Research on Gas-Water Recognition Method in Natural Gas Reservoir

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Abstract. With the development of sustainable economy, natural gas as a clean energy has received great attention, but there are still many problems to be solved in the exploration and development of natural gas. Among them, gas-water identification method of natural gas reservoir is a hot research topic at present. Correctly identifying reservoir properties and improving the ability of gas-water identification are the key points of expanding natural gas reserves and enhancing the exploration value of discovered gas reservoirs. With the deepening and development of the research on gas-water identification of natural gas reservoir in recent years, the experimental methods and technical means have been constantly enriched and improved, and more research results have been obtained, but they are still in the exploratory stage. Therefore, it is necessary to continuously strengthen the research on gas-water identification methods of natural gas reservoirs, make full use of current advanced technologies, and improve the coincidence rate of computer interpretation of gas-water layers.

Keywords: Natural gas, Storage, Gas identification.

1. Research status of gas water identification in natural gas reservoir at home and abroad

Gas-water identification method of natural gas reservoir has always been the focus of attention and research at home and abroad. Especially with the increasing difficulty of development and the continuous development of logging technology, the study of reservoir fluid properties and distribution law becomes more important. Whether at home or abroad, the research on the identification of gas and water is very concerned, especially for the identification of gas-water layer tumor and logging stones, more energy has been put into it [1]. The water content of most gas fields in China is relatively high, so it is more important to strengthen the research on gas-water identification methods. Therefore, China has carried out more research and evaluation work in related fields, and there are more methods of gas-water layer interpretation. The gas identification technology is mainly a breakthrough from the development of intuitive crossplot technology. With the development and wide application of intuitive crossplot method, new logging technology and comprehensive identification technology, the research work of gas-water identification of logging stone reservoir has made great breakthrough and development, and it is also the research focus of natural gas reservoir identification in the future.

2. Identification method of gas and water in natural gas reservoir

2.1 Fuzzy cluster analysis

Fuzzy cluster analysis is a commonly used method of gas-water layer identification, which originated from taxonomy. A diversified statistical analysis method by classifying the characteristics, samples and variables of the research object. Classification is a measure of closeness between things based on similarity scale [2]. Cluster analysis is applied to unclassified groups. It comes from the actual requirements of the classification of things. Fuzzy cluster analysis is a fuzzy mathematical method that combines multivariate data analysis with classification. It refers to cluster analysis of foods with fuzzy characteristics by using fuzzy mathematical method, which has been widely used in the classification of various things and phenomena. Its fundamental nature is based on the construction of fuzzy matrix for the attributes of the research direction itself, and on this basis, the classification relationship is clear according to the membership degree, which usually needs the help of professional analysis software. Application steps: divide the research object into n samples to be classified, set the corresponding characteristic parameters, and divide the n samples into gas layer, water layer and gas water layer. The first step is to standardize the sample data according

to the requirements of fuzzy matrix and compress it within the interval of [0,1]. The second step is calibration, and the fuzzy similarity matrix is established. We can use distance method, correlation coefficient method, included angle cosine method, etc. [3]. The third step is to establish the fuzzy equivalent matrix. The main methods include transitive closure method and Boolean matrix method. The fourth step is to determine the classification, determine an appropriate value, $\lambda \in \in [0,1]$, and classify the λ cut-off matrix of this equivalent matrix, and then classify it according to the λ cut-off matrix. Although the fuzzy cluster analysis method can effectively identify the gas layer. However, the recognition effect on the same layer of gas and water is relatively poor, and it is difficult to completely distinguish the same layer of gas and water. Therefore, there are still certain limitations in the application of gas and water identification in natural gas reservoirs.

2.2 Stepwise discriminant analysis

Stepwise discrimination is a multivariate statistical method widely used in mathematical geology, which can classify unknown samples into a known population. In geological research, there are many similar problems, such as judging sedimentary facies and dividing oil, gas, water and dry layers [4]. Step-by-step discriminant method can be used to study the minds of different populations. It is mainly based on various observation indexes of known populations to establish discriminant functions, which can be used as the basis for classifying samples. The main problem to be solved in the application of step-by-step discrimination method is how to select several variables and effectively identify the overall sample, which is characterized by dynamic variable selection. At present, the discriminant analysis method mainly uses Wilhelm criterion to test. In the process of using discriminant analysis, the following three problems need to be solved: ① testing the discriminant ability of variables; ② Selection criteria of variables; ③ Calculation steps of stepwise discrimination. The main calculation of stepwise discriminant analysis is divided into the following steps: ① prepare data and calculate the mean and total mean of variables in each group, intra group dispersion matrix and total dispersion matrix; ② Before the introduction of variables, the introduction standard of variables is determined by Weiss statistics; ③ Among the variables that have been introduced, the importance of variables can be judged by using Weiss statistics. If they are weak, they can be eliminated; ④ Repeat steps ② and ③ until variables cannot be eliminated and introduced; ⑤ According to the final matrix, the discriminant function is calculated; ⑥ According to the discriminant function, the previous significance test and the discriminant classification of samples are classified and tested. Stepwise discriminant analysis can effectively and completely distinguish the gas and water layers, and clearly see the distribution of gas and water layers on the single well profile, which can provide scientific and intuitive decision-making basis for perforation gas test.

2.3 Grey cluster analysis

Grey clustering analysis is a method of clustering some observation indexes or observation objects into several definable categories according to the whitening weight function of correlation matrix or grey number. A cluster can be regarded as a collection of observation objects of the same kind. However, when solving practical problems, each observation object often corresponds to multiple characteristic indexes, which makes it difficult to classify accurately [5]. According to different clustering methods, grey clustering can be divided into grey constellation clustering, grey correlation clustering and grey whitening function clustering. Among them, grey constellation clustering is based on the self-attributes of samples, using the principle of similarity to clarify the relationship between samples, and naturally clustering according to this relationship. Grey relational clustering method is to merge according to similar factors and extract the factors with strong correlation, so as to combine these related factors into a average index or use one of them as a discriminant parameter to ensure the integrity of information and simplify the complex system. If some large-scale research is carried out, the grey relational clustering method can be used to reduce the cost and avoid the collection of unnecessary variables [6]. Grey whitening function clustering method is mainly used to check whether the observed objects belong to different predetermined categories, so as to facilitate differential treatment. From the specific workload analysis, grey whitening function clustering method is more complicated than the other two.

2.4 Probabilistic neural network method

Probabilistic neural network method was first proposed by Dr. D.F.Spech in 1990. It is a branch of radial basis network and a kind of feedforward network. Probabilistic network method is a parallel algorithm extended from Bayesian minimum risk criterion, which is mainly used to solve classification problems. It is an artificial neural network based on statistical principles. It is mainly composed of Bayes classification rules, and uses parzen window function density estimation method to estimate conditional probability [7], and carries out classification pattern recognition. It has the advantages of simple structure, concise training, low computational complexity and easy algorithm implementation, and has been widely used. Compared with the traditional feedforward neural network method, the probabilistic neural network method has the advantages of radial basis function sedation network and classical probability density estimation principle, and is widely used in classification pattern recognition. The probabilistic neural network method is applied to the gas and water identification of natural gas reservoir. The gas layer, water layer and gas water layer are used as the output layer, and the control factors are used as the input layer to train and learn the network samples, so as to identify the low porosity and low permeability gas and water layer. Probabilistic neural

network model is mainly divided into three layers, namely input layer, hidden layer and output layer [8]. The structure is shown in Figure 1. The hidden layer is divided into unit layer summation and unit layer. The input layer uses linear function to transfer the sorted input sample values to the central control of the unit layer. The unit summation layer performs simple cumulative summation, and the output layer accepts various probability density functions transferred from the summation unit layer. The maximum output is 1 and the rest is 0. The probabilistic neural network identification model is applied to the gas and water identification of natural gas reservoir, which has a high effect on the identification of gas and water layer, and can be used to effectively identify the target layer in the target area.

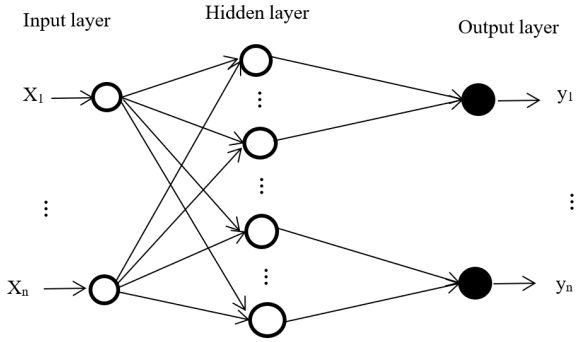

Figure 1 Probabilistic neural network model structure

2.5 KNN classification

KNN classification is called K-nearest neighbor method, which was first proposed in 1986. It is a nonparametric classification and counting method based on analogy learning. This theory is more mature, it is a relatively simple algorithm of machine learning, and it has ideal application effect in traditional pattern recognition. The idea of this algorithm is very simple and more intuitive [9]. A sample to be tested, if the sample has k most lovesickness in the feature space, that is, most of the samples in the nearest feature space belong to the same category, then it can be determined that the sample also belongs to this category. In KNN algorithm, the selected neighbors are generally objects that have been clearly classified. This method only relies on the category of one or more nearest samples to finally classify the category attributes of the samples. Nearest neighbor method is to classify the pattern to be recognized according to the principle of nearest distance under the condition of known training samples. Although KNN method mainly relies on the limit principle when making decisions, when making category decisions, it only works with a very small number of adjacent sample lines. Because this method mainly depends on the surrounding limited samples, rather than determining the category by discriminating the category domain, it is more suitable for the sample set to be classified with more overlapping or overlapping.

The idea of KNN classification method is more intuitive, and its application effect is better. Some of its technical theories can get more complete inflammation. Therefore, it is more suitable for the situation of complex domain distribution, and it is a very important pattern recognition technology. It has been widely used in many disciplines. KNN classification algorithm is the best classification method in vector space model, but there will be some shortcomings in actual operation. For example, when the application sample size is large, it will have higher complexity in time and space. In the process of similarity calculation, the dimension of feature vector is relatively high, and the correlation between feature parameters cannot be fully considered. When calculating the sample distance, each weighted value is similar, so the calculation of the distance between feature vectors or cosine of included angle is not accurate enough, which will affect the accuracy of classification. In view of the above problems, in recent years' research, corresponding improvement methods are constantly being put forward, such as improved algorithm to improve classification efficiency, improved algorithm based on features, improved classification algorithm combining KNN and SVM, etc. In the actual application process, gas and water layers can be effectively identified according to the improved KNN classification algorithm.

3. Conclusions

To sum up, with the continuous development of sustainable economy, more and more attention is paid to the development of clean energy. In the process of natural gas exploration and development, the identification of reservoir gas and water is very important. The correct identification of gas can greatly expand the reserves of natural gas and enhance the exploration value of discovered gas reservoirs. Based on the analysis of the current research status at home and abroad, it is found that the gas-water identification methods of natural gas reservoirs mainly used at present include fuzzy cluster analysis, stepwise discriminant analysis, grey cluster analysis, probabilistic neural network method and KNN classification, each of which has its own advantages and disadvantages, and needs to be further improved and improved in the future research work, so as to enhance the effect of gas-water identification.

References

1. Liu Hui, Luo Xiaoling, Lu Zhenquan, et al. Recognition and evaluation technology of gas hydrate reservoir in Muli permafrost area[J]. China Mining Industry, 2020, 29(1): 157-161,170.
2. Zhang Shimao, Ge Xiang, Wang Xin, et al. Two-dimensional nuclear magnetic resonance logging gas and water identification method for dolomite reservoirs in Western Sichuan Gas Field[J]. Journal of Spectroscopy, 2020, 37(3): 360-369.
3. Xiao Rui, Zhu Youhai, Lu Zhenquan, et al. Characteristics and significance of Triassic gas hydrate reservoirs in Well Qingdedi 2 of Halahu Depression, South Qilian Basin[J]. Geological Survey of China, 2020, 7 (4): 20-27.

4. Jiang Xiudi, Zhu Zhenyu, He Yangyang, et al. Natural gas hydrate reservoir and saturation prediction in the Pearl River Mouth Basin[J]. China Shipbuilding, 2019, 60(z1): 205-211.
5. Chen Ming, Liao Jin, Ouyang Min, et al. Characteristics and exploration potential of natural gas hydrate reservoirs in Songnan Low Uplift, Qiongdongnan Basin[J]. Well Logging Technology, 2021, 45(3): 290-296.
6. Liu Shengbiao, Han Tongcheng, Fu Liyun. Distribution of natural gas hydrates in fractured reservoirs: inspiration from seismic anisotropy measurements[J]. Science China (Earth Science), 2021, 51(5): 725-733.
7. Li Dongliang, Wang Zhe, Wu Qi, et al. Research progress on the mechanical properties of natural gas hydrate reservoirs[J]. New Energy Progress, 2019, 7(1): 40-49.
8. Song Zhen, Li Kaili, Sun Jiahang, et al. New broaching mining method and feasibility analysis of marine gas hydrate reservoirs[J]. The Chinese Journal of Process Engineering, 2020, 20(10): 1234-1240.
9. Wang Zhigang, Li Xiaoyang, Zhang Yongbin, et al. Analysis of reformation methods of non-diagenetic gas hydrate reservoirs in sea area[J]. Drilling Engineering, 2021, 48(6): 32-38.