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Lithological body identification and insider description of H12 well area in Beier Sub-sag

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Abstract. On the basis of high-resolution seismic data, a high-frequency framework was established for the H12 well area. Combined with drilling analysis and sedimentary facies research, we analyzed favorable lithological development areas. Interpretation of subdivision layers in favorable lithological development areas, optimization of target sand bodies, and multi-attribute analysis techniques, we accurately describe the distribution of lithological bodies. By using spectral decomposition technology to perform insider characterization of lithological bodies, and combine with actual drilling to predict the distribution of effective reservoirs, we have summarized a set of effective methods for identifying such lithological traps.

1 Introduction

The high-frequency-based well-seismic comparison technology has been applied in many rift basins in China. Through the high-frequency well-seismic comparison, the small layers of the target layer can be divided, and we can roughly judge the origin and source direction of the sand body and find the favorable target area. At present, the multi-attribute fusion technology at home and abroad has replaced the single-attribute prediction of the position of the sand body's planar distribution.

Through the comprehensive analysis of different types of seismic attributes, it is helpful to demonstrate the possibility of the existence of favorable geological targets, and it is also helpful to eliminate the ambiguity and uncertainty of a single seismic attribute, so as to realize the seismic multi-attribute to the sedimentary characteristics on the plane. But it still cannot describe the inside story and boundary of the turbidite fan in the horizontal direction[1].

By using spectral decomposition technology combined with logging facies and sedimentary facies data to comprehensively predict the inside of sand bodies is a hot topic at present. This article combines the above three technologies to effectively describe the sand bodies and inside of the H12 well area. The H12 well area is structurally located in the descending plate of the Hodomoer structural belt in the northern Beier sub-sag, Hailar Basin.

The H12 well obtained industrial oil flow in the southern 1st member, which further proves that the lithological exploration of the descending plate of the Beier sub-sag has great potential. Based on high resolution seismic data, this paper set up the high frequency stratum frame of well area H12. Then the ad-vantaged area of lithosome was obtained combined with drilling analysis and sedimentary facies study. In the advantage area, by subdivided layer interpretation, target sand body optimization and multiattribute analysis technique, the lithosome distribution was accurately described[2].

Thereafter, by using spectral decomposition technology, this paper described the inner structure analysis of lithosome. Effective reservoir was obtained combined with actual drilling data. A set of effective methods for recognition of litholog-ic trap were summed up. Attention must be paid to the physical risks of reservoirs with large buried depth and strong compaction in this area. Sand bodies have the characteristics of rapid lateral changes and difficult reservoir prediction. The difficulty in predicting this kind of deep-water fan is to accurately determine the boundary between the sand body and the favorable facies belt[3].

2 H12 well area is a favorable target area for lithological traps

From the perspective of sedimentary facies belts, the H12 well area belongs to the submarine distributary channel of the fan delta front. The core observation has obvious traction flow characteristics, the sorting, rounding difference is medium-medium, large and small trough-shaped cross bedding, wavy cross bedding, deformed bedding, etc., and the bottom scour is obvious.

The logging curve presents a typical combination of funnel-shaped and saw-tooth-shaped waveforms with a medium amplitude. The vertical parasequence is superimposed on the front product. From a plane analysis point of view, during the depositional period of the first member of the southern section, large-axis fan

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delta deposits developed in the Hodomor structural belt. The source is from the Laogang uplift in the northeast[4].

Frequency division calibration is a calibration principle of first coarse and then fine. Thicker formations are clearly reflected in the low-frequency profile, while some thin sand layers can be reflected by the high-frequency scale factor. After fine calibration, the sand body in which Well H12 is located was tracked in the earthquake. Due to the fine lithology grain size, the main lithology combination is mainly fine sandstone. Seismic multi-attribute simultaneously uses a set of attributes to predict reservoir parameters. Mathematically, these techniques are realized by multivariate geostatistical algorithms. The key issue of using multiple attributes to predict reservoir parameters is which attributes to choose and the size of the weight of each attribute, and a multiple linear regression algorithm is adopted for the region.

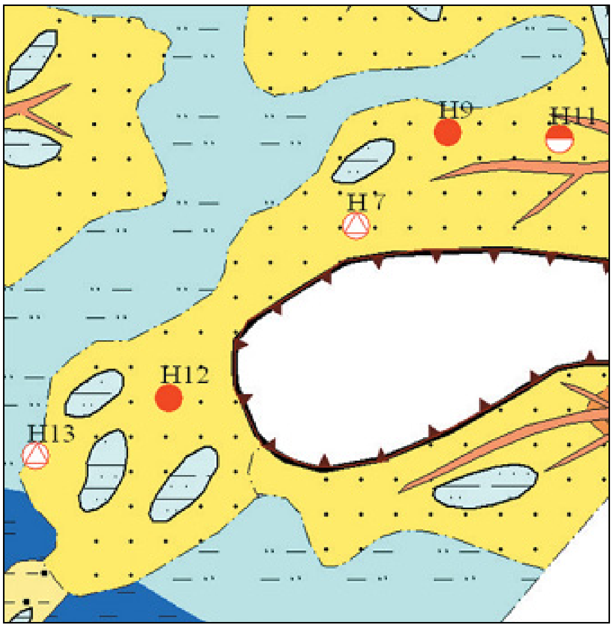

Figure 1. Sedimentary facies of the first section of Nantun strata in well area H12

The entire structural belt is located in the fan delta front facies belt. The H12 well area was a slope belt during the deposition of the first member of the south, near the edge of the lake basin. The early period of the first member of the south was filled and supplemented with sufficient provenance in the middle and late period. Thick fan delta deposits developed and injected into the lake basin along the northeast direction. The H12 well area is close to the center of the lake area, and the front sand body is directly connected to the deep lacustrine mudstone, laying the foundation for the formation of lithologic oil reservoirs.

From the corresponding relationship between the well and the sand body of the first member of the Nantun Formation between the wells, the overall distribution of the sand bodies tends to be thick in the north and thin in the south, gradually thinning into the trough, with large thickness changes. Among them, the thick sand body has better lateral continuity and extends farther, making it the main reservoir in this area.

3 Characterization of Lithology

After the pre-stack depth migration processing, the signal-to-noise ratio is high, the imaging is better, the wave group characteristics of each reflective layer in the area are relatively clear, and the interlayer structure is relatively clear. When the layer thickness increases to a quarter-wavelength tuning thickness, the reflection amplitude reaches its maximum. As the layer thickness increases, the reflection amplitude gradually decreases. The spectral decomposition technology transforms the seismic data into the frequency domain, the amplitude spectrum depicts the time thickness change of the formation, and the phase spectrum shows the lateral discontinuity of the geological body. The maximum reflection amplitude value in the time domain corresponds to the maximum amplitude energy value in the frequency domain. The dominant frequency of the data destination interval reaches 35 Hz, and the resolved thickness can reach 25 m, which provides reliable data for lithological body identification.

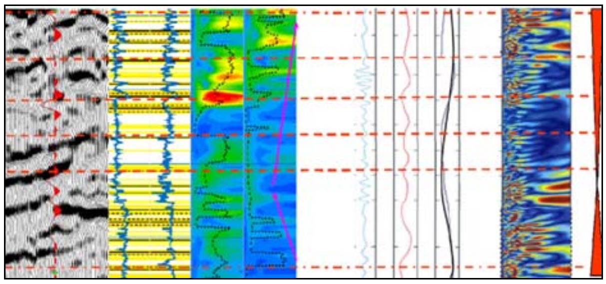

Figure 2. Well-seismic calibration chart in well area H12

Establish a high-frequency sequence framework in the H12 well area, establish the vertical relationship between rock, electricity, and earthquake of each sand group, and divide the Nantun Formation into six sand groups. Through fine frequency division calibration, the low-frequency profile represents the basic stratum pattern, and the high-frequency profile represents some details in the stratum[5].

From a plane analysis point of view, during the depositional period of the first member of the southern section, large-axis fan delta deposits developed in the Hodomor structural belt. The source is from the Laogang uplift in the northeast. The entire structural belt is located in the fan delta front facies belt. The H12 well area was a slope belt during the deposition of the first member of the south, near the edge of the lake basin. The early period of the first member of the south was filled and supplemented with sufficient provenance in the middle and late period. Thick fan delta deposits developed and injected into the lake basin along the northeast direction.

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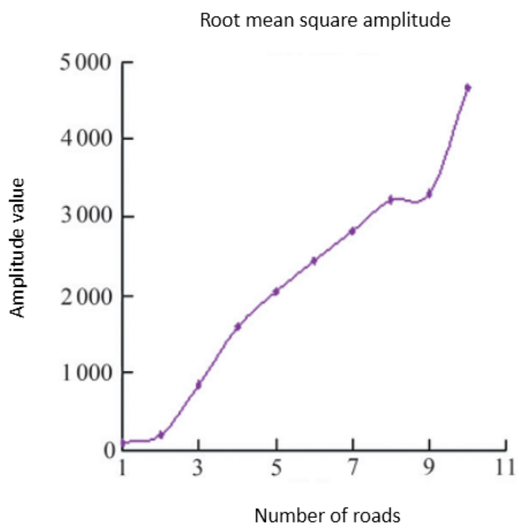

Figure 3. Response relationship of root mean square amplitude and seismic attributes

This calibration can implement the principle of step-by-step control and improve the accuracy of the calibration. Frequency division calibration is a calibration principle of first coarse and then fine. Thicker formations are clearly reflected in the low-frequency profile, while some thin sand layers can be reflected by the high-frequency scale factor. After fine calibration, the sand body in which Well H12 is located was tracked in the earthquake. Due to the fine lithology grain size, the main lithology combination is mainly fine sandstone.

Seismic multi-attribute simultaneously uses a set of attributes to predict reservoir parameters. Mathematically, these techniques are realized by multivariate geostatistical algorithms. The key issue of using multiple attributes to predict reservoir parameters is which attributes to choose and the size of the weight of each attribute, and a multiple linear regression algorithm is adopted for the region.

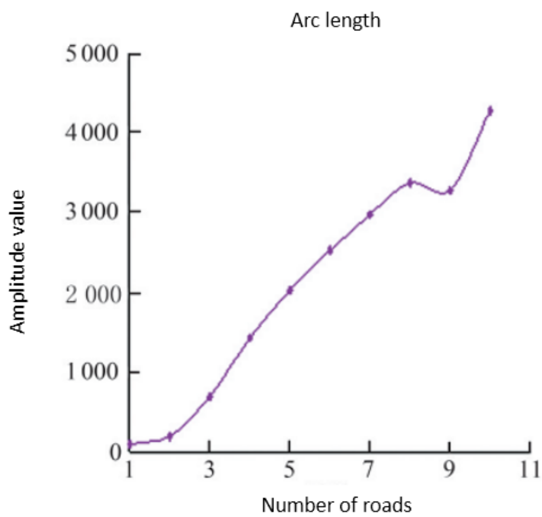

Figure 4. Response relationship of arc length and seismic attributes

Firstly, dozens of seismic attributes are extracted along the layer, such as statistical, instantaneous, frequency, absorption and attenuation. The accuracy of the horizon interpretation and the selection of the time window for the attribute extraction determines the quality of the extracted attributes. Secondly, through correlation analysis, we find out the seismic attributes that are independent of each other, have good correlation with the predicted reservoir parameters, and are more sensitive to reservoir oil.

Through the seismic response analysis of the thin inter-reservoir combination in the work area, it is found that the root mean square amplitude, arc length attribute and instantaneous frequency of the energy amplitude attributes have a linear relationship with the effective thickness of sandstone and have good correlation.

After weighted fusion, multiple attributes such as root mean square amplitude, arc length, instantaneous frequency, maximum amplitude, and average energy are mainly used in this area to describe the sand body and the development of sand bodies. However, for this set of reservoirs, wells H9 and H12 obtained industrial oil flow, while other wells only showed good results and did not succeed. How to find a good reservoir from the sand body is the key.

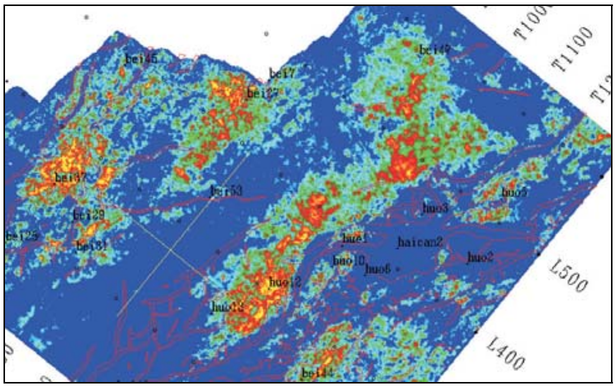

Figure 5. Sand body pattern predicted by the seismic multi-attribute fusion technique in well area H12.

4 Characterization of effective reservoirs in sand bodies

In theory, spectral decomposition technology is mainly based on the tuning principle of thin-layer reflection. For a thin layer whose thickness is less than one-quarter wavelength, in the time domain, as the layer thickness increases, the seismic reflection amplitude gradually increases. When the layer thickness increases to a quarter-wavelength tuning thickness, the reflection amplitude reaches its maximum. As the layer thickness increases, the reflection amplitude gradually decreases.

The spectral decomposition technology transforms the seismic data into the frequency domain, the amplitude spectrum depicts the time thickness change of the formation, and the phase spectrum shows the lateral discontinuity of the geological body. The maximum reflection amplitude value in the time domain corresponds to the maximum amplitude energy value in the frequency domain. Therefore, the seismic energy attributes and phase attributes at each frequency can be obtained through frequency division processing technology, and then the reservoir can be studied more precisely. On the basis of high-resolution seismic data, a high-frequency framework was established for the H12 well area. Combined with drilling analysis and sedimentary facies research, we analyzed favorable lithological development areas. Interpretation of subdivision layers in favorable lithological development areas, optimization of target sand bodies, and multi-attribute analysis techniques, we accurately describe the distribution of lithological bodies. By using spectral decomposition technology to perform insider characterization of lithological bodies, and combine with actual drilling to predict the distribution of effective reservoirs, we have summarized a set of effective methods for identifying such lithological traps.

For the H13 reservoir with poor physical properties and finer overall lithology, the description of the effective reservoir inside the sand body has become a difficult point that needs to be tackled. Using spectral decomposition technology, combined with drilling, the reservoir thickness was successfully identified. As can be seen in Figure 5a, at 10 Hz, the thick reservoirs of Well H9 and H12 can be reflected, but Well H13 is not depicted because the reservoir of Well H13 is relatively thin. There is no obvious reflection in Well H13 at 25 Hz, and the thin sand layer in Well H13 reflects when it reaches 45 Hz.

Through the fine calibration of Well H13, the thin sand layer is dominated by silt, and the lithological range delineated by it cannot be an effective reservoir. At 25 Hz, the area indicated by the black circle shown in Well H12 is compared to effective reservoirs in this area through drilling, which is dominated by fine sandstone. Through analysis, the effective reservoir distribution in this area is dominated by the range defined by the black dashed circle at 25 Hz.

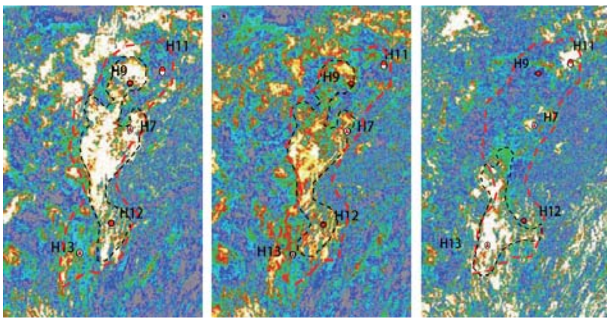

Figure 6. Effective sand body pattern predicted by the spectrum decomposition technique in well area H12.

5 Conclusion

With the increasing difficulty of exploration in the Hailar Basin, the identification and characterization of lithological bodies has become the focus of future work. The H12 well block uses high-frequency grids, combined with drilling analysis, and sedimentary facies research, to subdivide the layer interpretation in the target area, and optimize the target sand body.

Through geophysical techniques such as multi-attribute analysis, the lithological body and effective reservoirs in the well area are accurately described, and a set of effective methods are summarized for identifying this type of lithological trap.

1) High-fidelity seismic data is a prerequisite for lithological characterization. The improvement of seismic resolution can improve the accuracy of reservoir identification.
2) High-frequency well-seismic comparison is a key part of lithology identification. The establishment of a high-frequency framework and interpretation through subdivision layers are the basis for lithological characterization.
3) Multi-attribute fusion technology has played a key role in the description of lithological bodies in the H12 well area, and the distribution of sand bodies has been depicted on the plane.
4) The use of spectral decomposition technology and multi-attribute prediction technology to perform fine insider characterization of sand bodies, combined with known wells, to find the effective reservoir distribution range is an effective means to guide the next exploration.

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