GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES VOL. 8, NO. 2, MARCH 2002:265 - 269

THE USE OF THE MEASUREMENT WHILE DRILLING (MWD) DATA IN RESERVOIR IDENTIFICATION AND FORMATION EVALUATION

E. U. EGEH, C. S. OKEREKE and O. O. OLAGUNDOYI

(Received 26 June 2001; Revision accepted 3 December 2001

ABSTRACT

The use of the Measurement While Drilling (MWD) tool in formation evaluation has proved invaluable in terms of operational cost, time and reliability of data. The tool suffers less from invasion effect when compared to conventional wireline tools and so can be deployed in hostile borehole environments. Measurement While Drilling data when properly interpreted provide useful information on the hydrocarbon type saturating the pores of a formation, compaction condition and evaluation of over pressure zones in the field as well as the provision of porosity, density and fracture data of the formation logged. Interpretation of case history on the significance of both MWD and wireline data show that MWD offers better data borehole conditions change rapidly after drilling. However, data from both sources when combined offer a better and complete reservoir evaluation.

Key words: Drilling, invasion, MWD, reservoir, formation evaluation.

INTRODUCTION

Formation evaluation involves the determination of certain petrophysical parameters necessary in ascertaining whether or not a well is worth completion for subsequent production of oil/or gas. Ordinarily, evaluation methods from conventional wireline logs have yielded reliable results but owing to certain limitations inherent in these devices, the use of Measurement While Drilling (MWD) tool is fast gaining prominence in most exploration schemes for hydrocarbons (Schlumberger, 1996).

Simms and Koopersmith (1989) had accurately interpreted and defined gas, oil and water using MWD information. Such data apparently aided in the identification of producible oil in an objective interval in a well in which gas is expected without the benefit of wireline data. The choice for the use of MWD data in preference to wireline logging is generally governs by the following facts:

(i) MWD formation evaluation devices are normally placed closed to the bit so that mud filtrate invasion is usually small or negligible (which helps to identify gas and water Zones). On the other hand, wireline measurements occur long after the formation had been drilled and are always influenced by invasion, which reduces resistivity contrast between the gas and water zones. Also, the MWD logging allows relogging zones at various time interval after they are drilled and thus provide data for permeability and invasion profiling.

(ii) In wireline logging, the large volume of mud surrounding wireline tool frequently demands pad contact (as in density device) or eccentricity (as in neutron device) in order to minimize the effects of the mud on the measurements. MWD tools displace much of the borehole fluid, minimizing the volume of mud affecting the measurements, thus fever measurements and less data processing are required to obtain the same formation data using MWD measurements than are required from wireline measurements.

(iii) MWD logging saves much time and money since no additional rig time is required as it is the case with the wireline devices.

E. U. EGEH, Department of Geology, University of Calabar, Calabar, Nigeria
C. S. OKEREKE, Department of Geology, University of Calabar, Calabar, Nigeria
O. O. OLAGUNDOYE, Department of Geology, University of Calabar, Calabar, Nigeria

This paper focuses attention on the efficacies of the MWD tool in comparison with conventional wireline logging. The presentation is therefore a review of the general applications of the MWD and further shed more lights on the needs of increasing the present standard in the tool assemblage for increased optimization.

The MWD Tool

The tool is composed of a dual resistivity, log, compensated neutron logging device and compensated density log, all of which are housed in a single assemblage and used in formation evaluation (Schlumberger, 1996). The compensated dual resistivity component is an electromagnetic propagation and spectra gamma ray tool that is built into drill collar. It provides resistivity information from two depths of investigation as well as measures the phase shift (if any) between the receivers.

The density and neutron section (figure 1) of the device provide information on the formation porosity and density respectively. The compensated density-neutron tool (CDN) is located on top of the tool assemblage so that they can be fished out should the bottom hole assemblage (BHA) become stuck in the hole. The density source and detectors are positioned behind a full-gauge clamp-on stabilizer which excludes mud from the path of the gamma rays and by so doing greatly reduces borehole effect.

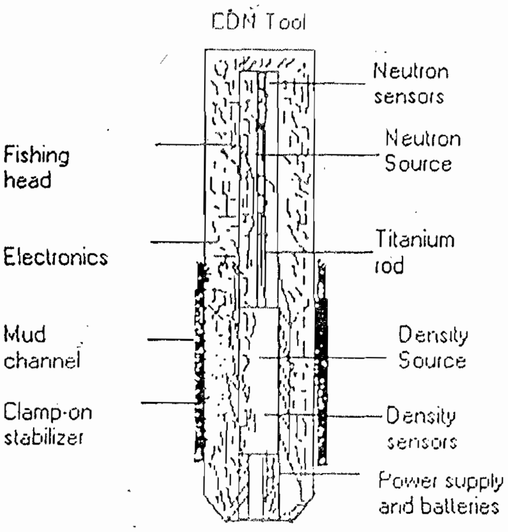

Fig. 1 Compensated density neutron tool (After Simms & Koopersmith, 1989)

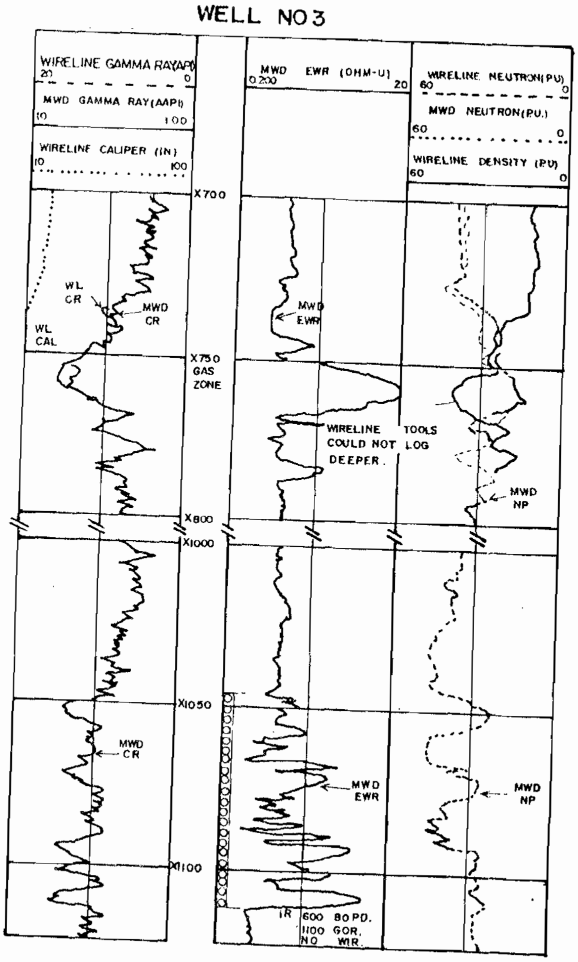

Fig.2 MWD Neutron used as primary evaluation tool, zone at x100 feet is oil productive. (After Simms and Koopersmith, 1989)

Hydrocarbon-type Identification from MWD

For an example, review of the comparison between MWD and wireline system a specific case study of the Louisiana field (off shore, SE belt of USA) which was worked upon by Simms and Koopersmith (1989) is being critically assessed from figures 2 and 3 made from wells 3 and 5 drilled between 1987 and 1988.

Well No.3

This well compares wireline and MWD neutron porosities through a water zone at depth 550, a shale zone at 700 and a gas productive interval at 750 feet. Wireline data indicated that the gas sand at 760 feet has 20% resistivity, 40% density log porosity and 12% neutron porosity. The MWD neutron reads a porosity of 15%. The MWD neutron alone easily identified the sand as gas productive and when combined with the offset well data indicated a true porosity of about 20%.

A second objective sand was encountered at the bottom of this well at X1050-X1110 feet. The zone was logged with MWD measurement as shown in figure 2. Here, wireline logs failed to reach the objective sand due to poor hole conditions. Therefore, the MWD data alone were used as the primary record of the well bore and hence the formation evaluation. Reservoir analysis prior to drilling this well suggested that the objective sand would be penetrated above gas-oil contact, and thus gas productive. However, based on a moderate MWD neutron porosity of 24-26%, it was determined that the reservoir had re-pressured and the zone was evaluated as oil productive.

Well No.5

Figure 3 which is a log plot of well No.5 clearly depicts an excellent agreement between wireline borehole corrected neutron and MWD neutron. Both neutron devices record 35% porosity in the shale at X600 feet. This well provides additional insight into the use of MWD neutron porosity for hydrocarbon type identification. MWD neutron response of approximately 15% porosity in the gas productive sand at X630-X670 feet is approximately consistent with the wireline neutron and suggest that the zone is gas productive in the interval X630-X655 feet. Analysis of the MWD neutron porosity curve alone results in an unambiguous interpretation of the lower productive zone from X655-X670 feet. Also, an analysis of the combined wireline density and neutron responses, reveal a "cross-over gas effect" in the third lobe at X655-X670 feet, suggesting that the lower zone is oil productive.

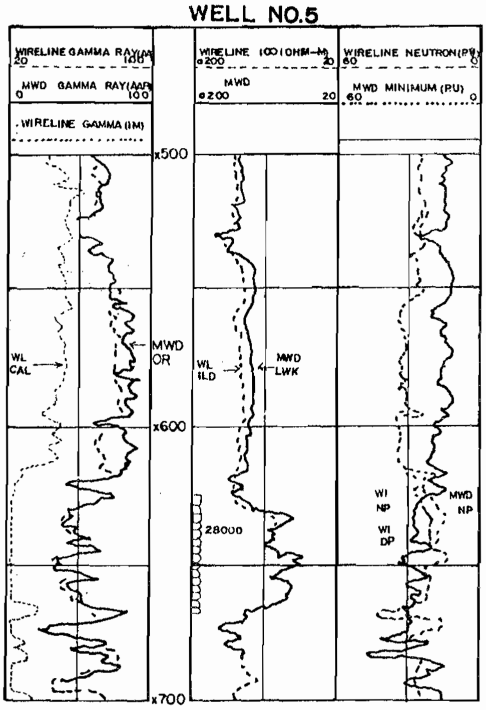

Fig. 3

Good quality MWD and Wireline Neutron: Gas Zone at x655 feet indicated by 15% NP high oil content at 600feet. (After Simms and Koopérsmith, 1989)

Evaluation of Formation Invasion

MWD logs can be used to evaluate formation invasion by the application of resistivity relog: Relogging porous and permeable formation using an MWD resistivity logging tool has provided a qualitative picture of the invasion process as it occurs.

Relog method means logging a particular section of interest more than once (Cobern, 1985). Here in drilling a hole, a resistivity sensor is inserted inside the drill bit, so that the driller can obtain information while drilling. After obtaining the first data, the same resistivity sensor is used to obtain information in the same hole as the drill assemblage is pulled out. If there are notable changes/differences between the first and second data obtained, these changes, according to Pirson (1963) may be due to invasion, since the same sensor is used for all the measurements made under an established equilibrium hole condition have remained about the same.

Prediction of Over Pressure Zones

A plot of density or neutron porosity made from CDN or CNL may be obtained using MWD measured data. Such plots when made on appropriate scales can provide a useful guide on the compaction trend in an area (Egeh et al., 2001). Porosity may be obtained from the density log using the expression.

$$\phi_D = \frac{\rho_b - \rho_{ma}}{\rho_f - \rho_{ma}} \quad \ldots\ldots\ldots\ldots\ldots (1$$

where

ϕ_D = porosity derived from the density log
ρ_b = bulk density
ρ_{ma} = matrix density
ρ_f = fluid density

In the same vein, the compensated neutron log (CNL) component of the MWD is a reliable porosity device and this together with bulk density values from the compensated density log (CDL) of the MWD tool can be used to generate either porosity and/or density versus depth plots. When such plots are examined, and a deviation from a downward increase in density or a downward decrease in neutron porosity is observed, it implies a reverse compaction trend which could be due to an over pressure horizon or under compaction. The depth and thickness of such an over pressure bed may be estimated using the depth scale of the plots. In the same vein, information on phase velocity which could be derived from data on phase shift, provided by the resistivity device of MWD tool could serve as an excellent compaction determinant when plotted versus depth.

IDENTIFICATION OF PERMEABLE AND NON-PERMEABLE BEDS

The commercially available MWD logging suite consists of Natural Gamma-ray sensors among other components. Therefore, since radioactive elements in sedimentary formation are often times associated with fine grain sediments (shales), a plot of gamma-ray response towards an increasing trend will indicate the presence of shales (Rider, 1986). Conversely, a decrease in the response will indicate the presence of coarse grain-sediments (sands). In this respects, the MWD tool could serve equally as a lithologic tool when appropriately conditioned.

CONCLUSION

The MWD tool is an invaluable device for formation evaluation and well development programmes. Since neutron reading generally compares well with the borehole corrected wireline neutron porosity, the tool therefore, provides the necessary impetus for hydrocarbon-type identification with minimum cost and maximum time gain. To optimize efficiency of the MWD tool, the incorporation of acoustic component is essential. In this way velocity analysis as well as fracture mapping may be done with ease. Such information could then be combined with porosity data obtained from the CDN component to evaluate both vertical and horizontal permeability for the interval being measured. In the same vein, velocity information would provide a more reliable lithologic identification than that which both CDN and CNL component would indirectly provide. Although, the cost savings of MWD versus wireline logging appear small, the expected trouble costs associated with the wireline technique are much higher than with MWD and this benefit suggests that MWD is the better alternative moreso, as no additional rig time is required. Finally, the potentials of MWD logging may be increase by the introduction of additional sensors that will enhance quantitative formation evaluation and hence proper reservoir management.

ACKNOWLEDGEMENT

We wish to thank SPDC, Port-Harcourt for providing some of the materials used in the work.

We are also grateful to Nzelu, Ifeyinwa for her various contributions.

REFERENCES

Berga, P.K.,1997. Bit Technology. Journal of Petroleum Technology, 49(12): pp.1310-1325.

Brooks, A.G. and Hall, P.E., 1989. Calculation of MWD Electromagnetic Resistivity Tool Response. Society of Petroleum Engineering, pp.537-548.

Cobern, M. and Nuckols, E., 1985. Application of MWD Resistivity Relogs to Evaluation of Formation Invasion. SPWLA 26th Annual Logging Symposium, Dallas, pp.1-8.

Egeh, E.U.; Okereke, C.S. and Olagundoye, O. O., 2001. Porosity and Compaction Trend in Okan Field (Western Niger Delta) based on well log data. Journal of Applied Sciences. 7(1): pp.91-96.

Ellis, D.V., 1986. Neutron Porosity, What Do They Measure? First Break. 4(3): p.1-8.

Glean, W.; Grimes 1992. The World's Deepest Horizontal Well Paper PEI 1992. pp.30-34.

Relley, R.H., 1990. Horizontal Well Technology. Paper World Oil. pp. 42 - 43.

Rider, M.H., 1986. The Geological Interpretation of Well Logs. Blackie, Glasgow and London, Halsted Press, a Division of John Wiley and Sons N.Y. pp.1-167.

Schlumberger, 1972a. The Essential of Log Interpretation. Practice Schlumberger Ltd. N.Y. 1972 ed. pp.1-55.

Schlumberger, 1989. Cased Hole Formation Evaluation, Principles and Applications. Schlumberger Educational Services, pp.10-14.

Simms, G. J. and Koopersmith, 1989. Hydrocarbon Type Identification Using MWD Neutron Porosity Logging. SPE 1962. pp.495-503.

Vichad, C.N. and Hoeksema 1987. Estimating Drilling for Optimum Production in a Fractured Reservoir. An Assoc. Petroleum Geol. Bull. 71(8): pp.958-966.