Research on Variogram Theory And Its Application in Property Modeling

Wang DaCheng
NO.3 Oil Production Plant, Daqing Oilfield Co.Ltd., PetroChina, Daqing 163113, Heilongjiang, China
wdc_dz@petrochina.com.cn

Abstract. Starting from the basic theory of variogram, the influence degree of data analysis on the result of attribute distribution calculation is given by parameter influence experiment. Combined with the practice of geological modeling, the "false fitting" phenomenon of the data analysis curve is found, and a new method of data analysis technology is put forward at the same time by using the theory of variation function. The technical method designs the parameter adjustment process, gives the parameter setting range, and realizes the transformation from experience to quantization of data analysis. In the actual modeling of an oilfield, the distribution of the one or two and three types of reservoir properties has been accurately characterized, and the accuracy of the attribute model has been greatly improved.

1. Introduction
In the process of data analysis of geological modeling, the variation function is the most basic and most important simulation tool. It is used to describe the spatial correlation of data values. The results directly affect the calculation and distribution of various property in the model, and it is the basis and core of the calculation of attribute modeling. In recent years, there are many theoretical descriptions and applications of variation functions. Most of them are focused on the description of concepts and statistical methods, and a part of the application of variation functions in the automatic setting of sedimentary microfacies. The acquisition of these achievements makes the technicians in the basic understanding and application of the variation function. However, because of its difficulty in theoretical application, many calculation parameters and interrelation, and complicated adjustment process, it has always been the difficulty and hot spot of data analysis and simulation. The research results of domestic and foreign research still lack the research on the data analysis and fitting process combining with the actual model. The discovery of "false fitting" phenomenon and the reason have not given a reasonable explanation. These practical problems directly lead to the large deviation of the actual calculation results. Therefore, based on the basic theory of variogram, the parameters and limits of variogram are fully discussed and studied combined with regional geological conditions. The purpose is to draw a parameter setting method which accords with the principle of variogram and combined with actual knowledge, and accurately calculates and describes all kinds of attribute distribution of reservoirs.
2. Experiment on the influence of data analysis results on property calculation

In order to compare the influence degree of data analysis results to the calculation of attribute distribution, the experiment is designed to influence the results of phase control, truncation effect and change range. The experiments are carried out according to the following instructions.

2.1. The principle of experiment:
(1) Identity: model, grid system, algorithm and so on.
(2) Uniqueness: the change of factors and the comparison of evaluation indicators are unique.
(3) Objectivity: the comparative data are based on the objective of the calculation results.

2.2. Experimental design:
(1) Comparing the effects of phase control on the distribution of attributes.
(2) Compare the effect of variable range size on attribute distribution calculation.
(3) Comparing the effect of truncation on efficiency and computation.

2.3. Comparison and analysis of experimental data:
Table 1 is the basic data and experimental results of this experiment. The 4 sets of experimental data are compared and analyzed as follows:
(1) Compared with experiment 1 and 2, it is found that the difference of permeability calculated by phase control is 8870800md.
(2) The 2 and 3 of experiments have been done with different cut-off settings. The comparison results show that the results of permeability calculation are the same.
(3) The variation range of Experiment 4 is greater than 3, but the permeability is smaller than the 3 value of experiment 7761950md.

| No. | Grid (m) | Area (km²) | Phase-control | Model type | Mathematical method | Variable range (m) | Permeability (md) |
|-----|----------|------------|---------------|------------|---------------------|--------------------|------------------|
| 1   | 20*20    | 6.62       | No            | Spheroidal | SGS                 | 400/350/3.5       | 90925700         |
| 2   | 20*20    | 6.62       | Yes           | Spheroidal | SGS                 | 400/350/3.5       | 99796500         |
| 3   | 20*20    | 6.62       | Yes           | Spheroidal | SGS                 | 400/350/3.5       | 99796500         |
| 4   | 20*20    | 6.62       | Yes           | Spheroidal | SGS                 | 1200/1100/6       | 92034550         |

2.4. The conclusion of the experiment:
Based on the comparison of experimental data, the following 4 conclusions can be drawn:
(1) Phase control not only delineate the boundaries of micro boundaries, but also affect attribute computation.
(2) The truncation setting does not affect the calculation result, so that the efficiency can be set uniformly.
(3) The calculation results of different range values are quite different, and the results of data analysis are significant for attribute calculation.

3. The "false fitting" phenomenon of data analysis

3.1. The discovery of "false fitting" phenomenon
In the process of attribute modeling in the study area, a large number of curve fitting experiments have been carried out by adjusting the range of various parameters according to the traditional data analysis method in the same case of model, data, calculation and analysis. It is found that the same sedimentary unit and the same lithology appear many well fitted curves. According to the requirement of the attribute calculation, the study area can only use a set of variable range values to calculate. In this
appearance, there must be a fitting phenomenon which is not in accordance with the practical significance, and it is called "false fitting" phenomenon, as shown in Figure 1.

3.2. Explanation of "false fitting" phenomenon
The variation function is the variance of the increment of the regionalized variable. In the process of research, the data of sample analysis point is very limited and the arrangement is irregular, which may lead to the requirement of the difference function of the data along a certain direction, so in the process of finding the variation function, many parameters, such as the azimuth angle, the lag distance and the number of lag distance, are often used. As shown in Figure 2, the dots represent the position of data distribution. Assuming that it represents similar or similar values, a number of variogram curves may be fitted by setting different directions, radii, and lag distances. As in a more regular and larger area of study, a small area is intercepted from it. By adjusting the parameters, both of them will synthesize the standard variation function curve, but the final variation is different. Because the parameters are interrelated and the range of setting is different, the parameters such as the search radius, the lag distance, the tolerance and so on are affected. Then a small area is intercepted, and then the fitting will naturally have a set of different range of variation values. However, because both of them have strong regularity, there is a set of fitting curves which conform to the standard, which reasonably explains the reason of the phenomenon of "false fitting".

According to this, we can draw two aspects of Enlightenment: first, parameter adjustment and calculation have a limited range, reasonable setting and quantitative solution are the basis of precision calculation of attributes; second, fine deposition description results have a guiding role in quantitative data analysis process.

4. Parameter setting method and effect comparison
4.1. Parameter setting principle
According to the principle of variation function, the number of point pairs decreases with the increase of the lag distance. After the lag distance reaches a certain limit, there is no more data. Because the number of points involved in the calculation determines the accuracy of the model, the greater the lag distance is, the worse the reliability of the calculation is. However, if the lag distance is too small, the search will not be sufficient for the number of points. Therefore, to get a reasonable difference function value, it is necessary to start from a smaller and reasonable lag distance.

According to the above analysis, in order to control the lag distance in a meaningful range, the maximum search radius is set to about half of the farthest effective data point in the study area, the minimum lag distance is about half of the average well distance, and the bandwidth is set to two times the well distance. Adjust the other parameters. The aim is to filter out as many points as possible in the study area and participate in the calculation to ensure the accuracy of calculation.

To sum up, although there are correlations among the parameters, there are different sizes. The setting can be carried out according to the steps and reference ranges. This setup conforms to the basic theory of variation function, and realizes the transformation of data analysis from experience to quantization, which ensures the precision of the model and improves the working efficiency.

4.2. Specific process and method
According to the above analysis, a simple process of calculating variogram is designed. (1) Select the calculation model. There are three kinds of variogram models: exponential model, spherical model and Gauss model. The applicable conditions of various models are shown in Table 2. Because the study area belongs to the river delta sedimentary environment, the variogram model is used to select the spherical model. (2) Select the main direction. In order to ensure that the study area has a higher correlation in this direction, the main direction angle of the variogram is consistent with the direction of sediment source or reservoir development. (3) Setting the search radius and the lag distance. Combined with the practice of the study area, a certain range of fine tuning is made. (4) Fine tuning lag tolerance, angle tolerance and other parameters to obtain range values. Until the variation function curve basically coincides with the regression curve, the variation range is large and the nugget value is very small.

| Model type  | Application of geological conditions                        | Randomness    |
|-------------|-------------------------------------------------------------|---------------|
| Exponential | River type geological conditions                             | More          |
| Spheroidal  | Large river channel and relatively stable delta sedimentary environment | Moderate      |
| Gaussian    | Stable sedimentary environment such as sea lake             | Less          |

4.3. Effect comparison
In order to get better proof of the new method in practice, a great deal of research, analysis and experimental work has been carried out in 84 sedimentary units in the study area. Reservoir No. 1, 2 and 3 are three typical sedimentary units. After data analysis, the range values are 664.5/615.1m, 408/370m and 818/706m respectively. Figure 3 shows the correspondence between the permeability distribution of the three typical sedimentary units and the sedimentary microfacies distribution. In the overall trend, the distribution of the permeability reflects the sand body distribution in various sedimentary environments. One by one comparison shows that the red area distribution of permeability exactly reflects the trend and bend of the channel in sedimentary facies, and the most obvious is a kind of reservoir (No. 1). The direction of permeability distribution reflects the direction of main channel and distributary channel, and the two type reservoir (No. 2) is most obvious. For the poor development of three types of thin reservoir (No. 3), the permeability distribution can not only reflect the discrete state of the tip-out area, but also reflect the continuity of the channel sand body.
Fig. 3. 1, 2 and 3 Comparison of permeability distribution and sedimentary microfacies

According to the above comparison, it is found that this method can not only realize the accurate prediction of the properties of well development, but also realize the accurate prediction of the properties of poor development and poor continuity.

5. Conclusions
(1) The experiment of data analysis is designed. It is proved that the value of variable range has great influence on the distribution of attribute calculation, and truncation and unified setting can improve work efficiency.
(2) The basic theory of the variable difference function and the actual modeling of data analysis are fully combined, and the geological meaning and operation basis of various mathematical parameters are given. The false fitting phenomenon is found and the reasonable explanation is given according to the theory.
(3) The technical method designs the parameter adjustment process, gives the parameter setting range, and realizes the transformation from experience to quantization of data analysis
(4) This method can not only accurately predict the properties of well-developed reservoirs, but also accurately predict the properties of poorly developed and discontinuous reservoirs.

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