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3D MODELING OF POROSITY IN SARVAK FORMATION VIA GAUSSIAN SIMULATION METHOD IN DEZFUL EMBAYMENT, A CASE STUDY

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Abstract

Porosity is a petrophysical property used for reservoir 3D modeling and prediction of production scenarios for the purpose of economic decisions play an important role in field and reservoir management. In this study, drilling data (logs) from 7 wells and geostatistical method including sequential Gaussian simulation were used to predict porosity petrophysical property. Sequential Gaussian simulation is widely used for porosity model construction since it is easily applied and is flexible in real heterogeneous conditions. In this method, with the available data including values and coordinates values of the same parameter in unknown points can be predicted. In Sequential Gaussian method cells having certain values from petrophysical parameters are taken into account. After, constructing reservoir structural model and analyses of petrophysical data, simulations models for 5 reservoir units of Sarvak in the Kupal oil filed were established for porosity with high precision. The results of this study showed that the applied method is highly accurate and can be used based on computational methods to identify reservoir zones contains hydro-carbon. The results of this study indicate that the concentration of petroleum in the layers 4 and 5 of Sarvak is higher than other formations and is suggested for the initial production, this reservoir will be developed.

Keywords*: Petrophysical Properties; Porosity; Geostatistical method; sequential Gaussian simulation; Dezful Embay-ment.*

1. Introduction

The oil and gas industry is one of the industries in which Geostatistics is rapidly becoming epidemic and has grown rapidly. One of the causes of this rapid growth is the nature of the reservoir data. Petrophysical data of the reservoirs, such as porosity and permeability, are those data that have a spatial correlation in the reservoir space and in the field of geostatic shows the spatial structure, and these are the same types of variables that the Geostatistics relates to. On the other hand, due to the low reservoirs data compared to reservoir volume, the reservoir engineers have always sought to find a method for estimating the spatial distribution of petrophysical parameters in the reservoir space [1]. Along with all the advan-tages of the Geostatistics estimation than the other statistical methods, Geostatistics estimations like the other methods of estimating, are based on the averaging method. This led engineers to find new methods. These methods express a quantitative spatial distribution of petrophysical parameters in a probable space. Thus, after gridding the reservoir, for each block, a range of data is created, and several probable facts are simulated for each petro-physical parameter [2].

The introduction of geostatistics has revolutionized the modeling of oil reservoirs. Many people have examined the use of geostatistics in reservoir modeling. George Matron is one of the pioneers in the use of geostatistics for modeling. The basis of his work is modeling based on variogram. Models based on variograms are divided into two categories [3].

The first category is definitive models that include estimation methods like consecutive Kriging and sequential Kriging. These estimation methods are geostatistical, which yields a model for each variograph, resulting in deterministic models due to estimation methods [4].

The second group is called probabilistic models. The basis of these models is simulation methods. In simulation methods, several models are obtained by using a variogram, for this reason, simulation models yield probabilistic models. Since the mid-1990s, simulation models have been developed in the petroleum industry. Simulated models have anomalous properties of petroleum reservoirs [3]. Since the mid-1990s, 3D seismic data has been used as a secondary parameter in estimating and simulating reservoir parameters [5]. Three-dimensional seismic data were obtained by means of sequential estimation or simulation methods. Until today, these methods provide an optimal model of the static parameters of the reservoir [6]. Over the past 30 years, the development of geostatistical methods and the development of various software, has led to changes in reservoir engineering and the estimation or simulation of reservoir parameters. In this study, the petrophysical parameter of porosity is estimated using a sequential Gaussian simulation method (a geostatistical method) in Kupal oil fields.

2. Geological settings

Sarvak formation has expanded in Fars, Khuzestan, and Lurestan [7]. In Bangestan Anticline (section type) Sarvak formation having a thickness of more than 830m has been noticed which consists of medium to thick layers and massive fossiliferous limestones. Kupal oil field is located in the Dezful embayment (Figure 1).

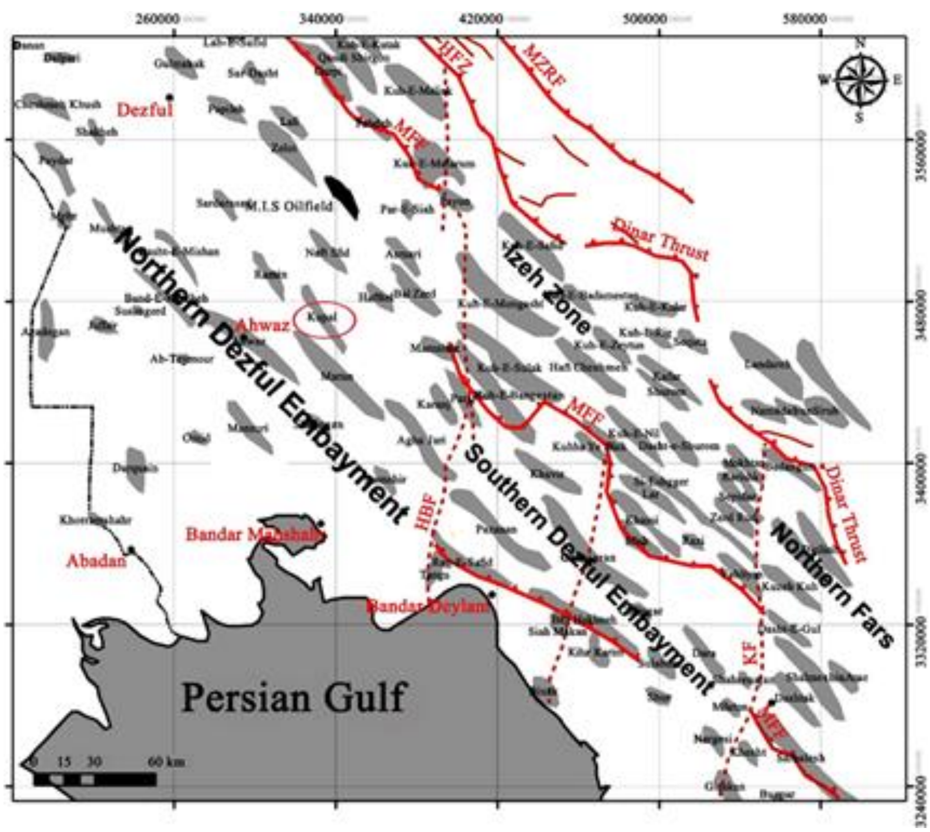

Figure 1. Located of Kupal oil field in Dezful embayment, Zagros, Iran

This oil field is located in Khuzestan provinces in the south west of Iran. Their lower limits (Albian-Cenomanian) are gradational and conformable from the Kazhdomi formation, and the upper limit has been distinguished from Ilam formation in Kupal oil field [8]. The boundary between Sarvak and Ilam Formation is the disconformities that determine some areas by breccia or conglomerates [9]. Disconformities between Sarvak and overlies Formation indicates some part of middle Cretaceous epirogenic activities in the Zagros. Lithostratigraphical column of Sarvak Formation has been controlled by Austrian tectonic activities, but variation aggradations pattern of Sarvak Formation depends on the rate of subsidence in the sedimentary basin. Sarvak Formation was deposited on the passive margin which existed in the east of the Arabian craton throughout much of the Mesozoic [9]. This passive margin was generally covered by shallow waters. However, a number of deeper-water intra shelf basins had been formed during the Cretaceous [10]. The thickness of the Sarvak Formation in the studied oil field is including two major facies (Benthic and pelagic). The Benthic facies includes a massive limestone containing algae, echinoderms, rudists, Gastropods, and Orbitolina. The pelagic deposits contain abundant Oligostegina. Pelagic facies in Sarvak Formation changes to benthic facies, which relates to Austrian movement [11]. Lateral and vertical variations in stratigraphic thicknesses in Zagros area can be related to the presence of locale faults in the Zagros Basin that effect in rates of sedimentation with lower rates of deposition in the basin.

3. Material and methods

Data from well logs and seismic data in petroleum researches are considered as the primary data and main parameters. In this study, data of 7 wells and part of seismic data have been used. The location of the wells in relation to the position of the data is shown in Figure 2, In this study, by using multivariate statistics methods, neutron logs, and density, total porosity was obtained, and the resulting total porosity values are used as well parameter values for use in the correlations. The histogram obtained from the total porosity of the wells in the studied area is shown in Figure 3.

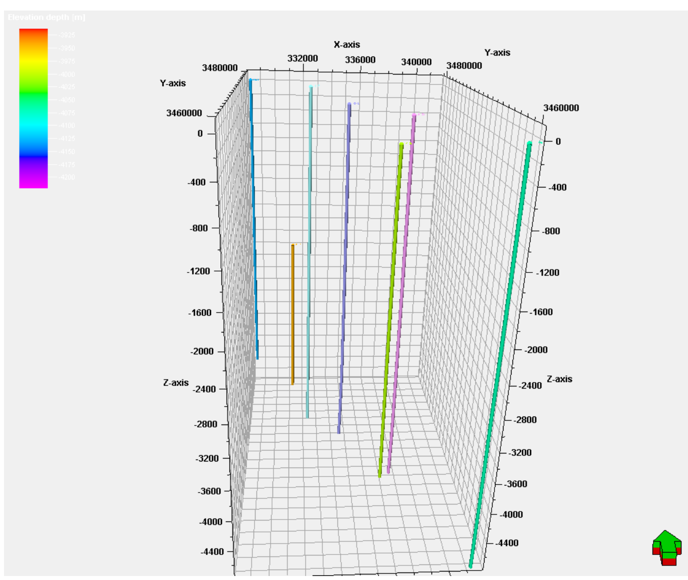

Figure 2. Position of wells No.3, 4, 25, 33, 37, 48 and 52, in the studied oil field

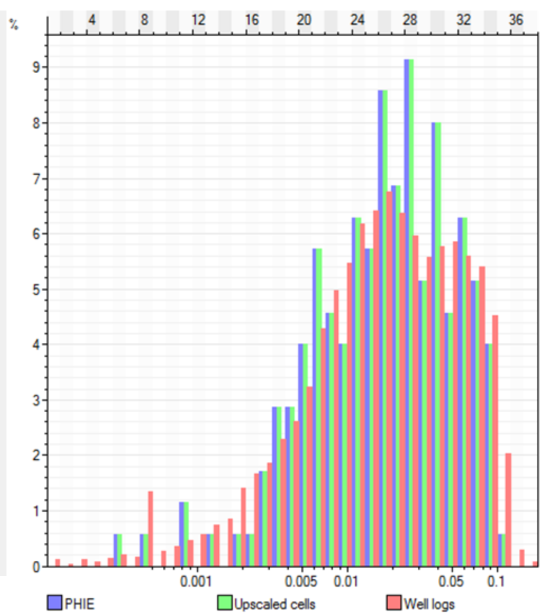

Figure 3. Cumulative histogram of porosity model derived from well logging data in Kupal oil field

4. Definition of reservoir geometry and gridding

After entering data and creating Ischore Map Logs, in the second stage, it is time to build a construction model. At this stage, a geocell network is created proportional to the dimensions of the field. This network as the main framework of the model allows for the simultaneous examination and integration of structural data and petrophysical properties for the creation of realistic models, and when making petrophysical modeling, it causes the defined petrophysical parameters for each well, can be extended to the entire reservoir. At this stage, where the reservoir is divided into a cellular network in which all properties of each cell, including petrophysical and lithological properties are the same in whole volume, and according to the distance between the networks and the amount of data, the same properties in cells without data, can be estimated. The dimensions of the network are 500*500, and the number of reservoir cells are 1620060, which are considered along X and Y directions. (Figures 4 and 5). After making the horizons at the time of layering, these blocks are separated in depth or Z direction.

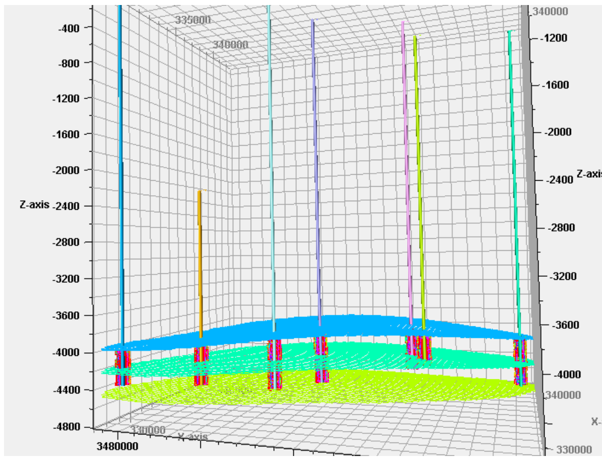

Figure 4. A view of created cellular network in Kupal oil field.

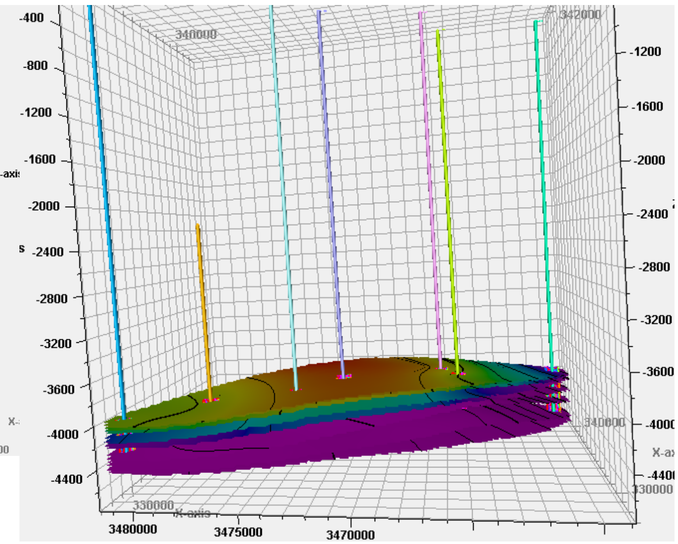

Figure 5. A view of the created horizons in the cellular network

5. Data analysis and variography

In the third step, the data obtained from petrophysical logs by scale up and analyzing data, Variography are ready to convert into a 3D model [12]. Scale up means attribution of logs recorded values to blocks of the three-dimensional network where its log information is available [13]. The Scale up the logs is necessary to distribute each one in each cell for use in modeling and generalizing these properties to the entire grid network. Given that, each cell can only have one value; the log values should be averaging. There are many techniques for averaging [14]. This is called the Scale up well logs. The data are processed in the variography stage, and the variograms are plotted (Figure 6). Property modeling is usually used for inherent properties of a parameter. A variogram is a tool for describing these inherent properties [15]. In other words, variogram is used as a method of analyzing and describing these spatial changes based on the principle that samples close together are more similar than samples far from each other [14].

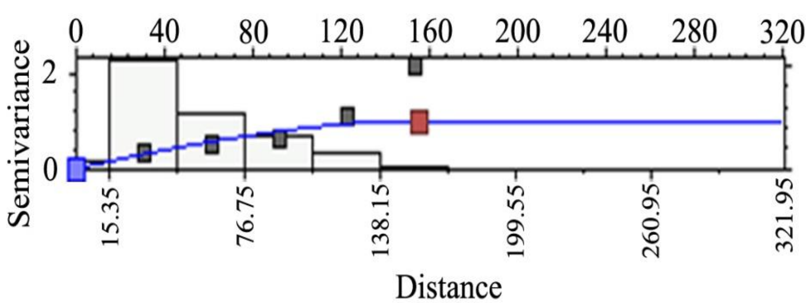

Figure 6. Variography model in the main-horizontal direction for porosity logs in zone 5

The modeling of reservoir porosity was carried out using the output of the variography stage by a consecutive Gaussian simulation method. Porosity values for different zones are given in Table (1).

Table.1 Average porosity foe each zona of Sarvak formation, Kupal oil field.

Zone	Average porosity	Thickness (m)
1	5.5	65
2	4	243
3	4.5	132
4	6.5	140
5	7	70

6. Discussion and results

Due to its simplicity and flexibility in generating real heterogeneities, sequential Gaussian simulation is widely used for modeling. The steps of performing a sequential simulation include 5 steps. These steps include conversion of main data to a new spac e; variogram modeling in new space; determination of a stochastic route in order to visit all of the places lacking sample; estimation of places without a sample in an alternate way and finally reversed conversion of simulated values (Figure 7).

Geostatistical simulation is a technique for producing data compatible with a regional variable. The main feature of the simulation data is that it can create a histogram and modifying the real data space.

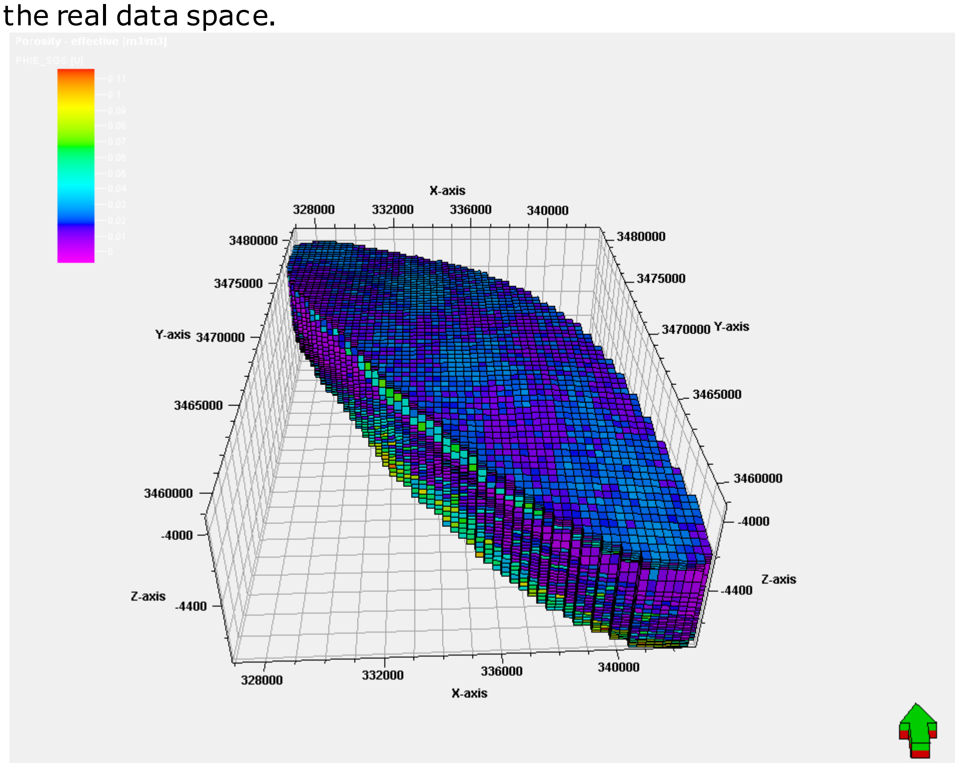

Figure 7. 3D modeling of porosity in Kupal oil field

7. Conclusion

The use of sequential Gaussian simulation (SGS) method is one of the common methods for determining petrophysical parameters. This method showed that simulation methods in cases where the initial data is less than the reservoir space are a suitable method for creating data in the space between the wells. In the simulation, decision-making it is not based on a simulated model, but based on the sum of simulated values, the probability of occurrence of each reality is determined. Of course, it should be noted that sometimes, the goal is to determine the operational risk in petroleum production planning. In these cases, it is necessary to select the best and worst of all simulated models, and in order to reduce the risk of operation, modeling of the reservoir is based on these two models. In this study, data of 7 wells have been used. For better modelling of reservoir properties, it is better to use more wells or to extend them in to the entire reservoir .The results of the porosity parameter for each zone are presented separately. According to these results, the concentration of petroleum in Layers 4 and 5 of Sarvak is higher than other zones, and it is suggested for the initial production, this reservoir will be developed

The average porosities are about 5.5% and for each zone is 5.5%, 4%, 4.5%, 6.5% and 7% in the Sarvak respectively.

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