MUDLOGGING AS AN EXPLORATION TOOL

(A CASE STUDY of Uzere WELL).

By

MOLUA, O.C[*], IGHRAKPATA .F O AND EMAGBETERE J.U[***] AND OKOH. H*****

.* Physics department, College of Education, Agbor. Delta State, Nigeria
** Physics department, College of Education, Warri. Delta State, Nigeria.
*** Physics department, College of Education, Mosogar. Delta State, Nigeria

Abstract

The aim of this study is to evaluate the characteristics of subsurface formation as obtained in original well of the Uzere area of Niger Delta. A preliminary investigation involved geophysical logging, or lowering various nuclear and electric apparatus into a strategic, near- shore monitoring well (or directly in ground) for the purpose of confining properties of a formation. Nuclear and electric logs were performed on location and have proven to be an important part of determining stratigraphic correlation between measured sites. The hydrocarbon saturation for the studied Uzere well was found to be 0.3. This value is low for the hydrocarbon prospect of Uzere well to be significant, at the present depth of investigation.

Introduction

Tools to detect oil and gas have been evolving for over a century. The simplest and most direct tool is well cuttings examination. Some older oilmen ground the cuttings between their teeth and tasted to see if crude oil was present. Today, a wellsite geologist or mudlogger uses a low powered stereoscopic microscope to determine the lithology of the formation being drilled and to estimate porosity and possible oil staining. A portable ultraviolet light chamber or "Spook Box" is used to examine the cuttings for fluorescence. Fluorescence can be an indication of crude oil staining, or of the presence of fluorescent minerals. They can be differentiated by placing the cuttings in a solvent filled watch glass or dimple dish. The solvent is usually carbon tetrachlorethane. Crude oil dissolves and then redeposits as a fluorescent ring when the solvent evaporates. The written strip chart recording of these examinations is called a sample log or mudlog.

Well cuttings examination is something of a learned skill. During drilling, chips of rock, usually less than about 1/8 inch (6 mm) across, are cut from the bottom of the hole by the bit. Mud, jetting out of holes in the bit under high pressure, washes the cuttings away and up the hole. During their trip to the surface they may circulate around the turning drill pipe, mix with cuttings falling back down the hole, mix with fragments caving from the hole walls and mix with cuttings traveling faster and slower in the same upward direction. They then are screened out of the mud stream by the shale shaker and fall on a pile at its base. Determining the type of rock being drilled at any one time is a matter of knowing the 'lag time' between a chip being cut by the bit and the time it reaches the surface. A sample of the cuttings taken at the proper time will contain the current cuttings in a mixture of previously drilled material. Recognizing them can be very difficult at times, for example after a "bit trip" when a couple of miles of drill pipe has been extracted and returned to the hole in order to replace a dull bit. At such a time there is a flood of foreign material knocked from the borehole walls (carvings), making the mud loggers task all the more difficult. In petroleum exploration and development, **formation evaluation** is used to determine whether a potential oil or gas field is commercially viable. Essentially, it's the process of "recognizing a commercial well when you drill one".

Only in rare, catastrophic cases and in Hollywood movies, do oil and gas wells 'come in' with a fountain of gushing oil. In real life, that is a 'Blow Out'—and usually also a financial and environmental disaster.

Modern rotary drilling uses a heavy mud as a lubricant and as a means of producing a confining pressure against the formation face in the borehole, preventing blowouts. This is a double edged sword—mud filtrate soaks into the formation around the borehole and a mud cake plasters the sides of the hole. These factors obscure the possible presence of oil or gas in even very porous formations. Further complicating the problem is the widespread occurrence of small amounts of petroleum in the rocks of many sedimentary provinces. In fact, if a sedimentary province is absolutely barren of traces of petroleum, one is probably foolish to continue drilling there.

The formation evaluation problem is a matter of answering two questions: 1, what are the lower limits for porosity, permeability and water saturation that permit profitable production from a particular formation or pay zone; in a particular geographic area; in a particular economic climate. Do any of the formations in the well under consideration exceed these lower limits?

It is complicated by the impossibility of directly examining the formation. It is, in short, the problem of looking at the formation *indirectly*. The three primary purposes of drilling mud or drilling fluids are to: Remove cuttings from the formation produced by the bit at the bottom of the hole and carry them to the surface. This is achieved by adjusting the rheology of the mud system. Lubricate and cool the drill bit during operation as friction causes high temperatures down-hole that can limit tool life and performance. Maintain hydrostatic equilibrium so that fluids and gas from the formation do not enter the well bore causing the well to flow, kick or blow out. This is achieved by adjusting the mud weight (density). High-density additives (barite, hematite) are used for preparation of **kill-weight fluids**, which create hydrostatic pressure that prevents water entering the well or hold the oil/gas inside, prevent a blowout and to physically stabilize the formation.

Other characteristics are considered important in modern drilling. Some of these include:

*Safety of the environment

*Prevent dispersion of reactive clays(gumbo)

*Ability to seal formation fractures/voids

*Non abrasive to tools and rig equipment

On a drilling rig pumping it with mud pumps through the drill string where it sprays out of nozzles on the drill bit (cleaning the bit in the process), the mud then travels back up the annular space between the drill string and the sides of the hole being drilled, up through the surface *casing,* and emerges at the surface. Cuttings are then filtered out at the *shale shaker* and the mud enters the *mud pits*. The mud is then pumped back down and is continuously recirculated. The mud is treated periodically in the mud pits to give it properties that optimize and improve drilling efficiency

Geology of the study area

Uzere area is located within longitude $6^o2'$ and $6^o4'$E and latitude $5^o24'$ and $5^o30'$N onshore of Niger delta basin, situated on the continental margin of Gulf of Guinea in the equatorial West Africa, between latitude 6^o North and longitude 5^o and 8^o East of Greenwich meridian.

It covers an area of 7500km^2 with about 1200m of clastic fill (Onuoha,1987). It is one of the most prominent basins in West Africa and actually the largest in Delta Africa. It includes cross River Delta and extends into the continental margins of neighboring Cameroon and Equatorial Guinea.

It overlaps the outline of Africa and South America when both continents were fitted together along 500- fathom bathymetric contours. The Niger is bounded on the North East by the Anambra basin, south western extension of the cretaceous anticlinorium's. Stratigraphically, it has been divided into three formations which are the continental sand. The Benin formation at the surface, the Agbada formation consisting alternating sands and shales and finally the marine shale Akata formation. The age of the basin has been put at Cenozoic (Molua & Ujuanbi, 2006) .

The benin formation comprises mainly of massive continental sand gravel. These sediments grade downwards or are over lying unconformable with Delta lithofacies. The age range is from Miocene to recent.

The Agbada formation on the other hand, is made up of mostly shore facies and channel sands with minor shale in upper part and alternation of sand and shale in equal proportion in the lower part. It has a thickness ranging between 600m-400m. The oldest deposits are of

Eocene age in the north and are being deposited in the near shore shelf domain. This has been noted to be the reservoir rock in the Niger Delta Area.

The Akata formation is made up of pro deltaic marine shales. They are generally low stand turbidite fan deposited in a deep marine setting. They are of Paleocene- Eocene age. It has the highest source rockof the Niger Delta.(Weber,1971).

Experimental method

The log data used for this study were acquired for Shell Petroleum Development Company by interdrill from 1998-2002. The data were acquired with modernized digital electronic system which consists of sensors, the cable, the cable telemetry and the signal pressor. With the use of the digital telemetry, there was enormous increase in the data rate that was being handled by the logging cable digital recording within the logging unit and this subsequently increased the record capacity. The digitalization also facilitated the transmissions of the log signal radio satellite to computing centre or base office.(Onuoha,1987)

Other instruments used during the logging of Uzere well included drilling bit, sonde, electrode mud, motor, jars, panel cartridge heavy with drilling pipe(HWDP). The type of drilling mud was the salt based (kcl polymer) drilling mud. The sizes of drilling bits were 16 inches, 12, 25 inches and 8.5 inches. The table below shows other parameters that were used in logging the well.

Date Drilled	Mud Type	Resistivity Of mud (Ohm m)	Temp. Of mud Deg F	Temp. Of Mudcake Deg F	Resistivity Of mudcake	Temp. Of Mudfiltrate Deg F	Resistivity Of mudfilt	Bottom Hole Temp
Jan 1998	BENTONITE & CMC	1.4	75	75	1.71	75	1.25	175^{o}F

Table 1

Theoretical consideration & calculations

In 1950, Archie defined petrophysics as the physics of individual rocks in relations to their petrology, and offers a viable tool in oil explorations. He proposed the formula

$$F = a/\Phi^m \quad \text{-------------------(1)}$$

Where F = formation factor

m = cementation factor, a is a constant

Φ = porosity

The values of a and m are constant for different lithologies and in case of Niger delta, a and m are generally taken to be 0.62 and 2.15 respectively.

Water saturation is the percentage of pore volume in a rock which is occupied by the formation water, mathematically

$$S_w = \frac{(a/\Phi^m . R_w / R_t)^{\frac{1}{2}}}{\sqrt{FR_w} / R_t} \quad \text{----------------------(2)}$$

Where S_w = water saturation

$FR_w = R_o$ when the formation is 100% water saturation

From equation 2, hydrocarbon saturation can be calculated from $S_h = 1\text{-}S_w$

The processing of signal was performed for at least three levels, the up hole in the truck, the down hole and at a central processing centre. The raw data were processed down hole and the processed signals transmitted to the surface. A well site digital computer system, called Cyber service unit (CSU) is now a standard on a Shlumberger units through out the world. The system provides the capability to handle large amount of data. It overcomes many of the past limitation of combination logging systems (the stacking or combination of many measurements sensor into a single logging tool string). The CSU system provided the obvious potential for well site process of data. Nearly all the log interpretation models and equations were executed on the CSU unit. Evaluation programs ranged in scope from single well evaluation program to a series of special application products to reservoir description services that were used in evaluating the entire well.

After processing, the logs were displayed in a continuous paper. The logs were mostly displayed as composite logs (two or more logs placed side by side so that trends could be corrected and compared easily). The average log width is 21 cm with three tracks each of 4.4 cm. the first & second tracks are separated by a column of 1.9 cm in which the depth was printed. Each tract contains more than one log type.

The results of the evaluation of the studied well, are shown in worksheet 1 below.

Worksheet 1

DEPTH	SP log	GR log	CAL log	RESISTIVITY Log (Ohm m)			NEUTRON log	DENSITY log	LITHOLOGY
Interval(ft)	millivolt	(API)	IN	msfl	LLS	LLD(RT)	Fraction	G/CC	
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
5330-5350	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	2.38	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	6.5	0.37	2.38	sandyshale
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	sandyshale
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	sandyshale
6260-6363	62	28	13.8	2	5	10.5	0.30	2.20	Sand interbedded with shale

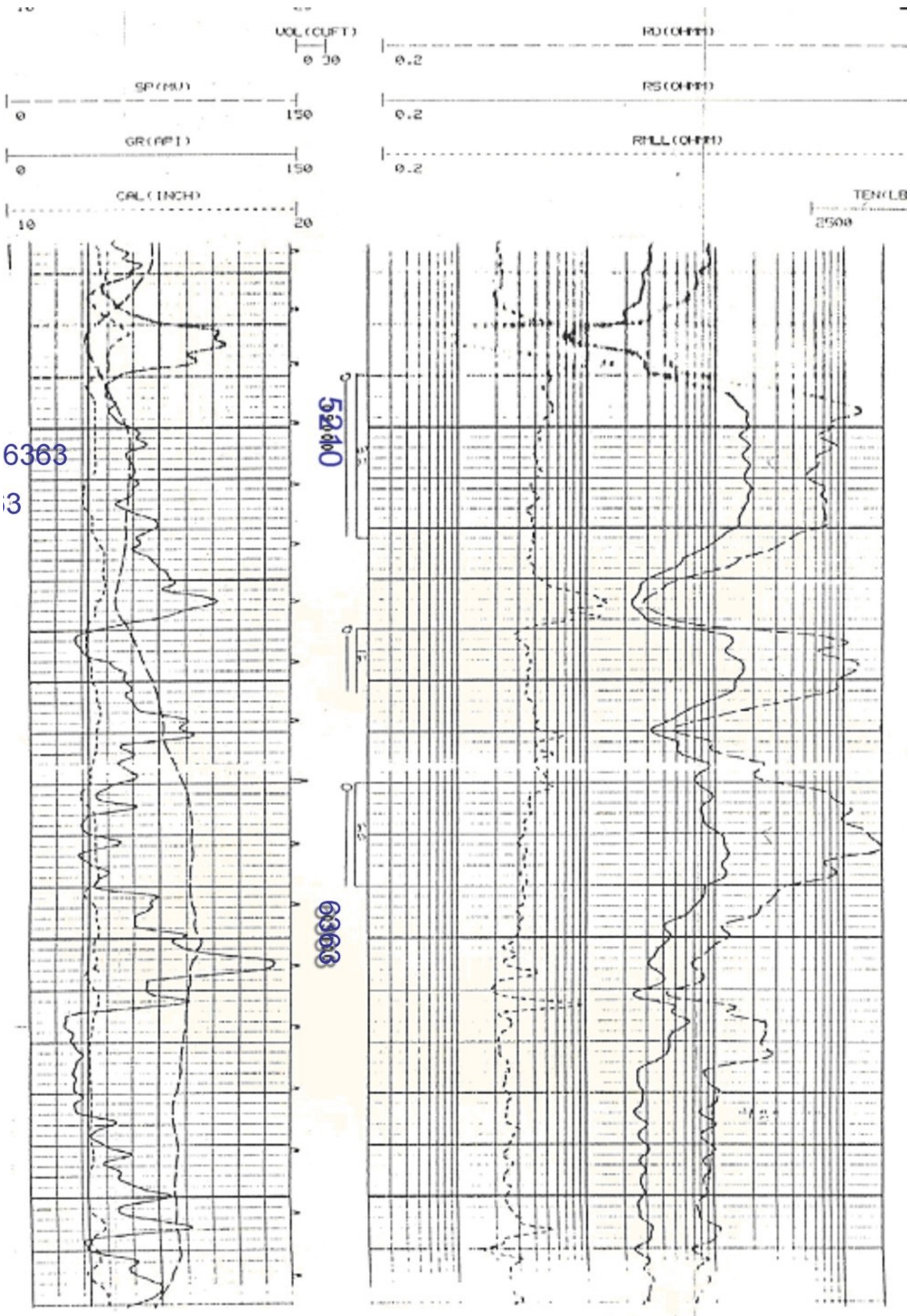
Results, Discussion & Conclusions

The well understudy, is logged in a fresh water environment between 05210 to 006363 feet of well. A number of assumptions were made for the determination of water saturation and hydrocarbon saturations for the various zones of the well. The results of these calculations are shown in the petrophysical evaluation worksheets 1

From worksheet, average hydrocarbon saturation is Total hydrocarbon saturation per number of intervals, ie 9.4/32 = 0.3

From this and other results on the worksheet, it can be found that the hydrocarbon saturation for the depth investigated revealed it as 0.3 or 30%, while water saturation is about 0.7 or 70%. Which implies that there are little traces of hydrocarbon and gas, with much water in the well.

However, quantitative analyses based on resistivity/conductivity log, compensated neutron log (CNL) and formation density compensated log (FDC). From where hydrocarbon saturations, water saturations, bulk volume oil, bulk volume water and index of oil movability formation factor. These, revealed that the hydrocarbon prospects in Uzere field is low and therefore more exploration should be carried out.



Well 1- Section of Geophysical well log

References

Archie G.E., 1942, the electrical resistivity log as an aid in determining, some reservoir characteristics: petrol tecni. vol. 5 no. 1

Molua O. C And Ujuanbi. O , "Microresistivity Log As A Viable Aid In Determining Hydrocarbon Saturation" (2006) Zuma Journal of pure & Applied science University of Abuja,pp129-133,

Onuoha,K.m(1987) Subtle Petroleum traps-A discussion on some of the tools and techniques for their effective search in the Niger Delta. NAPE Bull. Vol. 87,pp92-102

Schlumberger, 1989, log interpretation principles/applications schlumberger educational service.

SPE, 1971, well logging Page 42-82.

Weber,k.J (1971) Sedimentological aspect of oil fields in the Niger Delta. Geology en Mijinbouw, vol 50,pg 559-576.