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RESEARCH PAPER

Determination of characteristics related to reservoir of Sarvak formation in maroon oil field

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Abstract
In this study, characteristics related to reservoir of Sarvak Formation have been studied using well logs, two selected wells from Maroon oil field and specialized GEOLOG 6.7 software with probability statistics method (Probabilistic). Petrophysical parameters were determined from well log diagrams. Accordingly, there are appropriate porosity and water saturation in this horizon, such that the average effective porosity and water saturation are 41.2 and 28.2 %, respectively. Based on Neutron- density cross-plot, it is determined that Sarvak Formation lithology is composed of limestone, dolomite and in some intervals, shale. Also shale volume is low according to CGR charts so that its mean value is 0.55%.

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Introduction

Petrophysical evaluation is the knowledge of interpretation of data gained from well logs in order of evaluation of the quality of different parts of the formation and also reservoir zoning to determine the most appropriate zones in order to optimize the exploitation of reservoir and development of oil fields. Maroon oil field is one of the biggest oil fields in Dezful Embayment. This field is located in the north western part of Omidiyeh county and sout eastern of Ahwaz city in Khuzestan province among Aghajari, Kupal, Ramshir, Shadegan, Ramshir and Ahwaz (Motiee, 2009). Available oils of this field are in the formations of Asmari, Ilam and Sarvak (Arian, 2011). Recognition of lithology, calculation of shale volume (V_{sh}), total porosity (PHI_T), effective porosity (PHI_E) and water saturation (S_W), are the most important parameters in petrophysical evaluation to determine the quality of the reservoir formation (Hearst *et al*, 2000).

Shale is one of the most important parameters in all studies about petrophysical and reservation quality. Shale volume means the volume of clay minerals in the container. Calculation of the volume of shale is performed using GR (gamma ray) and CGR (corrected gamma ray) graph. Porosity is important property of a rock, since the capacity and volume of oil accumulation in rocks is a function of porosity. Probability method of GEOLOG software is based on solution of simultaneous equations.

The aim of this study is determination of data from two well logs in oil field of Maroon and petrophysics GEOLOG 6.7 specialized software have been used to determine petrophysical parameters affecting on the reservation quality of Sarvak Formation.

Material and methods

Lithology Determination

For lithology determination, cross diagrams (neutron-density), which are considered as porosity logs, have been used in this study after environment corrections. It is considered as the most accurate

available mean for lithology, when these two graphs are driven at the same time in the well (Schlumberger, 1989). Using this diagram, dominant lithology in the Sarvak formation has been investigated and from the lithological points of view, a mixture of limestone and dolomite in some intervals, the shale has been recognized (Figs. 1 and 2).
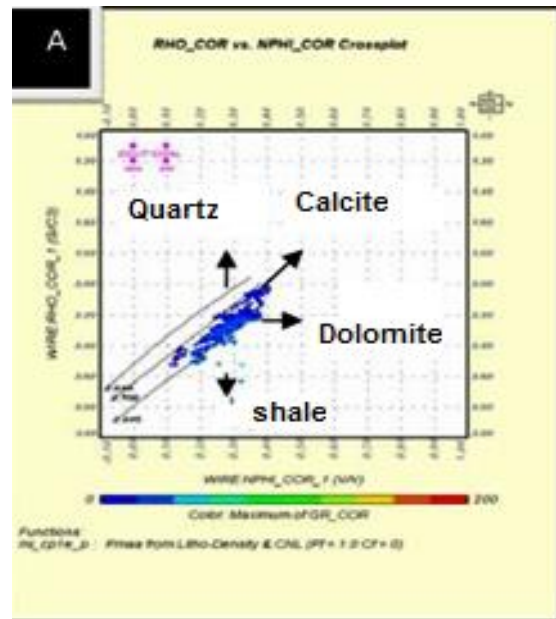
Fig. 1. Neutron density cross-plot in the studied area to determine the lithology of wells A.
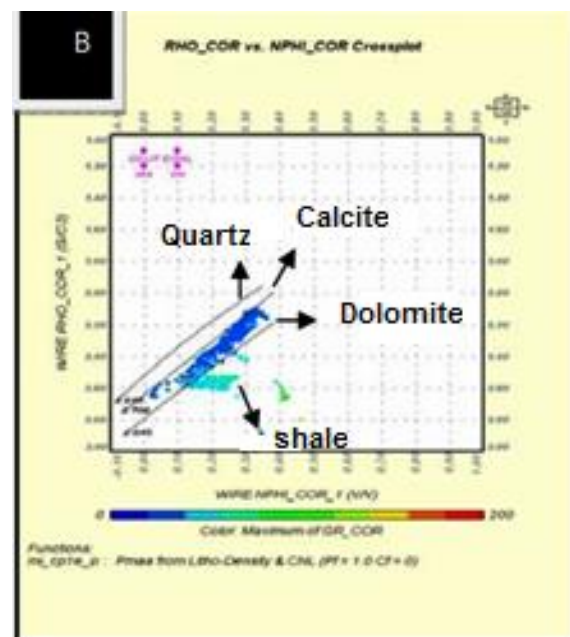
Fig. 2. Neutron density cross-plot in the studied area to determine the lithology of wells B.

Results and discussions

Calculation of the volume of shale

Shale is one of the most important parameters in all studies about petrophysical and reservation quality. Shale volume means the volume of clay minerals in the container. Calculation of the volume of shale is performed using GR (gamma ray) and CGR (corrected gamma ray) graph. Accurate assessment of shale volume could be achieved by calculating the volume of shale only by CGR method since GR graph records the Uranium (U) and non-clay minerals like dolomite beside potassium (K) and thorium (Th) which also are recorded by CGR (Tiab, 2000). So in this study, we used the CGR method and the results are given in the table. As it can be seen, mean shale volume is low which it represents that the Sarvak Formation is clean.

Calculation of porosity

Porosity is the most important property of a rock, since the capacity and volume of oil accumulation in rocks is a function of porosity (Motiee, 2009). Probability method of GEOLOG software is based on solution of simultaneous equations (Tiab, 2000). To calculate the porosity, porosity charts (density, neutron, sonic) have been used and the results are shown in Table 1.

Calculation of water saturation

To calculate water saturation, Archie (Fertle, 1981) and Indonesia (Archie, 1950) method were examined and the results were compared with each other:

Archie method

In clean and Shale free formation water saturation is calculated by Archie method. Archie formula is based on the fact that the only conductive material in the formation is salt water; but in sandy shale formations, ions that are released along with shale are also responsible for conducting electrical current. Presence of shale may reduce distortion in SP chart and increase actual conductivity (C_t). It should be noted that the ion exchange capacity, which indicates the potential of shale in the electrical conductivity,

May shows a significant effect on the assessment of hydrocarbon formations.

For non-shale formations, Archie introduced the principle of formation's resistively factor F as follows:

$$F = \frac{R_0}{R_W} = \frac{C_W}{C_0}$$

In this equation, R_0 is the resistance of the formation which is 100% saturated by an electrolyte with resistance R_w such as water. C_0 and C_w also considered as a conductor. C_0 plot vs. C_w is a straight line through the origin with the slope in $1/F$.

Archie concluded that resistance showed by clean formation is not only depending on the resistance of saturating salt water but also on the amount of electrolyte in the empty spaces in rocks. The results of Archie resistance equation confirmed this model for reservoir sandy formations.

$$C_t = \frac{C_W}{F} S_W^n$$

S_w is the saturation of water as a fraction of empty spaces. n is saturation capacity and C_t is the conductivity of reservoir stone in the saturation time S_w.

The following formula can be considered as Archie formula:

$$S_W = \sqrt[n]{\frac{a}{\phi^m} \times R_W \times \frac{1}{R_t}} \qquad (1)$$

a: Archie constant, mainly equal to 1
n: saturation capacity
m: Cementation Coefficient
ϕ: porosity
R_w: water resistivity of formation
R_t: real resistance
S_w: water saturation

According to the above definitions, in the clay mineral formations, water trapped between thin layers of shale leads to additional conductivity. This means that the Archie equation over estimates the water saturation than the real amount.

Indonesia method

In this method, water saturation is calculated by the following equation. These have been performed by the GEOLOG software.

$$\sqrt{C_o} = \sqrt{C_w/F} + V_{sh}^{1-v_{sh/2}} \times \sqrt{C_{sh}} \qquad (2)$$

In the oil zon

$$\sqrt{Ct} = \sqrt{C_w/F \times S_w^{n/2}} + v_{sh}^{1-v_{sh/2}} \times \sqrt{C_{sh} \times S_w^{n/2}} \qquad (3)$$

C_o: electric conductivity of Hydrocarbon

C_w: electrical conductivity of water

F: Formation factor

V_{sh}: shale volume

C_{sh}: electrical conductivity of shale

C_t: real conductivity of formation

S_w: water saturation

And also it could be written as:

$$S_w = \left[\frac{R_w}{R_t} \times \frac{R_{sh}}{\left(VSH^{1-\frac{VSH}{2}} \sqrt{R_w} + O_e^{\frac{m}{2}} \sqrt{R_{sh}} \right)^2} \right]^{\frac{1}{m}}$$

After comparing two methods, one can say that: Indonesia model estimates considerable amounts for water saturation. But Archie model lacks this feature. Indonesian model calculates the water saturation with better accuracy. This is because of the fact that Indonesian model considers resistance factor and shale volume for calculations of water saturation.

Thus, Indonesia model was used to determine water saturation equation and the results are given in Table 1.

Table 1. The mean volume of shale, effective porosity, total porosity and water saturation calculated in wells A, B.

WELL	Well A	Well B	Average
V_{sh}%	0.51	0.59	0.55
PHI_T %	40.1	42.9	41.5
PHI_E %	39.8	42.6	41.2
S_w %	27.9	28.5	28.2

Reservoir zoning evaluation results

Usually for zoning (modularity) is done by considering the answer of graphs in the reservoir. In this study, after data preparation, environmental improvement, analysis of data about petrophysical properties of well, Sarvak Formation was divided into 6 sections S_1 to S_6 in the studied region. Due to the specific characteristics, is divided S_1 to 6 subdivision from S_1-a to S_1-f. Finally, the S_1 has been recognized as the best part of the reservoir and the S_1-c as the best subdivision.

Conclusion

Sarvak formation evaluation in the oil field of Maroon exhibits following results: Using different evaluations, Sarvak formation lithology is a mixture of limestone, dolomite and also shale at some points. Using the CGR graph, average shale volume is low, so that Sarvak formation could be considered as a clean formation; Based on the these evaluations on well log curves in the studied area, the average porosity is completely appropriate (total average porosity of 41.5% and effective average porosity of 41.2 percent); Water saturation is calculated by Indonesia method and the average value in Sarvak formation is 28.2%; Sarvak formation has been divided to 6 main parts and part 1 is divided to 6 subdivisions; finally part 1 and subdivision 3 has been identified as the best reservoir part and subdivision, respectively.

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