

Low-order fault identification method of Putaohua oil layer of X block in Songliao Basin

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Abstract. With the exploration and development of oil fields to the later stage, the distribution of remaining oil is highly scattered, and the oil control area becomes smaller. It is necessary to carry out fine identification and description of small geological interfaces, so as to improve the accuracy of reservoir description. Therefore, low-level fault identification has become an extremely important link. However, due to the influence of seismic data resolution, it is often difficult to directly interpret small faults on conventional seismic profiles. In conventional seismic data, fault interpretation is often based on seismic attribute analysis. At present, there are many kinds of seismic attributes used for fault interpretation, such as coherence class, curvature body attribute, ant attribute body and so on. By comprehensively utilizing the time slices and seismic profiles of these seismic attributes, small faults can be identified more effectively. In the process of studying the three-dimensional work area of Putaohua oil layer of X block in Songliao Basin, the above methods are used in combination with various information such as seismic profiles to identify small faults that are difficult to identify on conventional seismic data volume and coherence volume, and good application results have been achieved.

Keywords: low-order fault; curvature attribute body; coherence technology; ant tracking.

1. Introduction

Fault refers to a geological phenomenon that rock or rock mass moves along its fracture surface. Fault plays an important role in the process of oil and gas migration and accumulation. Low-order faults (small faults) are derived faults of large faults, and their formation is closely related to large-scale fault activity and the resulting local stress field [1]. The small faults are characterized by small fault displacement and short extension. They are mainly distributed within natural fault blocks controlled by large faults, or intersect with other faults, or are isolated. This level of fault does not control the fault block and deposition, it only plays a complex role in the relationship between fault block and oil-water [2].

In the later stage of oilfield exploration or development, it is very important to explain and clarify the distribution law of small faults for the implementation of recoverable reserves, productivity construction, reservoir management and reservoir potential tapping.

At present, the methods of identifying low sequence faults mainly include: directly identifying faults by seismic profiles; seismic attributes indirectly identify faults, and logging comparison identifies faults [3]. However, in practical work, single attribute analysis can not meet the production demand. Therefore, this paper will combine the actual seismic data of X block to carry out multi-attribute comprehensive analysis to realize low-level fault identification.

2. Overview of the Study Area

The structure of Block X is located in the south of Daqing Placanticline in the central depression of Songliao Basin, with an area of 7.8km². It is a gentle anticline with basically symmetrical wings, and a micro-structure dominated by fault traps is formed locally. There are three sets of oil layer groups (SII group, SIII group, PI group) in the X block, which belong to the delta sedimentary system. The facies belt changes rapidly, showing the characteristics of vertical sand-mud interbedding and horizontal sand body pinching out quickly.

After decades of development, Block X has entered the late development stage of ultra-high water cut. The distribution of remaining oil is highly scattered, and the oil control area becomes smaller. It is necessary to carry out fine identification and description of micro-geological interface, and improve the accuracy of reservoir description from three aspects of structure, reservoir and remaining oil, so as to provide solid geological support for the subsequent accurate and efficient development of ultra-high water cut in water flooding (Fig. 1).

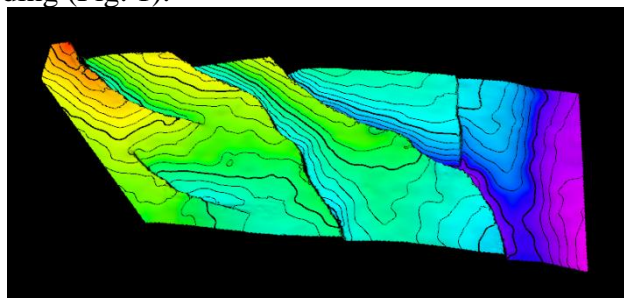


Fig. 1 Tectonic Trends of X block

3. Multi-attribute Low Order Fault Identification Method

3.1. Coherent Body Technology

Coherence is the best fault identification technology today. Coherence technology uses coherence attributes to reflect the similarity of seismic data. It can highlight the overall development characteristics of faults, micro-fractures, lithology or geological structures in space by coherent changes. Coherence technology can quantitatively identify faults on 3D seismic data and avoid the influence of interpretation errors, thus greatly improving the accuracy of fault interpretation [4].

Coherence technology has the following advantages in fault identification: transforming complex seismic data into a single coherence value to eliminate redundant information interference; the calculation parameters involved are less and the calculation speed is fast.

3.2. Curvature properties

The curvature attribute is very popular in the fault recognition method. It also has the characteristics of strong noise resistance and good three-dimensional visual interpretation. According to the curvature distribution law of fault structure, the smooth horizon interpretation line has the change characteristics of curvature from positive to negative or from negative to positive, so that the purpose of effectively identifying faults, cracks and other structures can be achieved through the curvature change of geological body itself. Curvature of three-dimensional space is the result of extracting curvature change of seismic data based on two-dimensional curvature algorithm. It has strong geological significance. Curvature attribute has certain guiding significance for fault plane combination.

3.3. Ant Tracking Technology

Ant tracking technology is one of the most widely used fault automatic identification technologies. Dorigo is inspired by the path selection behavior of ant colony foraging. This method is based on a new algorithm-ant tracking model. The principle is as follows: a large number of 'ants' are scattered in the seismic data. These 'ants' will spread the 'pheromone' to the place that meets the preset fracture conditions, and call other ants in the nearby area to the fracture until the target fault identification and tracking is completed. If there is an undetected fault zone, the undiscovered area is treated as a new breakpoint. And when the preset fracture condition is not reached, the ants do not gather. By analyzing the ant search strategy and related parameters, an ant colony clustering method based on ant optimization and adaptive adjustment mechanism is established [5]. After the ant

algorithm is used to track the seismic data volume, the data volume with low noise and obvious fracture trace will be obtained. The ant body is called to complete the automatic fault recognition.

4. Fault identification of Putaohua oil layer in X block

According to the structural characteristics of the X block, starting from the seismic profile, the reflection characteristics of the fault are clarified, and the fault in the study area is identified and traced by combining the attribute slice. The basic characteristics of the fault (strike, length, dip angle, fault distance), and determine the fault combination relationship in the study area. In the process of fault research, the main fault is identified first, and then the small fault is identified first. That is, the main fault with obvious characteristics is identified first, and the basic fault tectonic framework is determined, and then the profile and plane identification and interpretation of small faults are carried out.

4.1. Sectional characteristics of faults

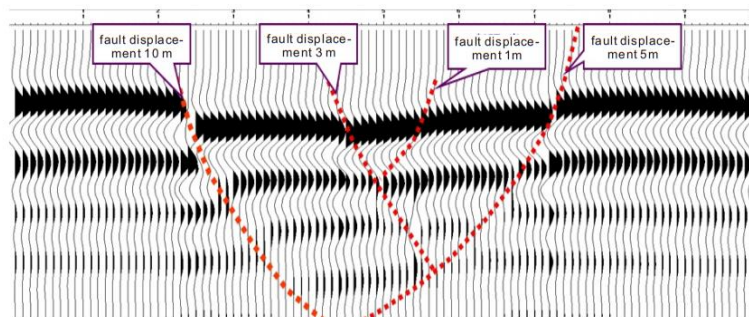


Fig. 2 Positive section of different fault intervals

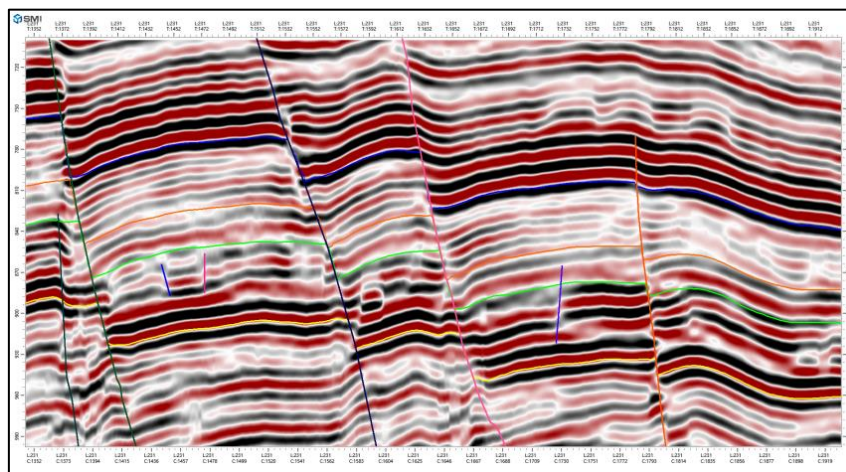


Fig. 3 Actual profiles of different fault intervals

It can be seen from the forward section (Fig. 2) that the fault with a fault distance of more than 5 meters shows obvious dislocation of the same phase axis on the seismic section, which can be directly explained by the reflection characteristics of the seismic section. The low-order faults with a fault distance of less than 5 meters show the flexural characteristics of the events, and it is difficult to identify the manual seismic profile.

4.2. Low Order Fault Identification Strategies

For low-grade faults, curvature attributes, coherence attributes and ant body attributes are used to identify and locate faults in the study, and fault profile interpretation is carried out under its guidance. In order to improve the recognition ability of attributes to faults, this paper fuses attributes based on single attributes such as curvature attributes and coherence attributes, and enhances them graphically, so as to effectively guide the interpretation of low-level faults.

In the process of fault interpretation of X block, the fault characteristics are more obvious by processing the seismic attributes. It can be seen from the curvature attribute slice (Fig.4) that some small faults can be identified in areas with good seismic data quality; in areas with poor seismic data quality, discontinuous information is developed, traces are intricate and unclear, and it is difficult to identify smaller faults. The coherence attribute body of the study area (Fig.5) can identify small faults in fine structural interpretation and eliminate human factors. Because the seismic fracture traces of each layer on the seismic section are offset from each other, the ant attribute slice is used to display the fault characteristics on the plane (Fig.6) to assist the identification of small faults. The objectivity and fineness of fault interpretation are improved by using the fused data volume (Fig.7) for structural interpretation.

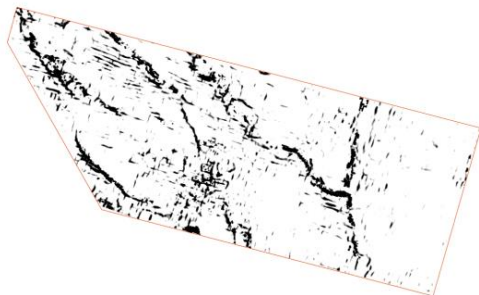


Fig. 4 Curvature Slice

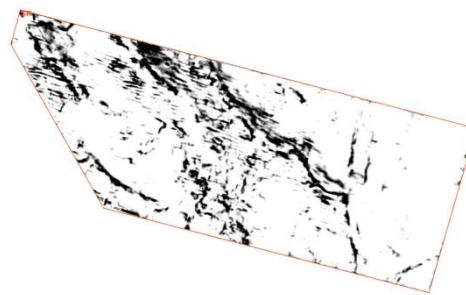


Fig. 5 Coherent Slice

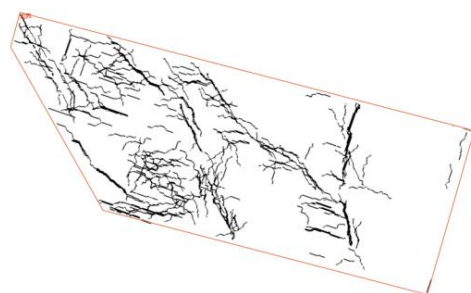


Fig. 6 Ant Body Slice

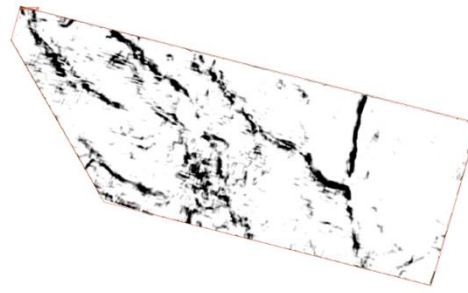


Fig. 7 Seismic Fusion Properties

Although small faults have obvious characteristics in seismic attribute slices, the attribute maps related to faults are mainly based on inter-channel differences. In addition to faults, differences in deposition, reservoir development and other factors will also cause differences between seismic profiles, that is, seismic attribute maps not only characterize faults. Therefore, how to identify the real fault in the ' fault ' imaging of the attribute map is a difficult problem for the identification of the low-level fault plane.

Aiming at this problem, a multi-attribute fusion method is adopted to improve the recognition accuracy of small faults. At the same time, the method of flat section combination and three-dimensional interpretation is used to explain the small faults in and between layers. The small faults in the layer break the top surface of the oil layer group on the seismic section, which are the internal faults of the oil layer group. Some small faults have no obvious characteristics on the seismic attribute map. Therefore, in order to accurately describe the actual spatial position of the small faults, it is necessary to determine the flexural characteristics of the events on the seismic section. After the fine interpretation of the structure, the number of small layers in the X block has increased significantly, and the lateral extension length has increased, which has improved the degree of structural implementation and laid the foundation for reservoir description in the whole area.

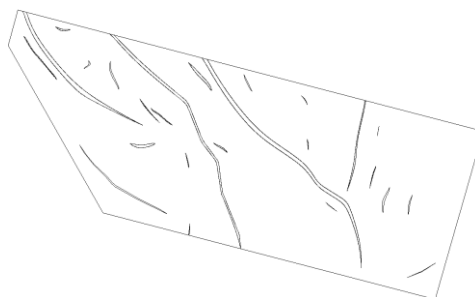


Fig. 8 Fault polygon of X block

5. Summary

Under the guidance of reasonable geological understanding, low-order faults can be identified quickly, accurately and effectively through various methods such as curvature attribute body, coherent attribute body, ant attribute body and comprehensive application of seismic profile. The above method has identified small faults that are difficult to be identified on conventional seismic data bodies in the X area of Songliao Basin, and has achieved good application results, providing strong model support for subsequent development work.

Acknowledgements

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