International Journal of Advanced Research in Engineering Technology & Science ISSN: 2394-2819
Email: editor@ijarets.or Volume-4, Issue-7 July- 2017 www.ijarets.org

PETROLEUM AND PETROPHYSICAL CHARACTERISTICS OF EKI -1 WELL, X- FIELD NIGER DELTA, NIGERIA

ADIELA, U.P [1], JACKSON, C. A [2], AYODELE MOSES [3]

[1] Department of Petroleum Engineering,, Nigerian Agip Oil Company, Port Harcourt, Nigeria

[2,3] Department of Geology, University of Port Harcourt, Port Harcourt, Nigeria

ABSTRACT

There are two hydrocarbon reservoirs observed in the Eki-1 Well. These are reservoir A and B.Reservoir A occurs at the interval of 5695 – 5824ft (1736-1775m) and has a gross (G) and net (N) thickness of sand, 129ft (39.3m) and 118.5ft (36.1m) respectively, with N/G ratio of 0.9; water saturation (S_w) of 19% and hydrocarbon saturation (S_h) of 81%, porosity (ø) and permeability (K) of 32% and 5024md while its transmissivity is 648148mdft. Therefore, the reservoir has both excellent porosity and permeability. Reservoir B occurs at the interval of 8370 – 8478ft (2551-2584m) and has a gross (G) and net (N) thickness of sand, 108ft (32.9m) and 97.4ft (29.7m) respectively, with N/G ratio of 0.9; water saturation (S_w) of 14% and hydrocarbon saturation (S_h) of 86%, porosity (ø) and permeability (K) of 30% and 1975md respectively. Its transmissivity is 213311mdft. Therefore, the reservoir has both excellent porosity and permeability

INTRODUCTION

The potential and performance of reservoirs depend on both engineering and petrophysical parameters. The engineering parameters are rock compressibility, reservoir storativity, transmissivity, etc, while the fundamental petrophysical parameters are porosity, permeability, and fluid saturation. The relationships among these properties are used to identify and characterize reservoirs. Reservoir characterization is the continuing process of integrating and interpreting geological, geophysical, petrophysical, fluid and performance data to form a unified, consistent description of a reservoir and produce a geological model that can be used to predict the distribution of reservoir properties throughout the field. It can also be defined as the quantification, integration, reduction and analysis of geological, petrophysical, seismic and engineering data (Tinker, 1996).

This research work is on the application of wireline logs to identify and quantify hydrocarbon reserves and evaluate rock properties in part of the offshore Niger Delta. The petrophysical analyses of the wireline logs provide reservoir characteristics (porosity, permeability and fluids saturation).

LOCATION OF STUDY

The field under study is pseudo-named “X’’ field. The field is located in the offshore Niger Delta, but the co-ordinates of the location of this field were concealed due to proprietary reasons.

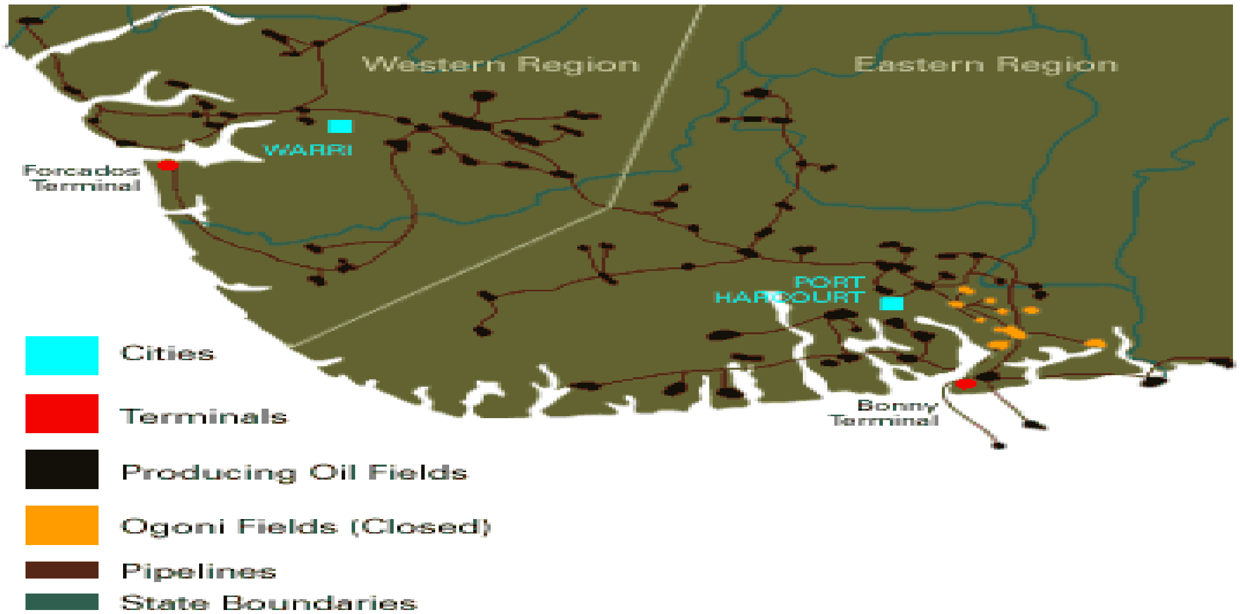

Figure. 1a: SHOWING MAP OF NIGER DELTA WITH PRODUCING OIL FIELDS.

OBJECTIVES OF STUDY

This research is aimed at evaluating the reservoir potential of X-field to achieve the following objectives:
To identify the various sand bodies and correlate them across the field, then to identify and quantify hydrocarbons in the reservoirs sand bodies and determine the petrophysical characteristics of sand bodies.

ORIGIN AND PALEOGEOGRAPHY OF THE NIGER DELTA BASIN

Accumulation of marine sediments in a sedimentary basin probably commenced in Albian time after the opening of the South Atlantic Ocean between the African and South American continents. True delta development, however, started only in the late Paleocene/ Eocene , when sediments began to build out beyond troughs between basement horst blocks at the northern flank of the present delta area. Since then, the delta plain has prograded southward unto oceanic crust, gradually assuming a convex-to-the sea morphology (Doust and Omatsola, 1990).

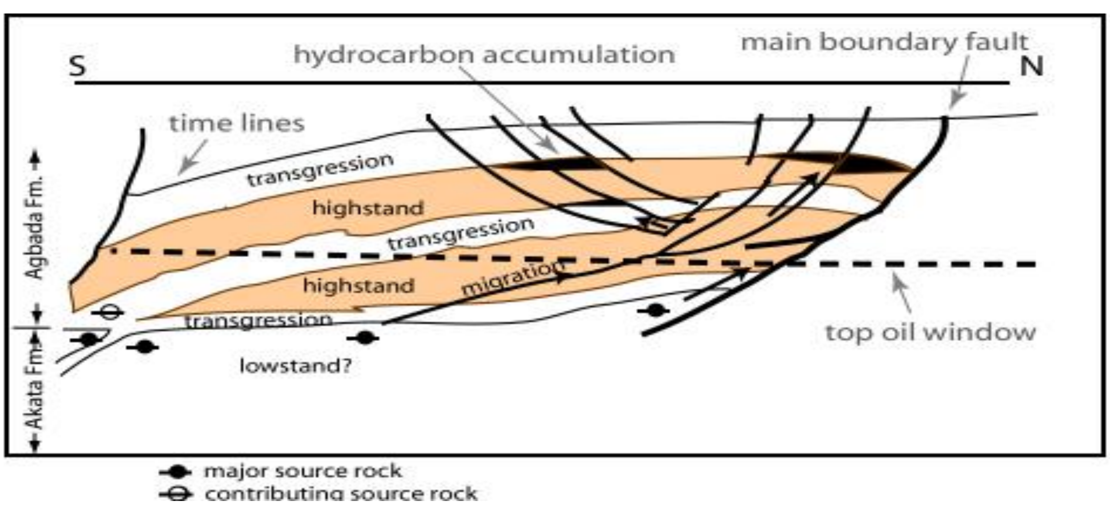

Figure 1b: Sequence stratigraphic model for the central portion of the Niger Delta showing the relation of source rock, migration pathways and hydrocarbon traps related to growth faults. The main boundary fault separates mega structures which represent major breaks in the regional dip of the delta.

METHODOLOGY

DATA ANALYSIS

Since the available data is not evenly distributed, there is need for using statistical and experimental method of data distribution. Variogram analysis characterizes the spatial continuity or roughness of the data set. The major and minor directions of the data distribution are changed from the default and normal statistical method of analysis was used for this research work. This helped us redistribute our data for better output during the modelling petrophysical process.

PETROPHYSICAL ANALYSIS

Geophysical well logging is the recording of the properties or characteristics of the rock formations transversed by measuring apparatus in a borehole, which largely obviates the necessity of the expense of coring. Petrophysical evaluation was carried out for the reservoir sand bodies across the well in the study area from wireline logs by using relations (formulae) that are universally used in the estimation of reservoir sands bodies of the following petrophysical parameters: Volume of Shale (V_{Sh}), Porosity (ϕ), Formation Factor (F), Irreducible Water Saturation (Swirr), Permeability (K), Water Saturation ($S_{w)}$, Hydrocarbon Saturation (S_h) and Bulk Volume Water (BVW).

RESULTS AND INTERPRETATION

PETROPHYSICAL RESULTS AND INTERPRETATION

Total of two hydrocarbon reservoirs in Eki-1 Well were identified and evaluated.

Petrophysical Quantitative Analysis

A Porosity log for Eki-1 Well was provided; calculated average porosity for reservoir's A and B are 0.32 and 0.30 respectively.

Calculation of Formation Factor

Using Humble's formula for unconsolidated formations typical of Niger Delta Sandstones:

$$F = \frac{0.62}{\phi^{2.15}}$$

Reservoir A

Where $\phi = 32$

$$F = \frac{0.62}{32^{2.15}} = \frac{0.62}{1722.2} = 0.00036$$

Reservoir B

Where $\phi = 30$

$$F = \frac{0.62}{30^2} = \frac{0.62}{900} = 0.000689$$

Calculation of Irreducible Water Saturation (Swirr)

Reservoir A

Swirr = $\left[\frac{F}{2000}\right]^{1/2}$, where Formation factor = 0.00036

By substitution,

$$Swirr = \left[\frac{0.00036}{2000}\right]^{1/2} = \left(1.8 \times 10^{-7}\right)^{1/2} = 0.000424$$

Reservoir B

Where F= 0.000689

$$Swirr = \left[\frac{0.000689}{2000}\right]^{1/2} = \left(3.445 \times 10^{-7}\right)^{1/2} = 0.000587$$

Calculation of Permeability (k)

Reservoir A

$$K = \frac{0.136 \times \phi^{4.4}}{(Swirr)^2}$$

Where ϕ = 0.32 and Swirr = 0.000424

By Substitution,

$$K = \frac{0.136 \times 0.32^{4.4}}{(0.000424)^2}$$

$$K = \frac{0.136 \times 0.00665}{1.80 \times 10^{-7}}$$

$$K = \frac{9.044 \times 10^{-.4}}{1.80 \times 10^{-7}}$$

K = 5024.4md

Reservoir B

Where ϕ = 0.30 and Swirr = 0.000587

By Substitution,

$$K = \frac{0.136 \times 0.30^{4.4}}{(0.000587)^2} = \frac{0.136 \times 0.005}{3.45 \times 10^{-7}} = \frac{6.8 \times 10^{-.4}}{3.45 \times 10^{-7}}$$

K = 1975.1md

Calculation of Transmissivity

Transmissivity = Permeability (k) x reservoir's thickness

Reservoir A

Where Permeability (k) = 5024.4md and reservoirs thickness = 129ft

By substitution,

Transmissivity = 5024.4 x 129 = 648148mdft

Reservoir B

Where Permeability (k) = 1975.1md and reservoir's thickness = 108ft

By substitution,

Transmissivity = 1975.1 x 108 = 213311mdft

Calculation of Water Saturation (S_W)

Reservoir A

Water saturation (S_w) = $\left(\frac{Ro}{Rt}\right)^{1/2}$

Where Ro = 2.621 ohm-metres and Rt = 71.223 ohm-metres
By substitution,

$S_w = \left(\frac{2.621}{71.223}\right)^{1/2}$

$S_w = (0.037)^{1/2}$

$S_w = 0.19$

Reservoir B

Where Ro = 1.700 ohm-metres and Rt = 86. 32 ohm-metres
By Substitution

$S_w = \left(\frac{1.700}{786.32}\right)^{1/2}$

$S_w = (0.020)^{1/2}$

$S_w = 0.14$

$S_w = 0.14$

Calculation of Hydrocarbon Saturation (S_H)

Reservoir A

Where S_w at reservoir A = 0.19,

$\therefore$ S_H = 1- S_w = 1 - 0.19 = 0.81

Reservoir B

Where S_w at reservoir C = 0.24,

$\therefore$ S_H = 1- S_w = 1 - 0.14 = 0.86

Calculation of Bulk Volume Water (BVW)

Bulk volume water (BVW) = Porosity (ϕ) X saturated water (S_w)

Reservoir A

Where Porosity (ϕ) = 0.32 and water saturation (S_w) = 0.19

Bulk volume water BVW = 0.32 X 0.19
= 0.32 X 0.19
= 0.061

Reservoir B

Where Porosity (ϕ) = 0.30 and water saturation (S_w) = 0.14

Bulk volume water BVW = 0.30 X 0.14
= 0.30 X 0.14
= 0.042

The following petrophysical parameters were quantitatively analyzed for the reservoirs: Volume of Shale (V_{sh}), Porosity (ø), formation factor (F), Irreducible water saturation (S_{wirr}), permeability (K), water saturation (S_w), Hydrocarbon saturation (S_h) and Bulk volume water (BVW). The results are summarized in Table 1.

Table 1: PETROPHYSICAL QUANTITATIVE ANALYSIS OF EKI-1 WELL

Reservoirs	**Depth Top**	**Bottom**	**Thickness (ft)**	**N/G Ratio**	**ϕ (%)**	**Swirr**	**S_W (%)**	**S_H (%)**	**BVW**	**K (MD)**	T(mdft)
A	5695	5824	129	0.919	32	0.0004	19	81	0.06	5024	648148
B	8370	8478	108	0.902	30	0.0005	14	86	0.04	1975	213311

The reservoir B is found at the interval of 7673 – 7761ft (2339-2366m) and has a gross (G) and net (N) thickness of sand, 88ft (26.8m) and 70.5ft (21.5m) respectively, with N/G ratio of 0.80; water saturation (S_w) of 14% and hydrocarbon saturation (S_h) of 86%, porosity (ø) and permeability (K) of 25% and 997.8md respectively. Its transmissivity is 87806mdft. Therefore, reservoir B has very good porosity and very good permeability.

The formation bulk volume water values calculated are nearly constant (Table 1) and this shows that the reservoir is homogeneous and is at irreducible water saturation (S_{wirr}) and therefore can produce water – free hydrocarbon. The transmissivity in reservoir A is higher than of B. This means that lateral migration of hydrocarbon from reservoir to a well bore will be easier in A than B.

CHARACTERISTICS OF RESERVOIRS OF EKI-1 WELL

There are two hydrocarbon reservoirs observed in the Eki-1 Well. These are reservoir A and B.
Reservoir A occurs at the interval of 5695 – 5824ft (1736-1775m) and has a gross (G) and net (N) thickness of sand, 129ft (39.3m) and 118.5ft (36.1m) respectively, with N/G ratio of 0.9; water saturation (S_w) of 19% and hydrocarbon saturation (S_h) of 81%, porosity (ø) and permeability (K) of 32% and 5024md while its transmissivity is 648148mdft. Therefore, the reservoir has both excellent porosity and permeability.

Reservoir B occurs at the interval of 8370 – 8478ft (2551-2584m) and has a gross (G) and net (N) thickness of sand, 108ft (32.9m) and 97.4ft (29.7m) respectively, with N/G ratio of 0.9; water saturation (S_w) of 14% and hydrocarbon saturation (S_h) of 86%, porosity (ø) and permeability (K) of 30% and 1975md respectively. Its transmissivity is 213311mdft. Therefore, the reservoir has both excellent porosity and permeability.

The formation bulk volume water values calculated are nearly constant. And this shows that the reservoir is homogeneous and is at irreducible water saturation (S_{wirr}) and therefore, can produce water-free hydrocarbon. Transmissivity in A is higher than B which means that lateral migration of hydrocarbon to the well bore will be faster in reservoir A than in B.

TABLE 2: RESERVOIR SAND/SHALE PERCENTAGE CALCULATIONS FOR THE WELL

	EKI-1 WELL	
RESERVOIRS	**% SAND**	**% SHALE**
A	**75**	**25**
B	**63**	**37**

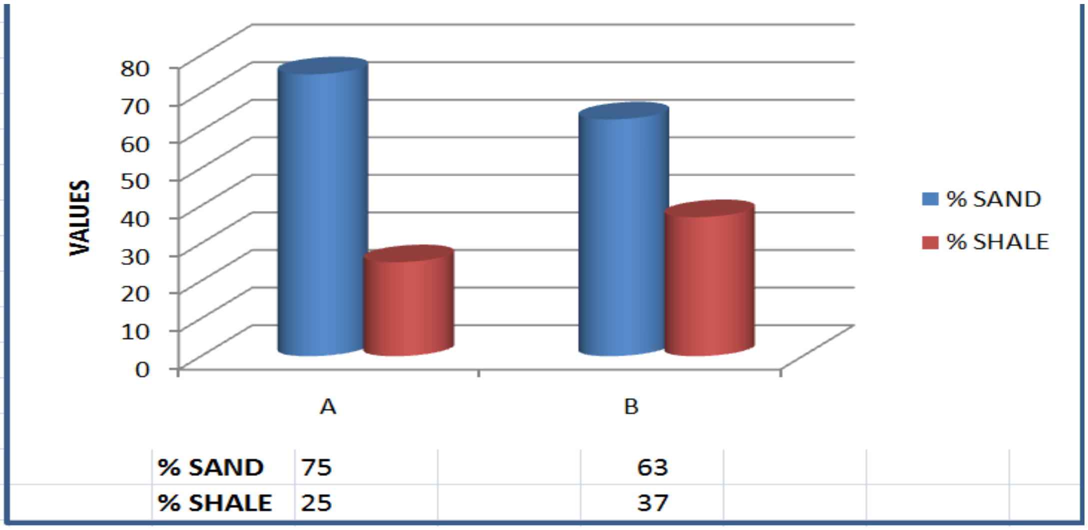

Fig. 2: Graph of reservoir sand / shale percentage for Eki-1 well.

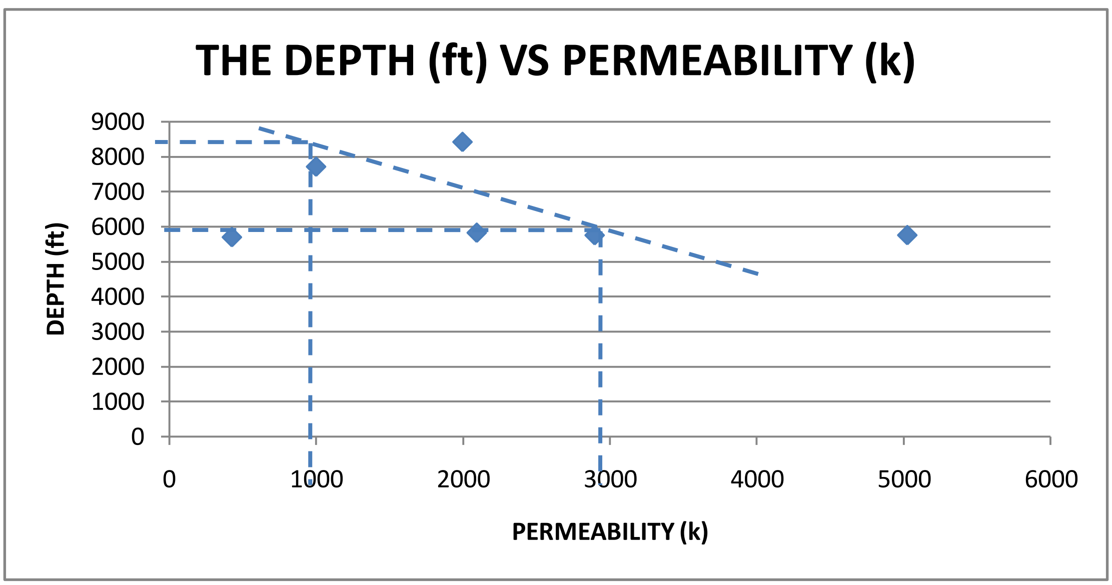

Figure 3: The graphs showing relationship between depth and permeability.

DISCUSSION

The petrophysical parameters of reservoir A range from 32-22%, 5024-116.2md, 20-14% and 86 – 80% for porosity (ø), permeability (K), water saturation (S_w) and hydrocarbon saturation (S_h), respectively. From the Dresser standard, the porosity (ø) ranges from excellent to very good, while the permeability (K) is excellent. Its transmissivity ranges from 50952mdft–648148 mdft.

The petrophysical parameters of the reservoir B range from 30-18%, 1997.8 -166.5md, 30-14% and 86 – 70% for porosity (ø), permeability (K), water saturation (S_w) and hydrocarbon saturation (S_h), respectively. Its transmissivity ranges from 14935 – 87806mdft. From the Dresser standard, the porosity (ø) ranges from very good to good, while its permeability (K) ranges from excellent to good.

With these petrophysical values, the reservoirs of the study area can be said to be prolific in terms of hydrocarbon production and they will produce water-free hydrocarbon due to the fact that all these reservoirs are homogenous and at irreducible water saturation.

The quality of the reservoirs in terms of porosity, permeability and transmissivity decreases down the depth. Therefore, it can be concluded that the hydrocarbon potential and productivity of the reservoir sands can be classified in decreasing order of arrangement as A, and B . The reservoir A in well is the best in terms of hydrocarbon production and hydrocarbon in such well can easily migrate to the wellbore as compared to other one reservoir.

REFERENCES

1. **Adedokun, O. (1981**). Petrology, provenance and depositional environments of the reservoir sandstone of Ossu-Izombe oil field, Imo State, Nigeria. *Journal of Geology*, 4:35-36.
2. **Adeleye, D. and T. Dessauvogie (1970).** Stratigraphy of the Niger embayment near Bida, Nigeria African Geol. Ibadan, p. 181-186.
3. **Allix, P. (1983).** Environments mesozoiques de la partie nordorientale du fosse de la Benoue, (Nigeria). Stratigraphie–sedimentologies. Evolution geodynamique. Trav. Lab. Sci. Terr., St. Jerome, Marseille France B21, p. 1-200.
4. **Amajor, L. and F . Lebekmo (1990).** The Vicking (Albian) Reservoir Sandstones of central and south-centra Alberta, Canada. Part 1 Geometry and Depositional History: Journal of Petroleum Geology 13 (3), p. 315 – 328.
5. **Akaegbobi, I. and O. Tegbe (2000):** Reservoir heterogeneities as a controlling factor to the abnormal production performance of the oil field “y”, NE, Niger Delta, NAPE bull., 15: 81-91.
6. **Beka, F. and M. Oti (1995).** The distal Offshore Niger Delta: from tier prospects of a mature petroleum province, in, Oti, M.M., and Postina, G., eds., Geology of Deltas: Rotterdam, A.A. Balkema, p. 237-241.
7. **Etu-Efeofor, J. (1997).** Fundamentals of Petroleum Geology, Paragraphics (An imprint of Jeson Services) Publisher, Port Harcourt. p. 1-146.