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The application of seismic attribute technology in reservoir prediction of Zhaoyuan area

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Abstract: Seismic attribute technology can extract the useful and latent information from seismic data, providing abundant and effective data for oil field exploration and development and a possible mean to solve complex geological evaluation. Therefore it improves the value of seismic information in the application of oil and gas exploration and development. On the basis of the fine horizon calibration and fine structure interpretation, Seismic attribute were extracted for the purpose layer in research area. Combining with the actual drilling and logging data and the sensitive analysis of seismic attributes, the post-stack seismic reservoir prediction research was carried out through optimizing the amplitude, dessert and frequency division attribute and favorable reservoir facies belt distribution and sand body distribution rule are qualitatively understood. Combining with geological characteristics and oil and gas enrichment regularity for the purpose layer, comprehensive evaluation of reservoir was studied. The Fuyu oil layer reservoir prediction in Zhaoyuan area obtained the good geological effect and provide important basis for the determination of exploration target zone.

Key words: *Zhaoyuan area; sedimentary characteristics; Fuyu layer; delta facies; distribution characteristics; reservoir pattern*

I. INTRODUCTION

The seismic attribute extracted from seismic data is characteristic parameters that can reflect the reservoir oiliness, such as amplitude, frequency, phase, energy, time, speed, absorption, etc[1-2]. Seismic wave propagation in stratum is a very complicated process and a comprehensive reflection of underground strata characteristics[3]. The spatial variation of underground formation property will inevitably cause the change of seismic reflection wave character, thus has led to the change of seismic attributes. Therefore, there is inevitably some corresponding relationship between seismic attributes and capability of reservoir, which also provides the basic theory foundation for our study of seismic attribute technology[4-5]. Seismic attribute analysis method is one of the important technologys for lithologic stratigraphic trap identification, optimization, description and evaluation, and can realize the quantitative description of sedimentary volume, lithology, etc[6].

Basing on Zhaoyuan area post-stack seismic data, this paper carry out the study of reservoir prediction, on the basis of attribute extraction and combined with drilling and logging data to conduct attribute optimization and find out the attributes, which can accurately reflect change of oil and gas reservoir properties. Results confirmed that the method can well predict the distribution of major oil and gas reservoir.

II. GEOLOGICAL SURVEY

Zhaoyuan area is located in Zhaoyuan territory in the Daqing city of Heilongjiang province. The area is the Songhua flood area and terrain is relatively low. Tectonic position is located in western

Zhaoyuan nose-like structure in the central depression area of Chaoyanggou terrace in the Songliao basin (Fig 1), connected with Zhaozhou and Yongle oilfield on the north, connected with Toutai oilfield on the west ,connected

with Chaoyanggou oilfield and facing southwest and Jilin Xinmin oilfield. Overall this area present high in south and low in north trend.structure formation is mainly controlled by fault and the number of local structure is proportional to the number of fault. Zhaoyuan nose-like structure in area is formed before Sifangtai formation sedimentary and reach peak oil source in the late Mingshui formation. the formation of the structure is earlier than the peak period of hydrocarbon expulsion. South raise nose-like structure is the main factors that induced the accumulation of oil secondary migration. Sediment source mainly is controlled by the southern Huaide source and the main source is in the south and south-east.

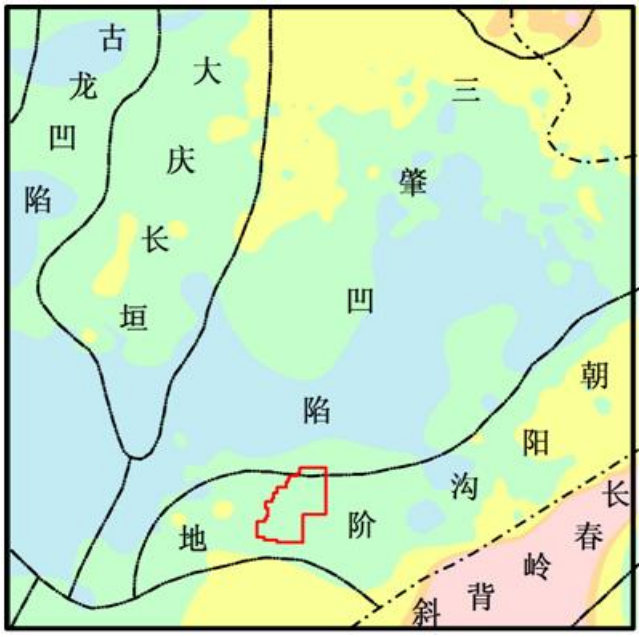


Fig 1 The study area tectonic locations

III. SEISMIC ATTRIBUTE ANALYSIS

The process of starting from the geophysical meaning of seismic attributes to its geological meaning is the process of seismic attribute analysis and its purpose is to convert seismic attribute to the information related to physical property, lithology, structure or reservoir parameters[7]. due to many many seismic attributes are related to reservoir characteristics, some properties are more sensitive to the reservoir features than other attributes and certain attributes can well explain the underground abnormalities, which show that seismic attributes for reservoir prediction is feasible[8]. In the past study, there have been many examples of application of seismic attribute for guidance on the basis of deep geological research. Relying on high quality seismic acquisition, processing and interpretation, seismic attribute analysis for reservoir prediction has obtained the some success.

3.1 Conventional seismic attribute suitability analysis

The reflection wave amplitude or energy characteristics are the commonly used kinetic properties for lithologic interpretation and reservoir prediction, using the analysis of characteristics of amplitude can extracte the following attributes: record energy, maximum amplitude value, root-mean-square amplitude, etc, which reflect the wave impedance thickness of strata, rock composition, porosity and fluid composition change ,in the target layer and can be used to identify the amplitude anomaly or analysis of characteristics of the sequence and can also be used to identify lithology change, unconformity, gas and fluid gathering, etc. Each kind of seismic attributes reflects the characteristics of reservoir from different prospects and they have complex relationship with reservoir lithology, reservoir property and pore fluid property. the same property has completely different meaning under

different conditions and the sensitivity, correlation of seismic attributes are also different in different geologic targets. Therefore, after extraction of seismic attributes, seismic attribute optimization is necessary.

3.2 Dessert attribute suitability analysis

Dessert attribute can be used for reservoir capability of detection. Dessert value is the ratio of reflected intensity and root mean square frequency. Its detection principle for oil and gas is: the reflection strength attribute can often effectivLY instruct the purpose layer reservoir situation. Due to oil and gas has strong absorption characteristics, when local seismic wave go through the oil and gas reservoir, the low frequency part of seismic wave attenuate and the high frequency part enhance. Therefore, the ratio of them can indirectly indicate the capability of reservoir. Actually the absolute size of dessert value it is difficult to determine from the perspective of geophysical, just a relative size. Reflected intensity is the absolute value of amplitude, so the impedance value of the sand is not important. Whatever peaks and troughs corresponds sand will has high reflection strength and dessert value. In other word, dessert attribute can be used to well distinguish lithology types. It is worth noting that the prediction effect of dessert attribute is poorer in the formation of the low wave impedance,such as sand and mudstone interbedding. sandstone and mudstone around it have no obvious difference of wave impedance, dessert attributes will fail.

3.3 Frequency division attribute suitability analysis

The spectrum decomposition technique is a reservoir interpretation technology based on frequency, presenting a kind of new method of seismic interpretation to us. Converting seismic data from time domain to frequency domain by discrete Fourier transform, the transformed amplitude spectrum can identify the change of formation time thickness and the phase spectrum can detect geological body lateral continuity. Spectrum decomposition processes the seismic data into frequency section rather than time or depth section. In essence, after the spectral decomposition algorithm is applied to the seismic reflection data, the seismic information is converted into frequency information. This helps interpretors browse specific frequency data, identifying the stratigraphic and structural characteristics that are easy to overlook in the full bandwidth. Researching purpose layers in the frequency domain, the user should firstly select purpose layer and then calculate this area frequency response in the Z axis direction by the spectral decomposition. The output result is a tuned body or a series of amplitude or phase diagrams, which have a particular tuning frequency. Therefore, in analysis of thin reservoir, decomposition has significant effect on describing the sedimentary features, such as river or reef. As long as there is difference between rock types in the original seismic data, the spectrum decomposition can provide very high resolution. If the rocks have similar speed, spectral decomposition maybe distinguish it. Besides providing high resolution figure, can also be used to spectral decomposition also calculate the formation thickness and identify hydrocarbon.

IV. SEISMIC ATTRIBUTE OPTIMIZATION

4.1 attribute optimization thinking process

The communicate and combination way among various seismic attributes information and the sensitivity of each attribute reflecting the characteristics of the reservoir have a lot of uncertainty. In different region or layer, the sensitive seismic attributes combinations to some kind of oil and gas type or reservoir characteristics have a big difference and some of the properties may interfere to predict classification. Therefore, it is necessary to optimize those useful information in numerous seismic attributes. Our research object or problem have complex relationship with the seismic attributes and there are strong uncertainty, so it is difficult to directly choose the useful information from a large number of attributes. Therefore, by the existing drilling data analysis,

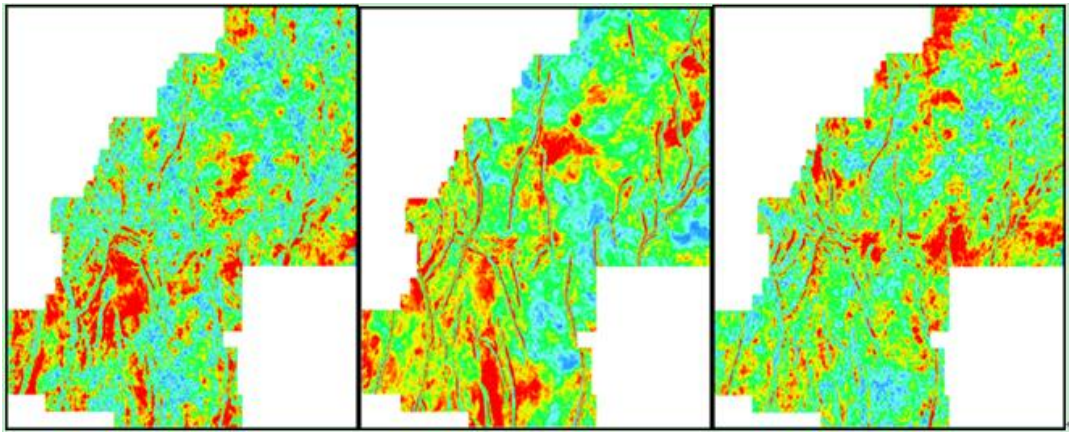
the attributes figure with obvious geologic body and high drilling coincidence rate is optimized; At the same time, based on the attribute diagram and subsequent deposition phase diagram, valuable attribut is choosed to analyze in further.

4.2 The applicable seismic attribute optimization

4.2.1 General attribute

In destination area, firstly the conventional seismic attribute extraction has been carried on, including amplitude, energy and phase properties.

From the point of the overall effect and the result of extract amplitude, energy, phase and other attribute extracted from the targeting layer, that the attribute anomalous response is more obvious in central and southern of the work area is found. In southern and central part in the area the large anomalous area appears. The attribute figure shows red or yellow areas and the blue areas on both sides. FII1 layer, for example (Fig 2 a), often present the largest anomal area in its regular sum amplitude attribute. It is characterized by large area of red in southern and the red areas gradually becomes smaller and scattered from the south to the north area; FI41 has continuous anomalies area in central and northern south(Fig 2 b); The response of amplitude attribute is better in FI and FII reservoir group(Fig 2 a, b, c), which can generally identify river development position, indicate distribution law and provide a good foundation for reservoir prediction.



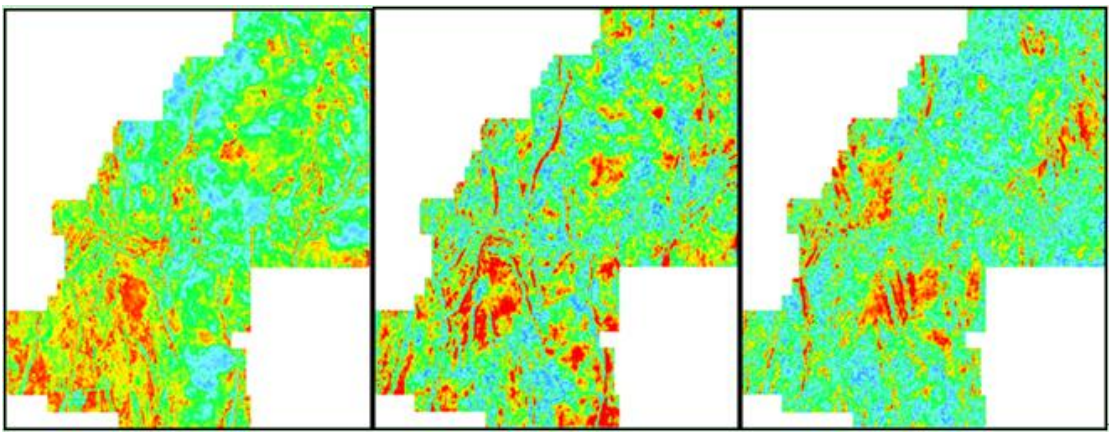
a.FII21sum attribute b.FI41 RMS attribute c.FI61 max amplitude attribute

Fig 2 conventional seismic attributes plan in area

4.2.2 Dessert attribute

On the basis of analysis of the properties between the layers, the dessert attribute and transverse extraction section for the properties result of the objective layer were conducted, which can predicte the channel sandstone development outline in horizontal and vertical.

Because dessert attribute identification mainly is confined to the pure sandy and smaller river sedimentary body, dessert attribute is more suitable for the characterization and prediction for balling sand reservoir. For example, the attribute in F151(Fig 3 a) performs sand in broad mudstone. Channel sand body shows dessert shape form and on the dessert attribute will show the of warm color abnormal area corresponding to the channel development area. Therefore, through the statistic of each unit, dessert property has better effect in the reservoir FI51, FII31 and FIII41 (Fig 3). Dessert property is applicable to the identification of lenticular or intermittent river sedimentary body, such us the delta front sedimentary bodies in this area.



a.FI51 Dessert attribute b.FII31 Dessert attribute c.FIII41 Dessert attribute

Fig 3 dessert attributes plan in area

4.2.3 frequency division attribute (spectrum decomposition)

Because of the geologic inherent attribute between river and river, the river and the no river between, the response also is different within the scope of the different frequency band. On the basis of amplitude attribute, spectrum decomposition can well show channel sand body shape. From the point of analysis of each attribute frequency, the frequency division attribute for low frequency(<30hz) response is the big exception, so it is difficult to accurately depict the river boundary; the seismic frequency division section for middle and high frequency band(30hz~70hz) appears to be stripe and some sand bodies get response, so it can be a effective attribute for channel sand prediction; The response for high frequency(>70hz) is sporadic divergent abnormal and disorderly irregular plane, so it can not be applied to identify sand body in the region. Therefore, the middle and high frequency band is the main frequency zone of seismic frequency division attribute.When the frequency is more than 80 hz, the effective component quickly reduce and noise and interference component increases, so frequency division attribute has no predictability. Comparing the different frequency property charts for FII1, it can be seen that with the increase of frequency, exception response began to increase and continuity become strong in north, which show northern sand body is thinner than the south and its specific response frequency is high. When the frequency is up to 75hz, its effect is the best. At the same time the southern exception response is relative less than the low frequency property, showing the south sand body is thick and its specific response frequency is low, when the frequency increases, partial responses disappear and plane reflection has a smaller area (Fig 4).

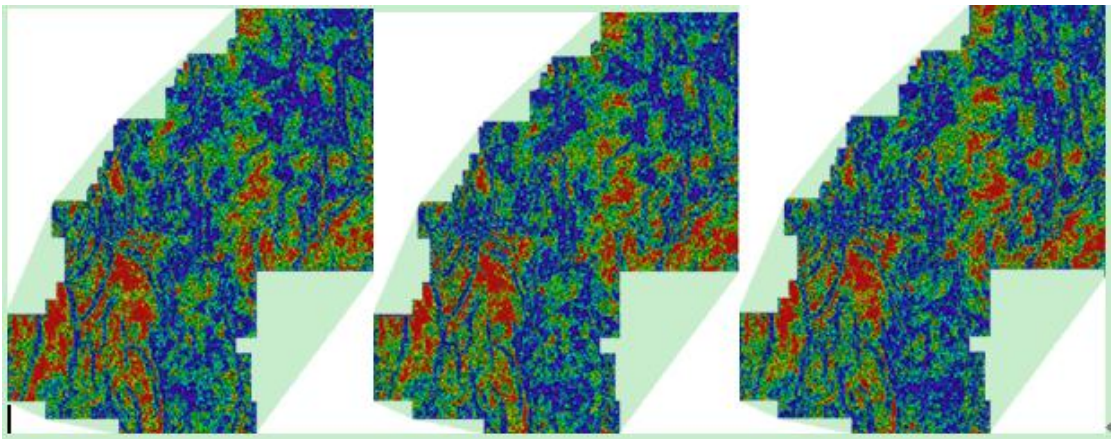


Fig 4 FII1 reservoir attribute plan in 55 hz and 65 hz and 75 hz

V. THE RESERVOIR PREDICTION RESULT

FI reservoir sandstone development is balanced. Sandstone is developmental in south-central area, and there are multiple thick sandstone areas. The south sand body distibutes length axis is northeast to southwest. The sandstone in northern is less development. Northern sandstone in the area is strips and lobate distribution, affected by the distribution of the faults cutting, and sand body is more developmental in fracture downdropped block; FII reservoir group sandstone thickness is obviously different from the one in FI(figure 5-2). The sandstone distributes in long strip or sheet and sand body distribution is relatively concentrated, overall distibuting near the development zone. The sandstone is developmental in north and relatively thin in south; FIII reservoir sandstone distribution is affected by the thickness of strata on the whole, and sandstone is thin, mainly distributing in the southwest and central zone. The sheet sand body generally grows in the syngenetic fault fall plate. The south sand body distribution in southern area is mainly northeast and strip shape. The sandstone in northern is not developmental basic development, mainly distributing in small area strips and lobate.

On the basis of the above research, combining with regional geological conditions, trap, sedimentary facies, accumulation conditions and adjacent Wells production situation research, seven favorable zones are forcasted in Zhaoyuan area. The reservoir sand body and lithologic trap near favorable for oil source fault is developmental. The target layer single sandstone thickness is big and control range is wide.

VI. CONCLUSION

5.1 The amplitude and frequency division attributes have achieved good results in FI, FII reservoir group in the region, of which the largest amplitude and sum attribute result is outstanding and can judge sand body contour distribution law in general. Frequency division properties are mainly concentrated in 50hz~80hz and the higher the frequency is, the more sensitive the response for the thin layer is; FIII group reservoir development is poor, and the amplitude attribute error relativly is big, and not suitable for sand body prediction. The dessert and frequency division attribute sensitivity is outstanding to the poor and thin reservoir, and obtains the good effect.

5.2 Fuyu reservoir sandstone is the southern provenance sedimentary in Zhaoyuan area. The sandstone is developmental in south and there are multiple thick sandstone areas; the south sand body distribution mainly is in northeastern long space; The sandstone development is poor and small thickness, ditributing in small strips or flower shape in north.

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