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Petrophysical Evaluation and the Effect of Shale Layers on Net Pay Zone Thickness in the Marun Oil Field, Iran

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Abstract

The Marun oil field is situated on the eastern part of Zagros, Iran. Aghajari Formation is cropping out on the surface. The Asmari formation, the Bangestan and Khami Groups are the Main reservoirs in this field and Asmari formation is the most important reservoir. Dolomitic carbonates are dominant lithology in the study well. Increasing of shale Layers in different layers caused to decrease of brittle property and this condition had investigated by petrophysical evaluation. According to this research, near to 29 percent shale has mixed with sandstone rock units in the study well which is comparable with maximum porosity there. Because, sandstone layers have shown the best porosity (near to 26 percent) in the study well. Also, good rocks based on water saturation and porosity are situated in sandstone units and poor rocks have existed in the limestone-dolomites. Therefore, facies changes in the Asmari formation can explain the observed variations in reservoir quality in the study area.

Keywords

Asmari Formation, Marun Oil Field, Petrophysical Evaluation, Well Logging

1. Introduction

The Marun oil field has located in the south east of Ahwaz city on the south west of Iran. It has got 65 Km length and 8 Km width on the Zagros fold-and-thrust belt. The Oligocene-lower Miocene [1]-[4] limestones and sandstone of the Asmari formation are the most important reservoirs in Iran.

The formation is categorized as the main reservoir of so many fields in the south western Iran. In general, due

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to its importance in petroleum geology, the study of Asmari formation has been always considered as an area of interest for many researchers. The formation consists of 300 - 500 meters thick gray limestone, with shale and clay beds in this area.

According to [5], Marun Anticline is a fault (thrust) related fold with faulted Detachment Fold mechanism. Two major fractures system in the Marun oil field could be recognized which are regional fractures (with east-west trending) and local fractures (fold and bending related fractures). The main fractured sectors, Marun Anticline, are being seen in the southern limb and the eastern part of northern limb by curvature investigation (by Differential and Graphical methods). The results of Iso-permeability, RFT, PI maps are consisted with the results of fracture study in order to identify fractured sectors in the Marun Anticline.

1.1. Location

The numerous studies of the Zagros, Iran which have been made, relatively little has been published concerning the Petrophysical evaluation and the effect of shale layers on net pay zone thickness of Marun oil field. Marun oil field is situated on the eastern part of Dezful Embayment zone (Zagros). Aghajari Formation is cropping out on the surface. Asmari formation, Bangestan and Khami Groups are the Main reservoirs in this field.

1.2. Geology Setting

The study area has situated on Zagros province. Dominant structural trends in Zagros province are NW-SE in northwestern part and E-W in southeastern part. From tectonics view, it contains the overthrust and simple fold belts of Zagros that formed on the northeastern part of Arabian plate's passive margin. Zagros Mountains have continued to East Taurus Mountains in Turkey and have named Zagros-East Taurus hinterland. Zagros-East Taurus hinterland is external platform (fold and thrust belt) of north margin of Arabian Craton. The vergence of folding in this hinterland is toward south and southwest [6]-[8].

2. Materials and Methods

For the preparation of the porosity from the density log, consideration of matrix values and fluid properties are necessary. Also, shale properties must be considered for sedimentary sequences for each interval [9] was obtained from well data. These values were then adjusted and corrected based on the data sources by use of Schlumberger charts. The chart is used to convert density to porosity. Values of log-derived bulk density (ρ_b) corrected for borehole size, matrix density to the formation (ρ_{ma}), and fluid density (ρ_f) are used to determine the density porosity (φ_D) of logged formation.

The ρ_f is the density of the fluid saturating the rock immediately surrounding the borehole and it can be show by below formula no. 1 [10];

$$\varphi = \left(\rho_{ma} - \rho_b\right) \Big/ \left(\rho_{ma} - \rho_f\right). \tag{1}$$

Then, ranges porosity (**Figure 1**) and water saturation (**Figure 2**), have prepared for all intervals of the well.

The rock types were determinate based on the porosity and water saturation for all intervals of the well by use of **Table 1**.

The net thickness (h_{net} = 368.04) was calculated by remove of the shale, Dense Rock and Wet Rock intervals. Then charts of shale volume percent, the corrected and measured porosity were prepared (**Figure 3** and **Figure 4**).

The corrected net to gross thickness (($h_{net/gross}$)$_{corrected}$) and corrected average of porosity ((φ_{ave}) corrected) have calculated by [10]-[18] use of below formulas no. (2)-(4):

$$\left(h_{net}\right)_{corrected} = \left(\left(h\right)_g\right)_{corrected} + \left(\left(h\right)_f\right)_{corrected} + \left(\left(h\right)_p\right)_{corrected} \tag{2}$$

$$\left(\frac{Net}{Gross}\right)_{corrected} = \frac{\left(\left(h\right)_{net}\right)_{corrected}}{\left(h\right)_{gross}} \tag{3}$$

$$\left(\varphi_{ave}\right)_{corrected} = \frac{\left(\left(\sum \varphi \cdot h\right)_g\right)_{corrected} + \left(\left(\sum \varphi \cdot h\right)_f\right)_{corrected} + \left(\left(\sum \varphi \cdot h\right)_p\right)_{corrected}}{\left(\left(\sum h\right)_g\right)_{corrected} + \left(\left(\sum h\right)_f\right)_{corrected} + \left(\left(\sum h\right)_p\right)_{corrected}}. \tag{4}$$

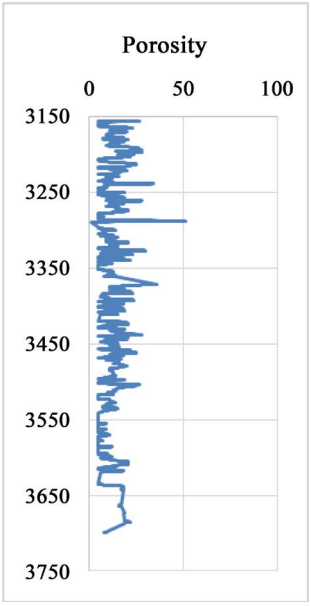

Figure 1. The corrected porosity chart of the study well.

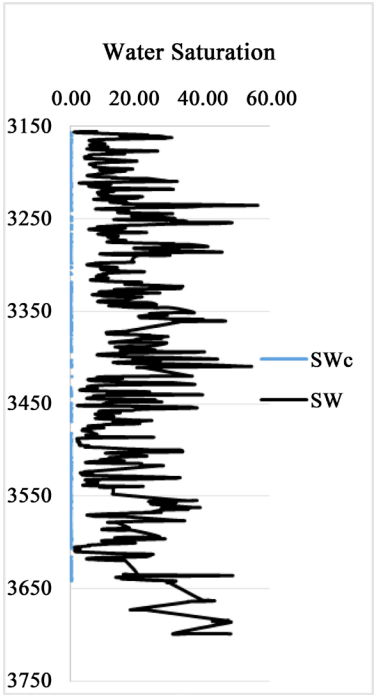

Figure 2. The corrected water saturation (SWc) and water saturation (SW) charts of the study well.

Table 1. The rock types based on water saturation and porosity.

(SW %)	(Φ %)	Rock Type
0 - 25	8/5 - 100	GOOD ROCK
25 - 50	8/5 -100	FAIR ROCK
0 - 50	4/5 - 8/5	POOR ROCK
0 - 100	0 - 4/5	DENSE ROCK
50 - 100	4/5 -100	WET ROCK

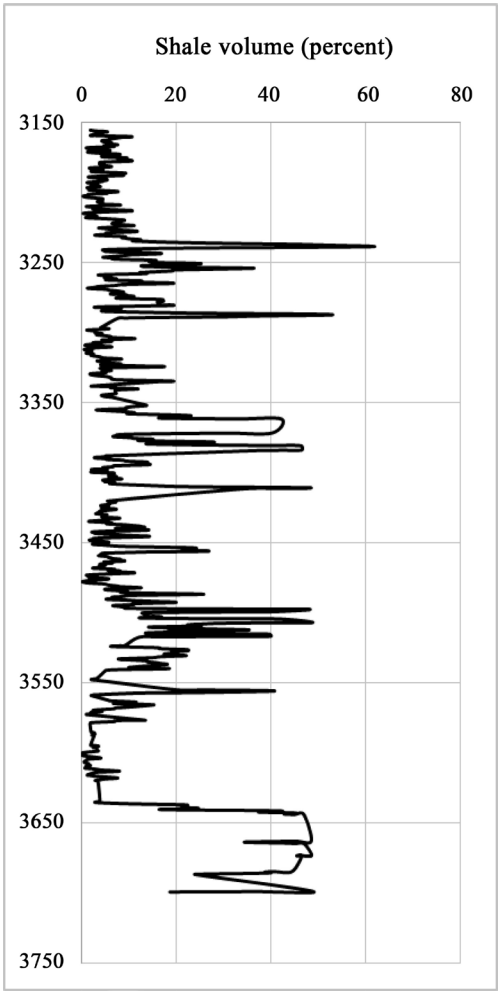

Figure 3. The percent of shale volume graph in the study well.

Then, the corrected average of water saturation ($(SW_{ave})_{corrected}$) has calculated by use of below formula no. (5):

$$\left(SW_{ave}\right)_{corrected}=\frac{\left(\left(\sum\varphi\cdot h\cdot SW\right)_g\right)_{corrected}+\left(\left(\sum\varphi\cdot h\cdot SW\right)_f\right)_{corrected}+\left(\left(\sum\varphi\cdot h\cdot SW\right)_p\right)_{corrected}}{\left(\left(\sum\varphi\cdot h\right)_g\right)_{corrected}+\left(\left(\sum\varphi\cdot h\right)_f\right)_{corrected}+\left(\left(\sum\varphi\cdot h\right)_p\right)_{corrected}}. \quad (5)$$

And finally, the corrected net hydrocarbon column ($(N\cdot H\cdot C)_{corrected}$) has calculated by use of below formula no. (6):

$$\left(N\cdot H\cdot C\right)_{corrected}=\left(\varphi_{ave}\right)_{corrected}\left(h_{net}\right)_{corrected}\left(1-\left(SW_{ave}\right)_{corrected}\right). \quad (6)$$

3. Results and Discussion

The study area is situated in Zagros fold and thrust belt (**Figure 1**). From tectonics view, it contains orogenic belt of Arabian plate. Based on previous work on the salt and mud diapirism [19]-[33] and neotectonic regime in Iran [34]-[39], Zagros is the most active zone [40]-[67]. Then, Alborz [68]-[109] and Central Iran [110]-[127] have been situated in the next orders. Therefore, active tectonics have got an important rule on the petrophysical properties of Asmari formation in the study area. The results of petrophysical evaluation have been shown in **Table 2**.

The calculated values for the net thickness (h_{net}), average porosity (φ_{ave}), average of water saturation (SW_{ave}), the net to gross thickness (h_{net}/h_{gross}) and the net hydrocarbon column ($N\cdot H\cdot C$) as normal and corrected have

presented in details. They are showing that the corrected values are less than normal values and the corrections must be consider in petrophysical evaluations of hydrocarbon wells. Also, lithologic distribution related to lithology percent, shale percent and porosity percent have shown in **Figure 5**. They have shown that limestone is the dominant rock in this reservoir and sandstone layers have got the maximum porosity. **Figure 6** is showing that near to 29 percent shale has mixed with sandstone rock units in the study well that consist with maximum porosity there (near to 26 percent).

4. Conclusions

The Limestones, Dolomites and Shale are dominant lithology in the study well at Asmari reservoir of the Marun oil field, Zagros Iran. The values for the net thickness (H_{net}), average porosity (φ_{ave}), average of water saturation (SW_{ave}), the net to gross thickness (h_{net}/h_{gross}) and the net hydrocarbon column ($N{\cdot}H{\cdot}C$) as normal and corrected

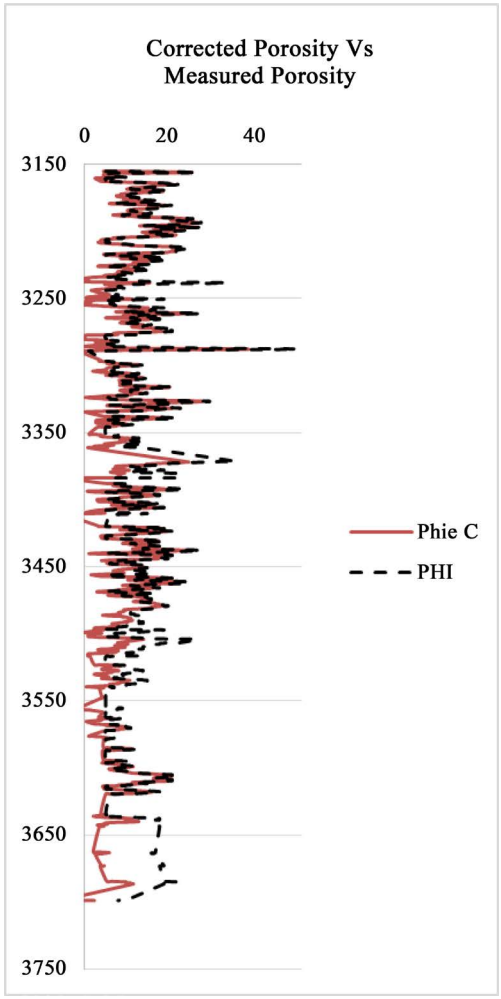

Figure 4. The corrected porosity and measured porosity graphs in the study well.

Table 2. The petrophysical properties of Asmari formation in the study well.

Item	Normal	Corrected
h_{net}	368.04 m	314.39 m
φ_{ave}	13.3	11.7
SW_{ave}	13.71	0.14
h_{net}/h_{gross}	0.665	0.5679
N·H·C	42.238 m	36.71 m

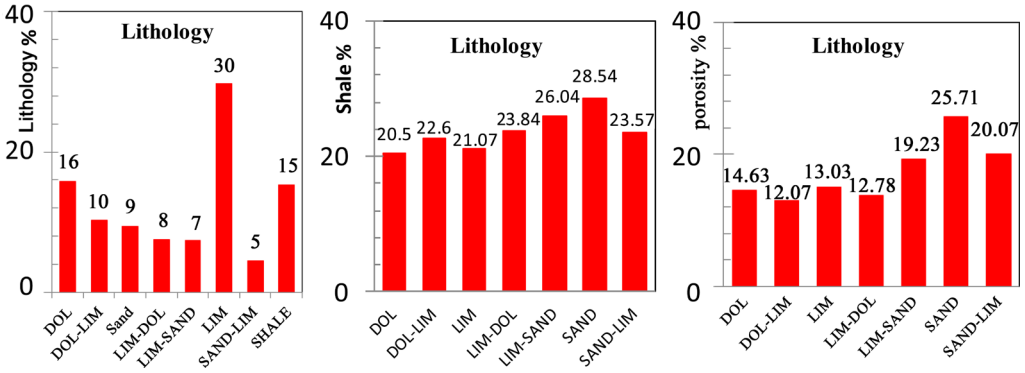

Figure 5. Lithology distribution related to lithology percent, shale percent and porosity percent.

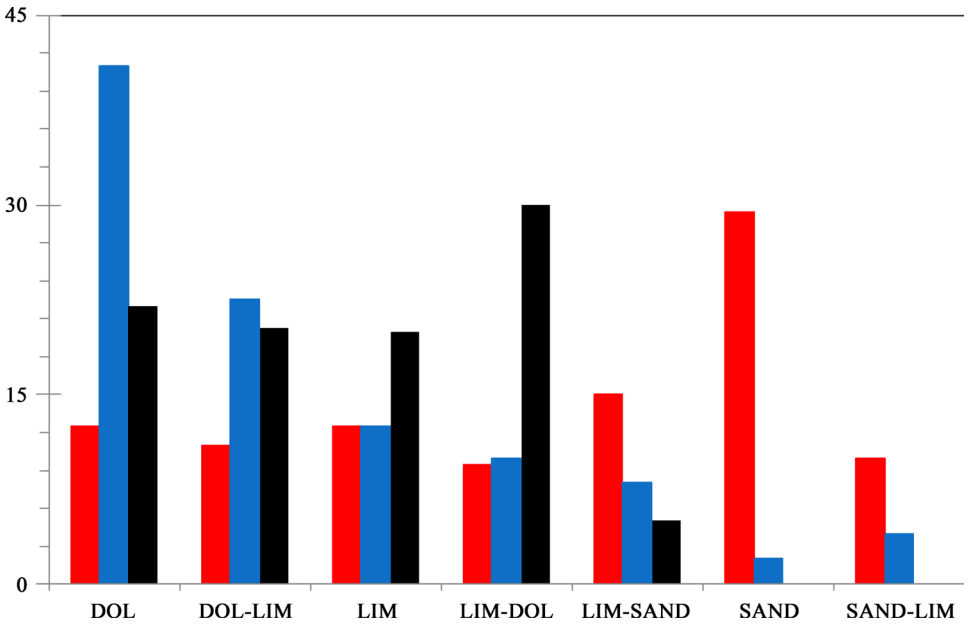

Figure 6. Lithology distribution related to the rock type percent. The good, fair and poor rocks have shown with red, blue and black colors, respectively.

were calculated. They are showing that the corrected values are less than normal values and the corrections must be considered in petrophysical evaluations of the hydrocarbon wells.

Based on this research, 28.54 percent shale has mixed with sandstone rock units in the study well which is comparable with maximum porosity there. Because, sandstone layers have shown the best porosity (25.71 percent) in the study well. Also, based on water saturation and porosity, good rocks are situated in sandstone units and poor rocks have existed in the limestone-dolomites layers. Therefore, facies changes in the Asmari Formation can explain the observed variations in reservoir quality in the study area.

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