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Research Paper

Reservoir Zonation Using Flow Zone Indicator, Electrofacies and Well Log Cumulative Standard Deviation in Dariyan Formation the Central Part of Persian Gulf

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Abstract: This study considers the ability of log deviation data in reservoir zonation. In this regard, 110 m of carbonate rocks from one well of the Dariyan Formation in the central part of the Persian Gulf were investigated by using 390 thin sections, well log data, and core porosity and permeability. Facies analysis led to the identification of nine microfacies in five sub-environments. To evaluate the reservoir quality in each zone, petrophysical rock types were determined by flow zone indicator and electrofacies methods. Based on the flow zone indicator, six hydraulic flow units were obtained for the reservoir interval. Using the multi-resolution graph-based clustering method and petrophysical logs of gamma, neutron, and density, 5 electrofacies were identified. Then, the two methods were compared, which show a strong correlation at many depth intervals. Zone 1 with the high frequency of electrofacies and flow units with higher reservoir quality, has the best reservoir quality. Zone 2 has low reservoir quality, flow units, and electrofacies with high gamma radiation. The frequency of high-quality reservoir electrofacies in zone 3 is lower than in zone 1. To determine reservoir zonation by the standard deviation method, each log data was subtracted from the average in the whole well and then the obtained values were added together to calculate cumulative deviation. This method is consistent with the three zones of the Dariyan Formation, but as the method of determining rock types, it is not suitable for the separation of reservoir units.

Keywords: Dariyan Formation, Hydraulic flow unit, Electrofacies, Cumulative deviation.

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INTRODUCTION

The Persian Gulf basin is one of the richest regions in the world in terms of oil and gas resources. The present study was performed on the Dariyan Formation from the Khami Group. In the studied well, this formation is informally divided into three zones, Upper Dariyan, Hawar, and Lower Dariyan [1], which are easily distinguishable by lithology. Carbonate reservoirs show high heterogeneity in terms of reservoir characteristics. Determining rock type is a proper way to evaluate heterogeneity at the microscale while reservoir zonation manages the heterogeneity at the macroscale. Cores and petrophysical logs are the most important data for reservoir studies. Reservoir rocks can be divided into hydraulic flow units based on the porosity and permeability relationships of the cores [2]. Information from well logs can also be classified as electrofacies. So far, many researchers have studied the electrofacies of Iran's carbonate reservoirs based on various mathematical and statistical concepts [3-5].

In this study, using the three methods of flow zone indicator, multi-resolution graph-based clustering (MRGC) and cumulative deviation logs in the studied well from the central part of the Persian Gulf, the reservoir quality is evaluated. Results will show the ability of the cumulative log deviation diagrams to evaluate the reservoir quality of carbonate formations and the method of cumulative deviation log will be compared with the two methods of flow zone indicator and MRGC.

METHODS

In this study, 110 m of carbonate rocks from one well of the Dariyan Formation in the central part of the Persian Gulf were investigated by using 390 thin sections, well log data, and 160 core porosity and permeability data. At first, petrographic studies were performed from various aspects and facies were named. To evaluate the reservoir quality in Dariyan Formation, three methods of flow zone indicator, MRGC, and cumulative deviation log were used. In determining the flow units by flow zone indicator method, porosity and permeability data of the cores have been used. Diagram-based MRGC method was used to determine electrofacies. Therefore, gamma, density, and neutron logs were selected to evaluate using Geolog software. To determine zonation by cumulative deviation method, each log data was subtracted from the average data in the whole well and then the obtained values were added together to calculate cumulative deviation from the mean value. Then, using the cumulative values of the calculated deviation, its diagram was drawn and analyzed [6,7]. To confirm the theory (standard deviation), this method was investigated in well (B) with no core data. Finally, the results of the three methods were compared with each other and also with the results of petrographic data.

FINDINGS AND ARGUMENT

Facies analysis led to the identification of nine microfacies in five sub-environments deposited in a carbonate ramp platform. Using the probabilistic cumulative diagram of the flow zone indicator values, 6 hydraulic flow units have been determined. Reservoir quality increases from flow unit 1 to flow unit 6 (Figure 1A). These six flow units are shown on the porosity-permeability diagrams, which show a good relationship between the distribution of hydraulic flow units and the porosity and permeability values (Figure 1B). Flow units 5 and 6 have higher reservoir quality and more frequency in the upper parts of the upper Dariyan and lower Dariyan. Flow units 1 and 2, which had the lowest reservoir quality, have the highest frequency in the Hawar zone.

In the MRGC method, 5 electrofacies were identified for this well, of which electrofacies 2 and 3 have the highest reservoir quality and are more abundant in the upper Dariyan and lower Dariyan. Electrofacies 1, 4, and 5 have the lowest reservoir quality and have also the highest frequency in the Hawar zone. According to the core porosity and permeability box plot, electrofacies 2 and 3 have the highest porosity and permeability (Figure 2).

Dariyan Formation zones were calculated and plotted based on the cumulative deviation logs in well A. In the studied well, this formation is informally divided into three zones of upper Dariyan, lower Dariyan, and Hawar [1] that the results of this method are consistent with this classification. This method is consistent with the three zones of the Dariyan Formation (Figure 3), but as the method of determining rock types, it is not suitable for separation reservoir units. The method was applied to well (B) with no core data. Results effectively showed three zones of upper Dariyan, Hawar, and lower Dariyan (Figure 3).

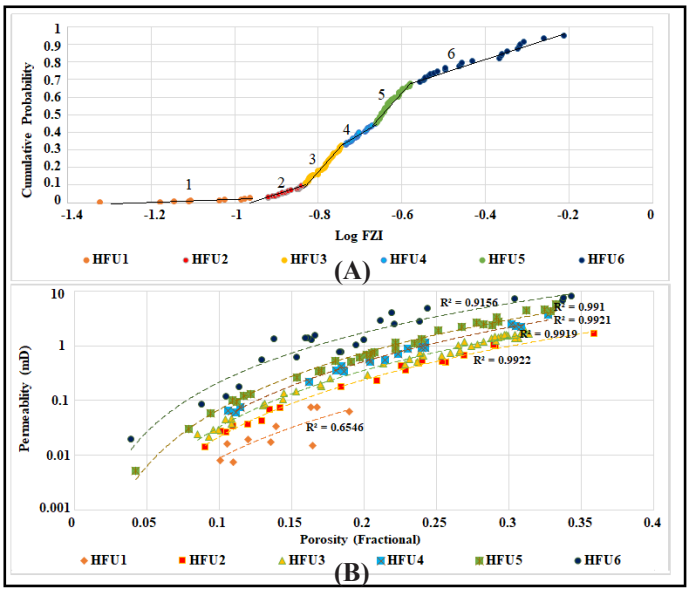

Figure 1. A: Determined hydraulic flow units on the cumulative probability frequency plot of FZI values in Dariyan Formation, **B:** porosity-permeability plot of flow unit

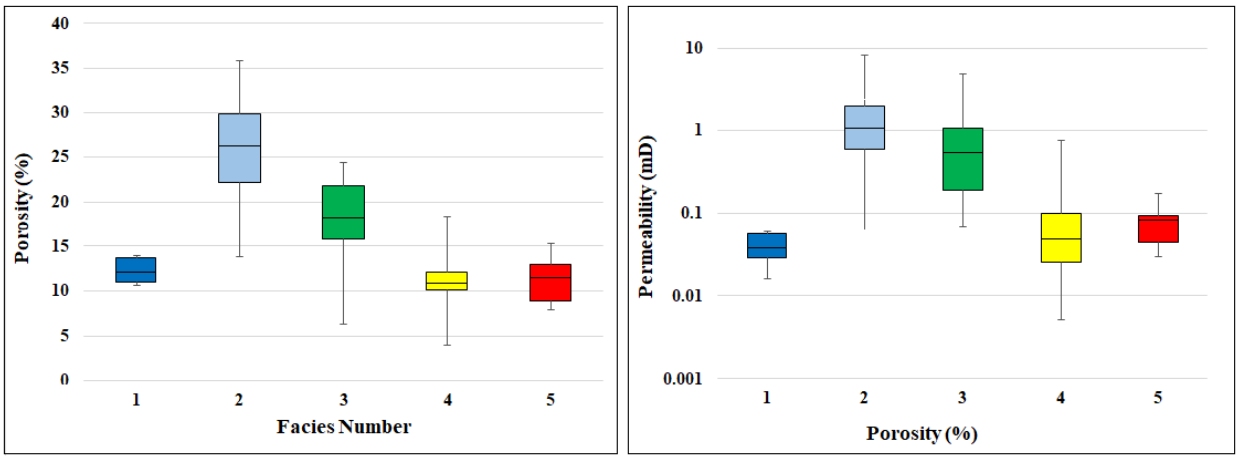

Figure 2. Box plot of core porosity and permeability for electrofacies of Dariyan Formation

CONCLUSIONS

The results of rock type determination by hydraulic flow unit method and MRGC method identified 6 flow units and 5 electrofacies, respectively. Combining the results of these two methods and petrographic studies, it was found that the upper Dariyan and lower Dariyan (especially their upper part) have the highest reservoir quality and the Hawar zone has a very poor reservoir quality. Among zones 1 and 3, zone 1 (Upper Dariyan) is the most important reservoir zone of the Dariyan Formation in the study area due to the greater abundance of units with higher reservoir quality. According to cumulative diagrams of density, neutron, and gamma logs, 3 zones (upper Dariyan, Hawar, and lower Dariyan) can be identified. Comparison of the results obtained from the determination of rock types with the cumulative deviation log showed that the cumulative deviation method can be a suitable tool in separating the three zones. It is also applicable in wells that have not been cored; but like the rock type determination method, it cannot be used to separate reservoir units.

REFERENCES

[1] Naderi-Khujin, M., Tavakoli, V., Seyrafian, A., and Vaziri-moghadam, H. (2020). *"How a mud-dominated ramp changed to a carbonate clastic oil reservoir: Sea-level fluctuations in cretaceous of the central Persian Gulf"*. Marine and Petroleum

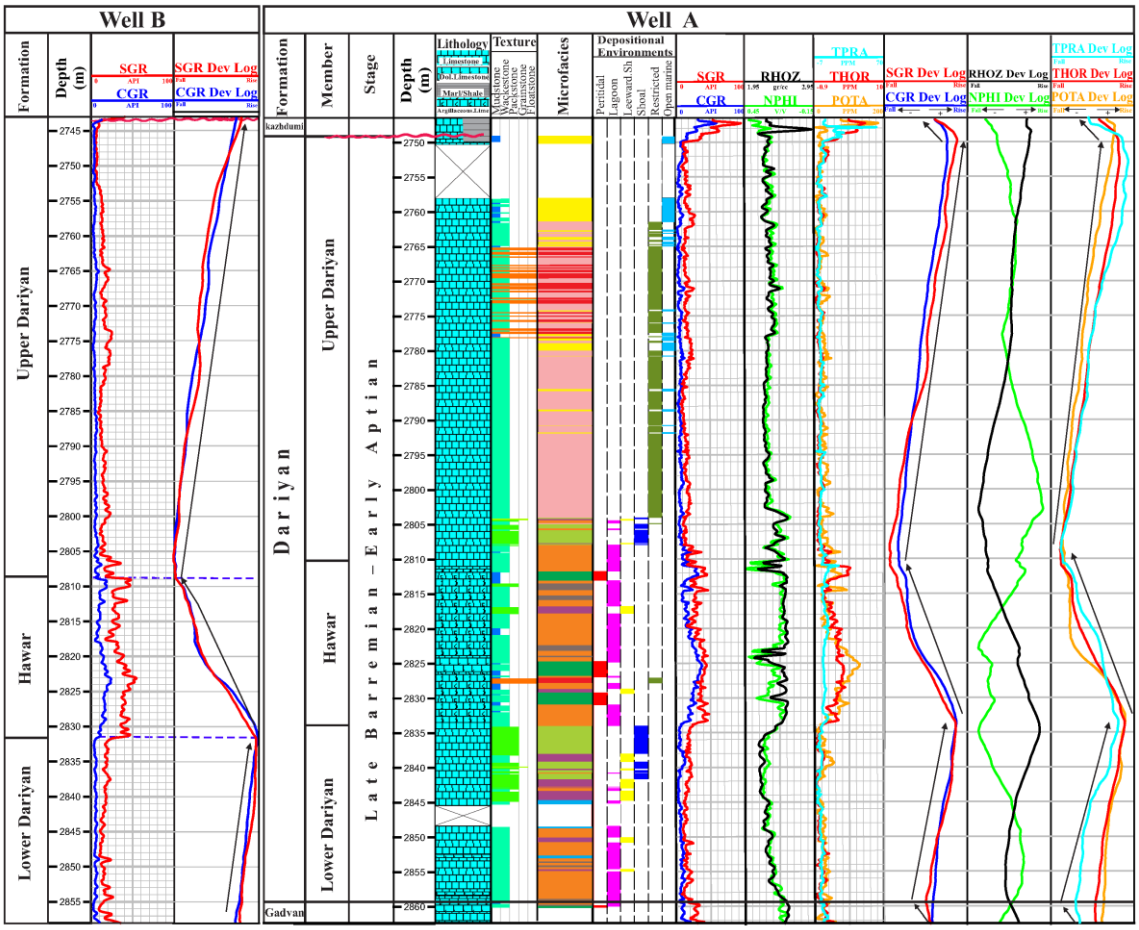

Figure 3. Comparison of cumulative deviation logs in wells A and B of Dariyan Formation in the central part of the Persian Gulf

Geology, 116: 104-301.

[2] Kadkhodaie-Ilkhchi, R., Rezaee, M. R., Moussavi-Harami, R., and Kadkhodaie-Ilkhchi, A. (2013). *"Analysis of the reservoir electrofacies in the framework of hydraulic flow units in the Whicher Range Field, Perth Basin"*. Western Australia. Journal of Petroleum Science and Engineering, 111: 106-120.

[3] Sefidari, E., Dashti, A., Kadkhodaie, A., and Asadi Eskandar, A. (2015). *"Facies Associations Modeling Based on Geological and Petrophysical Data (Wire Line Logs) in the South Pars Gas Field"*. Jornal of Petroleum Research, 25: 83-95.

[4] Rahimibahar, A., and Porseyami, H. (2013). *"Separating Different Zones of Hydrocarbon Reservoirs by Using Electrofacies"*. Jornal of Petroleum Research, 22: 144-153.

[5] Farazani, N., Khoshbakht, F., and Tavakoli, V. (2016). *"Improving Electrofacies Analysis by Integrating Wireline and Image Logs in Asmari Formation Using MRGC"*. Jornal of Petroleum Research, 25: 186-194.

[6] Tavakoli, V. (2017). *"Application of gamma deviation log (GDL) in sequence stratigraphy of carbonate strata, an example from offshore Persian Gulf, Iran"*. Journal of Petroleum Science and Engineering, 156: 868-876.

[7] Tavakoli, V. (2014). *"The gamma-ray deviation log (GDL): a new tool for sequence stratigraphic analysis in carbonate reservoirs, an example from Kangan and Dalan formations in South Pars Gas Field"*. Journal of Stratigraphy and Sedimentology Researches University of Isfahan, 30(54): 97-110.