarbons (Schiumberger, 1989). In order to map a hydrocarbon reservoir, studies of geologic structures that can hold hydrocarbons in place must be considered thus a need exists to thoroughly evaluate prospects so as to determine optimal production strategies and minimize uncertainties that may be associated with hydrocarbon exploration processes.

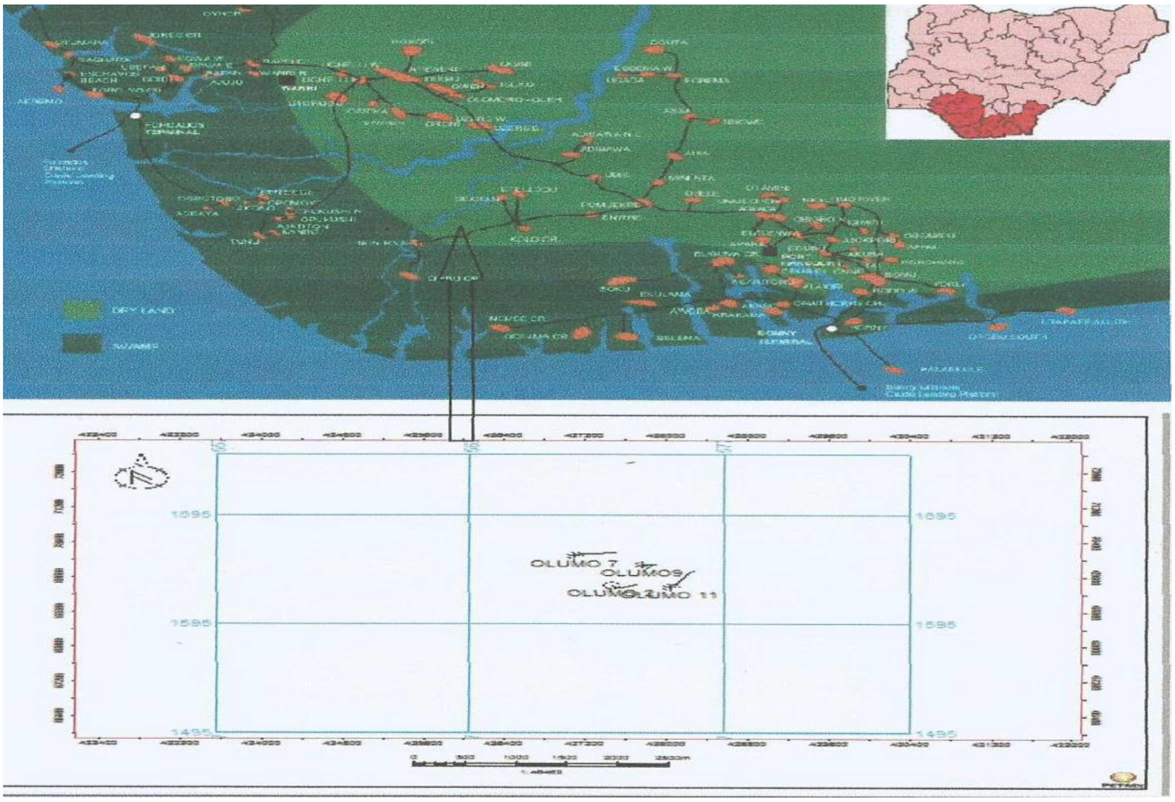


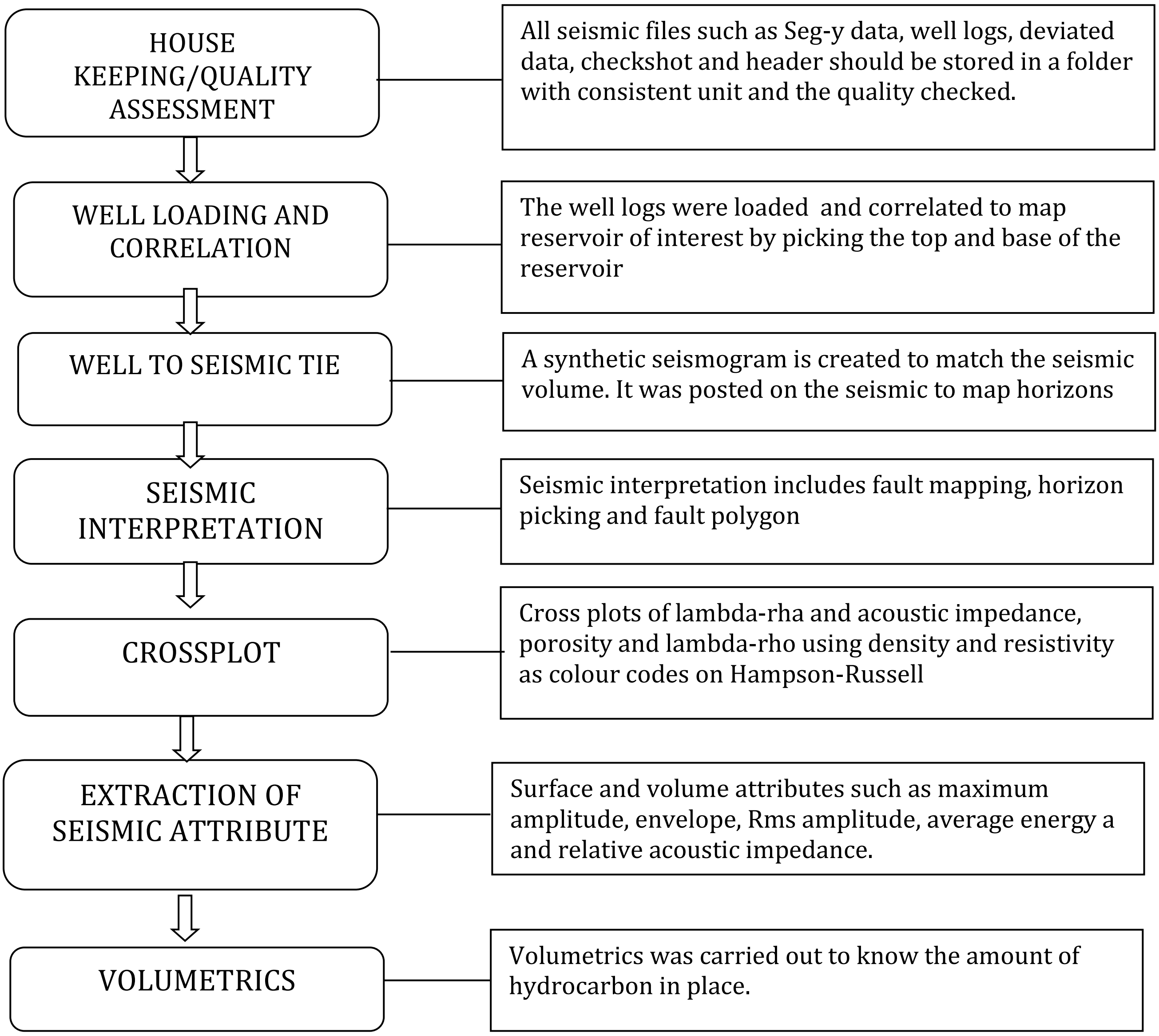
Figure 1; Location Map of the study wells and Area

2. AIM OF STUDY:

This project is aimed at characterizing two reservoir sands in OLUMO field by using seismic attributes extracted from the 3-D seismic data in order to reduce uncertainties in the Field.

3. METHODOLOGY:

The workflow for the project study is outlined in and the eight stage process starts from housekeeping/quality volumetric.



(A) HOUSE KEEPING GIQUAL1TV ASSESSMENT

The data sets given were stored in a folder and the quality of the data checked. During the quality check of the data, it was discovered that the wells were not logged at same depth and this could affect correlation of the well logs in petrel software. The seismic data used for this project is over-cropped and as such, it will be difficult to see by-passed hydrocarbon.

(B) DATA LOADING AND QUALITY CONTROL

Microsoft excel 2007 was used to QC the data received converting it from .las format to .txt format and was successfully loaded in petrel 2011.1 software and Hampson-Russell for interpretation

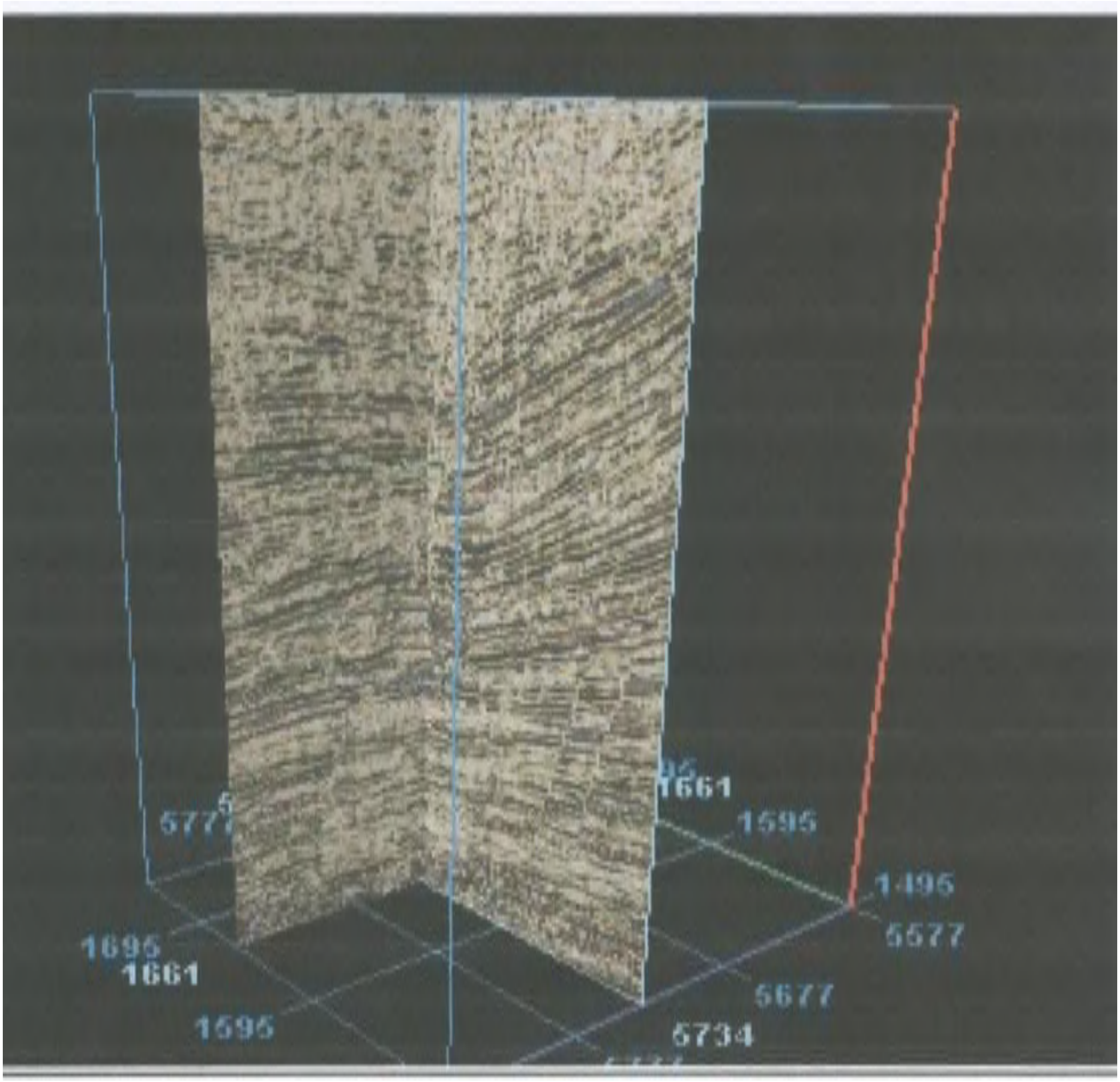


Figure 3; Inline and x-line on 3D seismic interpretation window to show the true depth of the wells

(C) WELL LOGS

The field of study contains four wells namely Olumo2, Olumo-7, Olumo-9 and Olumo11. Well logs were received in .las format but it was QC'ed in excel and gamma ray radiation encountered in the earth is emitted by the radioactive potassium isotope of atomic weight 40 (K 40) and the radioactive elements of the uranium and thorium series. Applications include: Bed Boundaries, Geological correlations, Shale content estimation, presence of radioactive minerals and depth matching of subsequent logs (Fusier, 2014).

(D) DATA SETS

The data used for this project includes the following:

I. 3D Seismic data of Olumo field.
2. Header information
3. Deviated well data
4. Well logs
5. Check shots

(E) WELL CORRELATION

Well correlation was done by displaying the four wells and some logs such as gamma ray, resistivity, and Neutron and density log. The well correlation was done on a well intersection window on petrel. Sand bodies with high resistivity and are laterally continuous were correlated to know the extent of the reservoir.

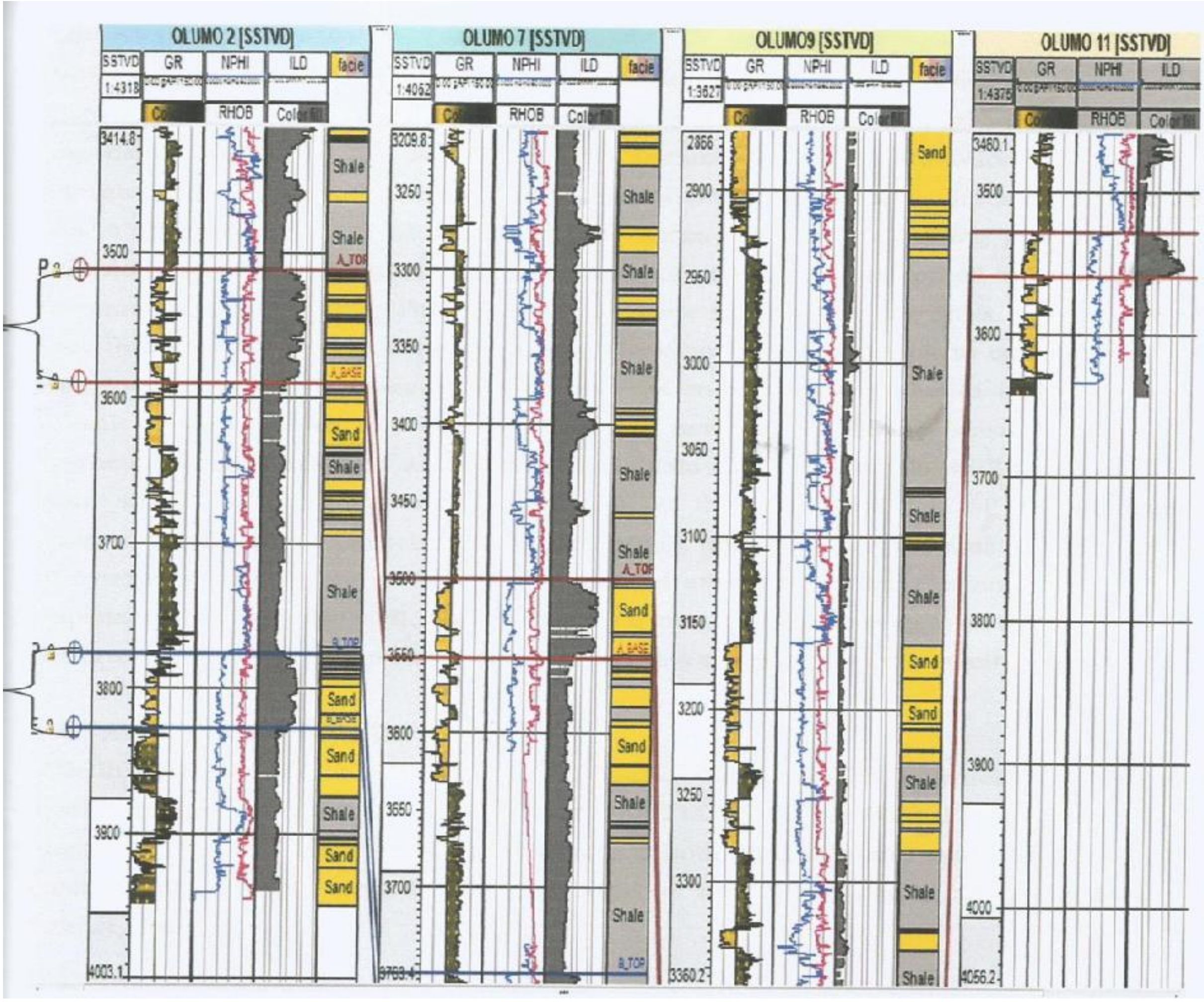


Figure 4; Well correlation view on petrel using section window

(F) SEISMIC TO WELL TIE

Well tie is a very important part of interpretation and it provides a means of correctly identifying horizons to pick, estimating the wavelet for inverting seismic data to impedance. Just as well ties are paramount in the calibration of a seismic interpretation, so too they are the cornerstone of using seismic amplitudes in impedance and AVO inversion, and ultimately of inferences fed into the risking process. Well- seismic ties allow well data, measured in units of depth, to be compared to seismic data, measured in units of time. This allows us to relate horizon tops identified in a well with specific reflections on the seismic section. There are several methods to carrying out the well to seismic tie. Two methods were used (Generation of synthetics and tying it to seismic). Sonic and density logs were used to generate a synthetic seismic trace. The synthetic trace is compared to the real seismic data collected near the well location. The main aim is to know the accurate location of the formation tops of the interested reservoirs and tie it to the seismic in other to pick horizon. This requires the generation of synthetic seismogram from a convolution of an extracted wavelet and the acoustic impedance log from the well. The synthetic seismogram can be displayed on the window to correctly tie reflection events to horizon markers encountered in the well .

(G) SEISMIC INTERPRETATION

This involves picking of horizons and mapping of faults on a 3D interpretation window. Two horizons of interest were considered (A0O 1 TOP AND BOO 1 TOP) and faults were mapped across the horizon. The faults include both antithetic and synthetic faults. An isochron map was generated using the horizons and it was depth converted using a velocity model.

(H) FAULT INTERPRETAT1ON

Knowledge of how to identify and locate faults is critical to understanding a geological system. One effect that faults have, which is of real commercial significance, is that they act as membranes to the movement of hydrocarbons. Therefore having a good understanding of the fault positions is critical for the effective planning of drilling site in order to maximise output efficiency. Identification of faults on seismic sections is based on the following criteria:

(a) Reflection discontinuity at fault plane.

b) Vertical displacement of reflection.

c) Abrupt termination of seismic events/truncations.

d) Overlapping of reflections.
e) Change in pattern of events across the faults.
Fault interpretation in this project was done by drawing of fault segments, on areas where the above named fault identification criteria were seen on the seismic section. Fault segments were interpreted by simply digitizing on a seismic intersection. To start a new fault interpretation, the existing interpretation folder was clicked on and an insert fault was selected and next the interpret faults are selected and the digitizing was done.

4. RESULTS AND DISCUSSION:

INTERPRETATION OF LOGS
Porosity, water saturation, formation volume factor and net to gross were calculated by using the calculator under global well log in petrel.

FAULT AND HORIZON MAPPPING
The seismic data is a zero phase SEG- Y data with a likely boundary fault to the north dipping basin ward. The seismic data reflects several faults typical of the collapsed crest of the Niger Delta growth fault which contributes to hydrocarbon accumulation and entrapment and so a detailed mapping was done. The identification of faults on the seismic section was based on the delineation of fault planes, reflection discontinuity at fault planes, vertical displacement of reflectors, abrupt termination of event and change in pattern of events across faults.
Two horizons were identified (horizon A0O1 and 13001). A horizon is the interface between two different rock layers and it is associated with continuous and reliable reflection on the seismic section that covers a large area, The well tops were picked using the gamma ray log, resistivity log, and neutron and density log. The horizon picks are on the crest of the waveform corresponding with the trough amplitudes that will be used for interpretation. Most of the faults didn't get to the horizons of interest but since the sands were thick enough and the log suites used shows it contains hydrocarbon, it was considered important for the interpretation of this project. The anticlinal structure serves as a seal and also a trap for hydrocarbon accumulation.

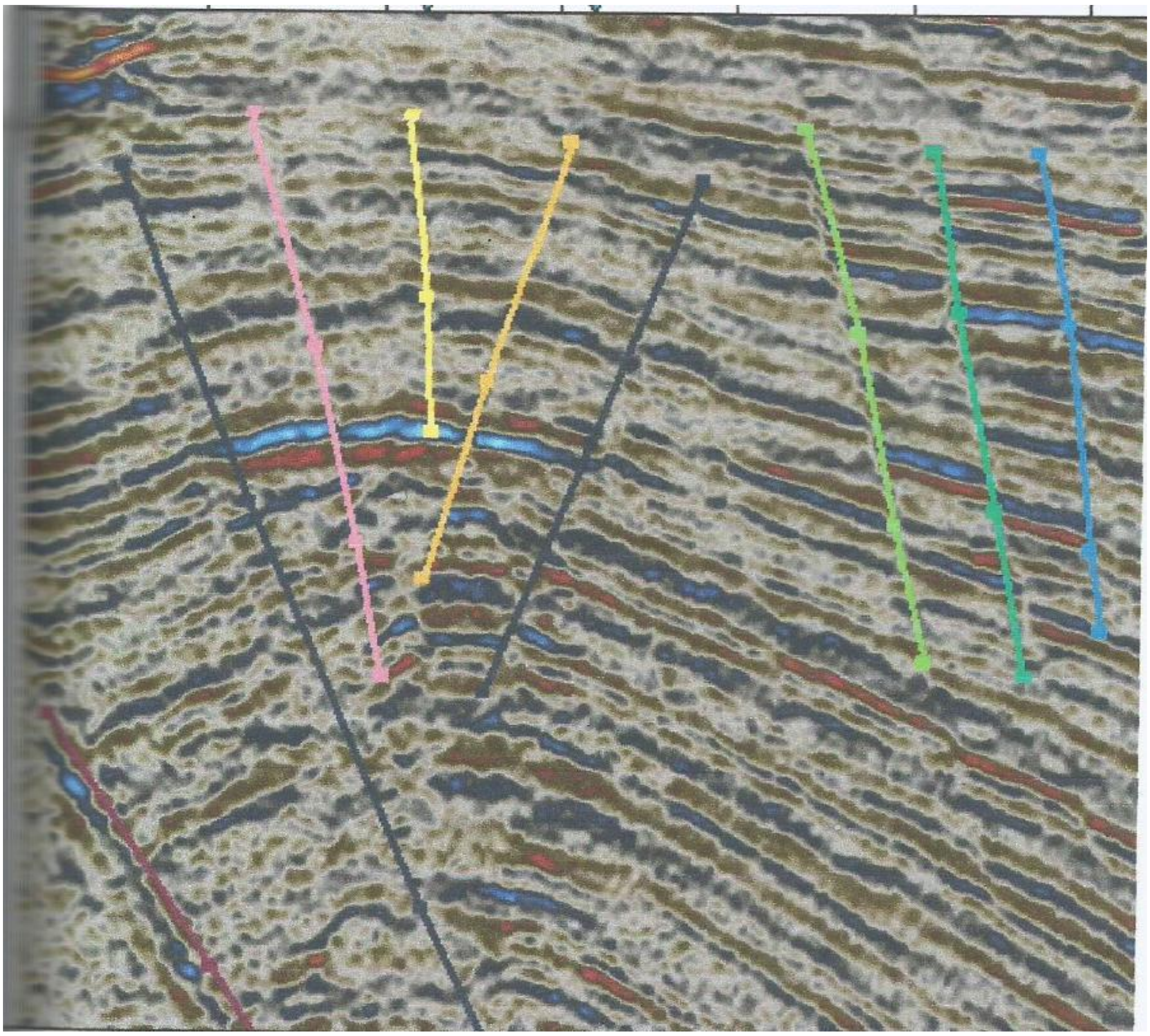


Figure 5; Mapped faults

SEISMIC ATTRIBUTES

(a) maximum amplitude

The amplitude maps show clearly the position of faults in the project area with a general trend of NW-SE by creating a discontinuity in the amplitude pattern around them. High amplitudes-which are indicative of lithologic changes or hydrocarbon presence- on the above two maps are seen on the crest and flanks of the anticlinal structure. As this map is more of sand body, the high amplitude represents more of fluid content than lithologic change. The location of these high amplitudes suggests the presence of fluid accumulation in the anticlinal structure or a migrating fluid navigating through the anticline which tends to act as a trap. The four wells Olumo-2, Olumo-7, Olumo-9 Olumo-1 1 on this field encountered high amplitude which indicates the presence of hydrocarbon in the wells. The wells were drilled away from the flanks of the anticline on the two reservoirs of interest such that if hydrocarbon is encountered, the wells will not have an early water cut/breakthrough.

(b) AVERAGE ENERGY

The average energy maps indicate a similar but less concentrated pattern, compared with RMS amplitude and maximum amplitude maps.

The higher value areas in the energy map are indicative of greater fluid conirast within the sand body. The four wells in both sand bodies experienced high energy.

RELATIVE ACOUSTIC IMPENDENCE

Acoustic Impedance (Al) attribute map is interpreted as lower values reflecting better reservoir quality and higher values indicates poorer reservoir quality. Reservoir quality here means lower porosity as acoustic impedance varies inversely with the magnitude of porosity. An acoustic impedance map could be used to predict reservoir porosity away from the well points. The general trend of porosities on the maps would better be discussed by placing the RAI and Average energy maps side by side. Relative AT attribute values generally should show the opposite representation of the average energy attribute values. This means, areas with higher energy should match with areas with lower A! values and vice-versa. This is based on the fact that the lower values in RAI are reflected by higher amplitudes which in return reflect higher energy values

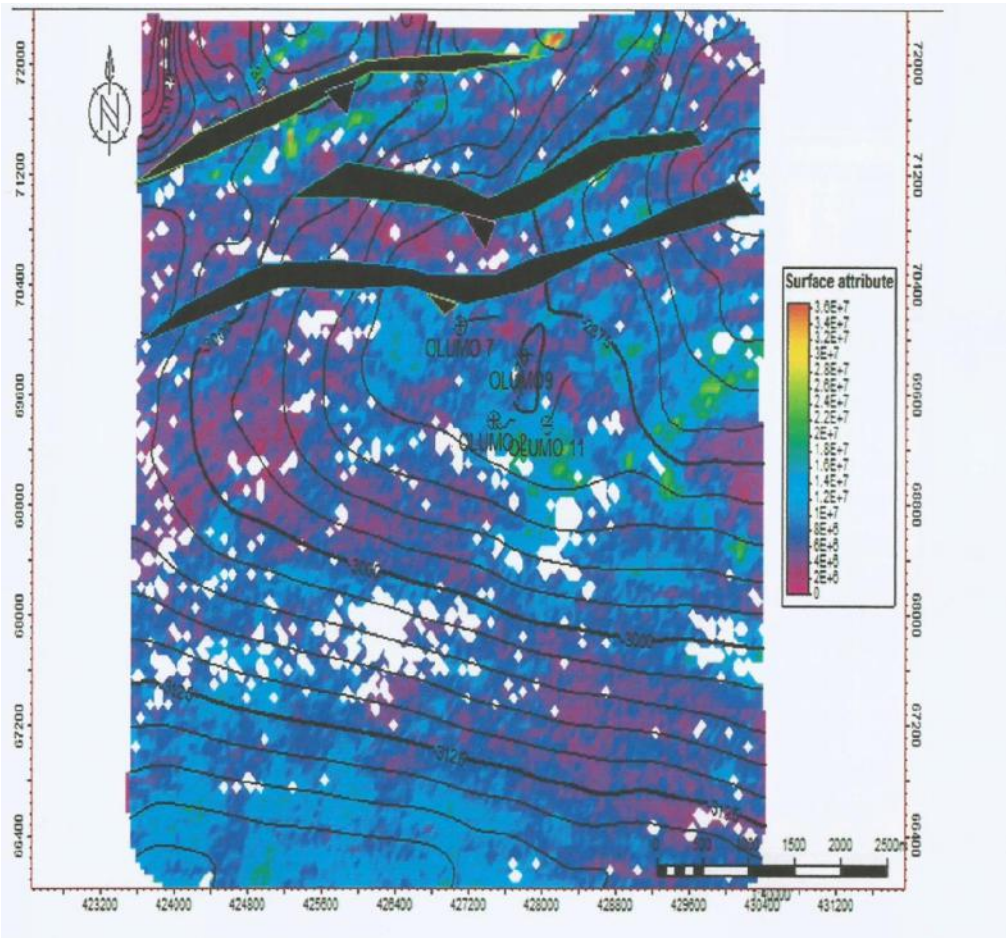


Fig. 6 Average energy for horizon A

For areas where this fact does not hold, contribution from other factors may be possible. For example, areas where bed thickness is less than the dominant wavelength, variation in thickness would lead to tuning effects resulting in changes

in wavelet shape and amplitude. The maps showed that the low values of RAT are most common in areas of high energy and high values of RA! common in areas of low energy thus confirming porosity of the sand body at those locations and the possibility of holding hydrocarbon The porosities obtained from well logs in this work can be used in predicting the porosity across the reservoirs.
The four wells Olumo-2, Olumo-4, Olumo-9 and Olumo-1 1 located on this field were found to be on the bright spots as revealed on the RMS amplitude maps and maximum amplitude which indicates the presence of hydrocarbons. A combination of these maps for Reservoir AOOl and BOOl (a region of high amplitude, high energy, and low relative Al) would aid selection of target for placement of new wells to tap hydrocarbons on each sand body.

TABLE 1; RESERVOIRS PROPERTIES FOR HORIZON A

Reservoir parameters	Olumo-2	Olumo-7	Olumo-9	Olumo-11
A-top (Ft)	3513.16	3507.61	3539.96	3527.41
A-Base(Ft)	3588.18	3557.76	3598.00	3627.42
Thickness(ft)	75.02	50.15	58.04	37.69
0 (fraction)	0.27	0.24	0.25	020
Sw (Fraction)	0.2	0.16	0.23	0.14
N/G(fraction)	0.71	0.57	0.63	0.65
STOIIP	192MMSTB	182MMSTB	193MMSTB	I77MMSTB

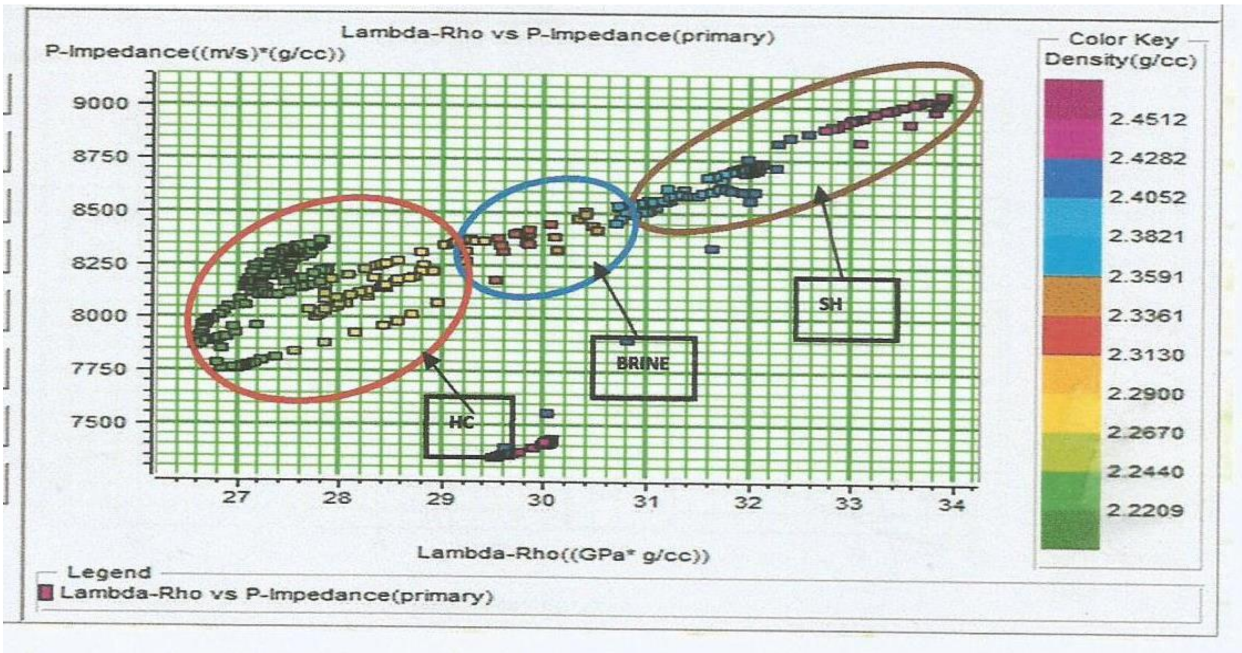


Figure 7; A cross section of acoustic impedance versus Lambda-Rho using density as colour code

5. DISCUSSION AND CONCLUSION:

The process of Reservoir characterization of a field is based on the ability of the interpreter to make use of available data in interpreting various parameters with minimum error margins. The Lithostratigraphic correlation which was done with a gamma ray log across four wells in reservoir AOOl and across two wells in reservoir BOOl helped in the identification of the reservoir with hydrocarbon shows. Resistivity logs, density and neutron logs were used to delineate the presence and type of fluid found in the reservoir. The basis of mapping the two reservoirs used for this project is the sand thickness and indication of hydrocarbon from the log suites used. Vertical displacement of reflections and abrupt termination of seismic events formed the basis for fault interpretation. Time map was generated from the horizon and depth converted using velocity model. Cross- plots of lambda-rho versus acoustic impedance and lambda-rho versus porosity was carried using Hampson-Russell software to delineate fluid type and porosity distribution present in reservoir A using the sand top depth. Seismic attributes were extracted from the 3-D seismic volume which was used for better visualization and interpretation of the morphological and reflectivity characteristics of the reservoir.
The result of the attributes showed high maximum amplitude, high energy, high RMS amplitude and low relative acoustic impedance which indicate the presence of hydrocarbon in the two reservoirs of interest. Bright spots were observed at the flanks of the anticlinal structure which can serve as possible target for drilling activities. Using the

results from the petrophysical analysis, stock tank oil in place was calculated for each reservoir, the area used was calculated from the depth map by creating a polygon around the oil/water contact (OWC). The formation volume factor (Bo) and dissolved gas was gotten from PVT data.

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