International Journal of
Science Inventions Today
www.ijsit.com
ISSN 2319-5436
Research Article

SEISMIC ATTRIBUTES AND PETROPHSICAL PROPERTIES OF IBA FIELD, NIGER DELTA, NIGERIA

Itiowe K[1], Adiela U.P[2] and Emudianughe J[3]

[1]*Department of Geology, University of Port Harcourt, Port Harcourt, Nigeria*

[2]*Department of Earth Sciences, Federal University of Petroleum Resource, Effurun*

[3]*Department of Petroleum Engineering, Nigerian Agip Oil Company, Port Harcourt*

ABSTRACT

In this paper we have described some commonly utilized seismic attributes that are of complementary value to the information acquire through traditional methods of seismic interpretation. Seismic attributes extraction and analyses have proven to offer new information and insights into structural and stratigraphic mapping interpretations. They further assist greatly in delineation of hydrocarbon leads and prospects which subsequently help to reduce exploration and development risk.

INTRODUCTION

A seismic attribute is any measure of seismic data that helps us better visualize or quanify features of interpretation interest. It could be described as powerful aid to improve accuracy of interpretations and predictions in hydrocarbon exploration and development. Seismic attributes allow the geoscientists to interpret faults and channels, recognize depo-sitional environments, and unravel structural deformation history more rapidly. They are also useful in checking the quality of seismic data for artifacts delineation, seismic facies mapping, prospects identification, risk analysis and reservoir characterization. Combining information from adjacent seismic samples and traces using a physical model (such as dip and azimuth, waveform similarity, or frequency content), seismic attributes often organize features into displays that provide enhanced images for either a human interpreter or for modern geostatistical or neural-network computer analysis. While seismic attributes are sensitive to lateral changes in geology, they are however also quite sensitive to lateral changes in noise.

Seismic attributes fall into two broad categories – those that quantify the morphological component of seismic data and those that quantify the reflectivity component of seismic data. The morphological attributes are applied to extract information on reflector dip, azimuth, and terminations, which can in turn be related to faults, channels, fractures, diapirs, and carbonate buildups. The reflectivity attributes extract information on reflector amplitude, waveform, and variation with illumination angle, which can in turn be related to lithology, reservoir thickness, and the presence of hydrocarbons. While in the reconnais-sance mode, 3D seismic attributes could be applied to rapidly delineate structural fea-tures and depositional environments. Whereas in reservoir characterization mode, 3D seismic attributes are calibrated against real and simulated well data to evaluate hydrocarbon accumulations and reservoir compartmentalization.

AIM OF THE STUDY

This study is mainly an academic exercise meant to exposing the researcher to the development of scientific skills and competency in carrying out an independent research work; analysis and interpretation of geologic data; and reporting of interpreted results.

Location of the area:

The Niger Delta occurs at the southern end of Nigeria bordering the Atlantic Ocean extend-ing from about Longitude 3° - 9° E and from Latitude 4° 30' - 5° 20'N (Figure 1)

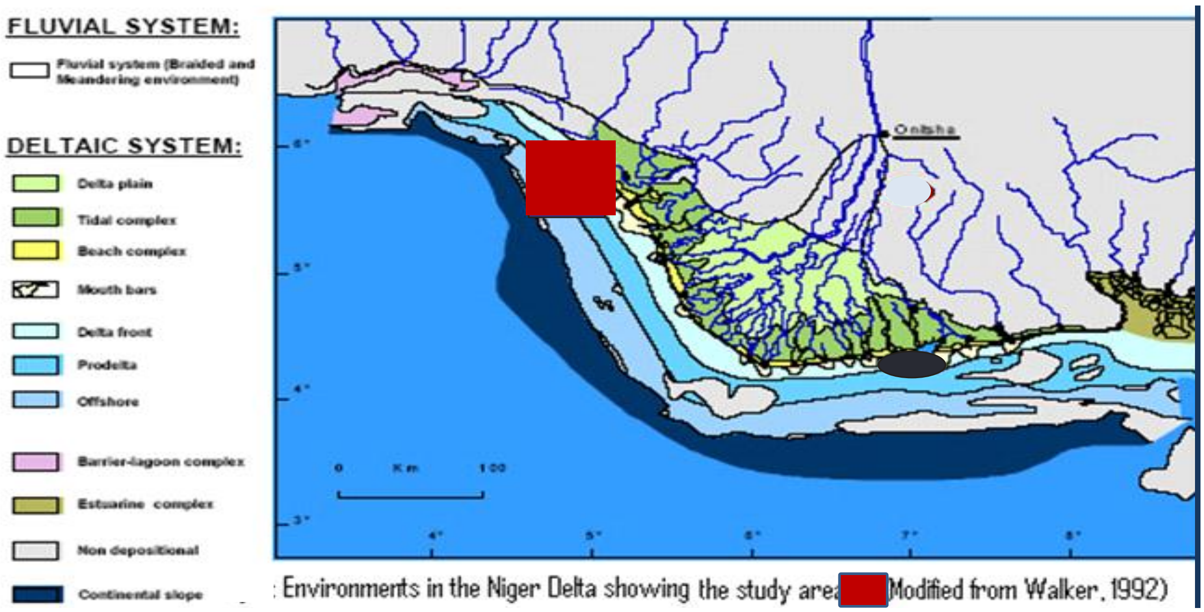

Figure 1: Location of study area (IBA Field) with respect to coordinates, fluvial and deltaic systems of the Niger Delta, Southern Nigeria.

OBJECTIVES OF THE STUDY

The objectives of this study include, but not limited to the:

- Definition of the rock properties of the IBA Field
- Determination of the seismic attributes of the IBA Field
- Identification and definition of potential reservoirs and key hydrocarbon horizons useful for field development
- Determination of fluid types and contacts in reservoirs
- Definition of the limits of gas and/or oil production of the reservoirs
- Determination of variables that influenced variation in rock properties of ETOP Field

METHODOLOG

DATA SETS:

The following data sets were obtained and used for this study:

- ❖ Base map of the field
- ❖ A suite of wireline logs of five wells
- ❖ 3D Seismic sections
- ❖ Check shot data
- ❖ Biofacies data

Seismic database and methodology:

The SEG-Y format 3D seismic dataset consist of inlines 5800-6200 and crosslines 1480-1700, with line spacing of 30 meters covering a total area of about 85.6 km^2. Horizons are usually picked based on the prospective zones identified from petrophysical analysis of well logs. Tops and Bases of these horizons were mapped and correlated across the available wells . The correlation was done using gamma-ray and resistivity logs. Three horizons were mapped and correlated. The tops and bases of these horizons were tied to the seismic section to aid the construction of time surface maps and generate subsequently depth maps using the inline and crossline numbers range from 7800 to 8200 and from 1600 to 1800, respectively. The reflection quality of the data is very good; faults and stratigraphic picks for horizons are easily recognizable. The wells IBA 01, IBA 02, IBA 03, penetrated depths of −14,019.00 ft, −10,996.00 ft, −16,000.69 ft. In order to increase the accuracy of subsurface imaging, generate maps and well log cross-sections, geophysical softwares like SMT Kingdom Suite, Schlumberger's Petrel, and Senergy's Interactive Petrophysics were used to produce a comprehensive geophysical and geological evaluation of the study area.

Petrophysical parameters and properties of rocks were determined from the following well log types:

- ❖ Gamma Ray Log (GR)
- ❖ Compensated Bulk Density Log (CDL)
- ❖ Compensated Neutron Porosity Log (CNL)
- ❖ Resistivity Log (LLD and LLS)
- ❖ Sonic Log
- ❖ Caliper Log

A series of volume seismic attributes such as variance edge and sweetness attributes visualized in Schlumberger's Petrel® software interface were run on the available 3D seis-mic volume data to investigate potential structural and stratigraphic controls within the study area. Similarly, surface attributes including interval average arithmetic, acoustic

RESULTS AND OBSERVATION

The prime motivation for using seismic reflection data to characterize the reservoirs comes from its ability to provide useful relationship between the seismic reflection data and physical properties. The results of running the volume attributes such as sweetness, variance edge, RMS amplitude and relative acoustic impedance on the 3D seismic data from the study area alongside with the mapped horizons and faults. The significant effects of the acoustic amplitude, lower loop and interval mean attributes on the mapped horizons surfaces are also presented

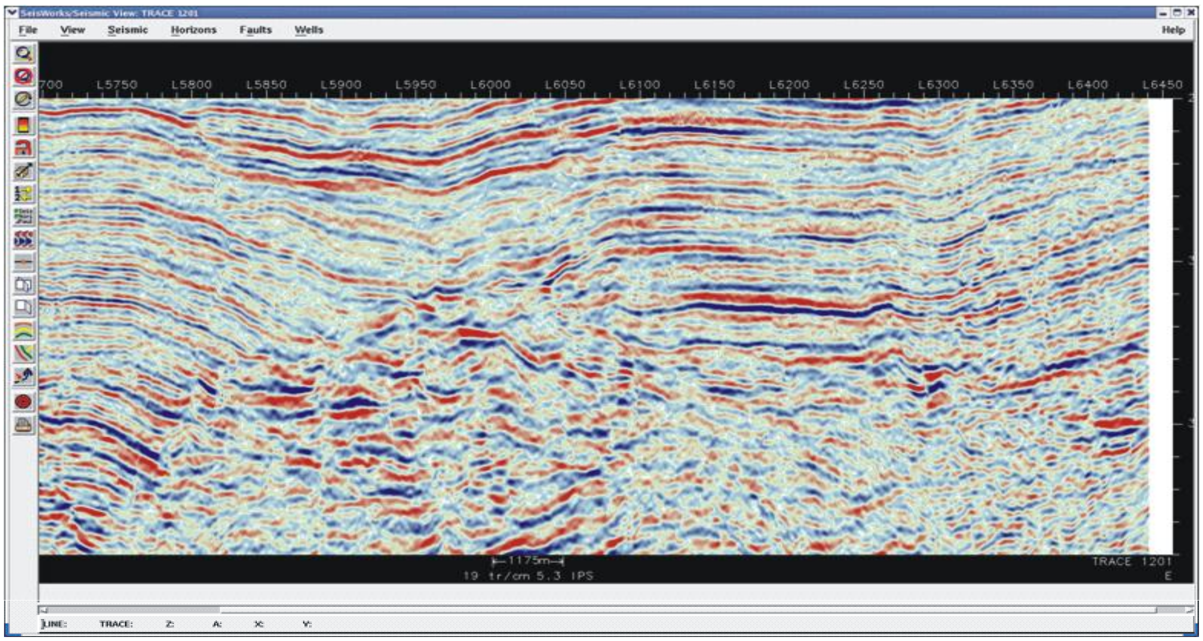

Figure 2: Trace 204 of 3D-Seismic of IBA Field

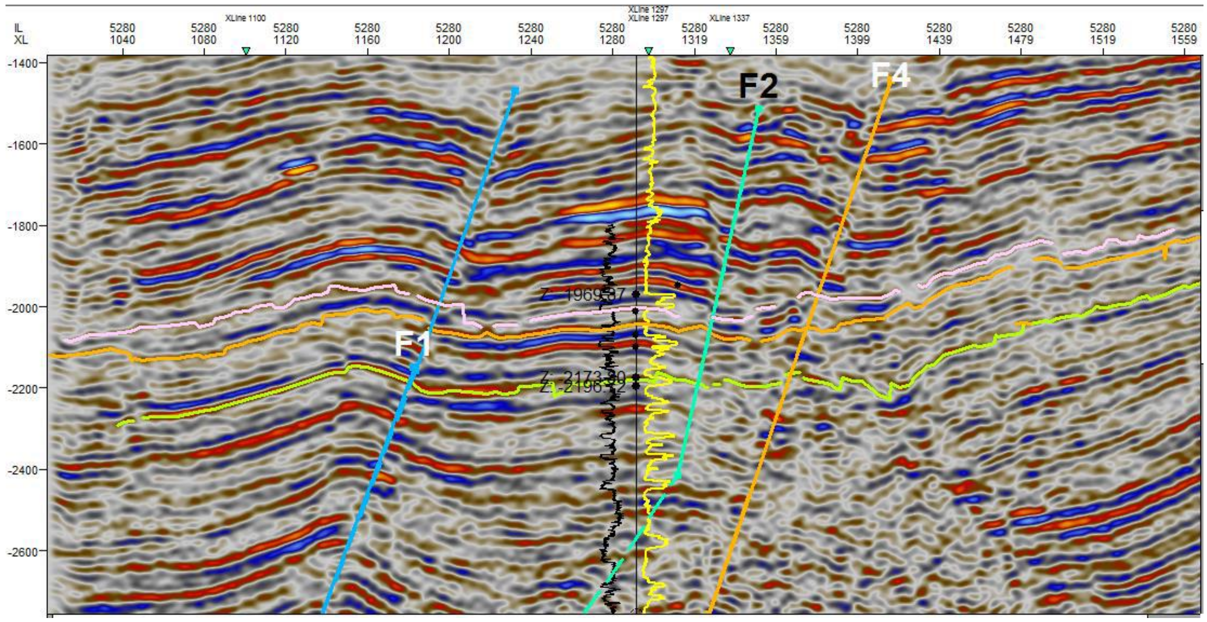

Figure 3: Well to Seismic tie

Faults signatures were enhanced through calculating the variance within the seismic data volume with an edge enhancement option, thereby enabling the mapping across discon-tinuities within the data. RMS amplitude attribute correlate strongly with formation porosity and/or liquid saturation (oil/water vs. gas). The attributes were able to demonstrate the prediction of lithology and porosity within the reservoir layers by extracting seismic attributes from the 3D seismic data.

STRUCTURAL STYLES AND HYDROCARBON PROSPECTS:

The predominant structural features within the area are concave upward faults with downdip planes. Three major faults, two intermediate faults and one minor faults cutting through the reservoir sand units were identified and mapped on the variance edge seismic attributes. The probable hydrocarbon prospects in the field consist of the anticlinal structure and roll over structure assisted by faults. Fault closure against down to south crescentic growth fault derived from a roll over anticline, is seeing localized south eastern section of the horizon H2

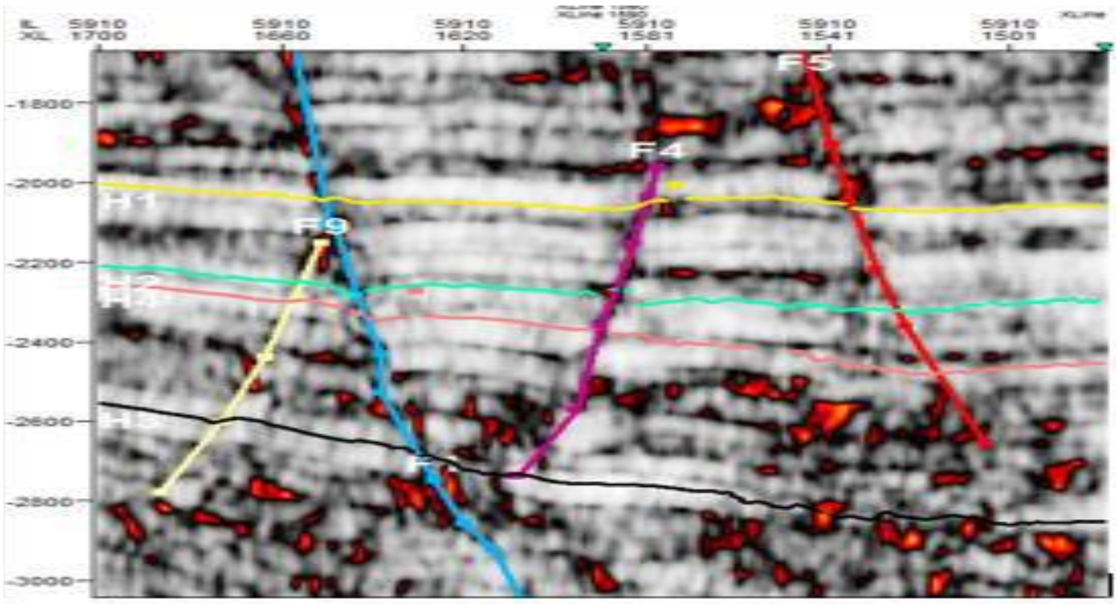

Figure 4: Volume attributes with Picked horizons and faults

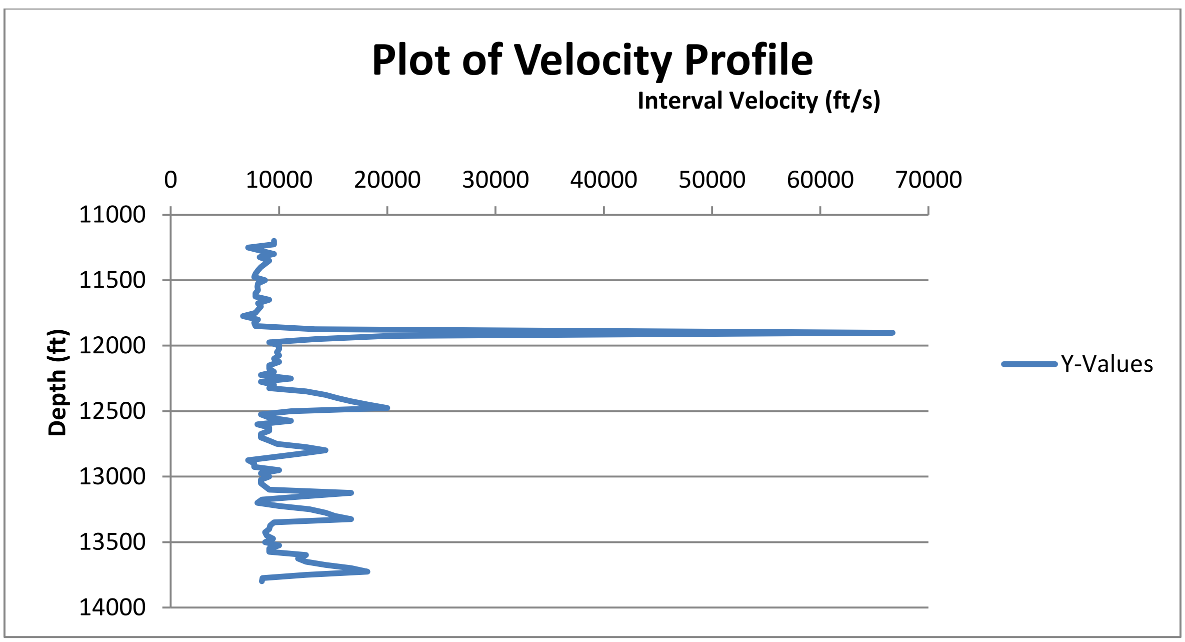

Figure 5: Interval velocity profile with depth at IBA 01

SEISMIC ATTRIBUTES ANALYSIS:

The essence of running sweetness attributes on seismic volume is to identify and sub-sequently map sweet spots on the seismic section. sweetness region within the seismic data indicating characteristically high amplitude and low frequency of hydrocarbon bearing sand units. Though sweetness attribute is quite effective for channel detection and characterization of gas charged bearing sand units, it is known to be less useful when the acoustic impedance contrast between shale and sand units are low, and also less effective when both lithologic units are highly inter bedded. The variance edge. The result of interval velocity obtained for lithologic units at the wells show shales as having higher interval velocities than the sand units, the average interval velocity increasing down the depth and higher for the units . However, shale 2 had unusually very high average velocity value of 27,272.25ft/s at Well 03 and it decreases laterally to an average value of 9,855.67ft/s, the average of this shale unit for the field being 21,433.96ft/s This is closely followed by shale 2 with average interval velocity of 14,336.13ft/s at and 9,635.44ft/s at , average field value being 11,585.29ft/s compared with shale units 4,with average field velocity values of 15,2733.13ft/s, 11,093.39ft/s respectively.

The close examination of the reflection and transmission values across the field reveals *non-zero* value for reflection coefficient and *non-unity* for transmission coefficient. This indicates that the bulk of seismic energy incident on a rock interface is transmitted and only a small proportion is reflected. According to Keary and Brooks (1984), if reflection coefficient is equal to zero (that is, $R = 0$), all the incident energy is transmitted. This happens when there is no contrast of acoustic impedance across an interface (that is, $Z_1 = Z_2$) even when the density and velocity values are different in the two layers. And, if R is equal to +1 or -1, all the incident energy is reflected.

Clay or shale smears along the fault planes during faulting provided a seal to migrating gas and oil. The abundance of hydrocarbon distribution within the field could possibly be associated with lateral spill-points at the termination of discontinuous faults and seals, or lack of seals along fault planes (Bouvier et al, 1989).

Shales have higher interval velocities than the sands. Their velocities increase down the depth while those of the sands decrease with increasing depth until at shale 4 / sand K boundary where the trend is otherwise. This boundary marks the limit beyond which the sandstone units begin to display marked reduction in porosity and permeability due to high volume of shale content.

Reservoir Sands of the study area were not at irreducible water saturation. Much water and wet hydrocarbons would be produced by wells bored through these units. Some other sand units, were at irreducible water saturation at some well locations and not at irreducible at other well locations. These reservoir zones would produce water-free hydrocarbons.

All the rock units evaluated belonged to Agbada Formation and dates Oligocene - late Miocene. The upper unit of Agbada Formation deposited in Coastal Swamp depobelt. dates middle – late Miocene.. The lower Agbada belonging to the facies of Greater Ughelli and Central Swamp depobelts date Oligocene – middle Miocene. It comprises of The upper Agbada which is identified with P784/P820 and F9600/F9620 fossil zones.

SEISMIC ATTRIBUTE INTERPRETATION X-Line section:

Seismic Unit	Reflection geometry	Reflection strength	Configuration	Continuity	Amplitude	Depositional setting
A	Contourite; sheet-like mound, downlapping of faults	Very strong	Parallel – sub parallel; weakly folded and tilted southerly	High/good, but are fault-truncated	High	Low energy deltaic plain / platform; Shelf margin shore face
B	Wedge shape, downlaps at base	Weak - Moderate	Sub-parallel – divergent; faulted, weakly folded; shows sigmoidal clinoform	Poor - Moderate	Low - Medium	Low – medium energy deltaic front; inner-middle neritic shelf margin
C	Slump structure; Base not defined	Weak	Hummocky and chaotic	Poor – very poor	Low	High energy basin slope, submarine canyon, lower slope and deep water

Table 1: Seismic attributes from the X-line section

The three (3) seismic reflection packages (figure 4), from top to bottom, was identified based on their reflection patterns. Between shot points T1000 and T1350 and between the time windows of 1500msec to about 2500msec, the beds in Unit A tend to be continuous with parallel – sub-parallel, strong reflection strength, uniform frequency and high amplitude. This unit is interpreted as massive sand body with shale intercalations deposited in a low energy deltaic plain / platform and shelf margin shore face.

The continuity of Unit A is distorted by folding and faulting. Six faults identified were designated F_1, F_2, F_3, F^1, F^2, and F^3. Fault F_1, F_2, and F_3 are synthetic (growth) faults that dip in the basinward direction while faults F^1, F^2, and F^3 are antithetic faults dipping in landward direction.

The seismic reflection package labeled Unit C displays hummocky to chaotic configuration, with weak reflection and low amplitude. Reflection continuity is poor to very poor. This unit might have been formed by gravity mass transport in a high energy basin slope, submarine canyon, lower slope and deep water environment

REFERENCES

1. Archie, G. E., 1942. The electrical resistivity log as an aid in determining some reservoir characteristics. *Petroleum Technology*, 5, pp. 54- 62.
2. Asquith, G. B. and Gibson, C., 1982. *Basic Well Log Analysis For Geologists*. AAPG Publications, Tulsa, 216p.
3. Bigelow, E. L., 1987. *Fundamentals of dip log analysis*. Atlas Wireline Services, Houston, 230p.
4. Keary, P. and Brooks, M. 1984. *An Introduction to Geophysical Exploration*. Blackwell Scientific Publications, Oxford, 296p.
5. Kulke, H., 1995. Nigeria. In: Kulke, H., ed., *Regional Petroleum Geology of the World. Part II: Africa, America, Australia and Antarctica*. Gebrüder Borntraeger, Berlin, pp. 143-172.
6. Nwachukwu, S. O., 1972. The Tectonic Evolution of the Southern Portion of the Benue Trough, Nigeria, *Geol. Mag.* 109, pp. 411-419.
7. Schlumberger, 1977. *Log Interpretation Charts*. Schlumberger Well Services Inc., Houston, 170p.
8. Schlumberger, 1985. *Well Evaluation Conference, Nigeria*. International Human Resources Development Corporation (IHRDC) publication, Boston, pp. 16-60.
9. Schlumberger, 1991. *Log Interpretation Principles/Applications*. Schlumberger Wireline and Testing, Texas.
10. Schlumberger, 2009. *Geological significance of seismic attributes.* http://www.glossary.oilfield.slb.com/DisplayImage.cfm?ID=222
11. Sheriff, R. E., 1980. *Seismic Stratigraphy*. International Human Resources Development Corporation (IHRDC), Boston, 227p.
12. Short, K. C. and Stauble, A. J.,1967. Outline of the Geology of Niger Delta. *AAPG Bulletin*, 51, pp. 761-779.
13. Stacher, P., 1995. Present Understanding of the Niger Delta Hydrocarbon Habitat. *In*: Oti, M. N., and Postma, G., eds., *Geology of Deltas*, A. A. Balkema, Rotterdam, pp. 257-267.