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Reservoir Characterization and Geostatistical Modeling of Ilam & Sarvak Formations in One of Oil Fields in Southwest of Iran

Neda Sasaninia¹, Davoud Jahani¹*, Bahram Habibnia², Nader Kohansal Ghadimvand¹

¹Department of Geology, Tehran North Branch, Islamic Azad University, Tehran, Iran
²Department of Petroleum Exploration, Petroleum University of Technology, Abadan, Iran
Email: sasaninia.n@gmail.com, *d_Jahani@iau-tnb.ac.ir, bhabibnia@Gmail.com, nkohansal@yahoo.com

Abstract

Exploration and exploitation of hydrocarbon reservoirs have been always time consuming with high risk and high cost. In this regard, assessment of reservoir characterizations and information about spatial distribution of its parameters play an important role in adaptation of suitable strategies for hydrocarbon resources management. There are only few numbers of oil wells cored in every oil field due to high cost, time-consuming process, and other drilling problems. Therefore, it is required to use alternative estimation methods in order to achieve the petro-physical parameter in total space of reservoir. In this research, geostatistical methods have been applied as a new approach to calculate and estimate porosity and permeability of reservoir in one of southwestern oil fields of Iran. The information obtained from 86 wells in one of southwestern oil fields of Iran has been available in this study. Physical parameters of porosity and permeability are vital parameters that should be estimated in studied reservoir. This study indicated that Gaussian Variogram Model is the best model to predict porosity and permeability values in field. Error means of actual values of porosity are equal to 6.9% and for permeability are 11.21% using Gaussian Model. Also, after prediction of porosity and permeability values for field, distribution of these parameters in field was illustrated in two-dimensional and three-dimensional modes besides distribution and location of wells in field in order to determine the best drilling spots and reduce risk of drilling operations.

Keywords

Porosity, Permeability, Geostatistics, Krigging

1. Introduction

Oil exploration is one of human achievements, but exploration and exploitation

from hydrocarbon reservoirs have been always time-consuming with high risk and high cost. Therefore, human needs to recognize hydrocarbon reservoirs and their characterizations and features in order to reduce risk of exploration and exploitation of oil and gas resources. In this regard, assessment of reservoir characterizations and information about spatial distribution of its parameters play an important role in adaptation of suitable strategies for hydrocarbon resources management [1]. Reservoir modeling is a significant step in development and management of oil reservoirs and anticipation of reservoir function. Decisions about development of oil field during life of reservoir including number and location of production and injection wells, maintenance and repair projects, etc. require an accurate heterogeneity model of reservoir. There are only few numbers of wells cored in each oil field due to high cost, time-consuming process, and other drilling problems so that well test is confined to limited numbers of wells in oil field. One of objectives of petro-physical studies is estimation of reservoir characterizations in which, measurement is not possible due to any reason [2]. Porosity and permeability are some of vital parameters to recognize and develop reservoir. The results obtained from these parameters are valuable for exploration and development objectives in oil reservoirs [3]. There have been numerous studies about estimation of reservoir characterizations [4]-[10]. Block three-dimensional estimation can be done for reservoir having a suitable network of wells, sampling and estimating well-stream parameters. The advantage of this estimation is knowledge of spatial distribution of reservoir rock that plays a vital role in directing management strategies of oil reservoirs. Since various estimators are able to do this task, it is necessary to choose the best estimation method. In this research, reservoir characterizations have been estimated and studied using geostatistical modeling through GS+ Software [11]. According to the importance of petro-physical parameters through three-dimensional geostatistical well-stream estimation in oil reservoir rock, the general goals of this research are based on two major bases:

1) Identification and determination of mathematical-empirical regression model to estimate petro-physical parameters of oil reservoir in studied formation (Sarvak Formation).

2) Calculation of distribution and spatial dispersion of these parameters in entire reservoir through block and three-dimensional methods using Krigging method as an unbiased estimator with minimum estimation error.

2. Geology of Studied Oil Formation

Sarvak Formation is one of geological formation of Bangestan category with middle Cretaceous age (Albian-Turonian) in Zagros. This formation is one of important hydrocarbon reservoirs in Zagros Basin. Sarvak Formation is placed on Kazhdomi Formation conformably; whereas, the upper boundary of it with Ilam Formation is erosional unconformable [12]. This formation is made of limestone and has a major porosity with fracture type [13].

This field has a more or less symmetric anticlinal structure and considered as

the last part of folded Zagros zone located on a horst formed in older classes. The main reservoir in this field is Asmari formation and Bangestan reservoir (Ilam and Sarvak) is located in almost 3333 meter depth [14].

3. Modeling of Studied Field

The studied oilfield is one of significant oilfields in Dezful embayment. This field is located in western part of Dezful embayment between Mansoori and Sosangerd field in southwest of Ahvaz City. Cross Plot (neutron-density) has been employed to determine lithology. Considering this plot, prominent lithology of Sarvak Formation, in terms of petrology, is a composition of lime and low percentage of Dolomite and a low amount of Shale in some seasons.

Evaluation of Sarvak Formation in considered oilfield is as follows:

1) Lithology of Sarvak Formation is composed of Lime, a low percentage of Dolomite and a middle-layer Shale in some seasons.

2) Analysis of CGR Chart indicates low mean of shale volume so that Sarvak Formation can be considered as clean formation.

3) Mean of saturation level (that is calculated through Indonesia Method) in Sarvak Formation is equal to 25.9%.

4) According to evaluated well logging charts in studied area, a high mean of porosity (porosity mean of 33.5% and effective porosity mean of 32.4%) is shown.

To predict permeability and porosity of well plates in Sarvak Formation in different heights and seasons, data related to permeability and porosity of this formation was used.

3.1. Linear Model

The results shows the chart related to description of Variogram chart of porosity and permeability of Sarvak Formation by a linear model. Parameters related to this model are also shown in Table 1. As can be seen, regression coefficient value (R^2) of this model, compared with the main chart, is equal to 0.879 for porosity and to 0.913 for permeability.

3.2. Spherical Model

The result shows the chart related to description of Variogram Model of porosity

Table 1. Different parameters of linear model to describe porosity and permeability data of Sarvak Formation.

Model	Parameter	Value
	C_0	0.1
Porosity	C	210.1
	A	208.30
	C_0	0.5
Permeability	C	411.9
	A	265.6

and permeability data of Sarvak Formation by Spherical model. Parameters related to this model are also shown in Table 2. As can be seen, regression coefficient value (R^2) of this model, compared with the main chart, is equal to 0.862 for porosity and to 0.896 for permeability.

3.3. Exponential Model

The results show the chart related to description of Variogram Model of porosity and permeability data of Sarvak Formation by Exponential model. Parameters related to this model are also shown in Table 3. As can be seen, regression coefficient value (R^2) of this model, compared with the main chart, is equal to 0.791 for porosity and to 0.847 for permeability.

3.4. Gaussian Model

The results shows the chart related to description of Variogram Model of porosity and permeability data. Parameters related to this model are also shown in Table 4. The correlation coefficient (R^2) of Gaussian model is equal to 0.913 for porosity and to 0.946 for permeability that are more than values of mentioned models. It means that Gaussian model is more fitted to Variogram chart of porosity and permeability data.

4. Data Analysis and Results

After illustration of Variogram chart of each parameter and determining the best model for each parameter, the permeability and porosity values should be predicated using Krigging process that is a predetermined option in Interpolate section

Table 2. Different parameters of spherical model to describe porosity and permeability data of Sarvak Formation.

Model	Parameter	Value
	C_0	0.9
Porosity	C	208.1
	A	208.3
	C_0	1
Permeability	C	389.49
	A	387.2

Table 3. Different parameters of exponential model to describe porosity and permeability data of Sarvak Formation.

Model	Parameter	Value
	C_0	1.1
Porosity	C	210.1
	A	208.3
	C_0	2.43
Permeability	C	389.22
	A	206.3

related to GS+ Software. The result shows the diagram related to predicted values porosity for different models and indicates predicted permeability value for different values.

In Figure 1, horizontal axis indicates actual values of permeability or porosity and vertical axis indicates estimated permeability and porosity values using GS+ Software, Regression Coefficients (R^2) of different models show that Gaussian Model has a more accurate estimation compared with other models, because its R^2 value for porosity estimation is equal to 0.970 and is equal to 0.971 for permeability prediction, which are higher than the same values in other models. Since Gaussian Model provides better and more accurate predictions among other models, results and predictions of this model are more examined. Figure 1 indicates AARD% predicted by GS+ Software and Gaussian model based on actual values if permeability and porosity.

According to this figure, error values are at ±10% interval that is an acceptable value for error of a predictor tool (Gaussian Model in GS+ Software). These figures also indicate that predicted values are well close to actual values.

5. Conclusions and Recommendations

In this study, porosity and permeability of Sarvak Formation were predicted using GS+ Software and following results were obtained. Information obtained

Table 4. Different parameters of gaussian model to describe porosity and permeability data of Sarvak Formation.

Model	Parameter	Value
	C_0	2.2
Porosity	C	203.1
	A	162.63
	C_0	1
Permeability	C	411.9
	A	157.2

(a)

(b)
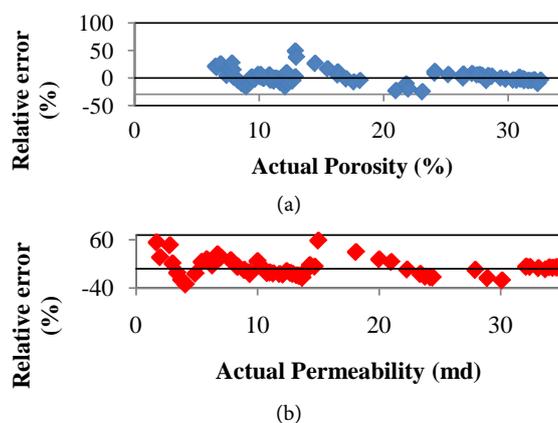
Figure 1. AARD% of predicted values by gaussian model through GS+ Software based on main values: porosity (a), permeability (b).

from 86 well were available in this research. Physical parameters of porosity and permeability are critical parameters that should be estimated in studied reservoir.

1) Gaussian model is the best model to determine distribution and predict permeability and porosity values in field. Regression coefficients and AARD% were equal to 0.97% and 6.3% for porosity and equal to 0.97% and 11.21% for permeability.

2) The best direction to plot Variogram diagram related to permeability and porosity data is north-south axis.

3) Permeability and porosity values from southwest to northeast indicate an increasing trend.

Recommendations

It is recommended for further studies to use more data within estimation of permeability and porosity value, because if the larger number, actual data of field wells are available, permeability and porosity values of field can be predicted more accurately and a more detailed distribution of these parameters can be determined in field. It is also recommended for further studies to use Petrel Software instead of GS+ Software to determine and predict porosity and permeability of field and compare the results of two models in order to provide a more accurate model.

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