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Reservoir Characterization of Nahr Umr Formation Luhais Oil Field. South lraq

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اقرار المشرف

أشهد بان موضوع البحث الموسوم... والمنجز من قبل الطالب ....قد اجري تحت اشرافنا في قسم علم الارض كلية العلوم جامعة بابل كمتطلب جزئي لنيل شهادة البكلوريوس في علوم الارض وذلك للفترة من 2023/10/1 ولغاية 2024/4/1

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بسم الله الرحمن الرحيم

هُوَ الَّذِي جَعَلَ الشَّمْسَ ضِيَاءً وَالْقَمَرَ نُورًا وَقَدَّرَهُ مَنَازِلَ لِتَعْلَمُوا عَدَدَ السِّنِينَ وَالْحِسَابَ مَا خَلَقَ اللَّهُ ذَلِكَ إِلَّا بِالْحَقِّ يُفَصِّلُ الْآيَاتِ لِقَوْمٍ يَعْلَمُونَ).

صدق الله العظم

سورة يونس- الآية 5.

الاهداء

الى خالق اللوح والقلم وبارئ الذر والنسم وخالق كل شي من العدم

الى من بلغ الرسالة وادى الأمانة .. ونصح الأمة .. الى نبي الرحمة ونور العالمين

الى السادات الاطهار وعروته الوثقى .. اهل بيت النبوة

الى مراد قلبي والاقرب لي من نفسي المغيب عن الابصار والكامن بعين البصيرة الى بقية الله الاعظم. صاحب

العصر والزمان (عجل الله تعالى له الفرج)

الى تلك الحبيبة ذات القلب النقي ... الى من اوصاني الرحمن بها برا واحسانا الى من سعت وعانت من اجلي الى من كان دعائها سر نجاحي .. امي الحبيبة الى من اشاركهم لحظاتي . . الى من يفرحون لنجاحي وكانه نجاحهم .. اخوتي بكل حب اهديكم هذا الجهد المتواضع

شكر وتقدير

اقدم شكري الجزيل الى عميد وعمادة كلية العلوم جامعة بابل لرعايتهم العلمية والتربوية القيمة طيلة فترة دراستي وإنجازي بحث التخرج.

شكري وتقديري العميق الاستاذه مها رزاق لاقتراحها موضوع البحث و توجيهاته العلمية النظرية القيمة ومساعدته العملية المتواصلة

كما أود أن أشكر رئيس قسم علم الارض التطبيقي الدكتور مهند الجبوري على تشجيعه المستمر ومتابعته مراحل انجاز البحث.

والشكر موصول الى جميع أساتذة القسم الذين بذلوا كل جهد ووقت وعلم طيلة فترة اربع

سنوات مدة دراستي في القسم، والذي تمكنت من خلالهم انجاز بحث التخرج المتواضع هذا.

واقدم الشكر والتحية لجميع المعيدين والموظفين في القسم لجهودهم العلمية والعملية الرائعة طيلة فترة دراستي في القسم

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Summary

The Nahr Umr Formation is one of the most important formations of the Cretaceous and one of the main important reservoirs in southern Iraq. as this formation represents the sandstone and shale deposition of the Albian in the country.

The study area is located in Zubair, South and North Rumaila oil fields, Southern Iraq. The studied region is located in the Mesopotamian Zone southernmost unit within the Zubair Subzone have been chosen throughout the fields to provide extensive information on the Nahr Umr Formation

Evaluation of reservoir characterization of Nahr Umr discussed with the changes in the secondary and effective porosities and permeability. According to Resistivity and porosity the hydrocarbon saturation was calculated and determinated zone in the studied section; (Low-non poros rocks).

Chapter One

INTRODUCTION

1.1 Preface

Nahr Umr Formation (Albian) is one of the important formations in central and southern Iraq, as this formation represents the sandstone deposition of the Albian in the country. It is also considered one of the important reservoirs due to its petrophysical characteristics and oil accumulations (Anadarko, 2005).

1.2 Aims of the Study

The determination reservoir Characterization of Nahr Umr Formation in Luhais Oil Field, South Iraq.

1.3. Location of the study area

The study area is located in Zubair, South and North Rumaila oil fields, Southern Iraq. The studied region is located in the Mesopotamian Zone southernmost unit within the Zubair Subzone (fig. 1-1).

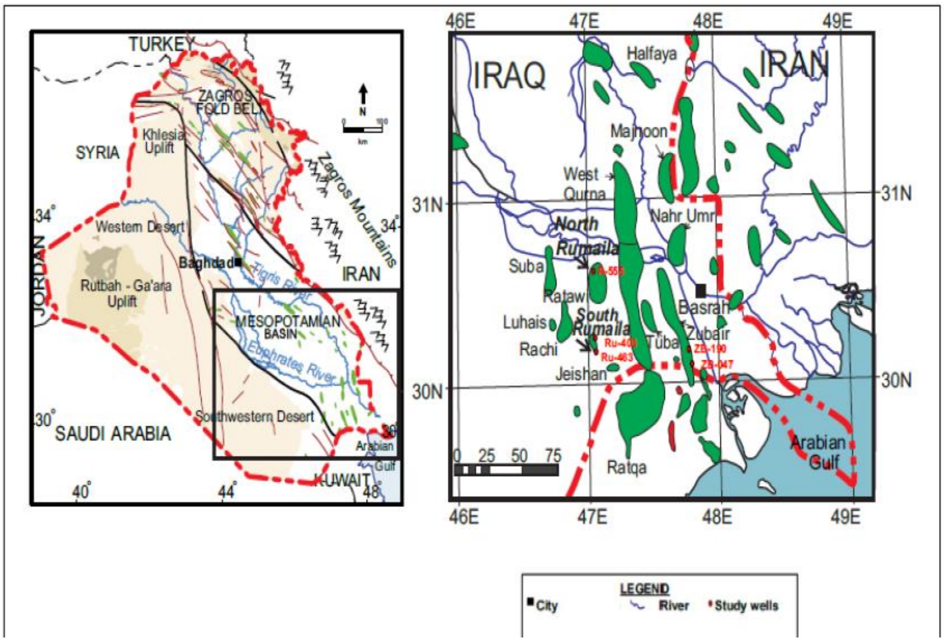


Figure 1.1: Location map of the study area, (modified from Al-Khafaji *et al*., 2021).

1.4. Stratigraphic Setting

The Nahr Umr Formation is one of the formations of the Albian cycle within the main cycle within the Lower Cretaceous- Late Berrisian Albian cycle ,which dates back to the Lower Cretaceous (Albian) (112-103.6 Ma).

Clynn jones,1948 is the first year in which the Nahr Umr Formation was known before (Owen and Naser,1958) and (Buday, 1980) presented it as an independent stratigraphic unit.

The Nahr Umr Formation consists of black shale rocks overlapping with medium – fine-grained sandstone containing lignite, amber and pyrite (Bellen *et al.*, 1959: in Buday, 1980).

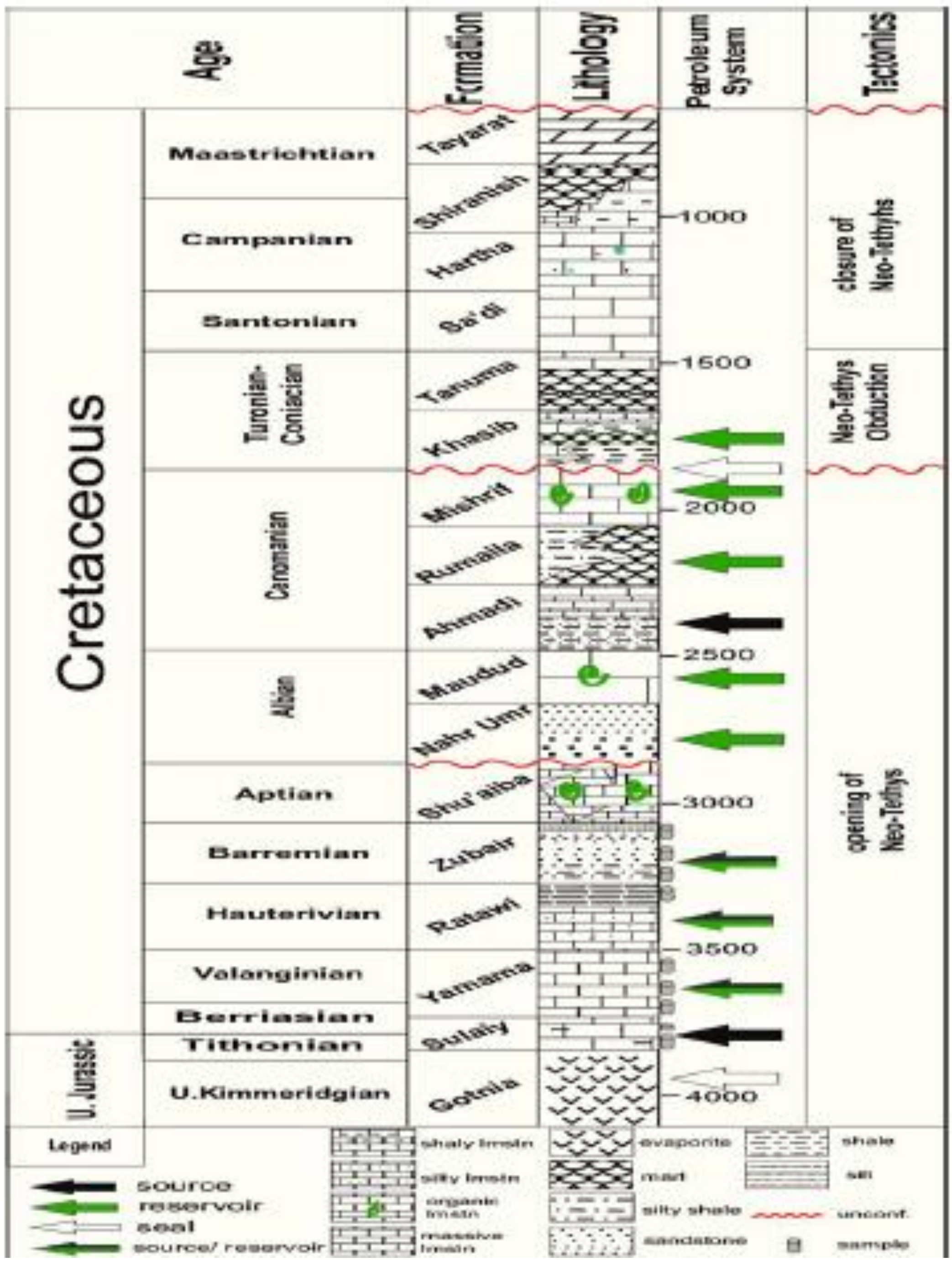
The formation consists of layers of black shale interbedding with medium – fine-grained sandstone and alluvial sediments with the appearance of thin layers of limestone that depended on the general division and definition (Jassim and Goff, 2006).

According to the general division and definition is given by,) Bellen *et al*., 1959: in Buday, 1980) the lower boundary of the Nahr Umr Formation in the typical area is conformable and gradual, as the surface of the unconformity appears in the Dujaila area (Safar and Maclead, 1961).

It was accepted by Ditmar *et al*., (1971 and 1972) that the upper contact is also conformable. The Mauddud Formation overlies the Nahr Umr Formation in a gradual conformable, as the base of the Mauddud Formation is topped by dolomitic limestone, while the base of the Mauddud Formation which is the top of the Nahr Umr Formation may consist of sandstone or layers of shale, the lower contact separating the Nahr Umr Formation from the Shua`aiba Formation is unconformity, which is represented by the presence of layers of dark, black, foliated shale as a base for the Nahr Umr Formation or at the top of the layers of yellow or pale gray dolomite of the Shua`aiba Formation (Qaradaghi *et al*., 2008).

In the southern part of the Salman and Mesopotamia Zones, the thickness of the formation reaches more than 360 m and its largest thickness is in Iraq and Kuwait at 400 m, and it reaches160m in southern Baghdad and northwestern Iraq(Jassim and Goff, 2006).

The Nahr Umr Formation is equivalent to the upper part of the Sarmord Formation in northern Iraq (Al-Naqib, 1959). In Kuwait, it is equivalent to the Burqan Formation and equivalent Khafji and Safaniya formations in the north of the Kingdom of Saudi Arabia (Power, 1968) .



(F.g 1.2) Stratigraphic Column of Nahr Umr Formation in Southern Iraq, modify (Al-Ameri *et al.,* 2009).

1.5. Tectonic Setting

The Middle East Region is located between two tectonic plates, the (Eurasian Plate) and the (Arabian Plate) (Hempton, 1987 in Numan, 2000).

Where Iraq is located in the northern and northeastern part of the Arabian Plate and is bounded by the Zagros and Taurus Zone from the north and north-east, and by the Levent Fault Zone and the depression of the Red Sea Rift from the west(Dewey *et al.*, 1973), the Gulf of Aden and the Owen Tissir Zone from the south(Buday and Jassim,1987) .On the other side, the location of Iraq is between two tectonic units represented by the western part of the African platform (Arab-Nubian) from its southern and southwestern sides, and between the unit represented by the Albian sedimentary basin from its northern and northeastern sides.The tectonic location of the study area is within the Mesopotamian Zone, which is part of the unstable shelf as it includes the southeast part of Iraq , where it was characterized by a large depression at the end of the Mesozoic when it reached its maximum end of the Cenozoic.

1.6. Previous Studies:-

Glynn Johns,1948 in Van Bellen *et al*.,1959 was the first who referred to Nahr Umr Formation when he described the sandy and shaley strata between Shua`aiba Formation at the bottom and Mauddud Formation at the top.

Owen and Nasr,1958 studied the Nahr Umr Formation in more detail and discovered that it is composed of black shale interbedded with fine to medium grain sands containing amber and pyrite.

Chatton and Hart,1960 in Buday,1980divided Nahr Umr Formation according to lithology into two units: Nahr Umr Shale and Nahr Umr Sands.

AL-Naqib,1967 divided Nahr Umr Formation and its type section into three lithological units according to lithology and shale content.

Castro,1978 referred to his sedimentological study in a Majnoon Nahr Umr area where Nahr Umr Formation was deposited in two major environments; the lower part represents a fluvial or tidal, while the upper part was deposited in the marine – deltaic environment.

Mansour, 1982 referred to in his sedimentological study in southern Iraq, that the sandstone deposits were mixed, with coastal plain in the upper part and deltaic-fluvial in the middle and lower parts, with beach environment effects and the sedimentary environments are controlled by transgression – egression.

Khurshed *et al*.,1982 studied the Nahr Umr Formation in Halfaya oilfield, south of Iraq and they referred that the clastic deposits of Nahr Umr Formation represent a small-scale sequence from coarsening upward, which is caused by a short regression phase, and these deposits are found mainly in the tidal marine part of the delta.

AL-Joubory,1985 referred that the thickness of Nahr Umr Formation increases from west to east, and has a maximum thickness of 360m in well Abu-Khima-1; whereas the thickness reaches in East Baghdad oil field to less than 100 m.

Ali *et al.*,1986 divided Nahr Umr Formation into two members in the Luhais oil field; claystone member and sandstone member and they divided each member into many units. They referred that the sandstone increased southward, and the upper and lower contact with Mauddud and Shua`aiba formations are gradient.

Abd *et al.*,1988 pointed out that Nahr Umr Formation was deposited in deltaic and beach environments enriched by dunes, where Kaolinite is the widespread mineral in addition to Illite.

Al-Rubaiy and AL-Joubory,1988 in the Luhais oil field studied the Nahr Umr Formation and divided it into three main parts according to shale content.

Kendall *et al.*,1991 in their study of the Arabian Gulf and the Gulf of Mexico referred that the deposition of the Middle Cretaceous was affected by several sea level events; for instant, the Nahr Umr Formation represented the clastic response to a major eustatic drop in the Late Aptian time.

Al-Hadithy,1994 divided the Nahr Umr Formation into two oil fields (Luhais and Subba) oil fields into eight lithological units and diagnosed eight lithofacies, and he referred that this formation was deposited in various environments including fluvial, pro-delta, and tidal flat.

Al-Sharhan, 1994 due to the dominance of deltaic, coastal, and shallow-marine environments, the Nahr Umr Formation shows rapid changes of facies in both lateral and vertical directions, according to his sedimentological and petroleum–geological studies. In addition, the formation rests unconformably on the Aptian Shua`aiba limestone, which is gradually overlaid by conformable Mauddud limestone.

Immenhauser *et al.*, 1999 in their study suggest the Aptian age to the base and late Albian to the top of Nahr Umr Formation in Jabal Akhdar, North of Oman. This study referred that this formation is organized into seven accommodation cycles.

Anadarko, 2005 studied the reservoir quality and depositional environments of Nahr Umr Formation in Luhais oilfield and show that the depositional environments of the formation were Barriers isle system aggraded over a deltaic platform and generally the reservoir quality is excellent within the sands. Nevertheless; within the formation, the reservoir quality is controlled

by facies diversity where delta and barriers are reservoir facies in contrast to mudflat and tidal flat facies.

Al-Dabbas *et al.*,2012 studied the sedimentological and depositional environments of the Nahr Umr Formation in central and southern Iraq and show that the formation is mainly composed of sandstone interlaminated with minor siltstone and shale, with the occurrence of thin limestone beds, and this formation was deposited in the shallow marine and fluvial deltaic environments and exhibit progradational succession of facies.

Ebraheem, 2015 the petrophysical and reservoir properties of the Shuaiba and Nahr Umr formations were studied in the Arab Qurna field, where they showed that the Nahr Umr Formation sequence consists of five main facies and four main sedimentary environments and its impact on five diagenesis processes.

Sahi *et al.*, 2017 A reservoir study for the Nahr Umr Formation in the Luhais oilfield. The formation was divided into three reservoir units (upper, middle, and lower) and each unit was divided into secondary units, where the upper and lower unit included one reservoir unit, while the middle unit included three reservoir units.

Al-Zaidy, 2018 facies analysis and stratigraphic development of the Nahr Umr Formation in Luhais oil field, southern Iraq.

Ali,2018 reservoir evaluation of Nahr Umr Formation in the luhais oilfield, Southern Iraq.

Al-Nafie,2021 estimation of reservoir properties based on core plugs, lithofacies, microfacies, and well logs for Nahr Umr Formation in Noor oilfield, southern Iraq.

Chapter Two

well logs

2.1. Preface

The parameters of log interpretation are determined directly or inferred indirectly and measured by one of three types of logs:

1. Electric
   - ❖ Spontaneous Potential
   - ❖ Resistivity
2. Radioactive
   - ❖ Gamma Ray
   - ❖ Density
   - ❖ Neutron

3. Acoustic or sonic logs

Well logging measurements influenced by Rock properties or characteristics are: sequence subdivision, porosity, lithology, mineralogy, permeability, and water saturation. Additionally, the resistivity of the rock is important because it is directly measured and is an essential part in the interpretation process.

2 .2 Sequence subdivision from well logs

According to Vail and Wornardt (1990)Well-log Sequence Stratigraphic analysis is a methodology that permits a geologist and geophysicist to subdivide a stratigraphic section into a series of time related 3rd Order depositional Sequences and Systems Tracts. The most common log types that are routinely employed for facies analyses (lithology, porosity, fluid evaluation) and stratigraphic correlations are summarized in table (2-1).

Table (2-1) Types of well logs, properties they measure, and their use for geologic interpretations (Catuneanu, 2006).

Log	Property measured	Units	Geological interpretation
Spontaneous potential	Natural electric potential (relative to drilling mud)	Millivolts	Lithology, correlation, curve shape analysis, porosity
Conventional resistivity	Resistance to electric current flow (1D)	Ohm-metres	Identification of coal, bentonites, fluid types
Micro resistivity	Resistance to electric current flow (3D)	Ohm-metres and degrees	Borehole imaging, virtual core
Gamma ray	Natural radioactivity (e.g., relater to K, Th, U)	API units	Lithology (including bentonites, coal), correlation, shape analysis
Sonic	Velocity of compressional sound wave	Microseconds/metre	Identification of porous zones, tightly cemented zones, coal
Neutron	Hydrogen concentration in pores (water, hydrocarbons)	Per cent porosity	Porous zones, cross plots with sonic and density for lithology
Density	Bulk density (electron density) (includes pore fluid in measurement)	Kilograms per cubic metre (g/cm^3)	Lithologies such as evaporites and compact carbonates
Dipmeter	Orientation of dipping surfaces by resistivity changes	Degrees (azimuth and inclination)	Paleoflow (in oriented core), stratigraphic, structural analyses
Caliper	Borehole diameter	Centimetres	Borehole state, reliability of logs

Gamma ray (GR) logs measure the natural radioactivity in formations and can be applied to identify lithological and for correlating zones. Abrupt changes in gamma-ray logs response are commonly related to sharp lithological breaks associated with unconformities and sequence boundaries (Krassay, 1998). Shale-free sandstones and carbonates have low concentrations of radioactive material and give low gamma ray readings. As shale content increases, the gamma ray log response increases because of the concentration of radioactive material in shale. However, clean sandstone (i.e., with low shale content) might also produce a high gamma ray response if the sandstone contains potassium feldspars, micas, glauconite, or uranium-rich waters (Asquith and Krygowski, 2004).

2.3 Shale volume calculation

Shale is usually more radioactive than sand or carbonate, so gamma ray logs can be used to calculate volume of shale in porous reservoirs. The volume of shale expressed as a decimal fraction or percentage is called V shale.

Calculation of the gamma ray index is the first step needed to determine the volume of shale from a gamma ray log (Larionov, 1969):

$$I_{GR} = \frac{GR_{\log} - GR_{\min}}{GR_{\max} - GR_{\min}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 2.1$$

IGR= gamma ray index

GRlog= gamma ray reading of formation

GRmin= minimum gamma ray (clean sand or carbonate)

GRmax= maximum gamma ray (shale)

For the first order estimation of shale volume, the linear response, where Vsh= IGR, should be used.

The nonlinear responses, in increasing optimism (calculated shale volumes), are: by (Larionov, 1969).

$$V_{sh} = 0.33 * \left(2^{2*I_{GR}} - 1\right) \quad \ldots\ldots\ldots\; 2.2$$

According to the values and the shape of the gamma ray log and shale values we can

Formation (Fig 2.2). This zone represents a high volume of shale (20-60%). The thickness of this zone is approximately (Table 2.2), this zone divided into four sub zone represented by four sub zone of high gamma ray and high shale alternative with three sub zone of low gamma ray and low volume of shale.

Table(2.2) thickness of zone in all wells in the study area

Wells	13	8	39	4	5	2	14
Thickness	93	116.5m	116m	83m	133m	150m	76.5m

2.4 Porosity

Porosity is an important rock property because it is a measure of the potential storage volume for hydrocarbon (Lucia, 2007). Porosity can be defined as the ratio of void to total volume of rock. It is represented as a decimal fraction as a percentage and is usually represented by the Greek letter Phi, □. (Asquith and Krygowski, 2004) porosity in carbonate reservoir ranges from 1 to 35% and, in the united states ,averages 10% in dolomite reservoirs and 12% in limestone reservoirs (schmokel*etal*.,1985). Porosity is a pore volume divided by bulk volume.

$$Porosity = \frac{\textbf{Pore volume}}{\textbf{Bulk volume}} = \frac{\textbf{Bulk volume} - \textbf{Mineral volume}}{\textbf{Bulk volume}}$$

The type of well logs used depends upon the characteristics of the rock being measured .The main purpose OF this procedure is:

1. To aid in testing completion and repairing of the well.
2. To provide data for evaluating petroleum reservoirs.

To calculate the Oil reserve in an Oil pool we need to know the following:-

- Thickness of the Oil bearing formation.
- Oil saturation.
- Porosity .

In addition to core analysis, rock porosity can also be obtained from logs such as the sonic log ,density log or neutron log and resistivity log For all these devices, the tool response is affected by the formation porosity, fluid, and matrix. If the fluid and matrix effects are known or can be determined, the tool response can be determined and related to porosity. Therefore, these devices are usually referred to as porosity logs. All three logging techniques respond to the characteristics of the rock immediately adjacent to the borehole. Their extent of investigation is shallow only a few centimeters or less and therefore generally within the flushed zone (Schlumberger, 1989). The porosity of a zone can be estimated either from a single "porosity log" (sonic, density, neutron log) or a combination of porosity logs, in order to correct for variable lithology effects in complex reservoirs. In the carbonates, mineral mixtures are primarily drawn from calcite, dolomite, and quartz (either as sand grains or as chert); anhydrite and gypsum may also occur (Doveton, 1999).

2.4 Density logs

Density is measured in grams per cubic centimeter g/cm3 and is indicated by the Greek letter ***ρ*** (rho). Two separate density values are used by the density log: the bulk density (***ρb*** or RHOB) and the matrix density (ρma). The bulk density is the density of the entire formation (solid and fluid parts) as measured by the logging tool. The matrix density is the density of the solid framework of the rock. It may be thought of as the density of a particular rock type (e.g., limestone) that has no porosity.

Porosity is derived from the bulk density of clean liquid-filled formations when the matrix density *ρma* and the density of the saturating fluids ρ*f* are known (Asquith and Krygowski, 2004):

$$\Phi_{\rho} = \frac{(\rho_{ma} - \rho_b)}{(\rho_{ma} - \rho_f)} \quad \text{………………2.3}$$

where:

ϕ p = porosity by Density log.

ρ_{ma} = matrix density (Table 3.5)

ρ_f = Density of fluid (g/cm^3) = 1 g/cm3 for fresh water or 1.1 g/cm^3 for salt mud.

ρ_b = bulk density recorder by log.

The matrix density can be calculated by flowing equation (Western Atlas,1995) is:-

$$\rho_{ma} = \frac{\rho_b - \Phi_{n.d} * \rho_f}{1 - \Phi_{n.d}} \quad \text{…..……..2.4}$$

$\Phi_{n.d}$= Neutron-density porosity

Table (2.3) Matrix densities values of common lithologies (Asquith and Krygowski, 2004).

Lithology/ Fluid	ρ_{ma} or ρ_{fl} g/cm^3 [Kg/m^3]
Sandston	2.644 [2644]
Limestone	2.710 [2710]
Dolomite	2.877 [2877]
Anhydrite	2.960 [2960]
Salt	2.040 [2040]
Fresh water	1.0 [1000]
Salt water	1.15 [1150]
Barite (mud additive)	

2.6 Neutron Logs

Neutron log is used principally for the delineation of porous formation and determination of their porosity. It responds primarily to the amount of hydrogen present in the formation. Thus, in clean formations whose pores are filled with water or oil, the neutron log reflects the amount of the liquid filled porosity.

A combination of the neutron log with one or two other porosity log yields even more accurate porosity values and lithologic identification, including evolution of shale content (Schlumberger, 1972).The combination of density and neutron logs is now used commonly as a mean to determine porosity that is largely free of lithology effects. Each individual log records an apparent porosity that is only true when the zone lithology matches that used by the logging engineer to scale the log. A limestone-equivalent porosity is a good choice for both neutron and density logs, because calcite has properties that are intermediate between dolomite and quartz. By averaging the apparent neutron and density porosities of a zone, effects of dolomite and quartz tend to cancel out. The true porosity may be estimated either by taking an average of the two log readings or by applying the equation (Doveton, 1999):

$$\Phi_{n.d} = \sqrt{\frac{\Phi^2{}_n + \Phi^2{}_d}{2}}$$ ……………..2.5

Where
n.dΦ= density and neutron porosities combination
nΦ= neutron porosity
dΦ= density porosity
The term effective porosity means the amount of void space that is interconnected and thus able to transmit fluids, this may be equal to the density - neutron porosity in free shale formation according to the next equation (Schlumberger, 1989).

$$\Phi_e = \Phi_t * (1 - V_{sh})$$ 2.6

Φ = effective porosity

2.7 Acoustic or sonic logs

The sonic tool measures the interval transit time (t) or the time in microseconds for an acoustic wave to travel through 1 feet (or 1 m) of a formation along a path parallel to the borehole. The interval transit time (Δt) is dependent upon both lithology and porosity. In this technique interval transit time are recorded of clicks emitted from one end of the sound travelling to one or more receivers at the other end. The sound waves generally travel faster through the formation than through the borehole mud (Selley, 1998). Therefore, a formation's matrix interval transit time (Table 2-6) must be known to derive sonic porosity either by chart or by following formulas:

Wyllie time-average equation (Wyllie et al., 1958):

$$\Phi_s = \frac{\Delta t_{\log} - \Delta t_{maa}}{\Delta t_{fl} - \Delta t_{maa}}$$ 2.7

Where:

Φs= sonic-derived porosity.

Δt= interval transit time in the formation(recorder by log).

Δtf= interval transit time of the formation fluid (salt water mud= 185 µsec/ft, fresh water mud 189 µsec/ft).

Δtma= interval transit time of matrix by using the table (2.6) (Schlumberger, 1972).or by using the equation (Western Atlas, 1995):-

$$\Delta t_{maa} = \frac{\Delta t_{\log} - \Phi_{n.s} * \Delta t_{fl}}{1 - \Phi_{n.s}}$$ ……………..2.8

$\Phi_{n.s}$ = neutron-sonic cross plot porosity

The interval transit time (Δt) of a formation is increased due to the presence of hydrocarbons (i.e. ,hydrocarbon effect). If the effect of hydrocarbons is not corrected, the sonic-derived porosity is too high(Selley,1998). Hilchie (1978) suggests the following empirical corrections for hydrocarbon and gas effects that are used in current study:

Φscorr = Φs * 0.7 ----- gas ……………. 2.9

Φscorr = Φs * 0.9 ----- oil ……………. 2.10

Φscorr = corrected sonic porosity

Φs =sonic-derived porosity

Table(2.6) Sonic Velocities and Interval Transit Times for Different Matrixes. These constants are used in the sonic porosity formulas above (Schlumberger, 1972).

Lithology/Fluid	Matrix Velocity ft/sec	Δt_{matrix} or Δt_{fluid} (Wyllie) µsec/ft[µsec/m]	Δt_{matrix} (RHG) µsec/ft[µsec/m]
Sandstone	18,000 to 19,500	55.5 to 51.0 [182 to 186]	56[184]
Limestone	21,000 to 23,000	47.6[156]	49[161]
Dolomite	23,000 to 26,000	43.5[143]	44[144]
Anhydrite	20,000	50.0[164]	
salt	15,000	66.7[219]	
Casing(iron)	17,500	57.0[187]	
Freshwater mud filtrate	5,280	189[620]	
Saltwater mud filtrate	5,980	185[607]	

fractures) computed as the difference between the sonic porosity and the neutron and/or density porosity (Schlumberger, 1997). Typically, moderate values in secondary porosity are caused by vugs, because fracture porosity does not usually exceed 1 to 2% by volume (Doveton, 1999).

To calculate the secondary porosity, we use the equation below by Schlumberger (1997):

$$SPI = (\Phi_{n.d} - \Phi_s) \quad \ldots\ldots\ldots\ldots\ldots..2.11$$

= Secondary porosity index SPI

= density and neutron porosities combination $\Phi_{n.d}$

= sonic-derived porosity Φ_s

2.9 Evaluation of sequence porosity

After the application of the wire log porosity procedures and drawing the porosity-depth relationship for each boreholes rather than logs reading with depth. These relationships include neutron/density log (total porosity)-depth, sonic porosity-depth and effective porosity-depth and the porosity evolution and reservoir characterization.

These types of porosity logs are studied for:-

1. Determination of the zones of void space that is interconnected and thus able to transmit fluids (effective porosity).

2. Combination of all of these features and their relationships with the water or hydrocarbon give the porosity evolution and reservoir characterization.

This zone is characterized by high- moderate inactive porosity because of precence a high volume of shale . This zone is represents the upper part of Nahr Umr Formation within the mud-dominated member.

Chapter three

Reservoir Characterization

3.1. Preface

Reservoir units have different characters such as lithology, types of porosity, permeability and types of fluids can be deduced from the study of logs. This study indicates the primary and secondary porosity as well as water and Oil saturation were determined in addition to subdividing the succession.

many boreholes(noor,2015), with their gamma ray, neutron, density, sonic and resistivity logs .

3.2 Resistivity Logs Analysis

The electrical resistivity of substance is its ability to impede the flow of electrical current through the substance. The unit used in logging is ohm meter2/meter, usually written as ohm-m. Electrical conductivity is the reciprocal of resistivity and expressed in milliohms per meter (mmhom/m) (Schlumberger, 1987, 1989, 1998; Halliburton, 2001).

3.21 Resistivity Logs Analysis

$$R = \frac{1000}{C} \quad \text{...............} \; 3.1$$

Where:

R= resistivity in ohm-m

C = conductivity in millimho/m (millisiemens)

In order to determine the saturations of hydrocarbons within the formations, first saturations of water should be calculated. The tools used for resistivity logging are classified within a depth of investigation as follows;

- ❖ Deep resistivity tools for uninvited zones.
- ❖ Shallow resistivity tools for transition zones.
- ❖ Microresistivity tools for flushed zones.

The most common resistivity tools in use can be classified as;

- ❖ Dual Laterolog Tool.
- ❖ Dual Induction Tool.
- ❖ Micro Spherically Focused Log.
- ❖ Microlog.

The resistivity of a formation with its matrix and fluid (water and hydrocarbon) and in the pores is true resistivity (Rt) of the formation.

A porous and a permeable formation has always water, even it contains hydrocarbon.The water in the pores of formation before it drilled is the formation water saturation (Rw) of the formation. After drilling operation, drilling mud invades and this affects the vicinity of the borehole forming different zones with different resistivity's. This zone is shown in Figure (3.1).

Rt is used for the determination of Sw in the Archie saturation model, that is considered the resistivity of a formation far enough from the borehole unaffected by invasion. Rxo is used to obtain the saturation in the flushed zone (Sxo) (represent the resistivity of the flushed zone near the borehole).

In favorable conditions, the focused deep-reading tools [the laterolog (LLd) and the deep induction (ILd)] may give measurements very close to (Rt) even without correction because they have the largest depths of investigation in most conditions (Schlumberger, 1972). The flushed zone (Rxo) can be measured directly with microtools.

An Interactive Petro physics programs are used to carry out environmental corrections (hole-size, mud cake and invasion effects) that conform to the Schlumberger requirements for the application of equations. Thus resistivity logs are used to:

• Determine hydrocarbon-bearing versus water bearing zones

• Indicate permeable zones

• Determine porosity

There are two main methods to calculate water saturation, Archie method and Ratio Method.

3.3 Formation Resistivity Factor (F) (Archie method)

A rock that contains oil and /or gas will have a higher resistivity than the same rock completely saturated with formation water and the greater the connate water saturation, the lower formation resistivity. This relationship to saturation make the formation resistivity factor an excellent parameter for the detection of hydrocarbon zone (Tiab and Donaldson, 2004). Archie (1942) showed that the resistivity of water filled formation (Ro) could be related to the resistivity of the water (Rw) filling the formation through a constant called the formation resistivity factor (F).

$$R_0 = F * R_w \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 3.2$$

Archie also revealed that the formation factor (F) could be related to the porosity of formation by the following formula that was used in the current study:

$$F = \frac{a}{\Phi^m} \quad \ldots\ldots\ldots\ldots\ldots\ldots \; 3.3$$

Where:

a= tortuosity factor = (1) for carbonate rocks.

m= cementation factor = (2) for carbonate rocks.

∅= total porosity.

n =saturation exponent

Rw = resistivity of formation water(Rw) = 0.065 ohmm

R_t= true formation resistivity as derived from a deep reading resistivity log

By combining equations and, the water-saturation formula can be rewritten in the following form:

$$S_w = \left(\frac{a * R_w}{R_t * \Phi^m} \right)^{\frac{1}{n}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 3.3$$

Where:

Sw= water saturation

a = tortuosity factor (a = 1.0)

m = cementation exponent (m = n = 2.0)

n = saturation exponent

Rw= resistivity of formation water(Rw) = 0.065 ohmm

= porosity□

Rt= true formation resistivity as derived from a deep reading resistivity log.

This is the formula that is most commonly referred to as the Archie equation for water saturation (Sw). All present methods of interpretation involving resistivity curves are derived from this equation (Asquith and Krygowski, 2004). The deep induction log does not always record an accurate value for deep resistivity in thin, resistive zones (where Rt> 100 ohm-m). Therefore, an alternate method to determine the true resistivity (Rt) should be used. The technique is called Rt minimum(Rt min) and is calculated by the following formula:

$$R_{t\min} = R_i * \frac{R_w}{R_{mf}} \quad \ldots\ldots\ldots\ldots\ldots 3.4$$

R*i*= resistivity tool measuring in the invaded zone

R*mf* = resistivity of mud filtrate, (*Rmf*) = 0.65 ohm-m,(Schlumberger, 1979*)*.

When a porous, permeable, water-bearing formation is invaded by drilling fluid, formation water is displaced by mud filtrate. Porosity in a water-bearing formation can be related to shallow resistivity (*Rxo*) by the following equations:

$$S_{xo} = \left(\frac{a * R_{mf}}{R_{xo} * \Phi^m} \right)^{\frac{1}{n}} \quad \ldots\ldots\ldots\ldots\ldots\ldots 3.5$$

Sxo= water saturation in the flushed zone

Rxo= flushed-zone resistivity

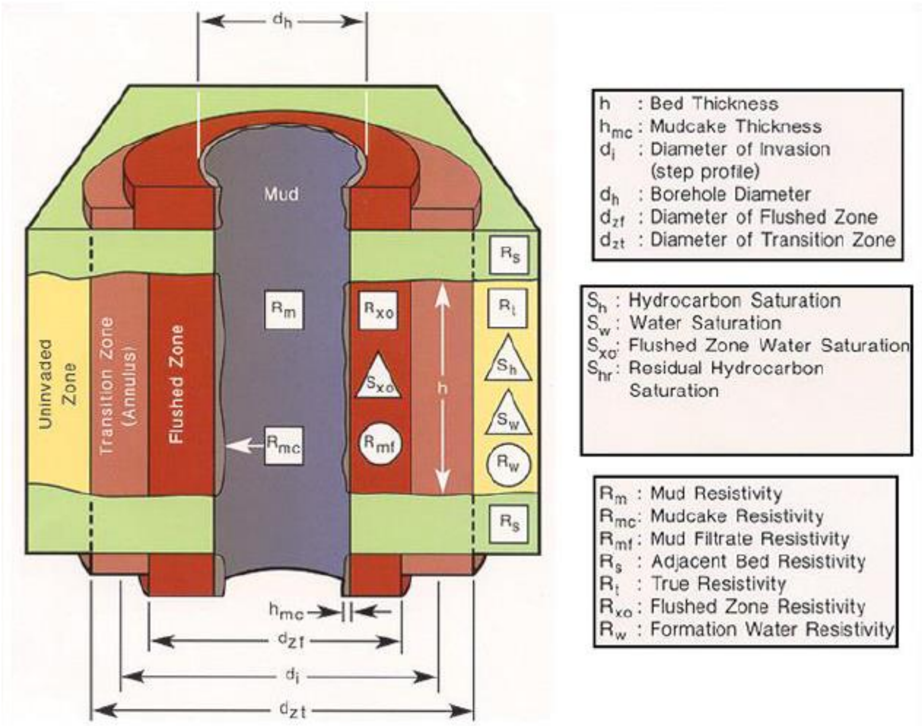


Figure (3.1) the zones around borehole due to mud invasion (Schlumberger, Log Interpretation Charts, 1988).

3.4Ratio Method

The ratio method identifies hydrocarbons from the difference between water saturations in the flushed zone (S_{xo}) and the uninvaded zone (S_w). When the uninvaded zone form of Archie's equation (2.15) is divided by the flushed zone form (2.17), the following results occur:

$$\frac{R_w}{R_{xo}} = \left(\frac{R_{xo}/R_t}{R_{mf}/R_w} \right)^{0.5}$$ **……………….3.6**

Where
Sw/Sxo= moveable hydrocarbon index

If the ratio *Sw*/*Sxo*is equal to or greater than 1.0, then hydrocarbons were not moved during invasion. This is true regardless of whether or not a formation contains hydrocarbons. Whenever the ratio *Sw*/*Sxo*is less than 0.7 for sandstones or less than 0.6 for carbonates, moveable hydrocarbons are indicated (Schlumberger, 1972).

To determine water saturation by the ratio method (Swr), you must know the flushed zone's water saturation. In the flushed zone of formations with moderate invasion and average residual hydrocarbon saturation, the following relationship normally works well:

$$S_{xo} = (S_w)^{\frac{1}{5}} \qquad \text{........................ } 3.7$$

Substituting Equation -a in Equation –b and solving for Sw, the ratio method water saturation (Swr) is:-

$$S_w = \left(\frac{R_i / R_t}{R_{mf} / R_w} \right)^{0.625} \qquad \text{..................... } 3.8$$

The water saturation of the uninvaded zone should be calculated by both the Archie equation (Swa) and the ratio method (Swr). The following observations can be made (Asquith and Krygowski, 2004):-

1. If Swa~ Swr, the assumption of a step-contact invasion profile is indicated to be correct, and all values determined (Sw, Rt, Rxo, and di) are correct.

2. If Swa>Swr, then the value for Rxo/Rtis too low. Rxois too low because invasion is very shallow, or Rtis too high because invasion is very deep. Also, a transition-type invasion profile might be indicated and Swais considered a good value for the zone's actual water saturation.

3 If Swa<Swr, then the value for Rxo/Rtis too high. Rxo is too high because of the effect of adjacent, high-resistivity beds, or Restimated from the deep resistivity measurement is too low because Rxo is less than Rt. Also, an annulus-type invasion profile might be indicated and/or Sxo<Sw 1/5 (from Equation 7.5). In this case, a more accurate value for water saturation can be estimated using the following equation (Schlumberger, 1977 in Asquith and Krygowski, 2004):

$$(S_w)_{cor} = S_{wa} * \left(\frac{S_{wa}}{S_r}\right)^{0.25}$$ …………………… 3.9

4. If Swa<Swr, the reservoir might be a carbonate with moldic (i.e., oomoldic, fossil-moldic, etc.) porosity and low permeability.

3.4Evaluation of reservoir characterization

In this part of study the water saturation (hydrocarbon saturation) of the Nahr Umr will be discussed with the changes in the secondary and effective porosities and permeability, according to original divisions for this sequence within the studied boreholes.

3.5 HydroCarbone saturation:

According to resistivity and porosity feature the hydrocarbon saturation was calculated for all studied wells.

The hydrocarbon saturation is calculated from the resistivity and porosity feature in all studied area. According to the type of reservoir rocks there are two important types reservoir, the thickness of these zone . This zone is representing the unimportant parts of the studied Oil wells. It is characterized by high total porosity with no hydrocarbons, due to the high shale content, lacking of hydrocarbon, and with closed pores of moderately shallow resistivity. This zone is representing the deltaic environment of the Nahr Umr Formation, characterized by the cementation as a digenesis process (Fig.3.2).

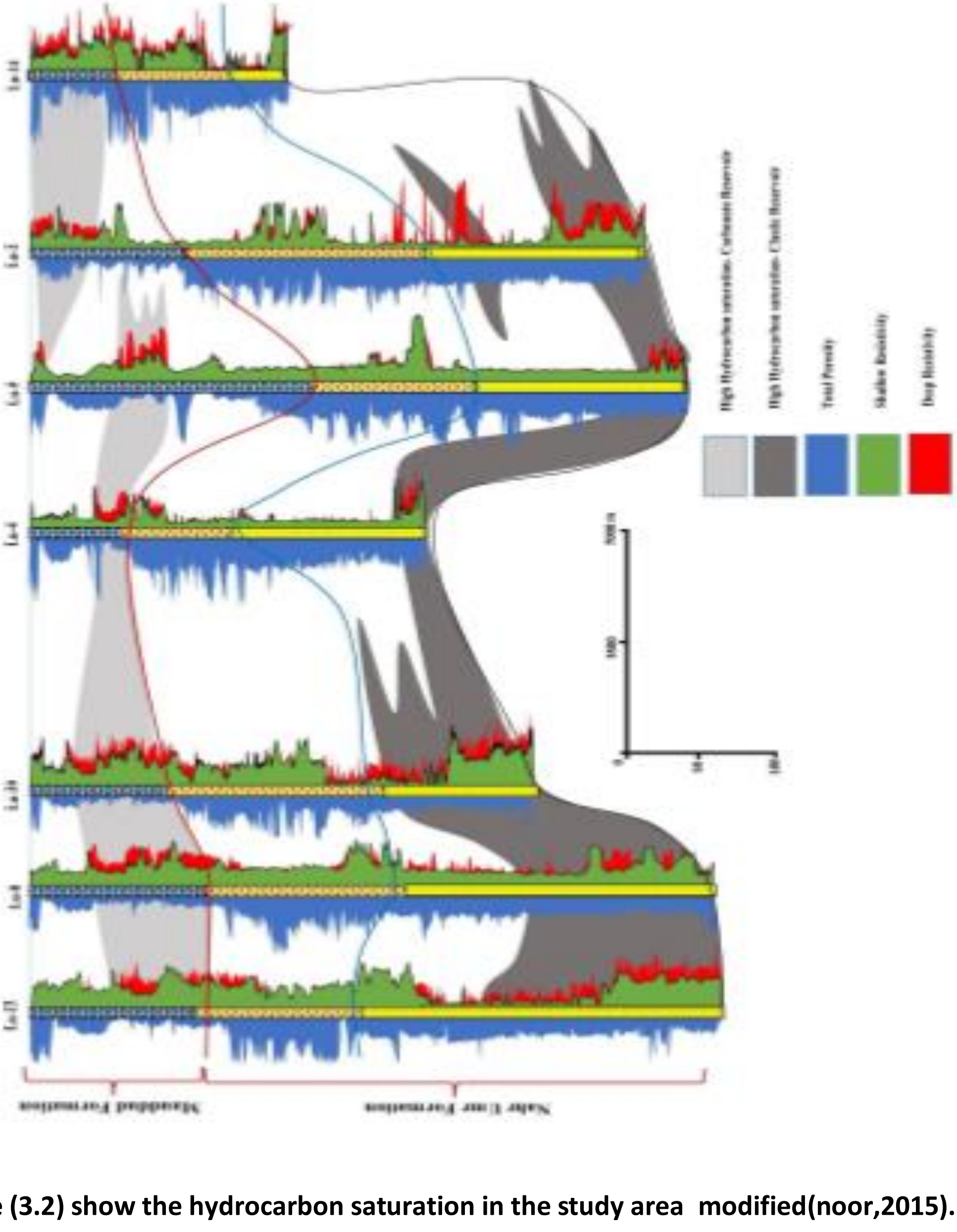


Figure (3.2) show the hydrocarbon saturation in the study area modified(noor,2015).

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الخلاصه:-

يعد تكوين نهر عمر أحد أهم تكوينات العصر الطباشيري وأحد الخزانات الرئيسية المهمة في جنوب العراق. حيث يمثل هذا التكوين ترسبات الحجر الرملي والصخر الزيتي في البلاد.

تقع منطقة الدراسة في حقول الزبير النفطي جنوب وشمال الرميلة جنوب العراق.

تقع المنطقة المدروسة في منطقة بلاد ما بين النهرين في أقصى الجنوب ضمن

منطقة الزبير الفرعية وقد تم اختيارها في جميع الحقول لتوفير معلومات واسعة النطاق عن تكوين نهر عمر.

ان تقييم الخواص المكمنيه لتكوين نهر عمر تم مناقشتة من خلال تغييرات المسامية وبالاعتماد على المقاومه والمسامية فان الاشباع النفطي تم حسابه وتم تحديد نوعه وهو(صخور ذات مسامية قليلة الى عديمة المسامية).

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للطالب

مصطفى هاشم خشان جلود

بكلوريوس علوم الأرض التطبيقي

للعام الدراسي ٢٠٢٣-٢٠٢٤

بإشراف

الاستاذه مها رزاق

١٤٤٥هجري. ٢٠٢٤ميلاد