

Petrophysical Properties and Sedimentology of the Palani Formation (Late Eocene-Early Oligocene) from Kirkuk Oil Field, Northeastern Iraq

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Abstract

The Oligocene sequences in northeastern Iraq encompass nine formations collectively referred to as the Kirkuk Group. This study emphasizes the Palani Formation within the Kirkuk oil field, specifically at well (KX16) located in the Baba Dome. The Palani Formation, dating to the late Eocene to early Oligocene, is predominantly composed of limestone and marly limestone. Its thickness measures approximately 29 meters, spanning depths of 768 to 797 meters. Petrophysical analyses, including Gamma Ray (GR), Neutron, and Density Logs, reveal a significant shale content (V-Shale up to 1.0) and variable porosity across zones. The formation is subdivided into four zones based on reservoir potential: Zone A (poor reservoir rocks), Zone B (moderate porosity), Zone C (poor reservoir rocks), and Zone E (good reservoir rocks with high productivity). Mineralogical identification through cross-plots underscores the limestone dominance, which is crucial for reservoir characterization and secondary porosity assessment. Additionally, the Palani Formation features fine-grained sediments and reflects deposition in a low-energy basinal environment. These findings underscore the importance of detailed petrophysical and mineralogical studies in enhancing the understanding of hydrocarbon reservoirs and evaluating their potential productivity in the context of regional geology.

Keywords:

Kirkuk oil field; Palani Formation; limestone; High porosity; Petrophysical analyses

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1. Introduction

The study of Tertiary sequences in Iraq is of great significance, encompassing some of the most crucial oil-bearing strata in Iraq and the Middle East, particularly within the Kirkuk Governorate in northeastern Iraq, specifically in the Kirkuk Oil fields. Over the past four decades, this area has garnered substantial attention, marked by active exploration activities that employ various modern methods and techniques for hydrocarbon exploration (Oil Exploration Company, 2019). A significant portion of these efforts has been undertaken by Iraqi researchers, complemented by the involvement of foreign companies operating in the region. These endeavors have yielded a wealth of critical and essential field data regarding the surface and subsurface geology of the area. The abundance of formations deposited during the

Eocene to Oligocene, along with the various tectonic movements that occurred, further expresses the importance of this era. Moreover, numerous oil reservoirs are situated within the formations of this period, distinguished by their substantial hydrocarbon content (Jassim and Goff, 2006).

The Palani Formation has been described in various subsurface profiles with a single outcrop at Qara Chauq by Bellen (1956). Within the Kirkuk oil field, the formation exists within the Targil Dome at well Kirkuk-85. The Palani Formation comprises dolomitized globigerinal limestone (Jassim and Goff, 2006). Ditmar et al. (1971) proposed a late Eocene age for the formation; others, such as Bellen (1956), Kharajany (2008), Banna (2008), and Al-Jwaini (2015), suggested an early Oligocene age, based on its stratigraphic context between the late Eocene Jaddala Formation and the early Oligocene Sheikh Alas Formation.

The stratified sequence of the Oligocene in the Sinjar region of Northern Iraq was studied by Al Banna et al. (2010), they indicated that the Oligocene sequences are incompatible with the formation of Jaddala with the age of the Eocene, and are compatible and sometimes incompatible with the formations of Anah and Ibrahim (early Miocene) age. Al-Tamimi (2011) studied the stratigraphy and reservoir properties in Oligocene sequences in the Kirkuk region, identified four depositional environments from this sequence, and pointed out that the Palani Formation represents the deep basin environment (basinal environment). Ghafur (2012) conducted a study of the characteristics of sediments and reservoirs of the Kirkuk Group in Northern Iraq (Oligocene – early Miocene). The formations of the Kirkuk Group were studied to determine the lithostratigraphic and biostratigraphic frameworks, in addition to identifying the diagenetic processes, types of carbonate platforms, and the depositional environment. The study stated that the environment of the Palani Formation is deep (basinal), characterized by fine-grained sediments, low-energy conditions, and deposition primarily in a pelagic or hemipelagic setting. Ghafur also highlighted the role of tectonic activity during the Oligocene and early Miocene in shaping the depositional patterns and influencing the distribution of facies within the Kirkuk Group. According to the study of Al-Bayati (2023), the depositional environment of the Palani Formation in central and northern Iraq is represented by an outer slope. Al-Hamdany (2023) conducted a study on the Palani and Sheikh Allas formations in wells K-218 and K-246 within the Kirkuk Oilfield. The study focused on microfacies analysis, petrophysical properties, and reservoir evaluation. The results indicated that the Palani Formation is of Early Oligocene age and was deposited in a deep marine outer shelf environment, whereas the Sheikh Allas Formation was deposited in a reef environment. The study also showed that the Sheikh Allas Formation has higher porosity and permeability than the Palani Formation.

The aim of the current research on the Palani Formation is to achieve the following:

Study the Petrophysical Properties of the formation to determine its significance as a reservoir and its role in preserving hydrocarbons.

Evaluate production potential for oil exploration to assess the production potential of

the Palani Formation by utilizing data analyzed and interpreted through the Petrophysics v3.6 program. This includes calculating porosity and other key properties to classify reservoir zones.

Classify sedimentary patterns: To divide the Palani Formation into areas with varying porosity characteristics based on data analysis results.

2. Location of the Study Area

The study area is situated in the Northeastern part of Kirkuk Governorate, within the Kirkuk oil field. The Kirkuk oil field spans approximately 100 km in length and 4.5 km in width (Figure 1). This research focuses on the Palani Formation, utilizing data from the well KX16, which is positioned in the Baba Dome, a segment of the Kirkuk oil field. The Palani Formation has a thickness of roughly 29 meters, between depths of 768 and 797 meters.



Fig. 1: Map showing the location of the studied well (AL-Tamimi, 2011).

3. Methods and Materials

The current research was conducted on Well KX16 in the Kirkuk oil field, utilizing available logs from the Northern Oil Company to study the petrophysical characteristics. The gamma-ray log was employed for porosity volume calculation, while neutron and density logs were used to calculate the total and effective porosity. These log data were input into a scanner and then converted from their paper or image format to digital data in a lase file format, easily manageable through the Neuralog V 2010.11 computer program. Subsequently, petrophysical properties were studied, involving porosity calculations using the Interactive Petrophysics v3.6 program. Petrophysical analysis was conducted primarily through common mathematical equations and some standard charts (Schlumberger) applied to

log data, following sensor studies (Schlumberger, 1997).

At Kirkuk well KX16, the Palani Formation is about 29 meters thick, spanning depths from 768 to 797 meters (Figure2). It is composed predominantly of gray, robust limestone and marly limestone, occasionally interbedded with very thin bands of marl. It contains foraminifera fossils and assorted bioclastic fragments. The Palani Formation is underlain unconformably by the Jaddala Formation and overlain conformably by the Sheikh Alas Formation (Figure 2).

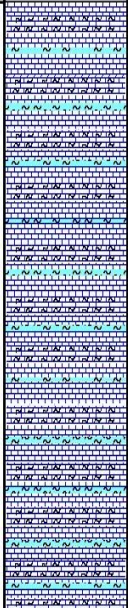
Period	Epoch	Age	Depth(M)	Formation	Lithology	Description
Period	Epoch	Age	DEPTH (M)	Formation	Lithology	Description
Paleogene	Oligocene	Rupelian	770	Palani Formation		Alteration Sequence of hard limestone and marly limestone containing globigerina shells and bioclastic fragments
			780			
			790			

Fig. 2: lithological column of the Palani Formation at well KX16.

4. Geological setting and Stratigraphy

Iraq is divided into three zones: the Mesopotamian Zone, the Foot Hill Zone, and the High Folded Zone. The current research area is situated in the northeastern part of Iraq within the Foot Hill Zone, in the Hamrin-Makhul subzone. This zone is characterized by narrow, asymmetrical, longitudinal anticlines separated by broad synclinal depressions, and it features a thick sedimentary cover (Jassim and Goff, 2006).

The Kirkuk oil field consists of three main domes: the Northern dome (Khurmala), which is gas-bearing; the central dome (Avanah), which contains Eocene strata suitable for oil reservoirs; and the third dome (Baba), which is located within

the study area and contains the Tertiary strata. The area of study lies in the northeastern part of the field within the Kirkuk Governorate and is intersected by the Kirkuk reverse fault (Sayab, 1982).

Due to the significance of the Kirkuk oil field, its stratigraphy has been thoroughly examined (Henson,1950; Bellen,1956; Dunnington,1958). Subsequent studies have been conducted by foreign companies, employees of the North Oil Company, and numerous researchers (such as Al-Hashimi, 1975; Al-Jubouri, 1982; Zaki, 1990).

The Tertiary formations are particularly important from a reservoir perspective, especially the so-called Main Limestone, due to its high permeability and porosity, making it a distinguished field in the Middle East (Dunnington, 1958). The sedimentary sequences of the Tertiary period range from the late Paleocene to the late Miocene. The Tertiary deposits are divided into seven depositional cycles, with the reservoir rocks belonging to the Oligocene cycle, dating back 25-35 million years. The Oligocene deposits in Iraq are characterized by their limited extent and distribution, disappearing in most parts of Iraq but appearing in the Kirkuk area, the Ana area (Tatar, 1988), the Sinjar uplift (Ismail, 2006), and Mount Ashtagh (Kharajiany, 2008). Their thickness is also reduced, and there are some issues regarding the stratigraphy of the boundaries of this cycle, including unclear boundaries due to ambiguous or transitional contacts, evidence of erosion and unconformities complicating depositional continuity, lateral facies variability making correlation across regions challenging, structural deformation disrupting the stratigraphic record, diagenetic overprinting altering the original sedimentary characteristics, biostratigraphic uncertainties due to ambiguous fossil records, and incomplete data sets hindering precise interpretations (Buday, 1980).

The Oligocene sequences comprise nine formations: Shurau, Sheikh Alas, Palani, Bajwan, Baba, Tarjil, Anah, Azkand, and Ibrahim. This group is known as the Kirkuk Group, a term introduced by Henson (1950), which established the foundational stratigraphic framework and reef concepts, dividing them into reefs, fore-reefs, and back-reefs within the Kirkuk oil field.

Bellen (1956) studied the stratigraphy of the so-called Main Limestone in the structures of Kirkuk, Bai Hassan, and Qara Chauq Dagh. He

concluded that the formations comprising this cycle are bounded by unconformities at the top and bottom and suggested the presence of Lower, Middle, and Upper Oligocene beds. Later, Bellen et al. (1959) further divided the Oligocene deposits into nine formations within three sequences, corresponding to the Early, Middle, and Late Oligocene ages (Jassim and Goff, 2006).

However, (Ditmar et al., 1971) and (Bellen, 1956) revised this classification, reducing it to two sequences instead of three, based on lithostratigraphic correlations and well log records.

The stratigraphic sequences of the Tertiary period show a transition from deep basin formations (Ibrahim, Palani, Tarjil) to shallower formations (Sheikh Alas, Baba), followed by even shallower formations (Shurau, Bajwan). This progression leads to restricted lacustrine environments, represented by the Fat'ha Formation, and ultimately to environments with continental deposits, as seen in the Injana and Mukdadiya formations. This study focuses on the examination of the first depositional cycle of the early Oligocene for well KX16, represented by the Palani Formation.

5. Shale Volume Determination

The first step involved employing a Gamma Ray (GR) log to calculate the shale volume (V-Shale) for the Palani Formation, impacting porosity values, water saturation, and hydrocarbon presence. The initial action was extracting the Gamma Ray Index (IGR) using the following equation

$$I_{GR} = \frac{GR_{log} - GR_{min}}{GR_{max} - GR_{min}} \quad \dots\dots\dots (1)$$

Where:

IGR Gamma ray index.

GRLog.....Gamma ray reading of formation.

GRmin..... Maximum gamma ray.

GRmax....(Shale) Maximum gamma ray Shale.

This facilitated the calculation of shale volume values in selected cross-sections, enabling their representation with depth and illustrating their vertical distribution within the formation sequences. Figure (3) illustrates the gamma ray values for well KX16, ranging from GR Clean at 17.22 API to GR Clay at 47.95 API. Figure (4) depicts the determined shale volume in the Palani Formation, indicating a maximum V. sh. value of

1.0, signifying high shale content. Figure (5), on the other hand, illustrates the relationship between GR and V. Sh. in the Palani Formation.

The second step involved applying the Larionov equation (1969) for post-Cretaceous sequences, specifically Tertiary rock :

$$V\text{-Shale} = 0.083 * (2^{(3.7 * IGR)} - 1) \quad \dots\dots\dots (2)$$

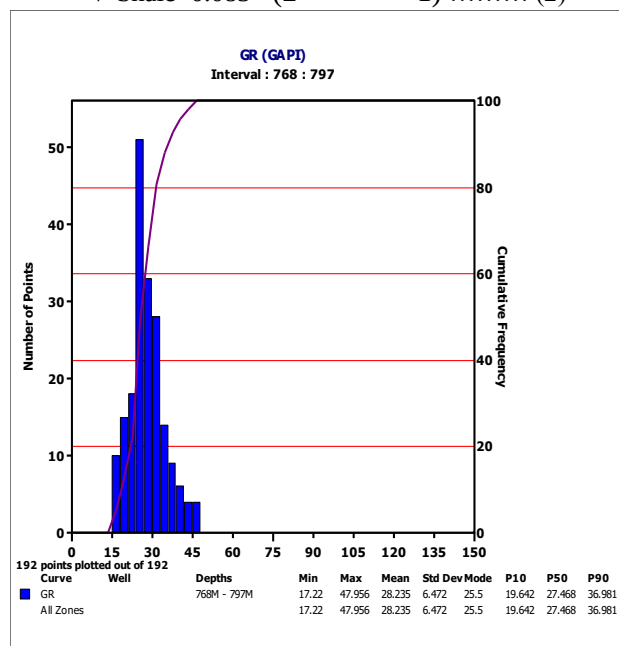


Fig. 3: A histogram illustrates the highest and lowest Gamma Ray (GR) values for well KX16 between the depths 797-768 in the Palani Formation.

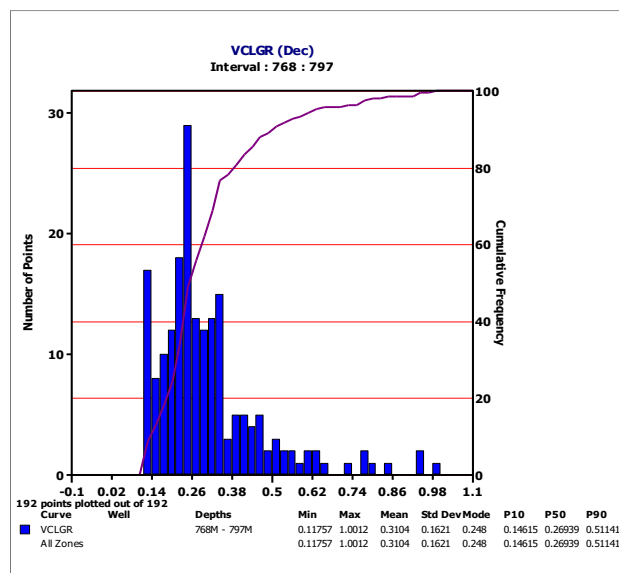


Fig. 4: A histogram illustrates the highest and lowest values for shale volume (V.sh.) in well KX16 between the depths 768-797 in the Palani Formation.

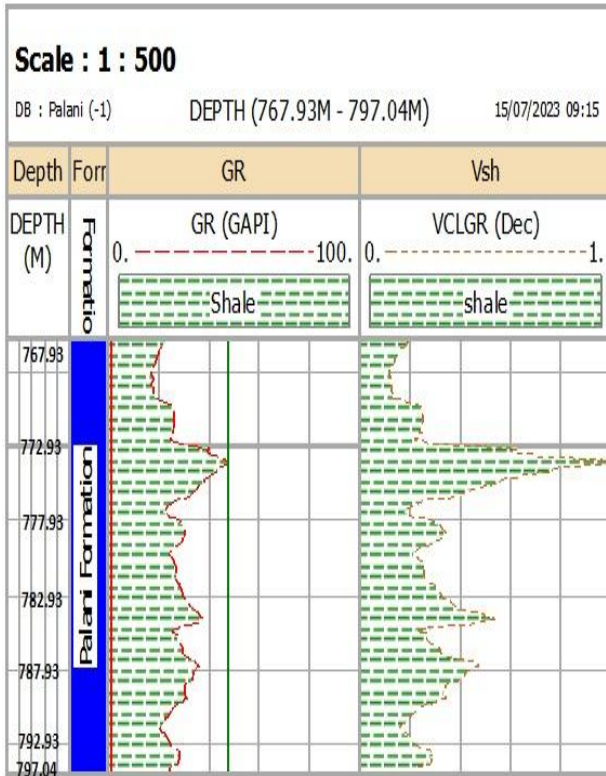


Fig. 5: Illustrates the relationship between Gamma Ray (GR) and shale volume (Vsh) for the Palani Formation in well KX16.

6. Porosity Estimation

Porosity, expressed as the percentage of rock pore volume to its total volume (Figure 6), is estimated using the formula of Schlumberger (1984) and Schlumberger (1997):

$$\text{porosity } \phi (\%) = \frac{V_b - V_{gr}}{V_b} \times 100 = \frac{V_p}{V_b} \times 100$$

Porosity is commonly measured indirectly using well-logging tools such as the Neutron Log and Density Log, combining their results with the equation:

$$\phi_t = \frac{\phi_D + \phi_N}{2} \dots \dots \dots (3)$$

Where:

ϕ_t : total porosity

ϕ_D : porosity from Density Log

ϕ_N : porosity from Neutron Log

This technique indirectly measures rock porosity by logging rock density and utilizing it in the porosity calculation:

$$\phi_p = \frac{(\rho_{ma} - \rho_b)}{(\rho_{ma} - \rho_f)} \dots \dots \dots (4)$$

Where:

ϕ_p : Porosity by density log

ρ_{ma} : Matrix density

ρ_b : Bulk density from log

ρ_f : Fluid density

For Palani Formation limestone, (ρ_{ma}) is calculated as 2.71 gm/cm³, and the fluid density ρ_f for drilling mud (salt mud) is (1.1 gm/cm³).

The neutron log is directly calculated from the tool using Equation ... (3)

Effective Porosity (ϕ_e) representing the connected pore volume to the total rock volume occupied:

by clay or shale, is calculated by:

$$\phi_e = \phi_t (1 - V_{sh}) \dots \dots \dots (4)$$

Secondary Porosity, formed within the reservoir after deposition, such as cavities in carbonate rocks resulting from dissolution or fractures in reservoirs, can be calculated using the Secondary Porosity Index (SPI):

$$SPI = \phi_t - \phi_s \dots \dots \dots (5)$$

Where:

ϕ_t : Total Porosity.

ϕ_s : Porosity from Sonic Log

To calculate Sonic Porosity (ϕ_s) using the Sonic Log, changes in lithology for the studied formations in well K-216 are considered, and the following equation is applied: Wyllie Typical values ($\mu\text{sec/ft}$)

Matrix Δt : 51-55 SS; 47.5 LS; 43.5 DOL

Fluid Δt : 189 (salt water)

$$\phi_s = \Delta t_{log} - \Delta t_{ma} / \Delta t_{fl} - \Delta t_{ma} \dots \dots \dots (6)$$

Where:

Δt_{log} : Sonic log travel time; Δt_{ma} : Matrix travel time

Δt_{fl} : Fluid travel time for the Palani Formation limestone (Δt_{ma} 47.5 $\mu\text{sec/ft}$).

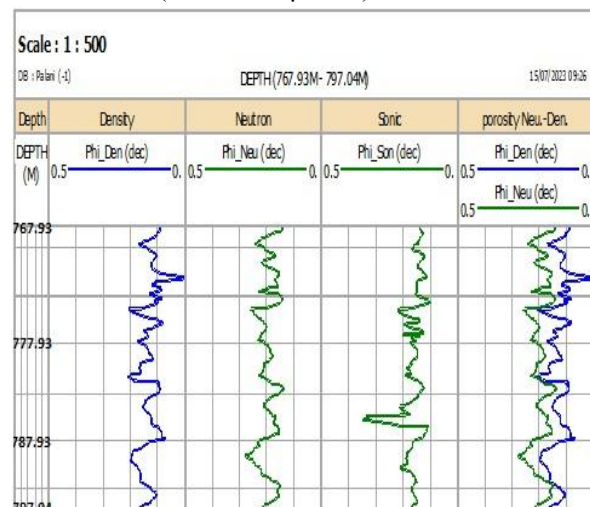


Fig. 6: Relationship between Density – Neutron and Sonic and Porosity in the well KX16.

7. Reservoir Zonation:

Based on the calculated porosity values for the selected formation using indirect methods (well-logging tools) and relying on effective porosity. The Palani Formation is composed of limestone. It has a thickness of approximately 29 meters, ranging between depths of 797 and 768 meters in well KX16. This zone was subdivided into several subzones (Figure 7):

Palani Zone A:

This subzone represents the rock sequences of the Palani Formation, consisting of limestone. It has a thickness of about 8 meters, ranging between depths of 776 and 768 meters in well KX16.

The porosity of the rocks in this zone is described as weak (6-10%), earning them the traditional classification of poor reservoir rocks according to conventional exploration literature.

Palani Zone B:

This zone comprises the rock sequences of the Palani Formation, characterized by limestone. It has a thickness of approximately 7.3 meters, ranging between depths of 783.8-776 meters in well KX16. The porosity of the rocks in this zone is described as ranging from weak to moderate (8-15%). Accordingly, according to traditional exploration literature, these rocks are classified as intermediate reservoir rocks with moderate productivity.

Palani Zone C:

This zone represents the rock sequences of the Palani Formation, consisting of limestone. It has a thickness of around 6.7 meters, ranging between depths of 790-783.8 meters in well KX16. The porosity of the rocks in this zone is characterized as weak (9-10%). Thus, following conventional exploration literature, these rocks are classified as poor reservoir rocks with low productivity.

Palani Zone E:

This zone represents the rock sequences of the Palani Formation, composed of limestone. It has a thickness of approximately 7 meters, ranging between depths of 797-790 meters in well KX16. The porosity of the rocks in this zone is characterized as very good (15-16%). According to traditional exploration literature, these rocks are classified as good reservoir rocks with high productivity.

It is noteworthy that the total porosity values do not show significant differences compared to the accepted effective porosity values in some small units due to shale volume. Zone B is characterized as having moderate productivity, while Zone E is classified as having good productivity. Zones C and A are characterized as having poor productivity due to a high shale volume in these zones.

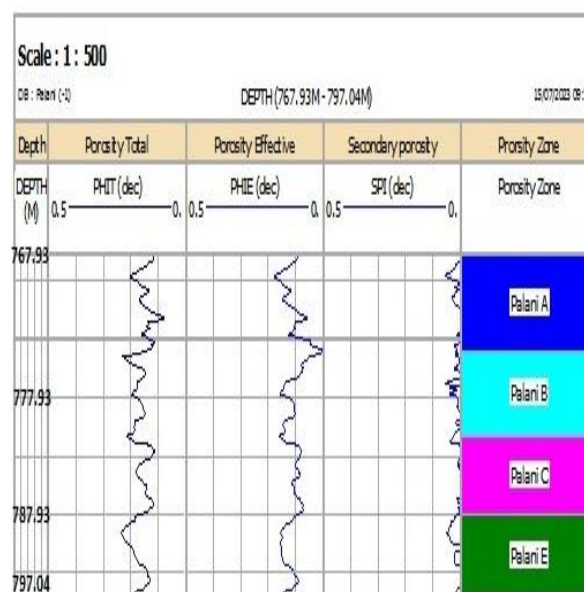


Fig. 7: Reservoir zonation of the Palani Formation depicting total and effective porosity along with secondary porosity in well KX16.

8. Identification of lithology and mineralogy

The identification of the lithology of the formation is crucial for reservoir characterization since the physical and chemical properties of rocks, including the presence of hydrocarbons or water, impact the estimation of formation properties. In the case of the studied Palani Formation, the density, neutron, and sonic logs were utilized for lithology identification.

• Neutron –Density Cross Plot for lithology identification

The Neutron-Density Cross Plot method was employed for lithology identification. This method relies on the intersection of the pb vs Neutron plots (Schlumberger, 1989), primarily representing the cross-plot values of both derived porosity and total density. This allows for obtaining porosity values resulting from their interaction. The plots exhibited

a scattered distribution of values, reflecting variations in the formation's lithology. Figure (8) illustrates that most of the Palani Formation sequences fall within the limestone range based on the points plotted on the cross-plot. Density-neutron and sonic logs.

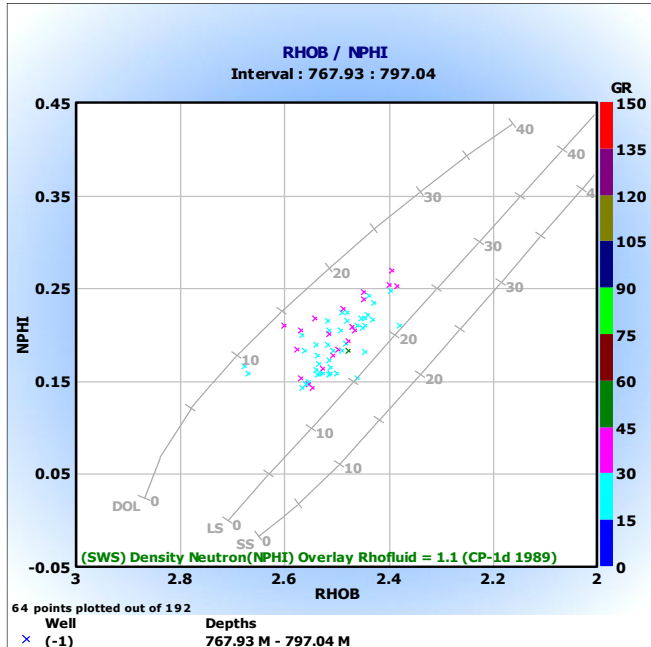


Fig. 8: The Pb vs Neutron cross-plot exhibits a scattered distribution of values, indicating variations in the lithology of the Palani Formation sequences in well KX16.

• M-N Cross Plot for mineral identification

For complex mineralogical identification of lithology, the M-N Cross Plot provides a dual- and triple-mineral mixture chart (Schlumberger, 1997). This chart includes values for individual minerals such as calcite, dolomite, sandstone, gypsum, sulfur, gas, and secondary porosity zones. By plotting M-N values and selecting a cross-section, mineral composition for the chosen formation is determined. It is observed that the formation consists of a mixture of limestone and secondary porosity by intersecting the M-N plot with the Pb vs. ØN porosity cross-plot, as depicted in Figure (9).

$$M = \frac{\Delta t_f - \Delta t_{log}}{\Delta t_{log} - \Delta t_{log}} \dots \dots \dots (7)$$

Where:

Δt log: transit travel time from sonic log μsec/ft.

Δt_f: transit travel time of the formation fluid equal to 189 μsec/ft.

ρ_b: bulk density from density log g/cc.

ρ_f: bulk density of the formation fluid equal to 1.1 g/cc.

Ø_N log: porosity from neutron log.

Ø_{Nf}: porosity for the formation fluid equal to 1.1

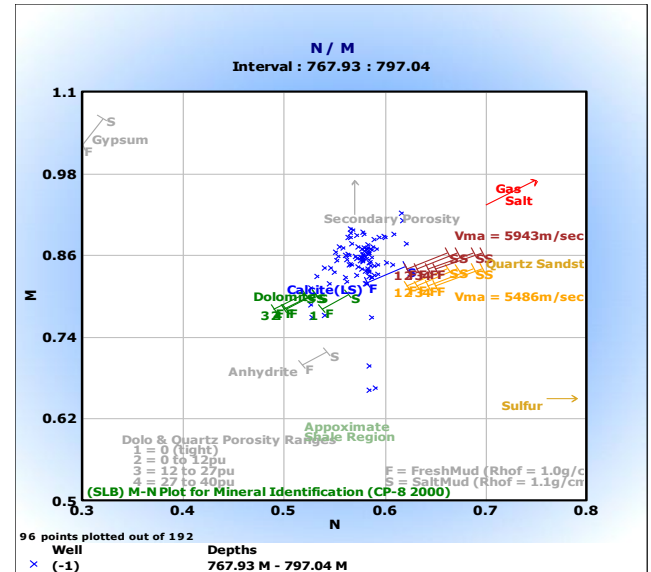


Fig. 9: Mineralogical Identification of the Palani Formation in well KX16.

9. Conclusions

The Palani Formation at well KX16 is situated between the Jaddala Formation (late Eocene) and Sheikh Alas Formation (early Oligocene) and is predominantly composed of limestone and marly limestone. Its thickness is approximately 29 meters, extending from depths of 768 to 797 meters.

Shale volume within the Palani Formation was determined by using a Gamma Ray (GR) sensor and the Larionov equation, revealing significant shale content with V-Shale reaching up to 1.0 in some sections. Porosity, a critical parameter for reservoir characterization, was estimated indirectly using well-logging tools such as the Neutron Log and Density Log. Effective porosity (Ø_e) calculations considered the presence of shale, impacting the reservoir's productivity potential across different zones.

Based on porosity values derived from these methods, the Palani Formation was divided into several subzones within:

-Palani Zone A: Thin, with weak porosity (6-10%), classified as poor reservoir rocks.

-Palani Zone B: Moderate thickness, exhibiting moderate porosity (8-15%), categorized as intermediate reservoir rocks.

-Palani Zone C: Limited thickness with weak porosity (9-10%), also classified as poor reservoir rocks.

-Palani Zone E: Substantial thickness, showcasing very good porosity (15-16%), categorized as good reservoir rocks with high productivity potential.

Mineralogical identification, crucial for understanding the formation's composition and its implications for hydrocarbon exploration, was performed using cross-plots such as the Neutron-Density and M-N plots. These plots indicated a predominant composition of limestone within the Palani Formation, essential for determining reservoir characteristics and potential secondary porosity zones.

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11. Conflict of Interest

The authors declare that they have no conflict of interest.

12. Funding Statement

This research received no external funding.

13. Author Contributions

I, Ezzat I. Al-Fandi, as the first and corresponding author, conducted the main petrophysical analysis and interpretation of the well-log data using Interactive Petrophysics (IP) v3.6. I was responsible for the interpretation and analysis of the petrophysical data, including shale-volume determination, porosity estimation, reservoir zonation, lithological and mineralogical identification, interpretation of cross-plots, and the overall scientific interpretation of the results. I also contributed substantially to the preparation and writing of the manuscript.

Dr. Zaid A. Malak contributed to the preparation and organization of the data and models, data processing, literature research, and revision and editing of the manuscript.

Dr. Rafee Ibrahim Al-Hamidi contributed to the scientific review, proofreading, and final checking of the manuscript.

The authors confirm that these statements accurately represent their respective contributions to the work and that all authors have reviewed and approved the final version of the manuscript.

14. References

- Al-Banna, N.Y., 2008. Stratigraphic Note: Oligocene/Miocene boundary in northern Iraq, Geo Arabia-Manama, 13,187. <http://dx.doi.org/10.2113/geoarabia1302187>
- Al-Banna, N.Y., Al-Mutwali, M.M. and Ismail, N.R., 2010. Oligocene stratigraphy in the Sinjar Basin, northwestern Iraq. Geo Arabia, 15(4), 17-44. <http://dx.doi.org/10.2113/geoarabia150417>
- Al-Bayati, Y.K.J., 2023. Sedimentology and Sequence Stratigraphy of Oligocene Succession in Selected Sites of Iraq, Ph.D. Thesis (unpublished), University of Tikrit, Iraq, 191 P. <http://dx.doi.org/10.33899/earth.2023.139106.1059>
- Al-Hamdany, D.M.I., 2023. Microfacies Analysis and Petrophysical Properties of Palani and Sheikh Allas Formations (Lower Oligocene) in Two Selected Wells of Kirkuk Oilfield, Northeastern Iraq. Unpublished M.Sc. Thesis, College of Science, University of Mosul, Mosul, Iraq, 119 P. (In Arabic)
- Al-Hashimi, M. H. 1975. Geological Investigations of the Kirkuk Oil Field. Journal of Petroleum Geology, 22(2), pp. 189-210.
- Al-Jubouri, J. R. 1982. Stratigraphy and Oil Potential of the Kirkuk Basin. Iraq Geological Society, 11(3), pp. 212-229.
- AL-Jwaini, Y.S.K., 2015. Sequence Stratigraphy and Reservoir Characterization of the Late Paleogene - Early Neogene Succession in Kirkuk Area" Ph. D. Thesis (unpublished), University of Baghdad, Iraq, 230 P.
- AL-Tamimi, A.M., 2011. Stratigraphy and Reservoir Characterization of the Oligocene Succession, Kirkuk Area, M.Sc. Thesis, University of Baghdad. <http://dx.doi.org/10.26842/binhm.7.2022.17.1.0049>
- Bellen, V.R.C., 1956. The stratigraphy of the Main Limestone of the Kirkuk, Bai Hassan and Qara Chauq Dagh structures in Northern Iraq. Journal of the Institute of Petroleum, 42, pp. 233- 263.
- Bellen, V.R.C., Dunnington, H.V., Wetzel, R. and Morton, D.M., 1959. Lexique Stratigraphique International. V. III, Asia, Fascicule, 10a, Iraq, Central National deal Recherche's Scientifique, Paris, 333 P.
- Buday, R.T., 1980. The regional geology of Iraq, 1, stratigraphy and paleogeography, Kassab, I. I. M. Jassim, S.Z. (ed). SOM, Baghdad, 445
- Ditmar, V. Iraq-Soviet Team, 1971. Geology conditions and hydrocarbon prospects of the Republic of Iraq (Northern and Central parts).
- Dunnington, H.V., 1958. Generation, migration, accumulation and dissipation of oil in northern Iraq. In Weeks, G.L. (Ed), Habitat of oil, symposium. American Association of Petroleum Geologists, pp. 1194- 1251.

Ghafur, A.A., 2012. Sedimentology and reservoir characteristics of the Oligocene Miocene carbonates (Kirkuk Group) of Southern Kurdistan, Ph.D. Thesis, 324 P.

<http://dx.doi.org/10.13140/RG.2.2.27521.30565>

Henson, F.R.S., 1950. Cretaceous and Tertiary reef formations and associated sediments in Middle East. American Association of Petroleum Geology Bulletin, 34, pp. 215–238.

Ismail, N.R., 2006. Biostratigraphy and Sequence Stratigraphy of the Oligocene-Early Miocene Formations in the Sinjar Basin, Northwest Iraq. Unpublished Ph.D. Thesis, College of Science, University of Mosul, 222 P.

Jassim, S.J. and Goff, J.C., 2006. Geology of Iraq, published by Dolin, Prague and Moravian Museum, Brno, First Edition, 318 P.

Kharajiany, S.O.A., 2008. Sedimentary facies of Oligocene rock units in Ashdagh mountain-Sangaw District-Kurdistan region, NE Iraq, Unpublished M.Sc. thesis, College of Science, University of Sulaymania, 137 P.

Larionov, V.V., 1969. Borehole Radiometry, Moscow, U.S.S.R., Nedra, 127 P.

Oil Exploration Company (OEC) Y., 2019. B. Study of the structural image of the Tertiary formations in Ismail field, unpublished study.

Schlumberger, 1972. Log Interpretation, Volume I - Principles, Schlumberger Limited, U.S.A., 113.

Schlumberger, 1979. Log Interpretation Charts. Schlumberger Wireline and Testing, Houston, Texas, 193 P.

Schlumberger, 1984. Well Evaluation Conference, India. Schlumberger Limited, 263 P.

Schlumberger, 1989. Interpretation Principles and Applications. Schlumberger Limited, U.S.A.

Schlumberger, 1997. Log Interpretation Charts, Schlumberger Wireline and Testing, Houston, Texas, 195 P.

Siab, A., 1982. Geology of Iraq, Dar Al-Kutub Printing and Publishing House, University of Mosul, 280 P.

Tatar, Y.A., 1988. Subsurface Sedimentary Study of Some Tertiary Formations in the Western Desert Region - Iraq, Unpublished MSc. Thesis, University of Mosul, College of Science, 176 P.

Zaki, K. 1990. Petrophysical Properties of the Kirkuk Field Reservoirs. Iraqi Journal of Earth Sciences, 7(4), pp. 250-263.



الخصائص البتروفيزيائية والرسوبية لتكوين بلاني (الايوسين المتأخر – الأوليجوسين

المبكر) من حقل كركوك النفطي ، شمال شرق العراق

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الملخص

تشمل نتائج الأوليجوسين في شمال شرق العراق تسعة تكوينات تُعرف مجتمعة باسم مجموعة كركوك. ركزت هذه الدراسة على تكوين بلاني ضمن حقل كركوك النفطي، وتحديداً في البئر (KX16) الواقع في قبة بابا. يعود تاريخ تكوين بلاني إلى فترة الأيوسين المتأخر حتى الأوليجوسين المبكر، وهو يتألف بشكل رئيسي من الحجر الجيري والحجر الجيري الصلصالي. يبلغ سمك التكوين حوالي 29 متراً ويمتد بين أعماق 768 إلى 797 متراً. تؤكد التحليلات البتروفيزيائية، باستخدام سجلات أشعة جاما (GR) والنيوترون والكثافة، عن وجود نسبة عالية من الطفل (V-Shale تصل إلى 1.0) ومسامية متفاوتة عبر تتابعات التكوين. تم تقسيم التكوين إلى أربع انطقة بناءً على القدرة المكمنية: نطاق أ (صخور مكمنية فقيرة)، المنطقة ب (مسامية معتدلة)، المنطقة ج (صخور مكمنية فقيرة)، والمنطقة د (صخور مكمنية جيدة ذات إنتاجية عالية). تشير التحاليل المعدنية باستخدام مخططات المتقاطعة هيمنة الحجر الجيري، مما يعد أمراً بالغ الأهمية لتصنيف المكن وتقييم المسامية الثانوية. بالإضافة إلى ذلك، يتميز تكوين بلاني برواسب دقيقة الحبيبات ويعكس بيئة ترسيب حوضية منخفضة الطاقة. تؤكد هذه النتائج أهمية الدراسات البتروفيزيائية والمعدنية المفصلة في تعزيز فهم المكامن الهيدروكربونية وتقييم إمكاناتها الإنتاجية في سياق الجيولوجيا الإقليمية.

الكلمات المفتاحية:

حقل كركوك النفطي، تكوين بلاني، الحجر الجيري، مسامية عالية، تحليلات البتروفيزيائية.

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