Well Log Interpretation and Petrophysical Modeling to Evaluate Zubair Reservoir in North-Rumaila Oil Field

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Abstract

This study uses well log interpretation and petrophysical modeling, which is one of the most influential tools for the evaluation of Zubair Reservoir in the X Oil Field. Understanding reservoir parameters and boosting output by picking the optimal location for future drilling candidates will be helped by these interpretations and modeling. 3D seismic and well log data were used to create and describe a petrophysical model in this investigation. Each parameter was upscaled when interpreting well logs and calculating petrophysical characteristics. The petrophysical model was created using geostatistical approaches such as Gaussian simulation, variogram, and Monte Carlo simulation. Techlog, Petrel, and HRS Software were used in this study. As a result, we analyzed porosity, shale volume, and water saturation for four wells named A, B, C, and C using a set of commercial software and applying the different well logs like; gamma-ray (gr) log, spontaneous potential log, porosity logs (Density Log, Neutron Log, and Sonic Log), and resistivity log. The range of porosity values is 0.23 to 0.30, the water saturation is around 10% in the crest and 60% in the flank, and Vsh is interbedded with sand and the value is decreasing 25% in the clean sand bed. This formation is characterized by clean sand and is interbedded with a sharp boundary. The sand in the main pay is characterized by homogeneous and uniform porosity patterns. The homogeneous nature of the sand leads to uniform saturation of water to fill this entire sand unit with oil and the absence of a transition zone.

Keywords: Rumaila Oilfield; Petrophysical analysis; Formation evaluation; 3D seismic; Geological modeling

1. Introduction

The Zubair formation is one of the most productive oil reservoirs in the X oil field, which is located in southern Iraq. The operators are well aware of the Zubair formation's importance in terms of oil production. An integrated reservoir model, on the other hand, provides a complete view of the Zubair reservoir's static model; therefore, this research combined seismic data and petrophysical modeling to evaluate the Zubair formation in an integrated way. This study was conducted using a complementary methodology to obtain the best evaluation of the reservoir by using up-to-date methods, including seismic, well log, and core data. These measurements were obtained at three different scales: micro, mega, and macro (pore scale, reservoir scale, and field-scale). The resultant models from this research

DOI: 10.46717/igj.55.2A.15Ms-2022-07-31

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can also be used as references to find out the economic value of the Zubair formation. Furthermore, the static models produced from this work and integrated with some reservoir properties can surely be used for establishing development plans in the Rumaila oil field. In this study, the petrophysical properties were studied and modeled based on seismic data and reverse modeling of the Zubair Formation in the Northern Rumaila oil field. Petrophysical models can be a set of processes used to interpret petrophysical data. Usually, such produced petrophysical models can be represented in the form of traditional equations, algorithms, or other mathematical processes, however, petrophysical models often have multiple procedures. For example, a deterministic model might include procedures that calculate the shale volume, calculate total porosity, calculate effective porosity, calculate water saturation, and calculate permeability. The main objectives are to determine the lithology, porosity, and water saturation.

1.1. The Study Area

The X Oilfield is located in West-central Basra; it encompasses approximately 1600 km² in the Mesopotamian Basin, West-central Basra (Almalikee et al., 2018). It is made up of two anticlines that form an 80-kilometer north-south anticline. It is the primary producing zone on Rumaila Field, with the Main Pay interval producing the majority of the field's output (Haider, 2018). It is 300 m to 450 m thick and dates from the Barremian (Aqrawi et al., 2010). The formation is thickest in the type area in the south of Iraq. The Zubair Reservoir shows delta progress created from the Arabian Shield (Ali and Nasser 1989), (Fig.1).

![Fig. 1. Location of the study area (ROO, 2016)](image-url)
1.2. Geological Settings of the Study Area

The lithostratigraphic column of the X oilfield is entirely composed of sedimentary rocks that belong from the Late Jurassic to the recent. The lithostratigraphic column is comprised of cycles of clastic, carbonate, and evaporite rocks. Fig. 2 Shows formations at Rumaila Field. The Zubair formation is a deltaic package that includes the upper sandstone member, middle shale member, lower sandstone member and lower shale member; it is the main producing zone in X Oilfield, with production dominantly from the Main Pay interval. It is early to mid-Cretaceous in age (Barremian) and is 300 m to 450 m thick. Thickness varies primarily to the north and on the crest, being thinner in these areas. The section comprises shale and sandstone lithologies. In the Upper Shale, the net to gross is ~ 40%, but this approaches 60 - 80% in some areas of the Main Pay. The Formation is subdivided further into producing sands separated by regional and sub-regional shale seals.

Fig.2. Stratigraphic chart showing formations at Rumaila Field (after Handhal et al., 2019)
2. Materials and Methods

In the current paper, the well-log data of four Rumaila wells, namely A, B, C, and D are employed to accomplish the Petrophysical model for the Zubair reservoir. The workflow of the methodology is shown in Figs. 3 and 4, the first step and before petrophysical analysis is a data, QC and data harmonize. The reservoir evaluation process is based on wire-line log analyses, which use computer software to estimated petrophysical parameters such as lithology, effective porosity (\( \varepsilon_{\text{eff}} \)), the volume of shale (Vsh), saturation of water (Sw), and saturation of hydrocarbons or gas (Shc or Sg) using pre-determined calculations/formulae, cross-plots, and charts.

![Techlog workflow for petrophysical analysis](image-url)

**Fig. 3.** Techlog workflow for petrophysical analysis
3. Results and Discussion

To start the reservoir characterization, essentially rock properties need to be estimated. In this study, we analyzed porosity, shale volume, and water saturation using a set of software (like; Techlog and Petrel) and applying the different well logs like; Gamma-ray (gr) log, spontaneous potential (sp) log, porosity logs (Density Log, Neutron Log, and Sonic Log.) and resistivity log, as shown in the below Fig.5.

3.1. Volume of Shale (V_{SH})

The volume of shale data from wells used to build the reservoir VSH model in Petrel. Fig.7 Show the VSH model in Zubair formation. Noticed that sand beds in the Main Pay unit are characterized by clean sand with average shale content of around 3%, while there is a sharp change and clear boundary between sand and shale where the shale layer shows a uniform pattern of shale content that ranges from 75 to 95 % with low effective porosity below 0.09 from Neutron-Density logs, which may suggest the presence of siliciclastic material like sand or silt.

The Zubair formation is consists of alternating sand and shale pattern where the sand is characterized as clean sand and homogenous. Neutron density cross plot shows the clean data cluster
aligns on the sand line while shaly data and shale move toward the shale effect position in the cross plot (Fig. 8).

3.2. Porosity (Φ)

The total and effective porosity in Zubair reservoir was calculated from density and neutron-density logs; the porosity calculated has been compared with core porosity in an example well that has core data. The comparison was used to calibrate the log with the core (Fig. 9).

The total and effective porosity data from wells were used to build the reservoir porosity model in Petrel (Fig. 10 and Fig. 11) Show the porosity model built by Petrel in the main pay unit. It is noticed that the porosity pattern across the clean sand is homogenous, there is little to no change in the porosity variations across the study area.

**Fig. 5. Petrophysical analysis for well A**
Fig. 6. Cross Plot of wells A

Fig. 7. $V_{SH}$ Model built by Petrel in main pay of Zubair formation
3.3. Water Saturation ($S_w$)

In this study, Archie’s model was used to calculate the water saturation, which used the following equation for calculation of water saturation (Archie, 1942):

$$S_w = \left( a \times R_w \right) / \left( R_t \times \phi_m \right)^{1/n} \quad (1)$$

The saturation data from wells were used to build the reservoir $S_w$ model in Petrel. Fig. 12 shows the example of saturation calculated for the Zubair formation; it is noticed that the clean sand zones are completely saturated with hydrocarbon. Fig. 13 shows the $S_w$ model built by petrel in the Zubair formation. It is noticed in the results of $S_w$ that a uniform saturation pattern across the clean sand unit with the saturation of water around less than 10% in the crest, and around 60% in the flank of the structure.
Fig. 9. Comparison of effective porosity between core and log data in well B
Fig. 10. PHIE Model build by petrel in main pay reservoir

Fig. 11. PHIT Model build by petrel in main pay reservoir
Fig. 12. Example of saturation calculated in Zubair formation

Fig. 13. Sw model built by petrel in main pay unit of Zubair formation
4. Conclusions

Well, log and petrophysical analysis can be used to determine calculations of the volume of shale, porosity, and water saturation, which can subsequently be utilized to characterize reservoir. In this study, the results of well log analysis on the calculation of shale content get a correlation value of 0.56, the prediction of water saturation gets a correlation value of 0.74, and the porosity of the correlation value obtained is 0.51. Effective porosity better-captured resolution of low porosity zones, which are most probably shaly sand intervals, while total porosity showed high values in the shaly zone. The core porosity matched well with total porosity only in the clean zone. However, it matches very well with effective porosity, especially in the shaly zone, as the shale effect was removed from the ineffective porosity calculation. The Zubair formation is characterized by clean sand and is interbedded with sharp boundaries, while the sand in the main pay is characterized by a homogeneous and uniform porosity pattern. Due to the homogeneous nature of the sand unit, this leads to uniform saturation of water to fill this entire sand unit with oil and the absence of a transition zone.

Acknowledgements

The authors would firstly like to thank the BOC. For permitting us to use the necessary data to get done this study. The authors would like to thank Geology Department, Basra University. Especial thanks to Mr. Haider Mosa, Mr. Maher Ismael, Mr. Haider K. Hassan (BOC) and Mr. Abdualrahman B. Jawad (Schlumberger Company). The authors are very thankful to the Editor in Chief Prof. Dr. Salih M. Awadh, the Secretary of the Journal, Mr. Samir R. Hijab, and the Technical Editors for their great efforts and valuable comments.

References


