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Application of multiple attribute and geostatistics inversion to predict reservoir in the A area, songliao basin

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Abstract: The A area is located in the songliao basin, the target layer of fuyu formation is characterized by thin reservoir thickness, transverse change fast, impedance overlapping of reservoir and surrounding rock, which lead to difficult reservoir prediction. According to the application of the integration of seismic data, logging data, drilling, logging, testing data, the high precision earth's physical parameters can reflect the reservoir lateral variation, and depict the basic characteristics of the reservoir depict the basic characteristics of reservoir. For geophysical conditions, optimizing coherent, frequency division attribute qualitative prediction of fuyu reservoir sand body distribution rule of every sand formation. Quantitative prediction of geostatistics inversion in this research area of every sand formation sand body distribution, combine with well logging and testing data, which is well matching with the existing drilling and provide a reference for the further oil and gas exploration.

Keywords: *coherent; frequency division; geostatistical inversion; reservoir prediction*

I. INTRODUCTION

As the further exploration work, the oil and gas exploration work of some fields has entered into the late development stage. Complex geological conditions make the exploration more and more difficulty. Thin reservoirs and residual oil exploration has become the direction of reservoir prediction. Based on the seismic data and other geological data, reservoir prediction technology aims to predict the geological characteristics of reservoir [1].

The target area have the characteristics of thin, horizontal change fast, impedance overlapping of reservoir and surrounding rock, which lead to difficult reservoir prediction. The conventional post-stack impedance inversion can't meet the requirements. This requires that we study the higher resolution inversion method, which is the integration of seismic data, logging data, drilling, logging and testing and so on. Thus, we can get higher precision physical parameters that can reflect the reservoir lateral variation and depict the basic characteristics of reservoir.For geophysical conditions, combining the coherent properties, such as frequency properties prediction in fuyu reservoir qualitatively predict the sand body distribution rule of every sand formation. In this research area, we use the geostatistics inversion to quantitative prediction the distribution of every sand formation. The existing drilling matching effect is good. This provides a reference for the further oil and gas exploration.

II. GEOLOGICAL SURVEY

The study area is located in songliao basin. The area's structure, reservoir physical property and lithology is complex, thin and poor physical property. Fuyu reservoir in overall in the depression slowly settling, the base-level cycle rise process, flat basin terrain, around the river basin development, broad river sedimentary formation, development of large rivers, shallow-water delta sedimentary system, mainly including meandering river, braided river and distributary channel, etc.

Fuyu reservoir in the study area mainly study F1 reservoir group (divided into F11, F12, and F13) and F2 (divided into F21, F22)reservoir group(seismic profile cross well1-well2-well3 as shown in figure 1).The

block structure show the type of "high middle and low surrounding". The middle part develop less fracture, the fracture development in the northeast and west dense, more secondary structure formation, has transform for oil and gas gathering and the role of the reservoir.

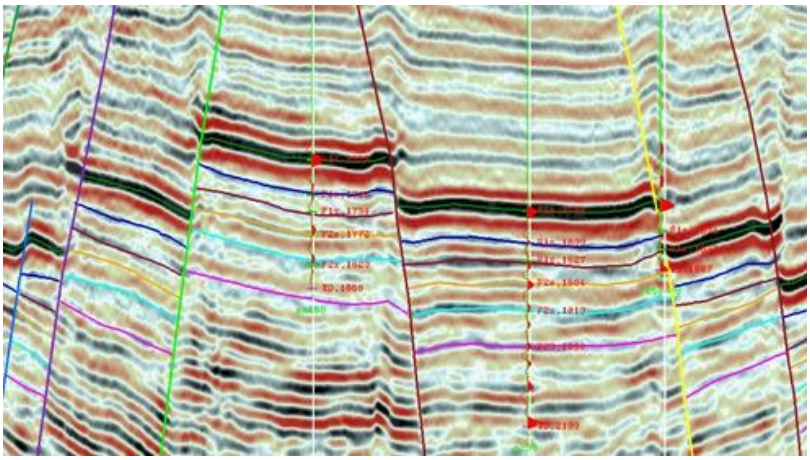

Fig.1 Seismic profile cross well1-well2-well3

III. RESERVOIR PREDICTION

3.1 Seismic attribute analysis

Through the application and research of comprehensive analysis and all kinds of algorithms, seismic attribute technology extract the special information from software system, storage, visualization, analysis, verification and evaluation of seismic attributes and converts seismic attributes to reservoir characteristics of a set of methods[2].

At present, seismic attribute can be extracted from seismic data nearly hundred kinds, such as amplitude, frequency spectrum. Based on the characteristics of stratum in this area, the writer chose the good correlation between the reservoir development in the study area and two seismic attributes: coherent and frequency division attribute.

Coherent analysis is developed in the 1990s, a 3d seismic data interpretation method multichannel seismic data is a measure of similarity degree between years of practice has proved that three dimensional seismic coherent data as a method of seismic data interpretation methods in determining fracture development zone, formation lithology, stratigraphic unconformity, the respect such as stratigraphic pinchout is quite effective.

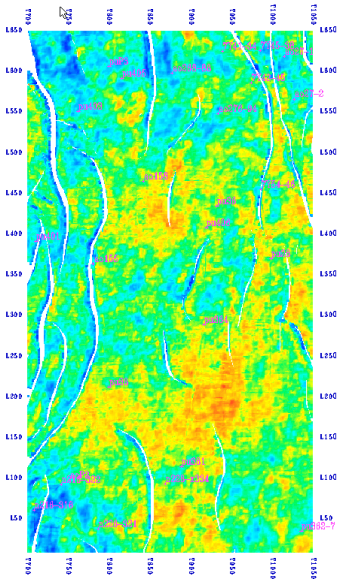

Fig2 50 Hz frequency division properties of F11, A area

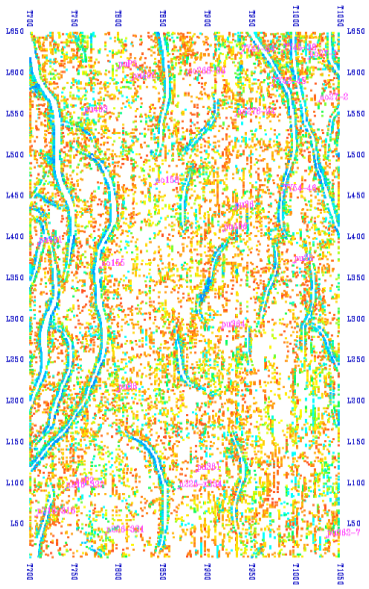

Fig 3 coherent properties of F11, A area

Frequency division interpretation technique is based on short-time window Fourier transform (DFT) or the maximum entropy spectrum based on Z transform method (MEM). The seismic data are transformed into frequency domain[3]. Reflex in frequency domain have instructions from the thin layer characterized time stratigraphic thickness. Seismic wavelet is generally across multiple layers rather than a simple thin layer, led to the complex tuning reflection, and this kind of tuning reflection has a unique frequency domain response. Due to the tune of reflection amplitude spectrum interference pattern determines the reflection of the relationship between the individual formation acoustic characteristics, so the amplitude spectrum can be used to describe the change of the thin layer, phase spectrum can be used to detect geological lateral discontinuity. After spectrum decomposition, every single frequency spectrum is corresponding to the tuning amplitude and different frequency is corresponding to different tuning thickness[4]. Time of strata thickness can be determined according to the Rayleigh criterion. Similar with other seismic inversion methods, the thickness of the formation time of calculation results must be corrected. But the determination of the relative thickness can be decided according to the frequency directly. The formation F11 of A area's coherent and frequency division attribute as shown in figure 2, figure 3.

3.2 Geostatistical inversion

Conventional deterministic inversion method produces a single best with certain seismic high-resolution impedance model. The result of the vertical resolution is usually a few meters, which is determined by the bandwidth of the earthquake. Thus, thin multilateral sand and shale is difficult to identify. Geostatistical inversion provides a set of broadband model and it is able to deal with small size heterogeneity. Geostatistical inversion is a method of combined stochastic simulation theory and seismic inversion, which is consists of stochastic simulation process and optimize the simulation results and make it conform to the process of seismic data. Geostatistical inversion integrates the advantages of seismic inversion, reservoir modeling and make full use of seismic data and well logging data to calculate multiple equal probability impedance. At present, more mature geostatistical inversion method is based on sequential Gaussian simulation method of geostatistics inversion. For the realization of the multiple P-wave impedance, the identical methods are various, but every method implementation meets two conditions: (1) on the well point, logging data is consistent with the

calculation results of P-wave impedance; (2) During wells, the results conform to the seismic data and geological statistical characteristics of the known data. Formation grid model is established by interpreting the results, the normalized processing logging curve (the histogram of GR curve after normalization processing as shown in figure 4). Through the analysis of rock physics, (GR curve intersection analysis as shown in figure 5) the geostatistical inversion parameters can be ensured. Combining with seismic data to calculate the inversion body, lithology, probability can be obtained (Prestack S- impedance inversion profile cross well 4 and well 5 as shown in figure 6).

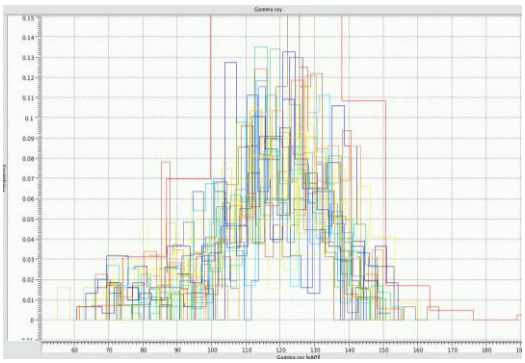

Fig 4 Histogram of GR curve after normalization processing, A area

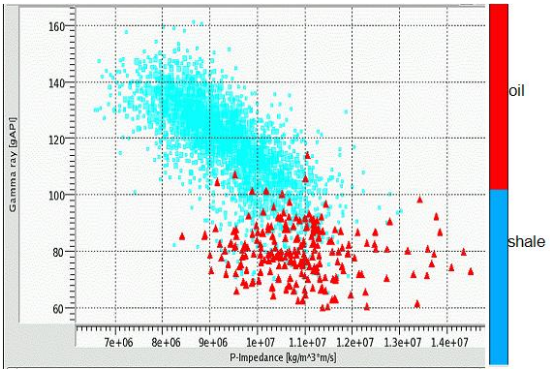

Fig 5 GR convergence analysis of A area

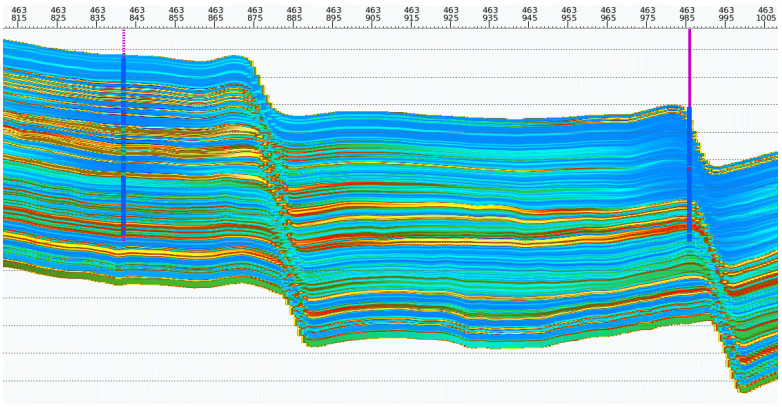

Fig 6 Prestack S-impedance inversion profile cross well 4 and well5

By calculating the relative errors denoting the difference between the measuring values and the prediction outputs, we can get the results that the prediction value is closed to the drilling value. The results show that the average absolute error is 2.3m; the maximum absolute error is 8m and the average error is 13%. The result shows that the geostatistical inversion method is effective in reservoir prediction in the region.

IV. CHARACTERISTICS OF RESERVOIR DISTRIBUTION

The upper two groups of Fuyu reservoir are divided into five small oil layers by seismic comprehensive interpretation. Considering the characteristics of this research area, each thin layer sandstone extension and deposit micro-facies are described and calibrated based on attributes and geostatistical inversion results and reservoir distribution characteristics in the study area is determined. Reservoir prediction results show that F11 reservoir mainly distributed in the central in band, mainly the North-East direction. The band moves eastward in the stratum F12. The F13 sand distribution range reduced, only scattered in southern and central of the study area. The distribution of F21 sand's mainly concentrated in the central band of east-west direction. F22 group reservoir sand distribution mainly concentrated in the eastern part of the A area, scattered in western part.

V. CONCLUSION

5.1 Coherent attribute and frequency division attribute interpretation technology is an effective means of reservoir prediction, it conduces to improve and enhance the accuracy of the results of seismic data and the qualitative prediction of reservoir distribution.

5.2 The method of geostatistics inversion combination with seismic, logging and geological data can quantitatively predict the distribution of reservoir. The predicting results agree with the drilling data shows that the method can effectively predict reservoir distribution rules in the region.

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