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The Application of the Fisher Discriminant Method in Water Flooded Layer Discriminant

Ting Yong Deng*, HengYu Zhang

College of Science, Heilongjiang Bayi Agricultural University, Daqing 163319, China

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***Corresponding author:** Ting Yong Deng

Abstract **Review Article**

With the deepening of oilfield development, the old oil field comprehensive moisture content is higher and higher and reservoir parameter has changed, that the conventional means of quantitative analysis of the condition of reservoir water flooding research has can't meet the requirements, so this needs to carry out the water flooded layer research new methods and new theory. In this paper Fisher discriminant method of multivariate statistical analysis is used to establish a new water flooded layer interpretation model, that the coincidence rate of Off-balance-sheet reservoir is 78.3% and the coincidence rate of in the table of the reservoir is 81.3%, which effectively improves the water flooded layer discriminant accuracy.

Keywords: Fisher discriminant method, Water flooded layer; parameter extraction.

The main principle of Fisher's discriminant method

With the development of economy and the continuous advancement of science and technology, people have entered the information age. In order to obtain scientifically valuable results in a large amount of information, statistical analysis methods have become increasingly important and become essential for research Tools and instruments. Multivariate statistical analysis is one of the rapidly developing statistical analysis methods in recent years [1]. It has been applied to various fields of social and natural sciences and has become a powerful tool for exploring the diverse world. Among them, multivariate discriminant analysis is an important part of multivariate statistics, which is mainly used to identify the category to which an individual belongs. It is based on the known classification results of observation objects and several variable values indicating the characteristics of the observation objects, Which makes the probability of misjudgment lower when using the discriminant criterion to discriminate a new type of observation object. The multivariate discriminant analysis method is mainly divided into Fisher discriminant method, Bayesian discriminant method and stepwise discriminant method according to different discrimination standards. Among them, Fisher discriminant method has important applications in various fields. This paper mainly uses Fisher discriminant thought to study the level of water flooding of the layer, the establishment of a discriminant analysis method for the water flooded layer has a certain practical significance for establishing a comprehensive interpretation method of the water flooded layer [2].

The main idea of the Fisher's discriminant method is projection. For a point $x=(x_1,x_2,\cdots x_m)$ in a m-dimensional space, finds a linear function $y(x_1,x_2,\cdots x_m)$, reduces $x=(x_1,x_2,\cdots x_m)$ to a one-dimensional value, and then uses this linear function to group the known categories and unknown categories in m-dimensional space. The belonging samples are all replaced with one-dimensional data, and then the unknown belonging data is judged according to the degree of density between them. This linear function can convert all points in the m-dimensional space into one-dimensional values, and borrows the idea of one-variance analysis, that is, the discrimination is based on the principle that the ratio of the mean square error between groups and the mean square error within the group is the largest. It can not only minimize the differences between the sample points in the same category, but also maximize the differences between the sample points in different categories, so that higher discrimination efficiency can be obtained [3].

Extraction and calculationof water flood discrimination parameters

The multiple regression analysis was used to establish the relationship between $\ln K$ and the shale content Vsh, the porosity index m and $PORJ$, and we got $Swi = 19.627 - 0.038PORJ - 8.082\ln K$, and then calculated the permeability Swi;

By using multiple regression analysis, the relationship between irreducible water saturation Swi and $PORJ$ and $\ln K$ is established, and $Swi = 19.627 - 0.038PORJ - 8.082\ln K$ is obtained, and then the irreducible water saturation Swi is calculated;

Calculate $RXOJ = \dfrac{Rmn - 0.45Rmg}{1 - 0.45}$,

$Rz = Sxo^2 \cdot PORJ^m \cdot RXOJ$, $Rwj = 1.03Rz - 0.2279$

to obtain the water saturation $Sw = [\dfrac{\frac{1}{2}Rwj[\frac{1}{Rlld} - \frac{(0.63Vsh)^2}{2.5}]}{PORJ^m}]^{\frac{1}{2}}$;

Calculate the difference $Sw - Swi$ between water saturation and irreducible water saturation;

Calculate $\dfrac{Rlld}{Rxo}$.

The establishment of water flooded layer discrimination method

In this paper, a total of 214 samples of flooded grades were selected, of which 37 were off-surface reservoirs and 177 were on-surface reservoirs. The off-surface reservoirs and on-surface reservoirs were discriminated about water-flooded levels, and the Fisher discriminant equation was established. The discrimination results are as follows:

Table-1: Fisher discrimination coefficient (37 off-surface reservoirs)

	Category			
	1	2	3	4
Rlld/Rxo	68.677	66.490	79.321	66.429
RLLD	0.223	0.310	0.578	0.198
sw-swi	0.284	0.212	0.378	0.303
K	-16.608	-18.242	-24.382	-16.720
Rwj	42.874	38.725	33.651	48.199
constant	-66.021	-59.962	-76.212	-67.947

Table-2: Fisher discrimination coefficient (177 in-surface reservoirs)

	Category				
	1	2	3	4	5
Rlld/Rxo	33.483	34.010	35.767	39.885	42.389
RLLD	.036	.146	.083	-.137	-.153
sw-swi	.278	.425	.367	.259	.303
K	83.100	85.692	87.190	74.471	71.384
Rwj	-6.619	-8.970	-5.903	-3.541	-1.873
constant	-64.545	-70.981	-73.973	-62.956	-64.585

From Table-1, there are 37 Fisher discriminant equations for off-table reservoirs:

$$Y_1 = 68.677\frac{Rlld}{Rxo} + 0.223Rlld + 0.284(Sw - Swi) - 16.608K + 42.874Rwj - 66.021$$

$$Y_2 = 66.490\frac{Rlld}{Rxo} + 0.310Rlld + 0.212(Sw - Swi) - 18.242K + 38.725Rwj - 59.962$$

$$Y_3 = 79.321\frac{Rlld}{Rxo} + 0.578Rlld + 0.378(Sw - Swi) - 24.382K + 33.651Rwj - 76.212$$

$$Y_4 = 66.429\frac{Rlld}{Rxo} + 0.198Rlld + 0.303(Sw - Swi) - 16.720K + 48.199Rwj - 67.947$$

From Table-2, there are 177 Fisher discriminant equations for in-table reservoirs:

$$Y_1 = 33.483\frac{Rlld}{Rxo} + 0.036Rlld + 0.278(Sw - Swi) - 6.619K + 83.100Rwj - 64.545$$

$$Y_2 = 34.010\frac{Rlld}{Rxo} + 0.146Rlld + 0.425(Sw - Swi) - 8.970K + 85.692Rwj - 70.981$$

$$Y_3 = 35.767\frac{Rlld}{Rxo} + 0.083Rlld + 0.367(Sw - Swi) - 5.903K + 87.190Rwj - 73.973$$

$$Y_4 = 39.885\frac{Rlld}{Rxo} - 0.137Rlld + 0.259(Sw - Swi) - 3.541K + 74.471Rwj - 62.956$$

$$Y_5 = 42.389\frac{Rlld}{Rxo} - 0.153Rlld + 0.303(Sw - Swi) - 1.873K + 71.384Rwj - 64.585$$

According to the obtained discriminant equation, the data of the water flooded layer to be judged is input into the discriminant equation described above, and the values representing the four categories are obtained respectively, and which value is the largest belongs to the corresponding category.

Table-3: Discriminant results of 37 off-surface reservoirs

Category	**1**	**2**	**3**	**4**
1	5	1	1	2
2	1	8	0	0
3	1	3	7	0
4	2	2	1	3

Table-4: Discriminant results of 177 in-surface reservoirs

Category	**1**	**2**	**3**	**4**	**5**
1	7	3	2	1	1
2	3	7	6	1	1
3	13	24	38	11	4
4	7	0	3	10	12
5	1	0	2	6	14

From Table-3, the discrimination results of 37 sample points can be clearly seen: There are 9 types of data in 1 category. There are 5 sample points judged as 1 category and 1 sample point judged as 2 categories; There are 9 types of data in 2 categories. There are 8 sample points judged as type 2 and 1 sample points judged as type 1; There are 11 data types in 3 categories, 7 sample points are classified as 3 types, and 3 sample points are determined as 2 types; There are 8 types of data in 4 categories. There are 3 sample points in 4 categories, and 1 sample point in 3 categories. From Table-4, the discrimination results of 177 sample points can be clearly seen: There are 14 data in 1 category, 7 sample points judged as type 1 and 3 sample points judged as type 2; There are 18 types of data in the 2 categories; There are 7 sample points judged as type 2, 3 sample points judged as type 1, and 6 sample points judged as type 3; There are 90 types of data in 3 categories. There are 38 sample points in 3 categories, 24 sample points in 2 categories, and 11 sample points in 4 categories; There are 32 types of data in 4 categories. There are 10 sample points in 4 categories, 3 samples in 3

categories, and 12 in 5 categories; There are 23 types of data in 5 categories. There are 14 points in 5 categories, and 6 points in 4 categories. It can be calculated from Table-3 that the basic coincidence rate of water flooded layer discrimination is $\frac{29}{37}=78.3\%$;It can be calculated from Table 4 that the basic coincidence rate of water flooded layer discrimination is $\frac{144}{177}=81.3\%$,which provides an effective method for the identification of water flooded layers.

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