Determination Of Recoverable Hydrocarbons In Kok Well-2 Of Niger Delta Area Of Nigeria.

Collins o. Molua, fidelia c. Ighrakpata

Abstract: Well-2 of KoK field was drilled as an exploratory well, and various analytical tests aimed at determining the petrochemical characteristics of the reservoir sand, was utilized in the evaluation of the hydrocarbon prospect of the well. The gamma ray log, resistivity/induction and compensated neutron logs were used in getting the above information, through the identification of the various lithologic units found in the well. From the information got from the various logs, it can be inferred that the hydrocarbon prospect of the area is low at the present depth of investigation.

Index Terms: Recoverable, Hydrocarbons, Kok Well-2, Niger Delta, Nigeria, depth, Gamma, lithologic, exploratory

1 INTRODUCTION

Oil and gas exploration began in Nigeria when from 1908 to 1914, the German Nigeria Bitumen Corporation and the British Colonial Company, drilled about 15 holes from dip from the heavy oil seeps which occur in the cretaceous Abeokuta formation, Okitipupa situated at approximately 60 miles east of Lagos. The venture was however, abandoned as a result of dry holes. The work was stalled because of world was 1. Interest in exploration died down in the 1920s and early 1930s, but from 1937 to 1940, interest was resurrected again when Shell D' Arcy prior to drilling the first deep test in 1951 at Ihno, some 10miles North East of Owerri in the Delta area, made some intensive geological and geophysical studies from 1946 to 1957. The name Shell D' Arcy was changed to Shell-Bp Petroleum Company on 30th April, 1956. The first oil show was experienced in Shell D' Arcy's Akata-1 well in 1953 and the first commercial find was made by Shell-Bp in the sediments of the delta complex in late 1955 in the tertiary Agbade formation at Oloibiri. Gas was found at Afam, 21 miles North North East of port-Harcourt in 1956. Nigeria exported her first oil cargo in 1958 and oil began to be produced from the offshore in 1965, from Gulf's Okan field, situated on the Westside of the Niger Delta. Consequently, over the years, geophysics became a rallying point in exploration, to locate those simple structural traps in the oil province of the Niger delta. The Niger Delta id now at a mature state of exploration and the location of these structural traps is becoming increasingly difficult as a great deal of it have been found [11] dependence on wire logs is much more than anything else in a bid to reveal the geology and reservoir properties of oil pools. We should always bear in mind that the logs measure the electrical and other physical properties which are often indirectly related to the reservoir properties.

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2.Theory

The formation density compensation log is useful for porosity determination, detection of gas, determination of hydrocarbon density, evaluation of shally sands and complex lithologies. It is the most commonly used indicator of the porosity of a formation. A source of high-velocity gamma radiation is pressed against the side of the borehole and the rays are emitted directly into the formation. The log often measures the amount of back scattering of the gamma radiation through collisions with the electrodes in the rock. The rebuilding is thus related to the true electron density which in turn is inversely related to the

$$porosity\phi = \frac{P_{ma}-P_b}{P_{ma}-P_f} - - - - - - - - - - - - -(2.1)$$

Where

ϕ = Porosity

P_m = apparent matrix, P_b = bulk density P_f = mud filtrate density in g/cm^3.

Archie (1950)(3), defined petrophysics as the physics of individual rocks in relations to their petrology, and this offers a viable tool in oil exploration. Some of the essential petrophysical parameters needed to evaluate a reservoir include porosity, Lithology and reservoir thickness, water saturation, index of oil morability, hydrocarbon saturation bulk oil volume, etc.

Porosity is the percentage of voids in a given volume of rock. It is the pore volume per unit volume of formation. It is the most important attribute of a reservoir rock because it determines the amount of fluid it can hold(15). The rock type and its matrix density are known, the porosity can be calculated from the bulk density as:

$$porosity\phi = \frac{P_{matix}-P_{bulk}}{P_{matix}-P_{fluid}} - - - - - - - - - - - - -(2.2)$$

For the purpose of this study, porosity will be determined as an arithmetic average of the density porosity ϕ_B and the neutron porosity ϕ_N

Where

P_{ma} =matrix density

P_f = fluid

Schlunberger (1994) gave the following values

P_{ma} = 2.65g/cm^3 for sand stones

P_{ma} = 2.71g/cm^3 for limestone

P_{ma} = 2.87g/cm^3 for dolomite

Archie (1942), proposed the fomula:

- $S_w = [(a / \square^m)*(R_w / R_t)]^{(1/n)}$ -------(2.3a)

- S_w: water saturation
- $\square$: porosity
- R_w: formation water resistivity
- R_t: observed bulk resistivity
- a: a constant (often taken to be 1)
- m: cementation factor (varies around 2)
- n: saturation exponent (generally 2)

Values of a and in are constant for different lithologies and in the case of Niger Delta, and in are generally taken as 0.62 and 2.15 respectively.

Water saturation is the percentage of pore volume in a rock, which is occupied by the formation waters and is given as[16]:

$$S_w{}^n = \frac{R_w}{(\Phi^m \times R_t)} \text{ ----------------------------------2.4}$$

where:

- S_w = water saturation of the uninvaded zone
- n = saturation exponent, which varies from 1.8 to 4.0 but normally is 2.0
- R_w = formation water resistivity at formation temperature
- Φ = porosity
- m = cementation exponent, which varies from 1.7 to 3.0 but normally is 2.0
- R_t = true resistivity of the formation, corrected for invasion, borehole, thin bed, and other effects

The empirical saturation equations which relate hydrocarbon saturation to quantities which can be derived from borehole measurements are:

$$S_h = 1 - S_w \text{ − − − − − − − − − − − − − 2.4a}$$

$$S_w = \left(\frac{R_t}{\emptyset^{-m} R_w}\right)^{-\frac{1}{n}} \text{ − 2.5}$$

For practical usage, equation 2.5 is often broken into three other equations

$$S_w^{-n} = 1 \text{ ---2.6}$$

$$I = \frac{R_t}{R_0} = \frac{R_t}{FR_w} \text{ − − − − − − − − − − − − − 2.7}$$

$F = \emptyset^{-m}$ or $F = a\emptyset^{-b}$ ----------------------------2.8

I is known as the resistivity index, a and b if used are empirically determined constants, by rock type.

The flushed zone water saturated is the amount of water in the zone affected by mud invasion. Hydrocarbon saturation is the fraction of the pore volume filled with hydrocarbons. It is estimated between water saturation and gas unity. The oil gas (hydrocarbon saturation) can be expressed as:

$S_h = 1 - S_w$ --- (2.9)

If the water saturation of a reservoir is 100%, it implies hydrocarbon absent.

The residual hydrocarbon saturation (S_{hr}) is the amount of hydrocarbon left in the flushed zone after the water saturation has been determined[16].

Mathematically,

$S_{hr} = 1 – S_{xo}$ ---(3.0)

Where,

S_{xo} = water saturation of the flushed zone index of oil movability is defined as the ratio of water saturation to the flushed zone water saturation (S_{xo})[16]

$$Therefore\ 1.0M = \frac{S_w}{S_{xo}} \text{ -------------------(3.1)}$$

Conventionally, 1.0.M is 1 or approximately so, it implies that no hydrocarbon have been flushed by the invasion where as movable hydrocarbon are indicated when 1.0.M < 0.7

When 1.0.M >0.7, it indicates immovable hydrocarbon.

The bulk volume oil (B.V.O) is the percentage of the expressed mathematically as[17]:

If B.V.O = 1 or within its range, it implies that the volume of the reservoir with immovable hydrocarbon is very minimal.

Therefore, the resistively of the formation water (R_w) for KoK well-2 was determined, using the formula below.

$$Sp = -K \log R_{mf} \text{ ------------------------------------(3.2)}$$

And

$$R_w = -K \log \frac{R_{mf}}{SP} \text{ --------------------------------(3.3)}$$

Where,

Sp = voltage difference between shale and sand stone in millivolt.

K = a constant, for Nacl solutions, K = 71 at 25°C or (77°F)

R_{mf} = resistively of mud filtrate in R_m

R_w = resistively of formation water in R_m

3.0 DATA ACQUISITION

The log data used for this study were acquired by interdrill between 1988 and 1992 for Shell Petroleum Development Company, Warri. The data were acquired with modernized digital electronics which consist of the sensors, the cable, the cable telemetry and the signal processor. With the use of digital telemetry, there was enormous increase in he data rate that were being handled by the logging cable digital recording within the logging unit and this in turn increased the record capacity. The use of the digitalized system also facilitated the transmissions of the log signal to computing centres or base offices. The processing signal was performed for at least three levels. The uphole in the truck, the downhole at a central processing centre. The raw data were processed downhole and the processed signals transmitted to the surface. A well site computer system, called cyber service unit (CSU) is now standard on Schlumberger units throughout the world. The system provided the capabilities to handle large amounts of data. It solved the many problems posed by past limitation of combination logging systems (the stacking or combination of many tool sting). The CSU system provided the clear potential for well site processing of data. Nearly all the common log interpretation models and equations were executed on the CSU. Evaluation programmes ranged in scope from single well evaluation program to a series of special application products to reservoir description services that was used in evaluating the entire field. The materials used for the well logging of KoK well-2 include drilling bit, electrodes, mud, motor, jar, panel cartage and heavy weight drilling pipe (HWDP). The type of drilling mud used was the salt based drilling mud. The size of the drilling bit were 16 inches, 12.25 inches and 8.5 inches. The table below shows the other parameters used in logging KoK well-2.

***Table 3**.1: DRILLING PARAMETER USED IN LOGGING KOK WELL-2*

Date drilled	Mud type	R-mud R_m	T-mud °F	R-mc R_m	T-mc °F	R-mf R_m	T-mf °F	BTH
Jan, 1988	BENTONITE & CMC	1.4	75	1.71	75	1.25	75	175oF

R-mud = Resistively of mud
R-mc = Resistively of mud cake
R-mf = Resistively of mud filtrate
T-mud = Temperature of mud
T-mc = Temperature of mud cake
T-mf = Temperature of mud filtrate
BHT = Bottom Hole Temperature.

4.0 Result and Discussion

The analysis of the various wireline logs provided were based on the several petrophysical parameters that was read directly from the logs and in other cases a comprehensive computation using the formula earlier stated in equation 2.11 was done.

Table 3.1: shows the general lithological units found in the KoK well-2 and table 3.2 gives the potential evaluation of Section of KoK well-2 area, while Table 3.3 gives the summary of probable hydrocarbon bearing internals and quantitative evaluation from wireline logs of KoK well-2 field.

Table 3.3:
AND QUANTITATIVE
POTENTIAL EVALUATION FROM WIRELINE LOG OF WELL-2 OF KOK AREA.

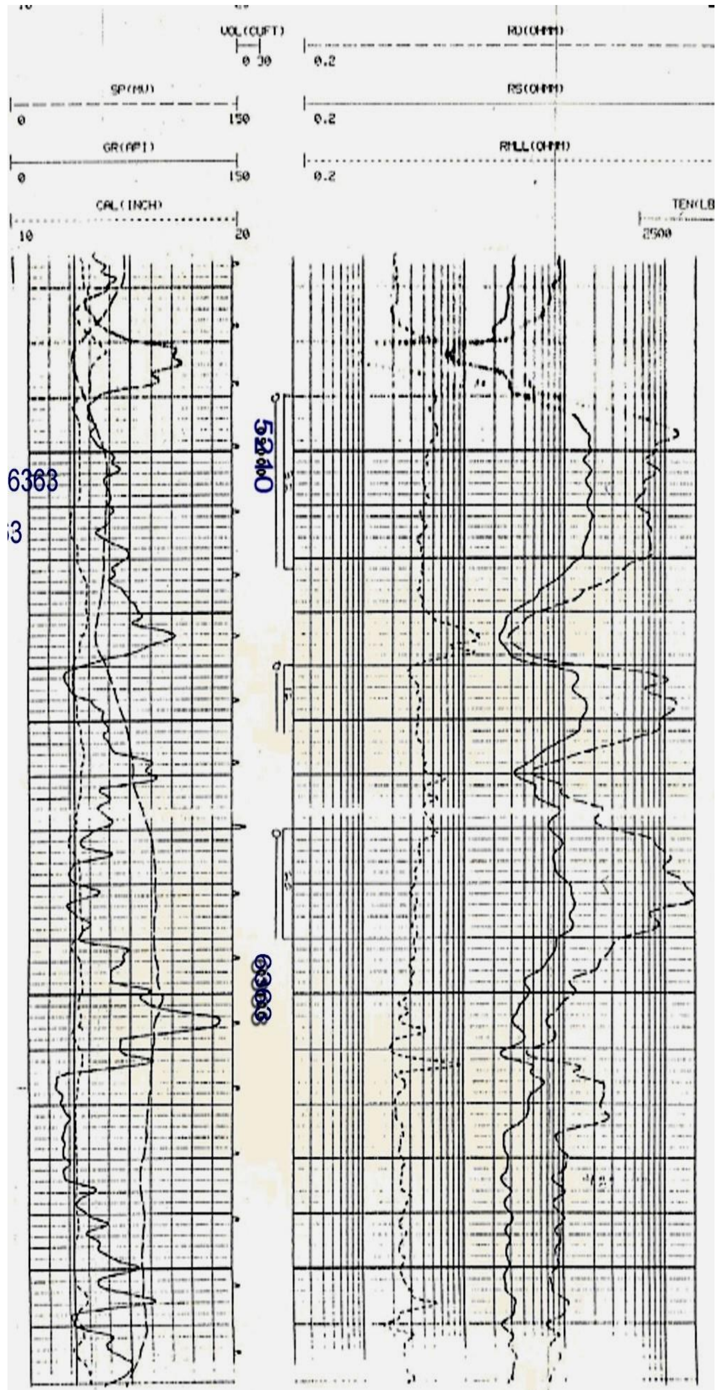
DEPTH INTERVAL (FLAH)	F	POROSITY øD	N	AV	FORMATION WATER RESISTIVIT Y Rw	S_w	Sh	Sxo	Shr	Mos	IOM	BVW	BVO
5210-571	8.25	30	30			0.74	0.26	0.94	0.06	0.20	0.79	22.2	6
5274-5281	7.43	28	35	31.5		0.99	0.01	0.99	0.01	-	1	312	-
5281-5330	10.65	87.3	26	26.6	1.32	0.40	0.60	0.83	0.17	0.43	0.48	10.66	11.44
5330-5350	8.16	33.3	27	30.2		0.60	0.40	0.90	0.10	0.30	0.67	18.12	9.06
5350-5362	16.6	27.3	16	21.65		0.65	0.35	0.92	0.08	0.27	0.71	14.1	5.85
5362-5372	24.3	13.3	23	18.2		103	0.03	101	0.01	0.02	102	18.75	0.36
5372-5409	13.8	21.2	26	23.6		0.06	0.33	0.92	0.08	0.25	0.73	15.8	5.9
5409-5415	9.8	30.3	25	27.5		0.66	0.33	0.92	0.08	0.25	0.72	18.2	7.2
5415-5450	13.6	20.6	27	23.8		0.67	0.33	0.92	0.08	0.25	0.73	15.2	7.2
5450-5464	540	26	47	365		115	0 15	1 03	0 03	0 12	1 12	119	438
5464-5475	762	27.3	35	311		098	002	099	001	001	099	305	031
5475-5592	913	242	33	286		055	045	089	011	034	062	157	97
5592-5598	1345	24.8	23	239		067	0.33	0.92	0.08	025	073	100	59
5598-5734	7.65	15.2	47	3.11		0.50	0.50	0.87	0.13	0.37	0.57	15.5	11.5
5734-5770	12.6	27.3	22	24.6		1.26	0.26	1.05	0.05	0.01	12	13.9	52
5770-5794	11.6	18.2	33	25.6		0.92	0.82	0.98	0.02	0.06	0.94	23.6	15.1
5794-5800	7.26	26.7	37	31.8		1.03	0.03	1.01	001	0.02	1.02	32.7	064
5800-5910	18.2	17.5	24	20.78		0.98	0.02	0.99	001	001	099	204	021

DEPTH INTERVAL							
5910-5920	52	27.3	47	371		0.99	0.
5920-5941	218	15.2	23	191		126	0.
5941-5948	7.12	27.3	37	32 1		0.38	0.
5948-6002	21 8	15.0	23	19 0		1 65	0.
6002-6025	52	27.3	47	37 1		1.17	0.
6025-6069	196	15.2	25	20		1.60	0.
6069-6100	6 84	28	37	32 7		1 02	00
6100-6119	218	15	23	191		1.65	0.
6119-6130	10.6	16.4	37	26.7		1 47	0.
6130-6159	14.46	21.2	25	23.1		1 35	0.
6159-6169	72	16.96	47	31.9		1.17	0
6169-6218	120	27.3	23	25		0 75	0.
6218-6260	95	21.2	35	28.1		1 25	0.
6260-6363	9 12	27.3	30	28 6		1 07	0

TABLE 3.3 PROBABLE HYDROCARBON BEARING INTERVALS

5210-5274	90	32	12.8	1.5	7	20	0.30	2.15	Sand
5274-5281	42	74	14.2	2	4.2	10	0.35	2.18	Shale
5281-5330	78	29	12.6	2	10	85	0.26	2.2	Shale
5330-3350	82	64	14.2	2	6	30	0.27	2.1	Shale
5350-5362	28	36	14.5	3.5	9	52	0.16	2.2	Sand
5362-5372	45	75	140	10	10	30	0.23	2.43	Shale
5372-5409	90	33	15.0	2	9	40	0.26	2.3	Sand
5415-5450	38	28	14.1	3	7	40	0.27	2.31	Sand
5450-5464	54	95	14.5	2	3	6	0.47	2.22	Shale
5464-5475	86	50	14.2	2	6	10.5	0.35	2.20	Sand
5475-5592	38	30	14.8	3	8	40	0.33	2.25	Shale
5592-5598	52	90	14.7	3	4	7	0.23	2.24	Sand
5598-5734	80	28	13.4	2	9	40	0.47	2.40	Shale
5734-5770	28	100	14.9	3	7	10.5	0.22	2.20	Sand
5770-5794	94	45	13.7	2	4	18	0.33	2.35	Shale
5794-5800	42	98	12.6	3.5	5	9	0.37	2.21	Sand
5800-5910	78	33	13.8	2	4	25	0.24	2.36	Shale
5910-5920	48	100	12.4	3	4	7	0.47	2.20	Sand
5920-5941	74	30	12.8	2	8	18	0.23	2.40	Shale
5941-5948	45	94	12.4	8	8	25	0.37	2.20	Sand
5948-6002	28	32	14.8	3	7	10.5	0.23	2.58	Shale
6002-6025	40	90	12.8	1.5	3.5	5	0.47	2.20	Sand
6025-6069	35	27	12.6	1.5	4.5	10	0.25	2.40	Shale
6069-6100	42	110	13.0	2	6.0	8	0.37	2.18	Sand

6100-6119	30	33	12.2	2	5	10.5	0.23	2.40	Shale
6119-6130	32	121	14.2	3	5	0.5	0.37	2.34	Sandy shale
6130-6159	70	30	14.8	2	5.5	10.5	0.25	2.30	Shale
6159-6169	48	100	12.0	3	5	7	0.47	2.37	Sandy shale
6169-6218	78	28	14.2	1.7	10	28	0.23	2.20	Shale
6218-6260	18	34	15.0	3	5	8	0.35	2.30	Sandy shale
6260-6363	62	28	13.8	2	5	10.5	0.30	2.20	Shale inter bedded with sand



Well 1- Section of Geophysical well log

5.0 CONCLUSION

The reservoir-bearing sands in the well have moderate to high resistivity values indicating either salt water or fresh water filling the pores. Nevertheless, light constituents of hydrocarbon in contact with salt water of fresh water was observed. Quantitative analysis based on the resistivity/conductivity log, compensated neutron log (CNL), formation density compensation log (FDC) revealed that the hydrocarbon prospect in KoK field is low and therefore, more exploration should be carried out.

This inference is based on the values obtained from the determination of hydrocarbon saturation, bulk volume oil (B.V.O), bulk volume ware, index of oil movability and formation factor. Therefore, the hydrocarbon prospect in KoK well-2 is low at the present depth of investigation.

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