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Petrophysical Properties of Euphrates, Bajwan, Jribe and Dihban Formations at Iraqi Gas Reservoir, in the north of Iraq

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Petrophysical Properties of Euphrates, Bajwan, Jribe and Dihban Formations at Iraqi Gas Reservoir, in the north of Iraq

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Abstract. Petrophysical Properties of Euphrates, Bajwan, Jribe, and Dihban Formations at Iraqi Gas Reservoir is distinguished from data interpretation of Open Hole Logs recorded in the field. A calculations were made for the total porosity (effective), secondary porosity, volume of shale and hydrocarbon saturation, water saturation (both moveable and non-movable in invaded zone and non-invaded zone beside). Some *Interpretation* and cross plots are done by Interactive Petrophysics (IP) software. The *Interpretation* also includes determination of Volume of Clay and Saturation of Water (Sw) by different Methods. It is concluded that dihban is cap rock, while the formations have good reservoir characteristics as it provided from log analysis.

1. Introduction

Petrophysical Evaluation of Carbonate Formations is too important in anticipating its behavior because the large variation of petrophysical properties of these Formations. Well Logs are one of the more important data sources about the Geological and Petrophysical Characteristics of Reservoir Formations. Determination of Archie's parameters are important in evaluation of certain Petrophysical Characteristics. Permeability, an important property in reservoir rocks and most hard of Petro physical Characteristics for determine. Permeability can be determine from core data or can be determine from transient well test. The current study contained is Kormor field at the north of Iraq fig.1, the reservoir of this field is Tertiary which included (Euphrates, Bajwan, Jribe, Dihban) formations.

2. The study area

Kormor Field is located the north east part of Iraq ,in the south east extension of Kirkuk field ,Kormor structurally lower than Kirkuk field, (30) km saddle separate between them. also kormor field parallel to Jambur field ,Kormor located 14 km to the south west of Jambur main fault separate between them. Figure (1.1) shows field location.

Kormor structurally is asymmetrical anticline (33) km length, (4) km width and (900) m closure . Nowadays Korrmor contain eight wells.

The field tests proved the existing of gas in Lower Miocene Age of Tertiary Era which consist of (jribe, euphrates, bajwan) reservoirs, dihban anhydrites separate between Jribe and Euphrates formations.As followed:

Jribe formation
it consists of upper unit which is wackstone and packstone with intergranular porosity, the lower part consist of brown dolostone with sporadic vugs filled with calcite and calcite veins.
Dihban formation: it consists mainly of anhydrates and separates the porous Euphrates formation from the rather dense Jribe formation
Euphrates formation: this is alternating sequence of vugular recrystallised. Limestone (sparstone) and fine-medium grained dolostone, the lower part contains a small percentage of bluish grey marl.
Bajwan formation: it consists of fine-grained brown limestone, porous and contains vugs filled with calcite.

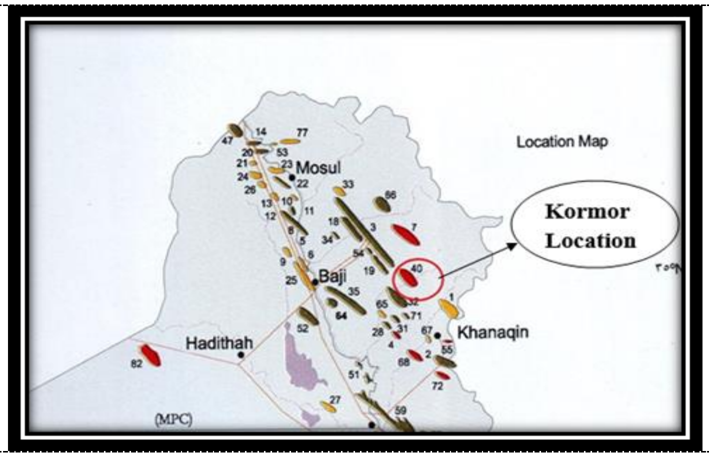

Figure 1. Kormor Field Location

3. Aims of study

The current study aims to:

1- Well Log analysis.
2- Prediction of permeability from petrophysical parameters in uncored.
3- Determination of porosity cutoff.
4- Spatial distribution of reservoir most important petrophysical properties.

4. Methodology

The Software called IP (Interactive Petro physical- Version 3.6) is using for well logs (Full Set) analyzes to distinguish the (Determination of Mineralogy, Determination of Lithology, Environmental Correction, Shale Volume (Vclay), Porosity (Φ) , Water Resistivity (Rw), Computer Process Interpretation (CPI) and Bulk Volume of water (BVW)).

5. Estimation of petrophysical properties

The term Interpretations of well Logs (also called Formation Evaluation), request the combining Logging Parameters response, Physics information, knowledge of Geological information and additional calculations to illation the maximum Petro physical data concerning formation [2] .

5.1. Analysis of Resistivity Log [3, 4]

With a view to distinguish the Hydrocarbons Saturations (Sh) within the Reservoirs, first Water Saturations (Sw) should be calculated. Formation Resistivity with the matrix and liquids (Hydrocarbon, Water) and inside the pores is True Resistivity of the Reservoir, the Flushed Zone is perfectly invaded in mud with Rmf. Resistivity logs (LLD, LLS, and MSFL) correction for invasion which give Rt and di (invasion diameter).

5.2. Determination of Clay Parameter

5.2.1. M vs. N or Litho-porosity Crossplot [3, 5, 6]

The M-N crossplot presented by Schlumberger (Burke et al., 1969), is a dimensional display of all Porosity Log types responses in the most complex reservoirs. M and N values are lithology property - dependent Tools and N values are defined by the following equation(1,and2):

- $M=\frac{\Delta tf-\Delta t}{\rho b-\rho f}*0.01$ (1)
- $N=\frac{\varphi Nf-\varphi N}{\rho b-\rho f}$ (2)

The M-N crossplots are shown fig.(2).Which can be used for determinations of Lithology, detection of Gas, classification of Clay Minerals, etc. Each type of Minerals may has unrivaled set from (M and N) values.

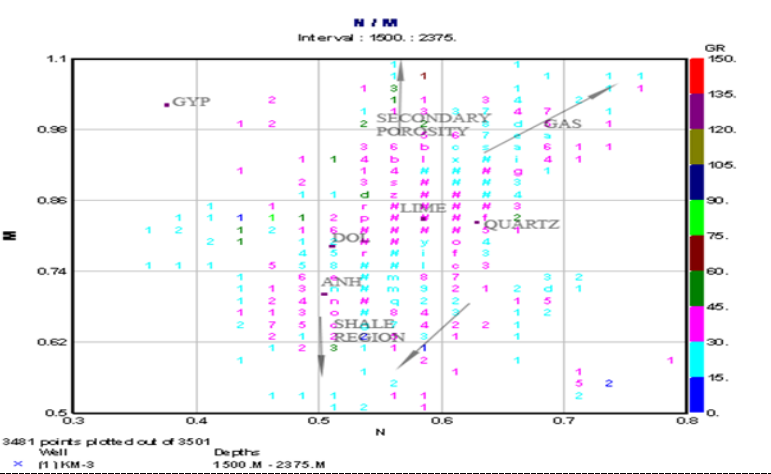

Figure 2. M-N Crossplot for Well KM-3

5.2.2. M vs. Δt; M vs. ρb; M vs. φN Cross plots

The use of these cross plots fig. (3) is to define major mineral trends (including shale), and define shale values. The value of Mclay is determined from M-N plot.

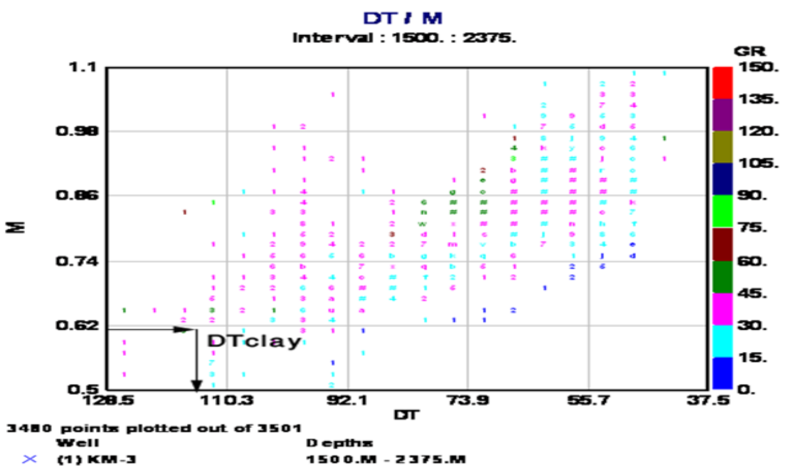

Figure 3. M-DT Crossplot for Well KM-3

And the same procedure for all other logs, Clay parameters are important in calculation of clay volume and determination of water saturation.

5.3. Determination Of Porosity [4]

Total porosity is calculated from neutron and density log as follow eq. 3 (Schlumberger, 1974):

- φND = (φNc+φDc) / 2 (3)

5.3.1. Matrix Identification (MID) Plot ((ρma)a vs. (Δtma)a)[8]

This Technique was preduced in 1976 through (Clavier and Rust). It locates the property of Lithology by using an apparent lithology values plot ( )a against ( )a . These values are calculation from the two following equations (3, and 4):

- $$\left(\rho_{ma}\right)_a = \frac{\rho_b - \varphi_x \rho_{mf}}{1-\varphi_x}$$

(4)

- $$\left(\Delta t_{ma}\right)_a = \frac{\Delta t - 189\varphi_x}{1-\varphi_z}$$ (5)

. The crossplot for tertiary reservoir Figures (4)

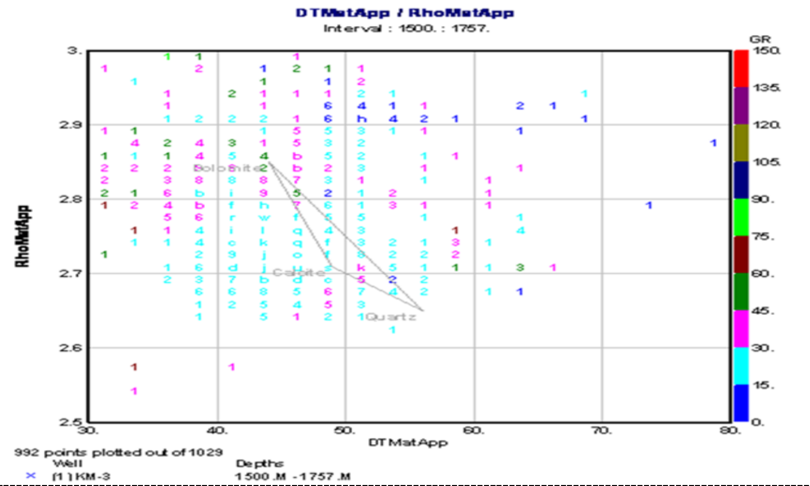

Figure 4. MID Plot for Well KM- 3

5.4. Formation Water Resistivity Determination

5.4.1. Apparent Water Resistivity (Rwa) Method [3, 7]

Apparent Water Resistivity (Rwa) is the resistivity of the formation calculated from the Low of Archie, which presumes clean(pure) water-bearing Reservoir. Apparent Water Resistivity is defined by the following relationship eq. 6:

- Rwa=Rt/F
  (6)

In clean, water-bearing zones Rwa is at a minimum, roughly corresponding to Rw.

5.4.2. Rw from SP Log [7, 3, 8, 9]:

This is widely used method to determine Rw and depends on the next equation between Resistivity of water and the value of SSP eq. 7:

- SSP= - K log ((Rmfe)/(Rwe)) (7)

5.5. Determination Of Archie Parameter

5.5.1. Resistivity - porosity Crossplot [10, 11]

- $Log(R_t) = -mLOG(\phi) + LOG(aR_w)$
  (8)

The relationship (8) is an equation of a straight line on the Paper (log – log), where the symbol m = slope and the symbol (a.RW) = intercept at (φ=1); as RW is recognized from another sources a can easily be found.

In oil bearing zone (no water zone) the value of m can be determine by crossplot of Rxo (microresistivity tools) vs. φ. This technique is applied to the flushed zone as follow [3] eq. 9:

Log(Rxo)=-mLog(φ)+Log(a.Rmf) **(9)**

A **log – log plot** of Rxo vs . φ would outcome in a straight line with a slope = (-m).

Saturation exponent (n) is calculated by applying least-square method for the points represent irreducible water saturation as appear in the top of Rt-φ cross plot (Pickett plot)[6] as follows eq. 10:

Log(Rt)= log (Swi^n .Rtirr) + (n-m) log (φ) **(10)**

Equation (10) is a relationship of straight line on scale (log - log scale) with Rt on the (y – axis) and φ on the (x – axis); the intercept: (Swn . Rtirr) with a slope of the (n - m). Commonly the utmost importance of this chart is to estimate (n) as (m) is recognized from (pickett chart). It should be noteed that as, the derivation of relationship (10) relys on residual water saturation (Swirr) levels .

An application to this method is shown in fig. (5).

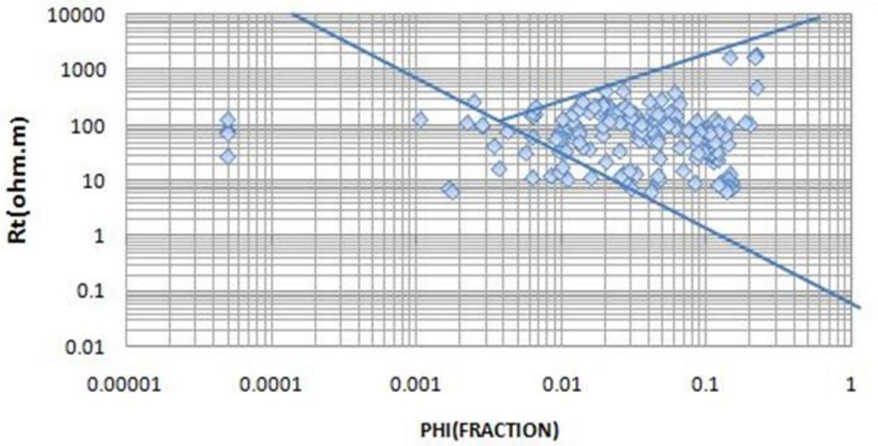

Figure 5. Pickett Plot for Jribe Formation KM-3

5.6. Fluid Saturation Determination

water saturation determination consider the essential procedure in Interpretations of well logs as all above work accomplished to obtain more perfect information about Saturation of water (Sw) and Saturation of Hydrocarbon (Sh).

5.6.1. Equation of Archie [13]

Water saturation (Sw) is given by eq. 11:

$$Sw^n = \frac{a.Rw}{\emptyset^m \ Rt} \quad (11)$$

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5.6.1.1. Formation Fluid Bulk Analysis [2, 14]

The Following Equations are used:

Bulk of Free Water

$$Vwf=\varphi_e Sw \quad (12)$$

Bulk of Flushed Zone Water

$$Vwxo=\varphi_e Sxo \quad (13)$$

Bulk of Hydrocarbon

$$BHC=\varphi_e(1-sw) \quad (14)$$

Bulk of Moveable Hydrocarbon

$$Moveable\_hydrocarbon=\varphi_e(S_{xo}-S_w) \quad (15)$$

Bulk of Residual Hydrocarbon

$$Residual\_hydrocarbon=\varphi_e(1-sxo) \quad (16)$$

The fig.(6) show results of above Equations, these plots represent ***Computer Process Interpretation (CPI).***

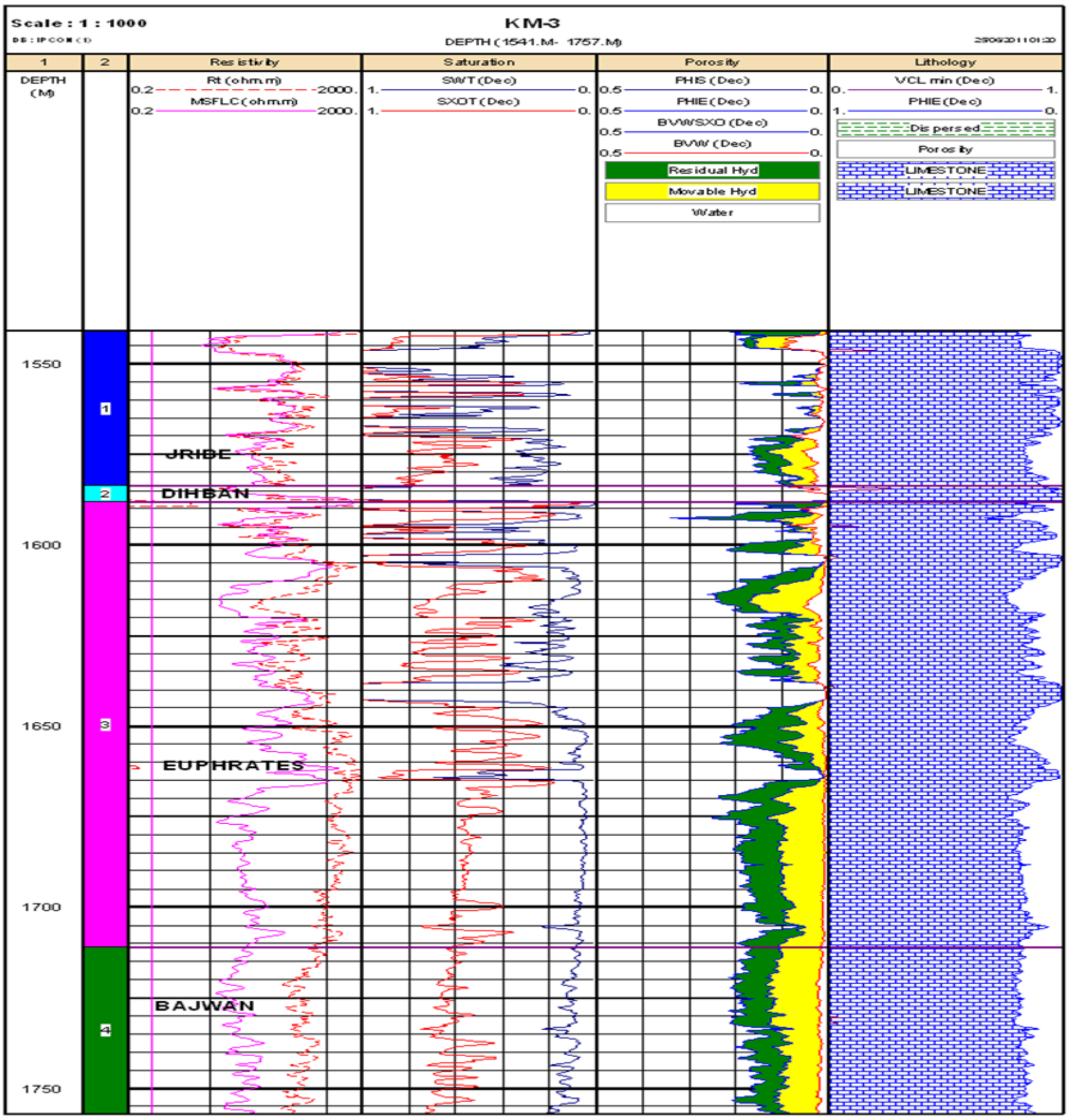

Figure 6. CPI Plot for Well KM-3

5.6.2. Determination of Irreducible Water Saturation (Swi) [12]

We can determine Irreducible Water Saturation (Swi) by plotting Saturation of Water against Porosity (**φ**) in a (linear or longitudinal scale) and styling (hyperbola) from the least value of Saturation of Water and chose the Levels that draw up on this parabola which exemplify Residual Water Saturation (Swi) levels. The implementation of this process is illustrated in (figure.7).

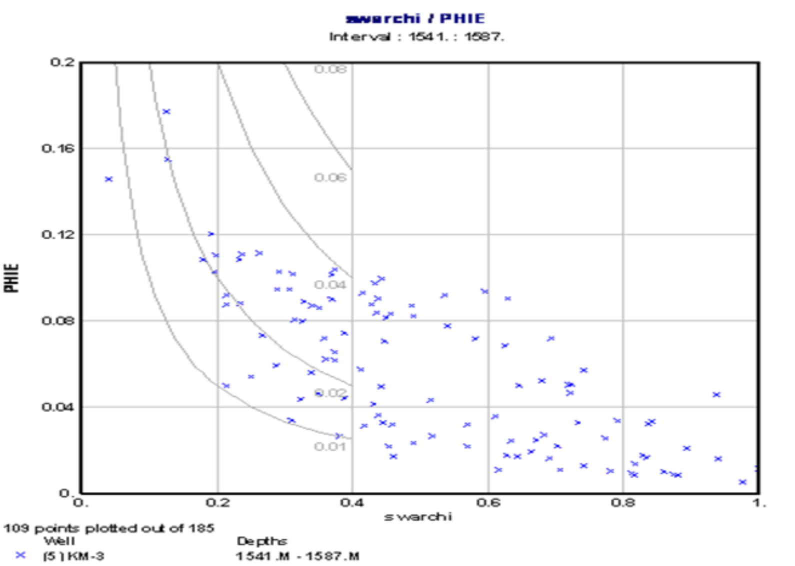

Figure 7. Swi for Jribe Formation KM-3

6. Conclusion

1-The paper composition of Interpretations of well logs and Correlations Generation using statistical methods for an Iraqi Tertiary reservoir in Kormor field.

2-The difference in Archie parameters from unit to unit and from well to well shows the extent of heterogeneity in the area of study.

3-From M-N cross plot and MID plot it was concluded that the formations in Kormor consist of (Limestone) though it is (Dolomitize) in several positions, also there is a little Shale.

4-Approximately all wells in Iraq that were explained by using different *Computer Process Interpretation* ways have used constant *Archie* tools while these Tools in fact have different values particularly in Carbonate Reservoirs which affect saturation of fluids. The steady values of *Archie* reflect low values of Hydrocarbon Saturation.

5- From the term (deep *Invasion Diameter*), The (SPI) low, and (m), it is complement that the Formation is Fractured. This is also proved by core sample analysis.

6-The (ACE) method shows superiority against traditional regression in estimating permeability, especially when many independent variables are used (Group of Logs) which improve the overall permeability statistical model.

7. Nomenclatures

a: Tortuosity Coefficient.
ACE: Alternative Conditional Expectation.
CPI: Computer Process Interpretation.
di: Invasion Diameter, inch.
DT: sonic transit time, µs/ft
GR: Gamma Ray, API.
k: Permeability, md.
LLD: dual lateral log, ohm . m.
m: cementation exponent.
M: Factor of M - N crossplot
n: saturation exponent.
N: Factor of M - N crossplot
φ: Porosity, p.u.
φe: Effective Porosity, p.u.
R^2: Correlation Coefficient.
Rt: True Formation Resistivity, ohm.m.
SP: Spontaneous Potentional, mv.
SSP: Static Spontaneous Potentional, mv.
SPI: Secondary Porosity Index, fraction.
Sw: Saturation of water, Fraction.
Sxo: Saturation of Flushed Zone.
Swi: Residual water saturation(Swi).
(Δtma)a: : Apparent Acoustic Travel Time, ms/ft.
ρma)a: Apparent Matrix Density, gm/cc.(

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