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Petrophysical Evaluation of Arab Formation using Multimin, Petrography and Petrography Carbonate Methods in one of Iranian Oilfields, Persian Gulf

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Abstract:
In the present research work, petrophysical parameters of Arab Formation (equal to Surmeh Formation) were evaluated using three methods: petrography, petrography carbonate and multimin. Wirelog data are input in GEOLOG software by probability method in one of southern Iranian oil fields. Arab Formation in this oil field divided into 7 zones. Dolostone and anhydrite with a less value of shale are the main lithological components. Lithological comparing results provided that the calcite variation is not following a sharp trend. Carbonate petrography method is also showing weak correlation to the log in spite of high resolution of limestone presentation than multimin.
The results of petrographic, petrography carbonate, core data and corrected well logs were uploaded in GEOLOG software to construct the basic petrophysical model. To get the high quality and improving the petrophysical evaluation data, the results were compared to core data. The porosity data variation in multimin to petrographic processes, carbonate petrographic and core data revealed that the correlation coefficients are 0.69, 0.71, and 0.91 respectively. This is concluded that the carbonate petrographic procedure in view of the porosity estimation is provided us more suitable results than other methods. Water saturation study is however, provided that the results of the carbonate petrography are scattered and so the petrography method is preferred and matched well with core data. Porosity and permeability variation indicated that they are not correlated well but depend on the reservoir lithological variation. Based on these results, reservoir zones 1 and 3 are indicating the best reservoir quality in view of porosity and water saturation values.

Keywords: *Arab Formation, multimin, petrography carbonate, porosity, water saturation*

1. Introduction

Petrophysical evaluation is carried out to study the quality of different parts of the reservoir and classify the reservoir zonation. These processes are important to determine the hydrocarbon potential horizons in optimization production and development oil fields (Tiab, 2010). Lithologically, shale volume, total porosity (PHIT), effective porosity (PHIE), water saturation (Sw) are the main parameters in petrophysical studies (Hearst et al., 2000). In the present work, petrophysical parameters of the Arab Formation (eq. to Surmeh Formation in) in one of Iranian oil fields in Persian Gulf are discussed through GEOLOG software using different methods such as multimin, petrography and petrography carbonate.

Arab Formation (upper Jurassic) in the Persian Gulf was generally studied by several authors in Arabic countries located around the Persian Gulf which are summarized as: rock types, depositional environment and its diagenesis (Mitchell et al., 1988; Meyer, and Price, 1992), the porosity effects on the logs responses in Saudi Arabia (Cantrell, and Hagerty, 1999), characteristics of Palino facies and sedimentary facies in Qatar (AL-Saad, andIbrahim, 2005; Al-Sharhan, & Kendall, 1986), sedimentology (Powers et al., 1966; Powers, 1968; Sugden, & Standring, 1975; Sugden, & Standring, 1975; Moshrif, 1987; Al-Silwadi et al., 1966), stratigraphic correlation (Steineke et al., 1958;Meyer et al., 1996; Al-Husseini, 1997; AL-Saad, & Sadooni, 2001), and hydrocarbon habit (Al-Sharhan, & Kendall, 1986; Beydoun, 1988; Al-Sharhan, & Nairn, 1994; Kieke, and Hartmann, 1974).

All studies are cited that the Arab Formation was deposited in platform (AL-Saad, and Ibrahim, 2005)/tidal flat or shallow platform (Sahrapour et al., 2010). The main lithological components are limestone, dolomite and anhydrite. They have classified it to 5 zones: A, B, C, and D from the top to base. They were also correlated the upper part of the formation to the Surmeh Formation.

To achieve more knowledge about the Arab Formation as one of the oldest petroleum reservoirs in Middle East, it therefore seems to focus more studies on this formation individual in view of computational software which are now applied as a routine tool to determine the petroleum potential and lithological distribution. However, it is possible to overestimate petrophysical parameters such as water saturation by logs (Kieke, and Hartmann, 1974; Keith, and Pittman, 1983). This subject related to this point that this tool cannot be considered as alone. By considering these data it may terminate to wrong estimate of hydrocarbon volume of the reservoir.

So it is necessary to compare the results of multimin which is feed by the logs data and other windows such as petrography and petrography carbonate.

1.1. Arab Formation

Arab Formation was deposited at Jurassic time underlined the Heith Formation as the caprock. In the field understudy, the formation consisted of dolostone, limestone, anhydrite and shale. In the northern part is possible to connect with upper reservoirs due to faulting or lateral lithological variation. Repeat formation test (RFT) was also verified this connection in the area.

2. Methodology

Data sources in the present research work are wire well logs, core analysis, and petrography. After collection and evaluation, data selected for Geolog software, version 7, as input data. Several logs were used to get the information about lithology, porosity, and water saturation. Shale volume, porosity and water saturation were estimated using porosity logs (Density, Neutron and DT logs), GR and CGR (shale indicator), resistivity logs (MSFL,LLS,LLD) and Indonesia method (Sw) (Poupon & Leveaux, 1971). To get an accurate and optimize the petrophysical evaluation, all results of applied methods are compared and discussed. It seems to be necessary to give a very brief of the software to familiar its application in petrophysical evaluation.

All primary los data were integrated as XLS format and readable by Excel. All these data must be checked and evaluated before uploading in the software. To start the work by the software it should be produced a new project, then all raw petrophysical date as LAS format uploaded in connect part.

After loading data, there is a precalc step. However, some parts of data are as pre suggestion but the remaining data should be loaded manually such as bottom hole temperature (BHT), mud resistivity (Rm), filtered mud resistivity (Rmf), mud cake resistivity (Rmc), and Bit size (BS).

In the software calculations are made in two methods: deterministic and probabilistic. Determine step can be used for all estimation such as lithology, porosity and water saturation.Probabilistic calculation is based on optimization of logs data and their responses will create a model. Multimin method referred to analysis multi mineral and multi fluid (Mayer &Sibbit, 1970). This method can be able to select the best responses of the log and creates a predicted log as a final result according to input data.

3. Discussion

Nowadays it is believed that the core data provided the whole information about the reservoir. However, there is possible to find some errors due to the lack of sampling or the wrong selected program (Bennes and Hamon, 2007). Accurate estimation of the values of petrophysical parameters such as porosity and water saturation and lithology can be taken from the wirelogs in individual intervals and then this information can be extrapolated to the wells without core data. Therefore, theoretically, these calculations are possible to be effected by the local condition and so needs to be corrected (Aduojo and Oseghe, 2013). Petrophysical evaluation was made in several reservoirs (Amin-ul Islam, 2009).

In the present work the lithological, mineralogical and reservoir characteristics of the Arab Formation (eq. to Surmeh Formation) were discussed in one of Iranian oil fields in Persian Gulf.

According to neutron-density cross plot indicates that dolostone and anhydrite are the main components and shale as a subsidiary constituent (Fig.1). The average shale volume is very low (2.9) using CGR log (Table 1) and so it cannot be considered as a negative factor in reading and log responses.

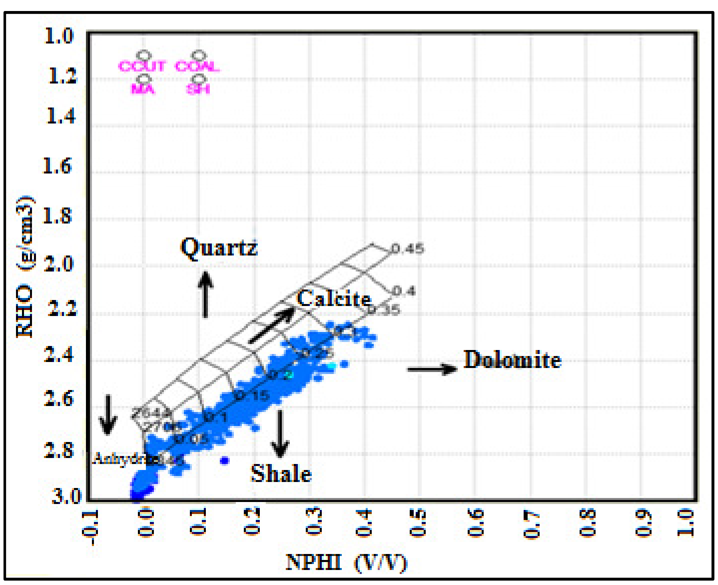

Figure 1: Neutron-Density cross plot to determine the porosity and lithology

Vsh(CGR)	25.0272
PHIT %	9.83
PHIE %	8.86
SW %	42.44

Table 1: Average shale volume, effective and total porosity, and water saturation calculated for Arab Formation in studied borehole

Lithology-The study indicated that anhydrite variation to depth is not distributed in uniform pattern. Its frequency increased in depth. Estimated values of anhydritein cross plot of multimin and petrographic data are showing a positive correlation with a high correlation coefficient of R^2 (0.99). In the cross plot of multimin-petrographic carbonate, exhibited a uniform trend in all zones with different correlation coefficient values (R^2=0.88). This may be related to scattering in individual horizons, different depositional condition while deposition or the lack of suitable fluid while diagenetic processes.
Estimated volumes of dolomite in cross plot of multimin-petrographic carbonate data are not showing a positive correlation and not correlated well to log data. Its correlation coefficient is (R^2=0.91) lower than multimin-petrographic(R^2=0.99).

Calcite determined in very less quantity. Its distribution is also indicating a well correlation coefficient in petrography-multimin plot in all zones (R^2=0.95).In petrography carbonate and multimin plot presents non uniform pattern with a general low correlation coefficient (R^2=0.23).This is verified a low correlation of petrography carbonate data in comparing to petrography data to multimin (logs data).
By comparing the results in general distributions in cross plots of multimin- petrographic and multimin-petrographic carbonate, it is revealed that the correlation coefficient of multimin-petrographic carbonate is lower (R^2=0.88 for anhydrite and 0.91 for dolomite, and 0.23 for calcite). Therefore, the results of multimin to petrographic methods are well correlated than multimin to petrographic carbonate method (Fig 2).

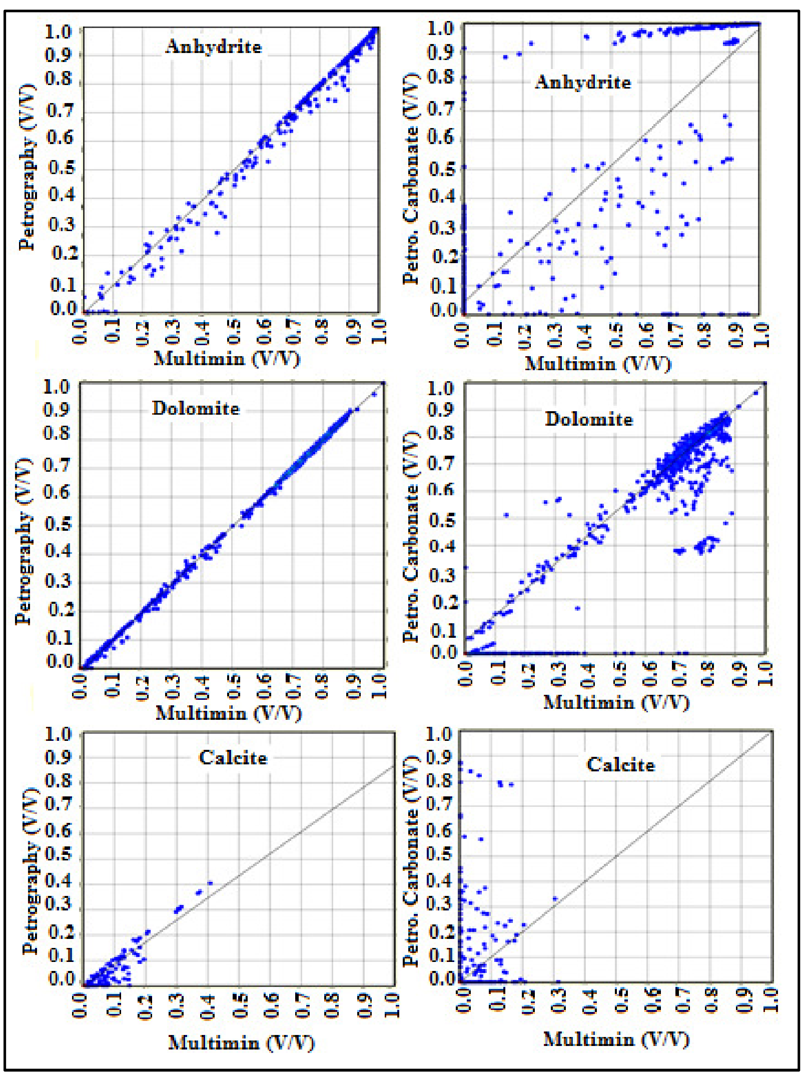

Figure 2: General distribution plots of Anhydrite (A, B), Dolomite (C, D) and Calcite (E, F) according to Multimin to petrography and petrography carbonate, respectively.

It is consequently terminated to this fact that the multimin-petrography method has higher resolution and differentiation potential in lithological determination than multimin-petrography carbonate method. In spite of the high potential of petrography carbonate method in resolution of limestone.

Porosity-The present available data indicated that the porosity average is 14.7%. However its average in the case of effective porosity is lower (Table 2). The porosity variation in multimin-core plot is showing a correlation coefficient of R^2 (0.69) while in the plot of petrography-core data is 0.71 (Figure 3). This appeared that the petrography data is correlated well to log data. In the case of petrography carbonate –core data, the correlation coefficient is also higher than two other methods and indicates R^2 equal to 0.91 that is too harmony to real (core data) data.

The histogram of porosity variation in all zones presented that zone 6 and zone 5 has the highest and lowest porosity values respectively. Zone 4 shows a very wide range of variation. By comparing this it appeared that is also presented in zone 1. This matter will be related to the values of dolomite and anhydrite in these zones (Figure 4).

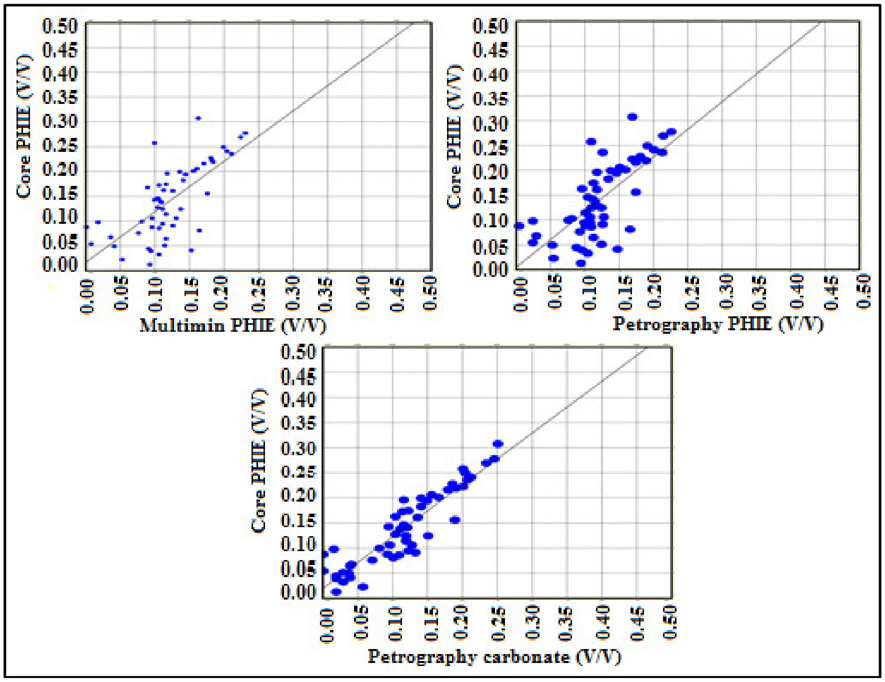

Figure 3: Total porosity variation based on core data vs Multimin, Petrography and petrography carbonate vs. core data

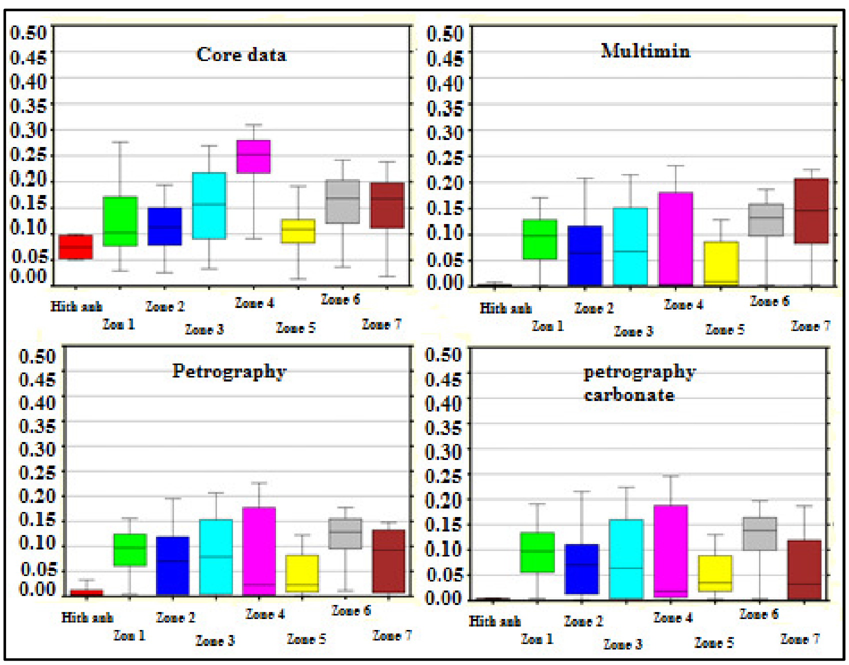

Figure 4: Total porosity variation histograms of core data, multimin, petrography and petrography carbonate methods. Hith anhydrite is indicated as a comparison layer.

Water saturation- Water saturation values are given in Table 2. Its variation showed that zones 1, 3 and 5 are having less value than other zones. However they have different effective porosities. Water saturation estimated in all zones by multimin vs petrography and petrography carbonate methods (Fig.5).The correlation coefficients (R^2) are 0.72 and 0.87 in the plot of multimin-petrography and multimin-petrography carbonate, respectively. In spite of higher value in second plot, there is observed a discrepancy in data.
The histograms of water saturation variation in multimin vs petrography and petrography carbonate methods (Fig.6), demonstrated that zones 2, 3, 4, and 5 are containing high degrees but zone 1 and 6 are showing low degrees. However, the estimated values are lower in petrography method.

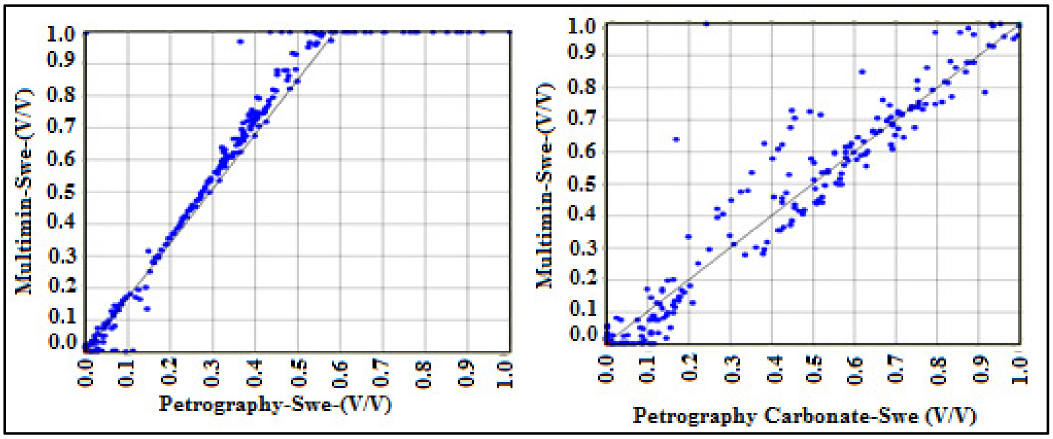

Figure 5: Water saturation distribution using multimin to petrography and petrography carbonate

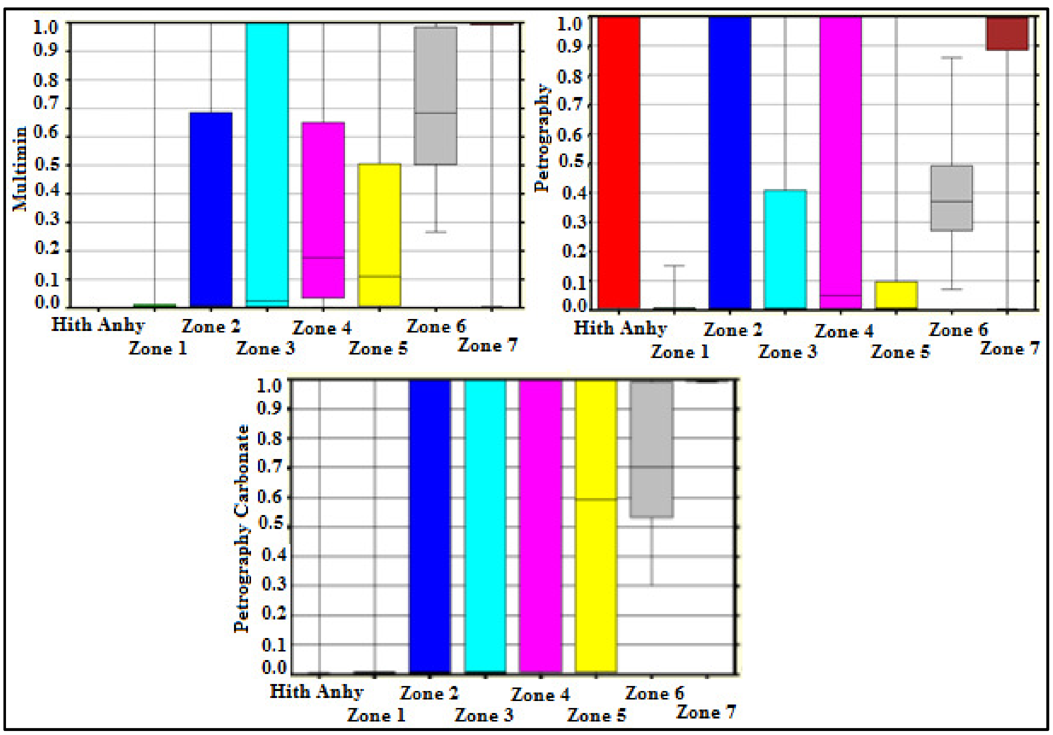

Figure 6: Histogram plots of water saturation in each zone based on multimin, petrography and petrography carbonate

ZONE	PHIE %	Sw %
Arab1	9.569	2.121
Arab2	7.024	31.246
Arab3	8.421	26.363
Arab4	7.564	31.549
Arab5	4.543	17.884
Arab6	11.968	61.699
Arab7	5.937	84.616

Table 2: Effective Porosity and water saturation averages for Arab reservoir zones

Statistical parameters such as error standard, skewness, curtesis, median and mode in all applied methods (Table 3) are indicated that these methods are well correlated in view of porosity variation than water saturation values.

		Std. Deviation	Skewness	Kurtosis	Median	Mode
Porosity	Multimin	0.07629	0.32757	2.18725	0.09339	0.11250
	petrography	0.07113	0.32785	2.16800	0.09062	0.01250
	Petrog. Carbonate	0.07229	0.33195	2.08761	0.08577	0.11750
Water saturation	Multimin	0.45581	-0.12868	1.17481	0.62625	0.99500
	petrography	0.41402	0.66810	1.70153	0.62625	0.99500
	Petrog. Carbonate	0.42514	0.52251	1.52923	0.23000	0.02500

Table 3: Statistical parameters of porosity and water saturation compared in multimin, petrography and petrography carbonate methods

All lithological results of three methods: multimin, petrography and petrography carbonate are given in Figure 7 to comparing purposes. The figure presents that the resolution potential of petrography carbonate is matched more and lithologically differentiated well in comparing to the lithologic log (right).

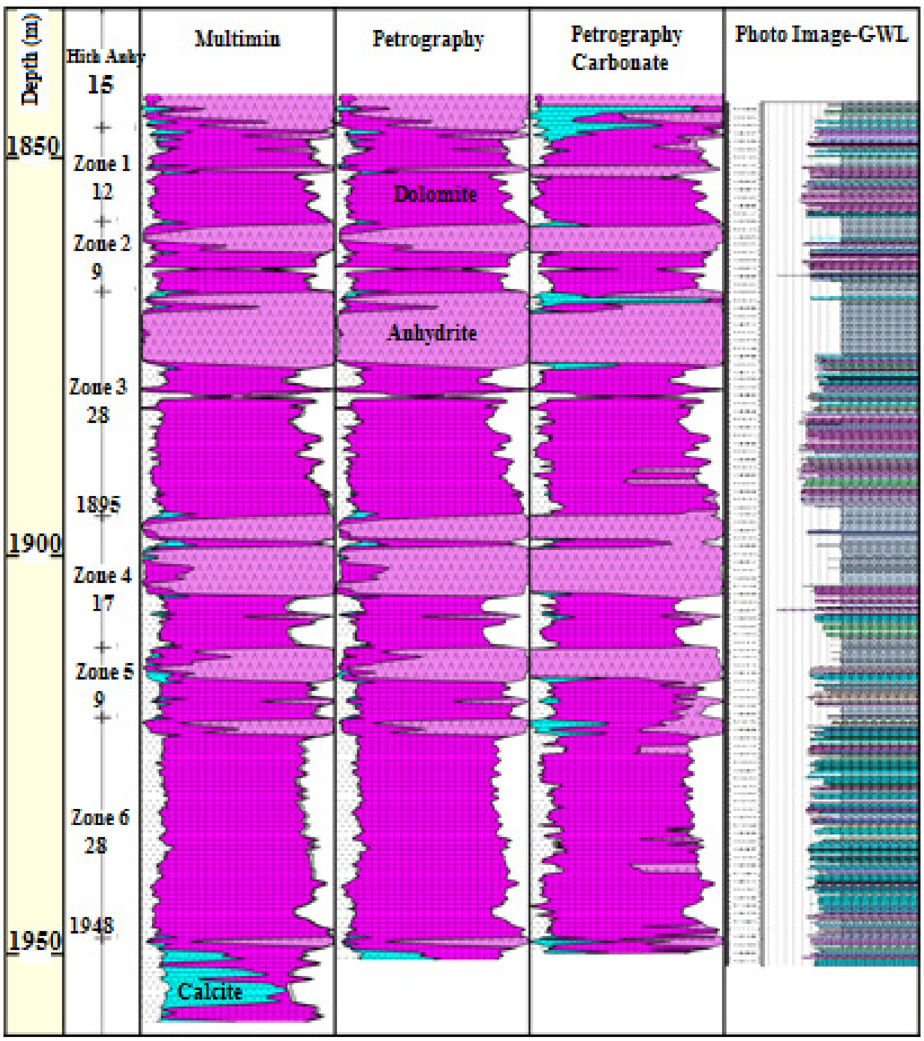

Figure 7: The comparison of lithological results by different methods: multimin, petrography and petrography carbonate in Arab Formation

By comparing to the real data (core analysis) (Figure 8), there is observed the highest correlation of porosity results in petrography carbonate. The petrography results are however showing a good match with the core data in view of water saturation as well. As observed that water saturation values are estimated higher in petrography carbonate than petrography results.

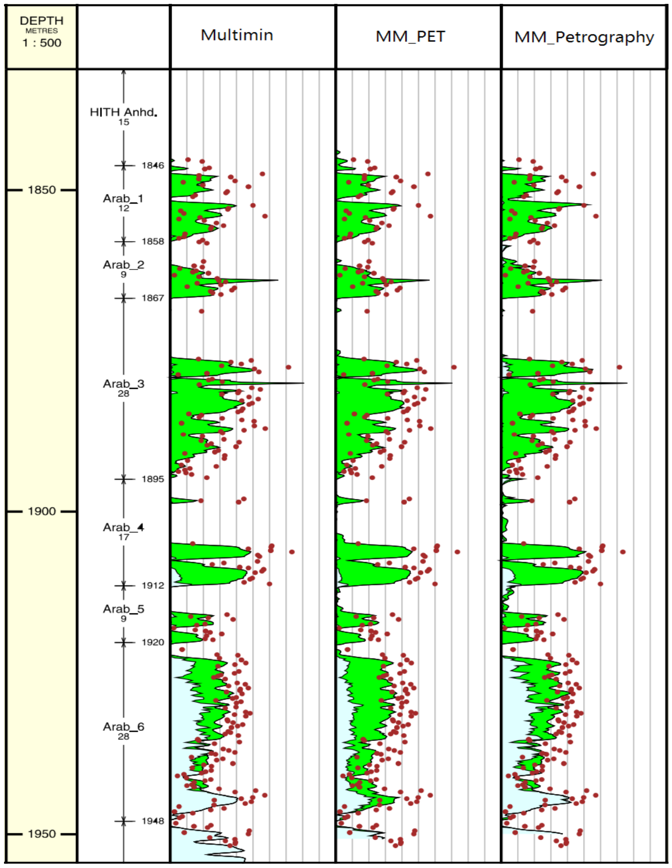

Figure 8: The comparison of Porosity (green) and water saturation (blue) results by different methods: multimin, petrography and petrography carbonate and the porosity core data (points) in Arab Formation

The porosity and permeability variations to depth is also verified not only they are not correlated well (Figure 9) to each other but also they seem to be depended on the reservoir lithology.

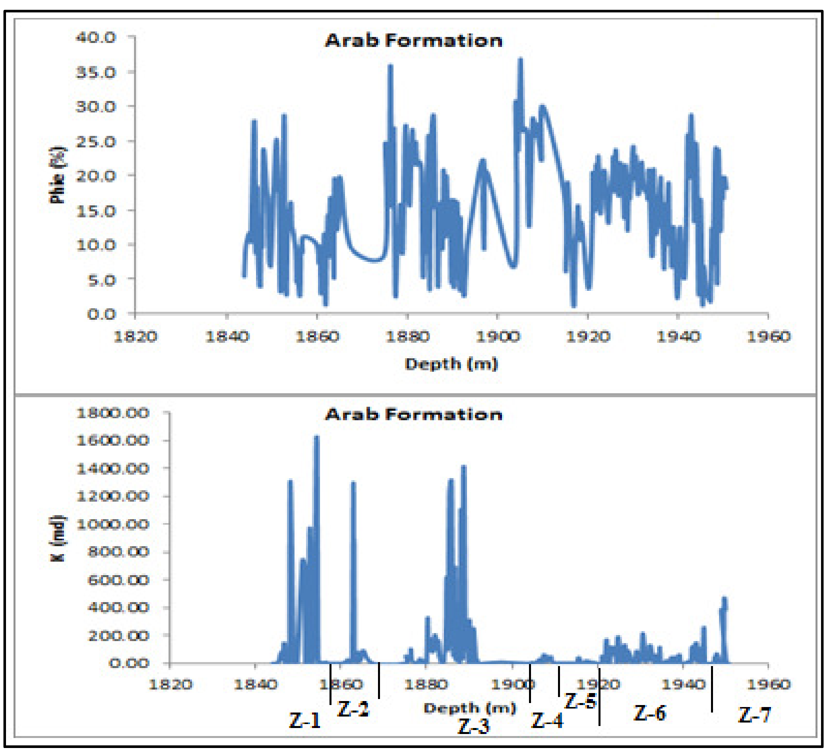

Figure 9: Porosity and permeability variations to depth in Arab Formation

4. Concluding Remarks

The main lithological components of Arab Formation in the field under study are dolostone and anhydrite.

The estimated volumes of dolomite, and anhydrite comparing to petrography carbonate method are not uniform in all zones. Multimin and petrography mineralogical estimation are showing good correlation than petrography carbonate.

The results of petrography, petrography carbonate, core data and corrected well logs were used and uploaded in Geolog software to construct the basic petrophysical model.

The porosity data variation in plots of petrography, petrography carbonate and core data to multimin data revealed that the correlation coefficients are varied from 0.69, 0.71, and 0.91 respectively. This is concluded that the petrography carbonate method is more suitable and showed well correlation to multimin results than other methods in view of the porosity estimation. Water saturation study is also provided the same results. However, the water saturation results of the petrography carbonate are scattered than petrography method and therefore for this purposes petrography estimation is preferred. If the porosity and permeability variation are compared it is observed that they will not correlated well since they depend on the reservoir lithological variation. Their variation resulted to this fact that among of 7 reservoir zones, the best reservoir quality is preserved in zones 1 and 3.

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