Formation Evaluation by Using Well logging (case study from Mishrif Formation in Noor)Oil Field, Southern 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)(Bar1,Bar2,Bar3,Bar4,Bar5,Bar6,and Bar7).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.**

Key Words: Petrophysical properties, , Mishrif Formation . well logs , Noor Oil Field.

INTRODUCTION

Petrophysical interpretation is crucial for understanding subsurface reservoir rocks [1]. Subsurface characterization requires physical measurements that made from well logging. Well Logging is a process of recording a detail for the geological formations have penetrated by borehole.Mishrif Formation is regarded as one of the most important reservoirs throughout of the Middle East (2).The Mishrif Formation comprises 30% of the total Iraqi oil reserves (3).

As logging tools and interpretive methods are developing in accuracy and sophistication, they are playing an expanded role in the geological decision making process. Today, petrophysical log interpretation is one of the most useful and important tools available to a petroleum geologist. Logging data are used to identify productive zones, to determine depth and thickness of zones, to distinguish between oil, gas, or water in a reservoir, and to estimate hydrocarbon reserves. Also, geologic maps developed from log interpretation help with determining facies relationships and drilling locations. Increasingly, the importance of petrophysics and well- log analysis is becoming more evident as more attention is being devoted to the ongoing management of reservoirs. (4)

The Study Area

Noor oilfield is located in the south of Iraq within Missan province. It is situated near the Iraq-Iran border, about 350 km southeast of Baghdad and 15 km northeast of Amara city., figure-1. Four wells are producing from Mishrif Formation the well that will be studied in this research are (No-1,No-3 ,No-4 ,No-5) geographic coordinate of these wells are shown in Table (1).

Table (1): The geographic coordinates of studied wells in Noor field.

Well name	Eastern	Northern
Noor 1	71600	3536550
Noor 3	71780	3533380
Noor 4	71465	3535350
Noor 5	71375	354600

Figure.(1) Location map of the study area

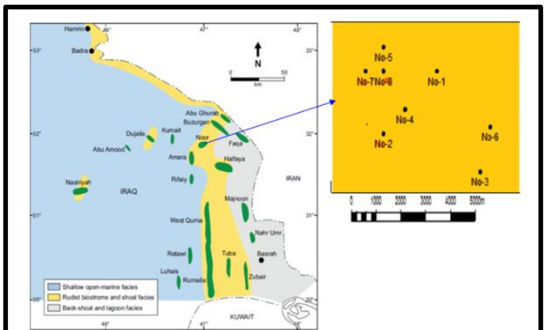


Figure (1.1) Location map of the study area

Data and Methods

5 borehole from Noor Oil Field have been studied In this study there are different logs were used including (Gamma-Ray, Density, Sonic, resisitivity, and Neutron logs. Interactive petrophysics (IP) software were used to integrate in formation evaluation.

Reservoir Temperature

Formation temperature (Tf)is an important factor or parameter in log analysis because of the relationship with the resistivity of the drilling mud (Rm), the mud filtrate (Rmf) and the formation water (Rw) vary with temperature.

The temperature of the Formation (Tf) is determined by knowing :

y = mx + c --------------------------------(1)

Where:

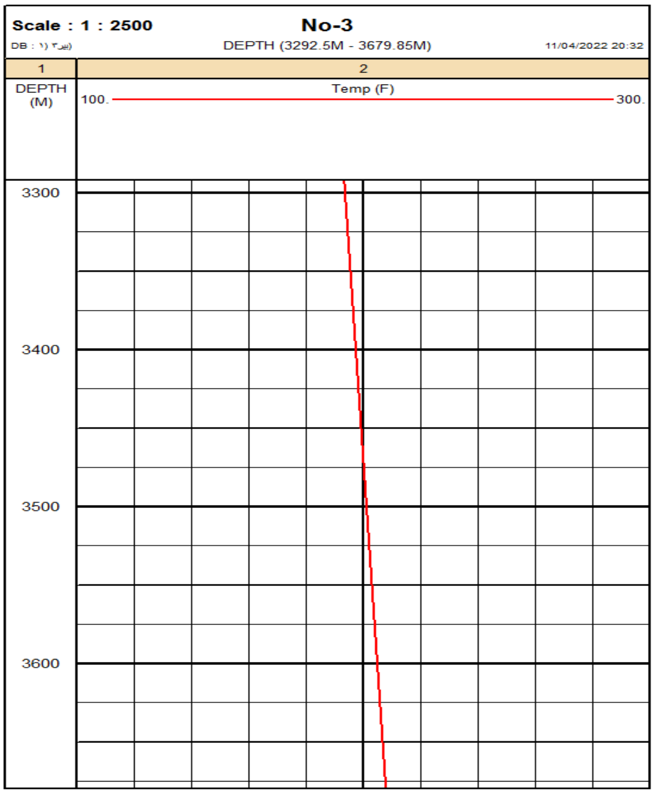
x = depth

y = temperature

m = slope (geothermal gradient), m = (y - c)/ x ----------------(2)

c = constant (mean annual surface temperature) (5).

Figer .2 Temperature gradient for well No- 3.



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, After complete all the previous corrections and calculation of borehole temperature, invasion corrections should be made.

Basic Parameters

The basic reservoir information and relevant parameters are first compiled and analyzed in advance to log interpretation are :

Fluids Resistivity correction

In general the borehole environment is electrochemically influenced by the drilling mud, which makes its resistivity graded from the drilling mud resistivity (Rm) in the borehole, mud filtrate resistivity (Rmf) of flushed zone, and uninvaded formation water resistivity (Rw). These resistivities are greatly affected by temperature changes from depth to depth (6)

After the temperature of a formation is determined by calculation, the resistivity of the different fluids (Rm, Rmf, or Rw) must be corrected to formation temperature before they are being used in any calculations.

$Rt = R\,temp.(Temp. + 6.77)/(Tf + 6.77)$ For depth in feet--------(1)

$Rt = R\,temp.(Temp. + 21.0)/(Tf + 21.0)$ for depth in meter--------(2)

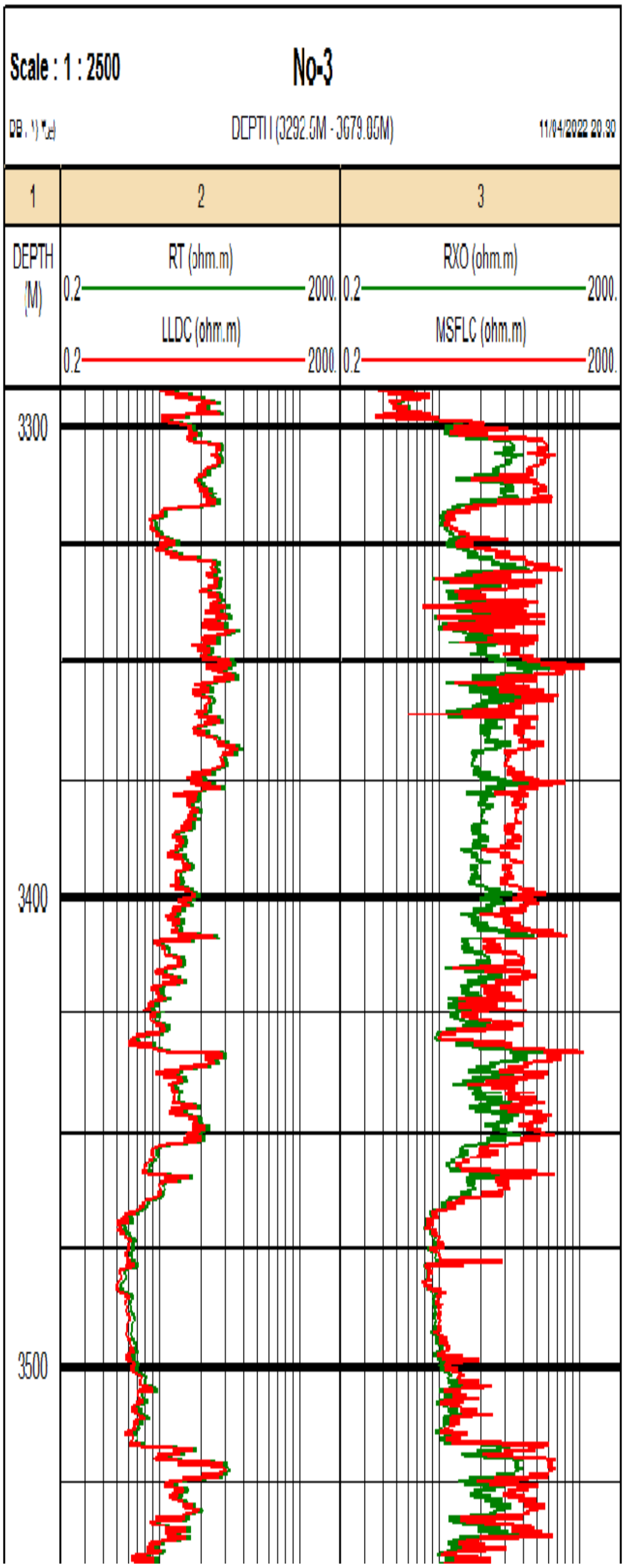
Where: Rtf = Resistivity at formation temperature.

R temp. = Resistivity at a temperature other than formation temperature. Temp = temperature at which Resistivity was measured (usually Fahrenheit. for depth in feet F°/ft, Celsius for depth in meters C°/m).

Tf = formation temperature (F°/ft, or C°/m).

After these corrections they were used in Archie's equation to calculate the fluid saturations.

Figer .3 Resistivity corrections for well No-3



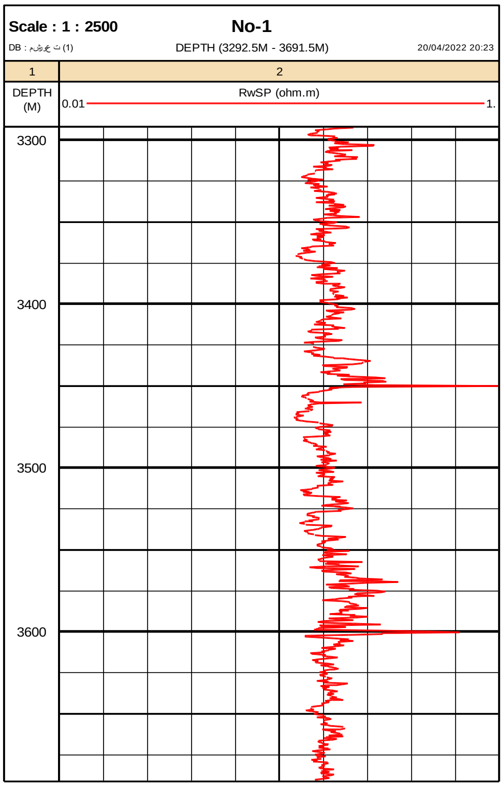
Determination of water resistivity

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).

Table (2): Illustrates formation temperature and water resistivity for all wells in Noor oil field.

Well Number	T_fFormation Temerature in F	R_w Formation Water resistivity
No-1	180	0.021
No-3	170	0.023
No-4	168	0.0223
No-5	166	0.018
No-7	182	0.020
No-8	178	0.026

Figure (4): Calculation of RW by using SP method of well No-1



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 (4)

$$IGR= \frac{GRlog-GR\ min}{GRmax-GRmin} \ldots\ldots(5)$$

Where:

I_{GR}= gamma ray index

GR_{log}=gamma ray reading from formation

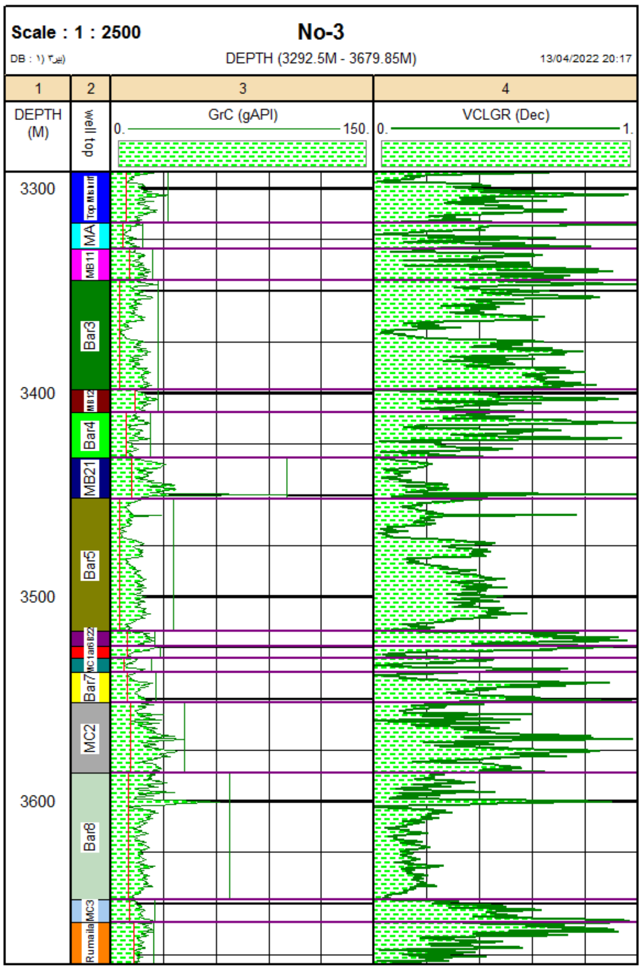
GR_{min}=minimum gamma ray (clean carbonates)

GR_{max}=maximum gamma ray

In this study, because the formation regards as an old rock, the equation of (Larinov, 1969) was used:

$$Vsh=0.33\times (2^{2\times IGR} - 1)\ldots\ldots.(6)$$

Figure (5): Calculate the volume of clay NO-3



Porosity

Rock porosity can be calculated from the combination of neutron-density logs. Density log represents as a porosity log that measures the electron density of the Formation[7]. 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:

øDCorrection=Ød-(Vsh×øDsh)(7)

For neutron porosity log according to [9]

øNcorrection=ØN-(Vsh×øNsh) (8)

Where,

Vsh: represents the shale volume.

ØN: represents neutron porosity in shale formation

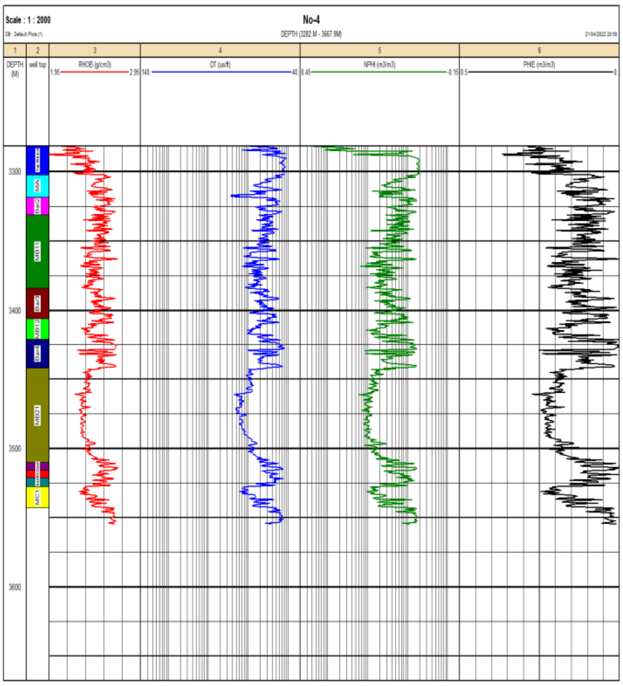
Total porosity can be calculated form the following formula [7]

Øt)=(ØN+ØD) (9)

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

Øeff=Øtotal×(1-vsh) [10]

Figure (6) The gamma and porosity logs with calculated PHIE of well Noor-4



Primary and secondary porosity

Primary porosity represents the pore space sediments that are deposited at or during the same time of deposition[10].Secondary porosity is the term triggered on the pore space sediment that are formed after deposition due to diagenetic processes[11]. Sonic log was used to determine primary porosity according to the following formula[12]

ØS=(Δlog-Δtma)/Δtfl-Δtma) (11)

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,[13] 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 (12)
S×0.9………oilØ=Ø(13)

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

ØScoreection=Øs-(Vsh-ØSch) (14)

Finally, the index of secondary porosity (SPI) can be calculated according to the following formula[8]

SPI= (Øt-ØScorrection).

Water Saturation

Water saturation for reservoirs in uninvaded zone is calculated by the Archie formula [14]

$$Sw = \left[\frac{a}{\text{Ø}^m} \times \frac{Rw}{Rt}\right]^{\frac{1}{n}} \quad (15)$$

Where the water saturation in flash zone can be calculated according the following formula [14]

$$Sw= \left[\frac{a}{\text{Ø}^m} \times \frac{Rmf}{Rxo}\right]^{\frac{1}{n}} \quad (16)$$

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 filtrate.

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 [4]

$$Shr=1-Sxo \quad (17)$$

$$Shr=1-Sw \quad (18)$$

Bulk volume water (BVW)

The product of a formation's water saturation (Sw) and it's porosity (ø) is the bulk volume of water [7]

Where, the bulk volume of water can be computed in the flushed zone using the following formula [15].

$$BVW=Sw\times øe \quad (19)$$

$$BVSXO=SXO\times øe \quad (20)$$

Where:

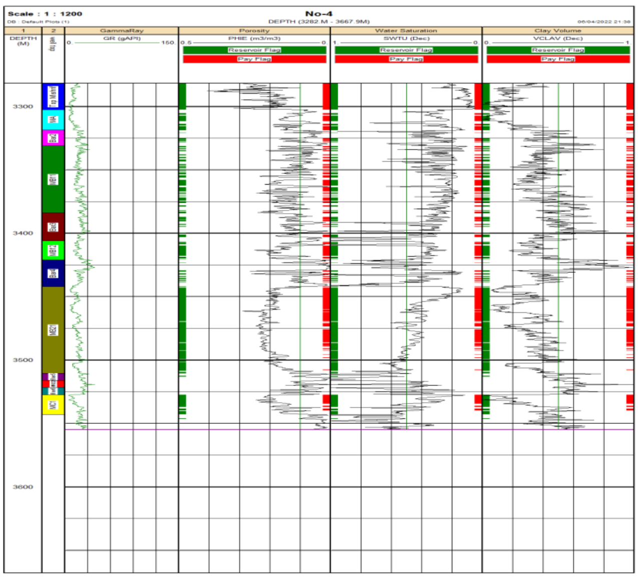
BVW: bulk volume of water in uninvided zone.

BVSXO=bulk volume of water in flushed zone

Net –Gross ratio

Net pay refers to the thickness of porous, interval permeable zone with commercial quantity of hydrocarbon.Net to- gross is an expression ratio of the thickness of net pay to the total pay thickness. This ratio is an important ratio in reservoirs volumetric calculation (16) Determination the net pay requires three important values. These values are, porosity, water saturation, to reservoir fluids.Net-gross ratio is a function of the quality of the limestone as potential reservoirs in Mishrif Formation

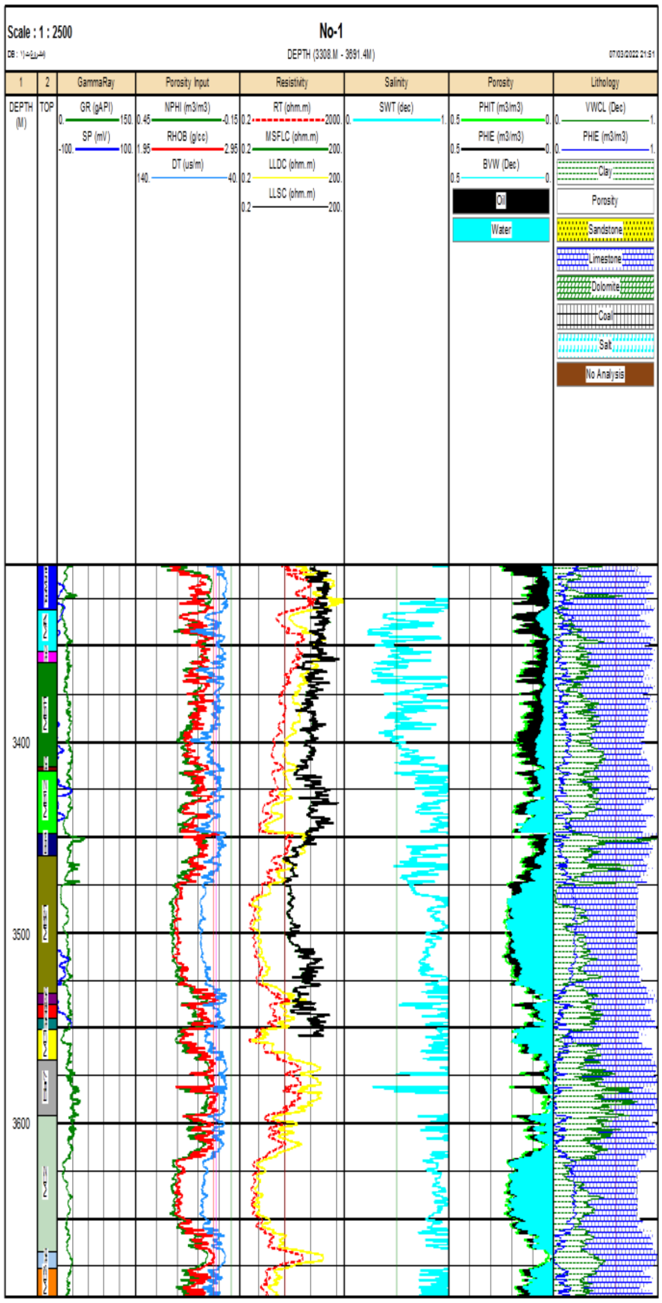
Figure (7): Net-Gross ratio for well No.4.



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.Figure

Figure (8) Computer Processed Interpretation (CPI) for well No-1



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 in MB increased especially in the No1,3, 4,and 5 respectively.

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. Barriers rocks: 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.

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