The Application of Seismic Three Dimensional Coherence Analysis Techniques in the Fine Structure Study of Oilfield

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Abstract. In recent years, with the emergence, wide application and continuous improvement of high-precision (high resolution) seismic acquisition technology, coherent data volume interpretation technology, 3d visualization technology and spectral decomposition technology, the identification ability and interpretation accuracy of seismic data interpretation have been greatly improved. Especially in the process of rolling edge expansion and development adjustment in the old oilfield, the small faults and microstructures in the oilfield have become one of the key contents of fine structure interpretation.

Keywords: Earthquake, 3d Coherent Analysis, Oil Field, Fine Structure

1. Introduction

With the development of 3d seismic exploration technology, tectonic interpretation technology has developed greatly in recent years, and 3d seismic interpretation has become a very mature technology[1-3]. The traditional three dimensional interpretation method is to interpret the three dimensional seismic data as the encrypted two dimensional seismic data, which has the problems of low information utilization rate, low work efficiency and low quality of results, so the interpreters need to spend a lot of time and energy on the layer interpretation, fault identification and combination. With the continuous development and maturity of attribute processing of seismic data and human-machine joint interpretation methods, the efficient and high-precision interpretation of 3d fine structure has become feasible by breaking the conventional 2d interpretation method of 3d data and making full use of 3d data information to obtain more precise structural morphology. The continuous development of 3d visualization technology promotes the development of 3d interpretation technology, and the emergence of true (full) 3d seismic interpretation technology[4].

2. Application of seismic three - dimensional coherent analysis technology in oil field
2.1. Coherent data volume technology

The 3D coherence technology has experienced the development of three generations of algorithms. Its first-generation algorithm is based on the cross-correlation coherence algorithm, which is relatively simple in calculation and has some limitations in processing noisy data. It is only applicable to high-quality seismic data. Second generation algorithm is by having a collaborators in mathematics covariance matrix, the main line and contact line direction two cross-correlation to multi-channel analysis of the multi-channel cross-correlation inside the window, and pass along the covariance matrix of each detection Angle or position calculations more coherent, its strong antinomies ability, can be instructed to identify the reflection surface inclination and azimuth, but lower resolution[5]. The third generation algorithm is an algorithm to calculate the eigenvalues in the covariance matrix. The third-generation algorithm is superior to the first-generation and second-generation algorithms in that when the signal is higher than the additional Gaussian noise level, the noise can be removed from the coherence calculation, and this method can provide the best horizontal resolution in noisy data.

2.2. Comprehensive azimuth detection technology

The time inclination of each grid point is calculated along the reflector. The time of each trace point is considered to be related to two adjacent points in the orthogonal direction. By calculating these parameters at each point on the time plane and displaying them in color, an inclination map is obtained. On the inclination map, the data bands with large inclinations correspond to the strike of the fault. The comprehensive detection of dip Angle, azimuth Angle and fracture edge is firstly carried out on the basis of fine interpretation of stratification and full three-dimensional interpretation of stratification, and then the stratification of the automatic tracking is smoothed according to the appropriate smoothing factor to eliminate local anomalies, and then the comprehensive detection of dip Angle, azimuth Angle and fracture edge is carried out[6].

3. Application of various technologies in the study of fine structure of oil field

3.1. Layer attributes technology

The identification methods of seismic attributes along the layer mainly include: coherent attributes along the layer, azimuth attributes along the layer dip Angle and residual amplitude attributes along the layer. The interlayer coherence property is in the window along the layer given, the calculation of the adjacent seismic channel between the coherence coefficients (similarity). The change of waveform similarity is the response of the characteristics of underground strata. The better the waveform similarity between adjacent channels is, the greater the coherence coefficient is, which reflects the more stable the formation deposition is. When a fault exists, the similarity between adjacent seismic channels near the fault becomes worse and the coherence coefficient becomes smaller, which is suitable for seismic data with obvious fault, high signal-to-noise and good phase characteristics in the same phase axis of seismic reflection. It is not suitable for small faults with good waveform similarity and continuous fault.
Figure 1. Comparison of amplitude slice and coherent slice in oil field

The azimuth property of dip Angle along the layer is to calculate the time rate of change and azimuth between the sample points along the layer one by one. The slope and azimuth mutation point position reflect the existence of the fault. It is suitable for the stratum on both sides of the fault to have obvious dip Angle and azimuth variation, and the level data tracking is less smooth. This method is an effective way to identify small faults. When the slope around the fault does not change obviously or the bedding smoothness is large, the recognition effect will be affected.

Figure 2. The fine structure of oilfield fault

Residual amplitude along the layer property is in the accurate layer tracking, first along the layer to calculate the average amplitude, and then with the corresponding true amplitude minus the average amplitude, the residual amplitude. When there is a fault under the ground, the amplitude of the seismic response often changes. The residual amplitude attribute actually "amplifies" the amplitude variation of the earthquake response, and highlights the area where the amplitude value produces regular variation as the basis for the explanation of small faults. It is suitable for seismic data with reasonable tracking of seismic reflection horizon, high signal-to-noise ratio and good phase characteristics[7].

3.2. Ant tracking technology

Ant tracking, also known as Ant Colony Optimization (ACO), is a technique for finding optimal paths in graphs. It was introduced by Marco Dorigo in his doctoral thesis in 1992, and was inspired by the behavior of ants that find their way around in search of food. The method simulates the behavior of finding the path in the process of searching for food, which is a selection technique of finding and optimizing the path in the graph, that is, the process of forming the optimal path by summarizing the
numerous paths. It is well known that ants generally do random walking around the nest, and when they find food, they carry it back to the nest alone and leave pheromones along the way to attract more ants to carry it.

| Table 1. The basic parameters of optical fiber array for seismic exploration |
|-----------------------------|-----------------------------|
| Index                      | Parameter                   |
| Array spacing              | 0.75m, 1m, 1.5m, 3.125m, 6.25m, 12.5m |
| Array diameter             | 30-36mm                     |
| Sensitivity                | -140--145dB                 |
| working frequency          | 10Hz~12kHz                  |
| Sensitivity consistency    | ±1dB（Full frequency band）  |
| Phase consistency          | <2°                         |

As Table 1 above shows, each ant actually does a very simple job: checking for food in a certain range and gradually moving in the direction of pheromone concentration. This process is introduced into the automatic identification and interpretation of faults, that is, the ant tracking method. It is through the sow more electronic ants in the seismic data body, abnormal values of faults, at the same time release fault pheromones, pheromones as communication media messages, called in a certain range of other ants focus, work together for fault identification, tracking, and finally generates a low noise, has a clear fault trajectory data volume. The automatic extraction of fault function, polar coordinates and various screening procedures can be used to extract the fault system of interest. The ant tracking algorithm can automatically extract faults in any proportion according to the needs of the workflow.

| Table 2. The fine structure comparison of seismic acquisition system |
|--------------------------|--------------------------|
| parameter                | Fiber optic system       | SEAL 428       |
| cable length             | 1800                     | 2250           |
| Number of tracks         | 1024                     | 360            |
| Cable depth              | 10~15                    | 5              |
| Track spacing            | 0.3~2.4                  | 6.25           |
| sampling interval        | 0.25                     | 0.5            |
| Low cut filter           | 6                        | 6              |
As shown in Table 2, in the exploration stage, the focus of work can be focused on finding large tectonic fault systems across the basin and determining their impact on the exploration prospect. In the reservoir evaluation stage and in the development and production stage, the same method can be used to focus on the local small faults and fault systems.

3.3. Wavelet multi-scale edge detection technology

Small fault is hard to identify and find on conventional seismic records, strong concealment, wavelet feature and excellent "mathematical microscope", when will the airspace of the seismic data transform into the wavelet domain, the domain of time and space on the seismic event cannot be directly found and real hidden features, in the wavelet domain becomes clear, direct, fully display. At the same time, the signal to noise ratio (SNR) enhancement and resolution enhancement are carried out in the wavelet domain, so that those hidden characteristics observed in the wavelet domain can still be better resolved in the reconstructed time domain, so as to break through the limit of the conventional time-frequency domain and improve the quality and resolution of seismic records.

4. Conclusion

With the development and maturity of seismic data attribute processing and man-machine joint interpretation methods; it is feasible to make full use of 3d data information to obtain more detailed structural morphology. The continuous development of 3d visualization technology has promoted the development of 3d interpretation technology, and 3d seismic interpretation technology has emerged. The automatic extraction of fault functions with the technology, as well as polar charts and various screening procedures, can extract the fault system of interest. The "ant tracking" algorithm can automatically extract faults in any proportion according to the needs of the working process and restore the ideal state of the seismic record, so as to improve the seismic resolution.

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