

Identification and Interpretation of fan deposits in Block H12 of Beixi subsag, Beier depression, Hailar basin

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Abstract. Fan deposits in the Nantun formation in Beier depression have been drilled in the past two decades. It's difficult to identify and describe subtle traps formed by fans by seismic interpretation. By using a combination of seismic interpretation techniques on the workstation, most of these traps can be identified. By high resolution seismic synthesis records, it is clear to know that the location of the fan body on the seismic profile, and its property. Because of multi-layered and uneven thickness, it is impossible to delineate fan delta features in Nantun formation by one single seismic attribute, Multi-attribute analysis can extend resolution of the seismic data, improve visualization of layer internal composition, see your sand bodies delineation more clearly. Seismic inversion using high resolution log curves and borehole data as a guide can get reservoir thickness. 3d visualization of automatic tracking results makes the reservoir more intuitive. Based on the stratum seismic interpretation, using seismic attribute analysis can depict the shape of the fan, using wave impedance inversion can predict the thickness of the fan, and using automatic tracking technology can display the whole fan.

1 Preface

Beier depression is the largest depressions in Hailar basin, Beixi subsag is one of the most important exploration area in the northeast of Beier depression. After decades of exploration oil was discovered in Nantun formation fan deposits. The fans in Beixi came from different sediment sources which migrated in short distance, and stacked on the longitudinal. The Nantun formation was piled up of poor sorting conglomerate, sandstone and mudstone. Because of small wave impedance difference between sandstone and mudstone, it is very hard to recognize the fans in the seismic profile. Astrict by synthetic records, we can interpret the phase axis corresponding to the fan in the seismic profile correctly, along the horizons, attributive analysis, spectral decomposition, impedance inversion, and 3d visualization techniques can be applied to identify the fan.

2 Project overview

The working area is located in the northeast slope of Beier depression, oil flow have been obtained from Wells. The main oil-bearing formations are nantun formation and damoguaihe formation, and the prognostic oil reserves and proved oil reserves have been submitted years ago^[1-5].

3 Fan type and seismic characteristics

3.1 Fan type

There are three types of fans in Nantun formation in Beixi: alluvial fan, fan delta and lake bottom fan and underwater fan. Alluvial fan is on the west slope of the depression, the burial depth is between 1800 and 2500 meters. The porosity of the reservoir is 5-9%. Fan delta on the east slope of the depression generally 20-30 meters thick, buried between 2300 and 3000 meters, porosity of 8-16%, is the main target of exploration of Beier depression. In this article we only talk about how to describe the fan delta located in east slope.

3.2 Seismic characteristics of the fan delta

T23 is the phase axis corresponding to the top of fan-developed strata. The seismic profile is characterized by moderate to strong amplitude, slightly continuous, and low frequency reflection. From slope zone to depression, seismic reflection features gradually change to strong amplitude, continuous, high-frequency reflection, this means rock grain size evolved from coarsness to fine. The profiles of well H12 are the most typical fan delta profiles.

4 Identification and description of fan delta

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4.1 Fine calibration of synthetic records and interpretation of subdivision layers to determine the position of fan section

Firstly, the fine calibration of synthetic records and subdivision interpretation technology are used to determine the position of fan section. Then the multi-attribute fusion technology is developed to determine the plane distribution of the fan body. Starting from the wells that have been drilled into the fan body, a high-precision synthetic record is made to calibrate the horizon, determine the specific position of the fan body on the section, and carry out fine seismic interpretation of the subdivision layer (Fig. 1).

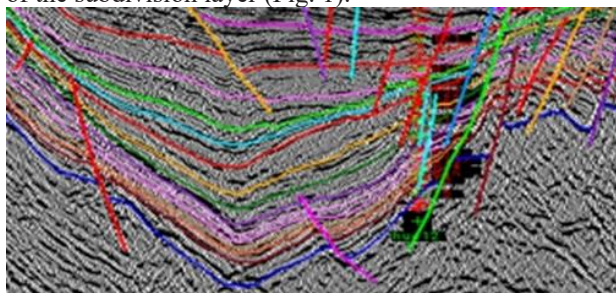


Fig. 1. Seismic interpretation profile of fine stratification passing through the well H12

4.2 Multi attribute fusion technique to determine the plane distribution of fans

After the fine seismic interpretation of subdivision layer is completed, the plane distribution characteristics of fan body are determined by extracting the seismic attributes along or between layers. Seismic attribute analysis is a series of methods to extract, analyze and evaluate seismic attributes and transform them into geological models. The following series are commonly used in seismic attributes: amplitude statistical series: minimum amplitude, maximum amplitude, average amplitude, average absolute amplitude, root mean square amplitude, standard deviation, average energy, value skewness, value peak state, time window arc length, energy over half time. Statistical series of complex seismic traces: including reflection intensity, instantaneous phase, instantaneous frequency and energy over half time.

Through the extraction and optimization of seismic attributes, and the use of waveform classification, the subdivided layer interpretation horizon and well in Beixi area of Beier depression are divided into different types of sedimentary units, and the reservoir structure and fitting relationship in each unit are analyzed, on the basis of which the geological relationship between the sedimentary units is further determined. The specific work steps are implemented according to the following methods: Preliminary optimization of the extracted seismic attributes, that is, the seismic attributes that are not related to each other and can reflect the plane distribution characteristics of the fan reservoir. According to the sedimentary characteristics, the subdivided layers are divided into different sedimentary units according to the classification of seismic waves, and the reservoir structure and fitting relationship of

each sedimentary unit are analyzed. The correlation analysis is carried out between the initially selected seismic attribute and the sand land ratio calculated by well point statistics, and the correlation coefficient of well point location is calculated, so as to further optimize the seismic attribute with better correlation with sand land ratio. The stepwise regression method is used to carry out the regression operation, and the mathematical relationship between seismic multi-attribute and reservoir is fitted. By analyzing the fitting degree and adjusting the fitting relationship in combination with geological characteristics, we can take multiple iterations to improve the fitting degree. Finally, the above methods are applied to the final mapping of multi-attribute fusion.

By using the technology of spectrum decomposition and extraction and analyzing the sedimentary characteristics of sand body, the spatial distribution of favorable sand body reservoir can be effectively determined. By using multi-attribute fusion technology, the plane distribution of fan in H12 well area is obtained (Fig. 2a).

4.3 Determination of the distribution range of the actual effective sand body in the fan body by spectral decomposition technique

Spectral decomposition technology, that is, frequency division interpretation technology, is a method to study thin layer changes through spectral decomposition in a short time window. It is a new seismic attribute interpretation technology suitable for three-dimensional seismic interpretation and reservoir prediction. It realizes the study of the lateral change rule of reservoir by tuning the corresponding relationship of amplitude in the frequency domain, so that the seismic interpretation can obtain a $1/4 \lambda$ fraction higher than the corresponding value of the normal seismic main frequency Resolution results. This technique is superior to the traditional seismic attribute research method in determining the boundary of oil-gas reservoir and estimating the thickness of stratum. By using the technology of spectrum decomposition and extraction and analyzing the sedimentary characteristics of sand body, the spatial distribution of favorable sand body reservoir can be effectively determined.

By using the spectral decomposition technique, the plane distribution of the actual effective sand body in the fan of H12 well block is obtained (Fig. 2b).

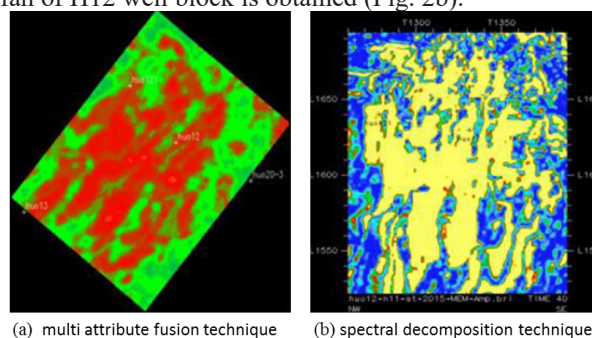


Fig. 2. Determination of plane distribution of fans by multi-attribute fusion and spectral decomposition

4.4 Quantitative prediction of thickness change of fan body by seismic inversion technology

Comprehensive application of geological stratification, acoustic logging and other data, using Jason software, seismic inversion is carried out on the basis of standardized processing of logging curve, fine calibration of reservoir, wavelet extraction, establishment of initial wave impedance model, editing of trend line and constraint line, and repeated inspection and testing of subsequent parameters and data. This time, the constrained sparse pulse impedance inversion method is used.

Based on the interpretation of seismic fine structural horizon, the geological model is established. According to the direction of seismic in-phase axis, the contact relation of formation model interface is defined to make it close to the underground reality, wave impedance inversion proceeded based on the model's high resolution constrained sparse pulse. Through the interpretation of the inversion data, the seismic inversion profile of well H12 (Fig. 3a) and the fan thickness prediction map (Fig. 3b) are obtained.

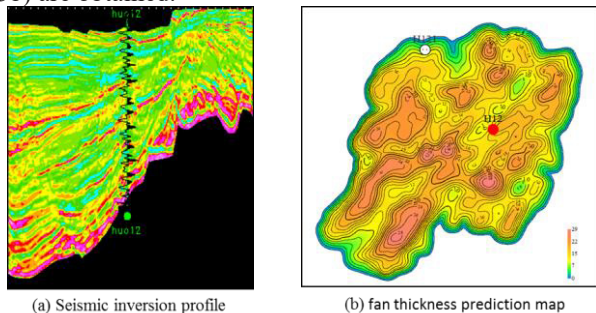


Fig. 3. Seismic inversion profile and fan thickness prediction map of the well H12

4.5 Three-dimensional visualization technology to depict the spatial distribution of fans

Three-dimensional visualization technology is applied to depict the spatial distribution of fans. In view of the characteristics of the fans of Nantun Formation in H12 work area, which have certain stratigraphic dip and overlap, we mainly adopt the three-dimensional visualization interpretation method of making seed point control "carving" after volume flattening, and then making reverse flattening recovery. This method is to select one or more seed points in the flattened data body, first determine the spatial position of the seed points, and then separate all the sample points that are larger (or smaller) than the vibration amplitude range of the seed points connected with the seed points, so as to realize that taking the single or multiple seed points as the starting point, part of the seismic data that meets the amplitude range connected with the seed points are taken from the earthquake. A new seismic data volume is obtained by separating the data volume. After back flattening, the seismic data itself can represent the true plane shape and spatial distribution of the fan. By adjusting the parameters of color and transparency, we

can display the "carved" data transparently, and study the external shape and internal structure of the fan.

Using three-dimensional visualization technology to browse data volume, perspective, seed point tracking, layer flattening and back flattening technology, the developed fan body of Nantun Formation in H12 work area is depicted, and the three-dimensional distribution diagram of fan body developed in Nantun Formation in H12 work area is obtained (Fig. 4).

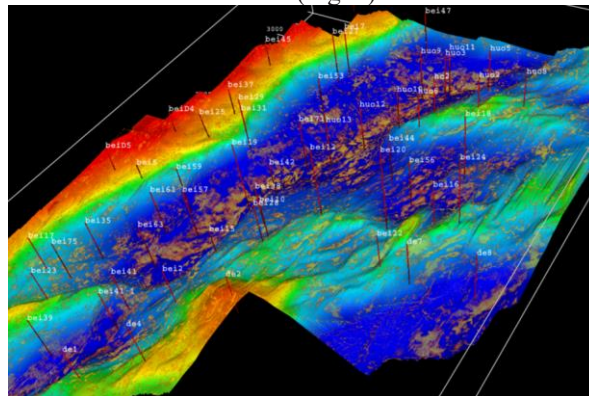


Fig. 4. The spatial distribution of fan body in the H12 Nantun formation.

5 Conclusion

(1) There are three types of fans developed in Nantun Formation of H12 work area, which have the sedimentary characteristics of multi-source and short source, and the reservoir changes rapidly in horizontal direction and overlaps with each other. Only using drilling and logging data to carry out fan layered correlation will inevitably lead to multiple solutions. Well seismic combination is an effective means to improve the accuracy of correlation.

(2) Seismic data can better reflect the lateral change of reservoir, but the vertical resolution is low; drilling and logging data have high vertical resolution but limited horizontal resolution, and the combination of the two can better carry out the reservoir prediction of fan body.

The development of lithologic traps in H12 work area is determined by the characteristics of multi-source and phase change fast deposition, which is the main direction of the next exploration. Because of the small scale and many periods, it is difficult to depict the fan body by stages. It is better to identify and describe the fan body by using various technical methods for comprehensive interpretation.

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