COMPUTATION OF SOME PETROPHYSICAL PARAMETERS OF FOUR ONSHORE WELLS IN THE NIGER DELTA USING WELL LOG DATA.

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Abstract

Well-by-Well Petrophysical analysis was carried out for all the identified hydrocarbon intervals, in the four wells studied in Held A, using suites of geophysical well logs. From the analysis of the geophysical logs comprising gamma ray, spontaneous potential, electrical resistivity, neutron and density logs, the total porosity in the hydrocarbon bearing zones was found to range from 17.2 to 22.7% and the water saturation range from 19.6 to 54.6%. Good well-to-well lithologic correlation has been established across the field (table 1). The researchers found that the bulk of hydrocarbon encountered in the Niger delta basin is within a depth range of (2917.0- 2968.6) m. From the analysis of the lithology and fluid contents, Wells 1,2,3 and 4 were found to have penetrated the Benin and the Agbada formations.

The hydrocarbon reservoirs were found to be in Agbada formation, which is in conformity with the geology of Niger Delta.

Introduction

For oil and gas to accumulated in a commercially exploitable reservoir three basic requirements must be fulfilled. First, the reservoir rock must possess sufficient void space, called *porosity,* to contain the oil and gas. Secondly, there must be adequate connectivity, or *permeability,* of the pore spaces to allow transportation of the fluids over large distances under reasonable pressure gradients. Thirdly, a sufficient quantity of hydrocarbon must be accumulated into a *trap* of impervious cap rock which prevents upward migration of the oil and gas from the source beds, forming a petroleum reservoir (Schlumberger, 1980). Usually in the Niger delta, the water saturation of 60% was used as the cut -off.

The field of study lies in the East-west of Edo in the Niger Delta between longitude 5° 35^1 E and 5° 44^1 N. It lies within the oil prolific' belt of Niger Della.

Three major lith o strati graphic units have been recognized in the Niger Delta (short and stable, 1967) (Franky and Cordy, 1967), and (Maron, 1969). These are the Akata, Agbada and Benin formations.

Details of -the geology of the Niger Delta has been discussed by several authors, (Schlumberger, 1984 and 1985, Merki, 1970, Short and Staublc, 1967, Reyment, 1965, etc.)

The Benin formation, which is a loose fresh water bearing sand with occasional lignite and clay and going up to 2,286m deep with no over pressures.The Agbada formation is made up of alternation of sands and shales. The sands are mostly encountered at (he upper parts while shades arc found mostly at the lower parts. The Agbada formation is thickest at the center of the Della, and goes up to 457.2m. This is the seat of most oil reservoirs and center of over pressures.

The Akata formation contains mainly shales deposited on a shallow marine shelf and usually over pressured, with soft and under- compacted plastic shales. Exploration rarely gets to it because of the absence of commercial oil deposits.

Methodology

The data for this study were collected from four wells in field A in the Niger Delta in N.N.P.C Concession. The data set provided by the company were carefully studied, analyzed and interpreted. The wells are arbitrarily designated 1,2,3 and 4. The well logs which form the data sets were run in the dry season. The various logs run in the wells include Lithology: Spontaneous potential (SP) Gamma. Ray (GR), Porosity: Litho- Density log (LDL), compensated Neutron log, Electrical: Induction spherical focused log (1SF),

A suite of borehole logs from well 1,2,3 and 4, in the Niger Della were analysed for hydrocarbon prospect in the study area The. borehole logs analysed are the Gamma ray, spontaneous potential, short normal, induction and po"'sily logs.

The Petrophysical characteristics of the reservoir rocks of the four exploratory well, were computed based on known measurable parameters. These parameters include the G.R readings, resistivity readings, and porosity readings. Tables (2) show the various computed values for well 1,2,3 and 4 respectively. The hydrocarbon bearing zones have been displayed for the four wells in Table 2. This is between the depth of 2917.0 and 2968.6m The various intervals of interest were chosen and corrected to mean sea level. Those intervals are porous and permeable. Hence these are the sand

Table 1
Field A: Well Correlation
Table

WFXLS RESERVOIRS	10 INTERVALS (m)	II INTERVALS (m)	12 INTERVALS (m)	13 INTERVALS (in)	14 INTERVALS (in)	16 INTERVALS (m)
01	2541.0- 2560.0	2550.0 2570.0	2580.0 - 2590.5	2517.5 - 2585.0	-	-
02	3006.0-3016.0	2874.0 2898.0	-	-	-	-
03	-	2827.5 - 2930.5	2951.0 2955.5	2929.0 - 2937.0	2917.0-2919.0	2986 29915
04	-	295 1.0 2959.0	2973.4 2981.0	2956.0 2964.0	2943.0- 2951.0	3007 3017
05	-	2976.0 2983.5	2997.2 3002.0	2973 .0 2992.4	2956.0 2964.0	3026 3067
06	3095.3 - 3104.5	2992.5 - 3000.1	3012.0 3022.0	.3001.5 301 1.8	2968.6- 2983.0	30652 - 3067
07	3319.5 3326.0	3219.5 - 3229.0	3224.0 - 3235.0	3228.0 3241.0	2991.0-3006.0	3269 - 3284
08	-	3371.0 - 3383.0	336! .0 3367.0	3395.0 3418.3	3232.0- 3245.5	NOT REACHED
09	3611.0-3642.0	3570.0 3590.0	3545.0- 3574.0	3553.0 - .3575.0	3399.0- 3426.0	
OH)	3673.0- 3700.0	3635.0 - 3680.0	3603.2 - 3607.5	3613.0- 3628.0	3566.5 - 3587.0	
013	3774.0-3797.0	3755.0- 3773.0	3721.0 - 3723.5	3702.0- 3707.0	-	
014	3800.0-3810.0	3775.0- 3788.5	3751.5 - 3757.2	3783.0- 3793.0	-	

Table 2 Field (A)

HYDROCARBON (IIC) INTERVAL MFTERS(MD)	HC INTERVAL SUBSEA(TVD) METERS	TYPE AND BASE (S/S) OF IIC	NET IK' TII1CKNESS(M)	THICKNESS WEIGHT I'OROSITY %	THICKNESS WEIGHTED WATER SATURATION %	REMARK	WELL NO
2870.0-2885.5		-	-	-	100	water	i
2882.5 - 2908.0	-	-	-	-	100	waler	2
							3
2890.5-2900.0	2864.9-2874.4	ODT-72874.4	7.0	21.6	64.9	Wafcr/fmt -her test	4

reservoirs. Table 2 shows the computed borehole parameters from well 1,2,3 and 4 respectively.

Table 3

HYDROCARBON (HO INTERVAL METBRS(MD)	IIC INTERVAL SUBSEA('I VD) METERS	TYPE AND BASE (S/S) OF HC	NET MC THICKNESS (m)	IIIICKNESS WEIGHT POROSITY %	THICKNESS WEIGHTED WATER SATURATION	REMARK	WELL NO
2918.0 2920.0					100	Wider	1
2932.4 2940.5					100	water	2
2927.0 2932.0					100	water	3
2929.0-2937.0	2903.4-2901.4	ODT-2910.4	3.0	22.7	39.3	oil	4

Table 4

HYDROCARBON INTERVAL METERS(MD)	HC INTERVAL SUBSEA(TVD) METERS	TYPE AND BASE (S/S) OF HC	NET HC THICKNESS(m)	1111CKNESS WEIGHT POROSITY %	THICKNESS WEIGHTED WATER SATURATION	REMARK	WELL NO
2945.0 2959.0					100	Walcr	1
2951.0-2958.5	2925.8-2933.3	GCC-2929.3	7.5	19.0	1 9.6	Gas	2
2973.4-2981.0	2948.7-2956.3	GDT-2956.3	7.6	18.3	29.8	Gas	3
2956.0-2964.0	2930.4-2938.4	GDT-2938.4	7.3	22.6	23.6	Gas	4

Results of Petrophysical
Field (A) Results of Petrophysical Analysis
Field (A) Results of Petrophysical Analysis

Tab5

Field (A) Results of Petrophysical Analysis

HYDROCARBON INTERVAL MI:II;RSIMD)	HYDROCARBON INI ERVAL SI JBSEA(TVD) MEIERS	TYPEAND BASH (S'S) Ol-HYDROCARBON	NET HYDROCARBON THICKNHSS(M)	THICKNESS WEIGHT POROSITY	rnicKNHSs WEIGHTED WATER SATURATION	REMARK	WHI.I. NO
2970.0 2999.5						Shalcd Out	1
2976.0 2983.5	3950.8-2958.3	CD I -2958.3	6.1	17.8	45.3	Gas	2
2997.2-7002.0	2972.5-2977.3	CDT-2977.3	4.2	17.6	54.6	Gas	3
2973.0-2992.4	2947.4-2966.8	CDT-2966.8	15.4	20.0	30.1	Gas	4

Table 6

HYDROCARBON 1NTHRVAL MH.TERS(MD)	HYDROCARBON INIHRVAL SUBSHA(TVD) METERS	I YPI- AND BASE (S/S) OF HYDROCARBON	Nil HYDROCARBON TIIICKNESS(M)	THICKNESS WEIGHT POROSITY %	TIIJCKNKSS WHIGHTHD WATER SATURATION %	RI-MARK	Will. 1 OG
2980.0 2992.5					100	Water	1
2992.5-3001.0	2969.2-2977.7	Ol) T-2977.7	5.5m	17.7	51.3	Oil	2
				19.2	100.0	Water	3
3001-5-3011.0	2986.2-2975.9	ODT-2986.2	8.3	19,9	52.8	Oil	4

Table 7

HYDROCARBON 1NTHRVAH MHTHRS(MD)	HYDROCARBON INI BRVAL SUBSHA(TVD) METERS	TYPE AND BASH (S/S) 01-HYDROCARBON	NHTHYDROCARBON THICKNH.SS(M)	THICKNESS WEIGHT POROSll Y %	THICKNESS WEIGHTED WATI-R SATURATION %	RI-MARK	WELL NO
7719.5-3326.0	3703.2-3309.7	ODT-3309.7	1.0	18.0	20.0	Oil	1
32)9.5-3231.0	3198.3-3209.8				80.0	Water	2
3224.0-32.7 .0	3199.3-3207.3	GDT-3207.3	2.0	20.0	48.0	Gas	3
3238.4-3240.5	3212.9-3214.9	ODT-3214.9	2.0	16.0 .	61.0	Oil	4

Table 8

HYDROCARBON INTERVAI METERS(MD)	HYDROCARBON INTERVAL SUBSEA (IVD) METERS	TYPE AND BASH (S/S) Ol HYDROCARBON	NHT HYDROCARBON TIIICKNFSS(M)	THICKNESS WEIGHT POROSH Y	THICKNESS WEIGH TED WATER SATURATION	REMARK	WHET NO
3444.0-3457,0	3427.7-3440.7					Slialcd out	1
3771.5-3382.5	7350.0-3361.3	COC-3354.8	9.5	16.5	28.6	(ias	2
.7761.0-3367.0	.7336.3-3342.3	GDI-3342.7	4.0	14,8	35.5	Gas	3
34)0.2 3420.0				13.7	100.0	Water	4

ld (A) Results of Petrophysical Analysis

Field (A) Results of Petrophysical Analysis

Field (A) Results of Petrophysical Analysis

Field (A) Results of Petrophysical Analysis

Table 9

HYDROCARBON INTERVAL Ml TI RS(MD)	HYDROCARBON INTERVAL SIJBSHA(TVD) METERS	TYPE AND BASE (S/S) OF HYDROCARBON	NET HYDROCARBON THICKNESS(M)	THICKNESS WEIGHT POROSITY	THICKNESS WEIGHTED WATER SATURATION	REMARK	WELL NO
7550.0 3580.0			0.0	13.8	100	Water	1
7570.5-3596.0	3549.3-3574.8	CWC-3574.8	18.7	13.9	32.4	Gas	2
3545.0-3574.0	3520.3-3549.3	CDT-3550.3	21,3	11.0	49.5	(ias	3
3560.5 3580.0						Shaly	4

HYDROCARBON INTERVAL METERS(MD)	HYDROCARBON INTERVAL SUBSEA(TVD) METERS	TYPE AND HASE(S/S)()[f HYDROCARBON	NET HYDROCARBON TIIICKNESS(M)	THICKNESS WEIGHT POROSITY	THICKNESS WEIGHTED WATER SATURATION	REMARK	WELL NO
3610.0 .3620.5				16.6	100 .	Wnlcr	1
3635.0-.3638.0	3613.8-3616.8	OWC-3616.8	1.5	15.0	42.0	Oil	2
3603.2-3607.5	3578.5-3582.5	CDT-3582.5	4.3	10.5	49.3	Gas	3
3624.5-3628.0	3508.9-3602.4	ODT-3602.4	2.0			Shaly	4

Tabic 10
Field (A) Results of Petrophysical Analysis

Table 11
Field (A) Results of Petrophysical Analysis

.HYDROCARBON INTER VAI METERS(MD)	HYDROCARBON IN HR VAI SUBSEACIVD) METERS	TYPE: AND BASE (S/S) OF HYDROCARBON	NET HYDROCARBON TIIICKNESS(M)	THICKNESS Wi lt il II POROSITY	THICKNESS WEIGHTED WAIEK SATURATION	REMARK	WEI.I. NO
3704.0-3711.0	3687.7-3694.7			18.7	73.7	Water	1
				9.4	KM)	Walcr	2
3660.3-3666.5	3635.6-3641.8			10.0	90	Water	3
3702.0-3707.4	3636.4-3682.1			14.0	86.0	Water	4

Table 12

HYDRO! ARBON INTliRVAI. ME.TERS(MD)	HYDROCARBON INTliRVAI. Sl)HSEA(TVD) METERS	TYPE: AND BASE (S/S) OF HYDROCARBON	Ni: 1'HYDROCARBON TIIIOKNESS(M)	THICKNESS WEIGHT POROSITY	THICKNESS WEIGHTED WATER SATURATION	REMARK	WEI.I. NO
.3749.0 3755.5	.3732.7-3739	CD 1 -3739.2		13.6	94.6	Wider	1
2740.0 2750.5				10.0	100.0	Water	2
3755.5 3760.0				11.0	100.0	Wider	3
3745.0 3760.0						Shaly	4

Table 13

HYDROCARBON INTER VAI. ME:TE:RS(MD)	HYDRCX'AKBON INTERVAL SUBSEA(TVD) METERS	TYPE: AND BASE: (S/S) OF HYDROCARBON	NET HYDROCARBON TIIICKNESS(M)	TIIICKNIiSS WEIGHT POROSITY	THICKNESS WEIGHTED WATER SATURATION	REMARK	WELL NO
3774.0- 3789.	3757.7-3772.7	GOT-3772.7		16.4	73.0	Wnler/Eui l-bcr lest	1
3735.0 3750.0				11.4	100.0	Walcr	2
3721.0- 3723.5	3696.3-3698.8	GDI-3698.8	2.5	11.0	77.0	Shaly/Eurt-hcr lesl	3
3720- 3725.0	3694.4-3699.1	GDT-3699.4ni	0.0		50.0	Gas	4

HYDROCARBON INTERVAL METERS(MD)	HYDROCARBON INTERVAL SUBSEA(TVD) METERS	TYPE. AND BASE (S/S) OF HYDROCARBON	NET HYDROCARBON THICKNBSS(M)	THICKNESS WEIGHT POROSITY	TIIICKNIiSS WEIGHTED WA FER SATURATION	REMARK	WEEI. NO
3800.0-3809.5	3783.7-3793.2	CDT-3793.2		14.7	73.3	Watcr/Furthcr test	1
3775.0-3789.5	3753.8-3767.8			11.2	92.4	Water	2
3751.5-3757.0	3726.8-3732.3		5.5	10.0	100	Water	3
3783.0-3793.0	3757.4-3767.9	CDT-3759.4	2.0	18.0	55.0	Gas	4

Field (A) Results of Petrophysical Analysis
Field (A) Well Correlation Table

lable 14
Field (A) Well Correlation Table

Discussion of Results

Archie, (1942) proposed a formula based on observations, relating porosity, (]) and formation factor F,. The relationship is

F a/f ' .....(1)

Where n is the cementation factor a is a constant determined empirically <j> is the porosity of the rock

For compacted formations, porosity and formation factor relationship may be written for sends as

$F = 0.62/cJ)^{2,15}$ .....(2)

or

F = 1/(ị)^I R (for compacted formations)..............................(3)

According to Arcliic, water saturation equation can he written as

Sw" - FR$_W$/RT = a/(t>" FR$_W$/RT ....(4)

Where R_w is the formation water resistively

R, is the true resistivity of the formation

n is usually taken as 2, a< 1, l<n<3

Equation (4) can be written as

Sw =$(FR_W/R,)^{I/2}$ (5)

Equation (5) is the Archie water saturation equation. If the formation is 100% water saturated

R,,=FR$_W$

Then equation (5) can be written as

Sw = (Ro/R,)'/2 ....(7)

The neutron log is read directly in porosity unit (p.u), while the density log is given in bulk density $p_{h(}$ e/cm^3) -The equation for porosity in this case is,

<I>D -■ pma - pb .... (8)

pma____pf----------

where OD =density porosity

pma=density of the matrix lithology (g/cm3)

pf =fluid density

and pma(sandstone) =2.65 (g/cm3) pf

(fresh water) =1.0 (g/cm3)

The weighted porosity(O) is the average value of both the neutron and density porosity values in sandstone matrix.

The analysis of the G.R and cal logs show that the overall lithology is an alternating sequence of sands and shale's, which conform with the standard lithological variations in the Agbada formation of the Niger Delta basin. Of the three 1ithostratigraphic units recognizable in the Niger Delta, only the top two were penetrated by the four Wells studied in Field A. The units penetrated are the continental Benin sands, at the lop, and the paralic Agbada sands and shales. These units and (heir boundaries were identified using well log data. Its believe that the Akata shale was not penetrated by any of the Wells. All the hydrocarbon reservoirs in field A occur within this formation. From the analysis of the data, the bulk of the hydrocarbon is within a depth range of (2917.0-3783.0) m, which is in agreement with the recent study in the Niger Delta by (Falebita and Babalola 2003).

The total porosity in the hydrocarbon bearing zones was found to range from 17.2 to 22.7% and the water saturation range from 19.6 to 54.6%. Good well-to-well lithologic correlation has been established across the field (table 1). The hydrocarbon are segmented into smaller strips of oil and gas columns as shown in tables (2 - 14). Some intervals were shaled out see table (2 - 14).

Recommendation

Since log data are highly interpretative and thus liable to subjectivity, it is strongly recommended that conventional cores be taken and thoroughly analysed to confirm all pertinent log derived information.

Conclusion

The four wells studied have indicated the presence of hydrocarbon reservoirs with varying thickness, lateral extents and fluid contents. All the identified prospective zones occur within the Agbada formation.

References

Archie, G.E (1942). The electrical Resistivity as an Aid: In Some Reservoir Characteristics, *Journal Pet. Tech.* 5(1): 54-62.

Falebita, C. A and Babalola, S. A. (2003). Petroleum Exploration: In the Niger Delta, Deep Drilling Option. *Vol 03 No2, NAPE Publications*

Frankl, E. .1 and Cordy, E .A (1967). The Niger Della Oil Province: Recent Developments Onshore and offShore,. *Seventh World Petrol.* Cons. Mexico City, PP 195-209.

Maron, P (1969). Stratigraphical Aspects ofThe Niger Delta, Nigeria, *Jour. Mining and Geology*, 41: 1-2.

Merki, D.J (1972.) Structural Geology of The Cenozoic Niger Delta. In: Dessauvagie, T.F.J and White Man, A. J(ed.s).African Geology, University of Ibadan: Ibadan, Press Nigeria, Pp. 635- 646.

Reyment, R. A (1964) Review of Nigeria Cretaceous Cenozoic Stratigraphy. *Journal of the Nigerian Mining Geological and Metallurgical Society,* 1 (3):

Schlumberger, (1984). Well Evaluation Conference, Nigeria Schlumberger International, Houston Texas. Pp 292, 320.

Schlumbcrger, (1980) Reservoir and production Fundamentals Pp Vol Viii. Schlumbcrgcr International, Houston Texas.

Short, K. C and Stauble A. J (1967)Outline of Geology of Niger Delta, AAPAG- Bull 51,(5 1): 761- 779.