Tikrit Journal of Pure Science Vol. 26 (6) 2021

TJPS

Tikrit Journal of Pure Science

ISSN: 1813 – 1662 (Print) --- E-ISSN: 2415 – 1726 (Online)

Journal Homepage: http://tjps.tu.edu.iq/index.php/j

Reservoir Properties of the Upper Oligocene-Lower Miocene Ibrahim Formation in the Garmian Area, Iraqi Kurdistan Region

Dler H. Baban , Shadan M. Ahmed

Geology Department, College of Sciences, Sulaimani University, Sulaimanyah, Iraq

https://doi.org/10.25130/tjps.v26i6.192

ARTICLE INFO.

Article history:

-Received: 16 / 7 / 2021

-Accepted: 24 / 8 / 2021

-Available online: / / 2021

Keywords: Sarqala, Hasira, Taza, Ibrahim Formation, Reservoir Characterization

Corresponding Author:

Name: **Dler H. Baban**

E-mail:

dler.mohamad@univsul.edu.iq

Tel:

ABSTRACT

Reservoir characteristics of the Upper Oligocene-Lower Miocene Ibrahim Formation has been studied from the well Hasira-1 (H-1) at Sarqala Oilfield and from the well Taza-3 (Tz-3) at Taza Oilfield in Garmian Area/ southeast Kirkuk City in the Iraqi Kurdistan Region. The available conventional wireline log data are used for detecting the dominant lithology of the formation which appeared to be limestone and argillaceous limestone. The formation in the well H-1 contains appreciable quantity of shale which in some horizons exceeded 35%. The formation is of poor porosity (5% and 8% as average porosity in the well H-1 and Tz-3 respectively) and of poor to fair permeability with an average of 1.9mD in the well H-1. The formation divided to five reservoir units depending on variations in the shale content, porosity and permeability in the well H-1. RU-2 and RU-4 at depth intervals 4125-4128m and 4109-4114m respectively are of relatively the highest reservoir quality among the five recognized reservoir units in the formation. Light hydrocarbons are exist along the Ibrahim Formation in the well H-1 with no effective movability for to be recovered. The examined 17 core samples of the formation in the well Taza-3 is lithologically composed of argillaceous and marly limestone which represented by planktonic foraminifera bearing packstone microfacies. The average porosity of the tested core plug samples of the formation in the well Tz-3 is about 5%, so the formation in this well is of poor reservoir quality as it is in the well H-1.

1. Introduction

Oligocene carbonates in northern Iraq (known as Kirkuk Group) are proposed to be divided vertically and laterally to three sedimentary cycles belonging to Early, Middle, and Late Oligocene in age [1]. Each cycle is formed of back-reef, fore-reef and basinal facies. Bellen et al. [1] named the formations from oldest to youngest, as Shurau, Baba, and Anah for the back-reef; Sheikh Allas, Bajawan, and Azkand for the fore-reef; Tarjil, Palani, and Ibrahim for the basinal facies.

Difficulties are always associated with the recognition of the mentioned three cycles in the drilled wells due to lack of clear and distinctive features at the contact between the cycles [2]. Later workers, however, modified the proposed ages for the three cycles (especially the Upper Oligocene one known as Ibrahim sequence) and believed that Ibrahim cycle may extend completely or partially to an age younger than Oligocene [3, 4, 5, 6, 7].

Lithologically, the back-reef facies are formed of skeletal lime wackestone to packstone, the fore-reef facies are formed of dolomitized skeletal wackestone and, the basinal facies are represented by detrital skeletal lime wackestone and dolomitized marly lime packstone [2].

The producing formations of the Kirkuk Group are mostly those belonging to the back and fore-reef facies. The basinal facies and due to higher clay and fine material content, are generally of low porosity and permeability. Fractures play a great role in improving the petrophysical reservoir properties of the group. According to [2], the dolomitized basinal and fore-reef facies are about 100 times more permeable than the unaltered basinal facies matrix.

Hydrocarbon producibility of the unaltered basinal limestones is enhanced by their thin-bedding and the presence of abundant joints.

Seldom are the complete formations of the Kirkuk Group existed in one oilfield. The patchy distribution of the reefal sediments belonged to the group was manifested when the complete absence of the Kirkuk group recorded in some fields or only one formation of the group found in some others.

In this study, the penetrated sections of the Kirkuk Group (Ibrahim Formation) by the two drilled wells of Hasira-1 (H-1) and Taza-3 (Tz-3) in Garmian area are studied using the available wireline log data and core rock samples. The aim of the study is to find out the reservoir properties of the Ibrahim Formation in the Sarqala Oilfield and supporting the results by some data from Taza Oilfield. This study about Ibrahim Formation in the mentioned two oilfields is the first to be published.

2. Geological setting and Tectonism

Geographically, the study wells are located in Garmian area south-east Kirkuk City (Fig.1)

Generally, recent sediments and the Upper Miocene - Pliocene formations of Fatha, Injana, Bai Hassan, and Miqdadiyah are representing cover sediments of the Garmian area. The thickness of the mentioned formations in some areas is collectively exceeding 3700m as recorded in the well Sq-1, Sarqala Oilfield [8]. Additional Tertiary formations, as recorded by the drilled wells in the area, are Jeribe, Dhiban, Euphrates, Serikagni, Hamrin, Kirkuk Group, Jaddala, and Aaliji formations. Among the Tertiary formations Jeribe, Euphrates, and Kirkuk Group are always the main targets of the exploration processes that carried out in the area. However, oil accumulation observed even in the Jaddala Formation (e.g. Kurdamir Field), upper part of the Dhiban Formation (e.g. Qumar Field), transition beds of the Fatha Formation (e.g. Chia Surkh Field), in addition to gas accumulation in the Injana and Bai Hassan formations (e.g. Mil Qasim Field) [9].

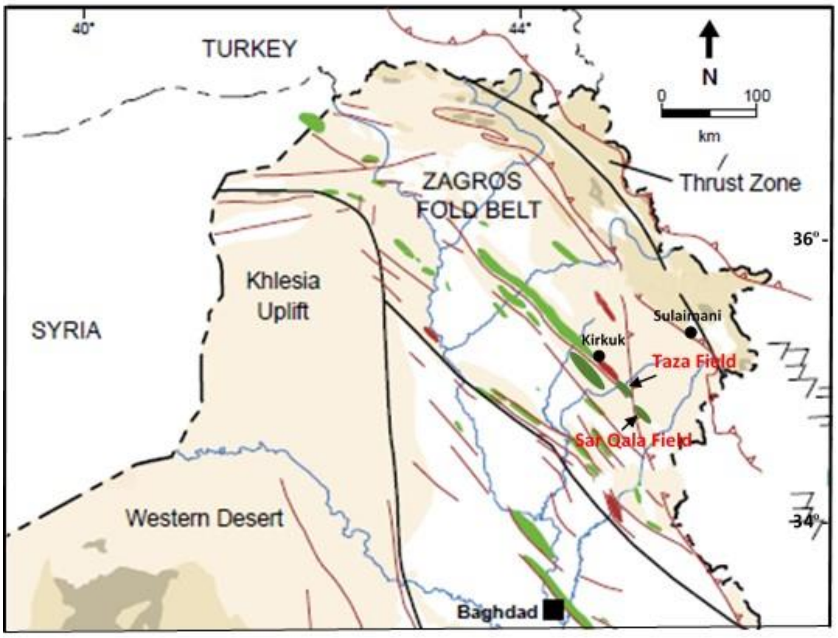


Fig. 1: Location of the studied fields of Taza and Sa Qala (the map is after [10] with modifications from [11]).

Older reservoir targets are primly Shiranish, Kometan, and Qamchuqa formations, whereas the Jurassic formations of Sargelu, Naokelekan, Barsarin, and Chia Gara are considered the main source rocks that generated the hydrocarbons in the area. The Paleocene Aaliji Formation is also not out of expectation as a source rock contributed in generating the hydrocarbons in the study area [8, 12, 13].

Tectonically, the studied wells are located in a part of the Zagros Foreland Folded Zone (ZFFZ) known as Zagros Foreland Low Folded Zone (ZFLFZ) (Ibrahim, 2009). ZFLFZ constitutes of low amplitude, NW-SE anticlines separated by relatively broad synclines [14]. The study area characterized by a lot of local thrusted faults responsible of creating many fault propagated folds acting as structural traps in the area (e.g. Sarqala, Taza, Shakal, and Pulkhana fields). According to [15], the geometry of the external Zagros and the oriental Iraqi areas is characterized by thin and thick skin deformation, thus as far as the active decollement is shallow, the related structures located above this level are small. Accordingly, the relatively shallow depth and small size of the structures (fields) in the study area can be related to the thin skin deformations occurred along some Jurassic and Tertiary incompetent sedimentary layers (Naokelekan, Barsarin, and Fatha formations) [16].

3. Sarqala Field

The Sarqala Oilfield lies in the Garmian area south-east Kirkuk City. First oil from the field was achieved in 2011, while commercial shipments started in early-2015. The field contains light crude oil with an API gravity of 40° [8].

The 'Sarqala Structure' is a faulted four-way dip anticline developed in response to a deep rooted fault system forming a positive flower structure with reservoirs in the Mio-Oligocene and Jeribe/U. Dhiban. Additional structural complexity at the Jeribe/U.Dhiban level results from halokinesis, with changing thickness of the underlying Dhiban Formation. The area of the structural closure is approximately 39 km^2 (Fig. 2) [8].

The Mio-Oligocene reservoir interval (as defined by the operator company) comprises the lower Miocene age Euphrates Formation porous carbonates over tight argillaceous carbonates of Oligocene age Ibrahim and Tarjil formations.

The field has been appraised by the Sarqala-1 (Sq-1) well, which was spud in 2008 but suspended in 2009 due to equipment problems. The well struck oil in three reservoirs including the Upper Fars sandstone, the Jeribe dolo-limestone and the Oligocene reservoir.

The well of Hasira-1 (H-1, named after the Hasira Village) drilled about 30km south-east Sq-1 in the hope of achieving two objectives: the first was to appraise the extent of the oil leg previously discovered in the Jeribe reservoir at the Sq-1 well; the second was to explore the deeper Oligocene reservoir that could not be evaluated when drilling Sq-1due to well control issues [17].

The well H-1 reached a total depth of 4,181.8m measured depth. Fig.3 shows the stratigraphic section of the well H-1 and the thickness of the penetrated formations. Petrophysical analysis of the wireline log data over the primary Mio-Oligocene reservoir interval shows matrix porosity development in the Euphrates Formation and fracture porosity over both the Euphrates and Ibrahim formations [17].

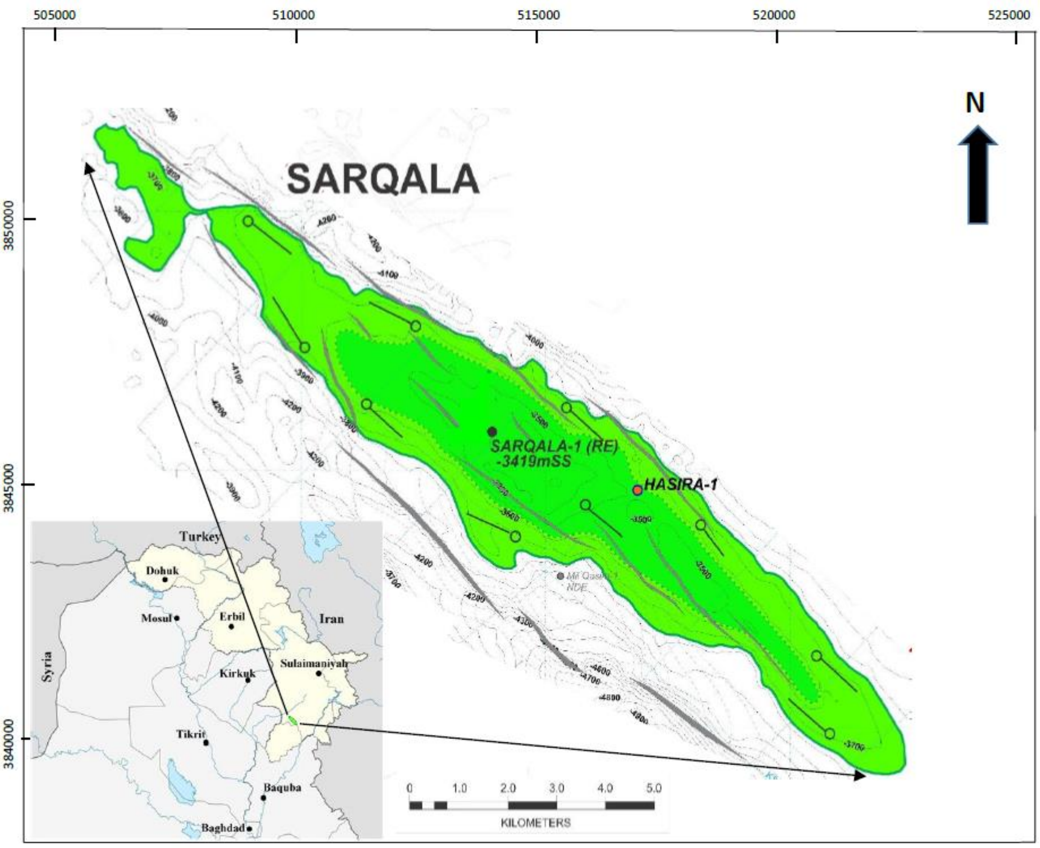


Fig. 2: Location of well Hasira -1 on structural contour map of Sarqala Oilfield (Top of Jeribe Formation), Garmian District-SE Kirkuk City, NE Iraq (modified after [18]).

4. Taza Field

Taza structure lies on structural trend with the giant producing Jambur Field to the northwest and Sarqala Field to the southeast. The first well (Tz-1) was drilled back in 2013, operated by the PNG Oil Search Company from which the company announced a proven discovery of 38°API oil, with associated gas in Jeribe/Dhiban and Euphrates/Kirkuk Group formations.

Tz-2 is located 10 km north-west of the discovery well Tz-1 (Fig.4) and drilled in 2014 to appraise the hydrocarbon-bearing intervals discovered by Tz-1. Additionally, the well drilled also to explore deeper Tertiary and Cretaceous targets, including the Cretaceous Shiranish Formation [19].

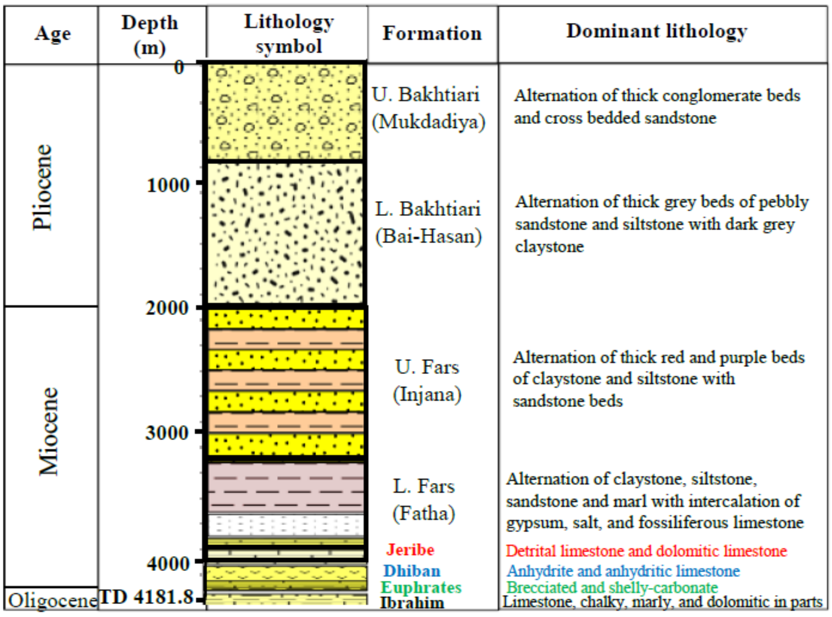


Fig. 3: Stratigraphic section of the well H-1 and the thickness of the penetrated formations with their dominant lithology (the section is after [17]).

5. Ibrahim Formation

Ibrahim Formation is initially well defined by Bellen in 1957 [1] from the well Ibrahim-1 in the Sheikh Ibrahim structure in the Foothill Zone, NW of Mosul. Lithologically, the formation consists of globigerinal marly limestone with fauna of planktonic foraminifera, flecks of pyrite and infrequent Glauconite. The thickness of the Ibrahim Formation in the type section is around 56 m. The formation deposited in basinal environment and Late Oligocene conditionally has been assigned as age of the formation [20]. The age was re-confirmed by [21]in [22], in which upper part of the Ibrahim Formation falls in the planktonic zone (P2/N3) (Chattian, Upper Oligocene) based on the occurrence of *G. Selli* and *G. nana*. Ibrahim Formation is unconformably overlain by the Lower Miocene Euphrates Formation and lies on the top of the Eocene Jaddala Formation unconformably too.

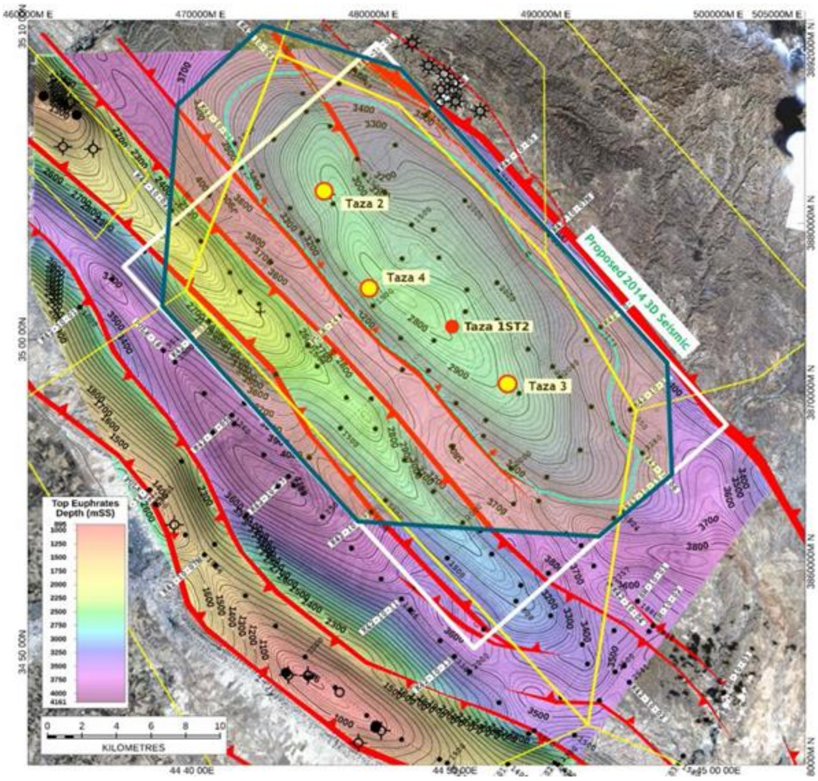


Fig. 4: Structural contour map on top of Euphrates Formation and location of the studied well Taza-3, Taza Oilfield (after [19]).

According to [23], planktonic wackestone and mud-wackestone is the most abundant microfacies type in the Ibrahim Formation, within an interval of radiolarian wackestone, which is distributed through different levels of the formation in eastern Iraq, reflecting highest deepening in a quiet depositional environment. [23] suggested their identified 160m thick Oligocene-Miocene sediments in the Zurbatiya, eastern Iraq as an alternative type section for Ibrahim Formation instead of the well Ibrahim-1.

6. Materials and Methodology

The used materials in this study includes conventional log data of Caliper, Gamma ray, Porosity logs (Density and Neutron), and Resistivity logs for the Ibrahim Formation which penetrated by the well H-1 between depths 4097m and 4135m. Additionally, core rock samples of Ibrahim Formation for the depth interval 3706.57 - 3722.9m in the well Tz-3 also used in this study for the purpose of microfacies analysis and porosity measurments.

The steps of the research methodology that followed to achieve the aims of this research are as follows:

- Digitizing the curves of the available logs using Neuralog software and replotting them in suitable scales using Interactive Petrophysics (IP) software.
- Converting the Bulk density (ρb) records of Density log to density porosity (ϴD) using the conventional Equation -1 below:

$ØD = (\rho mat - \rho b) / (\rho mat - \rho fl)$ ……Eq. 1

Where:

ØD: Density porosity

ρmat: Density of the matrix in gm/cc (2.71 for limestone the cases of this study)

ρb: Bulk density at any depth in gm/cc (from the log)

ρfl: Density of the mud filtrate in gm/cc (1.1 for salt water, the case of this study)

- Calculating shale volume using the data of the Gamma ray through applying Eq.2 for calculating gamma ray index (GRI) and then the equation of [24] (Eq.3) for calculating shale volume in the Tertiary rocks (the case of Ibrahim Formation).

$GRI = (GRlog - GRmin) / (GRmax - GRmin)$ ….. Eq.2

$Vsh = 0.083\ (2^{(3.71*GRI)} - 1.0)$ ………….. Eq.3

Where:

GRI: Gamma ray index

GRlog: Gamma ray reading from log (at any depth)

GRmin: Minimum gamma ray reading (from log at a clean zone)

GRmax: Maximum gamma ray reading (from log at a shale zone)

Vsh: Volume of shale

- Correcting the calculated density porosity and the recorded neutron porosities from shale impact depending on the proposed equations by [25] (Eq.4 for density porosity and Eq.5 for neutron porosity).

$ØDcorr = ØD - (Vsh \times ØDsh)$ ………Eq. 4

$ØNcorr = ØN - (Vsh \times ØNsh)$ ……….Eq. 5

Where:

ØDcorr: corrected density porosity

ØD: uncorrected density porosity

ØDsh: density porosity for adjacent shale

Vsh: volume of shale

ØNcorr: corrected neutron porosity

ØN: uncorrected neutron porosity

ØNsh: neutron porosity for adjacent shale

- Preparing and calculating the necessary parameter values and ratios (i.e formation water resistivity, Rw; Cementation exponent, m) for applying them in specific crossplots and diagrams in order to find out the requested properties of the studied Ibrahim Formation.
- Calculating water and hydrocarbon saturations for the Ibrahim Formation in the well H-1 through applying Archie's equations (Eqs.6 - 9).

$Sw = (F.\ Rw/Rt)^n$ ……… Eq.6

$Sxo = (F.\ Rmf/Rxo)^n$ … Eq.7

$Shr = 1 - Sxo$ ……………Eq.8

$Shm = 1 - Sw - Shr$………….Eq.9

Where:

Sw: water saturation in the uninvaded zone

F: formation factor

Rw: formation water resistivity

Rt: true resistivity of the formation that can be read from the deep resistivity log.

n: saturation exponent (usually = 2.0)

Sxo: water saturation in the flushed zone

Rmf: resistivity of the mud filtrate

Rxo: resistivity of the flushed zone

Shr: residual hydrocarbon saturation

Shm: movable hydrocarbon saturation

- Calculating Bulk Volume Water (BVW) which is the product of the reservoirs water saturation and its porosity (Eq. 10).

$BVW = Sw * Ø$.............Eq. 10

- Calculating Movable Hydrocarbon Index (MHI) which the ratio of water saturation in the uninvaded zone (Sw) to the water saturation in the flushed zone (Sxo) (Eq.11).

$Sw/Sxo = [(Rxo/Rt) / (Rw/Rmf)]^{0.5}$ ……Eq. 11

- Preparing thin sections from selected core rock samples of the Oligocene beds of the well Tz-3 and study them using transmitted light microscopy to find out the microfacies, porosity type, and diagenesis processes affected the formation.
- Mesuring porosity for the selected core plug samples of the well Tz-3 using Gas Porosimeter in the Geology Department of the Sulaimani University. The used gas porosimeter was of the model OFITE, BLP-530 which originally designed to measure porosity of the rocks on the basis of Boyle's law. Methane used as a test gas in the porosity mesurements.

7. Results and Discussion

7.1 Lithology Detecting from Neutron-Density Crossplot:

The readings of both neutron and density logs for the studied Ibrahim Formation in well H-1 are used in the N-D crossplot for detecting the lithology of the formation (Fig.5). Limestone appeared to be the common lithology of the Ibrahim Formation in the well H-1in addition to dolomitic limestone lithology in parts. As most of the sample points are of gamma ray readings between 30 and 60API, so preliminarily, Ibrahim Formation in the H-1 well looks to be containing appreciable percentages of shale.

7.2 Gamma Ray Log and Volume of Shale Calculation:

The recorded gamma ray log for the Ibrahim Formation in the well H-1 is shown in Fig.5. The recorded gamma ray values are fluctuated between 35 and 65API.

Gamma ray index and shale volume are calculated for the Ibrahim Formation by applying Eq.2 and Larionov's equation (Eq.3) respectively (Fig. 6).

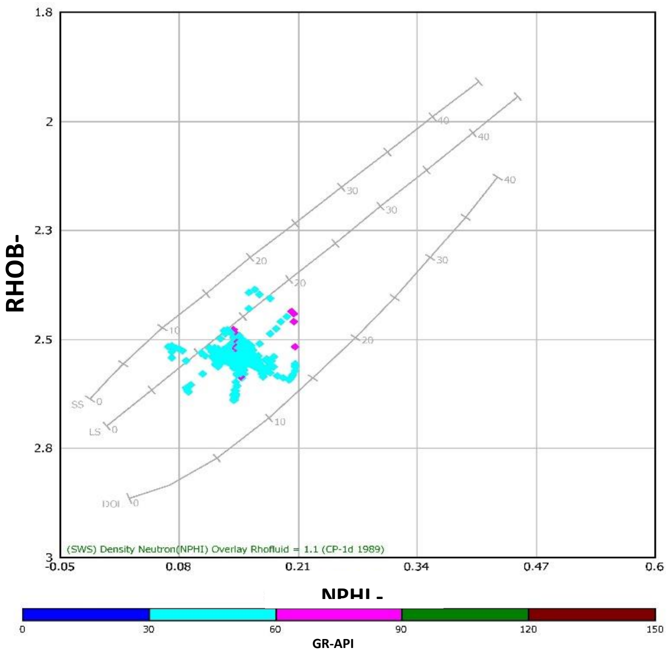


Fig. 5: Lithology identification from N-D crossplot for the Ibrahim Formation in the well H-1 (The crossplot is after [26]).

The proposed standard by [27] for describing shaleness in reservoirs is depended on to distinguish between clean, shaly, and shale zones. According to [27], beds with less than 10% shale content considered clean; beds with shale content between 10% and 35% are shaly, whereas beds containing more than 35% shale content are considered shale. It's clear that the overall studied section comprises of shaly zone with the existence of some shale zones which consecutively supported by high gamma-ray readings at those intervals. No clean zones recorded in the formation and hence, Ibrahim Formation thought to be of shaly nature in the studied well of H-1.

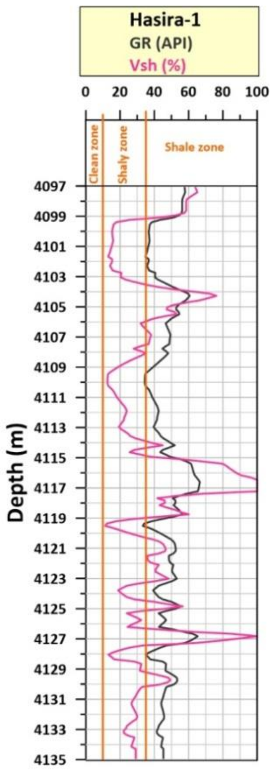


Fig. 6: The record of the Gamma-ray log and the calculated volume of shale for the Ibrahim Formation in the well H-1.

7.3 Porosity Logs and porosity Calculation:

Neutron and density logs were available for calculating the porosity. Neutron porosity directly obtained from the neutron log records. As the main lithology of Ibrahim Formation is limestone and the used drilling fluid in the well is salt-based mud, so, the value of 2.71 gm/cc for ρmat and the value of 1.1 gm/cc for ρfl are used when Eq. 1 applied for calculating density porosity of the Ibrahim Formation in the well H-1. The recorded values of neutron porosity, the calculated values of density porosity, and the average of N-D porosity are shown as curves in Fig. 7.

7.4 Correction of Porosity from Shale Effect:

The neutron, density porosities have to be corrected from the effect of shale. The proposed equations by [25] (Eq.4 for density porosity and Eq.5 for neutron porosity) are applied to correct the measured porosities from shale impact. The uncorrected and corrected density porosity (ØD), neutron porosity (ØN), and combination neutron-density porosity (ØND) with the calculated shale volume are displayed as curves in Fig.7. After correction, Ibrahim Formation showed an apparent reduction in ØN and ØND porosities in the overall section of the well and the reduction being higher at those intervals where shaleness is more than 35%. As a tool, the density logging tool looks to be less effected by the shale impact than the neutron logging tool, therefore no obvious reduction noticed in the calculated ØD values after correction from the shale impact. On the other hand, the existence of anhydrites (of higher density than limestone) within the lithology of the Ibrahim Formation [18] reduces the effect of the shale content (of less density than limestone) when Eq.1 applied using 2.71gm/cc as ρmat for limestone as the common lithology of Ibrahim Formation.

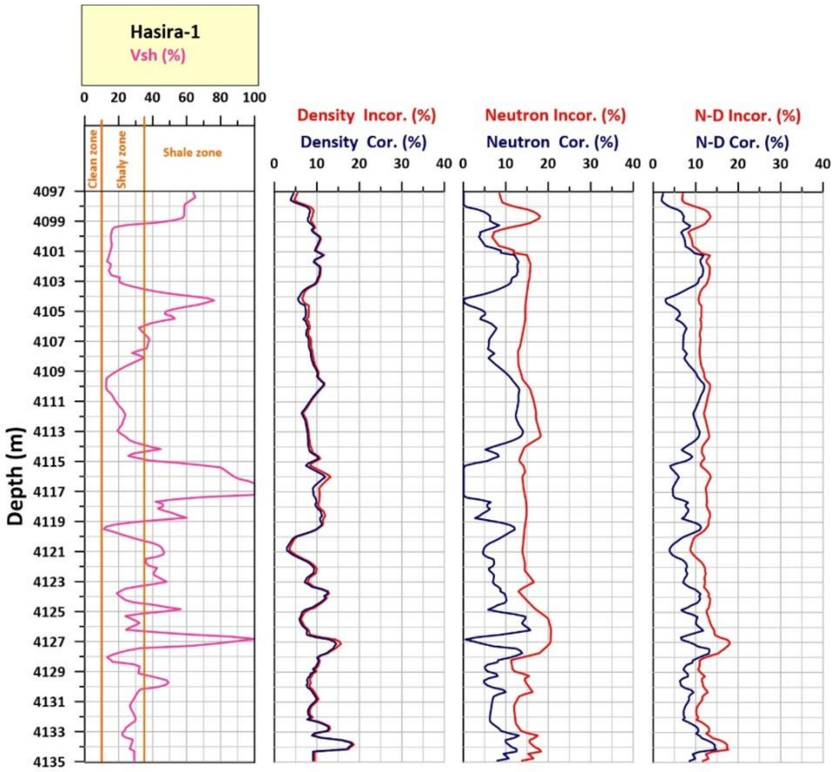


Fig. 7: Shale content and the incorrect and corrected porosities from shale effect for the studied Ibrahim Formation in the well H-1.

The values of N-D porosity for the Ibrahim Formation are qualitatively evaluated as advised by [28] (Table 1). The formation characterized by poor porosity, as the average ØND porosity appeared to be about 8%. The maximum recorded porosity is around 15% (Good porosity) at depths of 4133.8m and 4134.1m, which located at the lower most part of the studied Ibrahim Formation where shale content is generally less than 30%.

Table 1: Qualitative description of porosity and permeability as proposed by [28]

Qualitative description	Porosity (Θ, %)	Qualitative description	Permeability (K, mD)
Negligible	0-5	Poor to Fair	1.0 – 15
Poor	5-10	Moderate	15 – 50
Good	15-20	Good	50 – 250
Very Good	20-30	Very good	250 – 1000
Excellent	>30	Excellent	>1000

7.5 Neutron-Density Crossover:

The plot of the Neutron-Density crossover curves assists in detecting the type of hydrocarbons in the reservoir. Fig. 8 displays the crossover of neutron and density porosity curves for the studied Ibrahim Formation in the well H-1. As appear from the figure, separation between the two curves are clear at many depth intervals, which indicates to the existence of hydrocarbons. The wide separation between both curves (being neutron porosity of lower values than density porosity) signs to accumulation of gas or very light oil in the pore spaces of Ibrahim Formation in the well H-1. Relatively thick water bearing zones are intercalated the hydrocarbon bearing zones such as in the depth intervals 4101-4103m, 4109-4114m, and 4125-4127m. Usually, high water saturation zones in reservoirs are associated with low porosities due to the high capillary pressure of such zones resulted from the small diameters of the pore throats and hence disability of the hydrocarbons in overcome the capillary pressure and replace the water in the pores. But this is not the case at the water bearing zones of Ibrahim Formation at the mentioned depths, and accordingly those depth intervals should be better investigated to find out a reasonable explanation for the case.

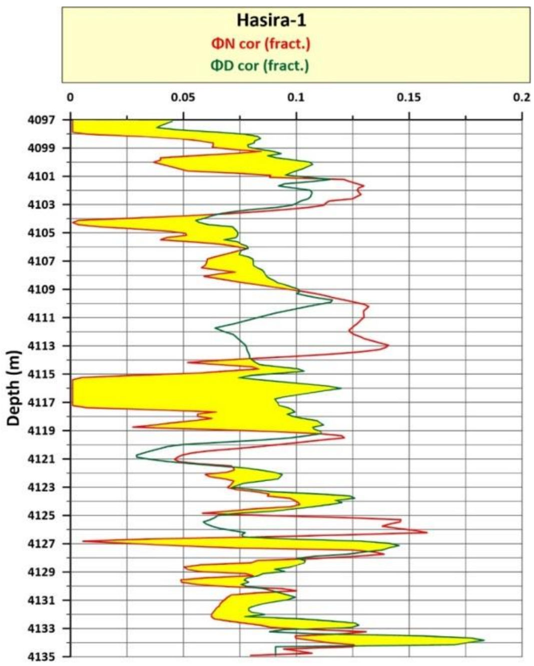


Fig. 8: Crossover of Neutron and Density porosity curves for the Ibrahim Formation in the well H-1.

7.6 Permeability (K) estimation:

Core test data (porosity and permeability) were not available for the studied Ibrahim Formation in the well H-1. Therefore, multi linear regression technique (MLR) was used for the permeability estimation from the accessible well log data. Permeability has been calculated for selected depths through applying the proposed equation by [29] (Eq.12).

$K = C^* (\Theta)^3 / (Swirr)^2$ …….Eq. 12

Where:

K: permeability

C: constant depending on hydrocarbons density (C=250 for medium density oil, C=79 for dry gas)

Ө: porosity

Swirr: irreducible water saturation.

The selected depths are those that believed to be of the lowest water saturation (at or very close to the irreducible water saturation condition, Swirr). MLR method applied to find out the best equation representing relationship between the calculated permeability values (as dependent values) and the different log values for the same selected depths (as independent values). Thus, Eq.12 appeared to be the best to be applied as shown from the excellent matching between the two curves of the permeability that calculated using both Eqs. 11 and 12 (Fig.9). Accordingly, Eq.13 applied later for calculating permeability for the whole Ibrahim Formation in the well H-1 as shown in Fig.10.

$K = 192.6569 + (-0.52498*GR) + (137.4748*\Theta N) + (-78.3*\rho b) + (-0.88062*LLS) + (3.550259*LLD)$…………..Eq.13

Qualitative permeability description that advised by [28] (Table 1) is used for explanation and evaluation of the calculated permeability values for the Ibrahim Formation in the well H-1. The following are noticed about the permeability of the Ibrahim Formation in the studied well:

- Generally, Ibrahim Formation considers as of poor to fair permeability (with an average permeability about 1.9 mD).
- The maximum permeability (around 11.30mD) recorded at depth 4126m, which associated with about 12% porosity.
- Existence of either high shale content (e.g. at depths of 4104m and 4116m) or high anhydrite (e.g. at depths of 4100m and 4114m) caused no or zero permeability at those depth intervals within Ibrahim Formation.
- The depth intervals that believed to be water bearing zones are showed considerable permeability values (between 6 and 11mD). In case of being fractures providing the permeability at those zones, the only explanation for the existence of the water is being due to easily filtering of the drilling mud and deeply invading the reservoir. Accordingly, it's expected to be the recorded resistivities in those intervals of relatively lower values than the adjacent zones.

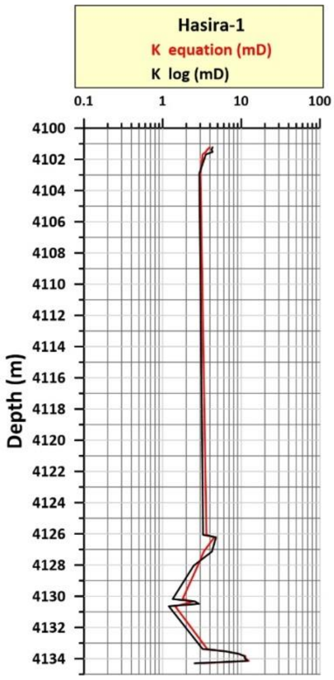


Fig. 9: Matching between the measured permeability from equation and from MLR method for the studied Ibrahim Formation in the well H-1.

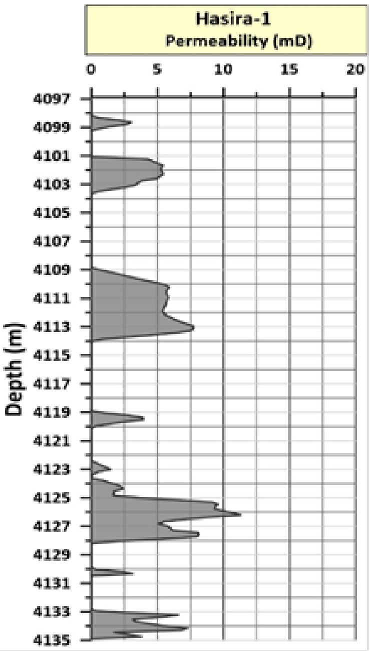


Fig. 10: Calculated permeability from log data for the studied Ibrahim Formation in the well H-1.

7.7 Reservoir Units:

Ibrahim Formation in the studied well H-1 is divided into five identifiable reservoir units (Fig. 11) based on the variations in the calculated values of porosity, permeability and shale content (Table 2). Vertical variation in the reservoir properties of the Ibrahim Formation in the well H-1 is very clear and observable. Such variations are mostly occur due to either change in the paleo-depositional environment with time during deposition of Ibrahim Formation or due to the diagenetic processes occurred later and lead to kind of heterogeneity in the reservoir properties of the Ibrahim Formation at the location of the well H-1.

7.7.1 Reservoir Unit 1 (RU-1):

This reservoir unit represents the lower most part of Ibrahim Formation with a thickness of about 7m. This unit is characterized by poor porosity (9%) and poor to fair permeability (1.34 mD). The maximum porosity recorded in this unit is about 15%. Average shale content is around 30%. Lithologically, composed mainly of limestone with the existence of anhydrite inclusions.

7.7.2 Reservoir Unit 2 (RU-2):

The dominant lithology of this unit is argillaceous limestone. This unit characterized by its low thickness (about 3m) among all the identified reservoir units. Average porosity is around 10% and average permeability about 7.68 mD. Although this unit is of relatively high shale content (around 44%) but still its porosity and permeability is noticeable if compared with the other parts of the formation. The contribution of fractures in providing permeability and contributing in the total porosity is highly expected.

7.7.3 Reservoir Unit 3 (RU-3):

Maximum average shale content among the distinguished reservoir units is recorded in this unit, which was about 48%. Minimum average of both porosity and permeability (approximately 7% and 0.48 mD respectively) are also recorded in this unit. The existence of high shale content in this unit has a destructive impact on both reservoir properties of porosity and permeability. Thus, this unit is the poorest unit amongst the others from the reservoir property point of view. Limestone and argillaceous limestone with anhydrite are the dominant lithologies of this unit.

7.7.4 Reservoir Unit 4 (RU-4):

From the shale content perspective, this unit is of lowest shale content (about 20%). The recorded average porosity is around 10% (fair) and average permeability approximates 5.11 mD (poor to fair). Besides the minimum average shale content, poor to fair reservoir quality is noticeable in this unit. Lithologically, composed of slightly argillaceous limestone in addition to considerable anhydrite content. Such extent of anhydrite enclosure undoubtedly has an impression on the porosity and permeability because anhydrite is known as dense, non-porous and impermeable lithology.

7.7.5 Reservoir Unit 5 (RU-5):

This unit is of high thickness (around 12m) and represent the upper most part of Ibrahim Formation in the well H-1. Characterized by high average shale content (about 36%). The average porosity is about 7% (poor porosity) and the average permeability close to 1.0 mD (poor permeability). The properties of this unit is somewhat similar to the RU-3. From the reservoir potentiality lookout, this unit has no significant porosity and permeability. As a lithology, it comprises chiefly of argillaceous limestone and inclusions of anhydrite.

Finally, due to the argillaceous nature, the recognized reservoir units of Ibrahim Formation in the studied H-1 well are generally of poor reservoir quality. Although, both reservoir units of RU-1 and RU-3 are relatively of lower shale content if compared to the other units but still of no significant porosity and permeability.

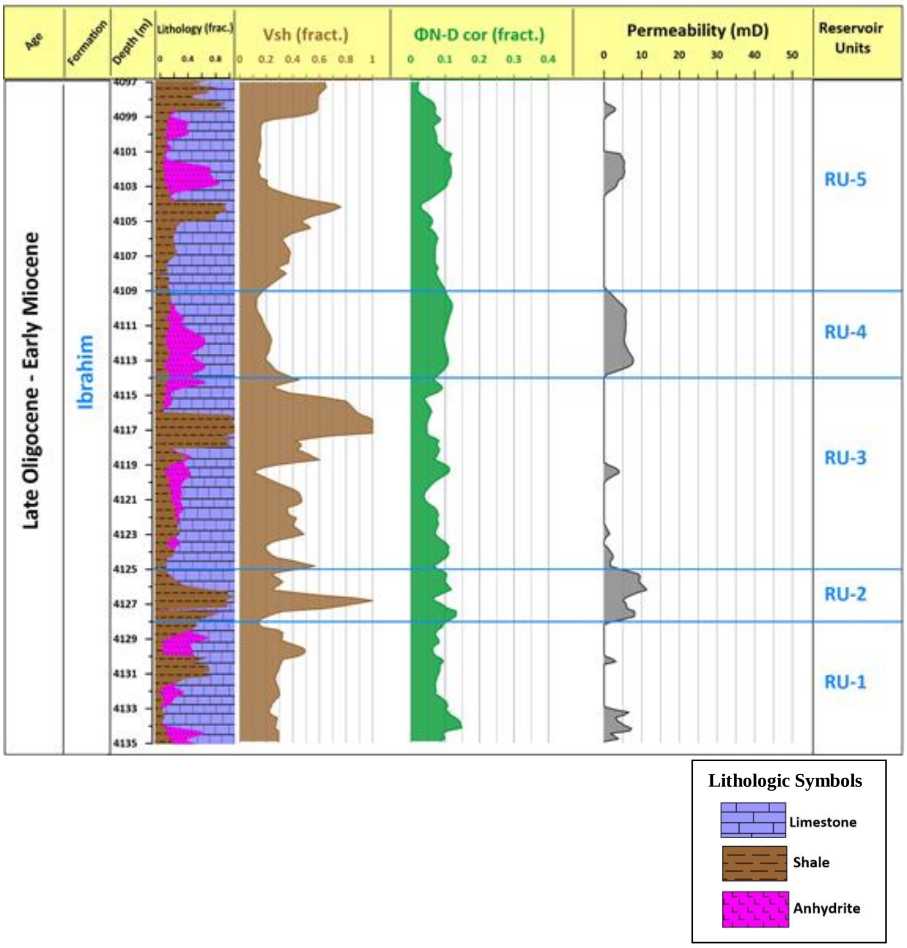


Figure 11: Division of Ibrahim Formation into reservoir units on the bases of variations in shale content, porosity, and permeability in the well H-1.

Table 2: Minimum, maximum and average values of shale volume, porosity, and permeability for the recognized reservoir units of the Ibrahim Formation in the well H-1.

Reservoir Units	Depth Interval (m)	Thickness (m)	Statistics	Vsh (%)	Porosity (%)	Permeability (mD)
RU-5	4097-4109	12	Min	13	2	0.00
			Max	76	12	5.46
			Average	36	7	0.99
RU-4	4109-4114	5	Min	13	8	0.62
			Max	34	12	7.72
			Average	20	10	5.11
RU-3	4114-4125	11	Min	11	4	0.00
			Max	100	11	3.95
			Average	48	7	0.48
RU-2	4125-4128	3	Min	16	7	3.72
			Max	100	13	11.30
			Average	44	10	7.68
RU-1	4128-4135	7	Min	13	6	0.00
			Max	49	15	7.29
			Average	30	9	1.34
Total Thickness (m)		**38**				

7.8 Resistivity Logs:

The readings of the Laterolog Shallow (LLS) and Laterolog Deep (LLD) for the studied Ibrahim Formation in the well H-1 are shown as curve plot in the Fig.12. During the drilling of the formation in the well H-1, salt-water based mud was used. Comparatively, low resistivity values are predicted along the entire section of the studied Ibrahim Formation. Separation between the curves occurred at some intervals (being values of the true resistivity of the uninvaded zone, Rt, greater than the resistivity values of the flushed zone, Rxo), and denoted probable hydrocarbon bearing zones, while non-separation between the curves refer to water-bearing zones.

7.9 Formation Water Resistivity (Rw) and Cementation Exponent (m):

The measured formation water resistivity by the oil company has been used, and corrected for the studied Ibrahim Formation's temperature in the well H-1. The corrected Rw is about 0.011 ohm.m. Depending on the corrected Rw value, Rt values, and the ΘD values; the cementation exponents estimated using the technique of Pickett's crossplot and appeared to be equal to 1.43 (Fig. 13).

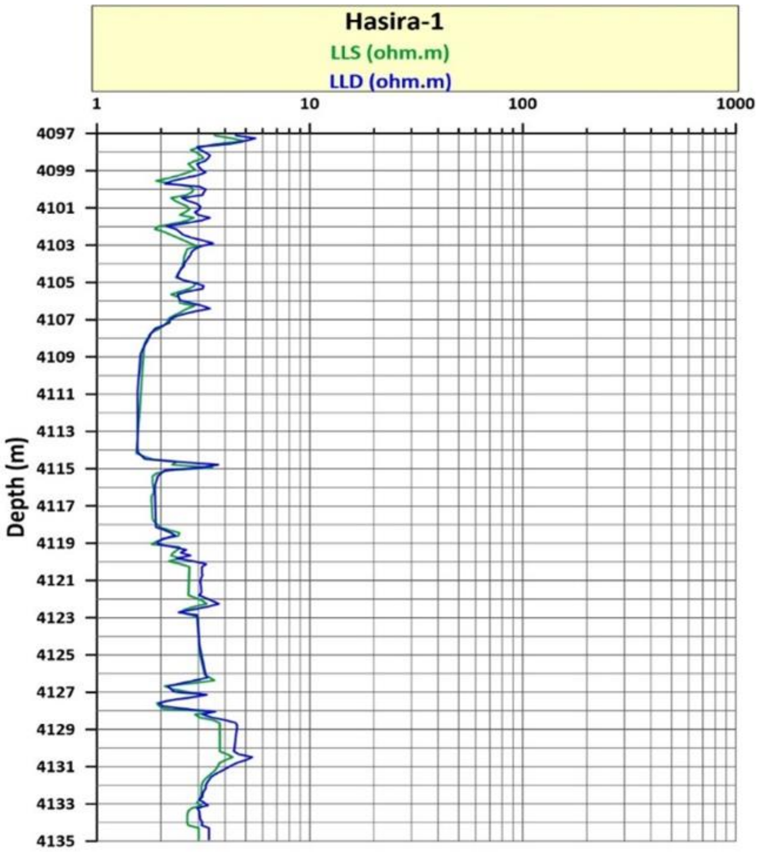


Fig. 12: The recorded LLS and LLD logs for the Ibrahim Formation in the studied well H-1.

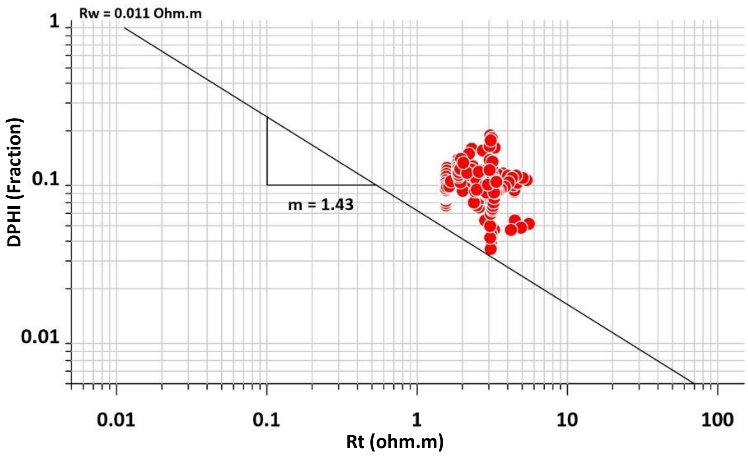
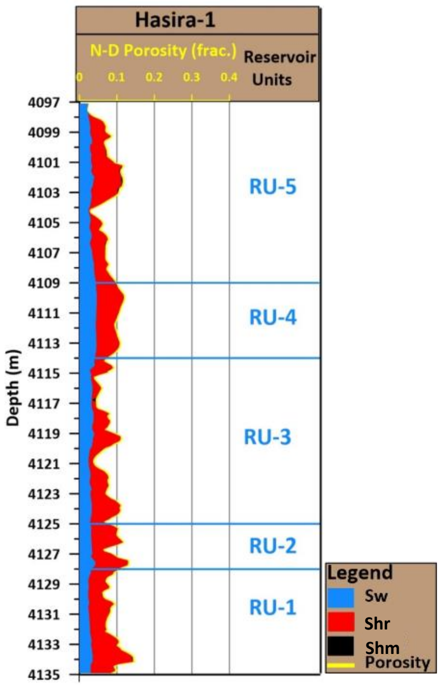


Fig. 13: Pickett's crossplot for estimation of cementation exponent (m) for the studied Ibrahim Formation in the well H-1.

7.10 Water and Hydrocarbon saturations:

Water saturation (Sw) in the flushed and uninvaded zones are calculated when all the parameters became available for applying Archie's equation (Eqs. 6 and 7). Subsequently, the residual hydrocarbon saturation (Shr) and movable hydrocarbon saturation (Shm) are calculated as well for the studied Ibrahim Formation in the well H-1 using Eqs. 8 and 9 respectively then the three saturations are plotted as curves in Fig. 14.



Figures 14: Water saturation and hydrocarbon saturation (residual and movable) with regard to porosity for the studied Ibrahim Formation in the well H-1.

Generally, the low porosity and the high volume of shale in the Ibrahim Formation caused existence of considerable water saturations along the formation. Highest water saturation values can be observed in zones of lowest porosity (i.e. 4097.5m, 4104m, 4115-4117m, and 4121m). As a rule of thumb, low porosity (small pore spaces and narrow pore throats) are often of high capillary pressure and thus the enclosed water within the pore spaces need a high buoyancy force to be inserted by the hydrocarbons for displace the water and invade the pore spaces. Additionally, wettability in tiny pore spaces play an effective role in increasing the capillary pressure especially in highly water wet reservoirs.

Although nearly the whole section of Ibrahim Formation in the well H-1 is containing hydrocarbons in different ratios but almost all of the hydrocarbons are residual with no ability to move.

7.11 Bulk Volume of Water (BVW):

Bulk Volume of Water for the studied Ibrahim Formation in the well H-1 has been calculated through applying Eq.10 and the values for the identified five reservoir units are displayed as plot in Fig. 15.

When values of BVW at different depths of a reservoir appear to be constant or very close to constant that means the reservoir is homogeneous and it's at irreducible water saturation (Swirr) condition [30]. Any reservoir at irreducible water saturation produces water free hydrocarbons, whereas reservoirs not at irreducible water saturation commonly show wide variations in the values of BVW.

In this study, Buckles plot is used to find out which of the identified reservoir units of Ibrahim Formation are in irreducible water saturation condition and which are not. Buckles plot according to [31] is a graph of porosity versus water saturation suggested by Buckles in 1965. Points of equal BVW form hyperbolic curves across this plot. If BVW is plotted using data from a formation at irreducible water saturation, the sample points fall along a single hyperbolic curve. If the data come from reservoirs with higher percentages of produced water, the points are more scattered.

Reservoir Unit 1 (RU-1) showed closely constant distribution of BVW values typically around the 0.02 hyperbolic line of BVW, while Reservoir Unit 2 (RU-2) showed BVW values around the hyperbolic lines 0.02 and 0.04 (Fig. 15). The BVW values in the Reservoir Unit 3 (RU-3) are in the range of 0.02 to 0.04 hyperbolic lines (being most of the sample points near the line 0.02 BVW). The concentration of the all points around the hyperbolic line 0.04 regularly is the characteristic feature of the Reservoir Unit 4 (RU-4) which means that the water saturations in this reservoir unit of Ibrahim Formation are very close to the irreducible state. Reservoir unit 5 (RU-5) is similar to the mentioned RU-3 in the view point of the BVW value distribution which remain between hyperbolic lines 0.02 and 0.04 with highest number of the points being close to the 0.02 line (Fig. 15).

Depending on above and in case hydrocarbon can be produced, RU-1 and RU-4 are regarded as attractive units of the Ibrahim Formation for hydrocarbon production with a lesser amount of associated water production, whereas hydrocarbon production in the other units will accompanied with appreciable quantity of water.

As the amount of water hold by capillary pressure in a reservoir will increase with decreasing grain size, therefore the BVW values also increase with decreasing grain size [31]. From the calculated BVW values for the identified reservoir units, intercrytslline (intergranular) is expected to be the dominant porosity type in all the reservoir units of Ibrahim Formation in the well H-1 [30]. Chalky porosity only exist at depth interval 4109.6-4110.5m which resemble to the reservoir unit RU-4.

7.12 Movable Hydrocarbon Index (MHI):

MHI has been calculated for the identified reservoir units of the studied Ibrahim Formation in the well H-1 by applying Eq. 11. According to [32], if the ratio of Sw/Sxo (known as MHI) is equal ≥1.0, then hydrocarbons were not moved during invasion (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 [32].

Altogether, the identified reservoir units of the studied Ibrahim Formation in the well H-1 seem to have no ability to produced hydrocarbons effectively as the calculated MHI along the Ibrahim Formation are greater than cutoff value of 0.6 (Fig. 16).

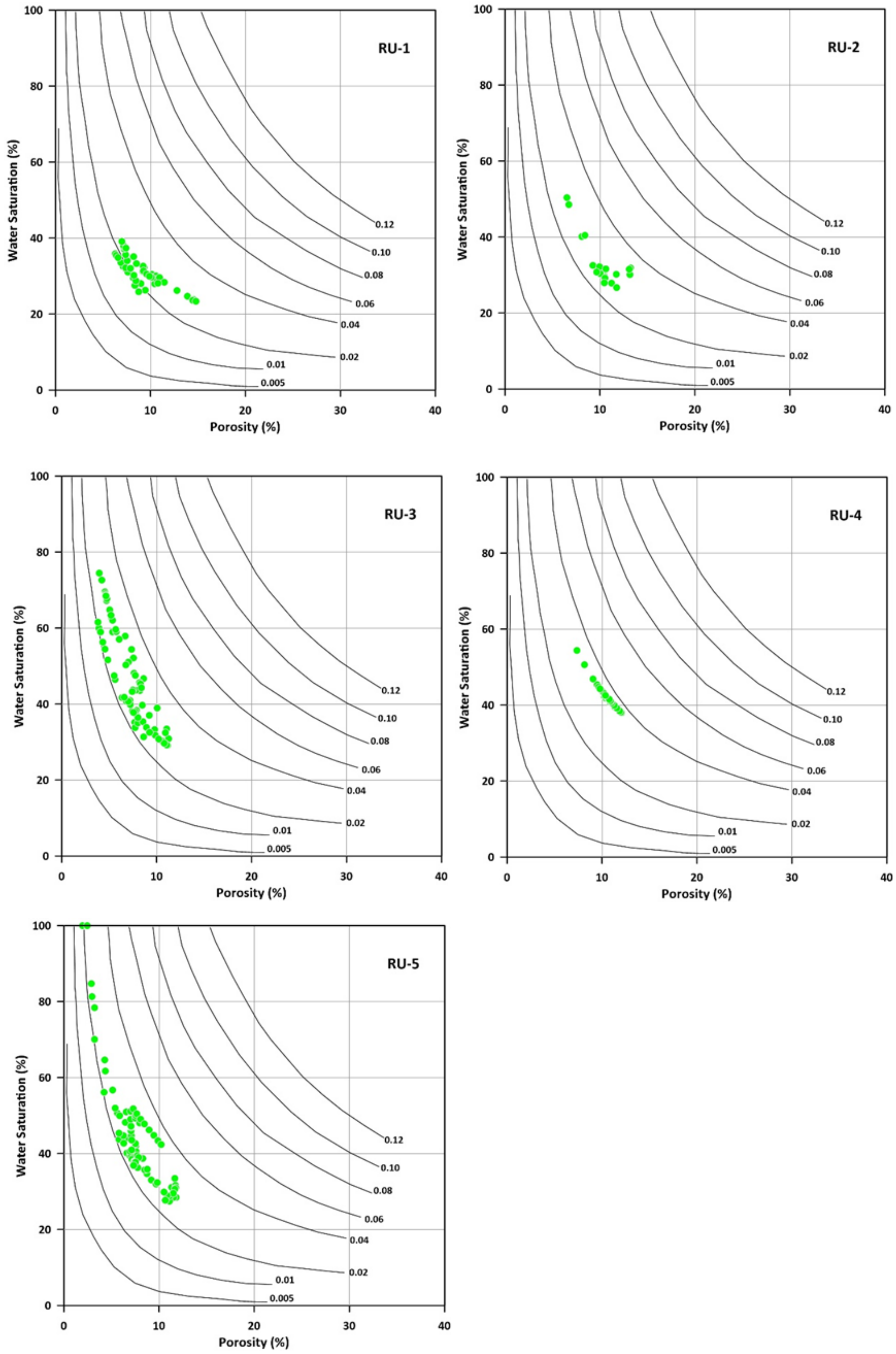


Fig. 15: Buckles plot for the BVW values of the reservoir units of the Ibrahim Formation in the studied well H-1.

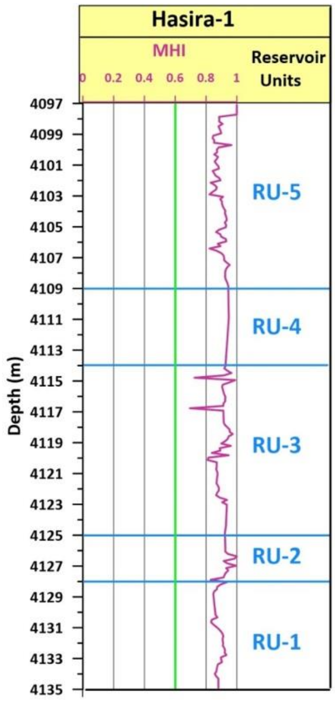


Fig. 16: Movable Hydrocarbon Index for the studied Ibrahim Formation in the well H-1.

7.13 Identification of the Ibrahim Formation in the well Taza-3 (Tz-3):

The appraisal deviated well of Tz-3 is drilled by Oil Search Company in 2014 near the southeast plunge of the anticline for structure, reservoir, and fluid constraint [19] (Fig. 4). As stated by the company, during drilling of the well Tz -3, they took core samples from an interval between 3706.3m and 3723.9m (about 18m thickness) nominated by the company generally as Oligocene Kirkuk Group without recognizing of any formation from the group. Later, and before the company suspending its activities in Kurdistan Region, the mentioned core samples were among the materials that the Oil Search Company has offered to the Department of Geology / Sulaimani University.

In this study, twenty-four thin sections were prepared from the mentioned cored samples and studied optically under transmitted light microscopy in order to identify which formation of Oligocene is exactly drilled and cored. Correspondingly, seventeen horizontal core plug samples selected for the purpose of measuring porosity by using Gas-Porosimeter instrument in the Geology Department of Sulaimani University.

After examining the thin sections under transmitted light microscopy, planktonic foraminifera appeared to be the most dominant fossils associated with some algae and radiolarian spines. Planktonic Foraminifera bearing Packstone was the only microfacies that represented the studied section. The lithology of the studied core samples was primly consists of argillaceous and marly limestone. Based on the identified planktonic foraminifera's species and the lithology, the studied core samples appeared to be belonging to basinal Ibrahim Formation of the Late Oligocene – Early Miocene age.

Plates 1 shows figures for the recognized Planktonic Foraminifera bearing Packstone microfacies type, whereas plates 2 and 3 shows the identified planktonic foraminifera's species that aid in recognizing Ibrahim Formation.

7.14 Evaluation of Ibrahim Formation in the well Tz-3:

The porosity for the mentioned seventeen available horizontal core plug samples were measured using Gas-Porosimeter. The measured porosity for the tested samples are listed in Table 3 and shown as curve in Fig.17. Ibrahim Formation in the well Tz-3 characterized by poor reservoir quality as noticed from the values of the porosity, which as an average was around 5.1% (poor porosity). The only exception was the sample at depth 3714m from which the maximum measured porosity recorded and was 19.6% (good porosity). The only mentioned porosity type by the Oil Search Company is the existence of the fracture porosity which has observed from the sidewall plug samples [33].

Conventional well log data of Ibrahim Formation in the well Tz-3 were not available for this study, therefore no calibration done for the measured porosity by Gas-Porosimeter with the recorded or calculated porosities by logs.

From porosity perspective, the Ibrahim Formation in the well H-1 with the average ϴND of about 8% is somehow of higher porosity than the Ibrahim Formation in the well Tz-3, but still the formation in the both wells considers as of poor porosity and poor reservoir quality. The basinal nature of the formation's depositional environment and the high shale content are the main reasons behind such poor reservoir quality of the formation.

Plate–1

The bar is equal to 100µm

A. Planktonic Foraminifera bearing Packstone Microfacies, Depth 3709m, Sample No. 5.

B. Planktonic Foraminifera bearing Packstone Microfacies, Depth 3720m, Sample No. 21.

Plate–2

The bar is equal to 100µm

A. *Operculina complanata* Defrance, 1822, (axial section), Pyritization effect, Depth 3707.15m, Sample No. 2.

B. *Globigerinoides bisphericus* Todd, 1954, Depth 3720m, Sample No. 17.

C. *Globigerina ampliapertura* Bolli, 1954, Depth 3709m, Sample No. 5.

D. *Globigerina ampliapertura* Bolli, 1954, Depth 3714m, Sample No. 11.

E. *Globigerinoides quaderilobatus* d'Orbigny, 1846, Depth 3710.8m, Sample No. 7.

F. *Orbulina* sp., Depth 3713.35m, Sample No. 10.

G. *Globoquadrina* sp., Pyritization effect, Depth 3714m, Sample No. 11.
H. *Globigerinoides trilobus* Reuss, 1850, (axial section), Depth 3714.50m, Sample No. 12.
I. *Scherochorella congoensis* Kender, Kaminski, and Jones, 2006, Depth 3714.50m, Sample No. 12.
J. *Globorotalia kugleri* Bolli, 1957 (spiral view), Depth 3721 m, Sample No. 18.
K. *Globorotalia kugleri* Bolli, 1957 (spiral view), Depth 3710m, Sample No. 6.

Plate–3
The bar is equal to 100µm
A. *Paragloborotalia opima* Bolli, 1957, Depth 3714m, Sample No. 11.
B. *Globigerinoides sicanus* de Stefani, 1952, Depth 3721.35m, Sample No. 19.
C. *Globigerina* sp., Depth 3722.05m, Sample No. 20.
D. *Globigerina bolloides* d'Orbigny, 1826, Depth 3715m, Sample No. 13.
E. *Chiloguembelina cubensis* (Palmer) Jenkinse, 1985, *(side view)*, Depth 3710m, Sample No. 6.
F. *Haplophragmium* sp., Depth 3718.20m, Sample No. 16.
G. Algae, Depth 3717m, Sample No. 14.
H. *Austrotrillina asmariensis* Adams, 1968, Depth 3717m, Sample No. 14.
I. *Brizalina alazanensis* Kender, 2008, Depth 3715m, Sample No. 13.
J. Radiolaria spine, Depth 3722.05m, Sample No. 20.
K. *Bakalovaella* sp. (Algae), Depth 3722.05m, Sample No. 20.

Plate-1

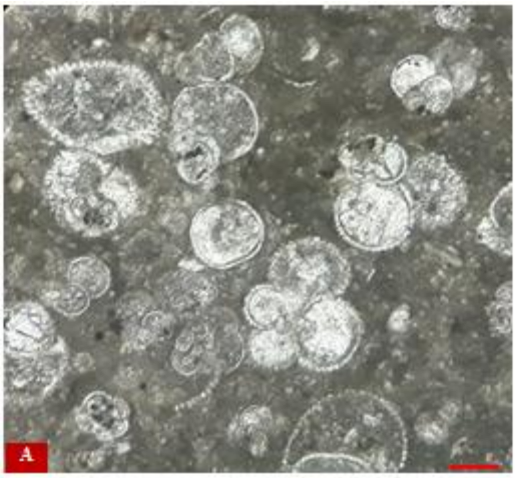


Plate - 2

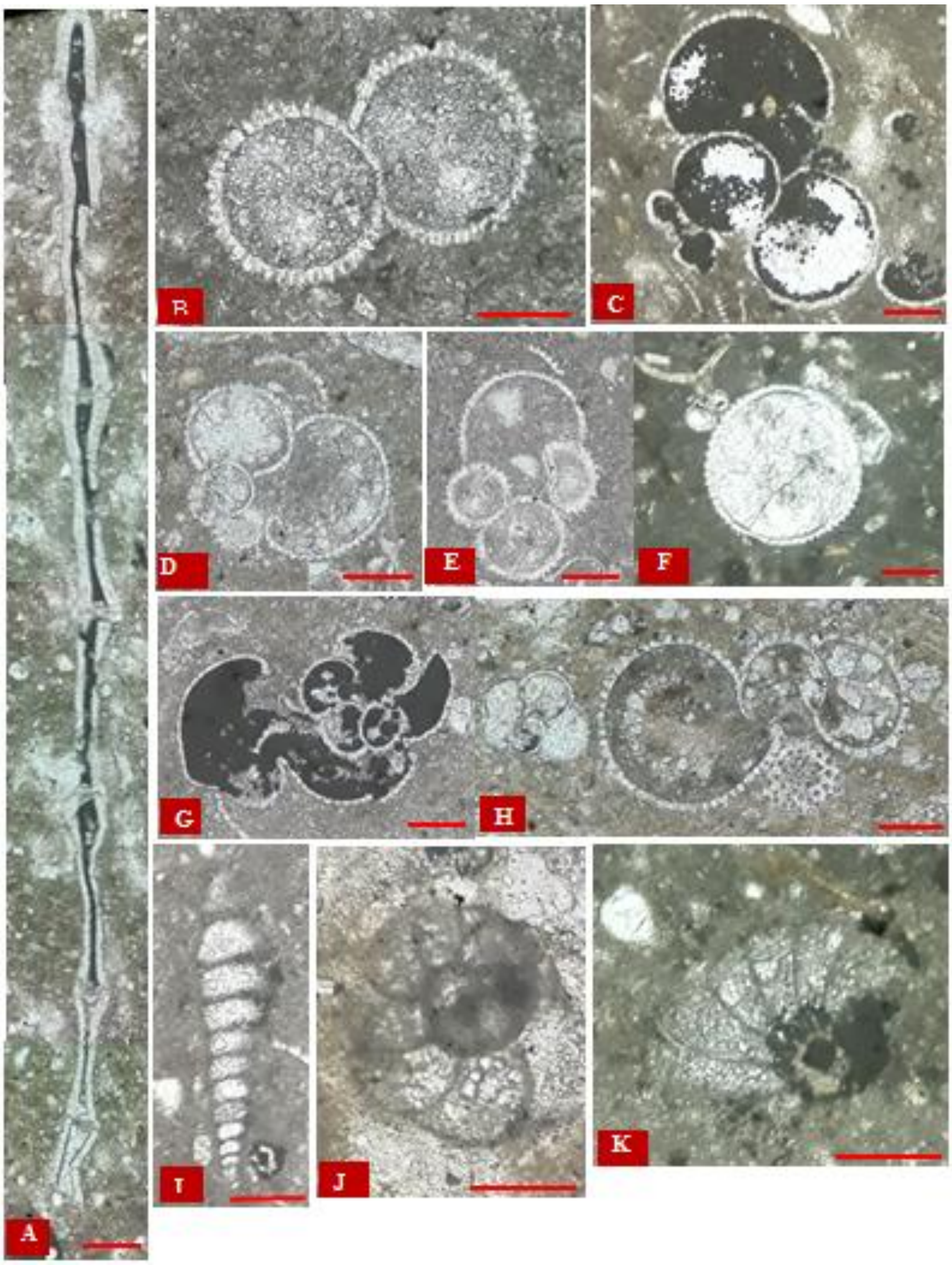


Plate-3

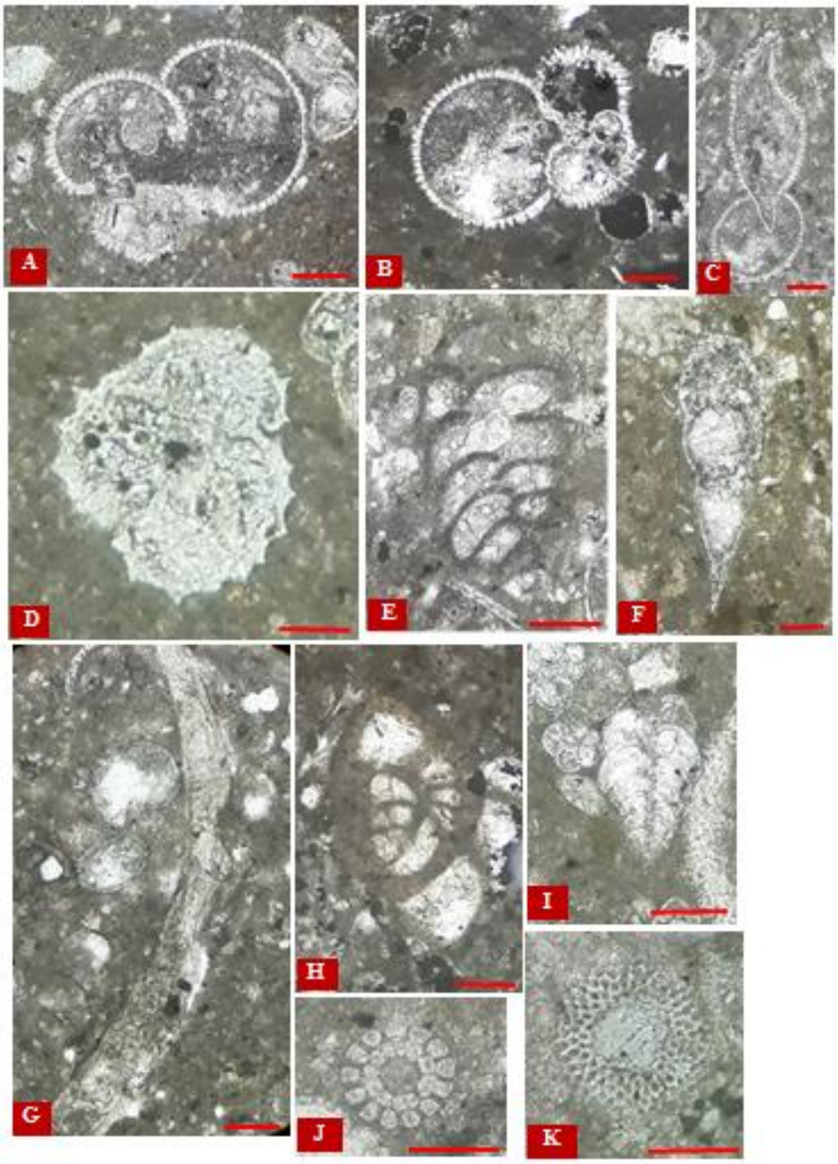


Table 3: The measured porosity by Gas-Porosimeter for selected core plugs from the studied Ibrahim Formation in the well Taza-3.

Sample No.	Depth (m)	Porosity (%)
1	3706.57	9.862
2	3707.5	4.357
3	3708.42	3.252
4	3709.6	3.481
5	3710.5	0.933
6	3711.4	5.271
7	3712.6	1.868
8	3713.23	6.975
9	3714.51	19.671
10	3715.45	5.814
11	3716.79	8.673
12	3717.39	5.380
13	3718.6	3.079
14	3719.2	2.304
15	3720.11	1.140
16	3721.09	2.872
17	3722.9	1.495

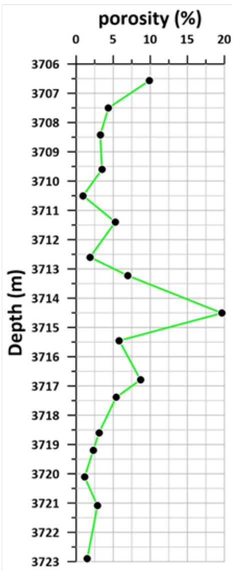


Fig. 17: Curve plot of the measured porosity for the studied Ibrahim Formation in Taza-3 well.

8. Conclusions

The Ibrahim Formation in the well H-1 consists mainly of argillaceous limestone with an average poor porosity of about 8% and poor to fair permeability with an average of about 1.9 mD. The formation can be divided to five reservoir units depending on variations in the shale content, porosity and permeability. RU-2 and RU-4 are of relatively the highest reservoir quality among the five recognized reservoir units in the formation. Hydrocarbons are exist along the Ibrahim Formation in the well H-1 but are almost completely of residual type with no effective movability for to be recovered. The examined core samples from the Ibrahim Formation in the well Taza-3 is lithologically composed of argillaceous and marly limestone and represented by the planktonic foraminifera bearing packstone microfacies. The average porosity of the tested core plug samples of the formation in the well Taza-3 is about 5%, so the formation in this well is of poor reservoir quality as it is in the well H-1.

Acknowledgments

Authors are very grateful for the Russian Gazprom Neft Oil Company, the Canadian Western Zagros Oil Company, and the Australian Oil Search Oil Company for providing the log data, core test data, and core rock samples used in this study.

References

[1] Bellen, R.C., Dunnington, H.V., Wetzel, R. and Morton, D.M. (1959). Lexique Stratigraphique International. National de la recherché scientifique, 13, quai, Anatole-France, Paris: VII, 333p.

[2] Sadooni, F.N. and Alsharhan, A.S. (2019). Regional stratigraphy, facies distribution, and hydrocarbons potential of the Oligocene strata across the Arabian Plate and Western Iran. *Carbonates and Evaporites*, **34**:1757–1770.

[3] Al-Qayim, B.A. and Khaiwka, M.H. (1980). Depositional environment and diagenesis of the Oligocene reef cycles, Kirkuk Oil field, Northern Iraq. *Modern Geology*, **7**(3): 177-190

[4] Youhanna. A.K. (1983). Biostratigraphy of some Tertiary and Cretaceous formations. Khleissia well no. 1, Northwest Iraq. (Unpublished Report), INOC, Geological Labs, Baghdad, 30 p.

[5] Al-Eisa, M.E. (1992). The two subdepositional cycles of the early Miocene in Kirkuk Oilfield area, North Iraq. *Journal of Geological Society of Iraq*. 25(1): 41-58.

[6] Al-Banna, N.Y. (2008). Oligocene / Miocene boundary in northern Iraq. GeoArabia. 13(2): 187-190.

[7] Al-Banna, N.Y., Amin, M.A. and Al-Hashimi, W.S. (2002). Oligocene-Miocene Boundary in Sheikh Ibrahim and Sasan areas, northwest Iraq. *Iraqi Journal of Earth Science.* **2** (2): 37-47.

[8] Final Report of Sarqala -1 (2011). WesternZagros Oil Company.

[9] WesternZagros (2012). http://www.westernzagros.com/documents/2012Feb WZR CorporatePresentation.pdf

[10] Pitman, J.K., Steinshouer, D. and Lewan, M.D. (2004). Petroleum generation and migration in the Mesopotamian Basin and Zagros Fold Belt of Iraq, results from a basin-modeling study: *GeoArabia*, Gulf PetroLink, Bahrain. **9**(4): 41-72.

[11] Aqrawi, A.A.M. (1998). Paleozoic stratigraphy and petroleum systems of the western and southwestern deserts of Iraq. *GeoArabia.* **3**(2): 229-247.

[12] Baban, D.H. and Ranyayi, K.S.M. (2012). Potentiality of Paleocene source rocks and their contribution in generating the accumulated oil in the Eocene Pila Spi Reservoir in Taq Taq Oil Field, Kurdistan Region, Iraq. *Arabian Journal of Geosciences.* **6**:4225–4237.

[13] Baban, D.H. (2013). Sedimentary organic matter and source rock potential of the Paleocene Aaliji Formation in Qumar Oil Field, NE Iraq. *Arabian Journal of Geosciences.* **7**: 4733–4744.

[14] Jassim, S.Z. and Goff, T. (2006). Phanerozoic development of the northern Arabian Plate, In: Jassim S.Z., Goff, J. C., Geology of Iraq, publication of Dolin, Prague and Moravian Museum, Brno: 341p.

[15] Bockel-rebella, M.O., Temps, J.M., Xavier, J.P and Flament, J.M. (1998). Zagros structural study for deep petroleum traps investigation. *Iraqi Geological Journal*. 31(2):52-68.

[16] Ibrahim, A.S. (2009). Tectonic Style and Evolution of the NW Segment of the Zagros Fold Thrust Belt, Sulaimani Governorate, Kurdistan Region NE Iraq. PhD Thesis, Sulaimani University, Iraq: 187p.

[17] Final Report of Hasira-1 (2014). Vol. 1. WesternZagros Oil Company.

[18] WesternZagros. (2014). Top Jeribe Formation Depth Structural Map.

[19] Oil Search (2014). https://www.oilsearch.com/__data/assets/pdf_file/0018/2295/1406-UBS-presentation-0c493aac-f5e6-4f91-94a0-4985ebede7e3-0.pdf

[20] Jassim, S.Z. and Buday, T. (2006). Latest Eocene – Recent Megasequence AP11 (Ch.14). In: Jassim S.Z., Goff, J. C., Geology of Iraq, publication of Dolin, Prague and Moravian Museum, Brno: 341p.

[21] Al-Hashimi, H.A.J. and Amir, R.M. (1986). Restudy of the Ibrahim Formation in the type section, Ibrahim well no.1, Mosul area, N. Iraq. *Journal of the Geological Society of Iraq*. **19**(3):93-100.

[22] Aqrawi, A.A.M., Goff, J.C, Horbury, A.D., and Sadooni, F.N. (2010). The petroleum geology of Iraq. Scientific Press Ltd, Beaconsfield, UK: 424 p.

[23] Abdulrahman, A. and Awadh, S.M. (2021). Depositional Environment of the Ibrahim Formation and Determining the Oligocene-Early Miocene Boundary in Eastern Iraq. *Iraqi Geological Journal*. **54**(1F):85-97.

[24] Larionov, W.W. (1969). Borehole Radiometry: Nedra, Moscow, U.S.S.R.
[25] Dewan, J. (1983). Essentials of Modern Open-Hole Log Interpretation: PennWell Publishing Company, Tulsa, Oklahoma: 361p.
[26] Schlumberger (1986). Log Interpretation Charts, Schlumberger publication. 122p.
[27] Ghorab, M., Ramadan, A.M., and Nouh, A.Z. (2008). The relation between shale origin (source or nonsource) and its type for Abu Roash formation at Wadi-El Naturn area, south of Western Desert, Egypt. *Australian Journal of Basic Applied Sciences*, **2**(3): 360-371.
[28] North, F. K. (1985). Petroleum Geology, Allen and Unwin Inc. London. 607p.
[29] Wyllie, M. R. J. and Rose, W. D. (1950). Some theoretical considerations related to the quantitative evaluations of the physical characteristics of reservoir rock from electric log data: *Journal of Petroleum Technology*. **189**: 105–110.
[30] Asquith, G. B. and Gibson, C. R. (1982) Basic Well Analysis for Geologist, American Association of Petroleum Geologists, Tusla, Oklahoma .USA.
[31] Asquith, G. and Krygowski, D. (2004). Chapter 7: Log interpretation. In: Asquith, G., and Krygowski, D. (eds.), Basic Well Log Analysis, (Second edition). AAPG Methods in exploration 16, Tulsa, Oklahoma: 37-76.
[32] Schlumberger (2009). Log Interpretation Charts, Sugar Land, Texas, U.S.A. 293p.
[33] Oil Search (2015). Report no. R1503. Horizontal plug. 2p.

الصفات المكمنية لتكوين ابراهيم (أوليگوسين الأعلى – مايوسين الأسفل) في منطقة گرميان/ أقليم كردستان العراق

دلير حسين بابان ، شادان محمود أحمد

قسم الجيولوجي ، كلية العلوم ، جامعة السليمانية ، السليمانية، العراق

الملخص

تم دراسة الخواص المكمنية لتكوين أبراهيم ذو العمر الأوليگوسين المتأخر–المايوسين المبكر في البئر H-1 من حقل سرقلا النفطي و لبئر Tz-3 من حقل تازه في منطقة گرميان جنوب شرق مدينة كركوك في أقليم كردستان العراق و ذلك بأستخدام المتوفر من معطيات الجس البئري و نتائج الفحص المختبري لنماذج مختارة من اللباب. تتكون صخارية تكوين أبراهيم بصورة عامة من الحجر الجيري و الحجر الجيري الحاوي على السجيل. يحتوي التكوين في البئر H-1 على نسبة معتبرة من السجيل والتي تعدت نسبة 35% في بعض أجزائه, كما يعتبر التكوين فقيرا من حيث المسامية اذ تبين انه يملك معدل مسامية 8% و 5% في كل من البئرين H-1 و Tz-3 على التوالي, أما من حيث النفاذية فالتكوين يعتبر أيضا فقيرا أو مقبولا و بمعدل نفاذية يبلغ 1.9 مللي دارسي. لقد تم تقسيم تكوين أبراهيم الى خمس وحدات مكمنية أعتمادا على التباين في نسب المحتوى السجيلي و قيم المسامية و النفاذية. يمكن أعتبار الوحدتين المكمنيتين الثانية و الرابعة و الواقعتين في المدى العمقي 4125–4128م و 4109–4114م على التوالي من البئر H-1 كأفضل وحدتين مكمنيتين بين الوحدات المكمنية الخمس التي تم تشخيصها. لقد بينت الدراسة بأن تكوين أبراهيم في البئر H-1 يحتوي على هايدروكاربونات خفيفة في معظم أجزائه الا انها هايدروكاربونات غير قادرة على الحركة لذا فهي بصورة عامة هايدروكاربونات غير قابلة للأنتاج. من ناحية أخرى و من خلال دراسة و فحص 17 نموذجا صخريا من اللباب لتكوين أبراهيم في البئر Tz-3 وجد بأن صخارية التكوين في هذه البئر عبارة عن حجر جيري سجيلي و حجر جيري صلصالي و متمثلة بسحنة الحجرالمرصوص الحاوي على الفورامنيفرا الطافية الدقيقة. لقد أظهرت نتائج قياس المسامية بجهاز قياس المسامية الغازي لنماذج اللباب آنفة الذكر بأن تكوين أبراهيم في البئر Tz-3 يحتوي على نسبة واطئة من المسامية بلغ معدلها 5% لذا فالتكوين في كلتا البئرين يعتبر بصورة عامة ذو مواصفات مكمنية رديئة.