Method and Application of Pseudo Acoustic Impedance Inversion Technique

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Abstract

Aiming at the problem that the main frequency of seismic data is low, and it is difficult to predict thin sand bodies, pseudo-acoustic impedance inversion is carried out, and the technical idea and method of pseudo-acoustic impedance inversion are formed, which has good effect in practice and provides reference for similar seismic data interpretation.

Keywords

Seismic data interpretation, Pseudo acoustic wave, Seismic inversion

Introduction

Through the analysis of petrophysical characteristics, it is difficult to distinguish sandstone and mudstone by acoustic wave curve, and it is difficult to distinguish thin sand reservoir by conventional acoustic inversion. The gamma logging curve is sensitive to sandstone and mudstone, so the pseudo-acoustic curve is reconstructed by using gamma logging curve and acoustic curve to carry out sandstone skeleton inversion. Porosity curves have a good correlation with acoustic wave curves, which indicates that porosity can serve as an important parameter to improve the reliability of inversion results. In practical application, combining porosity with acoustic impedance enhances the accuracy of reservoir prediction and reduces the uncertainty of lithological identification. The acoustic wave impedance body is used to predict porosity, and sandstone skeleton body is used for space constraint, and the following wave impedance parameter inversion process is established. On this basis, a more comprehensive inversion workflow is constructed, integrating both logging and seismic data to improve the resolution of thin reservoirs. A set of seismic data interpretation methods of quasi-acoustic wave is formed, which provides reference for seismic data inversion [1,2].

Quasi-acoustic reconstruction

Gamma curve arrangement: natural gamma curve (GR) and uranium-depleted gamma curve (CGR), and CGR curve is often used for lithologic homing of Silurian strata. There is little difference between the two curves in most wells, and the intersection diagram is a straight line; A small amount of lithology is distributed on both sides of the straight line, indicating that only a few wells have obvious differences in GR values. For example, when the value of uranium-depleted gamma curve is less than that of GR curve, but the trend is the same [3].

Therefore, the uranium-depleted gamma curve is mainly used to reconstruct the pseudo-acoustic curve. Gamma curves have high resolution of sandstone and mudstone, so the gamma value of mudstone should be zero to make the change of gamma curve only reflect sandstone characteristics. Then the gamma curve is standardized.

Reconstruction of gamma quasi-acoustic curve:

extract the high-frequency information of gamma curve that can reflect lithologic information after correction and add the low-frequency information of acoustic wave for reconstruction to generate GR quasi-acoustic curve.

The GR pseudo-acoustic curve is standardized again to form the final gamma pseudo-acoustic curve.

Acoustic curve calibration and quasi-acoustic curve calibration

In Silurian strata, the density of sandstone and mudstone is similar, the velocity difference is not big, there is no unified impedance interface in the strata, and the geological interface on seismic profile is unclear. For example, the interface between red mudstone and top and bottom (upper and lower sandstone mudstone) changes with the change of overlying strata thickness.

Calibration basis: first, the peak of the top boundary of Carboniferous bioclastic limestone, and second, the trough of the top boundary of the upper third member at the bottom of Silurian, which is a stable and symbolic event axis in the three-dimensional area. Detailed well seismic calibration is carried out by using synthetic records, and time-depth relationship is established. Only the target interval is calibrated, and the curve does not need to be stretched and compressed [4].

The weak in-phase axis in Silurian corresponds well to the synthetic record, and the correlation coefficient between the synthetic record and the seismic profile is over 85%.

Complete the time-depth calibration of the target interval and then calibrate the pseudo-acoustic curve. The change of pseudo-acoustic curve is inconsistent with acoustic wave, which changes the impedance characteristics in the longitudinal direction. By modifying the wavelet phase, the characteristics of earthquake and synthetic record profile are consistent, thus completing well seismic calibration.

Profile inversion to check consistency between wells

Firstly, the inversion calculation of cross-well profile is carried out to analyze whether the impedance characteristics of cross-well profile are consistent with those of wells, check whether there are abrupt points in the transition between wells and the rationality of horizon interpretation. Through the profile inspection of wells in the whole area, it is found that the main problems are as follows.

(1) The impedance difference between wells is obvious.

(2) The impedance of some wells is inconsistent and dislocated up and down.

(3) There is a sudden change of impedance [5,6].

In view of the above problems, the following measures have been taken: first, the pseudo-acoustic curve is normalized again to strengthen the consistency between adjacent wells; The second is to adjust the time-depth calibration to reduce the vertical difference between wells; The third is to modify the interpretation horizon to improve the local layer crossing. The fourth is that the normalized profile is still unbalanced, and the well does not participate in modeling and inversion. Through the above work, the consistency between cross-well profile and well is ensured, and the change and transition of cross-well profile are ensured naturally.

Correlation modeling

In view of the thin sand body in the target layer and the low degree of well control, it is necessary to establish a suitable inversion model and make full use of well data and seismic data to truly reflect the geological characteristics [7,8].

There are three modeling methods: 1. Interpolation modeling, which is suitable for blocks with high well control and stable sedimentation, and is divided into linear and classification methods; 2. Keli Jin Jianmo is suitable for blocks with many wells, relatively stable structure and sedimentation, and has strong well information constraint; 3. Correlation modeling, which makes more use of seismic information to establish the corresponding relationship between sand layers under well constraints, is divided into linear and correlation modeling methods [9,10].

According to different modeling methods, modeling experiments are carried out by using small blocks. Through model comparison, it is considered that interpolation modeling has a high degree of well control, and the plane sand body is obviously butted. The related modeling can solve the problem of high well control.

Conclusion

(1) Compared with seismic amplitude and energy attributes, the thickness of sand body predicted by pseudo-acoustic inversion has basically the same plane characteristics, and the inversion method is reliable.

(2) Quasi-acoustic inversion can be used to identify the thin sand bodies in this area. According to the error statistics of 3~5m reservoirs, the error is less than 15%, and the prediction results of sand bodies are reliable.

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Conflicts of Interest

The authors declare no conflict of interest.

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