Prediction Method of TOC Content in Mudstone Based on Artificial Neural Network

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Abstract. Total organic carbon (TOC) content prediction is an important index for evaluating geochemical characteristics of source rocks. Although the methods based on multiple regression and shale content index classification regression can predict TOC content of mudstone in different layers, the models are relatively simple and the results are not accurate. In this paper, the prediction method of artificial neural network is used to predict TOC content of Neogene source rocks in Liping area, Qaidam Basin. The results show that: (1) the correlation between TOC prediction curve and parameters of logging curve is significant; (2) the TOC prediction curve has obvious fluctuation, reflecting the strong heterogeneity of the stratigraphic organic matter; (3) the predicted TOC value is closer to the measured value. Using this method to predict TOC content can be widely used for oil and gas exploration and development in future.

1. Introduction
Total organic carbon (TOC) is one of the most important indicators to study the geochemical characteristics of source rocks [1]. The analysis of TOC content can be used to evaluate the source rock parent material type and oil and gas resource potential.

At present, the methods on calculating the TOC content are including experimental analysis and logging interpretation [1, 2]. Although the experimental analysis of core samples can provide accurate geochemical indicators of source rocks, it is often difficult to obtain continuous analysis data for a single well due to the limitation of sample sources and analysis and testing funds. The average value of limited analysis data is often used to represent the quality of source rocks. Therefore, the analysis data is difficult to meet the requirements of project research. Logging interpretation can indirectly reflect the lithology and fluid characteristics of the formation through various parameters. It has been widely used in reservoir evaluation. At the same time, logging data has a significant feature of good continuity, so it can comprehensively carry out the formation evaluation, so that the source rock can be analyzed continuously in the longitudinal direction.

There are many logging interpretation methods for testing organic carbon content currently, including crossplot method [3], multiple regression method and shale content index classification regression method [4]. However, these methods exist some shortcoming. For example, TOC prediction curve has weak correlation with logging parameters, and can't truly reflect the heterogeneity of formation organic matter. Artificial neural network (ANN) has a wide range of applications in many aspects, especially in those non-structural computing problems where the relationship between input
and output is difficult to be expressed by explicit functional equations. Based on the ANN learning, this paper analyzes and calculates the total organic carbon content of Neogene source rocks in Liping area of Qaidam Basin (Fig.1), and constructs a regional geochemical database, so as to provide theoretical exploration direction for realizing oilfield digitization.

![Figure 1. Location and structural characteristics of the study area](image)

2. Methods

SPSS modeler was used to build the model. According to the TOC prediction model of ANN, the calculation model of TOC content was established (Fig.2). The main operation steps are as follows:

1. Import data. Import the logging response parameters corresponding to the organic carbon content data of the existing well section. Import existing organic carbon content data to test the accuracy of the predicted value.

2. Set the role of each parameter. Set TOC as the target to be simulated, and 4 logging interpretation parameters (GR, AC, DEN, RT) as input roles.

3. Set training partition and test partition. The training partition is to ensure the adaptability of the model. A part of the sample is randomly selected for training, and the remaining part is tested.

4. Set up an ANN to build a standard model.

5. Run the program.

![Figure 2. Simulation of organic carbon content by artificial neural network](image)
3. Results and Discussion
Using the above method, this paper has predicted the TOC content of the mudstone section of 19 Wells in Liping area, and the results are shown in Table 1.

Table 1. Three Scheme comparing.

| Well | Layer | Simulated value/% | Measured value/% |
|------|-------|-------------------|-----------------|
| B-1  | N     | 0.46              | 0.5             |
| CH-1 | N     | 0.77              | 0.76            |
| ES-1 | N     | 0.09              | 0.11            |
| H-2  | N     | 0.12              | 0.11            |
| HC-1 | N     | 0.29              | 0.23            |
| HS-1 | N     | 0.36              | 0.34            |
| J-2  | N     | 0.25              | 0.25            |
| J-3  | N     | 0.91              | 0.99            |
| YS-1 | N     | 0.55              | 0.54            |
| LS-1 | N     | 0.46              | 0.47            |

Comparing the TOC simulation results of 19 wells with the measured results, it is found that the simulation results are highly reliable (Fig.3). These results show that the application of ANN simulation method in well logging interpretation can solve the problem of discontinuity of source rock abundance test data, and play a positive role in understanding the development characteristics of source rocks under sequence framework and dividing effective source rocks.

Figure 3. Comparison of simulated and measured organic matter content of source rocks in Liping area

4. Conclusion
The artificial neural network method has been applied to simulate the total organic carbon content of source rocks in Liping area of Qaidam Basin. The error between the simulated values and the measured values is small, which shows that there is a good correlation between them. In addition, the simulation method based on artificial neural network comprehensively reflects the heterogeneity of organic matter in source rocks.

5. Acknowledgments
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