The Application of Sequential Indicator Simulation and Sequential Gaussian Simulation in Modeling a Case in Jilin Oilfield

Xiaoyu Yu[1] and Xue Li[2]

[1] Exploration and Development Institute
Jilin oilfield Company
Jilin, China
Yuxy_jl@petrochina.com.cn
[2] College of Marine Geosciences
Ocean University of China, OUC
Qingdao, China
lix010@126.com

Abstract. Conditional simulation approach is the major trend and reseach focus of geostatistic development. In this paper, simulation result, statistical parameters and variogram is analysized by applying sequential indicator simulation to reservoir modeling, besides, the comparison between kriging and sequential simulation method has been made. The result proves the characteristic of conditional simulation and enriches the theory. This paper discusses indicator variation function and indicator model, the smoothing effect of kriging estimation can be seen from simulation results. Finally, the sequential conditional method has been applied to reservoir simulation modeling and theoretical basis and example provides a wide range of choices to describe the real geological conditions.

Keywords: sequential indicator simulation, reservior modeling, variogram, kriging estimation.

1 Introduction

Conditional simulation technology is a new geologistic tool that develops rapidly after the kriging geostatistic estimation technique.The kriging estimation is an optimal unbiased estimation method, an estimate on the average as well, and it only gives a single numerical model. Relatively speaking, conditional simulation can achieve more than conditional simulation. The differences between these results reflect the uncertainty of geological variables' spatial distribution. In recent years, conditional simulation is widely applied in stochastic reservoir modeling. It often results in reservoir's uncertainty and multiple solutions because of inadequate survey data. Conditional simulation not only can achieve the structure related to reservoir properties's spatial distribution, but also conditioning the known well data and get more results to satisfy the description and analysis of reservoir properties. Therefore, conditional simulation is widely applied in geological reservoir modeling and prediction in current.

W. Deng (Ed.): Future Control and Automation, LNEE 173, pp. 111–118.
springerlink.com

2 Differences between Conditional Simulation and Kriging

Compared with kriging, conditional simulation methods places much attention on reflecting volatility of the spatial data, while the Kriging method focuses on minimizing the estimation error. The differences are detailed in three aspects:

- The Kriging method is a kind of interpolation method, it only takes the accuracy of local estimation into consideration, including optimal assessment (minimum estimated variance) and unbiased estimates (the mean estimate value and the observation point), rather than specifically consider the ratio of the estimated spatial correlation value. Although the conditional simulation uses kriging algorithm to estimate point, it just estimates the points distribution that is to be estimated, it firstly consider the overall nature simulation results and correlation of statistical spatial value, followed by the accuracy of local estimation;
- Kriging method has a certain smoothing function, if the observation data is discrete data, the discreteness will be reduced by the smoothing estimation results with interpolation, ignoring subtle changes between wells: the conditional simulation makes the estimation results more true than interpolation by means of the "random noise" which is used in interpolation model system. "Random noise" is subtle changes between wells, although the value of each simulation for the local point is not entirely true, the estimation variance may be even greater than the interpolation method, the simulation curves can better manifest the real curves' fluctuations;
- Kriging method can only get a definitive result by interpolation, while the conditional simulation may achieve more results that is to say it can produces a number of optional model, the difference between each model is the reflection of the spatial uncertainty.

3 Advantages of Sequential Indicator Simulation

Sequential indicator simulation not only it can be used to simulate the continuous variables, but also to simulate the discrete characteristics with the fundamental principles of Kriging indicator, the indicator variables is determined by average frequency and variation function which characterizes its spatial continuity. This method speeds slower than the Sequential Gaussian Simulation, but its advantages is that it can simulate the complex heterogeneity, such as different relevance, anisotropy and different lithofacies, etc.. Sequential Gaussian Simulation is mainly used to simulate property parameters such as porosity and permeability.

4 Data Analysis and Variation Function

Data analysis is a very important step in property modeling:plays a key role in explaining the data, identifing geological features, the results can be directly used in property modeling module. Data analysis is divided into discrete and continuous data analysis. It is generally applied to discrete data. Discrete data is usually integer, the

object of analysis can be well log or discrete well points the whole model. As to facies modeling, for example, it can analyze discrete attributes and relativity of continuous variables' attributes.

Variation function which describes the spatial variation of the reservoir, takes a dominant action in the data analysis, the variation function produced from input data can be used for property modeling. Variogram should first set the main direction of the parameters such as bandwidth, search radius, step, etc., and then set the second direction and vertical parameters. Range, among all the various parameters, is particularly important. In the range area, the smaller the distance is between two points, the better the similarity will be. As to other points, the similarity is irrelevant to distance.

5 Specific Case

5.1 Data Preparation

The hierarchical data used in this modeling is the comparison data of sand group and sand body of each layer. Hierarchical data can be divided into different sand group and small layer, using sedimentary cycles contrast and log analysis method, each group includs a number of layers which contains sand body and mud. The following picture(Fig.1) shows the well section diagram of three wells' previous seven layers of qn3-I.

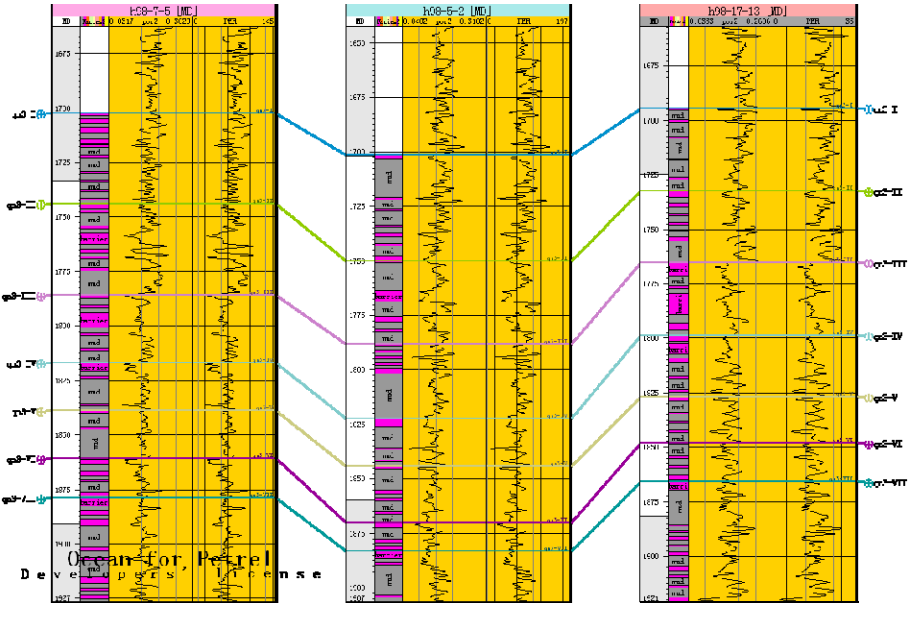

Fig. 1. well section diagram of part stratum(h98-7-5,h98-5-2 and h98-17-13)

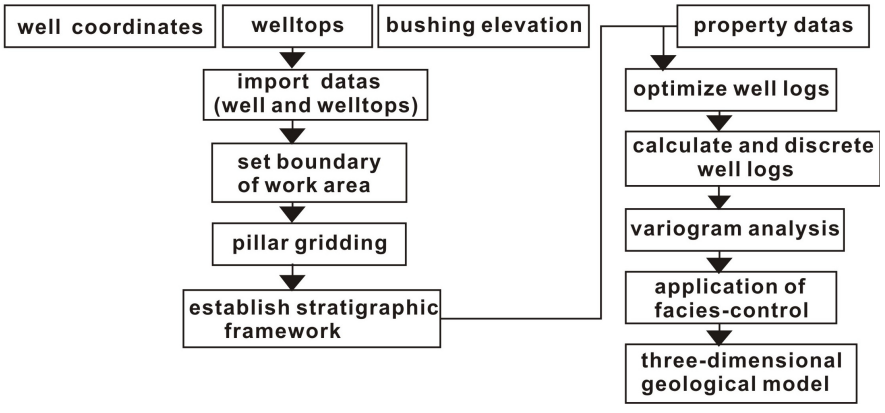

Fig. 2. Working flow chart used in simulation

Sequential indicator simulation applied in Daqingzi oilfield is based on the preliminary work as follows. Fig.2 is the working flow chart previous the facies and property modeling.

With the discrete property data, we calculate average well point data. The following contour map (including porosity and permeability contour map) is an expression of the average datas, take qn3-I sand group for example.

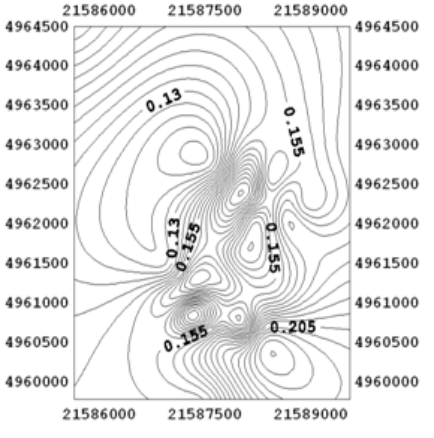

Fig. 3. Porosity contour map of qn3-I

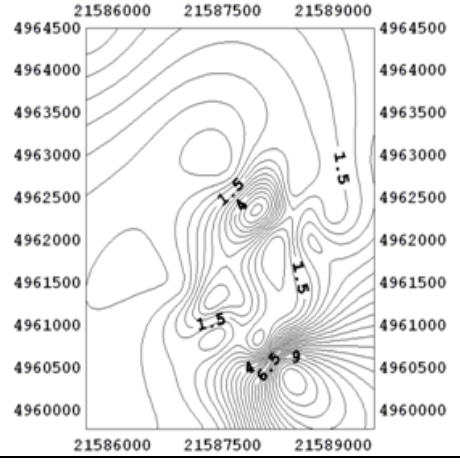

Fig. 4. Permeability contour map of qn3-I

6 Facies and Property Model with the Use of Sequential Simulation

In order to study the sequential simulation, one of the parameters for the simulation is facies, and the other is porosity and permeability. Sedimentary facies are discrete

parameters, using sequential indicator simulation method for simulation. Porosity and permeability parameters are continuous, using sequential gaussian simulation. The following graphs (Fig.5-Fig.7) are the facies and property model simulated by sequential simulation.

Fig.8-Fig.10 is the 3D fence map of the entire study area.

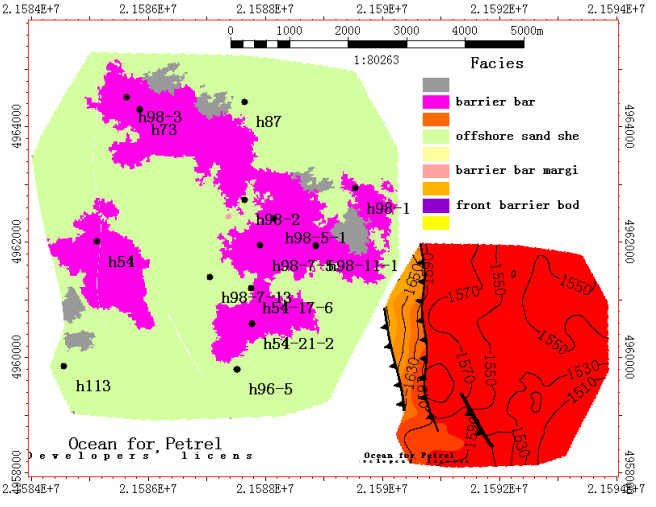

Fig. 5. Facies model of qn3-I

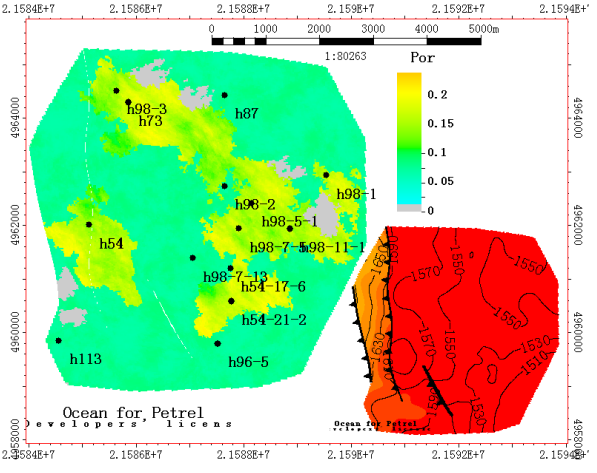

Fig. 6. Porosity model of qn3-I

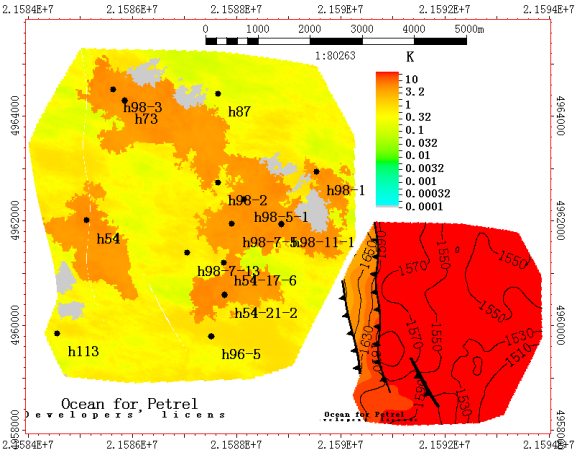

Fig. 7. Permeability model of qn3-I

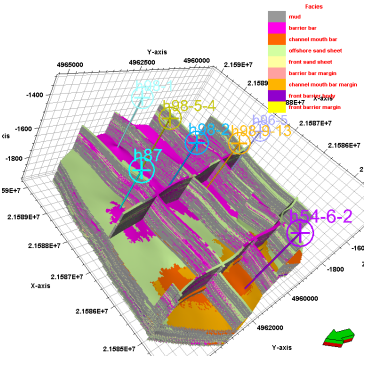

Fig. 8. 3D Fence map of facies model

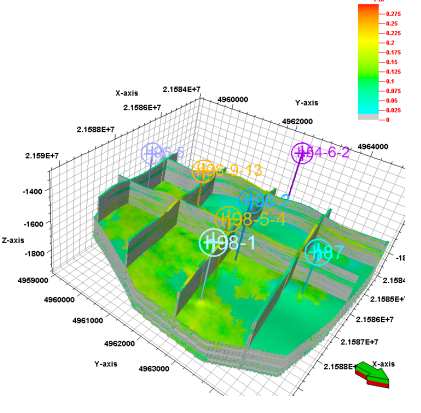

Fig. 9. 3D fence map of porosity model

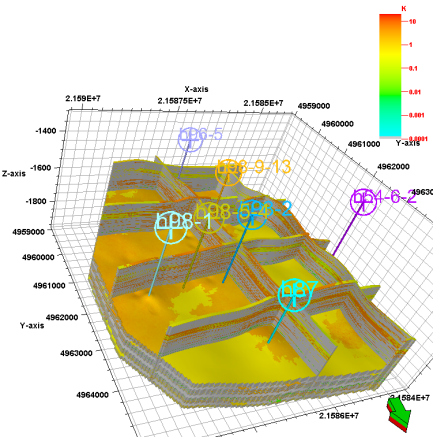

Fig. 10. 3D fence map of permeability model

7 Conclusion

a) It makes the smoothing function of Kriging methods more superior by the comparison of the results achieved by applying Sequential Indicator Simulation and Kriging methods for specific reservoir modeling.

b) Variance function is the groundwork of Kriging estimation and simulation, the variance function obtained by choosing different cut-off value is different, so we have to integrate all the data and select reasonable cut-off value.

c) More results can be achieved with the application of Sequential Indicator Simulation in reservoir modeling and its applicability for reservoir modeling can be best elaborated as well.

Acknowledgment. The authors thank the workers of Jilin oilfiled for supplying researching data and assistance.

References

1. Zhang, J., Jinkai, W.: Application of the 3D Computer Modeling and Numerical Simulation in the Lower-Middle Series of Strata of Hetaoyuan Formation in Xiaermen Oilfield. In: 2008 International Workshop on Education Technology and Training & 2008 International Workshop on Geoscience and Remote Sensing, pp. 201–205 (2008)
2. Zhang, J., Ma, X., Wang, J.: 3D Geological Modeling of Complex Reservoir Geometries in a Lacustrine-delta System, Sha19 Block of Shanian Oilfield. Sencond ISECS International Colloquiim on Computing, Communication, Control, and Management 4, 455–458 (2009)
3. Journel, A.G.: Stochastic modeling of a fluvial reservoir:a comparative review of algorithms. Journal of Petroleum Seience and Engineering 21, 95–121 (1998)

4. Zhang, J., Ma, X., Zhang, Z., Zhang, X.: The Importance of User Interaction In 3D Geological Modeling and Reservoir Exploitation. In: Proceeding of First International Conference on Modelling and Simulation, pp. 290–293 (2008)
5. Journel, A.G., Alabert, F.: New Method for reservoir mapping. Petroleum Technology 42(2), 212–218
6. Haldorsen, H., Damsleth, R.: Stochastic modeling. JPT 42(4), 404–412 (1990)