Improve The Efficiency Of The Study Of Complex Reservoirs And Hydrocarbon Deposits - East Baghdad Field

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Abstract: Practical value of this work consists in increasing the efficiency of exploration for oil and gas fields in Eastern Baghdad by optimizing and reducing the complex of well logging, coring, sampling and well testing of the formation beds and computerizing the data of interpretation to ensure the required accuracy and reliability of the determination of petrophysical parameters that will clarify and increase proven reserves of hydrocarbon fields in Eastern Baghdad. In order to calculate the most accurate water saturation values for each interval of Zubair formation, a specific modified form of Archie equation corresponding to this formation was developed.

Index Terms: Archie, Porosity, Well logging, Water saturation.

INTRODUCTION

The effectiveness of exploration of oil and gas fields is largely determined by the level and the amount of seismic work, the methods and techniques of well logging, certainty in problem solving based on the data of well logging to allocate bearing zones and determining their parameters which are then used for the calculation of oil and gas reserves. For characterizing water saturation of reservoir rocks, the coefficient of water saturation (Sw) is used. The formation water saturation is defined as the ratio of pore volume filled with water to the total volume of the pore space. To determine the Sw, many other petrophysical parameters, that can be obtained when logging the borehole or by laboratory measurements on the core, must be known. The most common of the methods used in determining the Sw is the famous Archie formula:

$$S_w = \sqrt[n]{\frac{a\,R_w}{\phi^m\,R_t}} \qquad (1)$$

Empirical constant (usually near unity); Resistivity of formation water, Ω-m; Water saturation, fraction; Cementation exponent (usually near 2); Saturation exponent (also usually near 2); Porosity, fraction; Resistivity of uninvaded formation, Ω-m

For clean granular sandstones generally accepted values are as follows: n = m = 2, a = 1 and (1) becomes;

$$S_w = \sqrt{\frac{R_w}{\phi\,R_t}} \qquad (2)$$

As Archie formula in this form gives good results only in Clean terrigenous strata [1], in this work a modified form of Archie's formula is proposed in which specific values of "m" and "a" was used. This modified form enable the use of Archie formula in clean and in clay formations as well, particularly for East Baghdad fields. As can be seen from the Archie equation, important for accurate determination of saturation is to determine the porosity coefficient (φ), [2].

Formation Porosity

The porosity of different intervals Zubair formation (East Baghdad Field, Iraq territory) was calculated according to several methods in order to select the most accurate value of the porosity, which is used in the determination of reservoir saturation. Due to the significant influence of porosity on the calculation of the water saturation (Sw), the following methods for determination of the porosity were discussed [3]:

1 -Neutron log method (NL);
2 -Density log method (DL);
3 -Method of constructing cross-plots on the complex of NL-DL;
4 -Acoustic(sonic log) method that uses the time average equation (SL).

As reference porosity values (to adjust the results of the interpretation of these methods), the porosity values determined by core were used. As a result of comparing the porosity values obtained according to the complex of these methods and the measured formation porosity values from core analysis, it was found that the most acceptable correlation parameters when compared to other used methods has integrated cross-plotting method (using the triangle method, see. Table1). Most preferred, in the task of determining the formation porosity, is to use the method of the triangle, since, according to the statistical analysis, the correlation coefficient for this method is the highest, and the percentage error - the lowest. This calculated porosity values are then used in the determination of water saturation using Archie equation.

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Table 1 *Correlation parameters for the method of NL, DL and SL as both individual indicators and combinational indicators in determining formation porosity.*

Method	Average Percentage Error	Absolute Average Percentage Error	Standard deviation Error	Correlation Coefficient
NL	+1.699	4.870	6.853	0.906
DL	+1.262	5.648	7.4931	0.883
NL-DL Cross-plot(triangle method)	+2.276	4.591	6.244	0.923
NL-DL Cross-plot (standard charts)	+13.096	13.096	14.739	0.884
SL	-11.555	11.576	12.511	0.922

The comparisons of the formation porosity values calculated by different logs methods with the measured porosity values are represented graphically on Fig. 3 .This Fig. confirms the result of Table 1. It shows that the most accurate values of formation porosity are calculated by cross-plot technique (using triangle method).

CEMENTATION M AND TORTUOSITY FACTORS

The main values of the degree of cementation m and tortuosity factor a (constant that depends on the state of the rocks) take the following values:
m = 2,0 and a = 1,0.

These values are widely used in various studies as the most typical values of these parameters. However, as noted by many authors, the values of these parameters may vary for different types of deposits and significantly influence the determination of reservoirs saturation particularly under interpretation of well logging data using methods such as a method based on the use of Archie's equations [4].

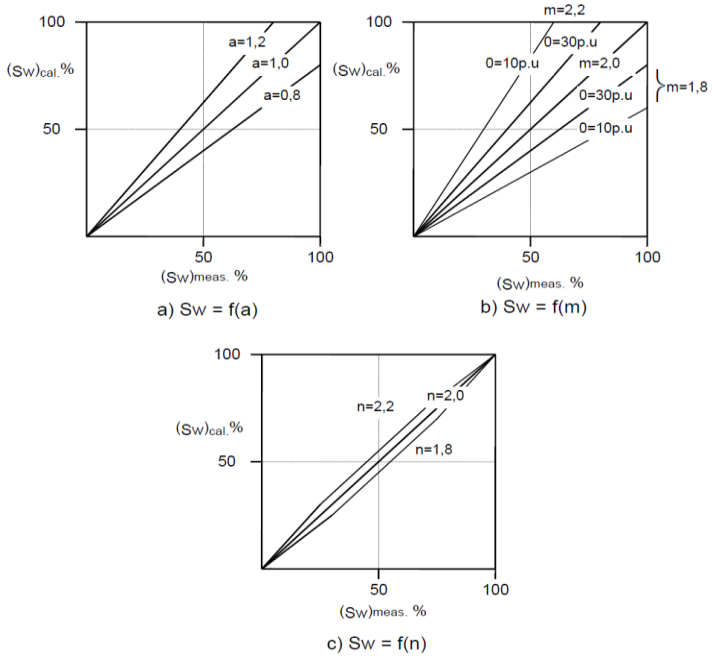

Fig. 1. *Influence of m, a, and n on the calculated values of water saturation, (Sw)cal. (where Sw_{meas} is lab. measured water saturation).*

It was found that the parameter m has greater influence on the calculation of the coefficient of water saturation than the parameter a, as can be seen from Fig. 1. Thus, the cementation factor m should be regarded as a more informative parameter [5]. The theoretical basis of the method applied can be easily installed at a logarithmic representation of the Archie equation, when the classical value adopted for the n, equal to 2.

$$logR_t = -mlog\emptyset + logaR_w - 2logS_w \qquad (3)$$

The above method provides a graphical determination of the values of formation water resistivity Rw and coefficient of water saturation Sw. To determine Rw, as can be seen from (3), at a value of Sw = 100% (in water-bearing zones at 100% water saturation), there is a linear relationship between resistivity and porosity as follows:

$$logR_t = -mlog\emptyset + logR_w \qquad (4)$$

A line defined by this equation must pass through the lower points of the resistivity on a logarithmic chart of (log R_t) and (log φ) for water-bearing zones. This line appears to be most accurate for the entire range of values. The slope of this straight line is numerically equal to m, as can be seen from (4), and its intersection with axis of φ = 100% determines the values of Rw and a as follows:

log (intersection point) – log (a R_t) (5)

In order to determine specific values of m and a , characteristic for Zubair formation, value of Rw = 0.018 ohm-m was used. This value was calculated from the apparent resistivity from the well logs data and the results of laboratory measurements. For the most accurate values of water saturation for each interval of Zubair formation, based on a modified form of Archie's equation, as shown in Fig. 2, the following values of m = 1,917 and a = 0,583 were obtained.

SPECIFIC MODIFIED ARCHIE EQUATION

Substitution of the values of m = 1,917 and a = 0,583 into (3) leads to the following form of the Archie equation:

$$logR_t = -1.917log\emptyset + logR_w - 2logS_w + \log 0{,}583$$

$$S_w = \sqrt{\frac{0.010}{\emptyset_{tr}^{1.917} R_t}} \qquad (6)$$

Where: $\emptyset_{tr}$ - Porosity, obtained using the method of the triangle [5].

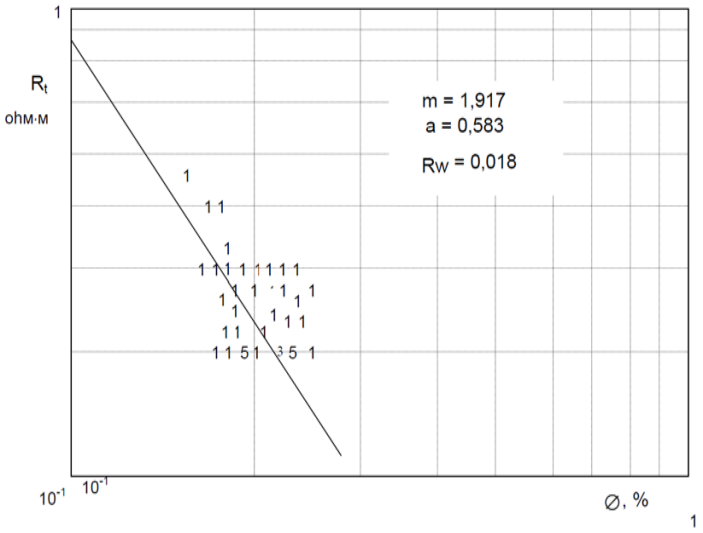

Fig. 2. *Relationship of R_t=f(φ)*

Table 2

Sw values , obtained according to the modified and standard Archie equations and the results of the laboratory measurements for a number of selected intervals of Zubair formation.

Well No.	Depth,m	Rt ohм·м	$\varnothing_{tr}$ %	S_w% Modified Archie Eq.	Sw% Standard ArchieEq.	Sw%, Measured
EB-55	3400 3457	20 20	13.0 16.3	16.1 13.0	23 18.4	15-7 14
EB-79	3030 3070	30 17	6.0 10.5	27.7 21.5	40.8 30.9	26-1 20-9
EB-77	3135	30	5.5	30.1	44.5	32-4
EB-55	3007 3150	5.5 6	16.3 15	24.8 25.7	35.1 36.5	22-8 27-5
EB-15	3558 3720	4 80	10.5 7.3	44.4 13.9	63.3 26.5	48-5 15
EB-18	3505 3855	18 1.7	5.3 14.1	40.3 51.2	59.6 72.9	43-6 53

The values of formation resistivity (Rt) determined according to data of the induction log. Evaluation of the accuracy of water saturation values, calculated in accordance to the modified Archie equation and standard equation of the Archie , were based on the results of testing the productivity of oil from the examined formations on drill pipes[6]. Data comparison (Table 2) shows that the water saturation values obtained according to the modified Archie equation are in better agreement with the results of the well testing than the values of water saturation obtained using the standard Archie equation.

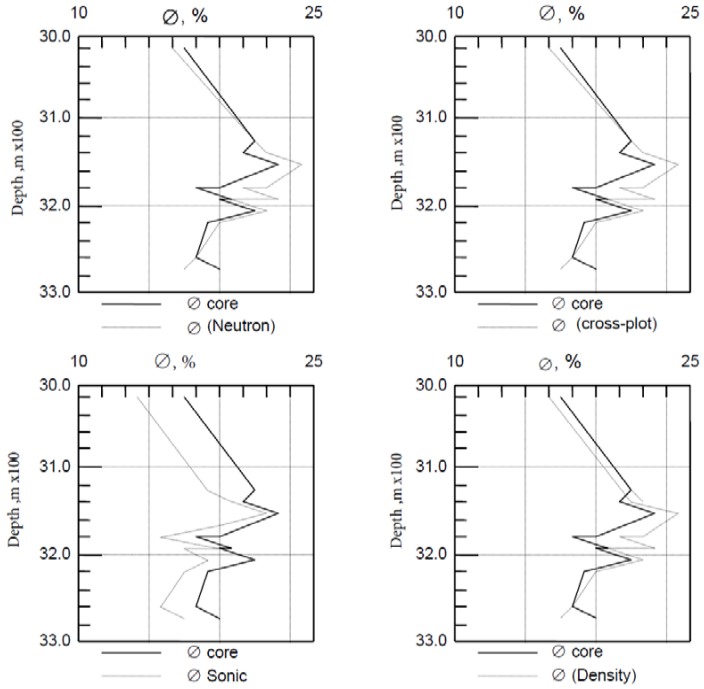

Fig. 3. *Comparison of the measured Porosity (φcore) with the calculated porosity (φlogs) for well No. (EB-56).*

CONCLUSION

On the basis of statistical analysis of the correlation parameters of different well logging methods used to calculate the effective formation porosity, the reliability of more accurate results increased through the use of complex techniques consisting of a neutron and density logs using cross-plotting technology. A specific and modified form of the well-known Archie equation for the determination of formation water saturation are derived .This equation allows to increase the accuracy of the determination of oil and gas saturation coefficients So and Sg.

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