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Formation Evaluation by using Well Logging of Mishrif Formation in the Noor Oil Field, , Southeast Iraq

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Abstract

Mishrif Formation regards one of the most important reservoirs in Iraq.Well logging represents one of the most important tool in the formation evaluation. According to the Petrophysical properties that have been gotten from well logging, Mishrif Formation in terms of reservoirs units, consist of several reservoirs units..Major reservoirs units divided into three reservoir units,MA,MB&MC. Each of these major units divided into minor reservoirs units (MB11,MB12,MC2&MC3).MB major reservoir units represent the best reservoir unit.These reservoirs units separated by cap rocks(mainly tight limestone)(CR1,CR2,CR3,CR4,CR5,CR6,and CR7).CPI were demonstrated for all wells.Hydrocarbon saturation vs. water saturation have been determined for each units.In addition, the types porosity and moveable vs.residual oil were calculated.

Keywords: Petrophysical properties, , Mishrif Formation .Noor Oil Field.

التقييم المكمني بأستخدام الجس البئري لتكوين المشرف في حقل النور النفطي جنوب شرق العراق

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الخلاصة

يعتبرتكوين المشرف واحدا من اهم المكامن النفطية في العراق والشرق الاوسط . الجس البئري يعتبر واحدا من اهم ادوات التقييم المكمني . من خلال دراسة الخواص البتروفيزيائية المستحصلة لهذا التكوين ، تكوين المشرف في مصطلح الخواص المكمنية يتكون من عدة وحدات مكمنية . الوحدات المكمنية الرئيسة في تكوين المشرف قسمت الى ثلاث وحدات مكمنية (MA ,MB ,MC) كل واحدة من هذه الوحدات المكمنية قسمت الى وحدات ثانوية (MB11,MB12,MC2&MC3).

الوحدة المكمنية الرئيسة(MB) تعتبر من أحسن الوحدات المكمنية . الوحدات المكمنية مفصولة عن بعضها بصخور صماء تتكون من الحجر الجيري(CR1,CR2,CR3,CR4,CR5,CR6,and CR7) . تم بناء منحنيات تفسيرات الجس البئري وتم تحديد نطاق التشبع النفطي والمائي لكل وحدة مكمنية.تم حساب انواع المسامية وتحديد النفط المتحرك من النفط المتبقي.

Introduction

Petrophysical interpretation is essential for understanding subsurface reservoir rocks[1]. Subsurface characterization requires physical measurements that made from well logging. Well Logging is a process of recording a details for the geological formations have penetrated by borehole. Well logging represents as an integrated process in the measuring the reservoir **.**The log depends on the samples taken from the subsurface or measurements made by physical instruments lowered into

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the hole. Formation evaluation in this study based on the well logging. Subdivision of reservoirs depends on several Petrophysical properties (porosity, permeability, mineralogy, water and fluid saturation).

The Study Area

Noor oil field is located about 15 km NE of the Missan governorate, southern Iraq. Noor structure field consist of anticlinal fold with general trend axis NW-SE. Figure-1

Figure1- Location map of the study area

Definition of Mishrif Formation

One of the most important reservoirs in the middle east is the Mishrif Formation[2],[3],[4],and[5].The Mishfrif formation make up about 30% of the total oil in Iraqi reserves[6].During the Cretaceous period within the secondary sedimentary cycle Cenomanian-Early Turonian the Mishrif formation was deposited.

Data and Methods

Petrophysical properties have been studied from 8 boreholes in Noor Oil Field(No-1,No-2,….. No-8). There are several steps are required before the process of interpretation of well logging. First, processes of the digitization. Second, stage of correction because well logging is indirect measurements that are influenced by the effects of environment (for example, mud circulation and mud properties). In this study there are different logs were used including (Gamma-Ray,Density,Sonic,Resisitivity,and Neutron logs. Interactive petrophysics(IP) and Techlog software were used to integrated in formation evaluation.

Environmental Correction

Environmental corrections are necessary for compensate the differences between the actual condition in borehole and the calibration of the test pit tool. All these corrections should be done with all logs (Gamma ray, Density, Neutron and Resistivity logs) according to the Schlumberger's environmental correction. In this study, IP software was used to apply these corrections. After complete all the previous corrections and calculation of borehole temperature, invasion corrections should be made.

Invasion corrections

The resistivity log measures apparent resistivity. It's represent a resistivity of isotropic, homogeneous medium. If the measurement conditions will be known, the apparent resistivity represents a true resistivity.This step were done by correction of Rt to LLDC and Rxo to MSFL.Figure-2

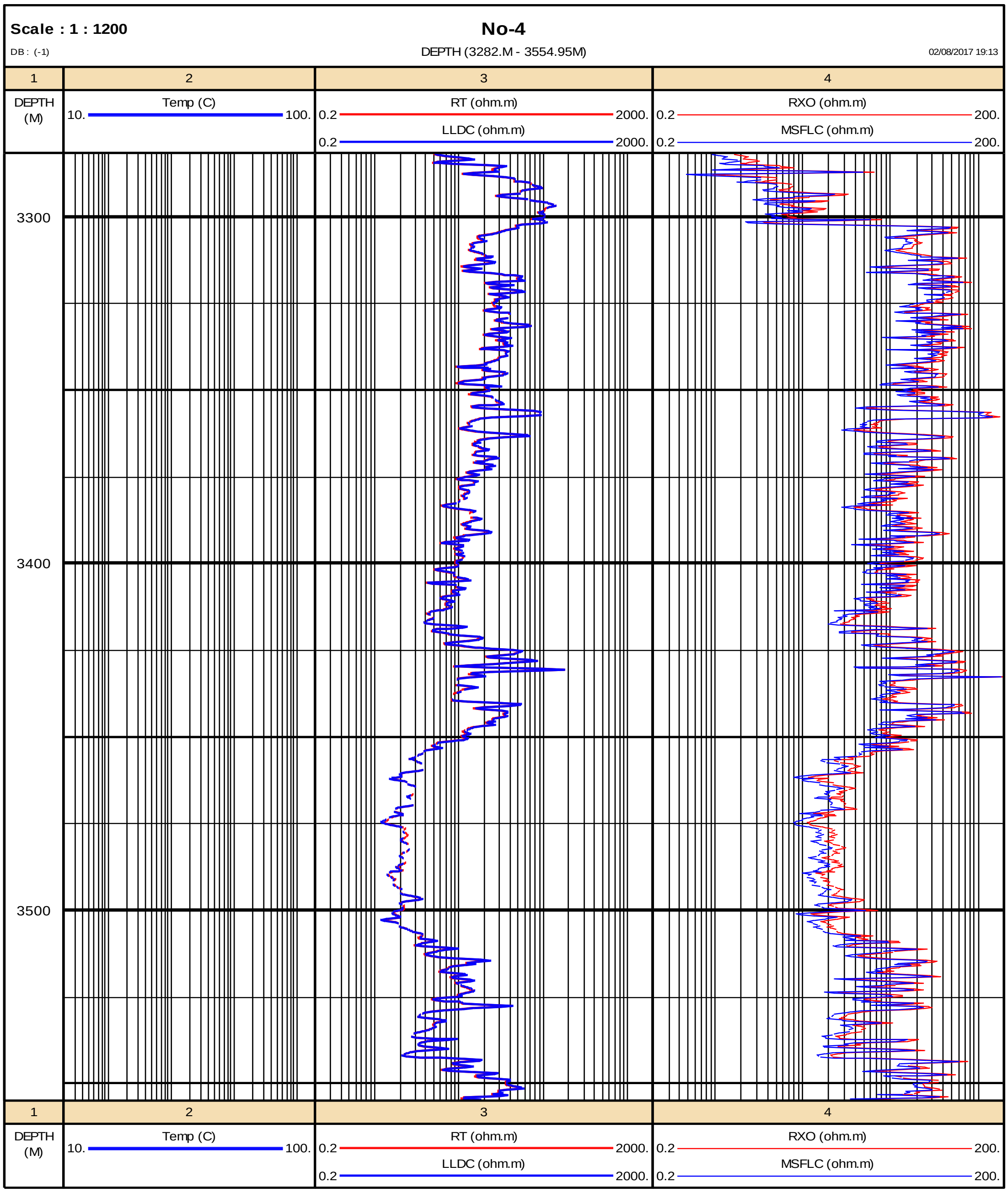

Figure 2-Invasion corrections and temperature Formation(Rt to LLDC and Rxo to MFSL) in No-4.

Determination of water resistivity

Formation water resistivity have to be known in order to calculation water saturation Sw.This method focused on strong salinity contrasts between formation water and the mud filtrate in specific conditions in thick-clean sand with well defines shale volume[1].Figure-3.

Petrophysical parameters:

1-Determination of clay volume (Vsh)

One of the most important logs is used to determine clay volume from Gamma Ray(GR).This type of logs measures the natural radioactivity in clay. In order to determine the clay volume in formation, formula will be used from[7]. Figure-3.

$$IGR= \frac{GRlog-GR\ min}{GRmax-GRmin} \qquad (1)$$

IGR= gamma ray index

GRlog=gamma ray reading of formation

GRmin= minimum gamma ray

GR max= maximum gamma ray

In this study, because the formation regards as an old rocks, the equation in [8]and [9] were used.

$$Vsh=0.33\times(2^{2\times IGR}-1) \qquad (2)$$

$$Vsh= 0.33\times (2^{2\times IGR}-1)$$

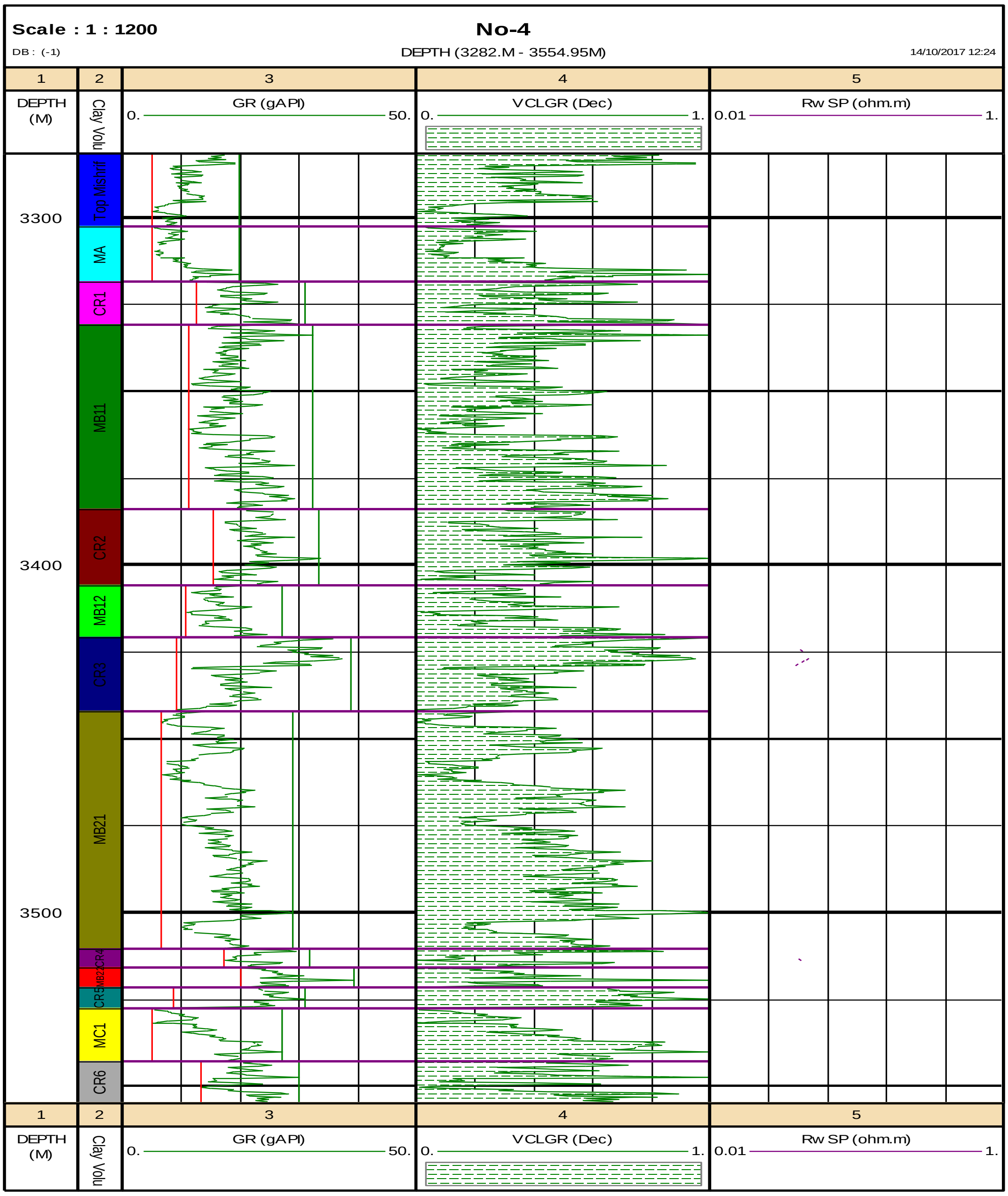

Figure 3-Vsh calculation from GR log and Rw in No-4.

Porosity

Rock porosity can be calculated from the combination of neutron-density logs. Density log representa as a porosity log that measures the electron density of the formation[10]. In order to get accuracy results, density and neutron logs must be corrected for the shaliness .Corrections were made according to the following formula relationships:

For density porosity log according to the [11]

øDCorrection=Ød-(Vsh×øDsh) (3)

For neutron porosity log according to [12]

øNcorrection=ØN-(Vsh×øNsh) (4)

Where,

Vsh: represents the shale volume.

ØN: represents neutron porosity in shale formation

Total porosity can be calculated form the following formula [9]

Øt) = (ØN+ØD) (5)

Effective porosity: the amount of pores that are interconnected[13].Effective of porosity can be calculated from the following formula:

Øeff=Øtotal×(1-vsh)[14] (6)

Primary and secondary porosity

Primary porosity represents the pore space sediments that are deposited at or during the same time of deposition[15].Secondary porosity is the term triggered on the pore space sediment that are formed after deposition due to diagenetic processes[16]. Sonic log was used to determine primary porosity according to the following formula[17]

ØS= (Δlog-Δtma)/Δtfl-Δtma) (7)

Where:

Øs=porosity derived from sonic log

Δtma=interval transit time in the matrix.

Δlog=interval transit time in the fluid in the formation.

Δtfl= interval transit time in the fluid.

Presence of hydrocarbon lead to the increase in Δt, therefore,[18] suggested the following formula in order to denied hydrocarbon effect.Secondary porosity was computed by the difference between total porosity and the primary porosity was derived from Sonic log.

Ø=ØS×0.7……….gas (8)

S×0.9……….oilØ=Ø

There is another step to avoid shale effect from sonic log:

ØScoreection= $Ø_S$ -(Vsh-ØSch) (9)

Finally, the index of secondary porosity (SPI) can be calculated according to the following formula[11]

SPI= (Øt-ØScorrection). (10)

Water Saturation

Water saturation for reservoirs in uninvaded zone is calculated by the Archie formula [13]

$$Sw = \left[\frac{a}{Ø^m} \times \frac{Rw}{Rt}\right]^{\frac{1}{n}} \quad (11)$$

Where the water saturation in flash zone can be calculated according the following formula [13]

$$Sw = \left[\frac{a}{Ø^m} \times \frac{Rmf}{Rxo}\right]^{\frac{1}{n}} \quad (12)$$

Where:

Sw: water saturation of the uninvaded zone(Archie method).

Rw: resisitivity of formation at formation temperature.

Rt: true resistivity of formation.

Ø= porosity

Sxo= water saturation of the formation in the flushed zone.

Rmf:resistivity of mud filterate.
A=tortuosity factor
m=cementation exponent
n=saturation exponent assumed to be 2.0
Two values Sw and Sxo are used to estimate the saturation in residual hydrocarbon (shr) and the movable hydrocarbon (shm) according to the following equation[9]

Shr=1-Sxo (13)

Shm=1-Sw (14)

Bulk volume water (BVW)

The product of a formation's water saturation (Sw) and it's porosity (ø) is the bulk volume of water[9]
Where, the bulk volume of water can be computed in the flushed zone using the following formula[19].

BVW= Sw× øe (15)

BVSXO=SXO× øe (16)

Where:
BVW: bulk volume of water in uninvided zone.
BVSXO=bulk volume of water in flushed zone.

Determination of lithology and Mineralogy

1-NPHI and RHOB cross ploting

Neutron and density logd where used to determine the lithology by using the separation of the curves visually or plotting the two values on special graphs[11].Figure-4.

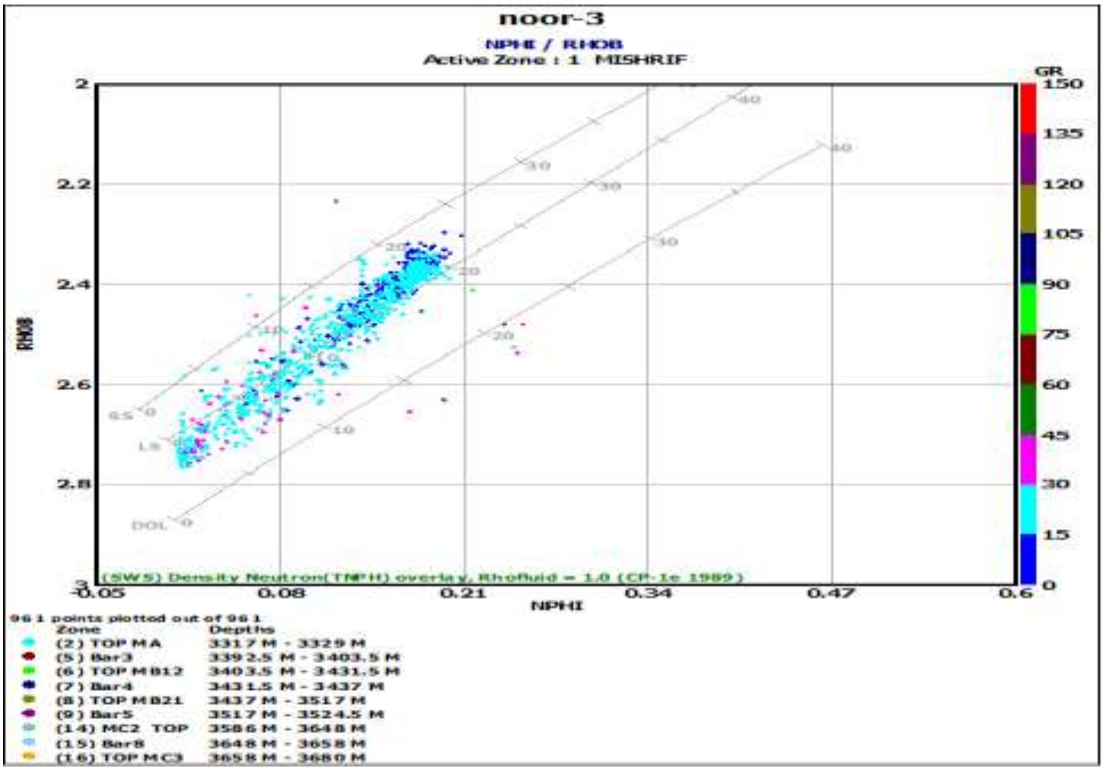

Figure 4-The NPHI and ROHB cross plot in No-3.

2-Matrix Identification Determination (MID)plot

Identification and secondary porosity can be obtained by using Matrix identification (MID) plot. Three types of data should be available to obtain this type of plot,the these data are, total porosity øt, an apparent matrix transit time Δt mma, finally, apparent grain density αmaa are required[14].Figure-5

$$\rho mma=\frac{\rho b-\phi t\times\rho f}{1-\phi ta}$$

$$\Delta t_{maa} = \frac{\Delta t - \O_{ta} \times \Delta t_f}{1 - \O_{ta}}$$

Where:
mma:apparent density matrix.ρ
Δtmma:apparent transit time in rock matrix.
Øta:apparent total resistivity.

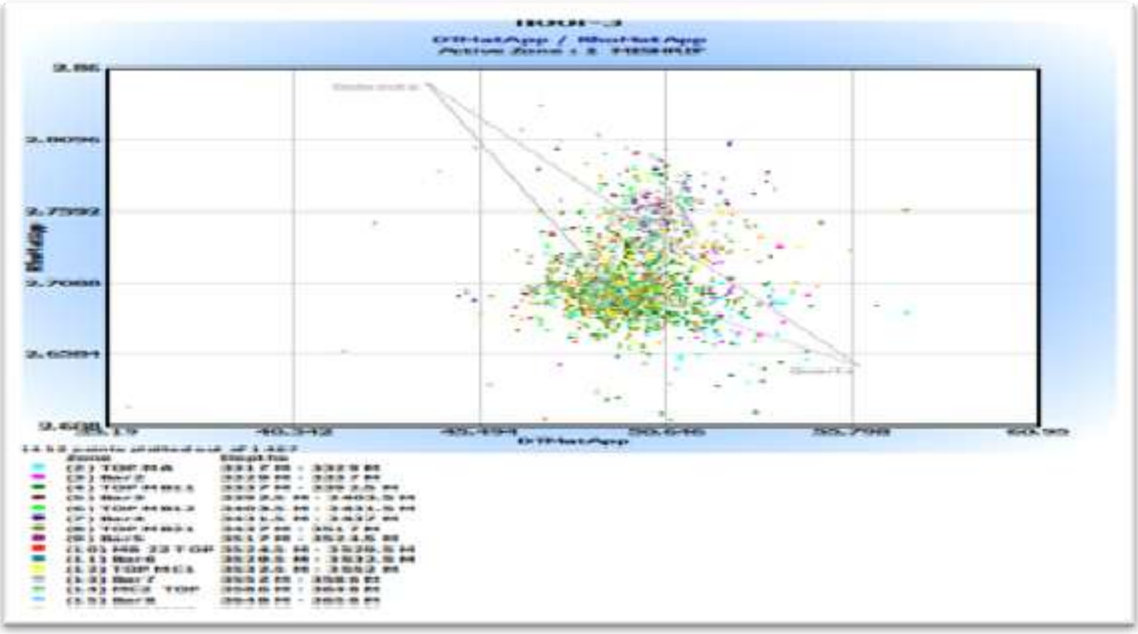

Figure 5-MID plot in No-3.

3-M-N cross plot

M-N cross plot can be detected the mineralogy of the formation. This type of cross-plot requires a sonic with neutron and density logs.M-N values are essentially independent of matrix porosity (sucrosic and intergranular)[13].

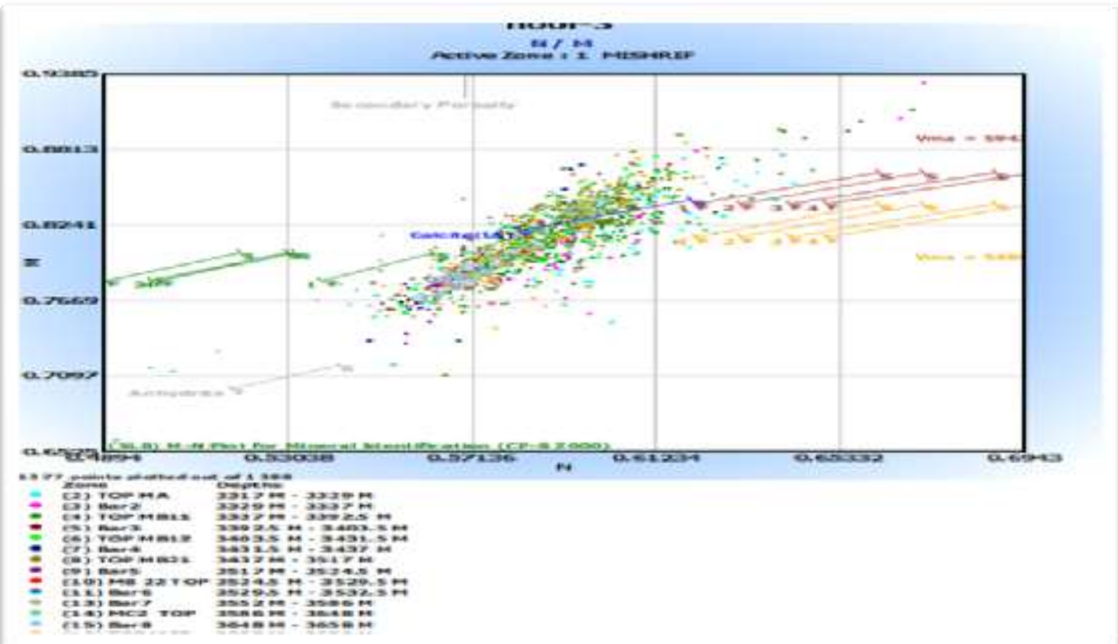

Figure 6-M-N cross plot in No-3.

Net –Gross ratio

Net pay refers to the thickness of porous, interval permeable zone with commercial quantity of hydrocarbon.Net to- gross is a expression ratio of the thickness of net pay to the total pay thickness. This ratio is an important ratio in reservoirs volumetric calculation[20].Determination the net pay requires three important values. These values are, porosity, water saturation, and permeability to reservoir fluids.Net-gross ratio is a function of the quality of the limestone as potential reservoirs in Mishrif Formation.Figure-7

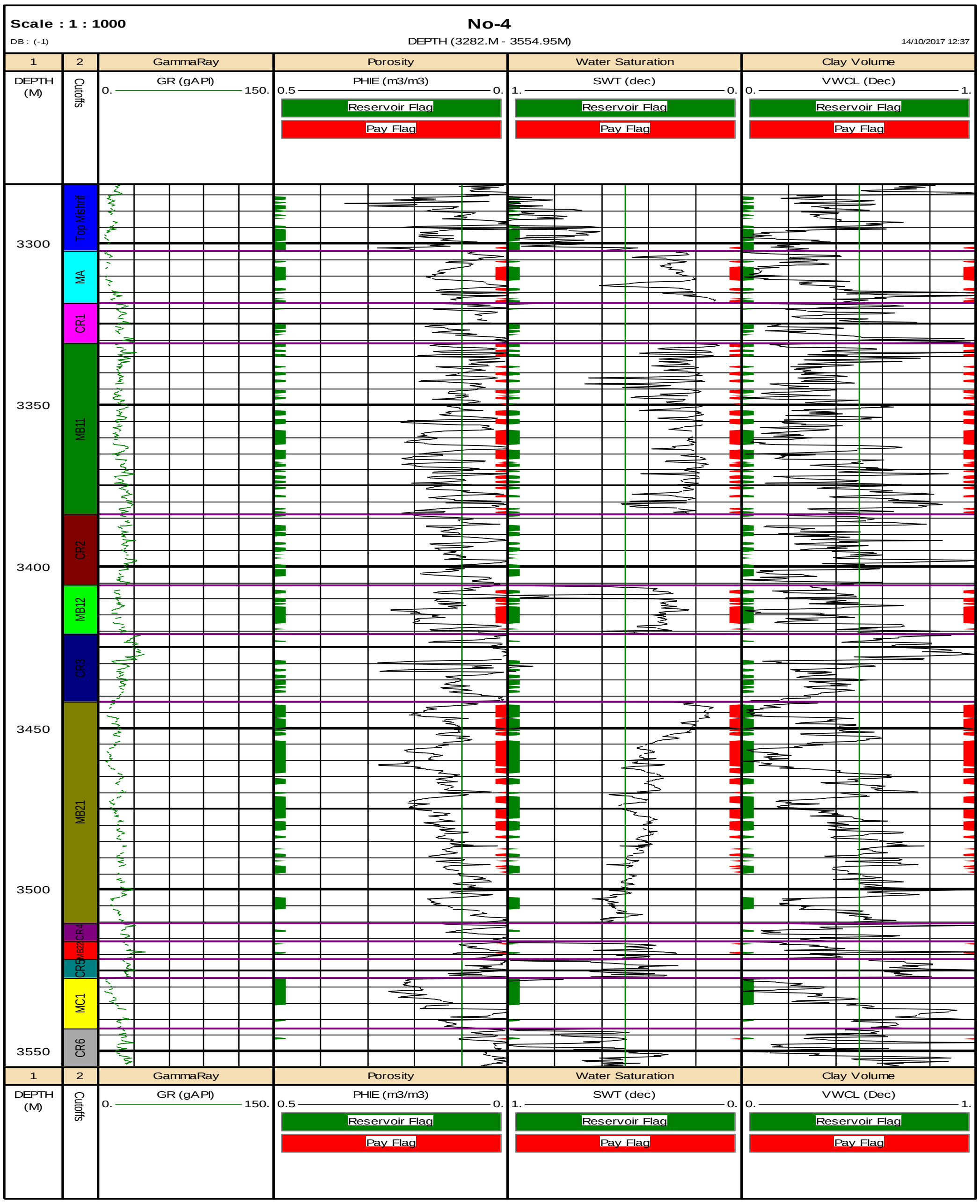

Figure 7-Net –Gross ratio cross plot in No-4.

Determination of Archie's parameters(m,n and a) using Pickett plot

Archie's parameters(m,n,and a) were determined by using pickett plot.This type of plot based on the true resisitivty (Rt) is a function of water saturation,porosity and cementation exponent(m)[9].Figure-8

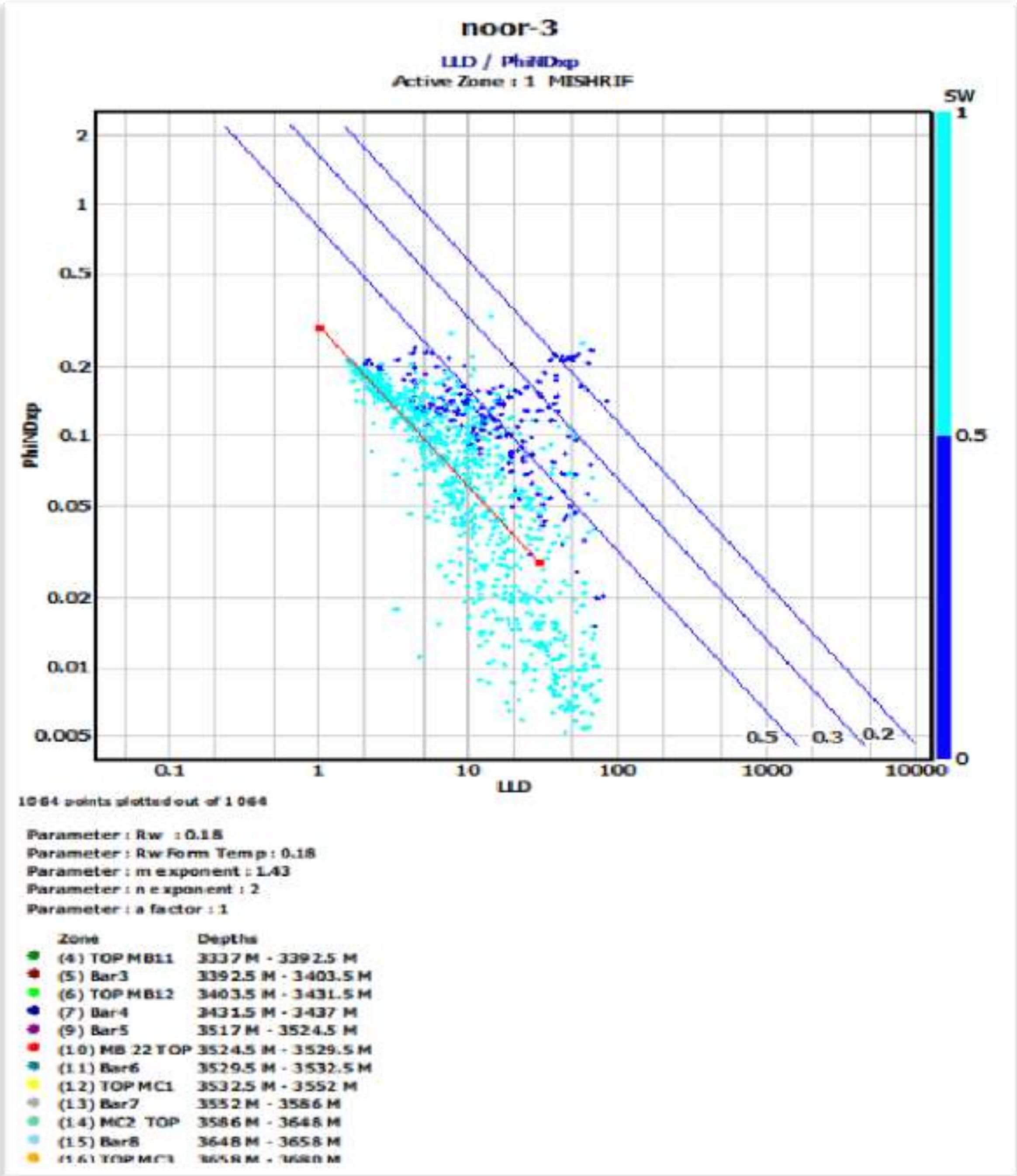

Figure 8-Archie's parameters(m,n and a) using Pickett plot.

Computer processes interpretation

These processes are valuable in order to Petrophysical analysis more easier.These processes were used for;1)Division the units of Formation into reservoirs and non-reservoirs(cap rocks);2) comparison of the reservoirs units according to the Petrophysical properties for each unit.Finally,these processes represent the last step in terms of petrophysical properties.Figures-(9, 10)

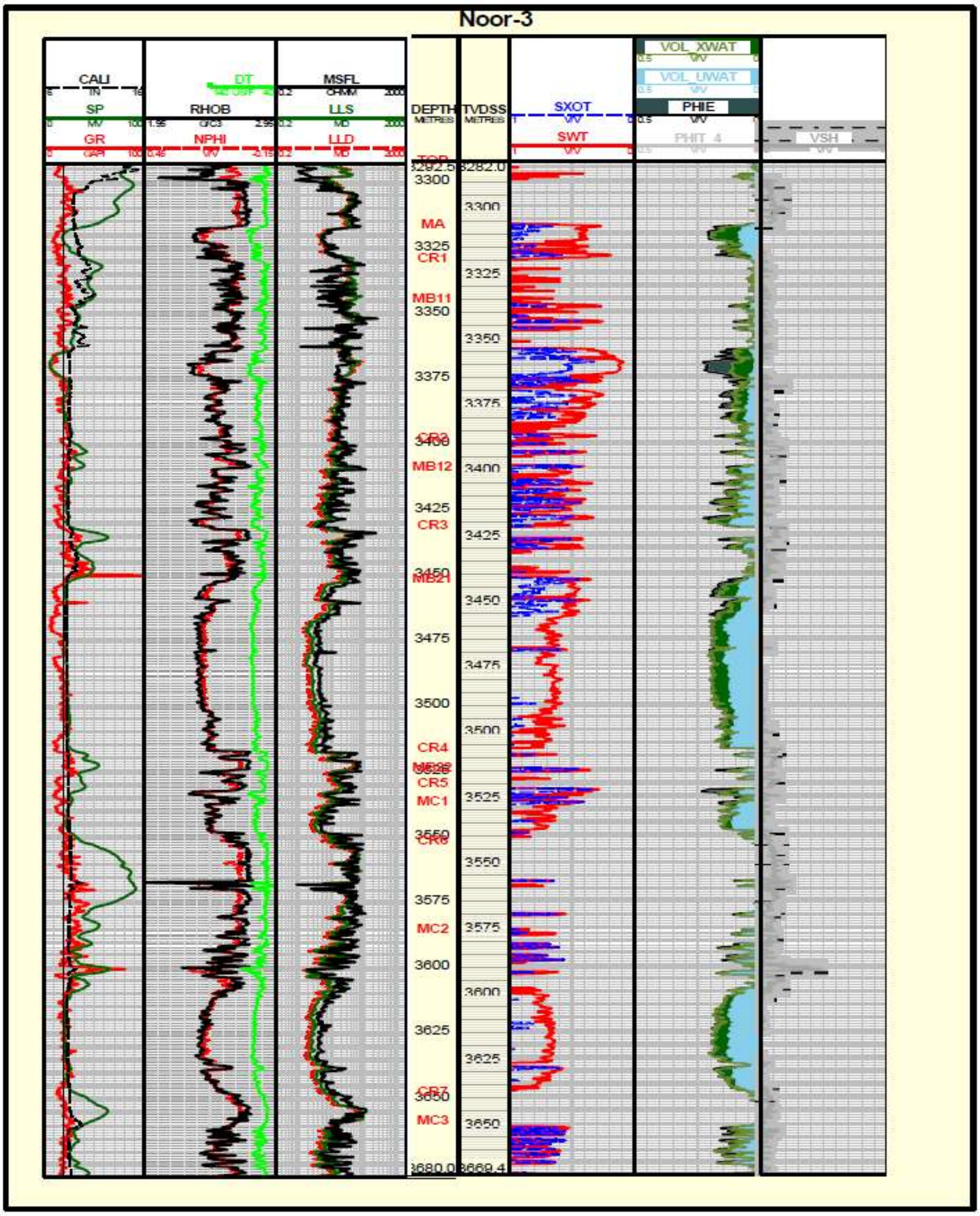

Figure 9-CPI for No-3.

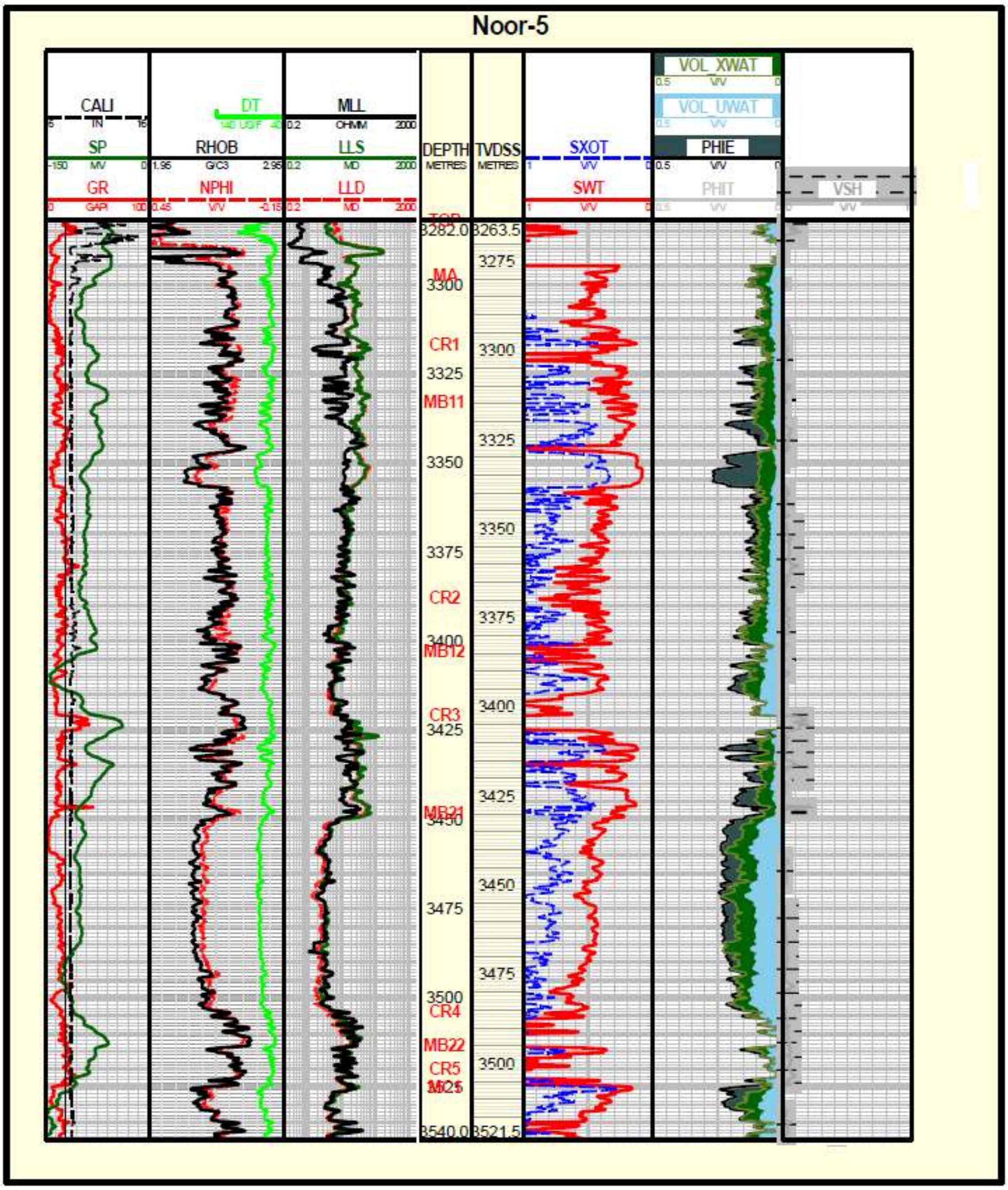

Figure 10-CPI for No.5.

Discussion and Results

1. Porosity: poor to-fair primary porosity in the reservoir unit MA acoording to the classification of porosity[21].MB1&MB21 show relatively higher porosity than other reservoirs units.

2. Hydrocarbon saturation vs. water saturation shows that Hydrocarbon saturation in the MA is varying from poor to moderately comparison with water saturation in the same reservoir unit.While, the hydrocarbon saturation values increased especially in the Nr5,7,&8.

3. Moveable vs.residual oil in general, the MB reservoir unit shows higher moveable oil comparios with the other units especially in No-5.Taking in consideration the less amounts of clay in the MB.

4. Cap Rock(CR):There are several non-reservoirs units(cap rocks) were recognized based on the reading of GR,resisitivity,RHOB,NPHI, and DT logs.These rocks composed mainly from compacted limestone.

5. From RHOB-NPHI cross plot,Mishrif Formation composed mainly from Limestone and some dolomite.
6. M-N cross plot shows the mineralogy of the Mishrif Formation composed mainly form calcite and dolomite.

Conclusion

1- From Petrophysical properties, Mishrif Formation consist of several reservoirs units separated by impermeable cap rocks zones.The main reservoirs units are (MA&MB).

2- Petrophysical parameters have been studied inNoor oil field, shows ,that MB is the main reservoir unit.

3- lithological cross plot analysis, RHOB vs. PHIN, indicates the Mishrif Formation consist mainly limestone with some dolomite.

4- M-N cross plot indicate the mineralogical of limestone in Mishrif Formation is mainly calcite with less amounts of dolomite.

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