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Characterization of Channel Sand Based on Forward Modeling and Waveform Clustering

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Abstract: For the specific issues, this paper, based on all kinds of seismic attributes, using the technology of the forward modeling, analysis the sensitive attributes of various types of sand body development model, select the seismic attributes which can reflects the reservoir development best and optimalize the seismic attributes. Based on this optimization, letting those seismic attributes doing cluster analysis attributes fusion. It overcomes the one-sidedness of the single seismic attribute for reservoir prediction. Because of this, it achieved the fine characterization of channel sand body in the layer of H22 in the area of Gu109 and it is confirmed by seismic data, forward modeling, log data and sedimentary facies and so on. Finally, through the analysis of the sand body of the different kinds of the reservoir, achieving the fine characterization of channel sand body under the controlling of combination of seismic and logging data, it gives the actual geological significance for the different kinds of seismic attributes, identifying, predicting and describing the situation of the reservoir.

Keywords: Technology of forward modeling; Sensitive attributes; Waveform clustering; Combination of logging and seismic; Characterization of sand body.

INTRODUCTION

For the specific issues, this paper, based on all kinds of seismic attributes, using the technology of the forward modeling, analysis the sensitive attributes of various types of sand body development model, select the seismic attributes which can reflects the reservoir development best and optimalize the seismic attributes. Based on this optimization, letting those seismic attributes doing cluster analysis attributes fusion. It overcomes the one-sidedness of the single seismic attribute for reservoir prediction.

GENERAL SITUATIONS

Puxi oilfield is located in Heilongjiang Province Zhaoyuan County, Daqing city and Duerbote Mongolian Autonomous County in the territory, the east of Daqing placanticline Putaohua oil formation, West to Tahala - Gulong syncline axis, South to Xinzhao oilfield. Tectonic position, located in the central depression of Songliao Basin, southern Qijia Gulong depression Putaohua nose like structure [1]. The research area is mainly for the Gu109 development zone. In this study area, the main sedimentary system of the formation of the central depression of the Songliao basin is the delta front sedimentary system. The sedimentary characteristics are influenced by the double geologic forces of the river and the waves, and the time unit is divided into the single river sedimentary cycle. The purpose of this study is to study the formation of the three members of the upper Cretaceous and the lower part of the upper Cretaceous.

APPLICATION EXAMPLES

Selection of model parameters

In the study area, the average thickness of the formation of the Gu109 development zone of Heidimiao oil layer is 101m, corresponding to the average time of seismic reflection 56ms, which is two identical phase axes in the section, including 3 sand groups, subdivided into 8 small layers. The layer H21 (T05) corresponding strong continuous and strong reflection, is easy to trace and compare; Hd (T06) corresponding to the same as strong continuous and strong reflection, is easy to track and compare; the identical phase between H21 and Hd is discontinuous strong peak, sometimes have holograms development, sometimes with the top or bottom of a connected, change quickly and significantly. Due to the influence of sand bodies in different layer, the amplitude, phase, frequency and the number of peaks in the seismic profile are changed. In view of these characteristics of seismic, designing forward model, to investigate the relationship of the seismic attributes and sand shale thin interbedding structure, finally, finding the study area sensitive seismic attributes to sand body development pattern, so as to guide the fine channel sand body description. Model of velocity, density, frequency and other parameters are in accordance with the actual data, speed of pure mudstone respectively for 2730m/s

(density 2226.49 kg/m^3), 3000m/s (density 2285.91 kg/m^3), develop in the central part of the sheet sand speed 3440m/s (density 2358.57 kg/m^3), river sand velocity 3680m/s (density 2408.96 kg/m^3), seismic wave frequency 40Hz.

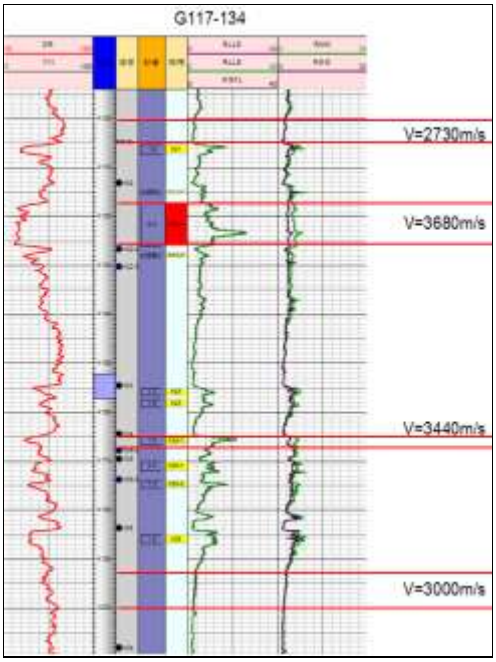

Fig-1: Selection of parameters in modeling

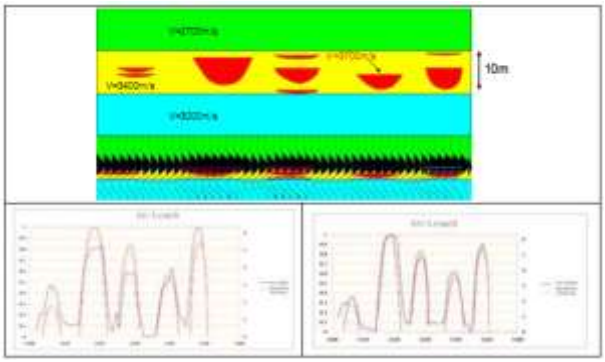

Fig-2: Forward model one and the sensitive attributes

Sensitivity analysis of seismic attributes

To further determine the relationship between attributes and the thickness of the sandstone and superimposed model, designed for the study area of sandstone and mudstone thin interbed of forward model, is performed with seismic data to extract various attributes, analyzing the attributes of sandstone sensitivity.

(1) Model one: The accumulated thickness of sandstone is larger

According to the actual well data of the study area, the following models are designed in this study, as shown in Figure2. According to the model to extract all kinds of attribute value, draw the curve of the seismic channel in Figure2. The analysis of seismic attribute curve and sandstone thickness curve, it is found that the amplitude of class property, property of arc length of sand had better sensitivity. The average absolute amplitude, RMS RMS amplitude, arc length and other three categories of best response properties.

(2) Model one: The accumulated thickness of sandstone is small

In accordance with the model one, according to the actual well data of the study area, a model of the sandstone with less accumulated thickness is designed, which is shown in Figure3.

According to the model to extract all kinds of properties, and draw the value of the property value of the road curve (Figure 3). Analysis of seismic attribute curves and sandstone thickness curves, it is found that the amplitude of the properties of the river sand sensitivity is best. Among them, the average reflection intensity and the root mean square amplitude of RMS are the better of the two kinds of attributes.

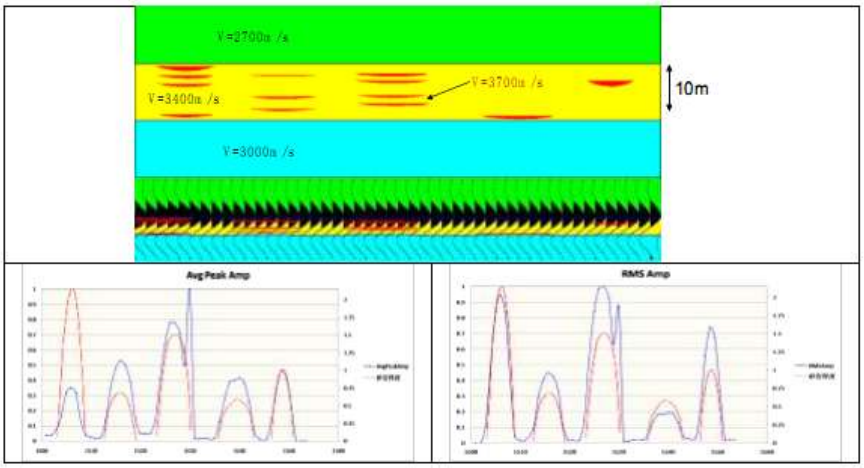

Fig-3: Forward model two the sensitive attributes

Through the analysis of the model, under the guidance of the forward technology, according to different sandstone thickness and stack model, optimizing the sensitive attributes, which the first model corresponding to the sensitive attribute mainly are amplitude attributes, the arc length attribute. Among them, the average absolute amplitude, RMS mean square root amplitude, arc length and other three types of properties of the best response. In second model, the sensitivity attribute of the river sand is the amplitude attribute. Among them, the average reflection intensity and the RMS mean square root amplitude of are the better of the two kinds of attributes.

Attribute fusion based on Waveform clustering analysis

The step of attribute fusion based on waveform clustering analysis is: firstly, statistics for each two independent single attribute waveform correlation coefficient, high correlation, and ultimately the waveforms classified as 2 class and 3 class (Figure 4); by the sacrifice and the classification of the waveform, analyzing of the waveform corresponding to attributes and sand body development correlation; after clustering all attributes, only selected one type which is related to sand body development best, to join attribute fusion, finally obtaining the attribute map which only by several kinds of typical attribute combinations to predict sand body plane distribution (Figure 5).

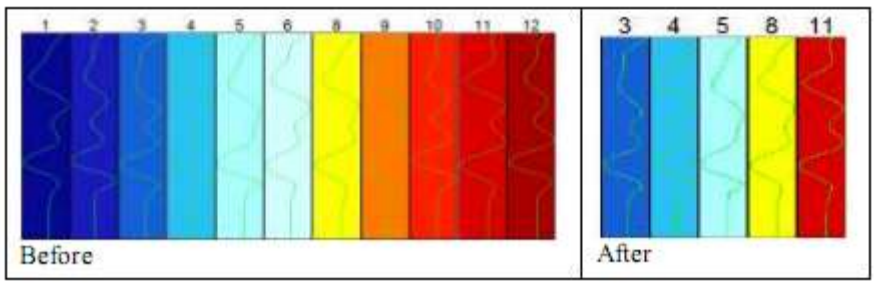

Fig-4: Comparison of waveform clustering before and after processing

Characterization of channel sand

As Figure 5 shows that the red high value region presents a multi branch strip bifurcation in Small River around, and obviously large sheet sand development characteristics. To confirm that the red high value development area represents the channel sand bodies, this paper make credibility analysis from seismic, logging and sedimentary facies aspects.

(1). Along the C to D to (blue line in Figure 5) pulls the seismic profile (Figure 6), as shown by①,②, ③ in Figure 5 and Figure 6, it is visible obviously that lens shaped body seismic response characteristics which indicate the channel fill deposits, the amplitude from the middle to both sides by the strong to weak and just as the river sedimentary model [2, 3]. In summary, from the southeast direction along the vertical in the river to sequentially observe seismic profile, it is obvious that stable lens shaped features. Therefore, from the perspective of seismic, the red high value area in Figure 5 indicates the development of channel sand body in H22 layer and the change of river channel.

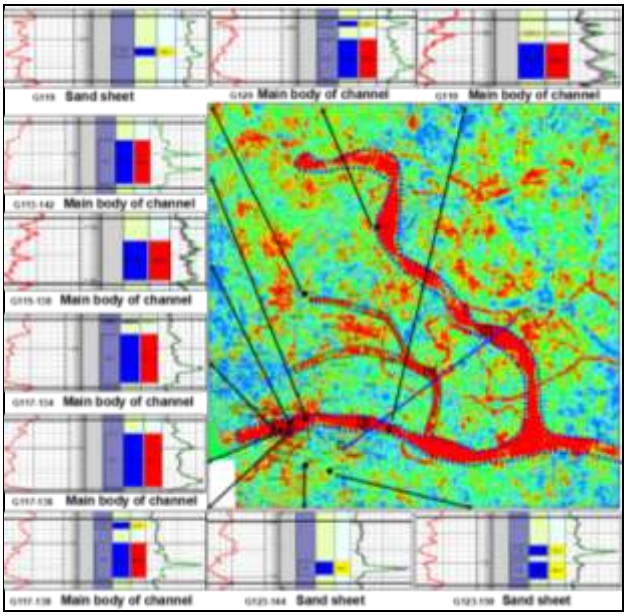

Fig-5: The verification of seismic attributes fusion based on multiple linear regressions and logging facies

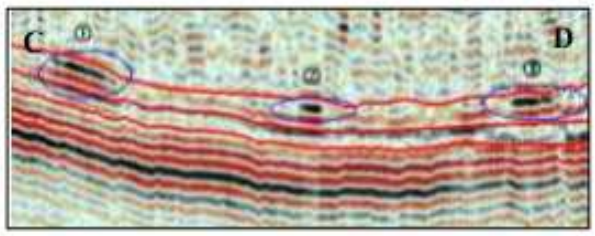

Fig-6: Actual seismic section

(2) Reliability analysis of logging and sedimentary facies. In the attribute map, there are the G110, G129 7 wells, in red areas, as shown in Figure5.The curve features in H22-1 layer of those wells are bell type, box type or the compound, combined with the 7 well sedimentary facies characteristics, confirmed the figure in the red area indicates precisely the good physical properties and sandstone thickness up to 6-10 meters of channel sand body. In addition, the analysis of the residual well data, such as G123-144, G123-150, G119 and other three wells as an example, the curve characteristics of the sheet sand deposition, the thickness of the development of thin sandstone, poor physical properties. For statistics, combined with logging curve and the characteristics of sedimentary facies, the coincidence rate reaches more than 90%, all wells in the red zone all indicate the channel deposits, its coincidence rate are 100%, the sedimentary facies of sheet sand wells with rate of more than 80%.

In summary, based on the evidence from the data of seismic, well logging and sedimentary facies, the accuracy and reliability of attribute fusion graph in reservoir prediction are fully verified. Under the guidance of forward modeling technique of sensitive attribute analysis and combination waveform clustering method for analysis of attribute fusion, it significantly improve the seismic attributes and reservoir sand body correlation coefficient and the lithology recognition ability and instruct and predict accurately the plane distribution of channel sand body reservoir [4-6].

CONCLUSIONS

(1) Forward simulation technology directly according to the actual logging data to establish development of sand body model, this ensure the effectiveness of the original sand body development, reduce the subjective interference, provide the reliable basis to determine the sensitive attribute.

(2) For the different type of reservoir development characteristics, the describe emphasis of the all kinds of seismic attributes is different, the prediction emphasis is also different. With the method of forward modeling, the sensitive attribute classification of various types of sand bodies is analyzed, and then the seismic attributes which can reflect the reservoir characteristics are locked fast. And on this basis, by waveform clustering analysis and attribute fusion, from the forward technology, logging data and the sedimentary facies, analyzing the reliability of results, it is perfectly to overcome the one sidedness of single seismic attribute to predict reservoir, achieving the high accuracy of channel sand body engraved painting.

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