PAPER • **OPEN ACCESS**

Identifying hydrocarbon and shaly zones of Mishrif Formation in Nasiriya Oil Field by using well logs

To cite this article: Ameer T. Hameed *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **579** 012033

View the article online for updates and enhancements.



IOP ebooks™

Bringing you innovative digital publishing with leading voices to create your essential collection of books in STEM research.

Start exploring the collection - download the first chapter of every title for free.

This content was downloaded from IP address 121.17.174.121 on 18/09/2019 at 14:09

IOP Conf. Series: Materials Science and Engineering **579** (2019) 012033 doi:10.1088/1757-899X/579/1/012033

Identifying hydrocarbon and shaly zones of Mishrif Formation in Nasiriya Oil Field by using well logs

Ameer T. Hameed[1], AbdulAali A. Aldabaj[2], Ahmad A. Ramadhan[2]

[1] Ministry of Oil, Petroleum Research and Development Center, Baghdad, Iraq

[2] University of Technology, Petroleum Technology Department, Baghdad, Iraq

Abstract Well logging is the process of recording physical, chemical, electrical and other properties of rock/fluid mixture penetrated by drilling a borehole into the earth crust. Many of these logs are electrical in measurements. Hydrocarbon may exist in a porous and clean formation. That is, gamma ray and spontaneous potential can identify shaly/clean zones while neutron, density, sonic logs or even NMR logs may be used for porosity estimation. Resistivity logging is used to differentiate between formation filled with salty water (low resistivity) and with those filled with hydrocarbons (high resistivity). Mishrif Formation in Nasiriya Oil Field was chosen as a case study. The Nasiriya oil field structure is an anticline with NW- SE trend. Mishrif Formation is the Majer middle cretaceous carbonate in the stratigraphic column of southern Iraq. The result of well logs interpretation for the first five wells showed that a shaly unit separate upper Mishrif (MA) from the lower one (MB). Also, both units MB1 and MB21 are considered the movable hydrocarbon zones. The CPI data reflect that in which good values of porosity of about 0.18 in unit MB1 and 0.2 in unit MB21, besides low values of water saturation 0.28, 0.45 in units MB1& Mb21, respectively.

1. Introduction

Well logs (electric logs or wireline logs) can be defined as a plot of a well between depth and any rock property like resistivity or formation bulk density. Well log readings can be processed either down hole and transmitted to the surface or processed at the surface. Porosity and fluid saturations are examples of some important rock properties that could be estimated from well logs. In spite of that, well logs data need equation or physical model to convert their recorded data to find these properties [1]. Well logs using different tools plays an important role in geological decision. After interpreting these logs, it is applicable to identify porosity, fluid saturation or even the lithology. That means, that hydrocarbon (oil or gas) and water can be distinguished [2].

2. Area of Study

Nasiriya Oil Field is located in Thi-Qar governorate about (38 km) north-west of Nasiriya city. Include an anticline structure with NW-SE trend. The exploration operation and the exploratory drilling had discovered the major reservoir in Mishrif, Yamama and Nahr Umr formations [3]. The field latitudes is 34 80’ -34 60’ N and longitudes 57 50’ -60 10’ E, as shown in Fig. (1). The Mishrif formation is considered heterogeneous formation described as organic detrital limestone with beds of algal, rudist, and coral-reef limestone, capped by limonitic fresh water limestone [4]. Mishrif formation had divided into two main units (upper Mishrif, MA & lower Mishrif, MB). They are separated by thin shale unit

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

within 10 m thickness and lower Mishrif is subdivided into MB1 and MB2 with barrier rocks in some areas of the field [5].

3. Methodology

3.1. Gamma ray log (GR)

It measures the natural radioactivity in a formation. Shale zones has a high radioactive material in which it reflect the high values of GR reading. The opposite is in the shale-free sandstone and carbonate formations so that it can be used to determine the volume of shale through equations (1),(2) and (3)[2].

$$I_{GR} = \frac{(GR_{reading} - GR_{min.})}{(GR_{max.} - GR_{min.})} \quad \text{.....(1)}$$

Then, volume of the shale can be estimated depending on the age of the formation, for cretaceous rocks;

$$V_{sh} = 0.33\,(22 * I_{GR} - 1) \qquad (2)$$

While for tertiary rocks;

$$V_{sh} = 0.83\,(23.7 * I_{GR} - 1) \qquad (3)$$

3.2. SpontaneusPotential log (SP)

It is a log which is used to identify permeable zones and distinguish these zones from shale. SP log based on the self-diffusion of the dissolved ions of fluid in both borehole and formation. It measures in millivolts. A deflection of SP log is a sign for a porous and permeable zones which has different ionic concentration than the mud. It can be used to identify formation water resistivity when formation temperature and mud filtrate are known [6].

3.3. Resistivity log

They are electric logs which are considered important in identification of water & hydrocarbon zones. Hydrocarbon, like rock matrix, are non-conductive in which current can't be transmitted. For that, it can be notice the high resistivity values in hydrocarbon zones in opposite to water zones. Two types of resistivity logs present, induction and electrode logs. The first one is better to be used in non-salt-saturated drilling mud ($R_{mf} > 3R_W$) while the electrode log is used when ($R_{mf} \approx R_W$).An indication of a permeable zone is the invasion in which resistivity in flushed zone (R_{xo}) doesn't equal the uninvaded zone (R_t). These zones are illustrated in Figure (1).Many types of resistivity which are deep in investigation like LL_3, LL_7 or ILD logs. While for flushed zone, we have MLL, MSFL, ML…etc[2]. It should be mentioned that a decrease in porosity may lead to an increase on R_t values for a zone saturated only with water. In this case, a comparison of a separation between R_{xo} (shallow) and R_t (deep) is made between this zone with the detected water zone and it can be said that it may contain hydrocarbon when it is less in separation [7].

3.4. Porosity logs

3.4.1. Density logs

Used to find the porosity in case we have about lithology of a formation. The measured bulk density tries to find the density of a formation with the uniform distribution of fluid pores in a rock matrix [8] as it declared in equation (4).

$$\rho_b = \Phi * \rho_f + (1 - \Phi)\rho_{ma} \qquad (4)\ [6]$$

3.4.2. *Sonic Log:*

It measures the transmitted pulse velocity from the transmission to the receiver. It can be used to transmit porosity when both transit time of matrix and fluid are available as presented in equation (5) [8].

$$\Phi = (DT - DT_{ma}) * (DT_f - DT_{ma})^{-1} \text{....(5) [6]}$$

3.4.3. Neutron log:

Its measurements is based on hydrogen which is considered effective in slowing-down the fast neutrons due to the large scattering cross section and small mass of it. Since the existed hydrocarbon or water contains hydrogen, then neutron log can easily be a reflection of porosity values [6].

4. Determination of formation Water Resistivity

A precise value of formation water resistivity (Rw) is fundamental in order to complete interpretation process. It can be determined when the chemical analysis of the formation water is available .Another approach is from SP curve [9].The concentration of a solution of pure Nacl has the same resistivity of (Rw) at a given temperature because major component of dissolved material in most of formation waters is sodium chloride. Then, Rw is expressed in terms of equivalent Nacl [9]. From water analysis report, the concentration of pure Nacl in well NS2 is (190788 ppm) . Equation (6) is applied to calculate Rw @ 75°F (equal to 0.0454 ohm.m) using Nacl concentration in ppm. Then, it is converted to the bottom hole temperature by using equation (7). Rw value for NS1 at formation temperature (185°F) is equal to 0.02 ohm.m.

$$Rw_{75} = \frac{1}{2.74*10^{-4}*CP^{0.955}} + 0.0123 \quad (6)\ [10]$$

$$Rw_{fm} = Rw75 * \frac{81.77}{ft+6.77} \quad (7)\ [10]$$

Where, Rw_{75} :Formation water resistivity @ 75°F Rw_{fm} : Formation water resistivity @ formation temperature, °F .CSP: Nacl concentration in ppm

Ppm: part per million It can be mentioned that mud filtrate resistivity is read from well log header reports at a given temperature.

5. Shale Volume Calculation

Gamma ray index in equation (1) was used with equation (2) to calculate shale volume for Mishrif Formation which is considered old rocks (Cretaceous age). Figure (1) represents the shale volume of well NS1 and temperature curve. It can be noted that there is a shale unit reaching (10) m which separates the two main units (MA & MB) of Mishrif Formation in Nasiriya Oil Field.

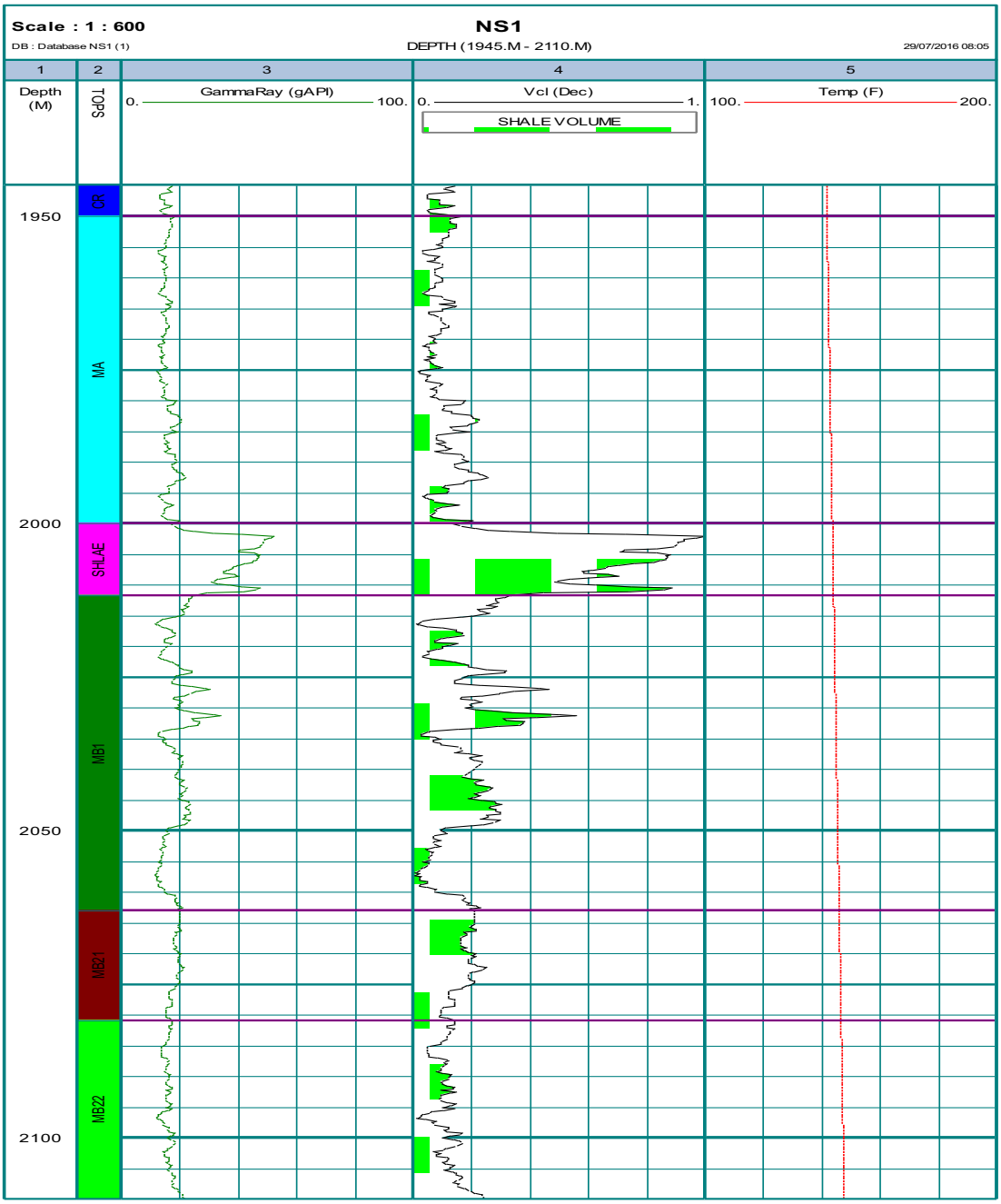


Figure (1): Shale Volume for Well NS1

6. Porosity Estimation

Equation (8) is used to determine the total porosity. The derived porosity from sonic, density, neutron and neutron-density logs are compared with the lab core data. The neutron-density porosity has given best match with the core porosity among other derived porosities and as shown in figures (2) for NS1. The obtained (N-D) porosity is then used to determine the effective porosity after extracting shale volume from equation (9). Secondary porosity index (SPI) can be determined by using equation (10).

$$\varphi_t = \frac{(\varphi_N + \varphi_D)}{2} \quad \ldots(8)$$

$$\varphi_e = \varphi_t(1 - Vsh) \quad \ldots(9)$$

$$SPI = \varphi_t - \varphi_s \quad (10)$$

Figure (3) shows the total & effective porosities for well NS1. From the figures mentioned above, it is shown that unit MB has the highest porosity values in the formation which reflects its important role in storage capacity.

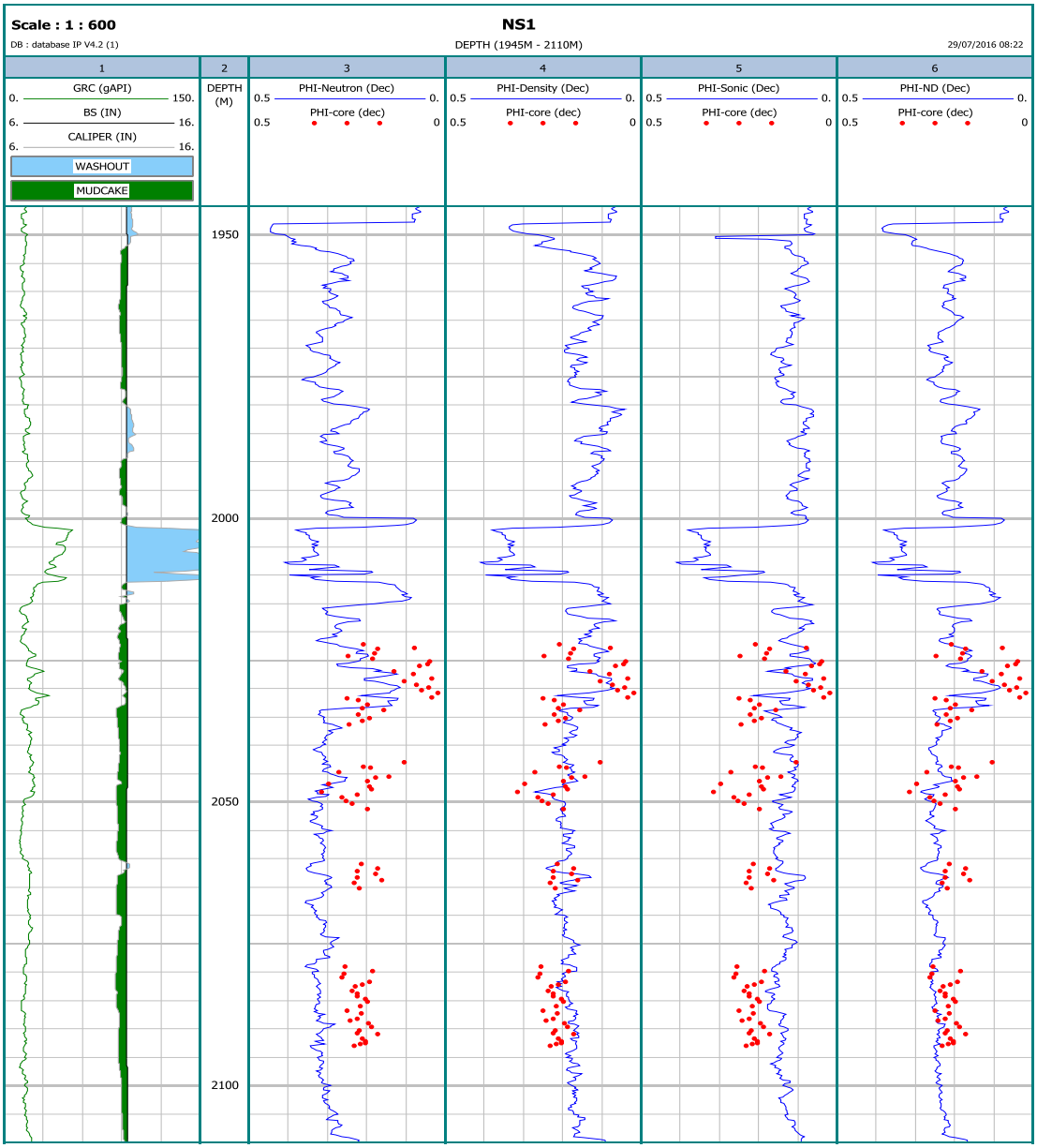


Figure (2): Comparison between the Derived Porosities for well NS1

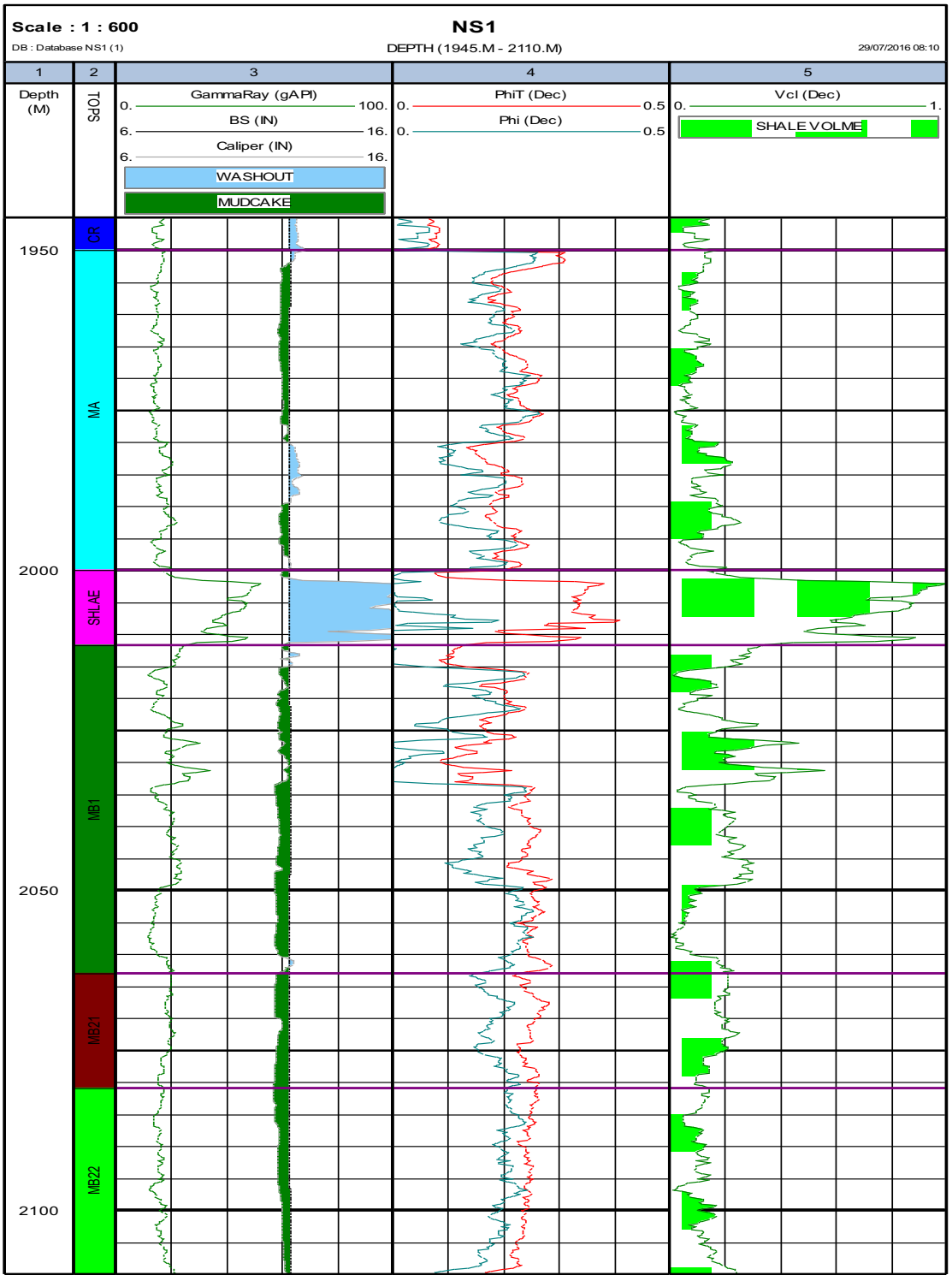


Figure (3): Total and Effective Porosity for Well NS1

7. Estimation of Archie's Parameters for Sw Calculation

Archie's equation (11) is applied to determine water saturation. The heterogeneity of carbonate reservoirs makes it somewhat difficult to apply the equation when its parameters depends highly on carbonate characteristics. Uncertainty analysis for Archie's parameter declared that (a, m & n) parameters have the higher influence on water saturation calculations than the resistivities (R_t & R_w) [11].

$$Sw^n = \frac{a}{\varphi^m} \cdot \frac{R_w}{R_t} \qquad (11)$$

Pickett's method was presented to calculate Archie's parameters by a basic rearrangement of his equation [12].

$$Rt = \frac{F.Rw}{Sw^n} \ldots \quad (12) \quad \text{and,}$$

$$F = a/\varphi^m \ldots \quad (13)$$

And by using logarithms, yields;

$$\log Rt = -m \log(\varphi) + \log aRw - n \log Sw \ldots (14)$$

In the water bearing zone, equation (14) becomes;

$$\log Rt = -m \log(\varphi) + +\log(aRw) \quad (15)$$

Equation (15) is a straight line on log –log plot with a slope=m and intercept equal to (a.Rw) at (φ=1) where Rw is known previously. It's good to keep in mind that this method should be applied in a clean water formation zones in order to give a good estimation of the parameters. Archie's Pickett's plot is also useful to know (n) parameters; for 100 % water bearing formation (SW=1), equation (14) becomes;

$$aRw = \varphi m Rt \quad (16)$$

Equation (11) can be rewritten for irreducible water levels;

$$Swi^n = \frac{a}{\varphi^m} \cdot \frac{R_w}{R_{tirr}} \quad (17)$$

Morris and Biggs in 1968, observed that the multiplication of Sw by φ for irreducible water levels is a constant value:

$(Swi * \varphi = C)$.Coates & Dumanoir in 1974 concluded from the studies of core analyses that the assumption of (n=m) for irreducible levels is fair, so that equation (17) can be reduced with the application of equation (16) [13];

$$(Swi\varphi)^n = \frac{\varphi^m Rt}{R_{tirr}} \quad (18)$$

With a rearrangement and the logarithm to both sides yields;

$$\log Rt = \log (Swi^n . R_{tirr} + (n - m) \log(\varphi) \quad (19)$$

Equation (19) is a log-log plot with a slope of (n-m) and an intercept of $(Swi^n . R_{tirr})$. Exponent (n) can now be easily estimated as (m) in known. Figure (4) represents Pickett's plot for the well NS1. Archie's parameters for NS1 have been estimated in which (a) equal to 1 and the value 1.8 is for (m) and (n).

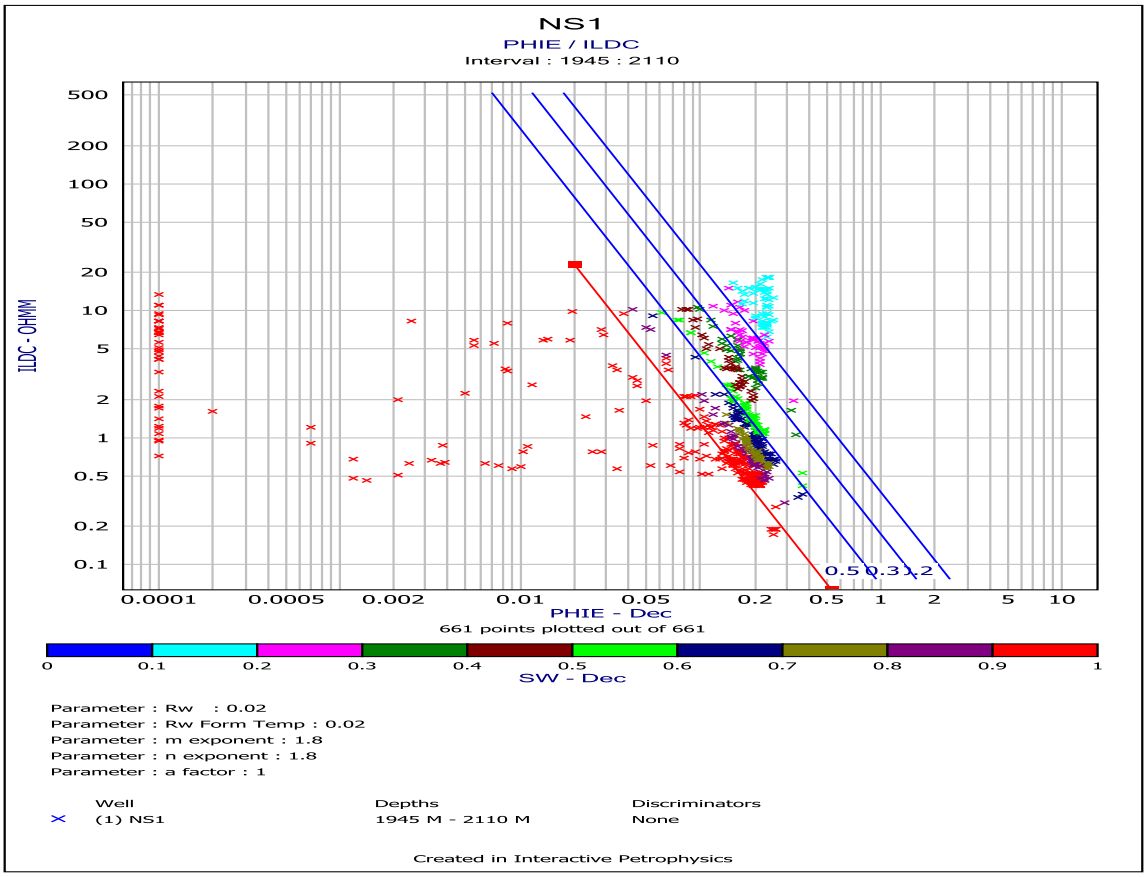


Figure (4): Pickett's plot for Well NS1

8. Reservoir Fluid & formation Analysis

8.1. Fluid Analysis

Archie's equation has been used in Mishrif formation, Nasiriya Oil Field to calculate the water saturation in uninvaded zone. Also, in flushed zone, water saturation can been calculated using equation (20).

$$Sxo^n = \frac{a}{\varphi^m} \cdot \frac{R_{mf}}{Rxo} \qquad (20)$$

Determination of flushed zone water saturation has its advantage where the ratio Sw/Sxo is an indicator of oil movability .When Sw/Sxo=1, then no moved hydrocarbon, whether or not the formation contains hydrocarbon or not. If Sw/Sxo is 0.7 or less, that means that there is an indication of movable hydrocarbon existence [14].

8.2. Bulk Volume Analysis

The bulk volume of water can be identified as a unit volume of porous media occupied by water. The bulk volume of hydrocarbon is the amount of hydrocarbon pore volume.

$$BVW = Sw * \varphi_e \qquad (21)\ [14]$$

$$BVW_{Sxo} = Sxo * \varphi_e \qquad (22)\ [14]$$

The bulk volume of the movable hydrocarbon can be identified by [13];

$$BVmo = (Sxo - Sw) * \varphi_e \qquad (23)\ [15]$$

The computer processed interpretation (CPI) is a set of logs for the results of porosity, saturation, fluid & matrix analysis tracks and other parameters of interpretation.

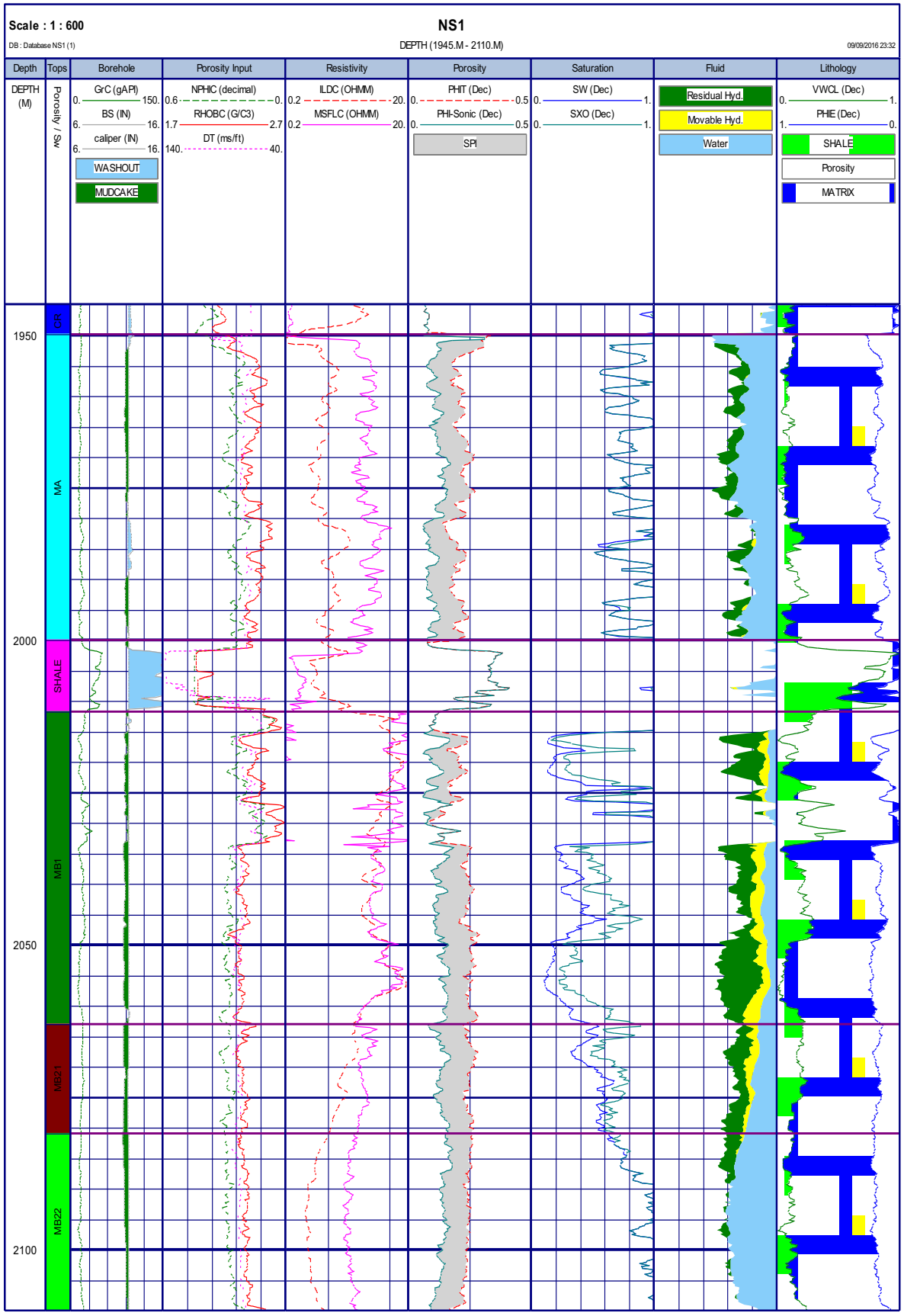


Figure (5): Computer Processed Interpretation for Well NS1

Table (1): Averages of properties for the first five wells

well	unit	Avg. Vcl	Avg. Phie	Avg. Sw	bulk Movable	Moveable
	MB1	0.187384507	0.142007	0.435077	0.029728169	0.209343
1	MB21	0.169784	0.184249	0.524608	0.025228947	0.136928
	MB22	0.115184071	0.193592	0.918077	0.000465487	0.002404
	MB1	0.075618033	0.194516	0.286207	0.073180328	0.376217
2	MB21	0.095752174	0.210604	0.603257	0.0627	0.297715
	MB22	0.0924	0.1988	0.908319	0.01380625	0.069448
	MB1	0.152816889	0.15806	0.444495	0.061167111	0.386987
3	MB21	0.140922667	0.188737	0.607369	0.057174026	0.302929
	MB22	0.138419481	0.183308	0.929418	0.012218182	0.066654
	MB1	0.124071548	0.19845	0.252542	0.066594979	0.335575
4	MB21	0.106473469	0.231465	0.570488	0.045542857	0.196759
	MB22	0.079521374	0.205156	0.874779	0.006782443	0.03306
	MB1	0.134812658	0.218559	0.249219	0.06607173	0.302307
5	MB21	0.1229475	0.225483	0.61860	0.0345225	0.153105
	MB22	0.094671429	0.221271	0.972528	0.001633835	0.007384

From the table (1) we can notice the following important notes:

1. Effective porosity, part of neutron- density porosity, has good values in all units of lower Mishrif which reflect the high hydrogen content, lower density and low values of clay volumes.
2. Unit MB1 has the lowest values of water saturation in lower Mishrif which with porosity values ensure the accumulation of oil. Beside that, unit MB21 has higher Sw values than MB1, but stills important. Mb22 is considered a water reservoir unit.
3. Good moveable hydrocarbon values in both MB1& MB21 units. Also, very low values in MB22 for the high values of water saturation.

9. Conclusion:

From using different well logs, the computer processed interpretation can give the following realities for the well NS. Both upper and lower Mishrif are porous with high index of secondary porosity. MA unit is almost water zone and Unit MB22 is a water zone where oil water contact (OWC) has been reached. Movable hydrocarbon is concentrated in the unit MB1 and in the upper part of MB2 (MB21).A thick shale unit (about 10 m) separate upper Mishrif from the lower one. Borehole diameter from caliper log (CAL) is much higher than BS in shale unit which is an indication of a washout while a mudcake can be seen from CPI in other units.

References

[1] Etnyre L M 1989 *Finding Oil and gas from well logs*, Springer science and business Media New York
[2] Asquith G and Gibson C 1982 *Basic well log analysis for geologists*, methods in Exploration Series, AAPG
[3] Handhel A M 2006 *Reservoir Properties Study for Mishrif Formation in Nasiriya oil field and their relation with oil production*, thesis, Department of Geology, university of Basra in Arabic
[4] Atiaa A A and Handhel A M 2009 A fuzzy Logic approach in infer reservoir permeability from depth and porosity measurements for Mishrif limestone Formation at Nasiriya Oil Field, south of Iraq *Journal of al-anbar university for pure science* **3** No.1
[5] Jreou G 2013 A preliminary Study to Evaluate Mishrif Carbonate Reservoir of Nasiriya Oil Field *International Journal of Engineering and Technology IJET-IJENS* **13** 5 69-82
[6] Ellis D V and Singer J M 2008 *Well Logging for Earth Scientists* 2nd Edition springer science and Business Media B V 692
[7] Hameed A T 2017 *Geostatistical Approach of Petrophysical Properties Distribution for Mishrif Formation in Nasiriya Oil Field* M.Sc. thesis Petroleum technology Dept. University of Technology

[8] Tittman J 1986 *Geophysical well logging* Technical Consulting Services Danury Connecticut Acadimic press 186
[9] Moore E J Szasz S E and Whitney B F 1966 Determining formation water resistivity from chemical analysis *SPE* **1337** 373-376
[10] Rabanit P M V 1952 *Rock units of Basrah area* BPC unpublished report
[11] Hamada G M Almajed A A Okasha T M and Algathe A A 2013 Uncertainty analysis of Archie's parameters determination techniques in carbonate reservoirs *Journal of Petrol Explor Prod Technol* **3** 1–10 DOI 10.1007/s13202-012-0042-x
[12] Kadhim F S 2016.,Correlation Between Cementation Factor And Carbonate Reservoir Rock Properties, *Researcher* **8** 1 29-65
[13] Schlumberger 1989 *Log Interpretation Principles/Applications*, Houston
[14] Schlumberger 2008 IP-Interactive Petrophysics V-3.5, Manual
[15] Ashour H 2016 *Reservoir Characterization and 3D petrophysical Modeling for Tertiary Reservoir in Khabaz oil field*, M.Sc. thesis, Petroleum engineering, University of Baghdad