

RESERVOIR CHARACTERIZATION OF ILLAM FORMATION IN KUPAL OIL FIELD, SW OF IRAN

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Received April 7, 2019; Accepted June 13, 2019

Abstract

Porosity, shale volume, and fluid saturation are the most important parameters used to determine the characteristics of oil reservoirs. The kupal oil field has located in Dezful embayment. Illam formation introduced as a fractured reservoir at the southwest of Iran. In this study, wells No.48 and 54 investigated. Based on this study and using well logging diagrams, the main lithology determined Limestone. It is worth mentioning that substrates of shale, dolomite and in some cases anhydrite can see. As well as based on the performed study, this formation divided into three zones, including two permeable zones and one non-permeable zone. In the non-permeable section, main minerals have determined as clay, being types of Montmorillonite, Mix layers, and Illite. Base on Gr log, the average volume of shale in wells No. 48 and 54 was 8% to 17% respectively, that overall shows Low percent volume of shale. In this field, the amount of porosity increased from SE to NW. Accordingly, the well log plot, there are appropriate porosity and water saturation in this horizon. To enhance the accuracy of formation of water saturation calculations, we calculate it by software using Indonesian and Simandoux methods. Such that the average effective porosity and water saturation are 7.9 and 43.4 %, respectively. Finally, it can be stated this formation has poor to mean reservoir characteristic, but it can achieve reservoir capacity from some wells and adjacent fields.

Keywords: *Petrophysical evaluation, Porosity, Water Saturation, Illam formation, Kupal oil field, Geolog Ver 6.7.1.*

1. Introduction

Achieve the information related to porosity and permeability of formations is one of the major problems of oil engineers [1]. These parameters are among the most important information in designing and controlling discovery operation [2]. The most significant application of wire line logs is an evaluation of petrophysical characteristics of the formations in order to survey the reservoir quality of different sections of reservoir formation and find the most appropriate zones for efficient exploitation of the reservoir and for a more assured development of oil fields [3]. Porosity, shale volume, and fluid saturation are the most important parameters that were used to determine the characteristics of oil and gas reservoirs [4]. For the first time, Illam formation was studied by James and Wynd [5].

Since Illam formation was considered one of the most prominent oil reservoir rocks in southwest of Iran, a comprehensive and precise revision of this formation and surveying petrophysical and petrofabric characteristics of this formation is of great importance in the oil industry.

2. Geological setting

The Kupal oil field located in the middle of Dezful Embayment. This anticline is an asymmetrical structure with NE-SW trend, and southern flank dip is higher than northern flank and causes to change the axis to follow the west trend in the northern part and southern trend in the west. The thickness of the Asmari reservoir in this field is 347m and divided into 8 zones

based on petrophysical data. The most important character of the Asmari presence of extended natural fracture systems, which causes high productivity of wells notwithstanding low matrix porosity (Figure 1).

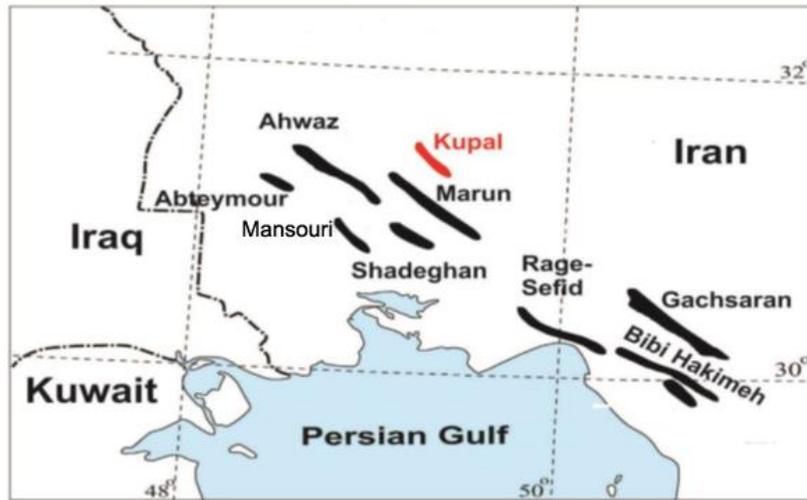


Figure 1. Located of Kupal oil field in Dezful embayment, near the other oil fields, Southwest of Iran

3. Methodology

In this study, 2 wells (Wells No. 48 and 54) in Kupal oilfield have considered for petrophysical studies. These wells have almost complete information and logging data. In this study, the raw data from two wells with Geolog ver. 6.7.1 software has been using to determine reservoir parameters affecting the reservation quality of Illam formation.

Recognition of lithology, calculation of shale volume (V_{sh}), total porosity (PHIT), effective porosity (PHIE) and water saturation (S_w), are the most important parameters in the petrophysical evaluation, and these are necessary to find the quality of the formation [6].

4. Result and discussions

In this study, 2 wells (Wells No. 48 and 54) in Kupal oilfield have considered for petrophysical studies. These wells have almost complete information and logging data. In this study, the raw data from two wells with Geolog ver. 6.7.1 software has used to determine reservoir parameters affecting the reservation quality of Illam formation.

4.1. Shale volume calculation

There are various methods for calculating shale volume. In some cases, only a log can be calculated, and in some cases, a combination of two or more logs can be used to calculate shale volume. Here, for more accuracy and removal of the effect of uranium, we use the available CGR results to calculate. Among of Shale volume has calculated for this Formation (Table.1).

$$V_{sh} = \frac{CGR - CGR_{min}}{CGR_{max} - CGR_{min}} \quad (1)$$

Table 1. Shale volume (V_{sh}) in Kupal wells (Well No. 48 and 54).

Well No.	Min Shale volume	Average Shale volume	Max Shale volume
48	0	0.1741	1.000
54	0	0.0808	1.000

4.2. Type of clay mineral

Shale does not have fixed mineralogy. Among clay minerals, Illite is found more often than other minerals, and chlorite is abundant, while kaolinite is relatively rare [7]. We need a CGR logs to determine the type of clay minerals in different wells, and thorium-potassium cross-

plots (Th vs. K) have used [8]. As shown in Figures 2 and 3, clay minerals are dominant in both wells.

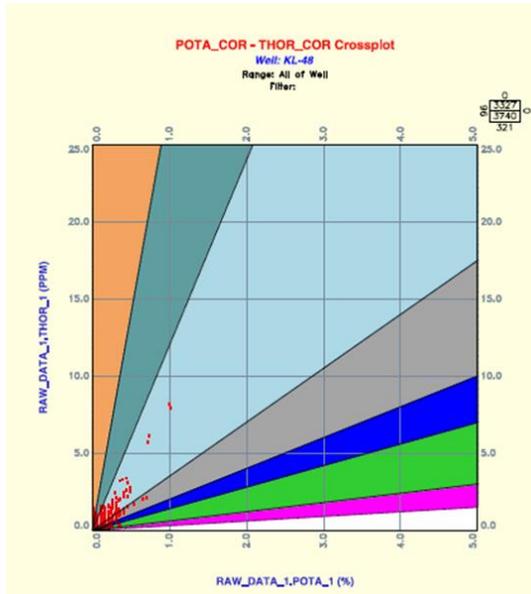


Figure 2. Type of clay minerals determination in well 48, Kupal oil field

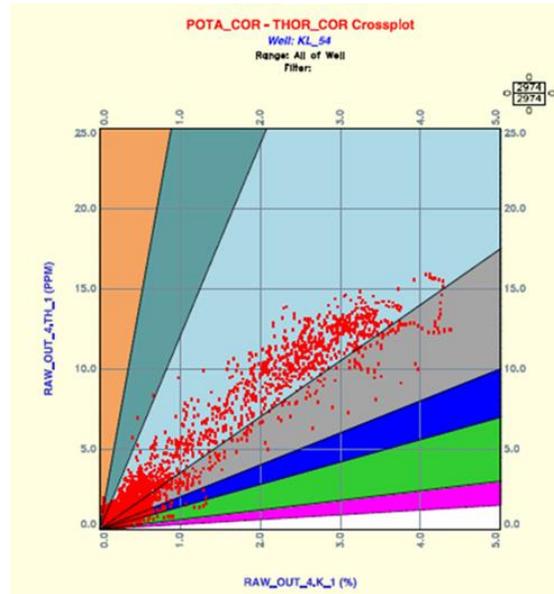


Figure 3. Type of clay minerals determination in well 54, Kupal oil field.

4.3. Porosity calculation

There are several methods for calculating porosity, depending on the type of logs available in each well. Porosity logs, i.e., neutron-density logs and sonic logs, used to calculate porosity. Porosity can be obtained from a log or a combination of different logs [9]. In this study, the porosity calculation (Table.2) was performed using the Sonic logs (Equation 2) and the neutron-density logs (Equation 3).

$$\phi_{Sonic} = \frac{DT - DT_{ma}}{DT_{fl} - DT_{ma}} \quad (2)$$

$$\phi_{ND} = \sqrt{\frac{\phi_N^2 + \phi_D^2}{2}} \quad (3)$$

Table 2. Calculation of sonic, neutron-density, effective, and total porosity

Well No.	$\phi_{Sonic} (v/v)$	$\phi_{ND} (v/v)$	$\phi_T (v/v)$	$\phi_E (v/v)$
48	0.059	0.130	0.0963	0.074
54	0.070	0.064	0.079	0.084

4.4. Detection of porosity types based on velocity log

The velocity deviation log will be computed from the composition of the sonic logs with the neutron or density log (Table.3), and it can be used to get information on the types of porosity (Table.4) in carbonates, the tracing of distribution of empty diagenetic spaces and prediction of permeability. In order to construct this log, in the first step, porosity log data will be converted to artificial velocity using the mean time-Willey equation, and its difference plotted with the actual velocity derived from the sonic log as the velocity deviation log [10].

In the well No.48, by examining the velocity deviation log, because most of the positive and zero deviations shown, we conclude that the porosity types in this well are moldic and intra porosity due to positive zones and intergranular and intercrystalline porosity due to zero zones. In two depths of 4146 and 4163 meters, with negative deviation in the velocity log, according to the Caliper logs, we conclude that the negative zone is due to casting.

In the well No.54, by examining the velocity deviation log, because of most positive deviations, we conclude that the porosity types in this well are moldic and intra, and in small amounts of zero deviation, we expect intergranular and intercrystalline porosity.

Table 3. Maximum, minimum and mean velocity deviations calculation

Well No.	VDL(m/s) min	VDL(m/s) mean	VDL(m/s) max
48	-2511.773	-85.3341	23152.0078
54	-267.778	149.6735	2842.0579

4.5. Secondary porosity

Given availability of neutron-density porosity logs to calculate total porosity and sonic logs to calculate initial porosity (this log ignores vuggy porosity), it is possible to calculate the secondary porosity which introduced as a secondary porosity index (SPI) [11].

Table 4. Secondary porosity calculation

Well No.	SPI
48	0.0496
54	0.0271

The most common method for determining the secondary porosity (Table.4), is to deduct porosity of the sonic logs (ϕ_{SONIC}) from porosity of FDC or CNL [8]. In this study, the following formula used to calculate the secondary porosity:

$$\phi_{secondary} = \phi_{ND} - \phi_{SONIC} \tag{4}$$

4.6. Lithology

One of the main uses of well logs is Lithologic detection. There are several methods for determining the lithology that their application is dependent on the availability and type of Lithologic-sensitive logs [12]. There are various cross-plots that combine two or three charts, suggest two or three different mineralogy; one of the most suitable are M-N plots. Considering the complex lithology of Asmari reservoir in the studied field, a combination of different logs can be useful for lithology detection, the best way to use M-N plot. This cross-plot obtained by combining three neutron, density, and sonic porosity logs. In this graph, the parameter M is the integration of the sonic-density measurement, and the N is cross plot slope of the neutron-density. M and N obtained according to the following equations (5 and 6) and drawn against each other [13].

$$M = \left[\frac{\Delta t_f - \Delta t}{\rho_b - \rho_f} \right] \times 0.01 \tag{5}$$

$$N = \frac{\phi_{Nf} - \phi_N}{\rho_b - \rho_f} \tag{6}$$

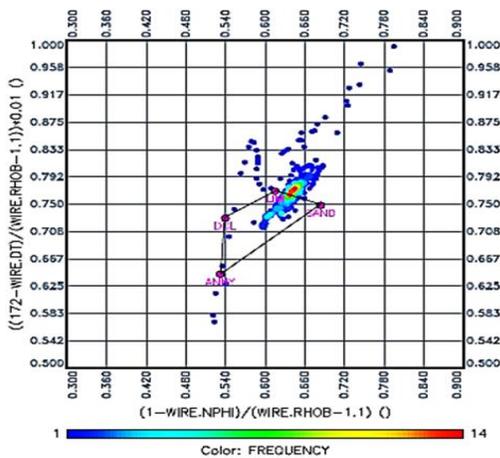


Figure 4. M-N Plot in Well No.48, Kupal oil field and lithological detection

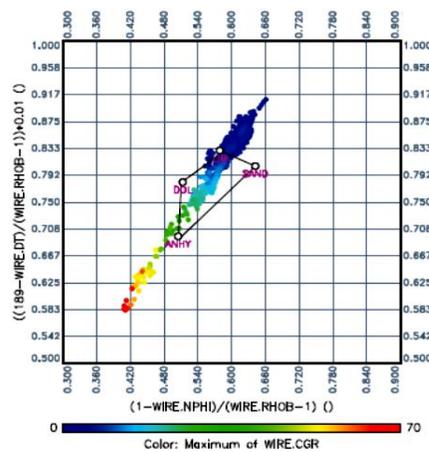
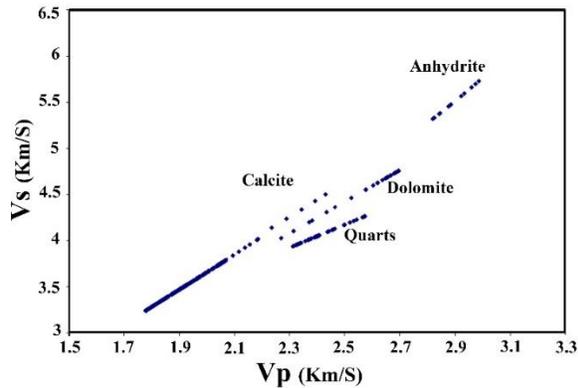


Figure 5. M-N Plot in Well No.54, Kupal oil field and lithological detection

Based on cross-plots drawn from the two wells, and according to the color range of CGR chart, the dominant lithology of carbonate detected (In well No.48, calcite is more than dolomite and in well No.54 is almost lime shale). Also, well No.54 shows shale's more (Figure 4 and 5).



In well logging with consideration to the well situation, some appropriate physical parameters chosen for surveying the geological layers. Among them, the ratio of pressure wave to cutting (V_p/V_s) can use as a key factor in diagnosing some important characteristics of the reservoir such as lithology [14]. In order to distinguish lithology, this ratio calculated in wells (Well No. 48) (Fig. 6).

Figure 6. Dispersion diagram of the ratio of V_p/V_s . in well logging data of Kupal oil field (Well No. 48)

4.7. Calculation of water saturation

There are different methods to calculate water saturation [15]. Among these methods, the Indonesian equation is more efficient in carbonate rocks. In this study, the Indonesian equation used as follows [8,16]:

$$\frac{1}{R_t} = \left[\frac{\phi^m}{a \times R_w} + \frac{V_{sh}^{(1-0.5 \times V_{sh})}}{R_{sh}^{0.5}} \right]^2 \times S_w^n \tag{7}$$

To enhance the accuracy of formation of water saturation calculations, we calculate it by software using Indonesian and Simandoux methods. The volume of water in each well can be obtained in this way as a result of these calculations, as shown in Table 5.

Table 5. Calculation of water saturation in well No. 48 and 54, Kupal oil field

Well No.	S_{W-E}	S_{W-SIM}	S_{W-INDO}	$V_{UW_{at}}$
48	0.427	0.441	0.448	0.018
54	0.473	0.419	0.420	0.023

Considering that in the previous calculations, the effective porosity and effective water saturation values calculated in each well, equation (8) can be used to calculate the volume of oil.

$$VOL - UOIL = (1 - SW_E)PHIE \tag{8}$$

5. Conclusion

Based on the analysis of well logs and calculation of petrophysical reservoir parameters, the results are as follows:

Illam Formation in this field has a low average shale volume, and the upper part of this formation is important in production, the reservoir made of clean lithology and the amount of shale in the lower parts of the formation is slightly higher. The low amount of shale is probably due to sedimentation of the formation in an energetic environment. Well logs analysis shows that this reservoir has good porosity, especially in the upper part of the formation. Porosity variations are not high at the surface of the field, but due to the low amount of shale, we conclude that most of this porosity is effective. Proper porosity in this field can be affected by sedimentation. For determining the porosity types, artificial velocity deviation logs have used. The tendency of these logs to the positive side indicates porosity of the mold, vuggy, and intra. The lithology of Illam Formation has estimated using various methods including two logs, three logs, and a variety of cross-plots. All of these methods indicate the predominance of carbonate lithology (calcite, dolomite). In this study, Indonesian and Simandoux equations have used to calculate water saturation. Due to the low amount of shale, the values obtained

from these equations are very close. Based on the thresholds defined for separation of gross and net sections, the thickness of these segments has calculated. Due to the amount of low shale and good porosity, almost all of the formation is a good reservoir, but due to the amount of water saturation, the thickness of the produced zone varies in wells. According to the lithological and petrophysical characteristics of Illam reservoir in the studied wells, this formation classified into different zones. Based on thorium-potassium cross-plot, in both wells the dominant clay minerals have identified as Illite.

References

- [1] Pickett GR. Acoustic character logs and their applications in formation evaluation. JPT, 1963; 15: 650-667.
- [2] Bhatt A, Hell HB. Committee neural networks for porosity and permeability prediction from well logs. Geophysical Prospecting, 2002; 50: 645-660.
- [3] Tiab D, and Donaldson CE. Petrophysics, theory and practice of measuring reservoir rock and fluid transport properties. Gulf Professional Publishing, Elsevier, Second edition, 926 pages, 2004.
- [5] James G A, Wynd JG. Stratigraphic nomenclature of Iranian oil consortium, agreement area. American Association of Petroleum Geologists Bulletin, 1965; 49(12): 2182 – 2245.
- [6] Poupon A, Leveaux J. Evaluation of water saturation in shaly formations. SPWLA 12th Annual logging symposium, 1971.
- [7] Patchett G. An Investigation of Shale Conductivity. The Log Analyst, 1975; 16(6):.25.
- [8] Rezaee MR. Application of Well Log Analysis. A short Course for N.I.O.C, 1997.
- [9] Shazly TF, Ramadan MA. Well logs application in determining the impact of mineral types and proportions on the reservoir performance of Bahariya formation of Bassel-1x well, western desert, Egypt. Journal of American Science, 2011; 7(1): 498-505.
- [10] Anselmetti FS, Eberli GP. The Velocity Deviation Log; A Tool to Predict Pore Type Permeability Trends in Carbonate Drill Holes From Sonics And Porosity or Density Logs. AAPG Bulletin, 1999; 83(3): 450-466.
- [11] Farzadi P, and Hesthammer J. Diagnosis of the Upper Cretaceous Paleokarst and Turbidite Systems from the Iranian Persian Gulf using Volume-based Multiple Seismic Attribute Analysis and Pattern Recognition. Petroleum Geoscience Journal, 2007; 13(3):227-240.
- [12] Clavier C, Rust DH. Mid-plot, a new lithology technique. The Log Analyst, 1976; 17(6): 16-31.
- [13] Burke JA, Schmidt AW, Campbell RL. The Litho/Porosity Cross Plot. The Log Analyst, 1969; 10(6): 1969.
- [14] Rezaee MR, Kadkhodaie A, and Barabadi A. Prediction of shear wave velocity from petrophysical data utilizing intelligent systems: An example from a sandstone reservoir of Carnarvon Basin, Australia. Journal of Petroleum Science and Engineering, 2007; 55: 201–212.
- [15] Archie GE. The electrical resistivity log as an aid in determining some reservoir characteristics. Petroleum Transactions of AIME, 1942; 146: 54–62.
- [16] Simandoux P. Mesure électriques en milieu poreux, application a mesure des saturations en eau. Etude du Comportement des massifs Argileux, Supplementary Issue, Revue de l'Institut Francais du Petrol, 1963.

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