Scholars Bulletin **ISSN 2412-9771 (Print)**
(A Multidisciplinary Journal) **ISSN 2412-897X (Online)**
An Official Publication of "Scholars Middle East Publishers",
Dubai, United Arab Emirates
Website: http://scholarsbulletin.com/

Application of Grey Relational Analysis in Daqing Oilfield Reservoir Evaluation

Pan Mengmeng
College of mathematics and statistics of Northeast Petroleum University, Daqing, Heilongjiang, China

***Corresponding Author:**
Pan Mengmeng
Email: 13644590618@163.com

Abstract: This paper introduces the basic theory and the thought of grey correlation method, through the method of Daqing in 45 block reservoir unit the physical parameters of quantitative analysis, to determine the impact on the quality of the region weights of evaluation indexes, and determine the comprehensive evaluation score and classification standard, through quantitative distinguish coefficient, the correlation coefficient, correlation, and weight coefficient to calculate more reasonable and accurate. The evaluation results are in good agreement with actual production worth popularization and application.
Keywords: Grey relational analysis; evaluation index; correlation coefficient; correlation; weights.

INTRODUCTION

With the development of science and technology, the grey correlation method also plays an important role in the field of oil and gas exploration, and reservoir study is the important step in the process of oil and gas exploration, reservoir evaluation is a comprehensive understanding and evaluation of reservoir research. The conventional reservoir evaluation methods in our country are still in the qualitative stage, mainly to the porosity and permeability to evaluate, among them, the porosity is largely decided by the research of reservoir quality good or bad, but at the same time there are some other factors, such as effective thickness, the coefficient of variation, etc. To comprehensively consider the effect of these parameters on the reservoir, so as to carry on the reasonable classification to the reservoir evaluation is particularly important, but how to objectively determine the influence of various factors in the evaluation of reservoir is involves the establishment of evaluation index and index weight determination of the problem. Intervention in this time, the grey system theory proposed by Deng Julong, through the theory, to the data processing, reservoir prediction and evaluation, in order to avoid the influence for the things of the man-made "albino" unknown factors, can't penetrate the structure information of data mining. In the process of application, involves the mother sequence and sequence of selected, correlation coefficient, correlation, weight coefficient and comprehensive evaluation factor calculation, etc. Not only improve the accuracy of the reservoir evaluation and credibility, and the method also has the advantages of convenient, effectively resist known-plaintext attack data.

THE BASIC PRINCIPLE OF GREY CORRELATION ANALYSIS

Grey relational analysis is based on the grey process of grey system, in essence is the dynamic development trend of quantitative comparative analysis, mainly based on the mathematical foundation of the theory of space, according to the standardization, integrity, accidentally, symmetry and proximity principle, determine the reference sequence and certain columns [1]. According to the degree of similarity or dissimilarity between factors research, to seek the main relationships of the factors in the system, find out the important factors influencing the target value, so as to grasp the main characteristics of things. Compared with regression analysis and other statistical methods, this method requires less data and lower requirement of the data, it will not appear in the process of analysis of quantitative and qualitative analysis result inconsistent phenomenon, so when the object of study is influenced by many factors, and relationship with uncertain, using the method of grey correlation analysis for correlation analysis, can achieve very good effect, provide the basis for reservoir evaluation. The main steps include the determination of the original sequence, the processing of raw data, calculation of correlation coefficient and correlation calculation and sorting, etc.

GREY RELATIONAL ANALYSIS OF THE BASIC FORECAST CALCULATION

The choice of evaluation index

In order to internal structure from the data analysis is to evaluate the relationship between objects and their influence factors must use a certain quantitative index quantitatively reflect the evaluation of the nature of things [2]**.** The number of indicators according to a certain sequence, called mother sequence correlation analysis, denoted as:

$$\left\{X_t^{(0)}(0)\right\}, t = 1,2,\cdots,n \tag{1}$$

Subsequence is decision or affects the evaluation of the nature of things, ordered arrangement of each factor data, considering the main factors of m is, have a sequence:

$$\left\{X_t^{(0)}(i)\right\}, i = 1,2,\cdots,m, t = 1,2,\cdots,n \tag{2}$$

Determine the correlation analysis of the parent and subsidiary sequence can form the original data matrix:

$$X^{(0)} = \begin{bmatrix} x_1^{(0)}(0) & x_1^{(0)}(1)\cdots & x_1^{(0)}(m) \\ x_2^{(0)}(0) & x_2^{(0)}(1) \cdots & x_2^{(0)}(m) \\ \vdots & \vdots & \vdots \\ x_n^{(0)}(0) & x_n^{(0)}(1)\cdots & x_n^{(0)}(m) \end{bmatrix} \tag{3}$$

In the development scheme design stage, dividing development layers of different layer and well spacing density as the main contradiction, compared with other evaluation index, porosity is the main influence factors. So the porosity determined in this paper studies mainly factors, while the remaining 5 indexes respectively from one side reflect the evaluation of the quality of the sample, can be seen as factors. (Table 1).

Table 1: Some key parameters of reservoir evaluation of daqing oilfield data

Position	Effective thickness	Porosity	Permeability	Variation coefficient	Mutation coefficient	Range
F Ⅰ 1	0.62	19.00	31.44	0.76	1.77	108.45
F Ⅰ 2	2.22	19.43	24.68	0.89	2.28	452.59
F Ⅰ 3	1.92	18.97	34.24	0.69	1.63	59.59
F Ⅰ 4	1.1	18.49	21.38	1.12	2.53	380.46
F Ⅰ 5	1.21	17.69	17.98	0.77	1.69	73.02
F Ⅰ 6	1.44	18.36	22.70	0.69	1.71	426.64
F Ⅰ 7	2.5	18.69	22.52	0.85	1.77	566.16
F Ⅱ 1	2.26	16.73	19.04	0.69	1.66	289.26
F Ⅱ 2	1.2	16.43	10.86	0.72	1.71	404.59
F Ⅱ 3	1.58	17.53	14.65	0.00	1.00	1
F Ⅱ 4	1.32	18.42	25.95	0.74	1.69	126.69
F Ⅱ 5	1.32	17.79	16.53	0.66	1.69	90.59
F Ⅲ 1	1.15	18.27	20.90	0.65	1.68	5.39
F Ⅲ 2	1.58	17.43	16.93	0.84	1.80	195.29
F Ⅲ 3	1.18	15.85	6.93	0.62	1.59	40.51
F Ⅲ 4	1.95	15.97	6.54	0.62	1.61	130.16
F Ⅲ 5	1.60	16.6	7.82	0.90	1.89	250.49

The original data transformation

Raw data transformation processing methods have preliminary treatment, the mean and maximum standardized and normalized processing method. This article uses the maximum value standardization method; make each evaluation scores dimensionless, standardization of data. Single parameter is usually in three conditions: 1) reservoir quality was positively related parameter, directly divided by the parameters of the maximum value; 2) and negatively correlated with quality of reservoir parameters, using the parameters of the maximum minus the single parameter data, with its difference divided by the maximum; 3) middle of values for the parameters selection, the reservoir quality, the better parameters with single parameter minus the median and calculate its absolute value, with the largest absolute value minus the parameter is the difference between the absolute value, divided by the maximum, so make it comparable [3, 4]. Through the statistics of Daqing in 45 block reservoir key well each index data, standardization of data obtained.

Calculating grey correlation coefficient

Original data available under after transformation type is calculated for each factor and the grey relational coefficient between the main factors:

$$\xi_{i,0} = \frac{\Delta\min + \rho\Delta\max}{\Delta_t(i,0) + \rho\Delta\max}, i = 1,2,\cdots,m \tag{4}$$

The above data were observed at the same time, with each factor and the main factors observed value the absolute difference between the value and its extreme value. In order to improve the significant difference with the grey relational coefficient, weaken the biggest absolute difference value, and cause data distortion and the effect of introducing distinguish coefficient, usually, the value of 0.5 in this paper [5].

The calculation of grey correlation degree

Relation degree defined as:

$$r_{i,0} = \frac{1}{n}\sum_{i=1}^{n}\xi_{i,0} \quad (5)$$

Through the calculation can be obtained:

r=(0.597、0.860、0.567、0.609、0.634、0.489）

Correlation is a bounded number, its values range between., Correlation between factors and main factor is close to 1, it indicates the sub factors on the influence of main factors, the vice versa.

The determination of weight coefficient

Measure the degree of impact on reservoir quality evaluation indexes, is to calculate their relative to the weight value of permeability, it will do the correlation obtained normalized processing, it result is relative to each index weight coefficient of reservoir quality evaluation. The normalized expression is:

$$a_i = r_i / \sum_{i=1}^{m} r_{i,0} \quad (6)$$

Using (9) it is concluded that the weight coefficient of six indexes are:

a=（0.159、0.229、0.151、0.162、0.169、0.130）

According to the size and weight coefficient of correlation, it will be ordered by the various indicators, we can get them without the related relational sequence. Coefficient of correlation order is: Porosity > Mutation coefficient >coefficient of variation>Effective thickness>Permeability>Range.

The results of assessment

Each evaluation index by grey relation analysis of weight coefficient, this paper USES the calculation reference hong-zhi sun 2004 calculation formula:

$$REI = \sum_{i=1}^{n} a_i X_i \quad (7)$$

The single evaluation index with this kind of "weight" coefficients multiplied can get parameters of each single index evaluation, and to classify reservoir. (see table 2)

Evaluation standard: $REI > 0.7$ Ⅰ Reservoir; $0.7 > REI > 0.6$ Ⅱ Reservoir; $0.55 > REI$ Ⅲ Reservoir.

Table 2: Comprehensive evaluation classification key reservoir in daqing oil field

Position	Effective thickness	Porosity	Perme ability	Variation coefficient	Mutation coefficient	Range	REI	Reservoir classification
FⅠ1	0.400	0.958	0.860	0.609	0.625	0.382	0.667	Ⅱ
FⅠ2	0.817	1	0.642	0.709	0.835	0.713	0.804	Ⅰ
FⅠ3	0.683	0.954	1	0.566	0.584	0.358	0.715	Ⅰ
FⅠ4	0.472	0.912	0.610	1	1	0.604	0.786	Ⅰ
FⅠ5	0.492	0.847	0.538	0.616	0.601	0.365	0.602	Ⅱ
FⅠ6	0.541	0,901	0.597	0.566	0.607	0.670	0.664	Ⅱ
FⅠ7	1	0.930	0.594	0.675	0.625	1	0.807	Ⅰ
FⅡ1	0.839	0.782	0.530	0.566	0.592	0.506	0.650	Ⅱ
FⅡ2	0.490	0.765	0.423	0.583	0.607	0.637	0.597	Ⅲ
FⅡ3	0.576	0.836	0.466	0.333	0.452	0.334	0.530	Ⅲ
FⅡ4	0.514	0.906	0.674	0.596	0.601	0.392	0.640	Ⅱ
FⅡ5	0.514	0.856	0.492	0.545	0.601	0.373	0.590	Ⅲ
FⅢ1	0.481	0.893	0.562	0.543	0.598	0.336	0.598	Ⅲ
FⅢ2	0.576	0.830	0.497	0.667	0.634	0.433	0.628	Ⅱ
FⅢ3	0.486	0.731	0.385	0.529	0.573	0.350	0.531	Ⅲ
FⅢ4	0.694	0.737	0.382	0.529	0.579	0.393	0.571	Ⅲ
FⅢ5	0.581	0.774	0.393	0.718	0.664	0.473	0.619	Ⅱ

According to the classification standard: Daqing sandstone reservoir can be divided into Ⅰ、Ⅱ、Ⅲthree types. Reservoir for the study of favorable reservoir, the total number of 23.5% units, the reservoir with high porosity, the variation coefficient is small; it is the oil enrichment, exploration and development of the favorable reservoir. Ⅱreservoir for medium reservoir, the total number of 41.2% units. Ⅲ reservoir for the poor reservoir, the total number of 35.3% units. The reservoir porosity is low; the reservoir will be a big challenge to the exploration and development. The classification results with the development direction of daqing oilfield are basically identical.

CONCLUSIONS

Daqing oil field studies have shown that using the grey correlation analysis method to determine the weight coefficient of evaluation index, it can be a very good reflect with the importance of each index in reservoir evaluation and rationality, it can avoid using the single factor evaluation of reservoir results to conflict issues, when considering the influence of many factors, is conducive to the correct classification of reservoir. It is the effective method to enhance accuracy and reliability of the final evaluation results.

REFERENCES

1. Ziqi, S., Chengqian, T., & Zheng, Q. (1996). Utilizing exact grey theory to evaluate oil and gas formation. *Acta Petrolei Sinica*, *1*.
2. Shengli, L. (2003). 1, 2 Yu Xinghe 1 Gao Xingjun 1 Wang Qingru 3 Liang Wei 3 Zhou Jin3 (1. China University of Geosciences, Beijing; 2. Geologging Company of Liaohe Oilfield, Panjin, Liaoning; 3. East Institute of South China Sea, CNOOC, Guangzhou, Guangdong); a new method for studying remaining oil distribution── grey association analysis. *Oil & Gas Geology*, *2*.
3. Li, J. (2012). Application of gray correlation technology in reservoir predication interpretation of maturing oilfield. *Fault-Block Oil & Gas Field*, *5*, 014.
4. Jin, Li. (2012). Grey correlation technology application in the old oil field reservoir prediction to explain. Journal of fault block oil and gas fields. *Fault-Block Oil & Gas Field*, *05*.
5. Xie, T., Chao, L., li, J. (2012). Grey correlation analysis in the application of green east sag area reservoir evaluation. *Natural gas geoscience.*