Iraqi Journal of Science, 2024, Vol. 65, No.1, pp: 210- 222
DOI: 10.24996/ijs.2024.65.1.19

ISSN: 0067-2904

Petrophysical and Statistical Analysis of Main Pay of the Zubair Formation in South Rumaila Oil Field

Heba Ahmed Al-Samer*, Fahad Mansour Al-Najm
Department of Geology, College of Science, University of Basra, Basra, Iraq

Received: 17/11/2022 Accepted: 4/2/2023 Published: 30/1/2024

Abstract

The Zubair Formation is one of the major reservoirs of high production in the Rumaila oilfield, southern Iraq. The petrophysical properties analysis of the Upper Sand Member (Main Pay) of the Zubair Formation was conducted. The study includes results analysis of four wells distributed along the South Rumaila oilfield. Using a set of open well-logs, the main pay was divided into three main pay (AB, DJ and LN) units separated by two insulating shale units (C and K). The unit DJ was subdivided into three secondary reservoir units: D, F, H and the LN unit, which is split into L, M, and N. The research also includes the statistical analysis of the petrophysical properties, the calculation of the heterogeneity of the reservoir, and the cluster analysis of the upper sand member. The results indicated that the petrophysical specifications are good. Whereas, the results of the statistical analysis showed that the study wells were heterogeneous reservoirs that could be and were divided into four facies (Sand, Shaly Sand, Sandy Shale and Shale) depending on the log data.

Keywords: Southern Rumaila Oilfield, Zubair Formation, Main Pay, Petrophysical properties, Statistical analysis.

التحليل البتروفيزيائي والإحصائي لعضو الرمل الأعلى لتكوين الزبير في حقل الرميلة الجنوبي

هبة أحمد السامر*, فهد منصور النجم
قسم علم الأرض، كلية العلوم، جامعة البصرة، البصرة، العراق

الخلاصة

يعتبر تكوين الزبير من أهم المكامن ذات الانتاج العالي في حقل الرميلة النفطي، جنوب العراق. تم تحليل الخصائص البتروفيزيائية لعضو الرمل الاعلى لتكوين الزبير وأشتملت الدراسة على تحليل النتائج لأربعة آبار موزعة على طول حقل الرميلة الجنوبي. وبأستخدام مجموعة من سجلات الابار المفتوحة تم تقسيم عضو الرمل الاعلى الى ثلاث وحدات مكمنية رئيسية (AB, DJ, LN) تفصلها وحدتين عازلتين من الصخر الزيتي (C, K) . كما تضمن البحث التحليل الاحصائي للخصائص البتروفيزيائية وحساب عدم تجانس المكمن والتحليل العنقودي. وأظهرت النتائج أن المواصفات البتروفيزيائية كانت جيدة وأظهرت نتائج التحليل الاحصائي أن آبار الدراسة كانت مكامن عدم تجانس وتم تقسيمها الى اربع سحنات اعتماداً على بيانات المجسات البئرية.

1. Introduction

*Email: hibaalsamir@gmail.com

South Rumaila oilfield was regarded as one of the most important oilfields in southern Iraq [1]. This field consists of multi-petroleum reservoirs. The South Rumaila oilfield was discovered in 1953 depending mainly upon geophysical surveys, the seismic survey that was carried out by Basra Petroleum Company (B.P.C). At the Rumaila oilfield, the average thickness of the Zubair Formation is 380-390 m. The reservoir here comprises sandstones of the earliest Aptian to Hauterivian age [1]. The Rumaila oilfield is located in southern Iraq about 50 km west of Basrah city and about 30 km to the west of the Zubair oil field [2]. The field lies approximately longitudes (47°14'46" - 47°26'14") Easting and latitude (30°5'5.7" - 31°12'41") Northing (Figure 1). Ismael, (2009) Used well logs, cores, and thin sections to calculate the petrophysical characteristics and the petrophysical study of the main pay in the Zubair Formation was completed. The study aims to analyse the statistics of the petrophysical properties, calculate the physical parameters of the Upper Sand Member for the Zubair Formation, measure the heterogeneity of the reservoir and cluster analysis of main pay.

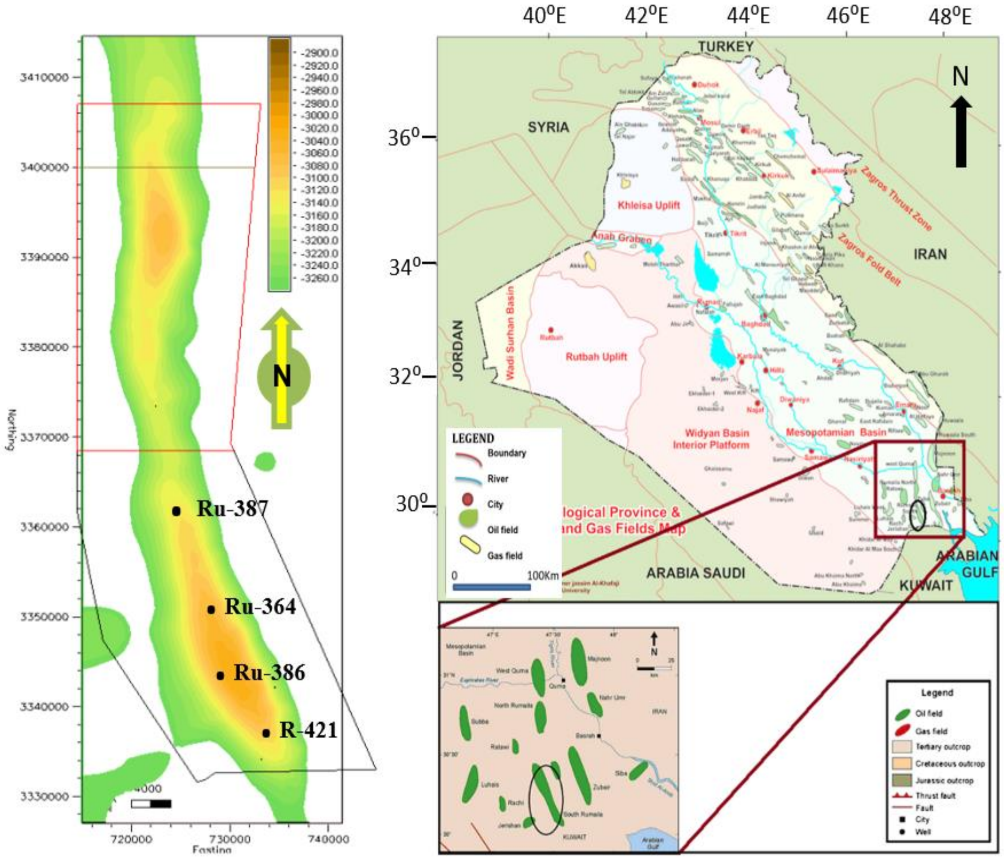

Figure 1: (A) Location of South Rumaila oil field, modified from [3]. (B) A map of the main pay in the Zubair Formation, showing the studied wells.

2. Geological Setting

Rumaila oil field lies within Zubair Subzone, The Zubair subzone forms the southernmost unit of the Mesopotamian zone. The Zubair Formation is one of the oil reservoirs that are represented by the sediments of the Lower Cretaceous (Late Berriasian-Albian) cycle. This formation is bounded from the upper part by Shuaiba Formation (Aptian), while the Ratawi Formation (Valanginian-Hautrivian) forms its lower boundary [4].

The Zubair Formation consists of five members. These members named from top to bottom are as follows: (Upper Shale Member, Upper Sandstone Member (main pay), Middle Shale Member, Lower Sand Member, and Lower Shale Member). The upper sandstone member of the Zubair Formation is the main pay zone of the South Rumaila oil field [5]. The main pay is comprised of three dominated sandstone units (AB, DJ, LN), separated by two shale units (C and K) [5], as shown in Figure (2).

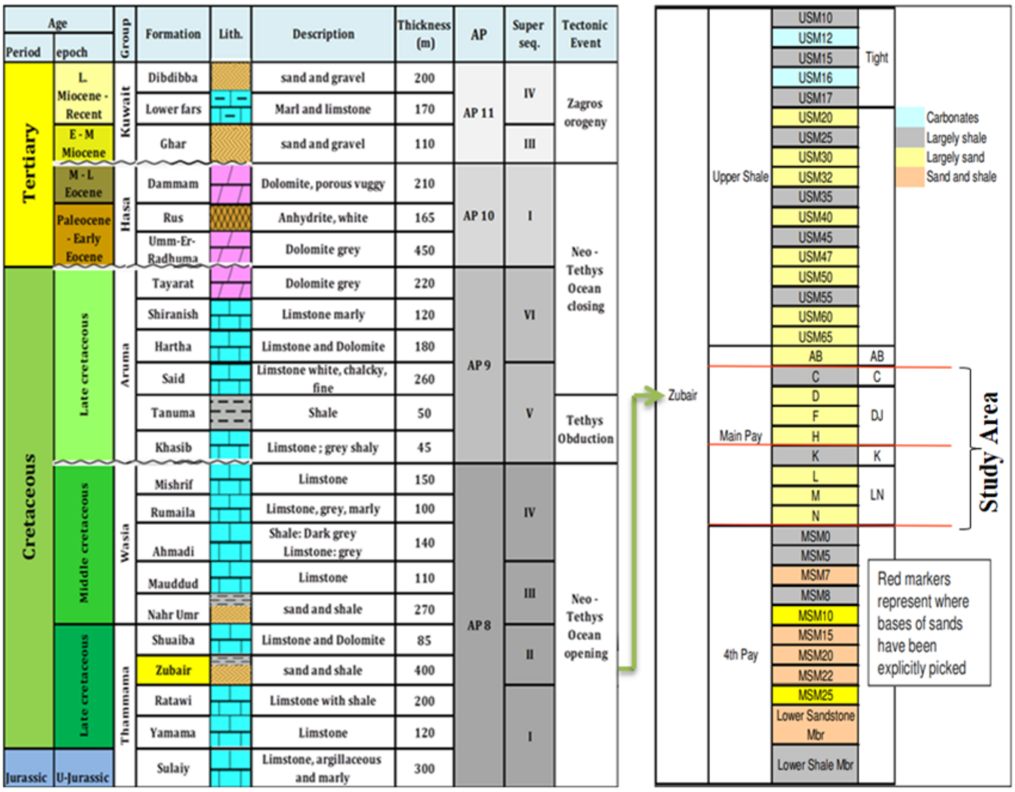

Figure 2 : The stratigraphic column of the Zubair Formation in the Rumaila oil field, modified from [6].

3. Materials and Methods

3.1 Petrophysical Properties Analysis

A different set of data logs were used (Gamma Ray Log (GR), Density Log (RHOB), Neutron Log (NPHI), Sonic log (Δt), Caliper log, and Resistivity Logs (Rxo, Ri, Rt) to calculate and analyze the petrophysical properties and evaluate the physical parameters of the study wells for the Main Pay of the Zubair Formation in the South Rumaila oilfield using the Excel (2010), then representation and zonation by using the Techlog software (2015). Four wells were selected for the study; Ru-387, Ru-364, Ru- 386 and Ru-421. To estimate the characteristics of the reservoir units as follows:

3.1.1. Calculation of Shale Volume (Vsh)

The Shale Volume is calculated from the gamma-Ray log [7].

$$\mathrm{IGR} = (GR_{\log} - GR_{min}) / (GR_{\max} - GR_{min}) \quad (1)$$

where IGR = gamma ray index; GR_{log} = gamma ray log (API); GR_{min} = minimum gamma-ray; GR_{max} = maximum gamma ray.

$$\mathrm{Vsh} = (2^{(2*IGR)} - 1)/3 \quad (2)$$

where Vsh = volume of shale.

Depending on Vsh value extracted from the “Eq. (1)” for each well, was determined in clean zones (sand) where the Vsh value (Vsh< %10) and unclean zones (dirty and shale) where the Vsh value (Vsh>%10) or (Vsh=%10).

3.1.2. Porosity Calculation

The total porosity is calculated from the neutron porosity and the density, where the density porosity is calculated using "Eq. (3)" in the depths where the proportion of shale volume was less than (10%) [8]. To calculate the porosity for dirty intervals (shale volume of more than 10%) use "Eq. (4)" [9].

$$ØD = (\rho_{ma} - \rho_b)/(\rho_{ma} - \rho_f) \quad (3)$$

$$ØDc = [(\frac{(\rho\ ma - \rho\ b)}{(\rho\ ma - \rho\ f)})] - [(\frac{(\rho\ ma - \rho\ sh)}{\rho\ ma - \rho\ f}) \times Vsh] \quad (4)$$

where ØD = density derived porosity; ØDc = Shale-corrected density porosity; ρ ma = matrix density (2.65 g / cc); ρ b = the density log reading; ρ f = fluid density (1 g/cc); ρ sh = density of nearby shale.

Measure the porosity directly from the neutron log for clean zones. As for the unclean (dirty zones) the porosity corrected for the shale effect by using equation "Eq. (5)" [10].

$$\boldsymbol{ØNc = ØN - (ØNsh \times Vsh)} \quad (5)$$

where ØN = neutron log derived porosity; ØNc = corrected neutron porosity; ØNsh = the neutron log value versus the highest value in Vsh.

Calculate the total porosity for the clean depths using "Eq. (6)" [11].

$$\boldsymbol{ØN.D = (ØN + ØD) / 2} \quad (6)$$

Calculate the primary porosity from the sonic log "Eq. (7)" [8], used to calculate porosity in clean zones, while "Eq. (8)" [9], used in the dirty zones with a Shale content of more than (10%) (Shaly zones) to correct porosity for the shale.

$$\boldsymbol{Øs = (\Delta t_{log} - \Delta t_{ma})/(189 - \Delta t_{ma})} \quad (7)$$

$$\boldsymbol{Øsc = [(\frac{(\Delta t\ log - \Delta t\ ma)}{(\Delta t\ f - \Delta t\ ma)})] - [(\frac{(\Delta t\ sh - \Delta t\ ma)}{(\Delta t\ f - \Delta t\ ma)}) \times Vsh]} \quad (8)$$

where Øs = Sonic–derived porosity (the formation porosity); Øsc = corrected sonic porosity; Δt log = sonic reading by log, Δt ma = the interval transit time in the rock matrix, Δt f = the interval transit time in the formation (189), Δt sh = the sonic value versus the highest value in Vsh.

Secondary porosity is calculated at depths where the shale content is less than 10% according to the "equation" [11].

$$\boldsymbol{SPI = ØN.D - ØS} \quad (9)$$

3.1.3. Calculation of Water and Hydrocarbon Saturation

In the invaded and uninvaded zones (Sxo and Sw), water saturation is calculated for the depths where the volume of shale (Vsh) is less than 10% by using "Eq. (10)" [12].

$$\boldsymbol{SW} = \sqrt{\frac{F * Rw}{Rt}} \quad (10)$$

where S_W = water saturation; Rt = true resistivity recorded by log (Ωm); Rw = Formation Water Resistivity; F = Formation factor.

$$SXO = \sqrt{\frac{F * Rmf}{Rxo}} \quad (11)$$

where Sxo = Water saturation of the invaded zone; Rmf = Resistivity of mud filtrate at formation temperature; Rxo = Resistivity of the invaded zone.

To calculate the formation factor, we use the "Eq. (12)" [12].

$$F = a / Ø^m \quad (12)$$

where a= tortuosity factor = (0.81) for Sandstone rocks; m= cementation factor = (2) for Sandstone rocks.

while Sw for unclean depths (dirty-shale), where the volume of shale (Vsh) is more than 10%, is calculated using the "equation" of [13].

$$SW = [\frac{0.4*Rw}{\emptyset^2}] * [\sqrt{\{(\frac{Vsh}{Rsh})^2 + (\frac{5*\emptyset^2}{Rt*Rw})\}} - (\frac{Vsh}{Rsh})] \quad (13)$$

where Rsh = true or deep resistivity versus the highest value in Vsh.

As for the hydrocarbon saturation (S_h), it is determined by the "equation" [14].

$$Sh = 1 - Sw \quad (14)$$

3.1.4. Calculation of the water formation resistivity

The are several sources from which the formation water resistivity can be calculated, including resistivity-porosity computation, cross plots, water catologs, chemical analysis, and the spontaneous potential (SP) curve [15]. In this study, the value of resistivity of formation water (Rw) was calculated from resistivity-porosity logs.

$$Rw = \emptyset_m * R_t \quad (15)$$

where Rt = true resistivity; from a deep-investigation resistivity log; Ø = Porosity; m = cementation factor. In the clean, water-bearing zone, Rt = Ro, so the "Eq. (15)" becomes *Rw = Øm * Ro.*

3.1.5 The bulk Volume of water

It was calculated in the uninvaded zone "Eq. (16)" and in the invaded zone "Eq. (17)" as follows [15].

$$BVW = SW * \emptyset_{N.D}$$

(16)

$$BVXO = SXO * \emptyset_{N.D} \quad (17)$$

3.1.6 The bulk Volume of hydrocarbon

It is calculated from "Eq. (18)" as follows [15].

$$BVh = Sh * \emptyset_{N.D} \quad (18)$$

It also calculates the movable oil saturation (MOS) through the "equation" [16].

$$MOS = SXO - SW \quad (19)$$

The residual saturation of the oil is calculated through the "equation" [15].

$$ROS = 1 - SXO \quad (20)$$

3.2. Statistical Analysis

Statistical analysis will be studied from two sides: The first aspect is the qualitative interpretation of the reservoir units by histograms between frequency and petrophysical properties. As well as performing a cluster analysis using SPSS and Geolog 7 software. On the other hand, reservoir heterogeneity will be measured using the Dykstra parson index.

4. Results and Discussion

4.1. Interpretation of Petrophysical Properties

4.1.1. Reservoir units

Based on the results of the petrophysical properties, the Main Pay in the studied wells was divided into three main reservoir units, separated by two insulating layers of shale (Figure 4).

- *AB unit*

This unit has an average thickness of between (9-15.01) meters in the study wells. As shown by the results of the logs analysis, this unit consists of sandstone mainly overlapping the shale. The boundary of the layer terminates with a tight layer C below it of shale and is considered an important reservoir unit. It is observed through the results of the petrophysical properties of the study wells, that the effective porosity (PHIND ef) appears good in all wells. And so, it appears from the results of Vsh that the least amount of shale is in a well (Ru-386) while the hydrocarbon saturation SH appears high in all wells, as shown in (Table 2).

- *C unit*

A layer consisting of shale, its thickness ranges between 1.5- 3.5 in the study wells.

- *DJ unit*

This unit has an average thickness of between 54.9-61 m in the study wells. Consists mainly of sandstone with thin layers of shaly sand, and it was divided into secondary units. The boundary of the layer terminates with a tight layer K below it of shale. It is observed through the results of the petrophysical properties of the study wells, that the effective porosity (PHIND ef) appears good in all wells. And so, it appears from the results of Vsh that the amount of shale is low in all wells. while the hydrocarbon saturation SH appears good except in a well (Ru-387), as shown in Table 2.

- *K unit*

A layer consisting of shale, as shown by the logs, its thickness ranges between 1.21- 3 in the study wells.

- *LN unit*

This unit has an average thickness of between (48-54.6) meters in the study wells. Consists mainly of sandstone and shaly sand with thin layers of shale, and it was divided into secondary units as below. It is observed through the results of the petrophysical properties of the study wells, that the effective porosity (PHIND ef) appears good in all. And so, it appears from the results of Vsh that the least amount of shale is in a well (Ru-386, 364) while the hydrocarbon saturation SH ranges from good to medium.

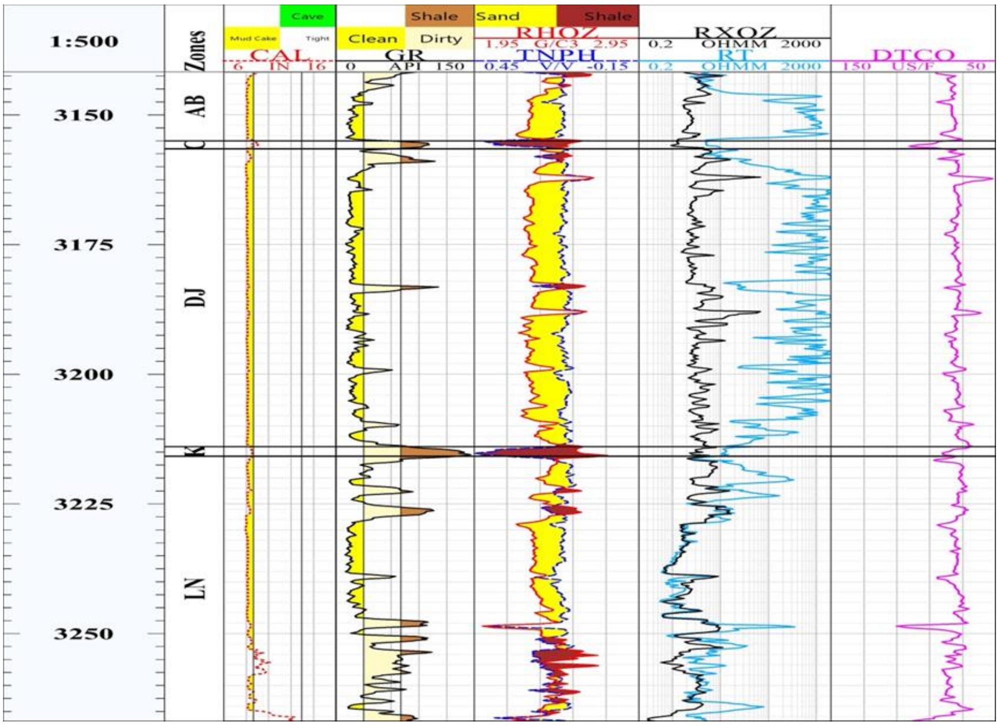

Figure 3 : The logs for the well Ru-386.

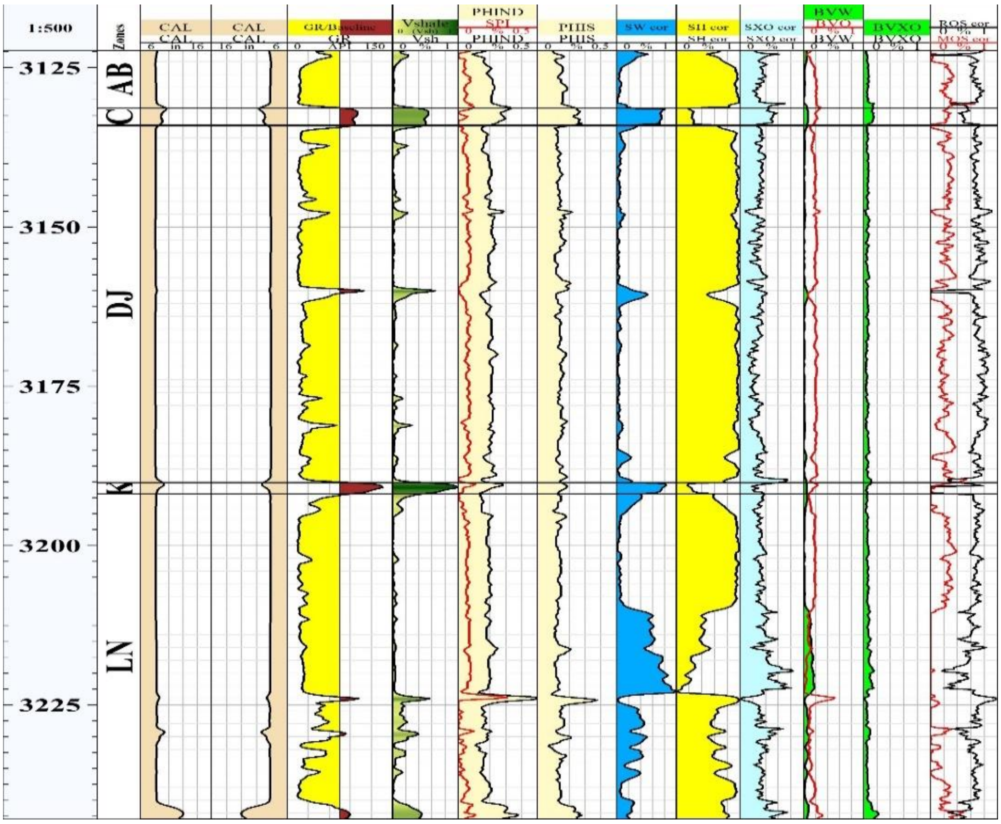

Figure 4 : The computed petrophysical properties of the Main Pay in Ru-386.

Table 2 : It shows the thickness, reservoir units depth, and the petrophysical results of the Main Pay, Zubair Formation in the studied wells.

Well	Units	Depth (m)	Thickness (m)	Vsh Average	PHIND ef Average	SH Average
Ru-387	AB	3184.15-3195.50	11.4	0.12	0.13	0.82
	DJ	3196.97-3257.92	61	0.07	0.17	0.54
	LN	3258.75-3306.63	48	0.12	0.14	0.66
Ru-364						
	AB	3142.95-3153.81	10.86	0.16	0.17	0.81
	DJ	3155.50-3212.98	57.44	0.10	0.18	0.71
	LN	3214.90-3269.50	54.6	0.08	0.18	0.63
Ru-386						
	AB	3122.30-3131.30	9.0	0.06	0.19	0.87
	DJ	3134.06-3190.10	56.04	0.05	0.19	0.93
	LN	3191.87-3243.30	51.34	0.09	0.18	0.69
Ru-421						
	AB	3163.96-3178.97	15.01	0.18	0.17	0.90
	DJ	3181.17-3236.05	54.9	0.09	0.17	0.68
	LN	3238.01-3289.28	51.27	0.16	0.16	0.57

4.2. Interpretation Statistical Analysis

4.2.1. Statistical Analysis of reservoir units

The reservoir units of the Main pay were statistically analyzed. The purpose of the construction of a histogram is to know the petrophysical specifications of the reservoir units. The AB unit has good porosity and hydrocarbon saturation in all wells. The DJ and LN units have good porosity and hydrocarbon saturation in all wells except the R-387 and Ru-421 wells.

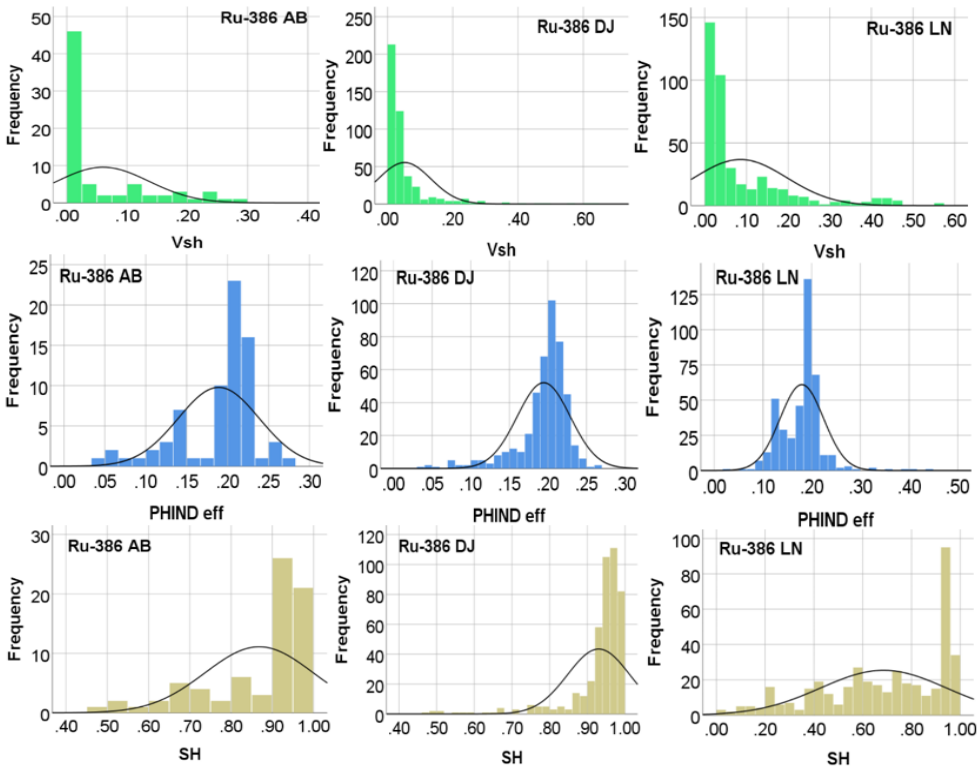

Figure 5 : Histogram of petrophysical properties of reservoir units of the Main Pay, Zubair Formation in (Ru-386 well).

Table 3 : Statistical summary of Vsh, PHIND ef and SH of the Main Pay, Zubair Formation for the well (Ru-386).

Parameter	Unit	Minimum	Maximum	Mean	Standard deviation
Vsh	AB	0.00	0.29	0.06	0.08
	DJ	0.00	0.65	0.05	0.08
	LN	0.00	0.57	0.09	0.11
PHIND ef	AB	0.05	0.27	0.19	0.05
	DJ	0.03	0.27	0.19	0.03
	LN	0.03	0.44	0.17	0.04
SH	AB	0.48	0.99	0.87	0.13
	DJ	0.48	0.99	0.93	0.08
	LN	0.00	0.99	0.67	0.26

4.2.2. Cluster Analysis

The data is grouped in a cluster, as this data is a set of depth values that are related to a set of petrophysical properties values that were measured along the well. The cluster analysis divides data into supple data clusters. The number of clusters must cover all the data that appear in the logs. And the cluster can be represented by using the cross-plot using Geolog 7 displays as shown in (Figures 8 and 9) [17]. Depending on the cluster analysis can specify electrofacies in the Main Pay based on the distribution of sand and shale ratio [18]. Based on the cluster analysis by using Geolog 7 identified four electrofacies in the main Pay of the Zubair Formation in the South Rumaila oil field. A set of well-logs that might reflect the lithofacies characteristics were ultimately selected to partition the electrofacies clusters as GR, RHOB, NPHI and the logs intervals were set as GR (0-150 API), RHOB (1.95-2.95 g/cm^3), and NPHI (-0.15-0.45 V/V). The distribution of model logs is illustrated in (Figure 6). Based on the determination of the model logs, the cluster was set as four. After applying, each cluster corresponded to a different color and the barycenter. The colors and the barycenters of the model logs in the four optimal electrofacies clusters model are shown in (Figure 7).

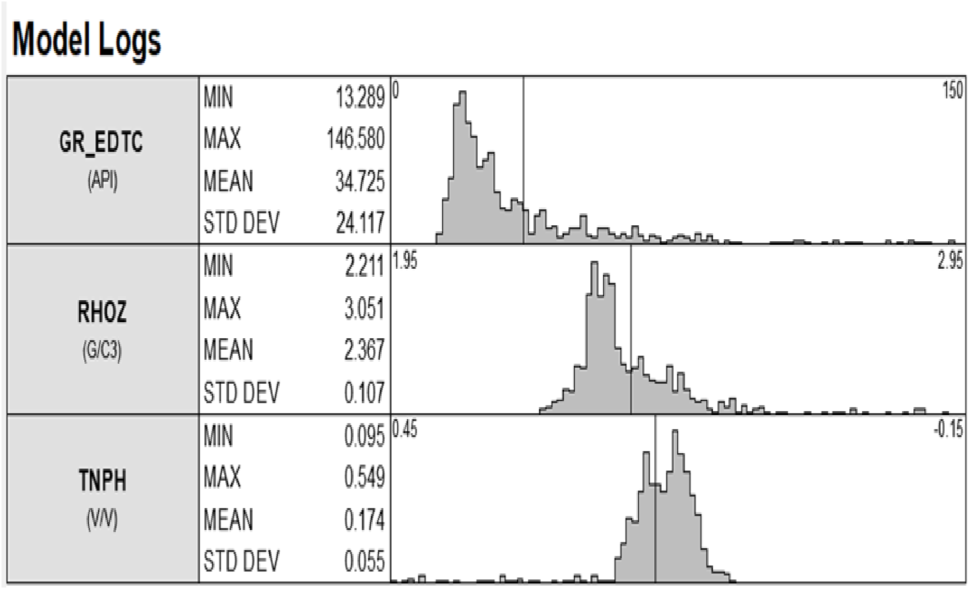

Figure 6 : Histogram and distribution of model logs of the Main Pay, Zubair Formation (Ru-386 well).

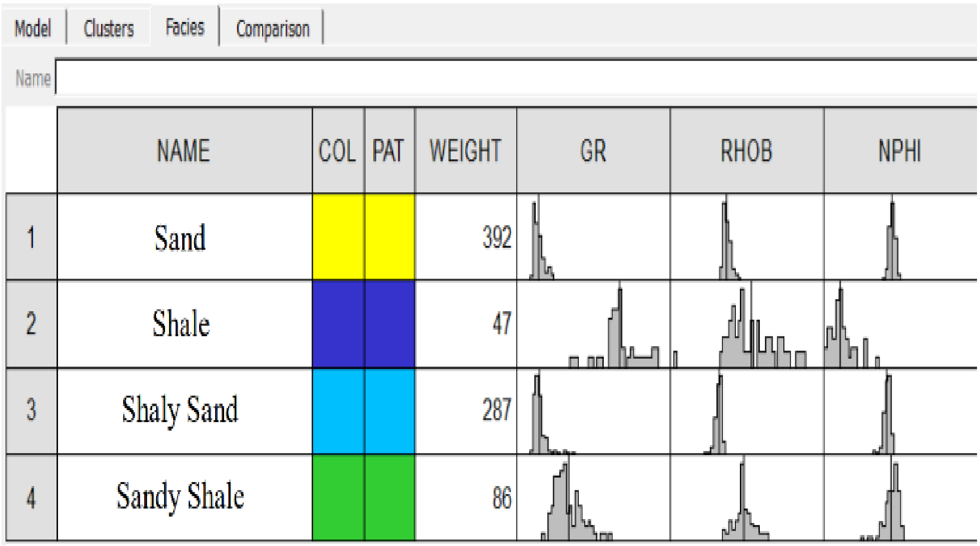

Figure 7 : 5 Colors and barycenters of the four clusters for Ru-386 well.

Four electrofacies were identified in the target interval and classified into four lithofacies based on gamma-ray log response [19]: yellow = sand (clean); light blue = shaley sand; green = sandy shale; dark blue = shale, as shown in (Figures 8 and 9).

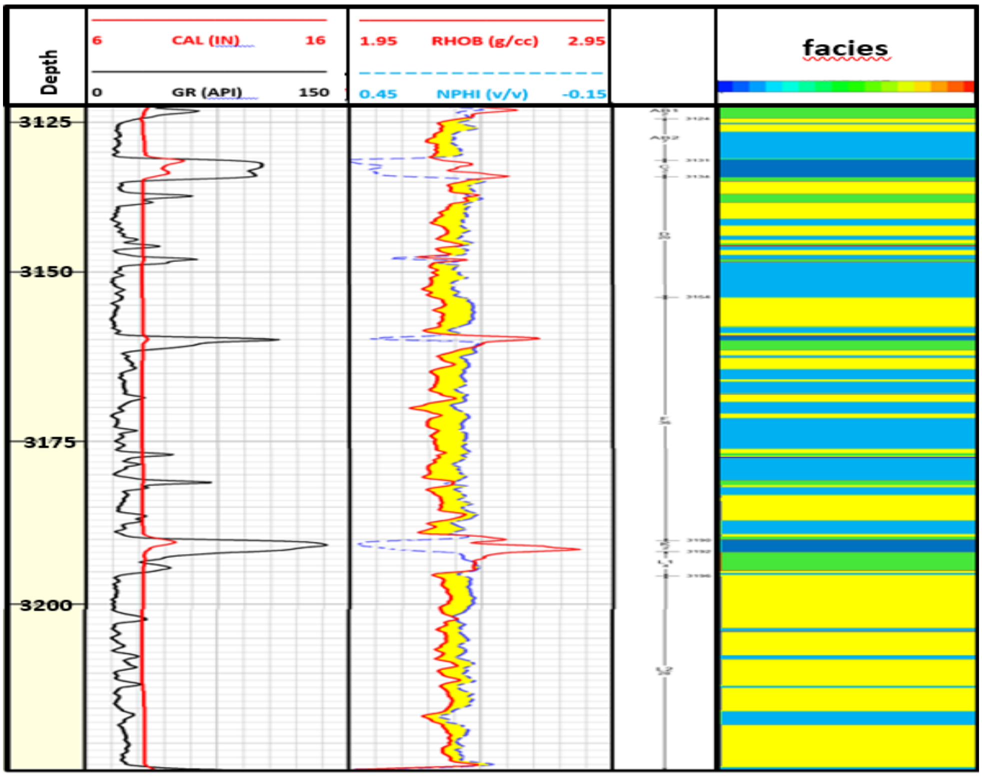

Figure 8 : Electrofacies of Main Pay, Zubair Formation in Ru-386 well.

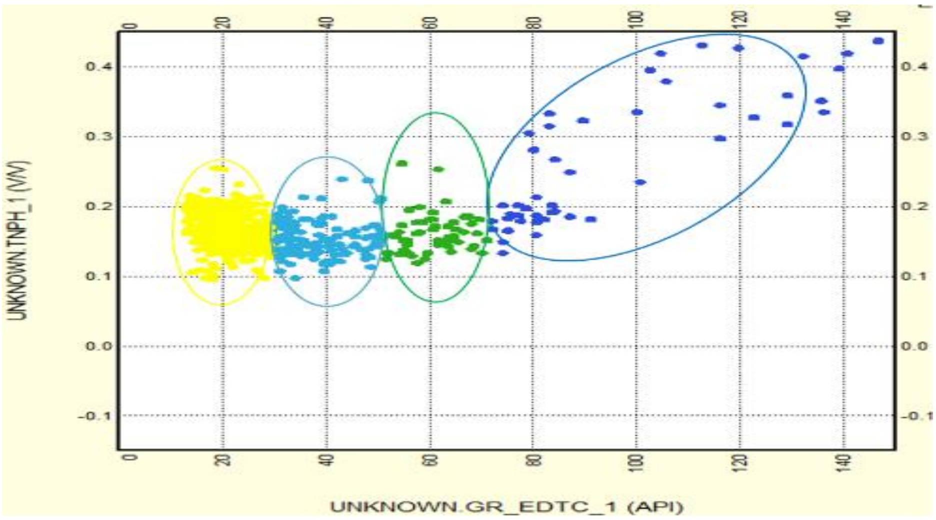

Figure 9 : Plot of clustering of four electro-facies (EF) for Ru-386 well.

4.2.3 Quantifying Heterogeneity

The study of oil-field reservoir heterogeneity is important in the oil industry as it affects optimizing hydrocarbon production. To measure heterogeneity, we use geostatistical techniques to describe the heterogeneity in a dataset [20]. For defining heterogeneity, statistical parameters are frequently used the Dykstra-Parsons permeability variation [21]. The Dykstra-Parsons coefficient is an excellent tool for characterizing the degree of reservoir heterogeneity. The original permeability values have been plotted on the graph with the perce
nt sample with larger permeability. The Dykstra-Parsons coefficient ranges from a minimum of 0 (homogeneous) to a maximum of 1.0 (heterogeneous), and is defined as follows:

$$V_k = (K_{50} - K_{84.1}) / k_{50} \quad (21)$$

K_{50}: Permeability value at the 50 percentile, $K_{84.1}$: Permeability value at the 84.1 percentile.

The permeability values must first be calculated and then the Dykstra-Parson coefficient is applied. The permeability of the study wells was calculated using well logs data through the relationship between porosity and water saturation (Hyperbolic lines), which can be calculated only when the reservoir is at irreducible water saturation, which depends on the values of the total water volume. By applying the relationship between irreducible water saturation and porosity for each reservoir unit in each well, only some units were found for which it was possible to calculate the permeability Because the rest of the units of the study wells are mobile water saturation. So, this equation cannot be applied to it to calculate the permeability (Figure 10). Then the "equation" [8] was applied to calculate the permeability:

$$\mathbf{K} = \left[\boldsymbol{C} * \left(\frac{\emptyset^3}{Swirr} \right) \right]^2 \tag{22}$$

where C = constant, its value equals 250 for medium oil and 79 for dry gas; K = permeability (mD); Ø = porosity. The results showed in (Table 3) that the permeability values of the reservoir units of Main Pay of the Zubair Formation for the study wells were between (Good – Excellent).

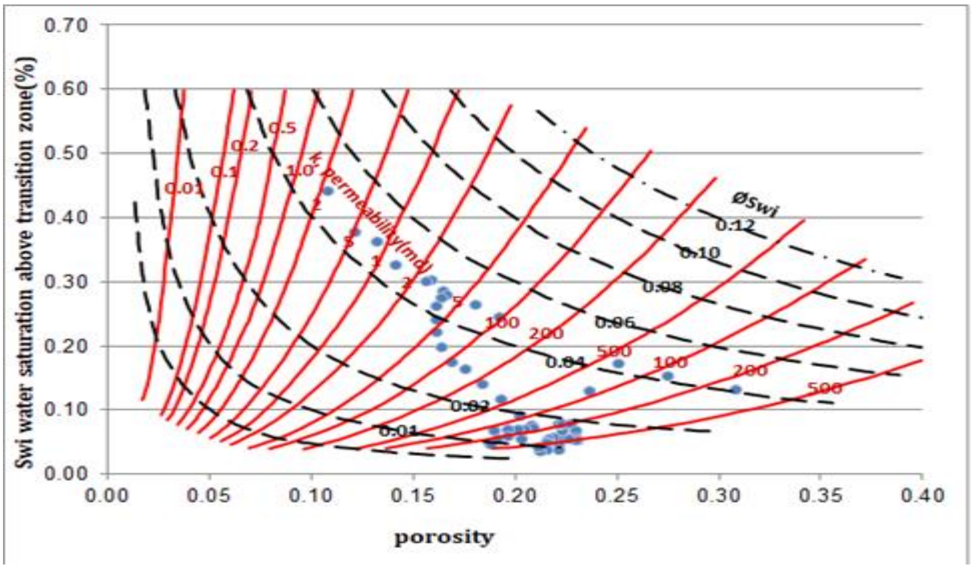

Figure 10 : Charts for estimating permeability for reservoir unit AB of Ru-386 well between porosity and irreducible water saturation.

In this study, the heterogeneity of the reservoir for the Main Pay was measured using the method of the Dykstra-Parsons coefficient for study wells. Where the results indicated, after calculating the coefficient, that the study wells were a reservoir of heterogeneity (Figure 11).

Table 3 : Permeability values for the Main Pay, Zubair Formation wells of the study area.

Well	Unit	Minimum	Maximum	An average of Permeability	Level
Ru-387	AB	1.3	4767.6	580.76	Very good
Ru-364	AB	1.8	4808.1	597.28	Very good
	DJ	1	1731.3	195.99	Very good
Ru-386	AB	1.5	4659.2	1270.21	Excellent
	LN	1	2653.3	511.42	Very good
Ru-421	AB	6.9	4699.6	980.75	Very good
	DJ	3.5	2600.7	288.46	Very good
	LN	1	2664.9	295.88	Very good

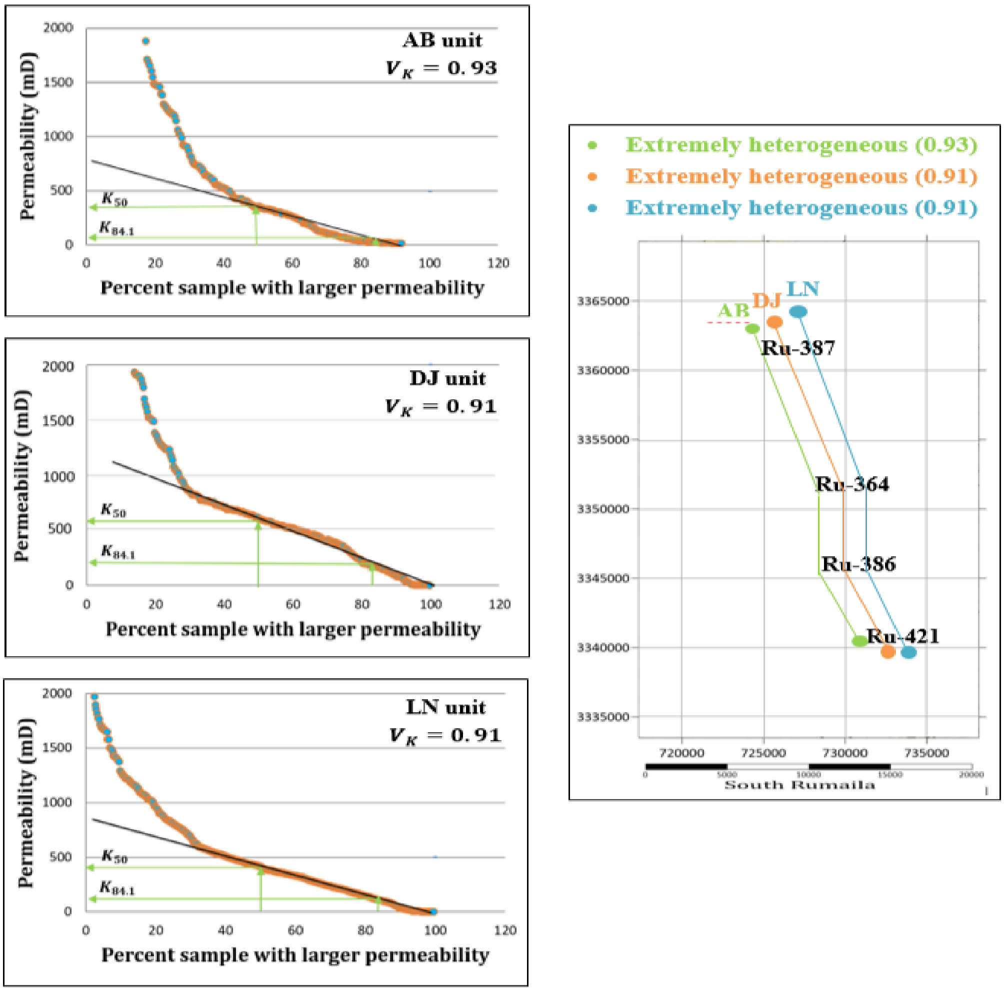

Figure 11 : The Dykstra-Parson coefficient of permeability variation.

5. Conclusions

The petrophysical properties of the Main Pay were analyzed and calculating their values (Vsh, ØN.D, SW, SH). The results showed that reservoir units' lithology ranges from sandstone to shaly sandstone and a few percentages of the shale in all study wells. After calculating the petrophysical properties of Main Pay in the studied wells, it was divided into three main reservoir units (AB, DJ, and LN), separated by two insulating units of shale (C, and K). The DJ unit was then divided into three secondary reservoir units (D, F, H), while the unit LN was divided into three secondary units (L, M, and N).

The results of the statistical analysis of the Main Pay showed that the study wells were heterogeneous reservoirs and were divided into four facies depending on the GR Data.

References

[1] Jamil and A. K. Jamil, ""Hydrochemical and hydrodynamic zones and the probable direction of water flow within Zubair reservoir of Zubair and Rumaila oil fields (southern Iraq)," in *Geol. Jb.*, Hannover, 1977, pp. 199-211.

[2] R. Al-Ansari, "The petroleum Geology of the Upper sandstone Member of the Zubair Formation in the Rumaila South," in *Geological Study*, Baghdad, Ministry of Oil, 1993.

[3] T. K. Al-Ameri, A. J. Al-Khafaji and J. Zumberge, "Petroleum system analysis of the Mishrif reservoir in the Ratawi, Zubair, North and South Rumaila oil fields, southern Iraq.," in *Geo Arabia 14.4*, 2009, pp. 91-108.

[4] T. Buday, "The Regional geology of Iraq," Mosul, Dar Al-Kutab publication House, 1980, p. 445.

[5] D. Mikes and C. R. Geel, “Standard facies models to incorporate all heterogeneity levels in a reservoir model.,” in *Marine and Petroleum Geology 23*, 2006, pp. 943-959.

[6] A. A. Aqrawi, J. C. Goff, A. D. Horbury and F. N. Sadooni, “T*he petroleum Geology of Iraq.,” UK, Scientific press Ltd.,* 2010.

[7] G. B. Asquith and D. Krygowski, “Basic well log analysis.,” Oklahoma, Tulsa: American Association of Petroleum Geologists, 2004, p. 244.

[8] M. R. J. Wyllie, A. R. Gregory and G. H. F. Gardner, “An experimental investigation of factors affecting elastic wave velocities in porous media.,” Geophysics 23.3, 1958, pp. 459-493.

[9] D. Atlas, “ Log interpretation charts: Houston.,” Texas, Dresser Industries Inc, 1979, p. 107.

[10] D. Tiab and E. C. Donaldson, “Petrophysics: theory and practice of measuring reservoir rock and fluid transport properties.,” Texas, 1996, p. 207.

[11] Schlumberger, “Log interpretattion chart,” in *Wireline and Testing*, Houston, Schlumberger, 1997, p. 193.

[12] G. E. Archie, “The electrical resistivity log as an aid in determining some reservoir characteristics,” in *Petroleum resistivity, Vol. 5*, 1944, pp. 54-62.

[13] P. Simandoux, “Mesures dielectriques en milieu poreux, application a mesure des saturations en eau, Etude du Comportment des massifs Argileux,” in *Revue de l’Institut Français du Pétrole,* 1963, pp. 193-215.

[14] Schlumberger, “Log interpretation charts,” USA, 1987.

[15] Schlumberger, “Log interpretation principles/Applications, seventeen printing,” Texas 77478, 1998.

[16] D. R. Spain, “ Petrophysical evaluation of a slope fan/basin-floor fan complex: Cherry Canyon Formation,” Texas, AAPG bulletin, 1992, pp. 76(6), 805-827.

[17] J. H. Doveton, “Geologic Log Analysis Using Computer Methods,” in *AAPG Computer Applications in Geology, No.2,* Geological Society Special Publication, 1994, p. 181 – 252.

[18] K. Saikia and C. Baruah, “A Practical Solution to Overcome Challenges in Unconventional Reservoir Simulation and History Matching Using Integrated Petrophysical and Facies Modeling Approach.,” SPE Oil and Gas India Conference and Exhibition, 2017.

[19] H. K. Almayyahi and M. H. Aljaberi, “Sedimentalogical study for the Upper Shale member in Zubair Formation to enhance and comparison oil production in North Rumaila oilfield,” Modeling Earth Systems and Environment, 2018, pp. 981-1006.

[20] W. J. Al-Mudhafar, “Baysian kriging for reproducting reservoir heterogenity in a tidal depositional environment of a sandstone formation,” Geophys, 2019, pp. 84-102.

[21] D. Tiab and E. C. Donaldson, “ Petrophysics: theory and practice of measuring reservoir rock and fluid transport properties,” Gulf professional publishing, 2015.