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Full Length Research Paper

Reservoir fluid differentiation case study from Oredo field in the Niger Delta – Nigeria

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The formations in the Niger Delta-Nigeria consist of sands and shales with the former ranging from fluvial (channel) to fluviomarine (Barrier Bar), while the latter are generally fluviomarine or lagoonal. These Formations are mostly unconsolidated and it is often not feasible to take core samples or make drill stem tests. Formation evaluation is consequently based mostly on logs, with the help of sidewall samples and wireline formation tests. From the comparison between the FDC/CNL (Formation Density/Neutron Logs spell out) separation and SWS (sidewell sample) petrophysical data, it is possible for fluid differentiation to be done from SWS measurement with a good measure of reliability, in the absence of production data and FDC/CNL logs. This may not apply to liquid – rich gas and condensate reservoirs. The FDC/CNL log responses are better defined in thick clean sands as against thin marginal sands in this case study.

Key words: Formations, Gas/Oil, Sands and Shales, Hydrocarbon, Porosity, Resistivity.

INTRODUCTION

The Operators of older oil fields in the Niger Delta are currently engaged in rigorous re-appraisal exercises of remaining reserve in response to recent attractive fiscal terms offered by the Federal Government. In year 2005, the crude oil reserve base stands at nearly, 35 billion barrels and government is targeting 40 - 50 barrels in 2010 (Aigbedion, 2004; Onuoha, 2004).

In the absence of production data, gas/oil differentiation is usually performed based upon the FDC/CNL (Formation Density/Neutron Logs) response and sidewell sample (SWS) information. The response of the FDC/CNL is traditionally regarded as the more effective indicator of the two options. Since most of the wells drilled in the Oredo field have SWS data and no FDC/CNL logs, the objective of this study is to evaluate the fidelity of the existing data and thereby determine their validity when SWS measurements are used for differentiating gas from oil and water.

Although the search for oil deposits started in Nigeria in 1908, records show that Shell Darcy drilled the first well in 1938. Only haphazard efforts have been made towards drilling deep wells since then (Serra, 1986). These efforts, to much extent, have not been met with encouraging results. The reason could not be traced to a total absence of hydrocarbon at such depths, but was due to attendant drilling problems that were not adequately addressed proactively (Aigbedion, 2005). The map showing the area of study within the Niger-Delta is shown in Figure 1.

Geology of Oredo field

The Oredo field is situated in OML 111, about 40km of WEW of Benin city, Edo-Nigeria. The field consists of a NW – SE oriented roll – over structure about 14 km long and 5 km wide. It lies within the oil prolific belt of Niger Delta-Nigeria, (Figure 1).

The STOIIP and GIIP are currently estimated as 506 $\pm$ 0.9 Mbbls and 1.1 $\pm$ 0.039 billion cubic feat of gas respectively. Nine major reservoirs out of twelve contain approximately 90% of the total GIIP. The formations found in the Niger Delta are mostly unconsolidated sands and shales. Formation evaluation is consequently based on logs with the help of side wall samples and wire line formation tests (Schlumberger, 1985).

MATERIALS AND METHODS

The data available should provide a good base to determine a

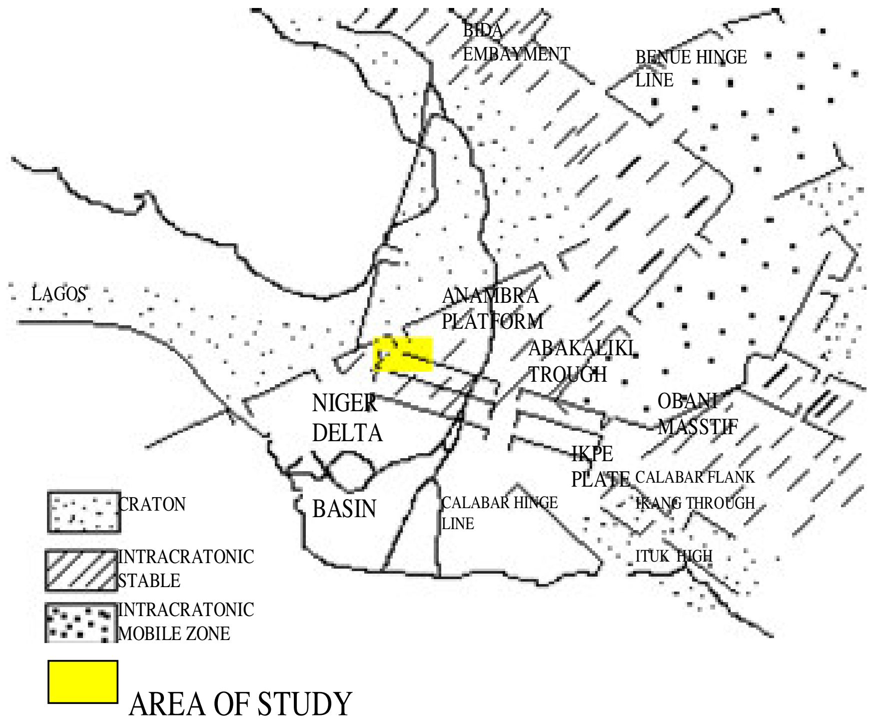

Figure 1. Showing the study area in the Niger Delta, Nigeria.

measure of confidence by comparing the FDC/CNL response with the recovered SWS. Five wells were used for this study. The wells are favoured for the study in terms of their coverage (in depth / lateral spread) and data quality for detailed evaluation. The major sand levels in these wells were analysed individually and correlated with one another where possible. The major sand levels considered are the $O_1 – O_{13}$. The FDC/CNL separation for the hydrocarbon in each case was compared through correlation with the corresponding SWS data observed on the petrophysical data log.

In terms of fluid type differentiation, the typical FDC/CNL log response as compared with the resultant data expected for occurrence of gas, oil and water are as plotted on Figures 2 and 3. These form the basis on which the observations and conclusions are made on the comparison of the FDC/CNL separation with the SWS data obtained from Oredo field. For the SWS data obtained from this field, the calliper (hole diameters in inches), spontaneous potential (in millivolts) and gamma-ray (API units) curves are plotted on the left, and resistivity log (ohms – metre) are plotted at the middle, with porosity logs on the right handside of the same log. In equivalent terms on the FDC/CNL log, the calliper is plotted on the left handside track while the neutron porosity (in %) and bulk density (grams/cc) with their correction are plotted on the right handside tracks.

COMPARING FDC/CNL SEPARATION WITH SWS

A first indication of the probable presence of a sandstone reservoir is the sudden change in value of the GR and SP curves as seen on the open-hole logs. The log response to typical sandstone reservoir in this field is exemplified in Oredo by a cylindrical gamma – ray curve shape indicating deltaic channel sands, featureless, massive with constant permeability (Figure 4). The average porosity (Ø) and water saturation (S_w) are 20% and 27% respec-tively, while the water resistivity is 0.14 ohm-m.

The GR curve is a measure of the natural radioactivity of the formations. The GR readily is lower in sand than in shale since sandstone is generally less radioactive than shale. The SP curve is a recording of the natural potential difference between a point in the borehole and the surface. In Nigeria, the salinity of the mud filtrate is often greater than that of the formation water, this causes the SP deflection opposite permeable beds to be positive towards the right (Schlumberger, 1985), and positive SP deflections usually indicate fresh water-bearing formations.

Water-bearing formations

The neutron porosity (Ø) is formulated by assuming a water-bearing limestone matrix. Since the reservoir lithology in the Niger Delta is predominantly sandstone, the sandstone compatible scales are used for the FDC / CNL logs. In this regard, the response is such that the density and neutron curves practically overlay each other (that is, an interplay) over the whole porosity range in clean water-bearing sandstones. The sidewall sample data is equally expected to exhibit indications of hydrocarbons. The resistivity log should indicate a highly conductive zone. Observations from relevant logs including Oredo reveal responses as described above in water-

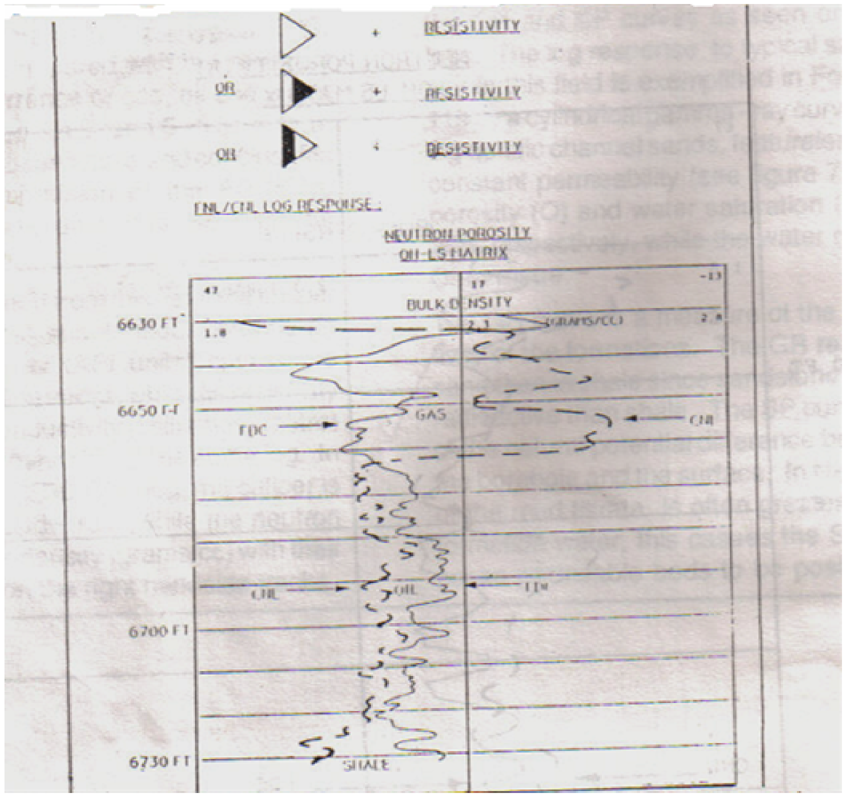

Figure 2. SWS data and FDC/CNL log response in gas bearing sand

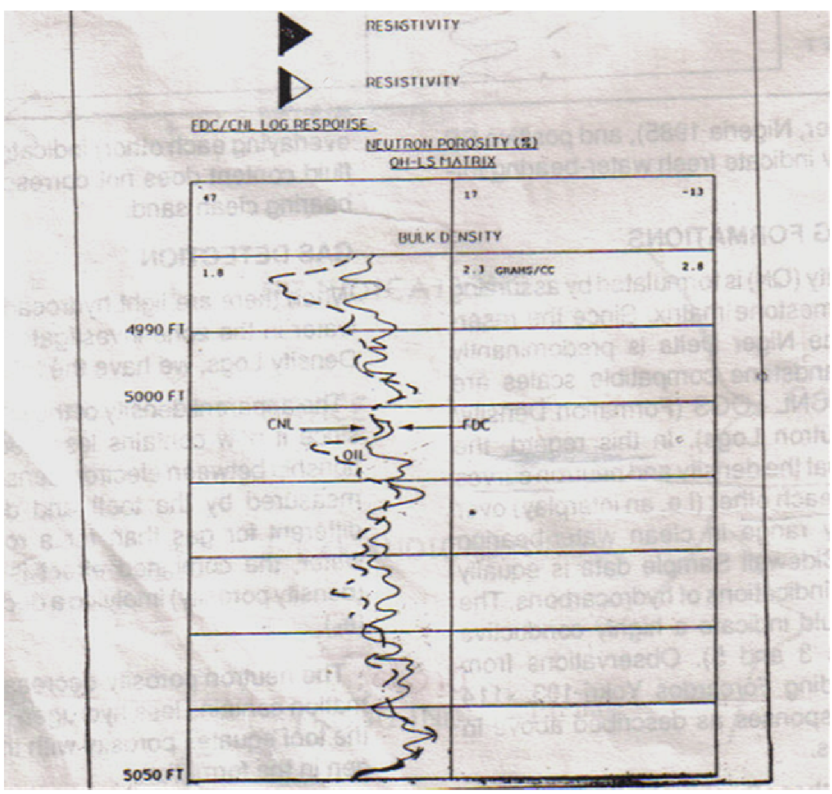

Figure 3. SWS data and FDC/CNL log response in oil bearing sand.

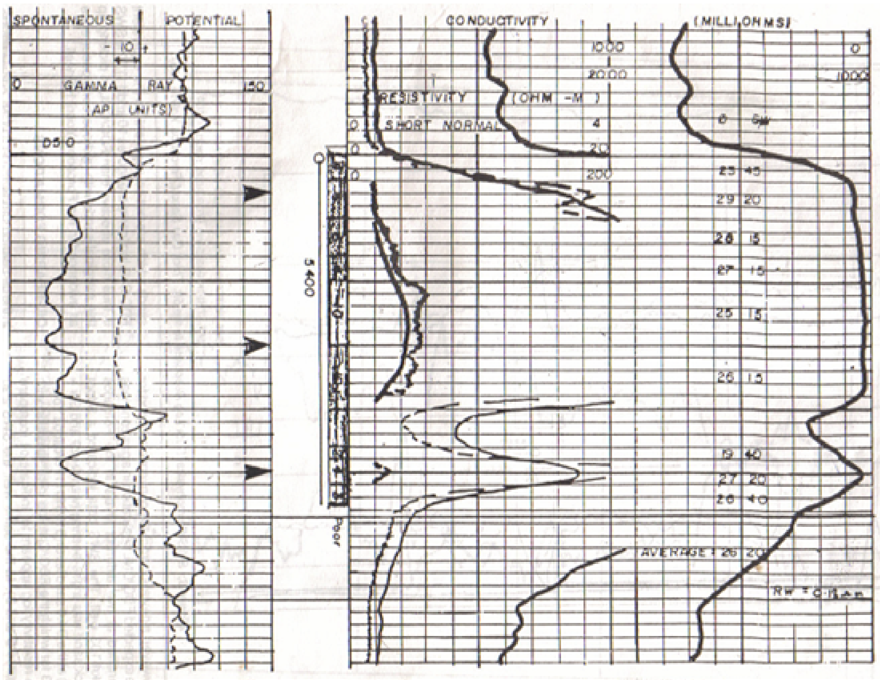

Figure 4. Oredo well (side wall sample).

bearing zones. A departure between these 2 curves (that is, FDC and CNL overlaying each other) indicates that the lithology or fluid content does not correspond to that of water-bearing clean sand.

Gas detection

When there are light hydrocarbons instead of oil or water in the zone investigated by the Neutron and Density Logs, we have the following effects.

The apparent density of the formation is decreased since it now contains less dense fluids. The relationship between electron density (which is normally measured by the tool) and density is somewhat different for gas than for a rock containing oil or water, the combined effect is an increase in ($Ø_D$) (density porosity implying a decrease in bulk density (e_b).The neutron porosity decrease because the formation contains less hydrogen per unit volume, and the tool equates porosity with the amount of hydrogen in the formation.

Hence the combination of these 2 effects results in the FDC/CNL separation. An increased resistivity response occurs when the formation is gas-bearing. The equivalent SWS data would show either some indication of recovered hydrocarbons or no trace but with evidence of increased resistivity response from the resistivity log for Zone.

A good correlation was observed between the FDC/ CNL and SWS data for the gas-bearing formations encountered in Oredo field.

However, a deviation from the conventional trend for the expected FDC/CNL separation in a gas zone was identified at two different levels in the Oredo field. The SWS data indicated a 5-foot thick sand was a gas-bearing (with Ø=29 and S_w = 55) at the O_4 sand level (5195ft) in Oredo field for which the FDC/CNL log in combination with the resistivity log appears to indicate oil. In the same well, the SWS also noted gas and strong indications of oil at the O_8 sand level (5548 ft), another 6 ft gas and 8 ft oil pay sands which are not so apparent on the equivalent FDC/CNL log. The SWS is thus more effective than FDC/CNL in picking up thin marginal sands with hydro-carbons occurrence as evidenced in the Oredo field.

Oil-bearing formations

In the oil-bearing sands, the FCD/CNL curves tend to track together, with evidence of high resistivity. The SWS data equally exhibits weak or strong indications of oil with an increase in the resistivity log. There is, in general a good correlation between the FCD/CNL log response and the SWS data for the oil-bearing sands encountered by Oredo field in particular.

Conclusions

From the above comparison between the FDC/CNL separation and SWS petrophysical data in various hydro-carbon zones, it can be concluded that fluid differentiation (gas, oil or water) in the Oredo can be done from SWS measurements with a good measure of reliability, in the absence of production data and FDC/CNL logs. As observed from the analysis of Oredo field, wells 1,2,3,4 and 5, there is a very good correlation between the FDC / CNL log response and equivalent SWS data for accumulation of gas and oil at the various levels. It was noticed that SWS data better differentiated thin marginal gas and oil sands of the order of 5 - 6 ft pay in each case, while the equivalent FDC/CNL logs did not pick them up. The FDC/CNL log responses are better defined in thick clean sand formations as against thin marginal pay sands. The SWS petrophysical measurements, consequently, have proved to be effective tool and potential for reserves/production additional recommended for use in the Niger Delta lithological setting. However, the method may not be applicable to liquid-rich gas and condensate reservoirs.

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REFERENCES

Aigbedion I (2005) Petrophysical Analysis of Some Onshore Wells in the Niger-Delta, University of Benin (Ph.D thesis).

Aigbedion I (2004) Petrophysical Analysis of Two Onshore Wells in The Abura Field. Afr. J. Appl. Sci. Enugu Niger. 7: 102-107.

Onuoha M (2004). Oil and Gas exploration and production in Nigeria. Paper delivered in the university of Ibadan at the post graduate school interdisciplinary discourse. NAPE Bull. 4(6): 3-6.

Schlumberger Inc., Nigeria (1985). Well Evaluation Conference. Schlumberger Books p. 62.

Serra O (1986). Advanced interpretation of wire line logs Schlumberger Books p. 295.