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Pseudo-Acoustic Inversion Technology in The Prediction Application of Deep Volcanic Reservoirs in Songliao Basin

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Abstract

In recent years, volcanic reservoirs in the Songliao Basin in China have been an important layer for deep oil and gas exploration and development in the basin. However, due to the complex lithology and diverse pore types of volcanic reservoirs, including primary pores and pores formed by late diagenesis, the distribution range of the reservoir is difficult to determine; volcanic reservoir prediction is the bottleneck technology restricting deep oil and gas exploration in the Songliao Basin in recent years It is also the difficulty of oil and gas exploration research in this area. In this paper, based on the geological characteristics of deep Cretaceous volcanic reservoirs in the Songliao Basin, as well as logging and seismic data, it is proposed to use pseudo-acoustic high-resolution seismic inversion on the basis of rock physical analysis such as volcanic lithofacies and reservoir sensitivity. It is used to predict the deep Cretaceous volcanic reservoirs in this area, and provide technical support for oil and gas exploration research in this area, which has important research significance.

Keywords: Volcanic Rock Reservoir; Pseudo-Acoustic Inversion Technology; Petrophysical Analysis.

1. Introduction

Volcanic rocks are widely distributed in the basins of the world. In recent years, volcanic oil and gas fields have been discovered in the United States, Japan, Indonesia, Cuba, Mexico, Argentina, Russia, Ukraine, Ghana and Pakistan. A number of volcanic oil and gas reservoirs have been discovered in the Songliao Basin, Junggar Basin, Erlian Basin, and Bohai Bay Basin in China. However, there are few research results that can be used for seismic prediction of volcanic facies and volcanic reservoirs. Earthquake prediction is a worldwide problem in oil and gas exploration and research, mainly manifested in: (1) Volcanic eruptions are rarely isolated, most of which are crossovers or superposition of various eruptions, resulting in large changes in volcanic facies distribution in the vertical and horizontal directions, making it difficult for volcanic targets Description; (2) The thickness of the volcanic rock is large, it is difficult to select the study time window, and it is difficult to invert the seismic inversion and attribute analysis; (3) The crater controls the distribution of volcanic facies, which directly affects the evaluation of the volcanic reservoir, but the seismic identification of the crater location is difficult. With the increasing interest in volcanic oil and gas reservoirs in recent years, research on seismic prediction of volcanic reservoirs at home and abroad has received increasing attention. How to effectively predict the distribution and development of volcanic reservoirs is of great significance for the study of volcanic reservoirs.

2. Pseudo-Acoustic Inversion Technology

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For a long time, sonic logging curves have been used for seismic geological horizon calibration and wave impedance inversion. The model-based broadband constrained inversion method is based on convolution theory, and its initial model is the formation acoustic wave or wave impedance. However, in many cases, due to the influence of wellbore pollution, reservoir cementation and porosity, or other non-stratigraphic lithological factors, the high-frequency information in the sonic logging curve in many cases cannot represent lithological changes, and the stratum profile cannot be clearly distinguished. The lithology. Therefore, the logging sound waves cannot reflect the difference between the reservoir and the surrounding rock, reservoir and reservoir. This also makes it difficult to identify the lithology and reservoir type, resulting in poor matching between the logging curve and the seismic profile, the impedance inversion results do not match the drilling geology, and reservoir prediction is difficult. To use seismic inversion technology to predict volcanic reservoirs, we first need to perform rock physical analysis to analyze the sensitivity of the logging curve to the reservoir. For the deep volcanic rocks in this study area, the density curve is more sensitive to the division of volcanic reservoirs and non-reservoirs, and the density decreases, which is the location of the development of volcanic reservoirs; density has a good correspondence with volcanic reservoirs, as shown in Figure It shows that red is a volcanic rock reservoir and blue is a dense volcanic rock layer.

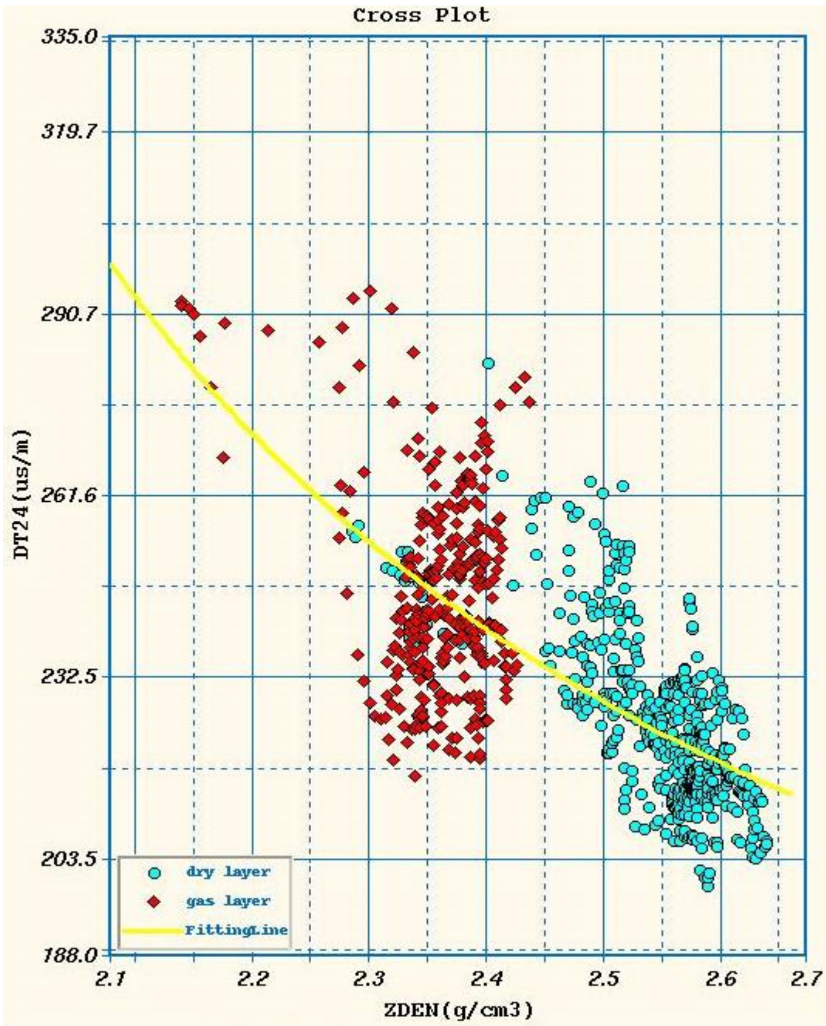

Fig. 1. Acoustic wave-density intersection analysis diagram of volcanic rock

Combining density standards, volcanic reservoirs can be accurately classified. Therefore, the density curve is used to make pseudo-acoustic waves, and the pseudo-acoustic waves are used as the geological constraints of the model to perform impedance inversion to predict favorable reservoirs of volcanic rocks. Based on the sonic logging curve, effectively integrate various information, use information fusion technology to unify them into the same model, and realize the organic fusion and effective control of various information. Therefore, the natural gamma, compensated neutron, resistivity and other logging curves reflecting the sensitive changes of the reservoir are converted into quasi-acoustic curve with sonic dimension. This makes it possible to have high-frequency information such as natural gamma, compensated neutrons, resistivity, etc., and low-frequency information of sound waves. In the study area, a new curve with sonic dimension is constructed by using a well-defined logging curve-density curve that reflects changes in stratigraphy and lithology. Combined with a low-frequency model of sonic waves, a pseudo-sonic curve is synthesized. It can be seen from the single well curve lithology analysis and the intersection analysis of pseudo-acoustic wave and density curve that it can reflect not only the change of formation velocity and wave impedance, but also the slight difference of lithology. In this block, a pseudo-acoustic curve is used to model the inversion density and wave impedance data volume to predict the distribution of volcanic reservoirs. Figure 2 shows the density pseudo-sonic curve of well w1 in the study area.

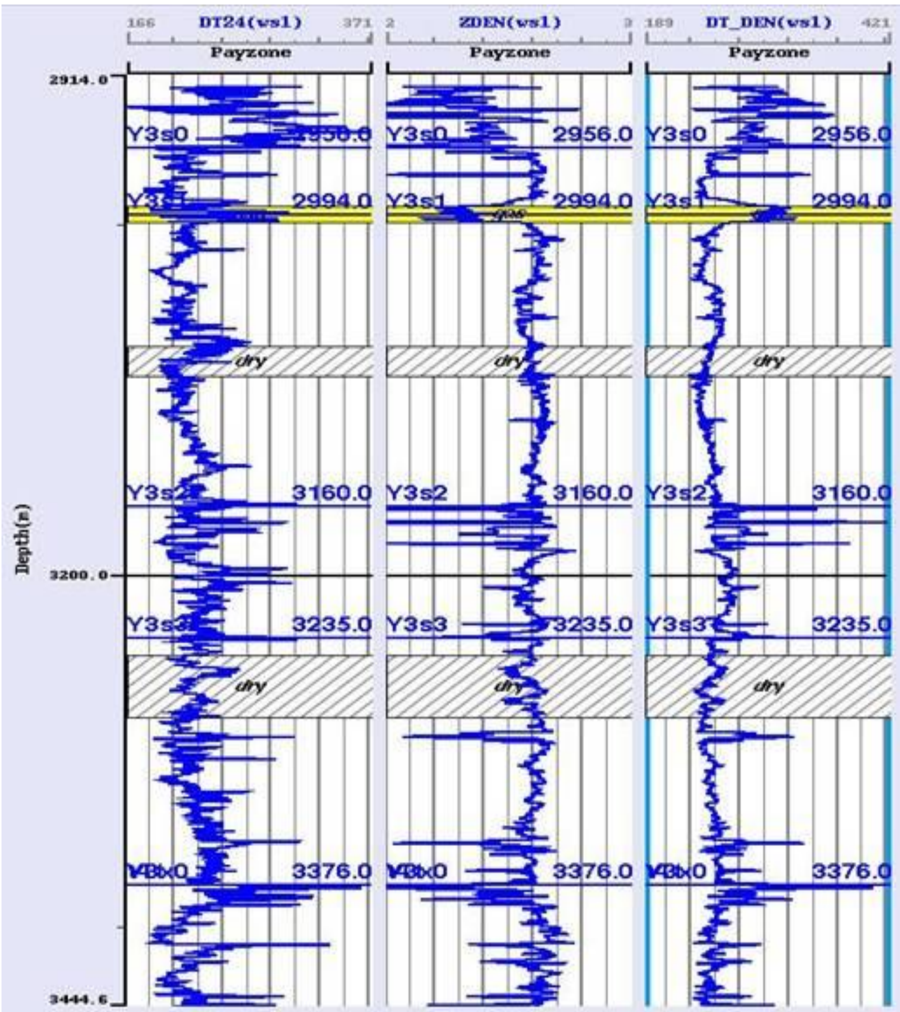

Fig. 2. Pseudo-acoustic curve of well w1

3. Application Effect of Density Pseudo-Acoustic Inversion to Identify Volcanic Reservoirs

The inversion technology combines geological and geophysical data, thus increasing the credibility of the inversion results. The structural and volcanic facies constraints are used for modeling, which retains the complex structural features and volcanic mechanism features, and the related technologies of collaborative modeling are applied to the construction of the initial geological model. The Gaussian Collaborative Kriging method is used to synergistically use well data and seismic data to establish a geological model. This model can be used as the initial wave impedance model for inversion. Compared with methods that only use well data for modeling, the collaborative modeling method introduces lateral resolution of seismic data. Under the condition of good correlation between seismic data and well logging data, it can greatly increase the geological and geophysical information of the model. This method plays an important role in alleviating multiple solutions in seismic inversion and improving the reliability of inversion. At the same time, it can overcome the modeling phenomenon of inversion results to a great extent. The control function of volcanic facies and volcanic body on reservoir prediction is realized, and its internal reservoir is predicted within the scope of volcanic body. The inversion results are consistent with the actual structure and lithology and lithofacies changes. From the inversion density profile, it can be seen that it can well reflect the volcanic reservoir, as shown in Figure 3 and Figure 4, the low density of yellow-red is the development range of volcanic reservoir.

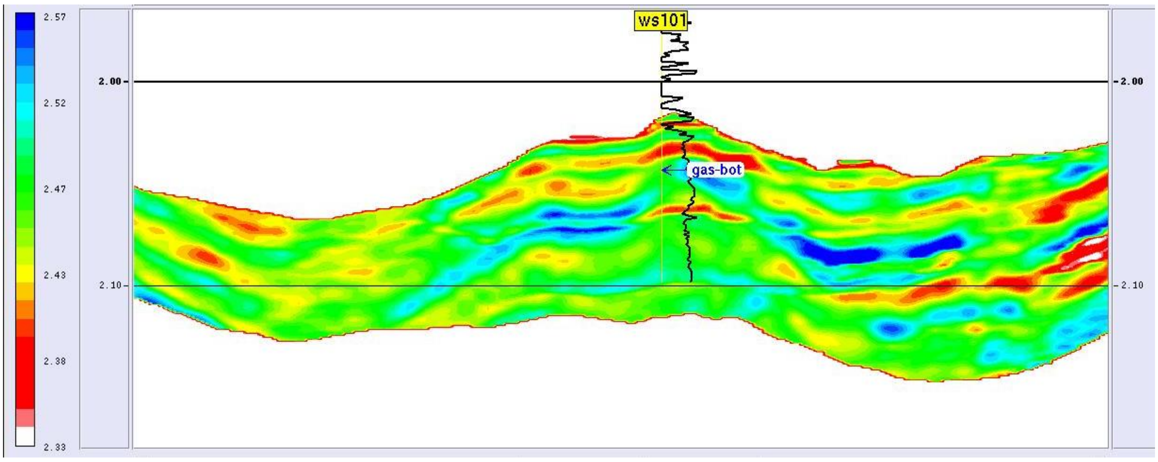

Fig. 3. Profile of volcanic rock density inversion profile in well w101

Distribution characteristics of volcanic rock reservoirs: the reservoirs are controlled by the distribution of volcanic structures, mainly distributed in the eruption and spouting phases near the crater; in the remote source phase zone between the volcanic body and the volcanic body, the reservoir is not developed; Previous studies on volcanic rock theory and practice have shown that the development of volcanic rock reservoirs is controlled by the volcanic organization stage and lithofacies. Therefore, under the guidance of the theory of volcanic mechanism, combined with the understanding of the type and period of eruption of the volcanic mechanism in the area, the seismic reservoir inversion structure is adopted with the method of quasi-acoustic collaborative modeling to carry out the volcanic mechanism petrographic and volume control constraints. It may reflect the actual state of volcanic reservoirs in this area. According to the prediction results of quasi-acoustic density inversion reservoirs, the characteristics of the reservoir development in this area are as follows: the reservoir is mainly developed in the main part of the volcanic structure, distributed in an irregular shape, the distribution form is close to the main structure of the volcano, and gradually decreases towards the surroundings thin.

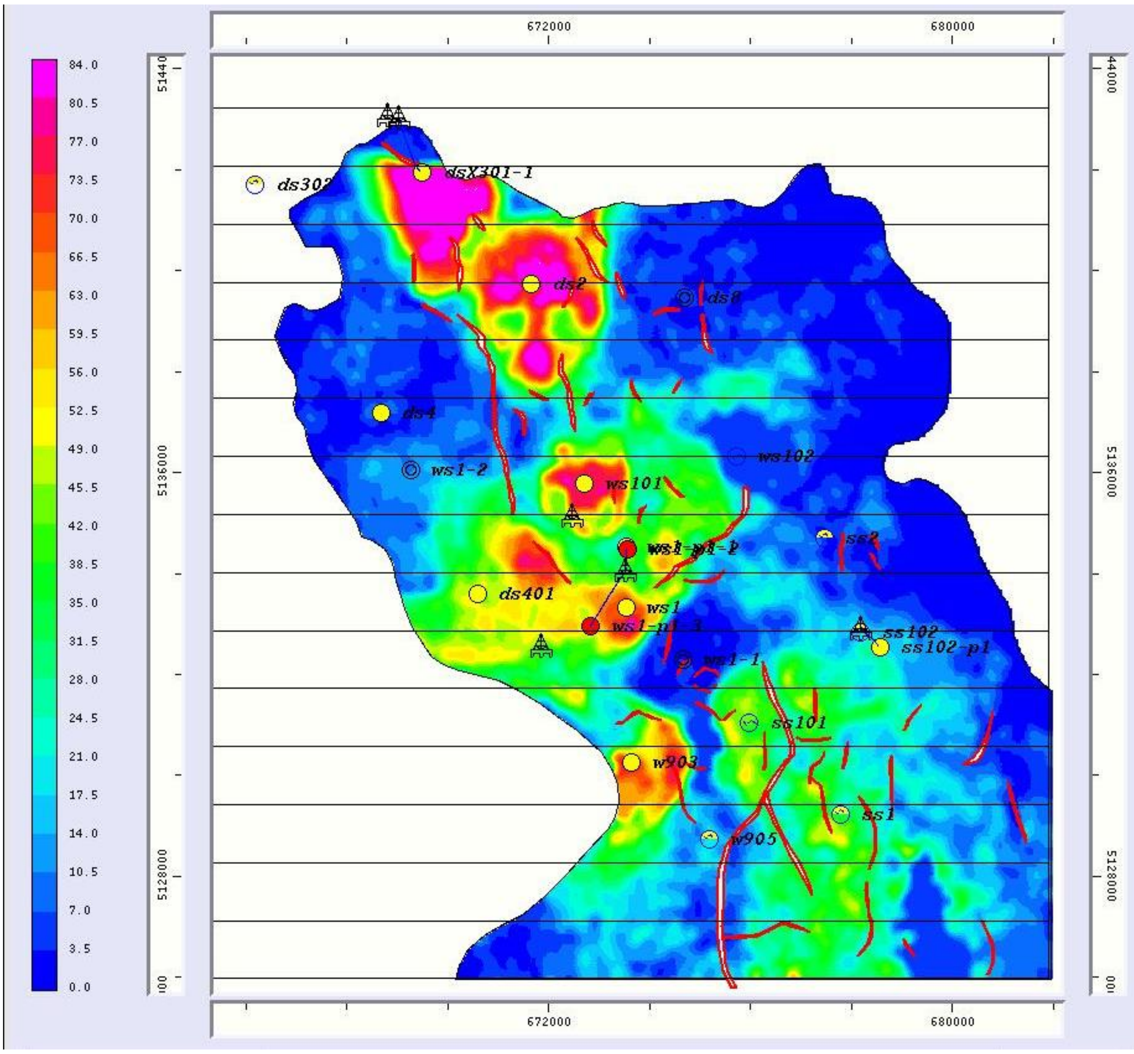

Fig. 4. Plane distribution map of volcanic rock reservoir

4. Conclusions and Suggestions

Combining the above construction methods of pseudo-acoustic curve and its application research in volcanic reservoir prediction, the following conclusions have been made:

(1) In the deep Cretaceous volcanic reservoirs in the southern Songliao Basin, the density curve on the well logs has a good effect in identifying volcanic reservoirs and tight layers.

(2) Use density pseudo-acoustic inversion technology to predict the spatial distribution of volcanic reservoirs in this area, and the effect is good; the development range of volcanic reservoirs is in line with the scope of volcanic bodies and volcanic institutions studied by previous people.

(3) The development of volcanic reservoirs is controlled by the stage of the volcanic structure and lithofacies. The deep volcanic reservoirs in the Songliao Basin are mainly developed in the main part of the volcanic structure, distributed in an irregular shape, and the distribution form is close to the main structure

of the volcanic body. Gradually thinning to the surroundings; in line with the geological understanding of the distribution of volcanic rocks in the area.

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