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Oil initial in Place (OIIP) Determination Using the Volumetric Method of the Wells F1, F2, NC74- in Sirt Basin

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Abstract
Oil and gas industry is full with many challenges for a wide range of operating jobs, one of these challenges throughout the early life of the oil and/or gas field is to determine the petrophysical properties of the production zone and predict of many million barrels of hydrocarbons are there. The aim of this study is to determine the original oil in place (OOIP) using well logging methods to determine the petrophysical properties of the potential production zone for two wells in Beda oil field. Through calculating the petrophysical properties of wells F1 and F1 (NC74)-F2, it was found that the average porosity was 27.76%, while the clay content was low and did not affect the porosity or permeability, ranging between 10 and 20%. The oil saturation rate was 77.60%, which is a good and economical rate. The oil reserves of the two wells (oil reservoir) present in the reservoir amount to 285MM STB.

الملخص
تواجه عمليات انتاج النفط او الغاز تحديات عديدة في مختلف مجالات التشغيل، ومن هذه التحديات تحديد الخصائص البتروفيزيائية لمنطقة الإنتاج والتنبؤ بوجود احتياطي اقتصادي من الهيدروكربونات (نفط او غاز) فيها خلال المراحل المبكرة من عمر حقل النفط و/أو الغاز، حيث يتأثر المكمن النفطي بعدة متغيرات قد تؤدي الى انخفاض في الإنتاج وبالتالي لابد من اجراء العديد من القياسات.
تهدف هذه الدراسة إلى تحديد النفط الاحتياطي الذي من الممكن استخراجه بالطرق التقليدية في المكمن النفطي (OOIP) باستخدام أساليب تسجيل الآبار لتحديد الخصائص البتروفيزيائية لمنطقة الإنتاج المحتملة لبئرين في حقل البيضاء النفطي.
من خلال حساب الخصائص البتروفيزيائية للبئرين F1 و F2 - (NC74) تبين أن متوسط المسامية 27.76%، بينما كانت نسبة الطين قليلة لا تؤثر على المسامية ولا النفاذية وهي تتراوح ما بين 10 الى 20%, اما نسبة التشبع النفطي 77.60% وهي نسبة جيدة واقتصادية، اما الاحتياطي النفطي للبئرين (المكمن النفطي) الموجودة في المكمن تساوي 285 مليون برميل عياري.

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Introduction
Al-Beda field follows a group of oil fields: Al-Dur field, Al-Mansour field, Balaun field, Umm Al-Froud field, Al-Kalqa. The current production from the Al-Bayda fields is about 11 thousand barrels per day, and the production from the Al-Bayda fields is pumped through a 24-inch diameter line, then a 30-inch diameter line belonging to FEPA to the port of Ras Lanuf. The remaining reserve is 34% of the total reserve recoverable by conventional means. total reserve recoverable by conventional means.

There are many methods to calculate the amount of the hydrocarbon in the reservoir, one of them is the volumetric methods which based on geological data such as: porosity, permeability, oil saturation, net pay thickness and the area of the reservoir.
In this case steady the analysis of results from well logging has been used in calculation of OOIP, but first we have to calculate the basic reservoir characteristics (Asquith and Gibson, 1982).

1.1 Problem statement

The problem statement in this study is how to determine the petrophysical properties of an oil reservoir. Oil reservoirs undergo several changes resulting from overproduction, the most important of which are porosity, permeability, and an increased water-to-oil ratio. Therefore, it is necessary to calculate oil reserves at different intervals to identify the factors that lead to decreased production.

1.2 Purpose of Study

The purposes of this work are:

- To evaluate reservoir characteristic in two wells at Beda field through the fallowing: calculate volume shale (Vsh), reservoir porosity, Fluid type content, net pay thickness, find oil water contact, hydrocarbon reserves and re-study the core in terms of porosity and permeability.
- Estimation of reservoir original OOIP.

1.3 Methodology

Well logging data is used to evaluate the reservoir characteristics based on available data a variety of well logs and equations are used to get results as it will represent in the following chapters.

1.4 Method of Study

By using manual calculations using well logging equations and excel sheet we can get the results about the reservoir.

1.5 Location of Study Area

The study area of the block NC74 is located in the southwestern part of the Sirt Basin Between Lat 27˚ 48' and 28˚ 5' and between Long 18˚ 30'and 19˚ 20'in the northeastern Al Haruj Al Aswad (Asquith and Gibson, 1982), figure1.

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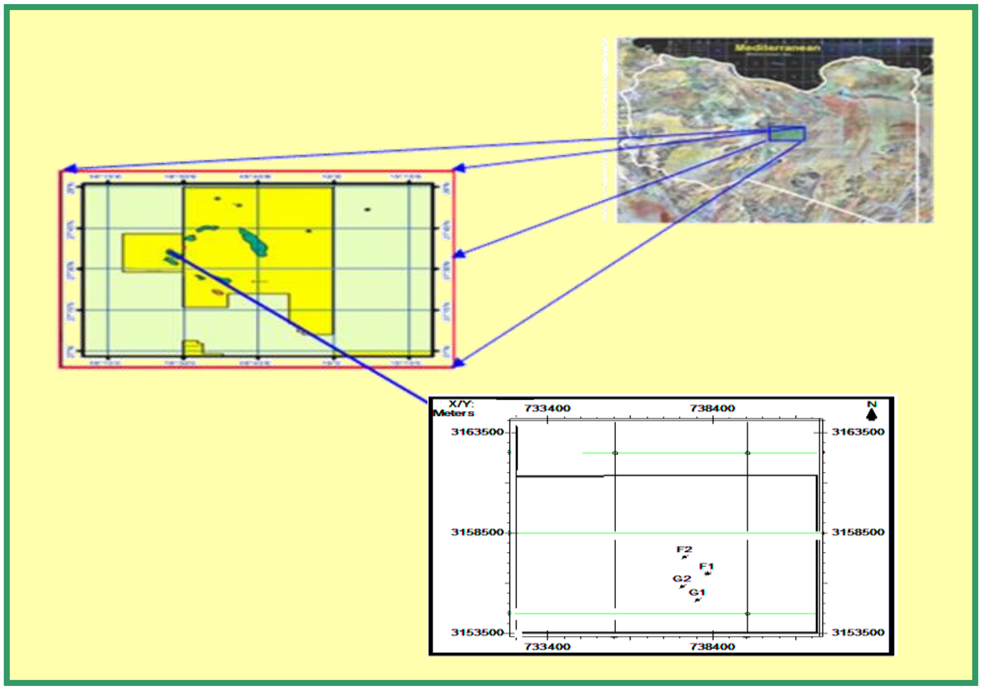

Figure (1): location map of case study (AL-Waha Company 2021)

1.6 Oil Initial in Place

Oil initially in place (OIIP) is the amount of crude oil first estimated to be in a reservoir. Oil initially in place differs from oil reserves, as OIIP refers to the total amount of oil that is potentially in a reservoir and not the amount of oil that can be recovered. Calculating OIIP requires engineers to determine how porous the rock surrounding the oil is, how high-water saturation might be and the net rock volume of the reservoir. The numbers for the aforementioned factors are established by conducting a series of test drills around the reservoir (Bigelow 1992).

1.6 Understanding Oil Initially in Place (OIIP)

Oil initially in place is known more simply as oil in place (OIP). It is also referred to by a few variations. Stock tank oil initially in place (STOIIP) is the same volumetric calculation with it being made explicit that the volume being estimated is the volume filled by the extracted oil at surface temperature and pressure rather than the compressed volume the crude oil fills in the reservoir due to geological pressure. Original gas in place (OGIP) is again the same volumetric calculation but for natural gas reservoirs. Finally, hydrocarbons initially in place (HCIIP) is the generic term that can be used for both oil and gas when doing a volumetric calculation to estimate the contents of a potential drill site (Bigelow 1992).

1.7 The Importance of Oil Initially in Place (OIIP)

Determining oil initially in place is one of the major components taken into account by analysts determining the economics of oil field development. Oil initially in place hints at the potential of a reservoir. This is a critical data point, but it is only the start of the analysis prior to the decision to drill or sit on a lease. Oil in initially in place gives an oil company an estimate of the total number of barrels sitting under the various leases. If all the oil initially in place was recoverable, then oil companies would just need to start at their biggest reservoir and work their way down to the smallest, trying to keep drilling costs fixed along the way. In reality, only a portion of the oil initially in place will ever be recovered and characteristics of the formation will impact drilling costs.

So, analyzing oil initially in place is the trigger for further analysis of how much of the OIIP is recoverable with the current technology. The estimated recoverable oil for a reservoir will allow the oil company holding the lease to decide if current prices support drilling and production. For example, if an oil company can only be able to extract 50% of the oil initially in place with current technology, it may make sense to move those acres into its probable reserves and hold them for future development. The company can then use the money saved by not drilling that reservoir to tap a different one with better overall production for the cost of drilling. If, however, global oil prices climb, then the reservoir may be put into production simply because the new price makes the cost of getting that 50% out of the ground economical. For this reason, oil companies are constantly re-evaluating their lease holding and the oil initially in place against global prices to make decisions on where and when to drill (Bigelow 1992).

1.9 Volumetric Method

Oil in place (OIP) (not to be confused with original oil-in-place (OOIP)) is a specialist term in petroleum geology that refers to the total oil content of an oil reservoir. As this quantity cannot be measured directly, it has to be estimated from other parameters measured prior to drilling or after production has begun.
Prior to oil production from a new reservoir, volumetric methods are used to estimate oil-in-place. A series of test drills are used to map the rock conditions at and around the drilling site and to estimate the size of the oil-bearing rock field. The oil in place is calculated as the product of the volume of porous oil-bearing rock, the porosity of the rock, and its saturation.[1] Correction factors have to be applied for the difference between the volume of the same mass of oil in the reservoir to its volume when brought to the surface, which is caused by the different physical conditions (temperature, pressure) there (Helander 1983).

1.10 Sirte Basin

The Sirte Basin, or embayment, is the youngest of the Libyan basins. It has the largest petroleum reserves in Libya and is ranked 13th among the world's petroleum basins. The basin's recoverable reserves are about 45 billion barrels of oil and 33 trillion cubic feet of gas. Generally, the origin of the Sirt Basin is attributed to the collapse of the Sirt Arch during latest Jurassic to Early Cretaceous times. (Massa and Delort 1984) reported that the Sirt Basin was a permanent high from the Middle Paleozoic until the Early Mesozoic. In the Early Paleozoic the basin was the site of siliciclastic deposition, and clastics accumulated all over North Africa. In the Cretaceous and Tertiary, large quantities of organic-rich shales and other terrigenous clastic materials accumulated in the basinal area.

The Sirt Basin contains some sixteen giant oil fields with about 117 Billion barrels of proven oil in place recoverable reserves. The two principal source rocks in the Sirt Province are the Upper Cretaceous Rachmat Shale and Sirt Shale, as figure (2). Hydrocarbon distribution of the Sirt Basin has been controlled by the major tectonic elements. This is particularly true of reservoirs related to Cretaceous and Eocene to Miocene rift structures. These reservoirs in Sirt Basin are composed of 58% of clastic, mostly is of Mesozoic age and 42% of Carbonate rocks mostly of Tertiary age (Schlumberger 1982).

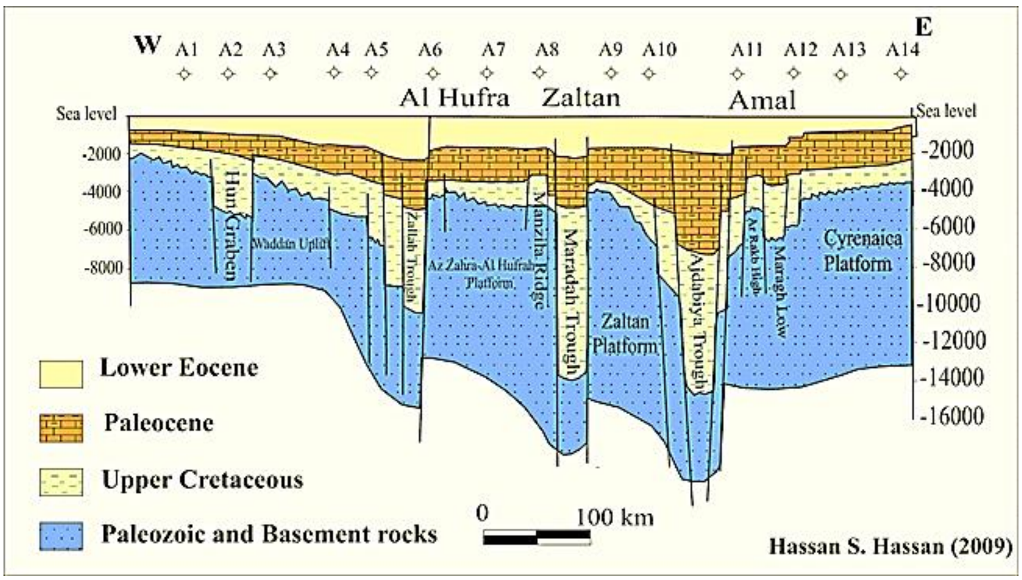

Figure (2) Geological Stratigraphy of the Sirt Basin (Hassan. S.2009)

This is a E-W structural x-section across in Sirt Basin with a NW-trending elongated rift structure that forms the Sirt Basin. As you see it is an asymmetric basin fill of sediments that accumulated during the Mesozoic and Cenozoic. Sediments deepen to the east toward the Ajdabiya Trough which probably represents the basin depocenter. The structural framework varies in the basin, with two principal directions: The Late Jurassic to Early Cretaceous Nubian rift phase E-W structural trend, in the southeast sector; and, the dominant NW-SE fault trends, representing the main rift phase, which was initiated during Late Albian - Cenomanian and these continued during the Upper Cretaceous which resulted in the formation of a series of horst and graben structures trending northwest-southeast. These are characterized by five major troughs (paleograbens): Hun, Zallah, Maradah, Ajdabiya, and Hameimat troughs. These paleograbens are separated by four major platforms (paleohorsts), namely the Waddan, Zahrah-Bayda, Zaltan, and Amal-Jalu, (figure3).

There are three main Upper Cretaceous source rocks in the Sirt Basin of Libya and they sourced the largest hydrocarbon reserves of the country. The source rock Group consists of the Rachmat shale, which is a marine dark shale varying it thickness from 1,200 feet thick across the basin, 2,000 feet thick in the troughs, and only 500 feet thick on some regional highs; the Sirt shale, which is a carbonaceous calcareous shale, ranges from 700 to 1,000 feet thick in the troughs and thinner over most of the highs; and the Etel Formation, which is a widespread, argillaceous, planktonic–rich micrite to calcareous limestone, generally 1 to 500 feet thick (Schlumberger 1982).

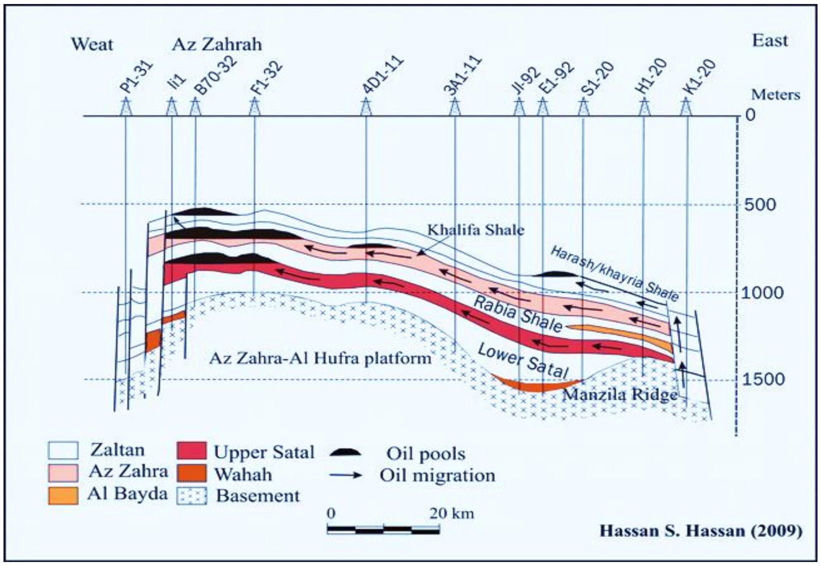

Figure (3) East-West Cross Section in Central Sirt Basin Showing the Oil. Migration Through Faults from Eastern Maradah Trough to Paleocene Carbonate Rocks on Az Zahrah - Al Hufrah Platform. Source: (Roohi, 1996; Hallett, 2002)

Figure (4) shows the stratigraphic column of the Sirte Basin reveals the characteristics of its constituent rocks, the reservoir units in the oil fields, their age, formations, lithological characteristics, major oil fields, and the tectonic events they have experienced.

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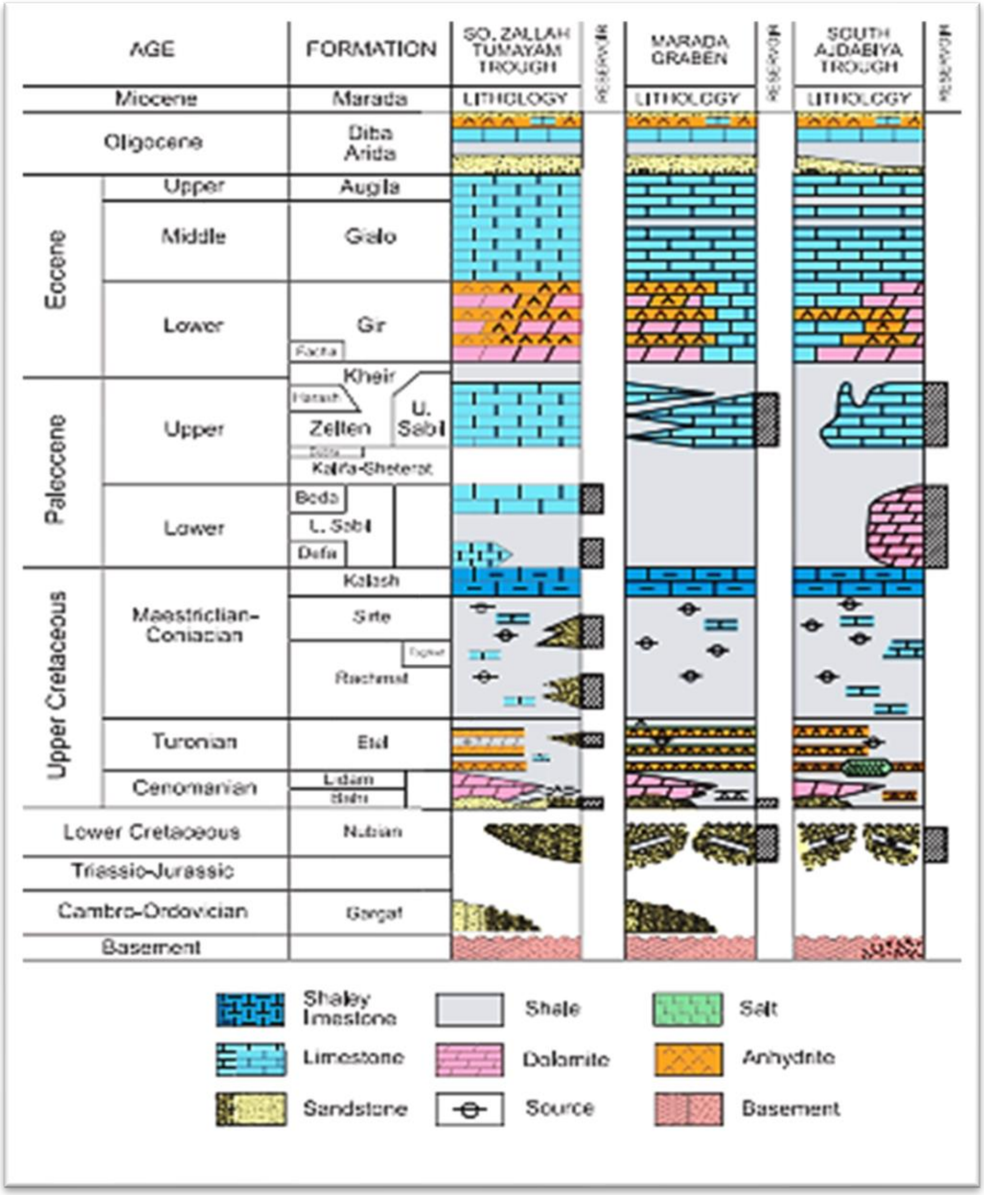
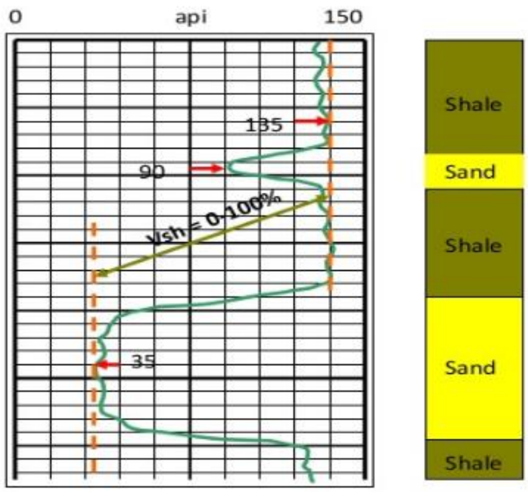


Figure 4: Generalized Stratigraphic Correlation Chart of the Sirt Basin (Hassan. S 2009)

1.11 Well Logging

1- Volume of shale



$$Vsh = \frac{GR_{log} - GR_{min}}{GR_{max} - GR_{min}}$$

Figure (5): Volume of shale device (Schlumberger. 2012)

2- Sonic porosity log

$$\Phi_s = \frac{\Delta t_{log} - \Delta t_{ma}}{\Delta t_f - \Delta t_{ma}}$$

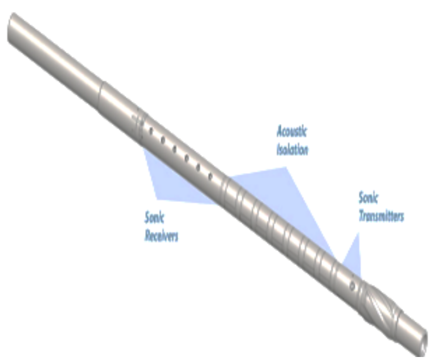


Figure (6): Sonic porosity device (Schlumberger. 2012))

3- Density porosity log

$$\Phi_d = \frac{\rho b_{log} - \rho b_{ma}}{\rho b_f - \rho b_{ma}}$$

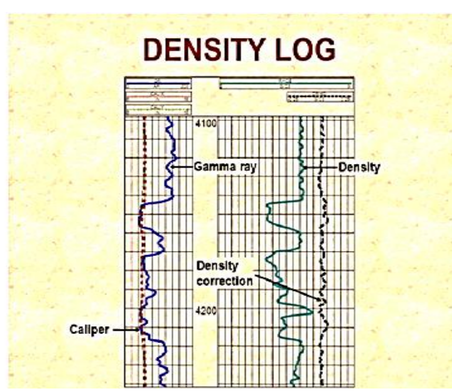


Figure (7): Density porosity chart (Schlumberger. 2012))

4- Neutron porosity log

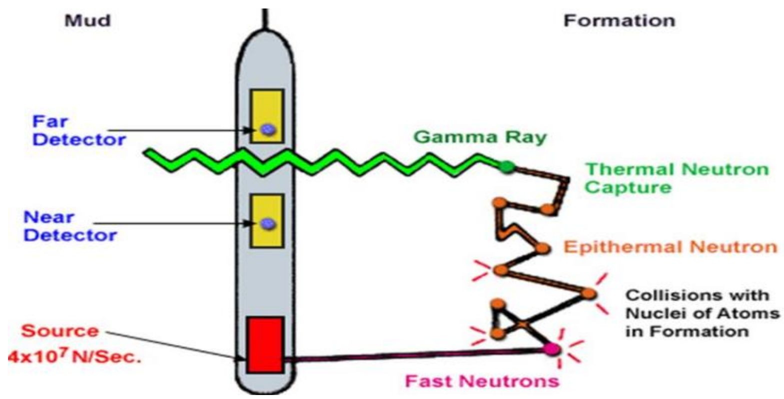
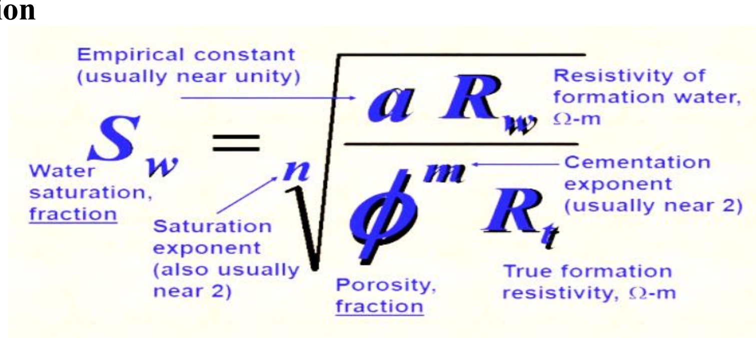


Figure (8): Neutron porosity device (Schlumberger. 2012))

5- Arche's Equation



1.12 Results and discussion

For this study 2 wells have been considered for the estimation of OOIP value and their available data are associated below:

Table (1) The Available Data of two Wells in Beda Oil Field

No	Wells parametric	ρb_{ma}	ρb_f	Δt_{ma}	Δt_f	GR_{max}	GR_{min}	Rw
Well F1	Well A	2.70	1.1	47	189	132.47	69.37	0.02
Well F2	Well B	2.70	1.1	47	189	72.47	16.97	0.02

1.13 Interpretation of Well Logging Data

1- Average Results petrophysical of wells

Table (2) average parameters for well F1

parameter	value
V_{sh}%	27.64613
Φavg%	30
Sw avg%	5.55691
So avg%	94.4431

Table (3) Results of Determined Parameters for Well F2

parameter	value
V_{sh}%	46.1
Φavg%	25.52
Sw avg%	39.24
So avg%	60.76

1.14 Calculations of Oil Initially in Place

From the given data forward, we can determine the value of OIIP:

$$OIIP = \frac{7758 * A * h * \Phi * So}{\beta o}$$

Whereas:
A = area of the reservoir (acre).
H = net pay thickness (ft).
∅ = porosity (fraction).
So = initial oil saturation (fraction).
Boi = oil formation volume factor (bbl/STB).

Table (4) Parameters Used for The Calculation of the OOIP Value

Average Parameters for wells F1 and F2	
Φ avg %	27.76
Swi Avg %	22.39
So %	77.60
Boi (bbl/STB)	1.3
A(ACRE)	2750
h(FT)	100

$$OIIP = 7758 * A * h * \Phi * So$$

$$OIIP = 7758 * 2750 * 100 * 0.2776 * 0.7760$$ **= 370.5 MMbb**

$$OIIP = \frac{7758 * A * h * \Phi * So}{\beta o}$$

$$OIIP = \frac{7758 * 2750 * 100 * 0.2776 * 0.7760}{1.3}$$ **= 285MM STB**

Conclusion

1. The basin considered one of the high petroliferous attractive areas in Libya.
2. The logs give clear indication on types of petrophysical properties of formation.
3. The main objective of this study is the petrophysical parameters, petrophysical properties and oil in place of Beda Formation (Beda-Field) using well logs, the main observations are:
  - The volume of shale notes the presence wide range of shale rates between 10-20%, this due to the change of water level.

- The porosity is wobbling between 5-30%, this range reflect the change of lithology and genesis of reservoir rocks.
- The water saturation equal 22.39%, while the oil saturation equal 77.60 of Beda field.
- Approximately oil initial in place 285MM STB.

Recommendation

- The well logs consider an important tool to evaluate the reservoir by: analyze the petrophysical properties to predict the reservoir quality and break down the reservoir into zones.
- To use the well logs on Beda reservoir might be good tool in other areas also to predict the Deposition Environment.
- Recommend to use Schlumberger formula to calculation the water saturation at correction (shaly sand), where in this case, it gives good results.
- Recommend to use volumetric method for oil calculation, it gives good results.

Conflict of Interest Statement

The authors declare no potential conflicts of interest

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Appendix

Keywords
ρb_{log} = Bulk density of formation
ρb_f = Bulk density of fluid
ρb_{ma} = Bulk density of matrix
Δt_{log} = Interval travel time of formation
Δt_f = Interval travel time of fluid
Δt_{ma} = Interval travel time of matrix
Φ_n = Neutron porosity log
Φ_s =Sonic porosity log
Φ_d = Density porosity log
S_w = Water saturation
S_o = Oil saturation
F= Formation factor
Rt = True resistivity
Rw = Water resistivity of formation
β_o = Oil formation volume factor
H= thickness
A = area
Vsh = Volume of shale
OIIP = Oil initial in place
STOIIP = Stock tank oil initially in
OGIP = Original gas in place