

Chemical, Petroleum and Environmental Engineering

Permeability Determination of Tertiary Reservoir/Ajeel Oil Field

Rihab Abbass Deabl*
Ms.C. Student
Petroleum Technology Dept./ University
of Technology
Iraq
rihababbass62@gmail.com

Ahmad A. Ramadhan
Assistant Professor
Petroleum Technology Dept./ University
of Technology
Iraq
150073@uotechnology.edu.iq

AbdulAali A. Aldabaj
Expert
Petroleum Technology Dept./
University of Technology
Iraq

ABSTRACT

This paper discusses the method for determining the permeability values of Tertiary Reservoir in Ajeel field (Jeribe, Dhiban, Euphrates) units and this study is very important to determine the permeability values that it is needed to detect the economic value of oil in Tertiary Formation. This study based on core data from nine wells and log data from twelve wells. The wells are AJ-1, AJ-4, AJ-6, AJ-7, AJ-10, AJ-12, AJ-13, AJ-14, AJ-15, AJ-22, AJ-25, and AJ-54, but we have chosen three wells (AJ4, AJ6, and AJ10) to study in this paper. Three methods are used for this work and this study indicates that one of the best way of obtaining permeability is the Neural network method because the values of permeability obtained being much closer to the values of K-core than the other methods. From this study we obtained many values of permeability for all depths from top to bottom for three wells in Ajeel Field as explained by figures below.

Keywords: Neural network, Gamma Ray Log (GR), Deep Resistivity (LLD), Shallow Resistivity (MSFL) and Formation Density (RHOB).

حساب النفاذية لمكمن العصر الثلاثي / حقل عجيل النفطي

د. عبدالعالي عبدالحسين الدباج
خبير
قسم تكنولوجيا النفط/الجامعة التكنولوجية
العراق

د. احمد عبدالله رمضان
استاذ مساعد
قسم تكنولوجيا النفط/الجامعة التكنولوجية
العراق

رحاب عباس دعبيل
طالب ماجستير
قسم تكنولوجيا النفط/الجامعة التكنولوجية
العراق

الخلاصة

ان من المهم ان نحدد النفاذية لكل الحقول الموجودة في العراق وذلك لانها جدا ضرورية لتحديد جميع الدراسات المتعلقة بحساب كمية النفط والغاز الأصلية. هذه البحث يناقش الطريقة الفعالة لتحديد قيم النفاذية لطبقة التيرشري في حقل عجيل لوحات (جربيبي, ذبان, فرات) وهذه الدراسة جدا مهمة لتحديد افضل قيم النفاذيات التي نحتاجها لتحديد القيمة الاقتصادية للنفط في طبقة التيرشري.

*Corresponding author

Peer review under the responsibility of University of Baghdad.

<https://doi.org/10.31026/j.eng.2020.07.14>

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Article received: 11/7/2019

Article accepted 21/10/2019

Article published:1/7/2020



هذه الدراسة هي طريقه نظريه, تعتمد على بيانات اللباب المقاسه من تسعه ابار وبيانات المجسات من اثنا عشر بئر وهذه الابار هي (عجيل 1 ، عجيل 4 ، عجيل 6 ، عجيل 7 ، عجيل 10 ، عجيل 12 ، عجيل 13 ، عجيل 14 ، عجيل 15، عجيل 22 ، عجيل 25 ، عجيل 54) ولكن تم اختيار ثلاث ابار (عجيل 4 ، عجيل 6 ، عجيل 10) للدراسة في هذا البحث. هناك ثلاث طرق استخدمت لأجل هذه العمل وهذه الدراسة تشير بأنه واحدة من افضل الطرق لحساب النفاذية هي طريقه الشبكة العصبية وذلك لأن قيم النفاذيه التي حصلنا عليها تكون قريه جدا من قيم النفاذية المقاسه من اللباب اكثر من الطرق الأخرى . نتائج الدراسة هو حصولنا على قيم النفاذية لكل الأعماق من قمة البئر الى القعر للابار الثلاثة في حقل عجيل وذلك بوضوح بواسطه الاشكال ادناه.

الكلمات الرئيسية: الشبكة العصبية ، مجس اشعه كاما ، المقاومه العميقة ، المقاومه الضحله ، كثافة الطبقة

1. INTRODUCTION

The evaluation of petrophysical properties such as permeability is very necessary to define the formation evaluation and reservoir quality processes that used in exploration, production and development for reservoir to determine whether a potential oil field is commercially viable (Handhel, 2009).

Ajeel Field was discovered in 1977 with drilling of Aj-1 on the crest of a seismically mapped area. Ajeel oil field is located in the portions of Tikrit and Kirkuk provinces about 30 km North-East of Tikrit city, in Iraq. It mostly extends toward (North-East)-(South-West), and parallel to "Alnikhila" dome in "Hemreen" Oil Field. **Fig. 1** shows Contour Map and Wells Location of Ajeel Oilfield. The Tertiary Reservoir in this field is divided into two reservoirs, the Transition Reservoir (an average depth 3175 ft RTKB) and the main reservoir (an average depth 3415 ft RTKB) (NOC, 2006).

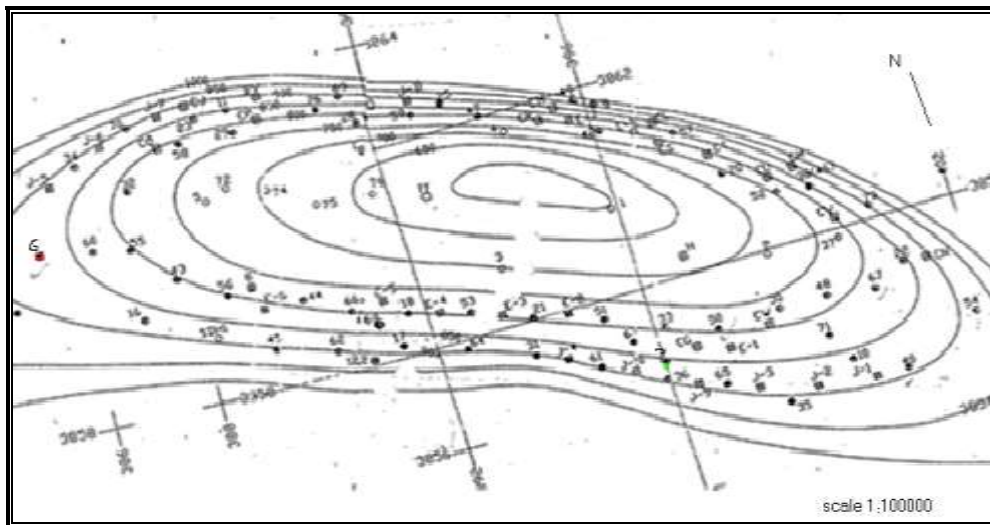


Figure 1. Contour Map and Wells Location of Ajeel Oilfield. (NOC, 2006).

Permeability (K) is one of the necessary and critical petrophysical properties to define the economic value (Rezaee, 2011), measured by Darcies or milliDarcies (Asquith and Gibson, 1982) and controlled by the size of the connected passages between pores. The Permeability is measured parallel to the bedding planes called horizontal permeability and it considered the chief path of the fluid to flow into the well. (Wherrett, 1996). The horizontal permeability is more than vertical permeability, due to the arrangement and composition of the rock grains (Halliburton, 2001) and measured across the bedding planes.



Permeability is determined from core analysis but all wells are not cored and permeability is estimated in uncored sections by porosity versus permeability relationships (Lucia, 2007).

2. METHODS TO DETERMINE PERMEABILITY

The well logs provide detection of the permeability for a zone. Some well logs and their results such as porosity logs can be used to estimate permeability by experimental correlation of log response to core permeability data and the Porosity (Kadhim, et.al. 2019). The evaluation of K from well log is very difficult because the correlation between porosity and permeability may not be very accurate because K is a measure of dynamic properties of the formation (Kumar, et. al., 2000).

Permeability of a reservoir near a well bore depends on fluid flow (invasion), buildup of mud cake, and spread between reservoir fluids and mud filtrate indicating that the mean permeability may vary with time and space (Avedisian, 1988).

The correlation coefficient (R^2), which ranges from (0) to (1), can be used as a criterion to compare between the k-estimated and k-core values. If the value of (R^2) equal to (1) correlation may be perfect in the sample and no difference between the k –estimated and the k–core values (Hamd- Allah, et. al., 2016; Abdul-majeed, et. al, 2020).

2.1 Classical Method

The results of core analysis in the laboratory can be used to calculate the permeability in uncored intervals where coring is usually available in a given wells shown in equation (2):

$$\log (k) = a \phi + b \text{ ----- (2)}$$

k: permeability (md), ϕ : porosity(%). a& b are factors.

The available core data are taken from the first nine wells (core plugs for wells AJ-1, AJ-4, AJ-6, AJ-10, AJ-13, AJ-14, AJ-22, AJ-25, and AJ-54).

The porosity is plotted with the logarithm of liquid permeability for each unit such as in Fig. 2, 3, and 4, for Jeribe, Dhiban and Euphrates respectively. The equation for each unit is then applied to detect the permeability in uncored intervals by using this way. Table 1 represents the equations for each unit. When the porosity is high that means the permeability may be high, but the amount of permeability is not directly proportional to porosity, that cause non-connected pores in the rocks that contributing to K (Kumar, et al., 2000; Hameed, et al., 2019).

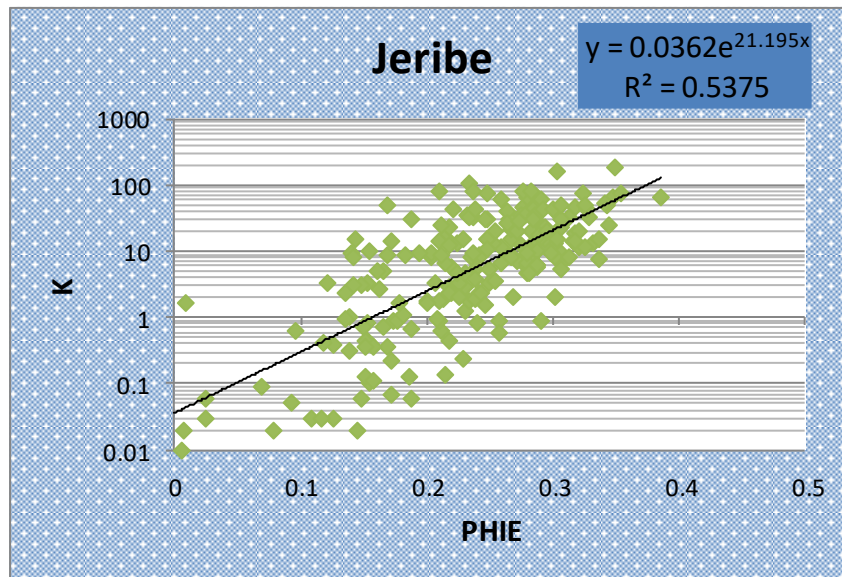


Figure 2. Permeability vs Porosity of Jeribe Unit.

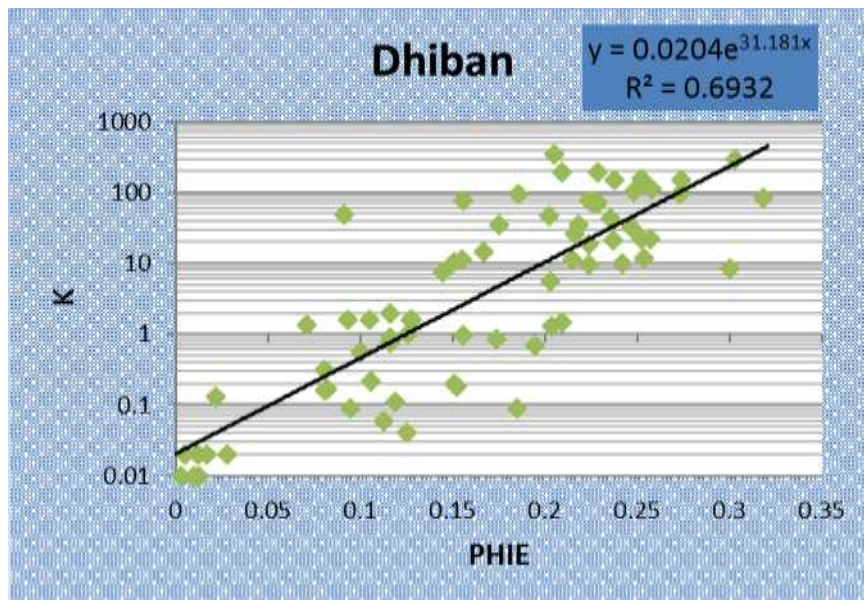


Figure 3. Permeability vs Porosity of Dhiban Unit.

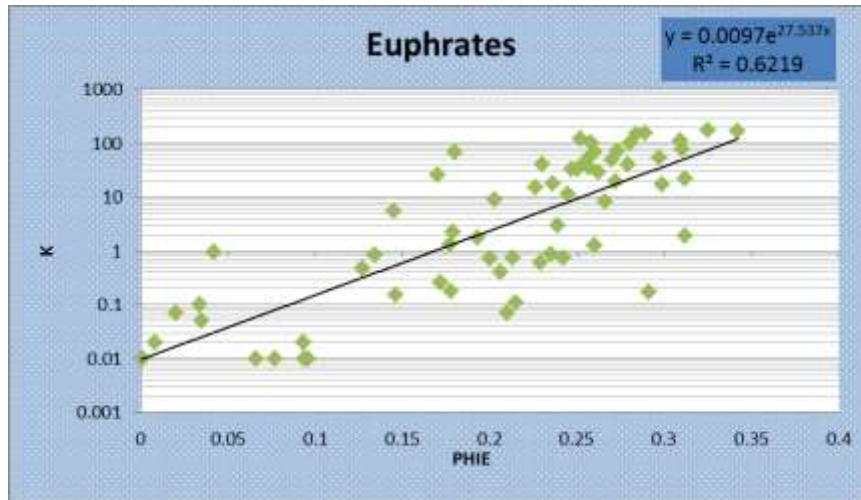


Figure 4. Permeability vs Porosity of Euphrates Unit.

Table 1. Results of the Classical Method.

The unit	Permeability Formula	R ²
Jeribe	$K=0.0362 e^{21.195\phi}$	0.5375
Dhiban	$K=0.0204e^{31.181\phi}$	0.6932
Euphrates	$K=0.0097e^{27.537\phi}$	0.6219

2.2 Neural Network

Neural networks, have gained in solving complex nonlinear problems. This method describes the use of the back propagation neural network technique (BPNN) to determine permeability in reservoir by using conventional well log data. Porosity, permeability, and fluid saturation are three main characteristics of reservoir systems. Porosity and permeability are measured from core were used as target data in the ANN.

Techlog software program is a program used to determine net permeability. This method aims to define reservoir permeability from digital data of well log by using neural network method. In this method we used five well log responses (Gamma Ray Log (GR), Deep Resistivity (LLD), Shallow Resistivity (MSFL), Neutron Porosity (NPHI) and Formation Density (RHOB)) such inputs in ANN method to predict permeability (Saner, et. al., 1997).

Fig. 5 shows the results obtained from Techlog software by using Neural Network method, Inputs are (first track of depth, second track of porosity analysis, third track of resistivity, fourth track of effective porosity, fifth track of gamma ray) and sixth track (K-core is input in blue points and K net is output in red line). On comparing between K-net & K-core we noticed good matching between predicted and core values. New studies have shown that neural network way may be highly accurate than statistical regression methods (Wong, et. al., 1995). AJ-4, AJ-6 & AJ-10 has been chosen to clarify this method as shown in Fig. 5, 6 and 7.

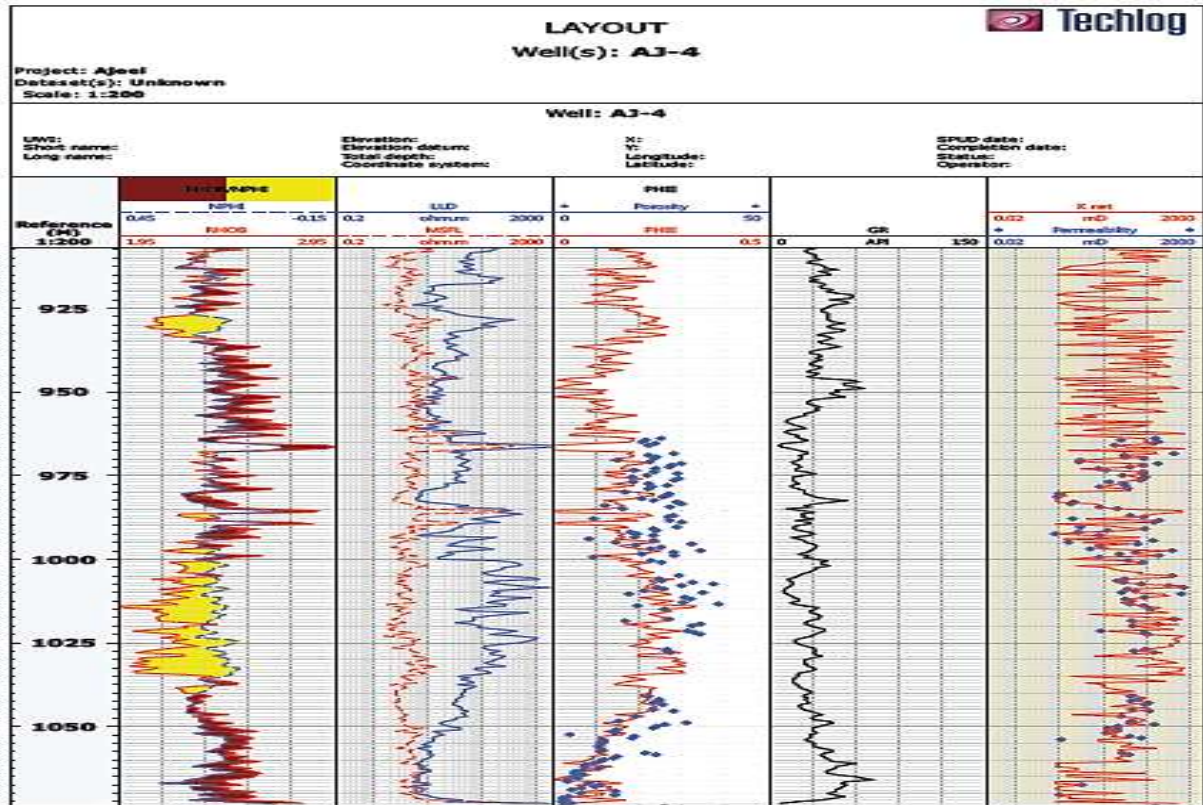


Figure 5. Comparison between K-net and K-core for Well AJ-4.

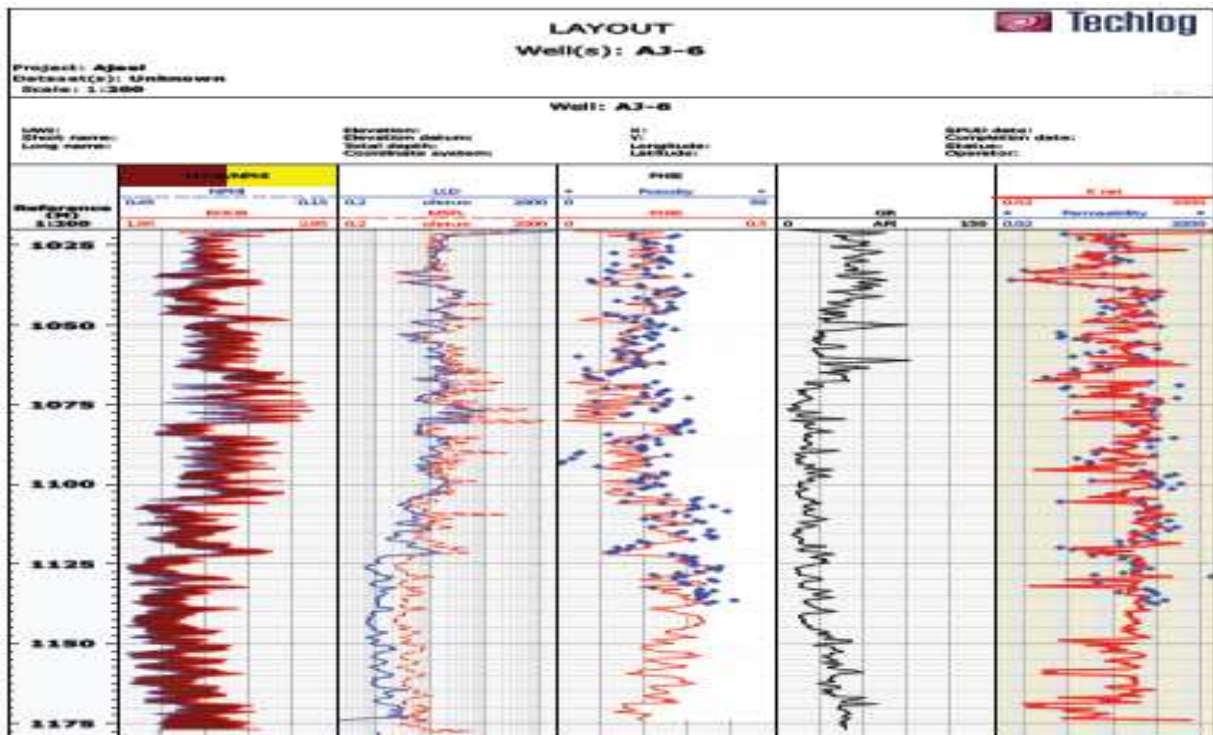


Figure 6. Comparison between K-net and K-core for Well AJ-6.

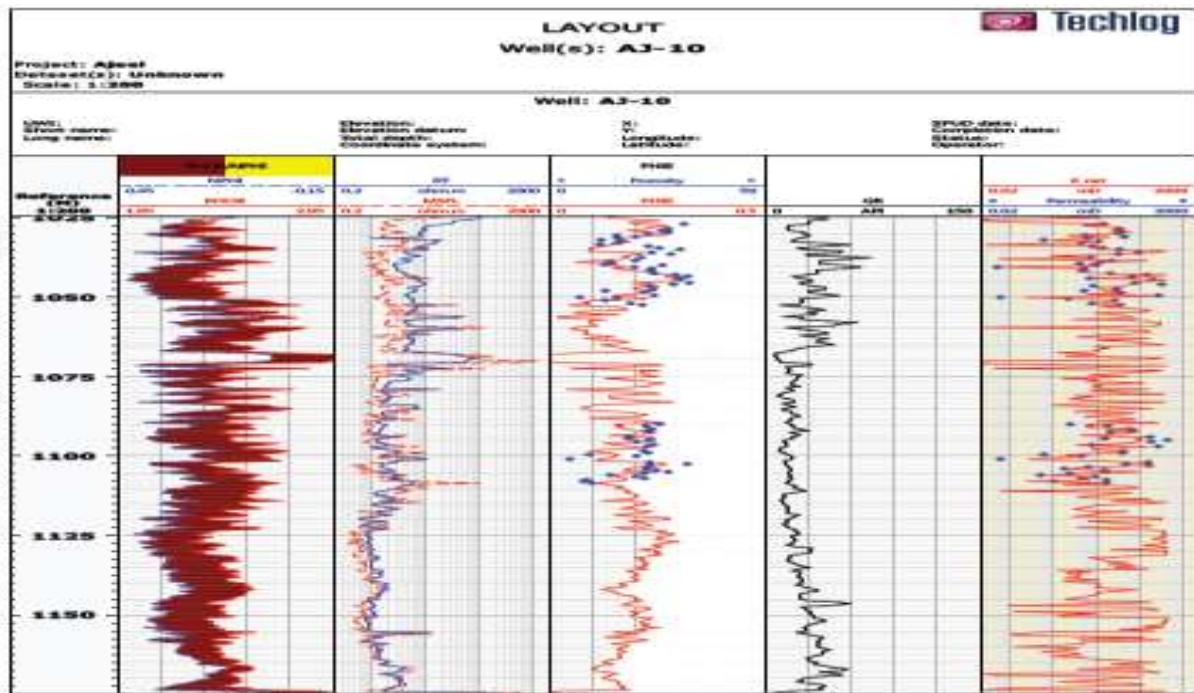


Figure 7. Comparison between K-net and K-core for Well AJ-10.

2.3 Flow Zone Indicator Method

The Flow Zone Indicator (FZI) is a number computed for the cumulative effects of texture (shape and size of grain, packing), pore throat sizes and tortuosity. It is regarded as a good basis to predict and describe the hydraulic flow unit of a reservoir (Fahad, et al., 2000). The hydraulic and flow units represent the total volume of rock in which the petrophysical properties that control on fluid flow (Amaefule, et. al. 1993).

The HFU approach has been used to predict the flow properties. Equations (3) to (5) are used to identify the FZI of the formation.

$$RQI = 0.0314 \sqrt{\frac{K}{\phi}} \text{ ----- (3)}$$

$$\phi Z = \frac{\phi}{1-\phi} \text{ ----- (4)}$$

$$FZI = \frac{RQI}{\phi Z} \text{ ----- (5)}$$

Where RQI: reservoir quality index (md^{1/2}), ϕZ : normalized porosity (%), FZI: Flow Zone Indicator (md^{1/2}), K: permeability (md).

Equation (6) is used to determine the permeability from Flow Zone Indicator (FZI).

$$K = 1014(FZI)^2 \frac{\phi^3}{(1-\phi)^2} \text{ ----- (6)}$$



Fig.8 shows a cross plot of the logarithm of the (ϕZ) versus the logarithm of the (RQI) for different FZI data. Results in Fig. 8 are divided to five groups and every group of points has different equation from the other group, this division depended on the series of points (classification of rock types).

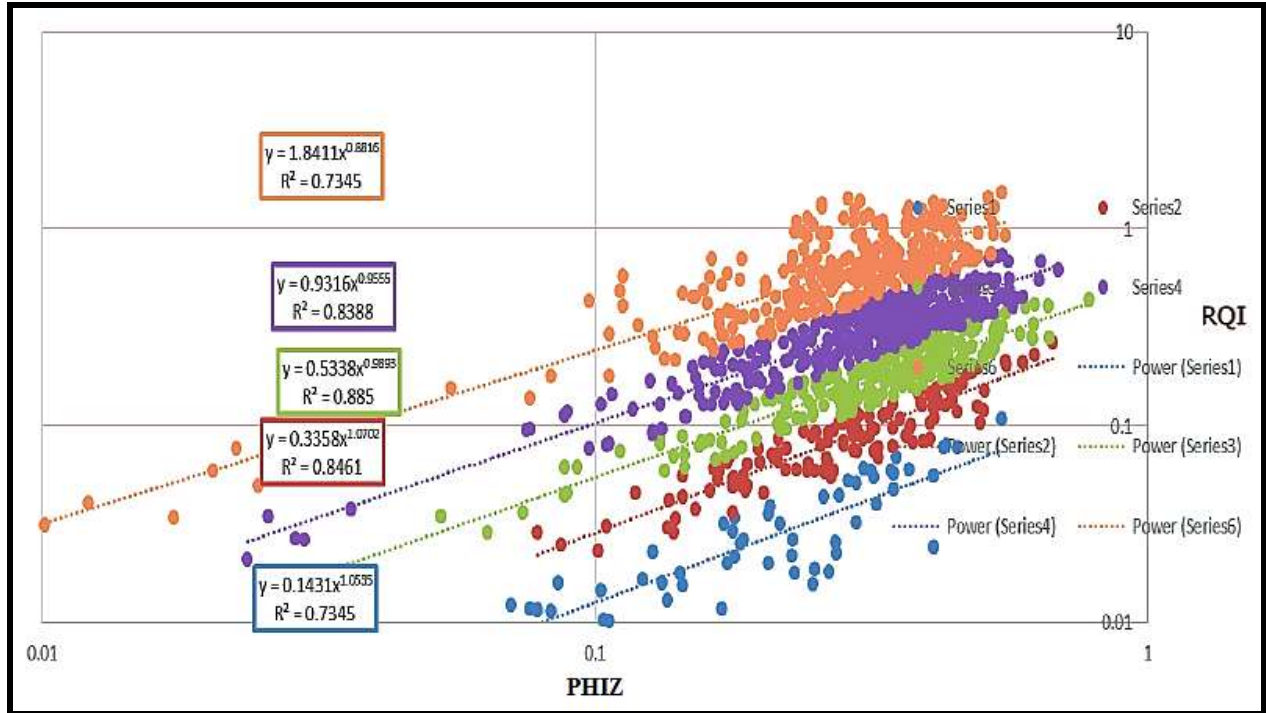


Figure 8. Reservoir Quality Index Vs Normalized Porosity.

3. RESULTS

Determination of permeability is the most important in the development of effective reservoir description. The evaluation of permeability in Tertiary Formation of Ajeel field was determined by three ways, classical, neural and flow zone indicator method (Al-Jawad and Ahmed, 2018). From the results obtained, it can be noticed that the neural network method can be considered as the most accurate among other methods. The values of permeability obtained by this method are being the closest to K-core values. The flow zone method may be considered as good also, but the classical method is considered an inaccurate. The permeability predictions results are shown in Figs. (9, 10 and 11) for AJ-4, AJ-6 and AJ-10.

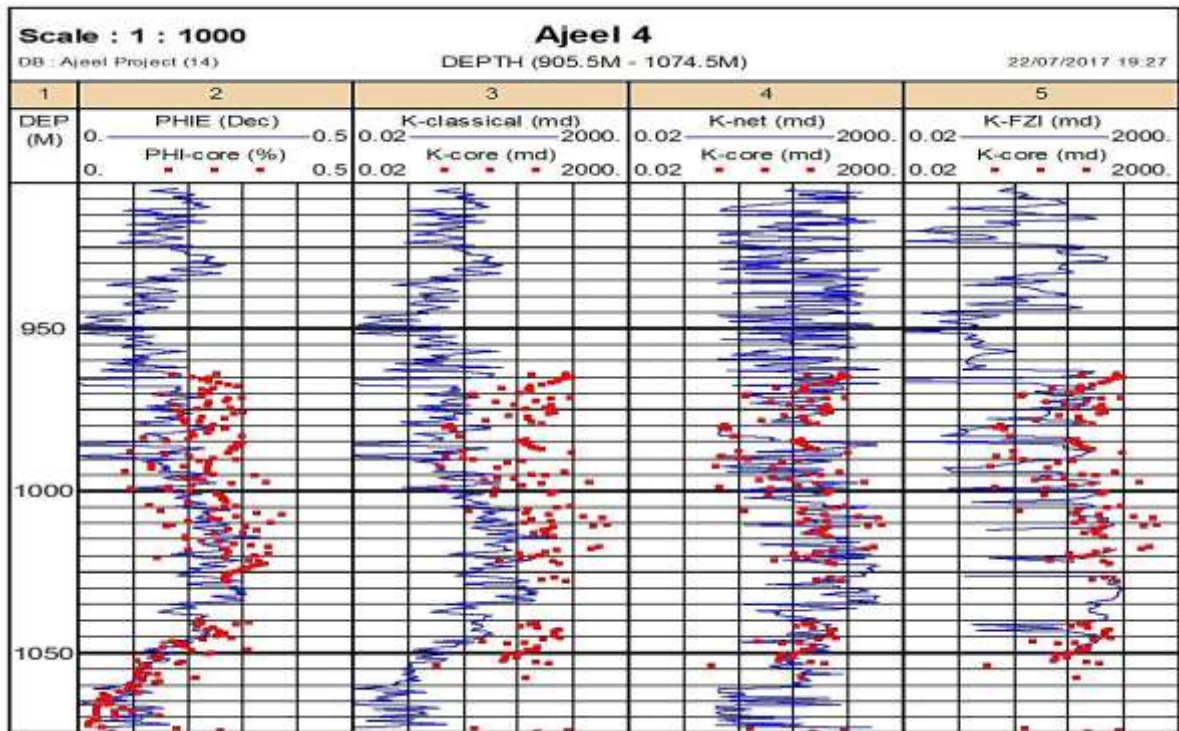


Figure 9. Results of Permeabilities Prediction vs. Permeability of Core for AJ-4.

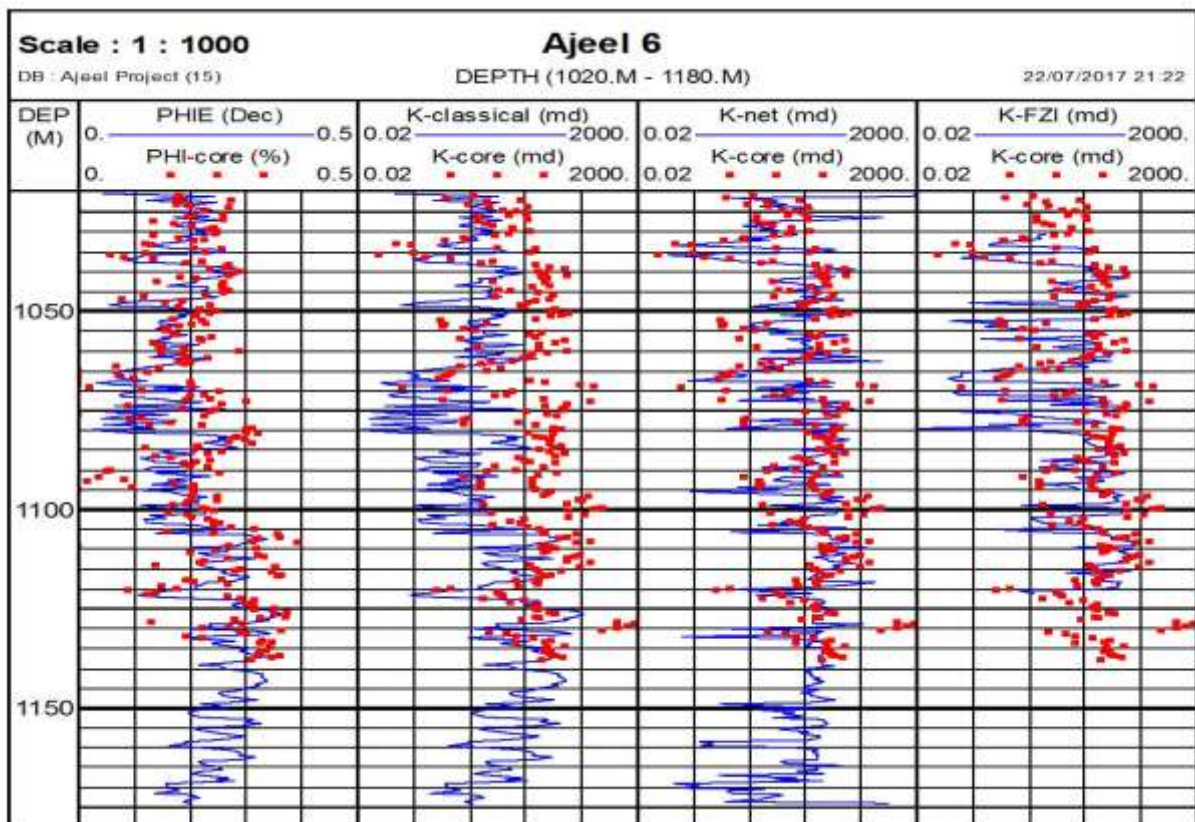


Figure 10. Results of Permeabilities Prediction vs. Permeability of Core for AJ-6.

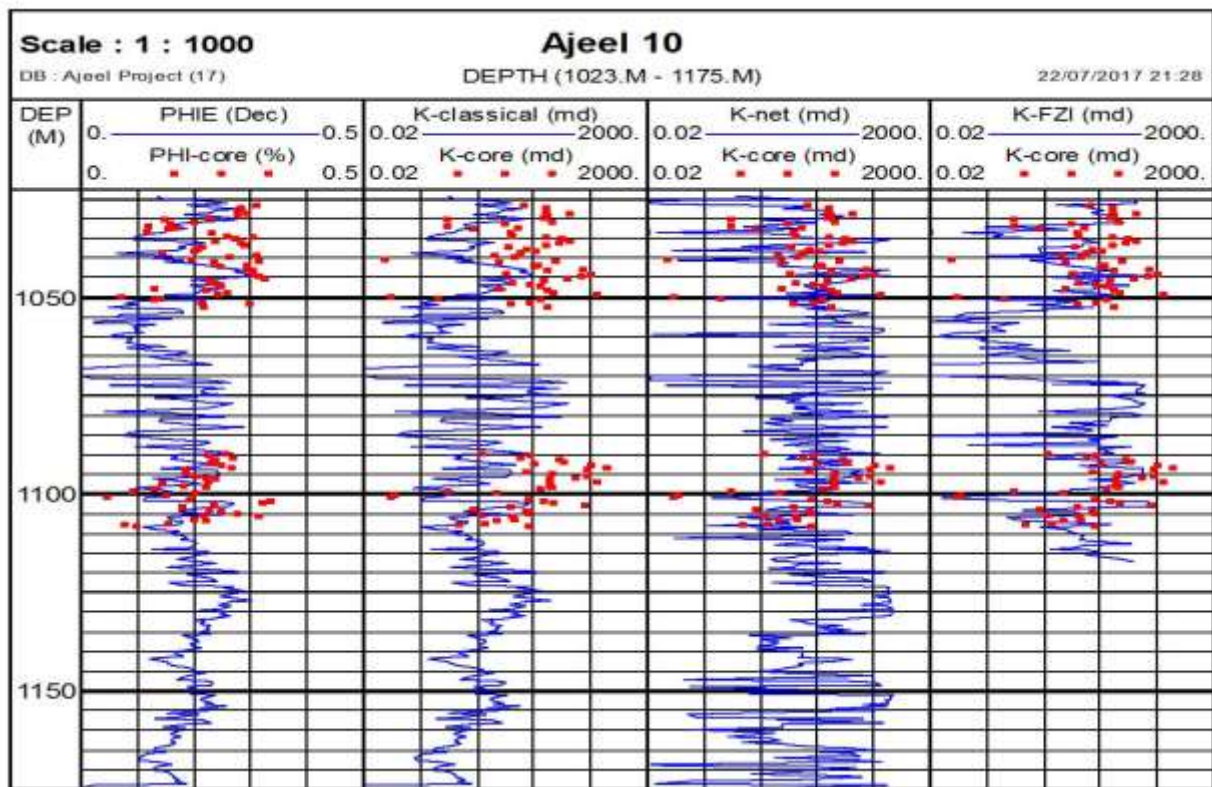


Figure 11. Results of Permeabilities Prediction vs. Permeability of Core for AJ-10.

4. CONCLUSIONS

Determination of permeability data of Tertiary Formation of Ajeel Field has been performed using three methods. The estimated results of permeability from the neural network method is more accurate as displaced in good matching between K-core & K-net as compared with other methods (classical and FZI) used in permeability estimation. By using the neural method, permeability in the uncored wells can be estimated.

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