Inversion Technology of Carbonate Facies-Controlled Reservoir

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Abstract

Since seismic resolution in the study area cannot meet the requirement of directly identifying reservoirs, it is necessary to make full use of the rich information provided by seismic waves for reservoir prediction. Therefore, it is helpful to improve reservoir identification by using phased reservoir inversion technology and reconstructing sensitive details of reservoir based on the analysis of seismic waveform sensitive information. The research shows that the phased inversion technology can effectively predict and characterize the reservoir, which has certain practical significance.

Keywords

Carbonate rocks, Geophysical inversion, Seismic data, Reservoir prediction

Introduction

Seismic technology plays an important role in the exploration of oil and gas fields. With the development of technology and the continuous improvement of exploration degree, there is a further requirement for the seismic representation of underground geological phenomena. Describing underground geological phenomena through different technical methods often leads to unexpected results. These methods include forward modeling technology, multi-component seismic exploration, multi-attribute analysis technology, true three-dimensional space domain automatic tracking technology, coherent analysis technology, waveform classification technology, three-dimensional visualization technology, post-stack data frequency division technology, seismic logging joint inversion and so on [1].

Fractures and caves formed in carbonate rocks can usually lead to significant differences in rock physical properties, such as P-wave impedance, density, Poisson's ratio, etc., thus affecting the corresponding seismic reflection characteristics. If the scale of fractures and caves are large, they usually show strong reflection energy anomalies in conventional seismic profiles, while if the scale is small, they usually show changes in the main frequency of earthquakes due to amplitude tuning, etc. In addition, because of the existence of cracks and caves, the P-wave velocity is significantly reduced, while the S-wave velocity is unaffected.

By analyzing the change of reflected energy of pre-stack AVO gathers, it can also be used to detect the existence of cracks and caves [2-4]. Seismic reservoir prediction is to make comprehensive use of these seismic characteristic changes and establish the relationship between fracture and cave parameters and seismic characteristic parameters in combination with known drilling information, to predict the possible spatial position and scale of reservoirs.

Basic methods and ideas

Various seismic attribute parameters are used to predict fractured-vuggy reservoirs, and many seismic attributes, including AVO attributes, are extracted from the target interval. known the principle of minimum cross-checking error of known well information, several kinds of seismic attribute parameters are selected, and the mapping relationship with reservoirs is established in this parameter space, to predict the possible fracture-vuggy locations and their scales. In areas with many known samples (wells), through the error analysis of cross-examination of known wells, a more reliable overall reliability evaluation of prediction results can be given. Through the adaptability analysis of reservoir prediction results, the local reservoir prediction results can be effectively evaluated [5].

Generally, this kind of reservoir prediction process includes five main contents: A: extracting various seismic attribute parameters along the horizon (including AVO information); B: Calculate the reservoir parameters of the known well in its target interval; C: Determine the number and types of seismic attribute parameters to be used, provided that there is a linear correlation between reservoir parameters and seismic attribute parameters, and the cross-test error is the smallest, and the mean square value of system parameters is the smallest; D: the results of linear reservoir prediction are further corrected, and the limiting conditions are firstly the correction range (in the seismic parameter space) and secondly the algorithm (using natural neighborhood interpolation (RBF) algorithm); E: Combined with the spatial distance of seismic parameters, adaptability analysis of reservoir prediction results and other factors, the reservoir is finally predicted comprehensively.

Extraction of seismic attribute parameters along the layer

The physical parameters of the target interval reservoir are usually determined by extracting the seismic attribute parameters of the target interval horizon, which is very important [6]. Under normal conditions, it is impossible to directly determine which parameters have a relatively close relationship with the reservoir parameters of the target interval to be predicted, so it is necessary to extract as many different types of seismic attribute parameters with different adjustment parameters as possible at the beginning to increase the probability of the occurrence of seismic attribute parameters with high coincidence rate and close relationship between the results and the reservoir parameters of known wells. Finally, according to the reservoir parameters of the target interval determined by known drilling, different types and different parameters extracted at the beginning are determined through certain procedures according to specific rules.

The data volume of extracting different types of seismic attribute parameters should be the superimposed data volume of partial angular gathers. The stacked data volume of angular gathers can usually be divided into five pieces according to the angle, and more than forty different types of seismic attribute parameters, including frequency attribute, correlation attribute and amplitude attribute, are extracted from these five pieces of angular gatherings.

After extracting these seismic attribute parameters, the seismic attribute parameters of amplitude class are selected and mixed, to reflect the weak reflection difference of seismic energy in the target interval.

Establish the mapping relationship between parameters

The mapping relationship between well point reservoir parameters and seismic attribute parameters is established. The so-called mapping relationship is the process of determining model parameters by using known sample (well point) data under given mathematical model conditions. The main process includes: the process of determining the model parameter space; The process of fine-tuning the model output; The process of evaluating the reliability of the result output.

(1) Determine the seismic attribute parameter space applied to reservoir prediction. Obviously, the types and numbers of seismic attribute parameters are positively correlated with the coincidence rate of reservoir parameters of known wells and negatively correlated with the stability of reservoir prediction system the more types and numbers of seismic attribute parameters are used, the weaker the reservoir prediction ability of the system will be. Therefore, under the linear relationship between the above-mentioned seismic attribute parameters and reservoir parameters, it is necessary to ensure that the best number of seismic attribute parameters and its number are obtained, and only in this way can the best reservoir prediction result be finally obtained. The method to solve the above problems is cross-check error, which means that each well is regarded as a detection well, so the standard for selecting the types and numbers of seismic parameters is cross-check, and the error should be the minimum, that is, its system prediction ability is the strongest in the sense of linear correlation.

(2) Nonlinear mapping in given seismic parameter space. The advantage of linear system is simple and stable, without too many human factors, and the prediction result is objective, because its output result is a simple linear superposition of other seismic attribute parameters, which can still be regarded as a new attribute parameter in essence, but its prediction result usually has some deviation from the known well point information. Based on the selected seismic attribute parameters, the RBF (Radial Basis Function) nonlinear algorithm can accurately predict the information of the known well point reservoir parameters [7-10].

(3) Adaptability analysis in given seismic parameter space. The established linear prediction system is based on the information of well points and their corresponding seismic attributes, with the minimum cross-test error as the criterion.

In each parameter space, whether other points except well points are also suitable for this linear prediction system is an analysis process called multi-parameter space adaptability analysis.

Conclusion

The final prediction result is the prediction result of each parameter space, and the final reservoir prediction result is the synthesis of the prediction results of four parameter spaces with respect to the cross-correlation coefficient corresponding to each parameter space and the weighted average of the adaptability analysis results.

The low-value area indicates that the matching relationship between the area and the established prediction system is poor, and the corresponding prediction results are uncertain and should be treated with caution.

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Conflicts of Interest

The authors declare no conflict of interest.

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