Prediction of oil and gas distribution in K area by inheritance classification

Yanling Shi, Yongtao Wang, Xuejun Liu, Zhineng Yun, Shichao Xu, Shujiang Yang
BGP Inc., China National Petroleum Corporation, Zhuozhou, China
Email: shiyangling01@cnpc.com.cn

Abstract. Inheritance classification is an interactive multi-attribute pattern recognition method. In the interpretation of geophysical data, combined with the advantages of multiple attributes of gravity, magnetic and electromagnetic in the identification of special lithologic bodies, complex reservoirs and other targets, the inheritance classification method can be used to qualitatively predict the distribution of favorable target. Multiple data complementing each other and multi-attribute intelligent classification can effectively reduce the multiple solution of geological interpretation.

1. Introduction
The basic concept of pattern recognition is to record and search for similar samples. This method has been applied to the identification of strata and structural traps for a long time [2]. Wu used the dynamic pattern matching algorithm to match the formation of electric logging curve and judge the strata pinch out boundary [1,3]. In seismic data processing and interpretation, pattern recognition is also used to extract and analyze seismic attributes, but there is no similar application in the integrated exploration of gravity, magnetic, electromagnetic and seismic.

The petroleum geological conditions of K area are superior, and there are many wells in the area with oil and gas display. The existing seismic data show that there are structural traps in the deep part of the area. However, the surface and underground geological structure of the target area is complex, so it is very difficult to determine the structural model and distribution of strata only based on the seismic data. Later, three-dimensional gravity, magnetic and electromagnetic exploration was deployed, and the attribute data volumes of density, susceptibility, and resistivity were obtained through inversion. Finally, the oil and gas distribution in the study area is comprehensively inferred by referring to the known drilling and seismic data in combination with the abnormal attribute of polarizability.

2. Attribute extraction and pattern recognition
2.1. Attribute extraction of gravity, magnetic and electromagnetic
The analysis of the lithologic distribution of a set of strata or a certain depth can be realized through the analysis of the stratum (depth) attribute. The function of attribute extraction can accomplish sounding curve, resistivity section, polarizability section, gravity and magnetic plane anomaly, etc. Based on the analysis of the abovementioned attribute characteristics, the geological information such as the distribution of formation lithology can be inferred. Figure 1 to Figure 3 show the density, resistivity and magnetic susceptibility properties of K area respectively.
A subsubsection. The paragraph text follows on from the subsubsection heading but should not be in italic.

Figure 1. Density attribute slice
Figure 2. Magnetic susceptibility slice
Figure 3. Resistivity attribute slice

2.2. Inheritance classification
Inheritance classification is conducted under the guidance of the interpreter. After the initial classification of data using pattern recognition technology, the regions of interest are classified again until the classification results are satisfied. Through unsupervised inheritance classification, the density, susceptibility and resistivity attribute volumes are preliminarily divided into four categories, as shown in Figure 4.

The regional geological conditions and early exploration results show that the Mesozoic is the main exploration target layer in the study area, which is characterized by low density, nonmagnetic and low resistivity. According to the volume data of density, susceptibility and resistivity, the target layer is located between T1-100 and L10-200. According to this, the yellow target area in level I classification is subdivided into earthy yellow and bright yellow.

Figure 4. Results of inheritance classification of gravity, magnetic and electromagnetic

The results of inheritance classification (Figure 4) show that the central and southern part of the study area is the main distribution area of the target layer, and the results are related to the characteristics of density, susceptibility and resistivity properties.
3. Distribution characteristics of oil and gas in K area

Based on the above analysis and inheritance classification results, the favorable target area of the study area should be between T1-100 and L10-200. For this area, the inverted polarizability attribute is extracted, and the oil production of shallow wells is overlapped with the abnormal polarizability attribute (Figure 5). The 3D time-frequency electromagnetic (TFEM) polarizability inversion section in K area shows that the polarizability anomalies are mainly distributed in Neogene, Paleogene and Mesozoic. From Figure 5, the polarization anomaly has a good correspondence with the oil and gas display of the drilling. The high production wells are mainly distributed in the high part of the abnormal polarization, and the polarization intensity increases with the increase of daily production.

Figure 5. Superposition graph of structural shallow well and polarizability horizontal slice

Figure 6. Polarization inversion profile and geological interpretation of TFEM-1 line

Figure 6 is the inverted polarizability profile of structure K1. The maximum abnormal polarizability of Mesozoic in the middle of the profile is 38.6%, and the stratum is complete. The thickness of Mesozoic is up to 1500m in structure K1. According to the interpretation of the inverted resistivity section, it is located at the structural high point, and the elevation of the Mesozoic top surface is 1050m. According to the matching relationship between local structure and polarizability anomaly, structure K1 is a favorable area for oil and gas distribution.

4. Conclusions

Using attribute pattern recognition technology to extract and analyze the gravity, magnetic and electromagnetic attributes, the favorable oil and gas targets in K area are predicted and confirmed in the subsequent drilling. This example shows that the attribute pattern recognition technology of gravity, magnetic and electromagnetic data can intelligently classify various attributes, and has advantages in identifying special lithologic bodies and favorable oil and gas targets. Compared with the conventional artificial experience interpretation, this technology can effectively reduce the multi-solution of geological interpretation, and improve the accuracy and efficiency of oil and gas prediction, which is worth popularizing in practical application.

Acknowledgement
Thanks for the support of the National Key R&D Program of China (2018YFC0603605).

References
[1] Fang J, Chen H and Shultz A W 1992 Computer-aided well log correlation *AAPG* 76 307-317
[2] Marwan S and Fred A 1996 Artificial intelligence and expert system in petroleum exploration
[3] Wu Z and He Q 2003 Application of dynamic pattern matching algorithm in stratigraphic correlation *World Geology* 22 181-184