EARTH SCIENCES

THE APPLICATION 3D SEISMIC DATA INTERPRETATION TO HYDROCARBON PROSPECT MAPPING IN "DEDE"FIELD,NIGER DELTA.

[1]Adeoye, T.O., [2] Johnson, L. M. and [3]Ologe, O.
[1]Department of Geophysics, University of Ilorin.
[2]Department of Geology, University of Ilorin.
[3]Department of Applied Geophysics, Federal University, BirninKebbi.

Corresponding Email: toadeoye@gmail.com.

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ABSTRACT
In certain frontiers, the dense sampling of 3D seismic surveys can help to identify subtle subsurface structures and thin beds through detailed imaging. The 3D technology can also provide a hint on reservoir quality. This research was carried out toshow how 3D seismic data interpretation is applied to robust subsurface imaging and prediction of lateral reservoir quality.The integrated study involved 3D visualization, direct reservoir identification, structural interpretation, amplitude extraction and seismic reservoir evaluation constrained by porosity at the wells. Initial 3D visualization was done by scanning through seismic lines to locate seismic amplitude anomalies that can be related to direct hydrocarbon indicators. Amplitudes of interpreted horizons were tracked to access stratigraphic features. The tie between the significant seismic reflections and borehole section were established from the synthetic seismogram. Well log analysis was done and results compared with seismic interpretation.The seismic interpretation confirmed reservoirs which have appeared on well logs. In addition, a bright spotwasobserved on some of the lines in areas not penetrated by wells.Trapping mechanism for the bright spotmay be stratigraphic.In addition, structural maps revealedfour way closures as traps for the reservoirs interpreted from well logs at the center of the field. Implications of these results in determining reservoir characteristics of sandstones and in permitting hydrocarbon production from well log analysis is further discussed.

Keywords: *3D seismic, well ties, reservoir, amplitude, horizons.*

INTRODUCTION

There are many published worksof exploration and exploitation successes attributed to 3D seismic data acquisition and interpretation (Brown, 2004). Today, many exploration and production projects rely upon 3-D seismic exploration technology to assess prospects and optimally position wells.

The advantages of 3D seismic acquisition and interpretation over 2D seismic are enormous. In 2D seismic data acquisition, since lines along which geophysical measurements are made are far apart, such that there are significant gaps between adjacent lines, there are limitations to the subsurface information that can be available for interpretation.3D seismic is distinguished by the acquisition of seismic lines at closely spaced intervals. This leads to a true data volume from which lines, slices or 'probes' can be extracted in any orientation.

The key components of 3D seismic interpretation may include the following: structural interpretation/modeling, stratigraphic interpretation, seismic inversion and reservoir evaluation(Bacon *et al*., 2003).Traps are accurately revealed using a well packaged structural interpretation workflow. To aid structural interpretation, seismic attributes may be employed for faults identification. Attributes may also be important in defining the shape, limits and characteristics of reservoir bodies. Sometimes, on a horizon slice, for example, a pattern which is not related to structure may be interpreted as a depositional, lithologic or erosional feature (Brown, 2004).

Reservoir evaluation on the other hand, deals with assessing the reservoir quality. The challenges of reservoir quality characterization include - the ability to assess and predict reservoir facies, its geometry, distribution as well as reservoir porosity estimation. Starting with the petrophysical information at well locations, this is averaged for a given reservoir, therefore a spatial distribution of porosity can be obtained on seismic, constrained at the wells and depending on the quality of seismic data available (Cosentino, 2001). It should be noted however, that, there may or may not be relationships inherent between seismic and log data. Therefore, a correlation must be established between well log data and seismic amplitude or acoustic impedance (David and Michael, 2010). If the correlation exists, the seismic data can be integrated with the well log data to predict the reservoir property of interest.

With this level of activity and euphoria, the issue that needs attention is that of maximizing the potential of 3D technology and applying the technology appropriately. Horizons need to be tied correctly and attention must be given to the limitations posed by data defects.

This study was carried out to explore the impact of 3D seismic interpretation on the dataset; imaging the subsurface with a view to delineateadditionalreservoirs. This was achieved bytying structures that may correspond to potential hydrocarbon traps to wells, identifying hydrocarbon prospects in area not penetrated by wells, determining the relationships between seismic properties and well log properties (amplitude and porosity) for a given areaand generating a model illustrating lateral and vertical distribution of reservoir porosity.

Data analyzed for the study include poststack 3D seismic data which has 161inlines and 195 crosslines. The study covers an approximate area of 24sqkm. Three wells are drilled in the field, labeled A, B and C respectively. Most of the wells have lithology, resistivity and porosity logs. Check shot surveys arealso available fromthe wells.

MATERIALS AND METHODS

Thisintegrated study involved structural interpretation, amplitude extraction of key surfacesand reservoir evaluation from log calibration.Schlumberger's *Petrel* workflow tools and The *IHS kingdom* suite were used for interpreting the data.

Using 3D visualisation, the whole volume was inspected to get a general impression of structural and stratigraphic features of interest.Reservoir horizons were picked from well logs.

Well to seismic tie is based on a synthetic seismogram correlation using sonic log, density log and checkshot data from well A. The tie, when achieved, formed the first step in picking events, which represents the tops of the reservoir sands for interpretation on the seismic sections.

Subsequent interpretation procedure for structural interpretation followed the process of manual picking of horizons on inlines and crosslines. This was combined with volumeautotracking and interpolation.Structural interpretation also involved seismic attribute analysis for fault identification. Co variance attributes was generated for the seismic cube and studied throughout the length of the data.

Time to depth conversion of the mapped time events was carried out using interval velocity obtained from checkshot data.Chosen reference surfaces are the surfaces above the 3D grid model. Velocity information was obtained using Linvel's method, the linear expression: $V=V_0$ for the first layer. Where V_0= *Interval velocity*;For the subsequent layers, where it is assumed that velocity changes vertically by a factor of K, the equation: $V=V_0+kZ$was used.

Where K= constant values between 0 and -0.2 and Z= Distance from point of observation to datum.

Assessment of stratigraphic features was conducted for target zones based on amplitude extraction of interpreted horizons. Reflection which could be misinterpreted for bright spots on the horizon slices were identified first on the seismic sections.

Before reservoir evaluation, quality check was done by plotting (from statistical extraction) seismic amplitudes against porosity logs in the wells for the reservoir zones. Porosity was modeled in the reservoir Sands only for scenarios where we have agood correlation between porosity and seismic amplitudes.

RESULTS AND DISCUSSION

Bright spots are identified in regions where well penetrations are not available. The natural pairing of the amplitudes was used to validate the existence of the bright spots (Fig. 2).In addition, structural features of interest, represented by seismic amplitude anomalies are revealed from seismic visualization (Fig. 2). The seismic anomalies fall within the hydrocarbon producing intervals in the Niger Delta and wells penetrating this zones have revealed hydrocarbon presence. This was observed in the central part of the field (Fig. 3).

Hydrocarbon zones were interpreted on the wells. Prospect P_1 is shown in Fig. 4. Matching seismic with log data revealed a moderate tie between prospective intervals on well A and seismic (Fig. 4). Well to seismic matching in Well B did not reveal a good match and therefore is not included in the study. Overall three prospects were identified, labeled as P_1, P_2 and P_3. Prospect P_1 and Prospect P_2 were mapped on well logs and tied to structures on seismic, while the P_3 reservoir was outside the range of well controlin most parts and observed as a bright spot (Fig. 2).

On the depth structure map in Fig.5, the hydrocarbon sands are trapped in the area, marked "P_1". The areas covered by "P_1 and P_2" are large (Approximately 9km^2 and 8.6km^2 respectively). They are interpreted as a four way dipping closures(Fig 5& 6). The maps shows moderate vertical relief for the dip of the observed closures. This is considered good for hydrocarbon amassing.*Co variance* cube did not show any evident faulting along the hydrocarbon trap area for prospect 1(Fig.5). Prospect P_1 is therefore interpreted as anunfaultedsimple rollover anticlinal structure (Fig. 5). The crestal blocks of simple structures are highly prospective and commonly contain considerable volumes of hydrocarbon (Ajaikaiye and Bailey, 2002). The same structural patterns are observed at deeper sections (Fig. 6). Prospect P_2 was identified at deeper depth but, in terms of location, there is a shift away from the center of the field (Fig. 6).

Attribute tracking on the prospective surface P_1 , using seismic attributes (r.m.s amplitude) did not reveal any stratigraphic features as amplitude conforms with structure.The generated attribute map revealed a well-defined area of high RMS amplitude values at the center of the field. This is a possible flat spot(Fig. 7). It is possible however, that, some of the high amplitudes are as a result of tuning phenomena. The amplitude anomalyin the bright spot region may represent porous channel belts since it can easily detect porous lithologies.

IMPACT OF 3D SEISMIC DATA INTERPRETATION ONRESERVOIR QUALITY

Cross plot of amplitude and porosity from well A reveals problem areas, which show up as outliers in the scatter plots (Fig. 8). Therefore, the generated porosity model is not an accurate representation of the lateral and vertical reservoir quality.Also, the heterogeneities within the reservoir caused by lithologic variations, are not captured by the petrophysical model. This may be obtained from facies modeling which is also intended at a later stage for this study. In the diagram, porosity and amplitude correlation has a correlation coefficient 0.501.The subsequent porosity map generated revealed porosity is highest in the central part of the field(Fig 9).In the diagram, porosity within the reservoir zone for prospect P_1 ranges between 0.05 and 0.20 while that of Prospect P_2, observed from the logs, ranges between 0.112 and 0.205. Porosity shows decrease with depth, a factor that may be caused by compaction and lithofacie association. Reservoir thickness obtained from the logs ranges between 29.73mand 30.0m for Prospect P_1 while that of Prospect P_2 ranges between 15.41mand15.42m. Vertical thickness and horizontal aerial delineation of sand body are good for hydrocarbon production and may be linked to environment of deposition.

CONCLUSION.

Prospective zones have been mapped with 3D seismic data interpretation. There is a match on seismic with the wells for prospect P_1. An additional prospect related to high amplitudes have been observed away from well zones. Trapping mechanism is mainly structural, a four way dipping closure. However trapping mechanism for the bright spot region is probably stratigraphic as no fault or structural deformation was observed in the area. Structural maps reveal a decrease in area of the closure at the center of the field at deeper depths.

Changes in seismic amplitude response at the reservoir zones in the field may berelated to lithologic and porosity changes. Reservoir characteristics from well indication are enough to permit hydrocarbon production. Seismic litho facie modeling and inversion is recommended for further studies.

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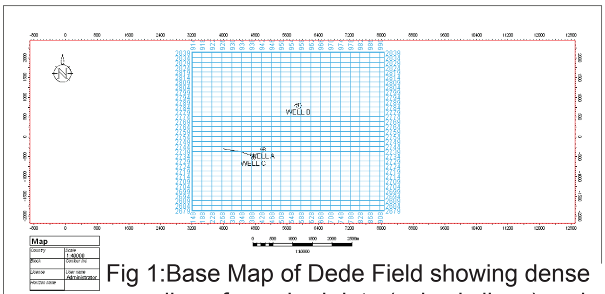

Fig 1:Base Map of Dede Field showing dense sampling of acquired data (seismic lines) and wells (A, B and C).Well C is a deviated well represented by a black curvy line.

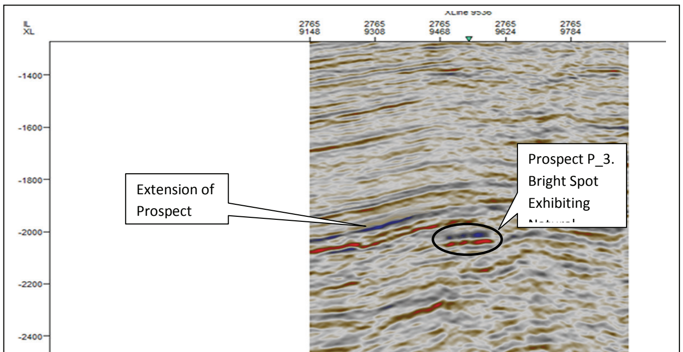

Figure 2: 3D Seismic Section over Prospect P_3. Amplitude anomalies representing bright spots are enclosed within oval

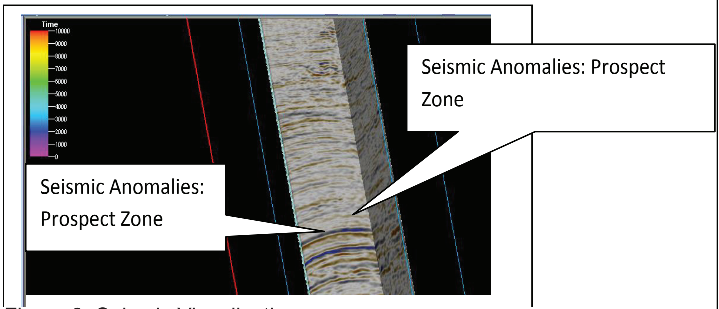

Figure 3: Seismic Vizualization:
Prospect Zone P_1 and P_2 were captured at a glance as bright zones before detailed analysis was carried out on well logs.

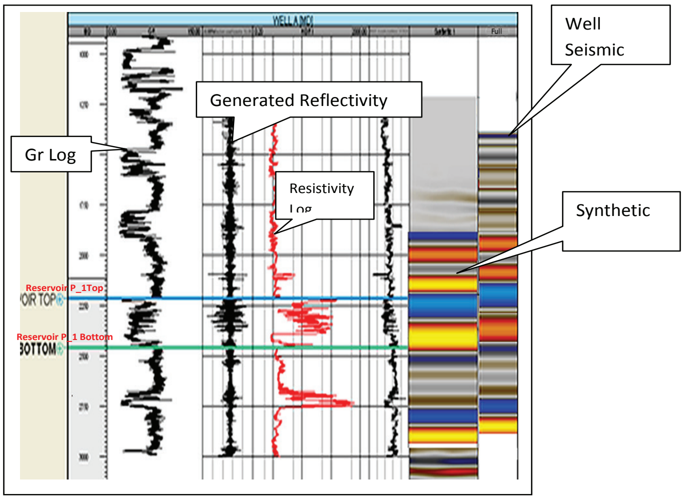

Figure 4: Well to Seismic reveals a moderatetie.
A time shift of 5ms was required to match

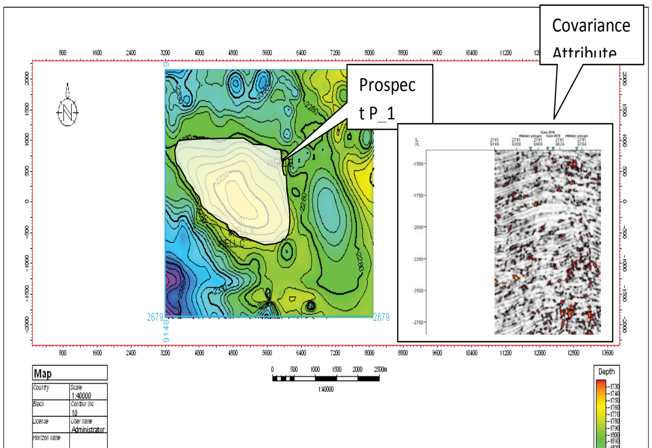

Figure 5: Depth Structure Map showing Prospect trapped in anticlinal closures. Covariance attribute not showing any prominent fault pattern

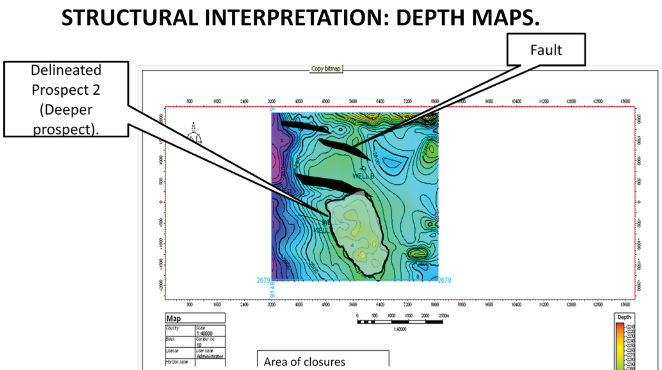

Fig. 6:Depth structure map draped over depth structure map of Prospect P_1. Area of closure decrease and there is a shift from the center of the field

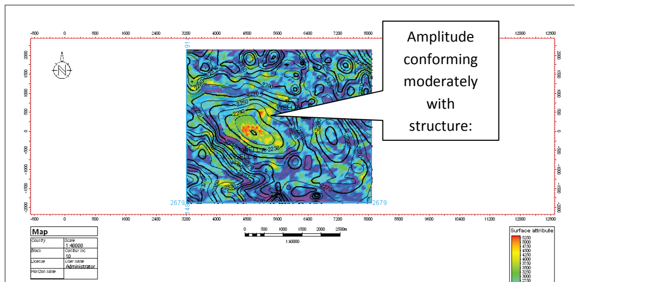

Fig. 7:AnomalyR.M.S amplitude map draped over depth structure map of Prospect P_1

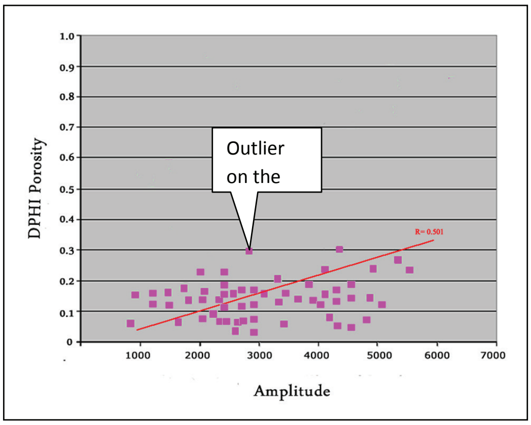

Figure 8: Crossplot showing correlation between statistically extracted porosity and Seismic Amplitude for Prospect P_1 interval.

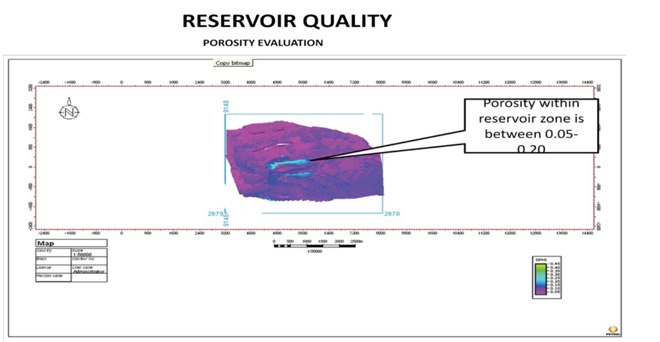

Figure 9: Porosity Model showing that areas within Prospect P_1 are within good porosity values.