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Geostatistical Lithofacies Modeling of Carbonate-Evaporite Succession -Kangan Formation-Based on Variography Analysis and Sequential Indicator Simulation Method in One of the Hydrocarbon Fields of Persian Gulf

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INTRODUCTION

Spatial lithofacies modeling is a very important step in reservoir characterization because it accurately reflects the stratigraphic reservoir structure and provides clear insight into how the reservoir is subdivided through characterization. A lithofacies model is beneficial because it helps understand individually the description of deferment depositional environment as well as capturing all of the heterogeneity levels and scales which are integrated into the reservoir model [1]. Moreover, the lithofacies model can also serve as a guide to predict reservoir properties in different locations with the same depositional environment. In addition, the process of integrating all available geological information into the numerical reservoir simulation in terms of 3D lithofacies distribution is called Lithofacies modeling. Moreover, several methods have been used for geostatistical lithofacies modeling including variogram-based methods, object-based modeling, and multiple-point geostatistics. In this research, the geostatistical methods have been done for carbonate-evaporite succession in one of the hydrocarbon fields in Persian Gulf.

GEOLOGICAL SETTING

The studied field is located in the center part of Persian Gulf area. In the studied area, the succession from pre-Cambrian to recent were deposited. The Permian Dalan and Triassic Kangan carbonate-evaporite successions are the main producer reservoir in the studied area [2].

Based on previous investigation and studies [3], the Kangan Formation were deposited in homocline carbonate ramp. Also, the studied interval, the Triassic formation, rests conformably upon the Permian Dalan formation. It is conformably overlain by the argillaceous Triassic Dashtak Formation. Furthermore, the Kangan succession consists of limestone, dolomite, anhydrite and some shale interlayers.

MATERIAL AND METHODS

In this study, data from 21 wells including: raw and evaluated petrophysical data, core and cutting, were investigated.

RESULTS AND DISCUSSION

The geostatistics knowledge offers a way of describing the spatial continuity of natural phenomena and provides adaptations of classical regression techniques to take advantage of this continuity [4]. Moreover, geostatistics integrates mathematical concepts, computer technology, and stochastic modeling with each other to generate multiple equiprobable realizations that keep the reservoir heterogeneity by honoring all the input data.

Most geostatistical reservoir characterization models are variogram-based algorithms such as sequential indicator simulation for lithofacies modeling and sequential Gaussian simulation for continuous petrophysical parameters.

The most common geostatistical facies modeling is SISIM which is designed for modeling the spatial distribution of facies based on the indicator variogram. The indicator variogram is used to build up a discrete cumulative density function (CDF) for the individual facies types, and the node is assigned a lithotype, selected at random from this discrete CDF [5].

After encoding facies into elementary samples 0, 1 given threshold values, the indicator variogram then can be formulated as:

$$I(Z_K;x) = \begin{cases} 0 & if \quad Z(x) > Z_k \\ 1 & if \quad Z(x) \le Z_k \end{cases} \tag{1}$$

where I (Zk; x) is the indicator random variable that is associated with random function Z (x) for a threshold value Zk. The expected value of the indicator random variable I (Zk; x) is equal to the cumulative probability:

$$\Pr\{Z(x) < Z_k\} \tag{2}$$

as shown below:

$$E(I(Z_k;x)) = 0 \times \Pr\{Z(x) > Z_k\} + 1 \times \Pr\{Z(x) \le Z_k\} \tag{3}$$

$$E(I(Z_k;x)) = \Pr\{Z(x) < Z_k\}$$

The first step in building the 3D property model is to construct the structural model that includes grid structure and horizon modeling. The grid structure involves setting the grid system for the reservoir to be considered for all the upcoming geological and reservoir modeling. In the studied filed, the carbonate-evaporite succession has been divided in two zones (A and B) and six sub zones (a1-a2-a3 and b1-b2-b3) based on petrophysical evidences and indications from cutting. Moreover, for modeling lithofacies, six lithofacies codes including anhydrite, limestone, dolomite, shale, dolomitic limestone, dolomite with anhydrite have been presented (Fig.1). After variography analysis, identified codes were propagated based on a sequential indicator simulation method by considering depositional environment of Kangan Formation (Early Triassic) in the studied area.

For the geostatistical lithofacies modeling, the sequential indicator simulation was adopted to reconstruct a 3D lithofacies distribution for the sector of studied field/main pay. The well lithofacies distributions were upscaled, given each layer prior to starting the 3D geostatistical lithofacies modeling. The main steps for the implementation procedure of sequential indicator simulation are outlined as follows:

1. Upscale well log data,
2. Construct and fit indicator variogram (Fig.2),
3. Random seed number,
4. Frequency distribution of upscaled data points (Fig.3).

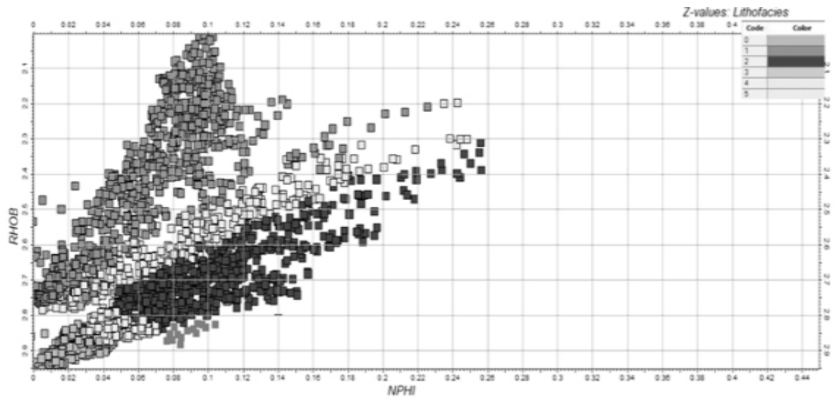

Figure 1: Lithofacies classification to 6 classes in this study.

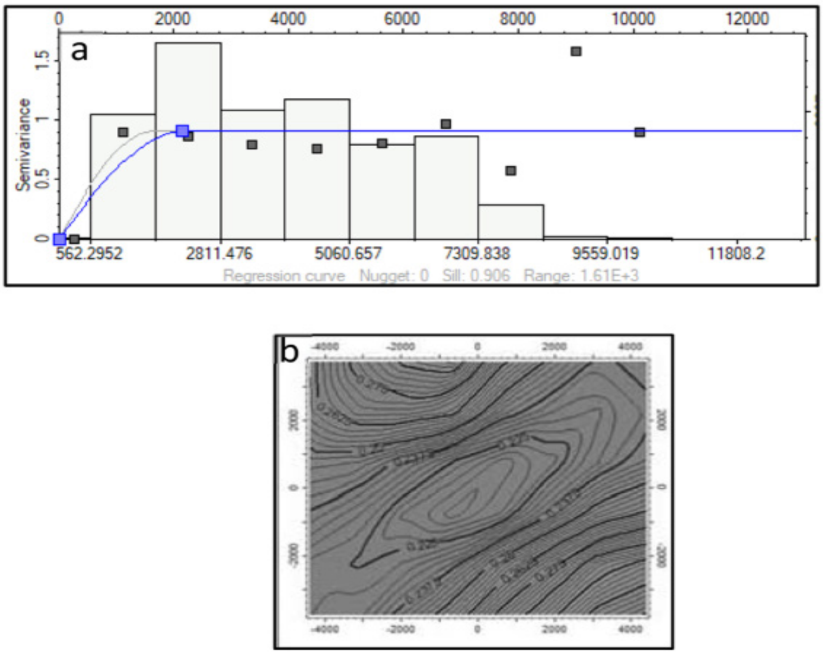

Figure 2: Indicator major variograms for zone a2 (a) and varigram map for zone a2 (b).

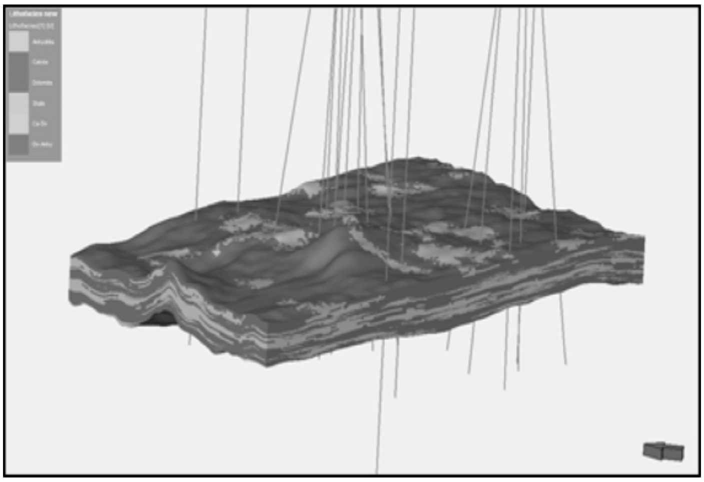

Figure 3: 3D SIS lithofacies distributions in the studied field.

The results of this study, which have been confirmed by new drilling well data, show that this method has a good accuracy and can be used in related sequences to predict the lithofacies and good reservoir properties.

CONCLUSIONS

To capture the most realistic geological model and to preserve the reservoir heterogeneity, the geostatistical model of Sequential Indicator Simulation (SIS) has been adopted for 3D lithofacies reconstruction of the Triassic carbonate-evaporite succession in one of the hydrocarbon fields in Persian Gulf.

In this study, data from 21 wells including petrophysical data (raw and interpreted), core and cutting have been used for lithofacies prediction and geostatistical propagation. Based on this investigation, six lithofacies classes have been defined and propagated based on SIS method.

Finally, the result of 3D lithofacies model can be used as basis for the petrophysical property modeling and heterogeneity of carbonate reservoir.

REFERENCES

[1]. Fadi Henri N., *"Multi-scale quantitative diagenesis and impacts on heterogeneity of carbonate reservoir rocks,"* Springer International Publishing AG 2017.

[2]. Alsharhan A. S. And Nairn A. E. M., *"Sedimentary basins and petroleum geology of the Middle East,"* Elsevier, Netherlands, pp. 934, 1997.

[3]. Rahimpour Bonab H., Esrafili Dizaji B. And Tavakoli V., *"Dolomitization and anhydrite precipitation in permo-triassic carbonates at the South Pars Gas field, Offshore Iran: controls on reservoir quality,"* Journ. Petrol. Geol., Vol. 33, pp. 43–66, 2010.

[4]. Journel A. G., *"Geostatistics for reservoir characterization,"* SPE- 20750-MS, presented at the SPE annual technical conference and exhibition, New Orleans, Louisiana, 1990.