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RESERVIOR CHARACTERISTICS OF KHASIB FORMATION IN AMARA FIELD, SOUTHERN IRAQ

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ABSTRACT

The Khasib Formation of Late Cretaceous (Upper Turonian – Lower Coniacian) is considered important reservoir in the Amara oil field.

Knowledge of reservoirs rocks composition including fluid saturation and mineralogical components is essential for formation evaluations. The current study represents an evaluation study of the Khasib Formation using logs and cored data to evaluate the Khasib Formation in terms of its mineralogical, lithological composition and its petrophysical properties such as porosity and fluid saturation.

Logs data of 15 drilled wells in the Amara Field and cored intervals of the well Am11 from the Khasib Formation were conventionally processed and integrated. Also, the mineralogical components of the Khasib Formation were revealed using a simultaneous equation approach by computer processed interpretation (CPI), where, combination of 5 logs including gamma ray, sonic, density, neutron and resistivity was integrated.

The results show that the Khasib can be subdivided into upper and lower unit. It suggests that the Khasib Formation mainly consists of limestone with abundance of thin shale streaks concentrated at the upper parts. In addition, the lower part has an averaged porosity of about 0.185 (18.5%) and better hydrocarbon saturation, whereas, the upper part has recorded 0.121 (12.1%) averaged porosity. However, the lower part seems to be narrower than the upper part in terms of its thickness. The study furthermore, identified that the Khasib has deposited in a ramp setting during a transgression event caused by sea level change. Further study is needed to reveal the diagenesis process which affected reservoir quality of the Khasib Formation using petrographical techniques and to assess the Khasib Formation using the routine analysis techniques to detect directly porosity and permeability from plug samples.

Keywords: The Khasib Formation; Amara Field; Logs data; Depositional Environment

INTRODUCTION

The Khasib Formation is considered one of the important reservoirs in the Misan oilfields. The daily and final geological reports of the Misan Oil Company (M.O.C) showed that the Khasib Formation obviously contains oil shows and hydrocarbon accumulations in the carbonate rocks. The Khasib Formation in the Misan oilfields has no clear studies, especially in the Amara oilfield.

The Khasib Formation in central and western Iraq, particularly in East Baghdad Oil Field has been studied by several studies (Al-Qayim *et al.*, 1993; Sadooni, 2004; Al-Ameri and Al-Obaydi, 2010; Al-Qayim, 2010). It must be stated that the Khasib Formation in central and western areas overlies the Kifl Formation which is the equivalent of the Mishrif Formation that underlies the Khasib in southern Iraq.

Al-Qayim *et al.* (1993) have examined the core samples of the Khasib Formation in East Baghdad oilfield. They stated that Khasib mainly consist of limestone and marly limestone. Also, the diagenesis processes such us dissolution, stylolitization, dolomitazation and voids filling have presented and influenced the reservoir characters. Sadooni (2004) furthermore, examined the Khasib Formation using core samples and thin sections of Zubair and East Baghdad oilfields. He found that the Khasib Formation comprises of limestone and marlstones containing calcipheres and plankton foraminifera. Sadooni also stated that the best porosity occurred in the middle part of the Khasib Formation within the studied area.

The examination of core samples and logs data in Al-Qayim's (2010) study and based on the identification of micro and electrofacies showed that the Khasib Formation has deposited in a ramp setting influenced by a transgression event and sea level change.

Al-Ameri and Al-Obaydi (2010) have concluded that the source of crude oil of Upper Cretaceous. The Khasib Formation is from the Upper Jurassic – Lower Cretaceous Chia Gara Formation. However, this might has an absence in Mesopotamian Basin.

Few studies have been carried out on the Khasib Formation to evaluate the reservoir in terms of its hydrocarbon reverse and accumulation.

Oil Exploration Company, Ministry of Oil (2011) has evaluated the Khasib reservoir and estimated its hydrocarbon reverse. They showed that this reverse can be much higher than the previous studies carried on the Khasib for the same purpose.

Consequently, it is clear that there are no studies focusing on the Khasib in the Amara Field have considered the available core intervals. Therefore, the prime aim of this study is to evaluate the Khasib Formation in the Amara Field. The study also aims to identify the primary depositional environment of the Khasib in this area. Furthermore, evaluating the Khasib Formation in terms of its petrophysical properties such as porosity and fluid saturation (with ignoring the permeability due to the absence of the core analysis data) in the Amara Oilfield is highly demanded by the M.O.C.

THE STUDY AREA

The area of study is located in Misan; Amara city, eastern south Iraq, approximately 360 Km south of Baghdad and 180 Km north Basra City (M.O.C) (Fig. 1).

The Amara Field is operated by the M.O.C, it is located 10 Km southern west Amara City, with approximate distance of about 10 Km north west of the Halfaya Field and 15 Km south west Noor Field (Fig. 1).

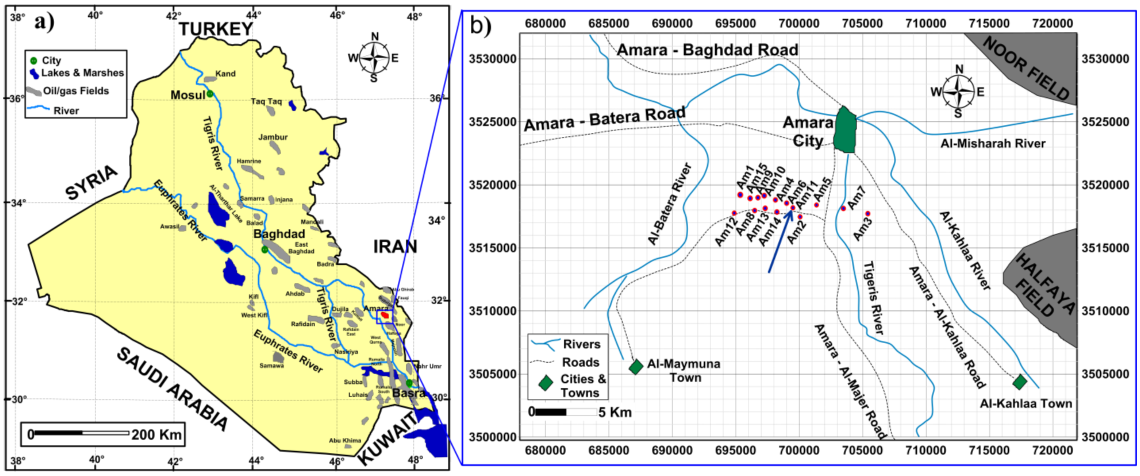

Fig. 1: a) The Iraqi map shows most oil/gas fields. The red field is area of interest, Amara Field. The location of fields is taken from (Sadooni, 2004); B) The Amara Field drilled wells location map, the blue arrow refers to Amara11 where the cores of this study were taken from {Adapted from Misan Oil Company (M.O.C) maps}

The study focuses on the Khasib Formation from Upper Turonian – Lower Coniacian (Fig. 2). The Khasib Formation is presented in northern, western and widely in Mesopotamian Basin (Sadooni, 2004). It also has been deposited in adjacent region, in Kuwait, whereas, it has clear absence in Saudi Arabia and Qatar regions.

As shown in Figure (3), The Khasib Formation is limestone from the late Cretaceous reservoirs of southern Iraq region. It underlies the Tanuma Formation and overlies the Mishrif Formation in most parts of its existence. It has an average of thickness of about 75 – 80 m in the Amara oil fields. This consists mainly of limestone rocks.

The sequence of the Misan fields and particularly the Amara Field consists of limestone strata starts from the Late Tertiary (Paleogene) and most Cretaceous period. The clastic sediments and the evaporated strata of Injana (Upper Fars) and Fatha (Lower Fars) have been deposited during the Upper Miocene, Middle – Lower Miocene respectively. Clastic sediments also deposited in the Zubair and Nahr Umr formations (Fig. 3).

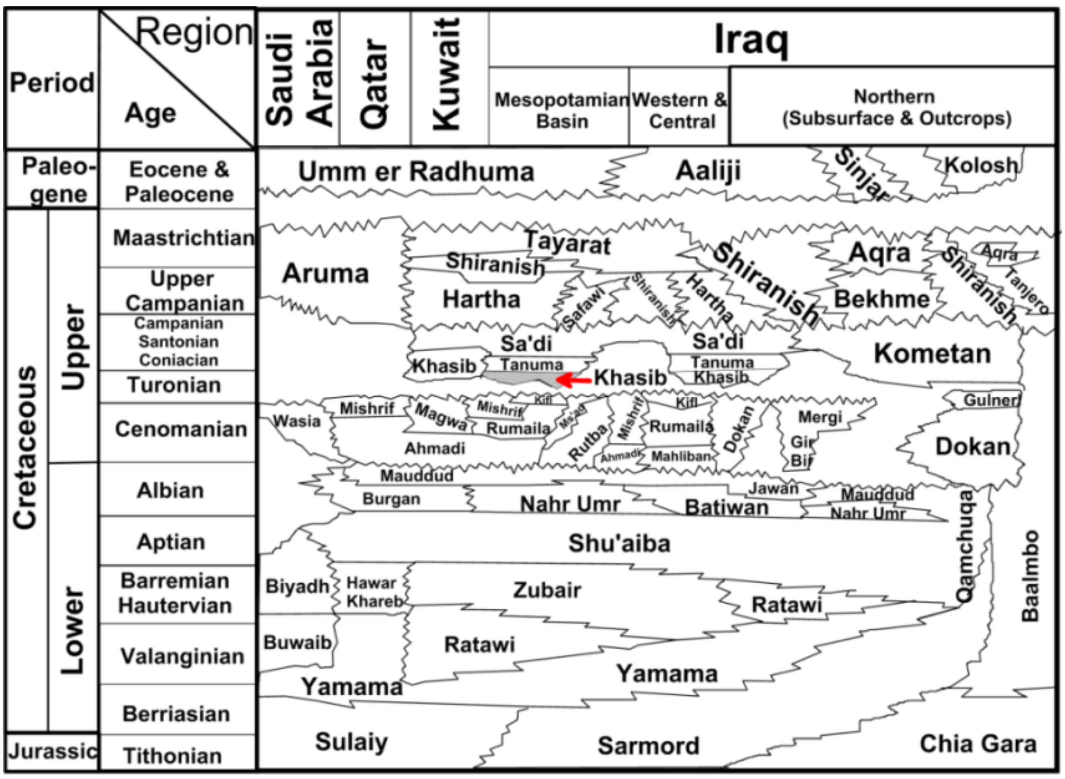

Fig. 2: Chronostratigraphic chart of the Cretaceous section in Iraq and some adjacent countries. (Modified after Sadooni, 2004). The red arrow refers to the Khasib Formation of this study

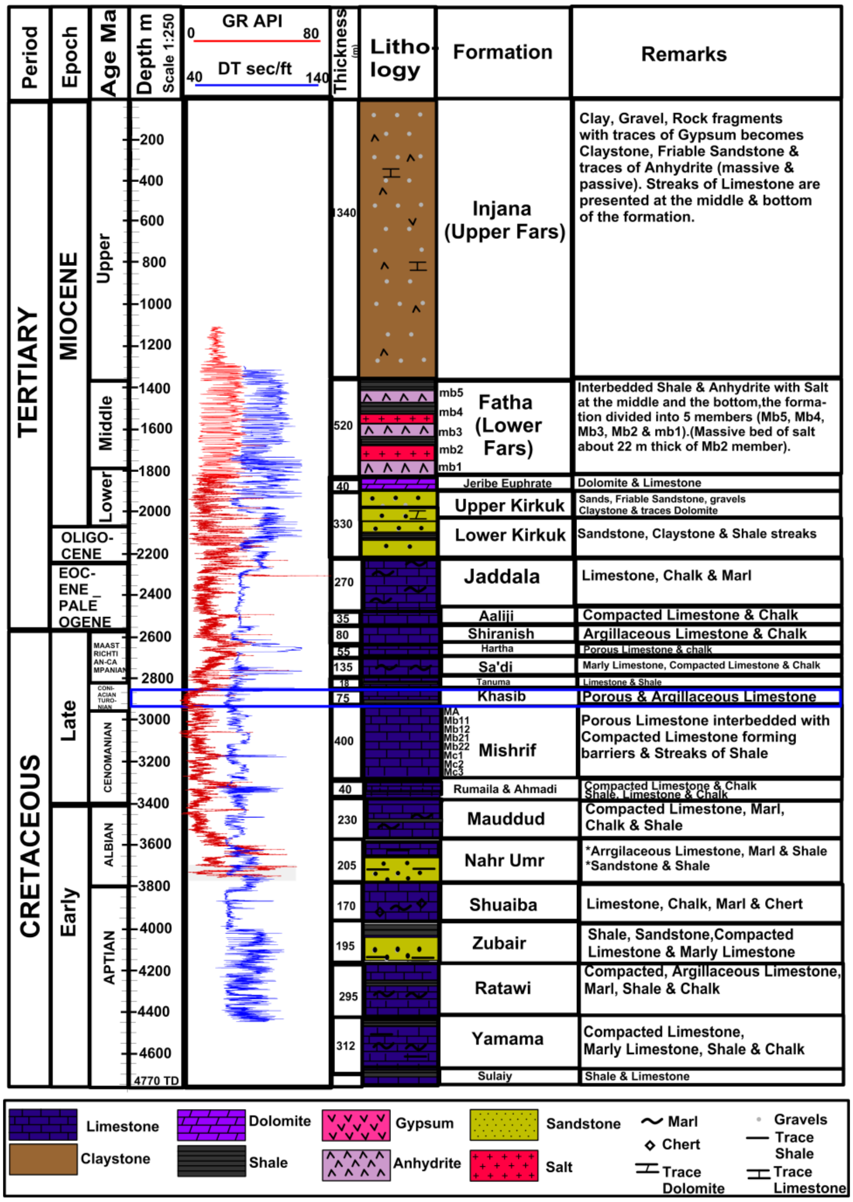

Fig. 3: A generalised stratigraphic sequence of Amara Field showing the averaged thickness of each formation. Based on the availability of logs data, the sonic log taken from depth 1800 – 4300 from Am3 well, GR from 1800 – 3730 from Am4 well, Sonic and GR from 1180 – 1800 from Am12 well. The blue rectangle highlighted to the Khasib Formation

METHODS

A detailed core description was carried on the available three cored intervals that have been taken from Am11 well which belong to the Khasib Formation. The software programs; Surfer13 and Excel were used for logging the cored intervals, mapping the area of study and drawing location maps. All available wells data of 15 wells in the Amara Field (From Am1 – Am15) were integrated to evaluate the Khasib Formation.

Logs data of the 15 wells including gamma ray, sonic, density, neutron and resistivity were integrated to assess the reservoir in terms of its porosity and fluid saturation using Microsoft Excel software. Porosity was calculated from different logs using the formula of each log, while, water saturation was obtained from Archie's equation. This also was compared to the porosity and fluid saturations that obtained by using a new approach for integrating the logs data based on the combination of 5 logs together which are gamma ray, sonic, density, neutron and resistivity.

The porosity processed and calculated from density log using the formula below:

$$\text{Porosity } (\emptyset) = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_{fl}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 1$$

Where: ρ_{ma} is the matrix density, assumed to be calcite (2.71 g/cm^3). ρ_b is the log density reading and ρ_{fl} is the fluid density, assumed to be oil (0.9 g/cm^3).

The clay minerals have an effect on porosity calculated from the density log. This has to be corrected and the effect of shale has to be subtracted using the following equation:

$$Porosity\ (\emptyset) = \left(\frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_{fl}}\right) - Vsh\left(\frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_{fl}}\right) \quad \ldots\ldots\ldots\ldots \; 2$$

Vsh was obtained using the Larionov equation below:

$$Vsh = 0.33(2^{2 \times GRI - 1}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 3$$

Where GRI (Gamma Ray Index) calculated using the gamma ray logs which has a linear relation with Vsh. This can be calculated using the following equation:

$$Porosity\ (\emptyset) = \frac{\text{GRmeasured} - \text{GRsand}}{\text{GRshale} - \text{GRsand}} \quad \ldots\ldots\ldots\ldots \; 4$$

Where: $GR_{measured}$ is the gamma ray reading, GR_{sand} is the gamma ray of sand, the lowest gamma ray reading and GR_{shale} is the gamma ray reading of shale, the highest reading.

Similarly, the porosity was also obtained from the sonic log by the same way for calculating the density porosity.

$$Porosity\ (\emptyset) = \left(\frac{\Delta t - \Delta tma}{\Delta tfl - \Delta tma}\right) - Vsh\left(\frac{\Delta tsh - \Delta tma}{\Delta tfl - \Delta tma}\right) \quad \ldots\ldots\ldots \; 5$$

Where: Δt is the sonic log reading, Δt_{ma} is the matrix reading which assumed to be calcite = 49 *µs/ft*, Δt_{fl} is the fluid sonic reading = 189 *µs/ft* and the Δt_{sh} is the sonic reading in shale.

Water saturation was calculated using the Archie's equation as below:

$$Sw = \frac{(a \times Rw)}{(\emptyset^m \times Rt)^{1/n}} \quad \ldots\ldots\ldots\ldots\ldots\ldots 6$$

Where: a is tortuosity factor (assumed = 1), n is saturation exponent (= 2), m is cementation factor (= 2), ϕ is the porosity fraction and the Rt is the true or deep formation resistivity (deep resistivity log). Rw is the water resistivity for the Khasib Formation which was obtained using Pickett plot (Fig. 4), as shown in the equation below:

$$Rw = \frac{(Ro \times \emptyset^m)}{a} \quad \ldots\ldots\ldots\ldots\ldots\ldots 7$$

Where m = 2, a = 1, Ro = 2.2

Therefore, $Rw = 0.022$

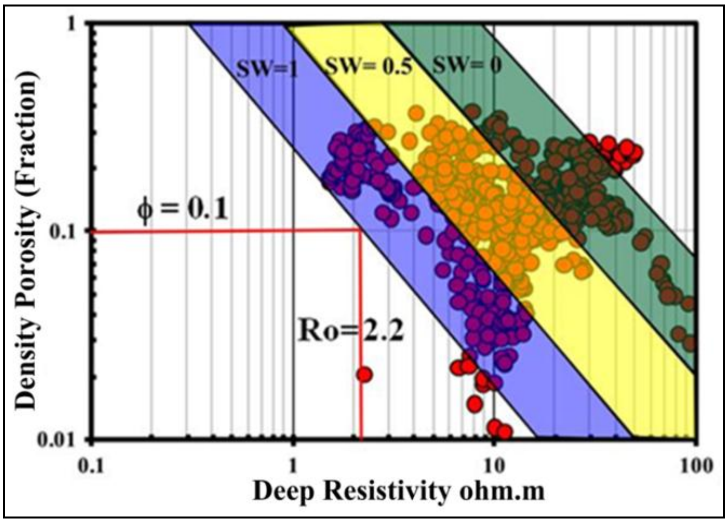

Fig. 4: Pickett Plot (Am11)

Logs data typically used to reveal porosity (typically using the density log, sonic and the assumption that the solid portion of the rock has the density of calcite (in carbonate rocks) and quartz (in siliciclastic rocks). This also typically used to suggest where mudstone is present using a gamma log and an assumed Vshale. However, routine logs data can also be used to reveal mineralogy. Mineralogy is a key to enhance the understanding of the reservoir properties. This should be routinely undertaken for reservoir quality (RQ) purposes.

Similarly to the one logs computer process interpretation, a combination of 4 logs (as well as resistivity to reveal fluid saturations) can be done using spreadsheet of Excel Software using a simultaneous equation approach (Worden, 2017). Excel software is free software and does not require licence and/ or spending money. Also, the one log cannot give us an idea about minerals component (only lithology), whereas, the main benefit of using the 4-logs integration is to reveal minerals (e.g quartz, calcite, dolomite, k-feldspar and shale as well as porosity including porosity filled hydrocarbon and water). Thus, this can link to assess the effects of minerals distribution on reservoir quality of the Khasib Formation.

Knowledge of rocks composition including fluid saturation and minerals is essential for petrophysical analysis and formation evaluations. The mineralogical composition can be estimated by solving a system of linear equations that relate logs measurements to the petrophysical parameters of known fluids and minerals.

As it is known that each mineral has its own logs reading responds (gamma ray, sonic neutron and density). Where, this can be gain by cross plotting the logs each other and detecting the end-member of each mineral. Therefore, the combination of those 4 logs as well as the resistivity log can be made to reveal minerals components and lithology (Worden, 2017). This can be achieved by integrating the four logs together, assuming log responses for each component, and assuming that there are linear relationships between mixtures and tool responses.

RESULTS AND DISCUSSION

It is essential to map the surface of the Khasib Formation based on its top in each well in the 15 drilled wells in the Amara Field (Fig. 5) to acquire an idea about the geometrical shape of its surface. It likely possibly from Figure (5) that the Khasib surface has a ramp shape setting. However, studying the core and the distribution of facies is required to prove this case.

FACIES DISTRIBUTION

The detailed core description has been done in order to recognize the different type of facies in the Khasib Formation (Fig. 6 and 7) and to identify the best facies in terms of reservoir quality. The facies recognition was based on Dunham’s classification (Dunham, 1962).

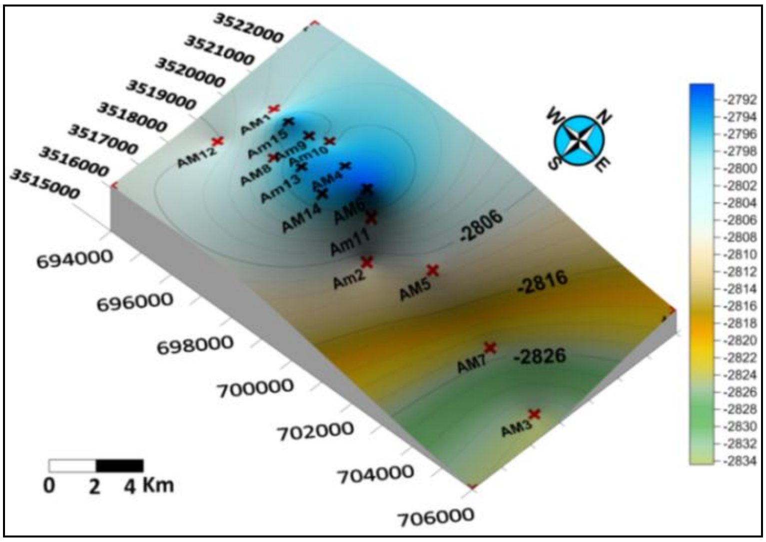

Fig. 5: 3D surface and contour map of the Khasib in the Amara Field

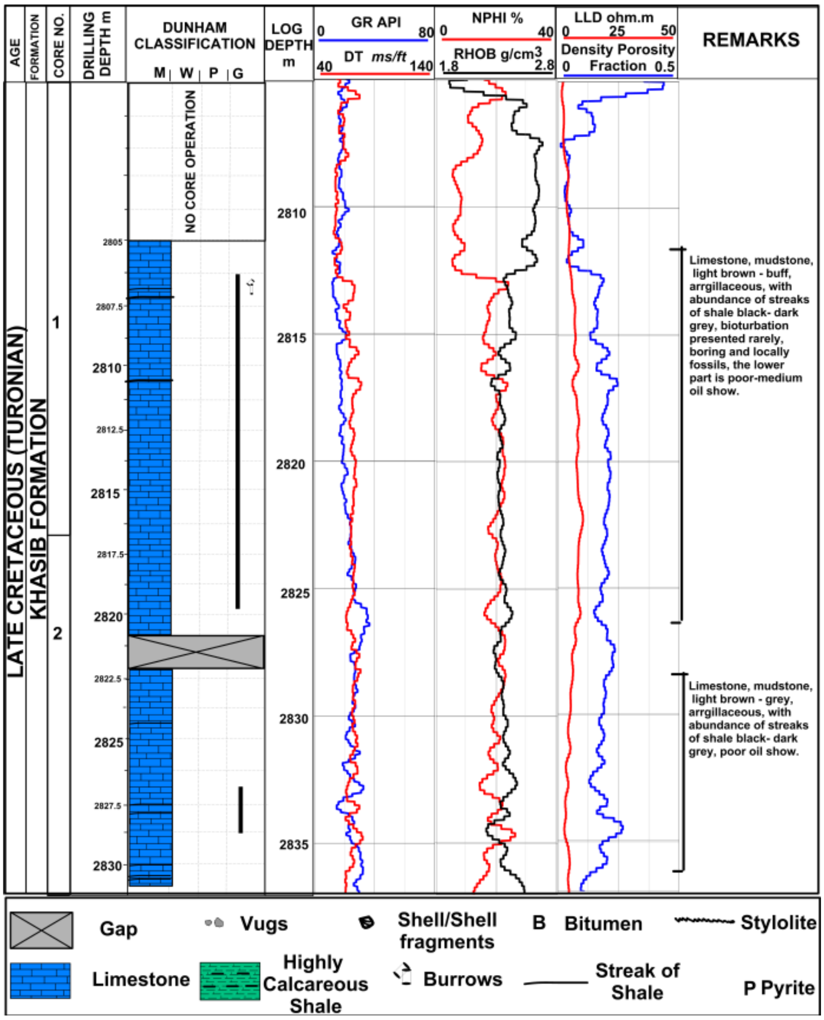

Fig. 6: The core description log from depth 2805 – 2831 m contains gamma, sonic, density, neutron, resistivity and porosity density logs. (Note: the resistivity log was drawn in normal scale not logarithmic)

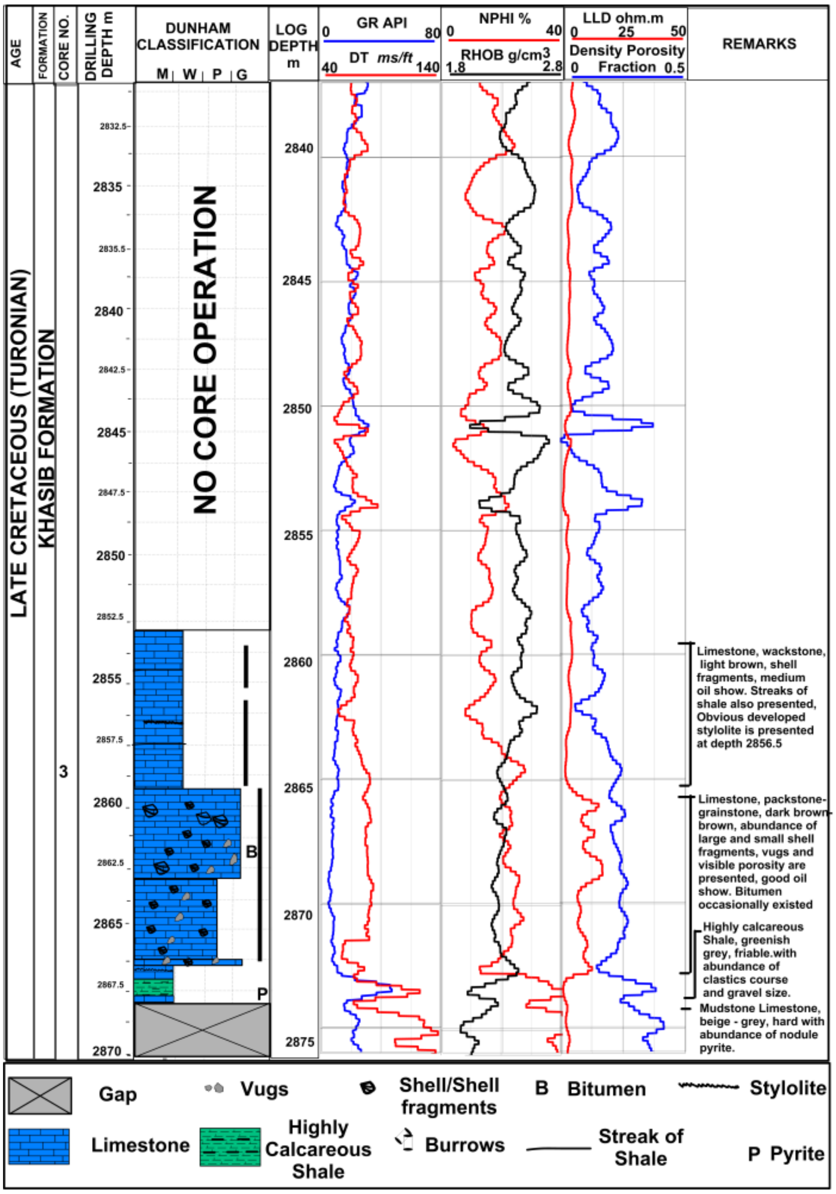

Fig. 7: The core description log from depth 2853 – 2870 m contains gamma, sonic, density, neutron, resistivity and porosity density logs. (Note: the resistivity log was drawn in normal scale not logarithmic)

Where, the textural features such as the absence and/ or presence of mud; the abundance of bioclastical grains and the signs binding during facies deposition are significant features to distinguish between carbonate facies (Dunham, 1962). Therefore, and from the visible features of the cored intervals (where no petrography was carried on the Khasib Formation), many types of facies have been identified, as following:

1. **Mudstone:** The most common facies, those kinds of facies has a very rare amount of bioclastics and grains in its composition. This presented in most parts of the core,

mainly at the top of the intervals and at the very bottom of the cores. The mudstone facies consists of around 60% of the entire core length. It is suggested that this facies has deposited in low energy environment within a deep water lag.

2. **Wackestone:** Wackestone facies has also presented within the Khasib Formation, particularly at the lower middle of the core sections. This kind of facies contains more than 10% grains and bioclastics. However, it still micrite supported based on Dunham's classification. Wackestone and mudstone facies could have deposited in a lagoon or open marine.
3. **Packstone:** Packstone facies contain more than 10% of bioclastics and grains and it is grains supported. This presented in the bottom section of the cored intervals. It contains shell fragments and bioclastics in its composition. Due to the lack of the mud and due to the amount of the bioclastics this type of facies suggests a higher level of energy than in mudstone and wackstone, and it could has deposited in shoal or shallow open marine.
4. **Grainstone:** This type of facies contains high amount of bioclastics and grains, the micrite has clear absence in those facies. The grainstone facies presented also at the bottom part of the core sections. Grainstone and packstone facies consist of about 20% of the entire cored sections. Large and small shells and shell fragments were presented in those facies suggesting a high level of energy which is likely to be deposited in a shoal environment.

Therefore, from overall the facies association, the results suggest that those facies has likely deposited in a ramp setting which is a type of carbonate platform. However, due to the lack in core data (only one well has cored sections), the type of the ramp has not recognized whether it is a homoclinal or distally steepened ramp.

DIAGENESIS PROCESSES

It is well known by many studies (Al-Qayim *et al*., 1993, Sadooni, 2004; Al-Ameri and Al-Obaydi, 2010; Al-Qayim, 2010) that diagenesis can play highly important roles in terms of enhancing and/ or reducing reservoir quality. Many types of diagenesis processes have been recognised within the Khasib Formation during describing the cored sections:

1. **Dissolution:** The dissolution appears clearly at the lower part of the Khasib Formation, particularly, in packstone and grainstone facies and rarely in wackestone.

Dossolution does not present in mudstone facies especially in the upper part (Fig. 8a). This diagenetic feature is greatly significant in terms of enhancing porosity and thus reservoir quality.

2. **Stylolitization:** The developed stylolite existed at depth 2856.5 m within the core section (Fig. 8f and h). This has been filled with siliciclastic materials.
3. **Pyritization:** Pyrite (PbS_2) obviously distributed in the Khasib Formation. This can be evidence of sulphite reduction (Fig. 8c).
4. **Cementation:** This process was presented in the Khasib Formation, where micrite has filled some vugs. This process can act as the opposite to the dissolution. Hence, it can reduce porosity and permeability of the Khasib Formation.
5. **Bioturbation:** bioturbation has also occurred, particularly, at the top of the Khasib Formation. Where some borings appeared, specifically in mudstone facies (Fig. 8b and e).

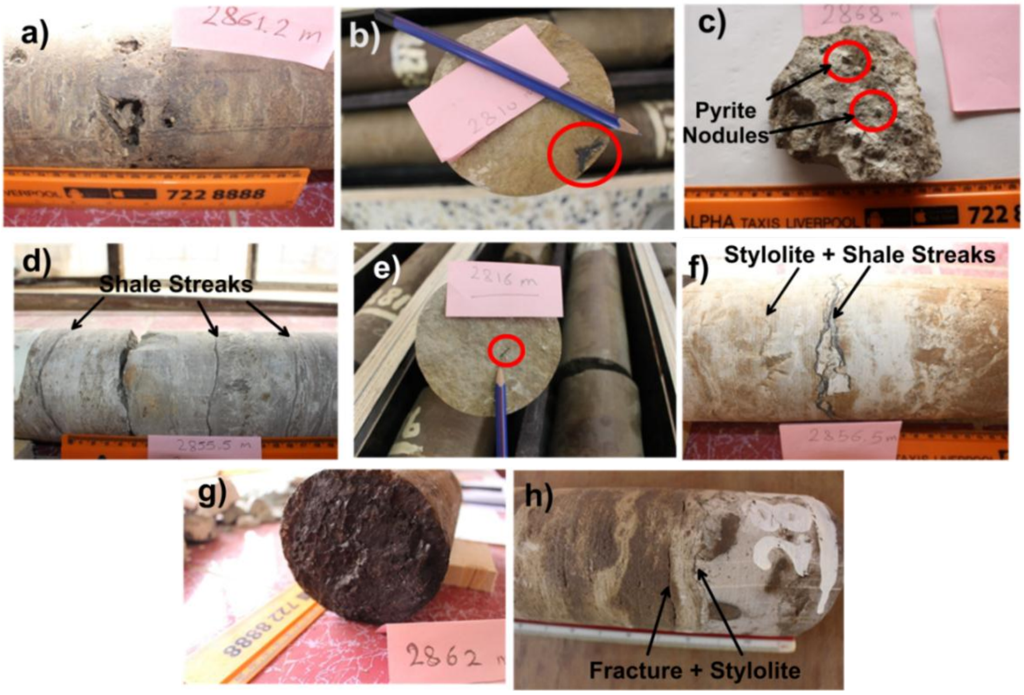

Fig. 8: Some core features and diagenesis process in the Khasib Formation (well Am11)
a) Dissolution in packstone limestone in the lower part; b) Boring in mudstone, in the upper part; c) Pyrite nodules in mudstone facies; d) Shale streaks in mudstone limestone at depth 2856.5 m; e) Another boring in mudstone at different depth 2816 m; f) Stylolite and shale streaks in mudstone; g) bitumen; h) fracture and stylolite at depth 2856.4 m

6. **Dolomitization:** according to (Al-Qayim *et al*., 1993; Aqrawi, 1996; Sadooni, 2004; Al-Qayim, 2010) Dolomitization has occurred in the Khasib Formation. However, this needs further investigation has to be carried on thin sections to investigate whether dolomitization has presented or not in the area of this study.
7. **Fractures:** close to the stylolite (around few centimetres), fractures have occurred (Fig. 8h). Fractures and stylolites together might be evidence of a near tectonic event.

Matching the cores and the logs data show obviously that there is a clear shifting has occurred by around 6m between measured depth (core depth) and log depth (Fig. 6 and 7), This has to be considered during the examination the core of the Khasib Formation and matching the results with logs data.

WELL CORRELATION

In order to identify the extension of the Khasib Formation in Amara Field, to investigate the extension of lower and upper parts and to assess the geometry shape of its surfaces (top and base), and based on the main logs such as gamma ray, sonic, density, neutron and resistivity, it is important to show the logs correlation of the drilled wells (Fig. 9).

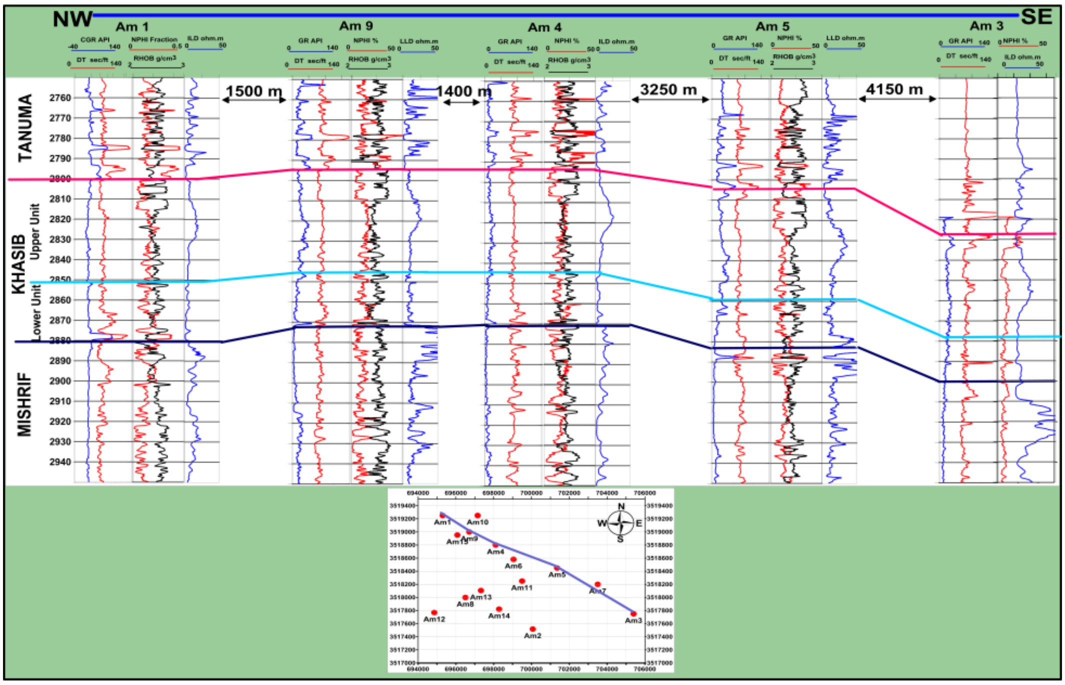

Fig. 9: Well logs correlation in Amara Field showing the Khasib tops and bases in the selected wells

From Figure (9), it is clear that there was a lack in drilled wells in NE – SW direction. The correlation has made from the well Am1 forwarding Am3 crossing Am9, Am4 and Am5 respectively. Therefore, and also from the Figure (5) it is obvious that the Khasib Formation is sloping NW – SE directions and dipping NE – SW. In addition, and from Figure (9), the Khasib Formation can possibly be divided into upper and lower units.

PETROPHYSICAL EVALUATION

It is mentioned that based on logs and core sections, the Khasib Formation has divided into two units (Upper and Lower the Khasib). It is also observed from the core description that the lower unit contains mostly grainstone, packstone and some wackestone. Those can have better petrophysical properties than the upper unit which dominated by the mudstone. It should be also mentioned that the Misan Oil Company's (M.O.C) reports have recorded that the upper part of the Khasib Formation has the main oil-bearing horizon. However, while, the integration of the logs data and core data of Am11 well in current study shows that the lower part contains good oil-bearing zone.

POROSITY

In order to evaluate the accuracy of the porosity that derived from logs such as density, sonic and neutron logs, an evaluation between those different porosity has done based on their relations to each other and the coefficient of determination trends. The cross plots of porosities (Fig. 10) shows a good correlation between neutron porosity and that porosity that derived from density logs. This reaches the 0.78 coefficient of determination (R^2). It is also clear that the density and sonic porosity has a fair relation reaching 0.6 (R^2).

Therefore, and from Figure 10), the density and neutron porosity logs have a reliable data and can be used for evaluating the Khasib Formation and estimate its porosity. However, sonic porosity log shows roughly overestimated values. This might back to the fact that the sonic log has a high reading in shale rocks which are existed as shale streaks in the Khasib Formation.

It should be said that the lower unit of the Khasib Formation has an averaged density porosity of about 0.185 (18.5%), whereas, the upper unit has recorded 0.121 (12.1%) averaged density porosity, whereas, the neutron porosity log records averaged porosity of around 0.117 (11.7%) at the upper unit and 0.172 (17.2%) at the lower part of the Khasib.

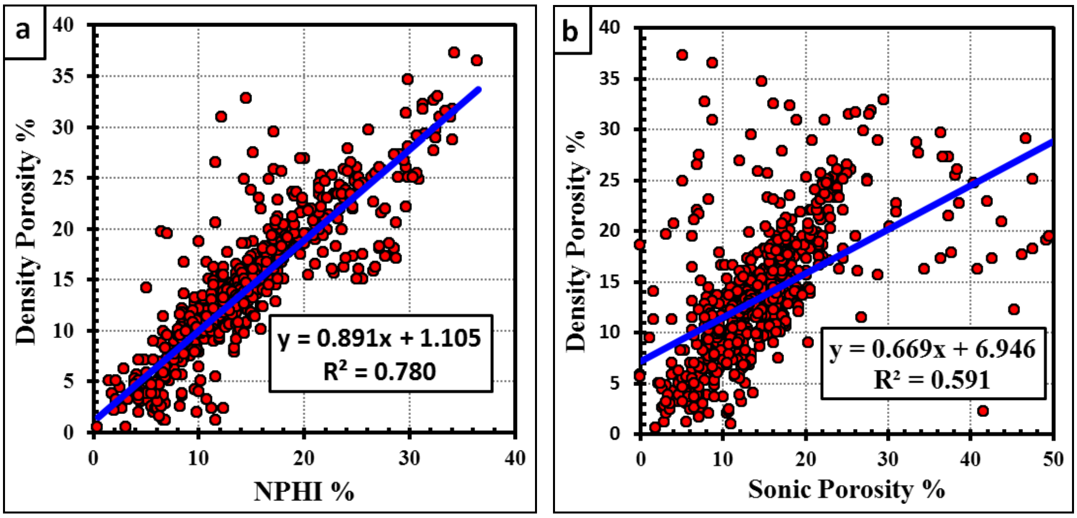

Fig. 10: a) Cross plots of the density derived porosity and neutron porosity (well Am11); b) Cross plot of the density derived porosity and sonic porosity, showing the good regression coefficient between density and neutron porosity and the fair relation between density and sonic porosity

FLUID SATURATION

Water and hydrocarbon saturation is a significant factor for calculating the original oil in place (OOIP). The fluid saturation in the Khasib Formation shows good oil-bearing zone with low water saturation in overall.

Where Figure (11) indicates that there is a good porosity filled hydrocarbon. The fluid saturation calculation also records that the highest water saturation is about 0.365 in the lower unit and 0.391 in the upper unit. However, and again, it should be noticed that the lower part is narrowest than the upper part in terms of the thickness. It is also important to mention that the study does not focus on the mobility of the hydrocarbons. Therefore, it is not clear that those hydrocarbons are moveable or not.

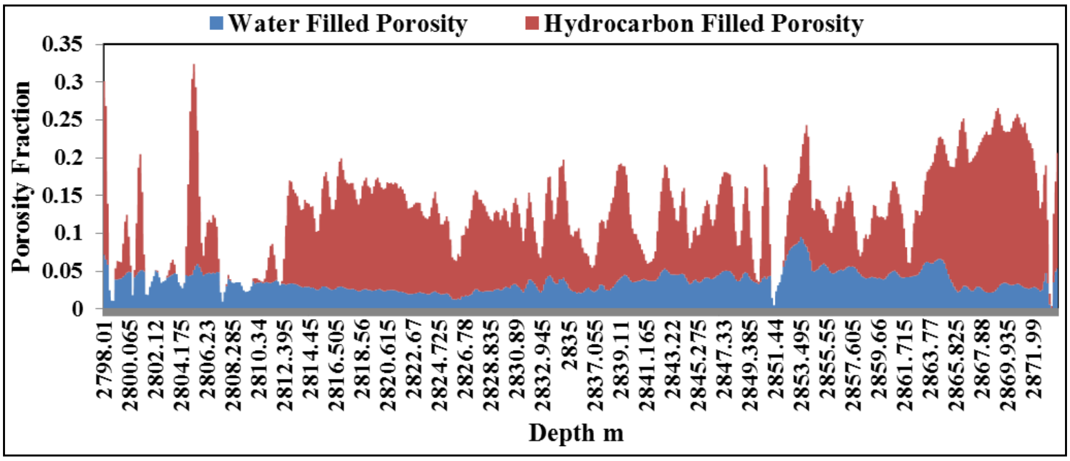

Fig. 6: Plot of hydrocarbon and water filled porosity of the one log

INTEGRATION OF THE 5 LOGS POROSITY

The integration of the combination of the 5 logs used in this study has been made. The results of the integrated porosity correlate very well with that porosity that obtained from density and neutron logs (Fig. 12). Figure (12) indicates that the porosity of the 5 logs integration excellently correlates to porosity derived from density log and porosity from neutron logs, where the coefficient of determination reaches to 0.978 in the case of the density porosity and 0.874 in the case of neutron porosity.

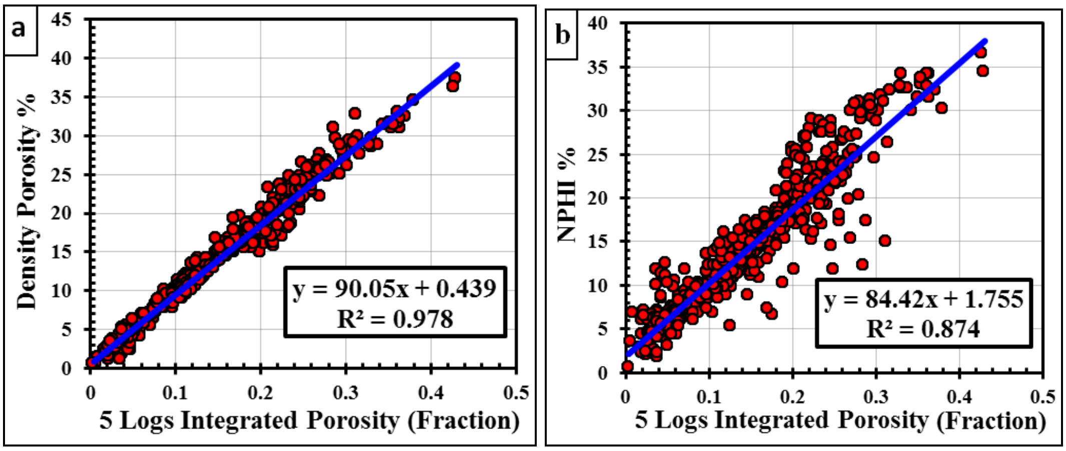

Fig. 7: a) Cross plot of the integrated porosity and the density porosity, b) Cross plot of the integrated porosity and the neutron porosity

FLUID SATURATION OF 5 LOGS

In order to assess the accuracy of the fluid saturation results achieved by the integration of the 5 logs, the water saturation of one log has plotted against the water saturation obtained from the integration (Fig. 13). Where, the water saturation obtained from the logs integration correlated very well compared to one log water saturation.

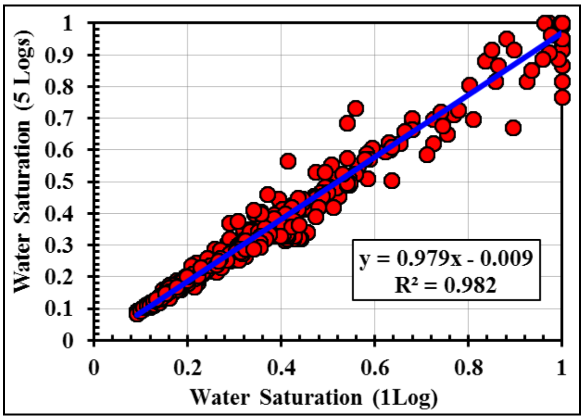

Fig. 8: Cross plot of the water saturation obtained from the integration of the 5 logs and against the saturation from the one log (conventional)

However, the plot of the porosity filled hydrocarbon and water obtained from the 5 logs integration shows roughly overestimated values in overall its results (Fig. 14). It is also clear from the Figure (12) that the porosity 5 logs integration have highest values than the one log porosity.

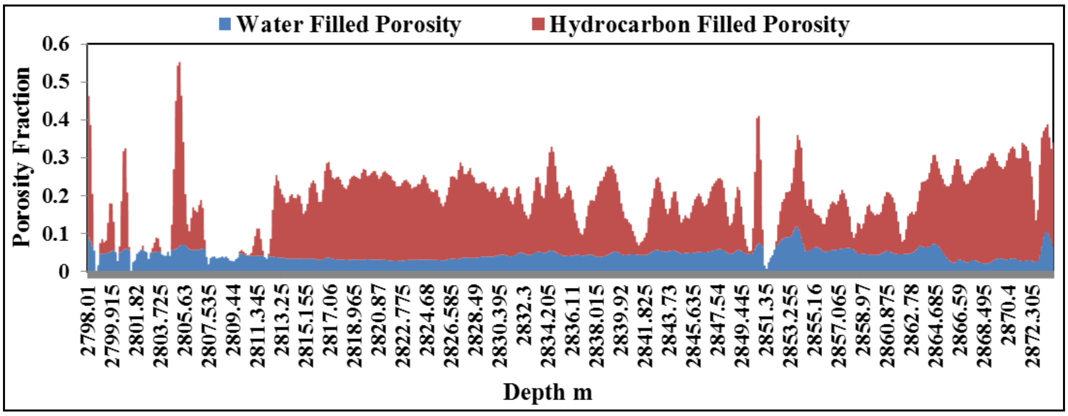

Fig. 9: Plot of hydrocarbon and water filled porosity of the 5 logs

MINERALOGY

In order to integrate the results obtained from the core description and those from the logs data, mineralogy detection process has done. Cross plotting the data of the neutron log (x axis) and the density log (y axis) (Fig. 15a) shows that the data highly concentrated on the limestone window. It is observed that some data reach the dolomite and some reach the sandstone window, which might be an indicator that there is a siliciclastic supplier in somewhere in the Khasib Formation. There also might happen dolomitization in somewhere in the Khasib where this been proven by many studies representing late diagenesis process (Al-Qayim *et al.*, 1993; Sadooni, 2004; Al-Qayim, 2010).

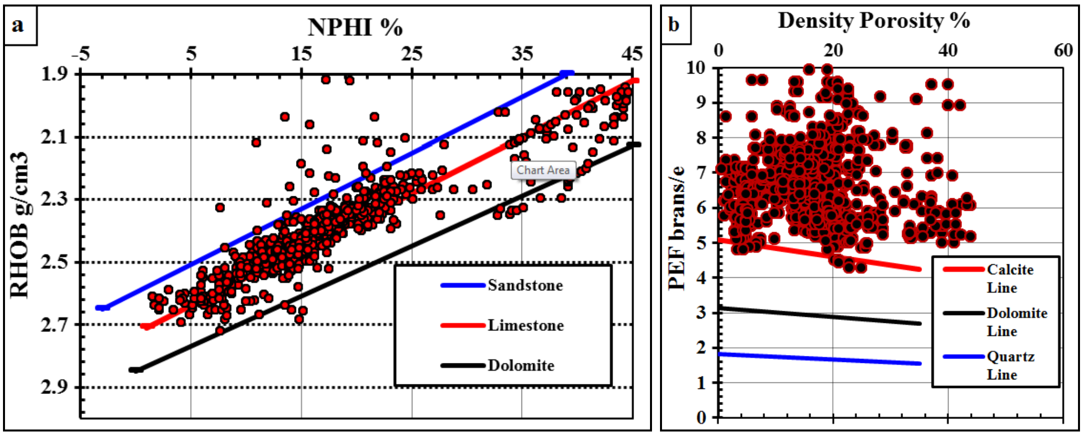

Fig. 10: a) Cross plot of density and neutron logs. (Baker Hughes interpretation charts); b) Cross plot of PEF Log versus density log

One explanation of why some point data are falling on the sandstone line is that the logs could be affected by the well conditions during logs operation; those points can be considered as anomalous data. Another explanation is that there was a siliciclastic (sands) supplier during deposition of the Khasib Formation. However, this needs more studies and investigations. Furthermore, this study has taken the advantage of existence the PEF log in Am15 (Photoelectric Effect, barns/e-). This log can be also used to reveal mineralogy. Cross plotting the data of PEF log against density log (Fig. 15b) indicates that the Khasib Formation mainly consists of calcite mineral.

MINERALOGY, POROSITY AND FLUID SATURATION (5 LOGS)

The results of the integration of the 5 logs show good correlation compared to one log interpretation and it matches the core details. The integration revealed the composition of the Khasib Formation in terms of its mineralogical components such as carbonate (calcite and dolomite), shale, quartz, k-feldspar and porosity.

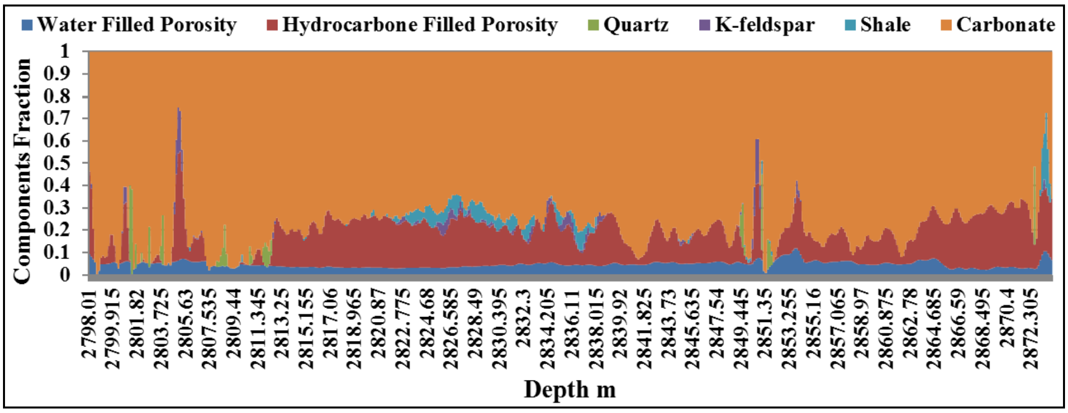

Fig. 11: Plot of mineralogy and porosity revealed from the processing of the combination of the 5 logs integration of the Khasib Formation

Figure (16) shows that the Khasib Formation mainly consists of carbonate rocks with some shale rocks and rarely quartz and k-feldspar (siliciclastic). The quartz presence in Figure (16) might be evidence why some data are falling in sandstone line in Figure (15a), and could be fact that there was a silisiclasts supplier during deposition the khasib. However, this not clear in using PEF logs (Fig. 15b). Figure (16) also shows that the lower units contain good oil bearing zone likely the upper unit.

PRIMARY DEPOSITIONAL ENVIRONMENT

Although there was only one core taken from the Kashib Formation in the Amara field, the primary depositional environment of the Khasib Formation within the Amara Field can be detected. From the integration of the core description, the contour map, the top surface, sequence stratigraphy and the facies distribution of the Khasib Formation of this study and form the previously published studies carried on the Khasib Formation in southern and central parts of Iraq (Al-Qayim *et al*., 1993; Aqrawi, 1996; Sadooni, 2004; Al-Qayim, 2010), it can be said that the Khasib Formation has deposited in a ramp setting (Fig. 17).

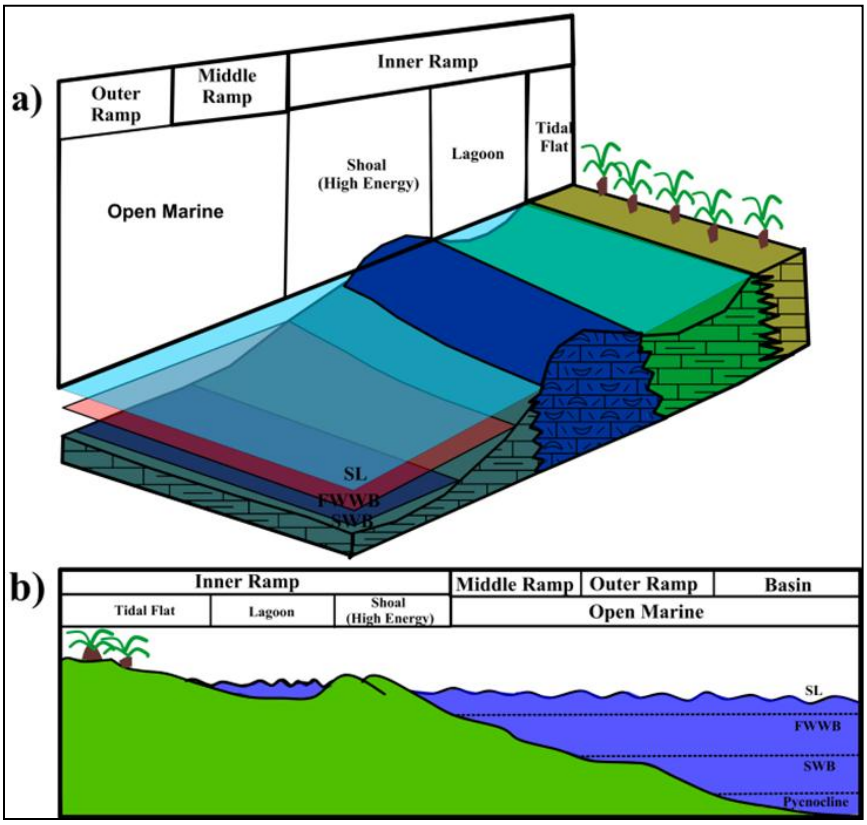

Fig. 12. a) 3D diagram represents the depositional environment of the Khasib Formation; b) Is 2D plot showing the depositional environment (not for scale)

This primary deposition environment has the main effect on facies distribution. The fining upwards from the grainstone and packstone at the base to wackestone and mudstone at the top can be an indicator to sea level change due to transgression event caused the mudstone facies to be deposited at the top of its extension. Most grainstone and packstone facies have deposited in the inner ramp (shoal) with high energy (waves and winds). This also matches the interpretation of (Al-Qayim *et al*., 1993; Aqrawi, 1996; Sadooni, 2004; Al-Qayim, 2010). The shale streaks probably deposited during a relative sea level change during deposition of the Khasib. Another possible explanation for that, it is possible to be caused by the late diagenesis process which occurred in somewhen after the Khasib deposition. However, this needs to be carefully examined using petrography techniques. As shown in Figure (15a), some points fall on the sandstone line, it is not really clear but it could be possible to state that was a sands supplier during the deposition of the Khasib in this area. However, again, this needs more investigation (for example, study the samples under XFR and XRD).

CONCLUSION AND RECOMMENDATIONS

The aims of this study were to integrate the cored intervals and all available logs and wells data to evaluate the Khasib Formation in Amara Field, to identify the primary depositional environment of the Khasib in this area, and to investigate the formation in terms of its petrophysical properties such as porosity and fluid saturation. Therefore, it can be concluded that the integration of the results between cored sections and the logs data closely matches each other. The lower unit of the Khasib Formation has good petrophysical properties (Porosity and hydrocarbon saturation). However, it is roughly narrower than the upper unit. The Khasib Formation mainly consists of mudstone and less grainstone, packstone and wackestone facies. The diagenesis processes such as dissolution, stylolitization, cementation and bioturbation have influenced the Khasib Formation in terms of reducing and/or enhancing its reservoir quality. The combination of the 5 logs integration has good correlation compared to the conventional logs petrophysical process. The Khasib Formation mainly consists of limestone rocks with some shale at the base and occasionally in the upper unit (shale streaks). The Khasib Formation has deposited in a ramp setting mostly inner ramp (shoal), middle ramp and outer ramp (open marine) with a transgression event caused by increasing sea level. Further studies have to be carried on the Khasib Formation to detect the influences of diagenesis process on its reservoir quality in terms of the micro parameters, where petrography study (thin sections) can hold the key in this way. XRD and XRF analysis technique can also be engaged to detect the dolomite and quartz (sands) minerals presence. It is also recommended that porosity and permeability of the Khasib can be measured using the routine analysis technique to gain better understanding about the reservoir quality of the Khasib Formation.

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