GEOPHYSICAL INTERPRETATION OF SEISMIC REFLECTION DATA OBTAINED FROM UMUREUTE AND AMIYNAIBO AREA OF DELTA STATE, NIGERIA.

Anomohanran, O
Physics Department, Delta State University, Abraka, Delta State, Nigeria.
Email: mrochuko@yahoo.com

ABSTRACT

Geophysical interpretation of seismic reflection data was carried out around Umureute and Amiynaibo to determine the hydrocarbon capabilities of the area under study. The data were collected using the seismic reflection technique of geophysical prospecting for hydrocarbon. A total of fourteen seismic reflection data were collected and interpreted using the principles of picking, timing, posting and contouring. This study revealed the presence of two major growth faults and two minor faults. The contour maps shows that the horizons deepen from north east to south west which is an indication that the migration path for fluid is from south west to north east. Results indicated further the presence of two closures against the major faults which acts as migration seal to the prospect. The study has shown that hydrocarbon capability exist in Umureute at a depth of 1822 meters while the capability of Amiynaibo exist at a depth of 2130 meters below ground level.

Keywords: Seismic Reflection, hydrocarbon, Geophone, Seismic Interpretation

INTRODUCTION

The seismic method is a geophysical tool commonly used in investigating the earth's internal constituent. It involves the generation of sound wave and the recording of the time required for the wave to travel from the sources to different layers of the earth and back to a series of geophones usually arranged in line along the surface (Okwuezi and Offong, 1992; Anomohanran, 2004). With the record of the arrival times of the various geophones and the velocity of the waves, the paths of the seismic waves can then be constructed (Wightman *et al.,* 2003). The motivation is usually the determination of sedimentary formations favourable for the occurrence of natural deposits of commercially valuable minerals (Hammer and Clowes, 1996).

Two techniques which are used in seismic survey are the refraction and the reflection techniques (Sheriff and Geldart, 1995). In seismic refraction, the distance between the sources and the receivers are almost always several times as great as the depths of the boundaries along which the waves travel. Information from this method makes it possible to plot the distribution of seismic wave velocities as a function of depth and thus obtain clues to earth's internal constituents (Guy et al, 2003). Refraction techniques are susceptible to errors produced by unknown lateral variations in velocity at depth due to large offset between geophone and shot point required and are affected by the existence of low velocity layers between layers of high velocity material.

Seismic reflection prospecting is described as the bouncing of seismic waves off boundaries between types of rock in the subsurface (Sheriff and Geldart, 1995). It involves the measurement of the two-way travel time of seismic waves transmitted from surface and reflected back to the surface at the interfaces between contrasting geological layers. Reflection of the transmitted energy will only occur when there is a contrast in the acoustic impedance (product of the seismic velocity and density) between these layers (Slein and Wysession, 2003). The strength of the contrast in the acoustic impedance of the two layers determines the amplitude of the reflected signal. The reflected signal is detected on surface using an array of high frequency geophones. Reflection prospecting is different from refraction prospecting as it is essentially an echo sounding procedure, since the source and the geophone spread is small relative to the depths usually measured (Deidda and Ranieri, 2001). As a result of this, reflection prospecting is not subject to inhomogeneity and low velocity layer limitations as refraction techniques. Reflection depths are generally more precise to the same interface than refraction depths (Woolery *et al.,* 2002). Seismic reflection exploration is known to be sensitive to small errors in data collection and processing hence care needs to be taken when interpreting the results (Seeples and Miller, 1998).

Seismic data acquisition requires a suitable sound source and an appropriate set of detectors. On land, dynamite is the main energy source, although this have been replaced in some areas by special trucks called vibrators with metal plates on their undersides to shake the ground in a controlled manner (Sheriff and Geldart, 1995). At sea, powerful air and water guns are the main energy source. The sensitive detectors, which record the reflection sound waves, are laid out to form directional antennae. These are called geophones on land and in water they are called hydrophones. The sound waves picked up by the detectors are recorded on tape.

For onshore 2D surveys, the geophones are planted on the surface of the ground along the survey line in patterns. The sound pulses are fired in sequence along the line, with the geophones being moved from the back to the front of the line to follow the progression of the survey. Seismic data are recorded digitally so they can be manipulated by computers. This computer processing is needed to ensure that the seismic image is as sharp and reliable as possible (Hatton *et al.,* 1986; Yilmaz, 2001).

Interpretation is a process in which the seismic and geological data are combined to obtain information about the subsurface of the earth. It may determine general information about an area, locate prospects for drilling exploratory wells, or guide development of an already discovered field. The process of normal interpretation usually involves identifying a reflection, picking the reflection, timing the reflection, posting the time on the base map and contouring (Miller *et al.,* 1995; Wightman *et al.,* 2003).

Seismic reflection profiling is the principle method that the petroleum industry uses to explore for oil and gas trapping structures in sedimentary rocks (Slein and Wysession, 2003). All commercial accumulations of hydrocarbons are formed within sedimentary basins of those areas of the world where subsidence of the earth's crust allowed the accumulation of thick sequences of sedimentary rocks. However, not all sedimentary rocks contain oil or gas. The presence of large quantities of hydrocarbons in a sedimentary basin, indicate that six independent requirements have been met. The first three relate to the formation of hydrocarbons within the basin which are: there must have been a source rock rich in organic carbon to be converted to hydrocarbons, there must have been sufficient heat over long periods of time to convert the organic carbon into hydrocarbons and there must have been migration pathways to enable the hydrocarbons to migrate upwards from the source rock and perhaps reach a trap (Sheriff and Geldart, 1995).

The other three conditions concern the trap, which prevents migrating hydrocarbons from escaping to the surface and they are that: there must be a suitable reservoir rock, such as limestone or sandstone, which have sufficient porosity to store the hydrocarbons and be permeable enough to allow them to be produced at economic rates, there must be an effective seal of impermeable rock such as clay, shale or slat above and against the reservoir and there much be a closed structure, a geometric disposition of the reservoir and seal to arrest the upward migration of the hydrocarbons (Sheriff and Geldart, 1995).

Seismic information is very expensive to acquire but more expensive if the data are poorly or wrongly interpreted. This study is therefore aimed at identifying the hydrocarbon capabilities of Umureute and Amiynaibo through the collection and accurate interpretation of the seismic data at two stratigraphic levels. This study will also map the subsurface structure of rock formations and structural traps that are potential house for hydrocarbons. This study will serve as a reconnaissance tools for further work in the area.

MATERIALS AND METHOD

The survey was carried out around Umureute and Amiynaibo both in Ika North Local Government Area of Delta State, Nigeria. The area lies between latitude $6^0 05^I$ to

$6^0 29^I$N and longitude $6^0 30^I$ to $6^0 37^I$E and covers an area of about 277 Km^2. The study area was first surveyed and the positions of each shot line marked to make sure that the positions of each shot point are in the right position on the base map as shown in figure 1.

The seismic data were obtained by using the dynamite as the energy source while the geophone was used as the recording instrument in accordance to standard reflection data acquisition as recorded by Sheriff and Geldart, 1995. The recorded signals were also subjected to signal processing and imaging processes to prepare them for interpretation.

A total of fourteen seismic reflection data using standard reflection technique were acquired and interpreted in this study. These consist of nine (9) dip lines and five (5) strike lines. Using the seismic section, two reflections representing two different strategraphic layers were identified and interpreted. First all faults observed in the seismic sections were posted on the base map. The interpretation was then carried out using the four basic steps which are as follows:

(i) Picking: The two identified reflections were picked simultaneously by marking the reflection with pencil and colouring lightly below to remove ambiguity in measuring time. The picking was first done on the reference seismic section (D5) and then carried on to the next sections. This was done by first determining the points of intersection of the two sections and making sure that they tie. The picked horizon was then traced on this new section. This procedure was carried out for all dip lines and strike lines.

(ii) Timing: The picked horizons were timed from the seismic section by reading the reflection times of the seismic signals from datum. This was achieved in this work by using a digitizing table to maximize the accuracy of the timing.

(iii) Posting: The reflection time for each digitized point for a particular horizon was plotted at the appropriate shot point location. This means that we take a shot point measure the time from datum and transfer this time to the base map.

(iv) Contouring: All points with the same reflection time on the base map were then joined together to produce the contour maps in this study.

The time on the seismic section represent some depth below datum hence it is necessary to convert the time scale to depth. This is possible by using velocity information either from the seismic data or well data (Anomohanran, 2004). In this study, the velocity information from the seismic data was used to convert the time scale to depth. The connecting equation as given by Anomohanran 2004 was used as shown in equation 1.

$$V(z) = V_0 + KZ \qquad 1$$

Equation 1 when integrated and rearranged gives

$$Z = \frac{V_0}{K} \operatorname{Exp}(KT) - 1 \qquad 2$$

By applying the data obtained in this study the time to depth equation was obtained as;

$$Z = \frac{6661.8}{2.112} [\operatorname{Exp}(0.0003T) - 1] \qquad 3$$

Z is the depth in metres and T is time in milliseconds. Equation 3 was used in this study to convert the time scale on the seismic section to depth.

RESULTS AND DISCUSSION

The base map which shows the positions of the dip and the strike lines are as shown in figure 1. The positions of all the recording geophones are shown on the base map and it is on these points that the time for the picked horizon are posted. The contoured maps for the two picked horizons are as shown in figure 2 and 3 while the conversion table of the observed time on the seismic section to depth of the horizon is as shown in table 1.

Table 1: Time to depth conversion table

Time (ms)	Depth (m)	Time (ms)	Depth (m)	Time (ms)	Depth (m)	Time (ms)	Depth (m)
760	808	1080	1207	1400	1646	1720	2130
800	856	1120	1260	1440	1704	1760	2194
840	904	1160	1313	1480	1763	1800	2259
880	953	1200	1367	1520	1822	1840	2324
920	1003	1240	1421	1560	1883	1880	2390
960	1053	1280	1477	1600	1943	1920	2457
1000	1104	1320	1533	1640	2005	1960	2525
1040	1155	1360	1589	1680	2067	2000	2593

The interpretation of the first reflection at depth of 1053 metres shows the presence of two major growth faults as shown in figure 2. The analysis of the contour map in figure 2 shows that the horizon deepens from the North East to South West with close prospect existing around Amiynaibo. The reflection started at a depth of 808 metres and deepens down to a depth of 1646 metres. The interpretation of the second reflection at a depth of 2005 metres shows the presence of two major growth faults as in figure 1 and two minor faults as is seen in the contour map shown in figure 2. The reflection which begins at 1646 metres also deepens from the North East down to the South West at a depth of 2593 metres. The contour maps shows a closure at Umureute at a depth of 1822 metres against the first major fault which act as seal to this prospect. Also at the horizontal, there is a second closure at Amiynaibo with the second major fault sealing up the closure at a depth of 2130 metres. These two closures in the contour are good prospects for hydrocarbon existence as they satisfy the enabling conditions for the discovery of hydrocarbons.

Analysis of the study therefore shows that Umurente and Amiynaibo have hydrocarbon capability at a depth of 1822 metres and 2130 metres. At these depths, drilling could be made to recover the mineral stored in the closure. This capability is lacking in horizon one.

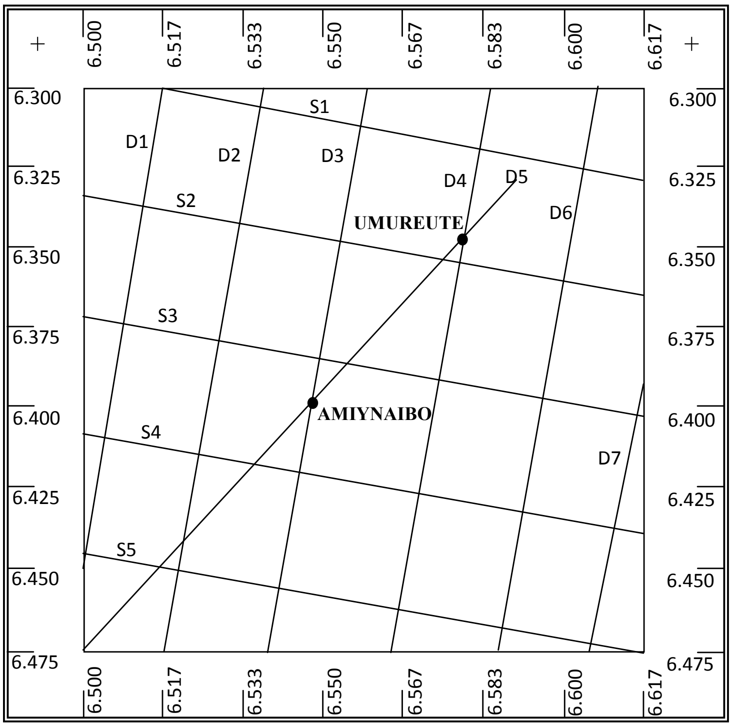

Fig. 1: Base map of the study area showing the shot lines

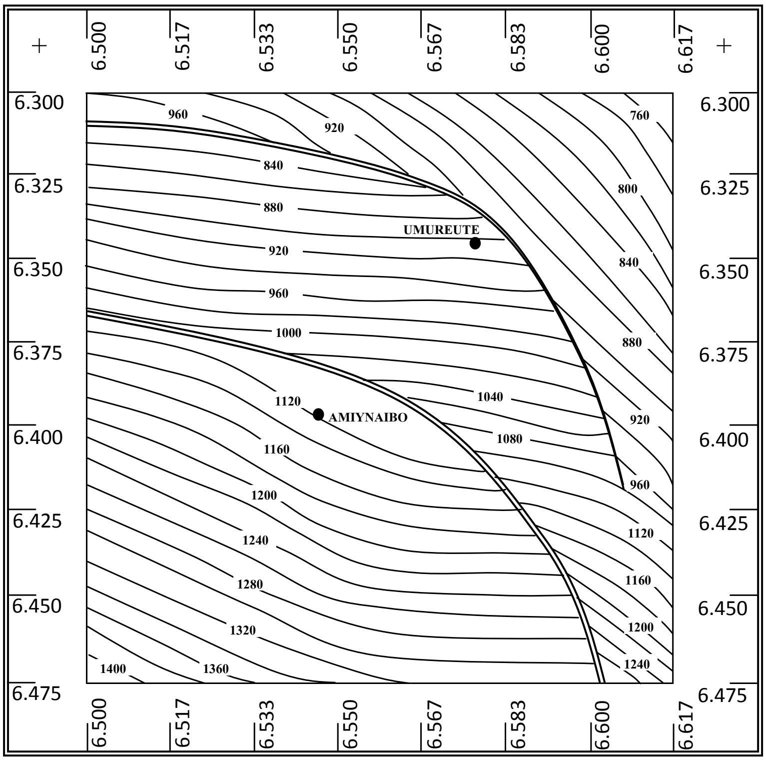

Fig. 2: Contour map of reflection 1 at depth of 1053 metres from datum.

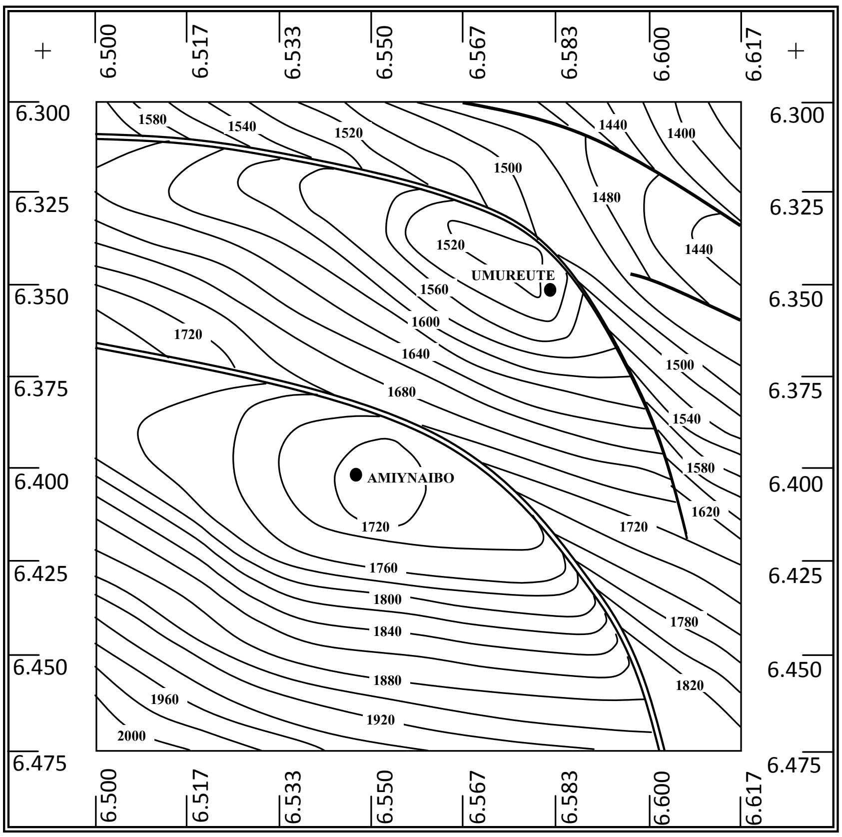

Fig. 3: Contour map of reflection 2 at depth of 2005 metres from datum.

CONCLUSION

This study which investigated seismic reflection data collected around Umurente and Amiynaibo was interpreted along two strategraphic layers. The study shows that hydrocarbon potential exist along the second horizon at a depth of 1822 metres for Umurente and a depth of 2130 metres for Amiynaibo. This study which is one among series of investigations to ascertain the presence of hydrocarbon in the area has uncovered the existence of two closures existing against two major growth faults respectively. The faults act as seal to fluid migration to the surface.

REFERENCES

Anomohanran, O. (2004). The use of third degree polynomial for accurate conversion of seismic time to depth and vice versa. *Journal of the Nigerian Association of Mathematical Physics* **8:** 241-246.

Deidda, G. P. and Ranieri, G. (2001). Some SH-wave Seismic Reflections from Depths of less than three meters. *Geophysical Prospecting* **49:** 499-508.

Guy, E. D., Nolen-Hoeksema, R. C., Daniels, J. J. and Lefchik, T. (2003). High-resolution SH-wave Seismic Reflection Investigations near a Coal Mine -related Roadway Collapse Feature. *Journal of Applied Geophysics* **54:** 51-70.

Hammer, P. T. C. and Clowes, R. M. (1996). Seismic Reflection Investigations of the Mount Cayley Bright Spot: A midcrustal reflector beneath the Coast Mountains, British Columbia. *Journal of Geophysical Research* **101(B9):** 119-20, doi: 10.1029/96JB01646.

Hatton, L., Worthington, M. H. and Makin, J. (1986). *Seismic Data Processing: Theory and Practice.* Blackwell, Palo Alto, CA. 177PP.

Kelly, K. R., Ward, R. W., Treitel, S. and Alford, R. M. (1976). Synthetic Seismograms: A finite difference approach, *Geophysics* **41:** 2-27.

Miller, R. D., Anderson, N. L., Feldman, H. R. and Franseen, E. K. (1995). Vertical Resolution of a Seismic Survey in Stratigraphic Sequences less than 100 m Deep in Southeastern Kansas. *Geophysics* **60:** 423-430.

Okwuezi, E. E. and Offong, A. O. (1992). Seismic reflection investigations of the foundation conditions of the rock soil in part of Akwa Ibom State of Nigeria, *Journal of Physics* **4:** 114-119.

Seeples, D. W. and Miller, R. D. (1998). Avoiding Pitfalls in Shallow Seismic Reflection Surveys. *Geophysics* **63:** 1213-1224.

Slein, S. and Wysession, M. (2003). *An introduction to seismology, earthquakes and earth structure.* Blackwell Publishing, Malden Massachusetts.

Sheriff, R. E. and Geldart, L. P. (1995). Exploration Seismology, Second Edition, Cambridge University Press, London.

Wightman, W. E., Jalinoos, F., Sirles, P., and Hanna, K. (2003). *Application of Geophysical Methods to Highway related Problems.* Federal Highway Administration, No. FHWA-IF-04-021.

Woolery, E. W., Wang, Z., Street, R. L. and Harris, J. B. (2002). AP and SH Wave Seismic Reflection Investigation of the Kentucky Bend Scarp in the New Madrid Seismic Zone. *Seismological Research Letters* **73:** 628-639.

Yilmaz, O. (2001). Seismic Data Analysis: Processing Inversion, and Interpretation of Seismic Data. *Society of Exploration Geophysicists,* Tulsa, OK.