ISSN: 2472-3703 DOI: 10.6911/WSRJ.202003_6(3).0018

Study on Well-Seismic Combined with Fine Interpretation of Faults

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Abstract

In recent years, seismic exploration technology has developed rapidly in high-precision acquisition, prestack imaging, and reservoir prediction. This paper adopts the method of close-well network seismic analysis and interactive verification to perform seismic interpretation of 8.16km2 high-density 3D seismic data in BE area, and a total of 19 faults in Sa II reservoir group have been identified.

Keywords

Well-seismic combination, seismic interpretation, fault identification.

1. RESEARCH SIGNIFICANCE

In order to meet the needs of tapping the remaining oil in the high water cut development stage of the oilfield, it is urgent to improve the seismic inversion method to improve its vertical resolution. At the same time, a combination of multi-disciplinary and multi-technology is required to improve the accuracy of reservoir prediction. This requires combining methods from new fields such as model discrimination technology and seismic facies waveform classification technology to provide strong guarantees for reservoir prediction; on the other hand, it is necessary to improve the implementation method of seismic inversion. Adopting seismic lithology inversion and reservoir prediction technology based on high-frequency isochronous sequence frame constraints, multiple inversion methods are combined with each other to overcome the seismic inversion Resolvability makes the results of quantitative reservoir prediction more objective and accurate.

2. RESEARCH PROCESS

Before determining the seismic response of the marker layer, since the instruments, scales, and operations used to collect logging data during the exploration and development process are different, there are certain errors between the logging curves, so it is necessary to standardize the logging curves.

Secondly, it is necessary to perform synthetic seismic recording processing on the well log data that has been standardized. Based on the comparison of formations across the entire area using resistivity, natural potential, acoustic waves, natural gamma and other logging curves, the acoustic characteristics of the top and bottom interfaces of each layer are analyzed, and the target section wavelets are extracted from the seismic traces next to the well to make each well Synthetic seismic records. A strict quality control analysis is performed on the quality of the synthetic seismic records.

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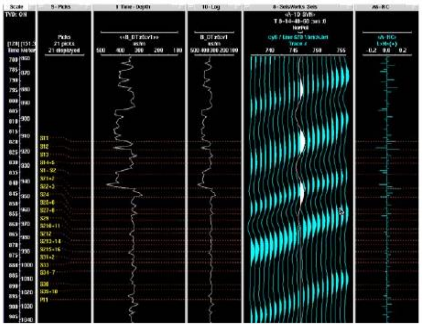

Figure 1. Synthetic seismic record of B1-310-P31 well

Finally, the synthetic seismic records were used to perform horizon calibration to determine the seismic response of the landmark. Then based on single-well calibration, multi-well closed calibration is performed using single-well and continuous-well profiles to achieve uniformity of geological-seismic horizons across the entire area. On this basis, the seismic sequence division, sequence contact identification and drilling stratification are combined to further determine the seismic interpretation horizon, so as to achieve consistent and reasonable structural interpretation in the whole area.

3. CALIBRATION RESULTS OF STRUCTURAL HORIZONS

The structural layers to be contrasted and interpreted this time are mainly the Sa II reservoir group. After calibration of synthetic seismic records, their corresponding relationship with the geological horizon is as follows:

3.1. Characteristics of Seismic Reflection Wave Group

From the above calibration, combined with the comparative analysis of the seismic profile, the characteristics of the reflection layer wave group of the structural horizons in this area are summarized as follows:

TS1 reflection layer: equivalent to the reflection on the top surface of the Sa I reservoir. The reflection layer is a strong continuous strong reflection in-phase axis, with consistent waveforms throughout the region, obvious characteristics, and easy tracking and comparison. The calibration is on the peak of the strong phase axis, the reflection time in the work area is between 749 ~ 853ms, and the video rate is about 40Hz.

TS2 standard layer: equivalent to the top reflection of the Yaojia Formation (also equivalent to the top reflection of the Sa II reservoir). It is one of the most obvious seismic landmarks in the middle and shallow layers of the Songliao Basin. The seismic profile is characterized by strong continuous and strong reflections. It is generally calibrated on the peaks of strong phases. The entire area is stable and easy to track continuously. 774.8 ~ 878.8ms, the video rate is about 40Hz.

TS29 reflective layer: equivalent to the top surface reflection of the S29 deposition unit. The overall reflection layer is a medium-to-medium strong continuous strong reflection in-phase axis. The waveforms in the entire area are more consistent and the characteristics are more obvious, which can be tracked and compared. This time calibration is on the peak of strong phase, the reflection time in the work area is between 796 ~ 901.8ms, and the video rate is about 45Hz ~ 60Hz.

TS3 reflection layer: equivalent to the reflection on the top surface of the Sa III reservoir. The seismic profile basically corresponds to the negative in-phase axis, and locally corresponds to the positive phase. It can be tracked based on comprehensive factors such as the contact

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relationship between upper and lower horizons, stratum thickness, wave group reflection characteristics, and calibration results of synthetic records. The reflection time in the work area is between 812 ~ 916ms, and the video rate is about 45Hz ~ 65Hz.

4. FINE INTERPRETATION OF FAULTS

4.1. Fault Interpretation Process

The fault interpretation is based on the well-seismic method. In view of the characteristics of high seismic lateral resolution and high logging vertical resolution, synthetic seismic records are used to calibrate the seismic layer of the well, and a number of technical methods such as seismic coherence volume analysis are used in combination with the breakpoint library to identify small faults and achieve the dynamic combination of well logging and seismic structural interpretation. The specific process is shown in Figure 2.

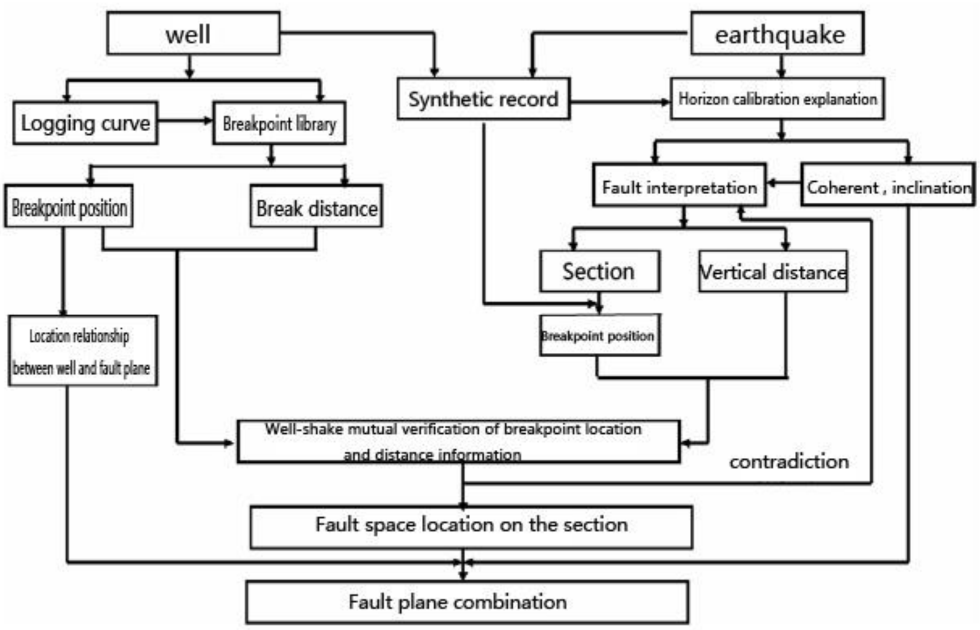

Figure 2. Flow chart of well-seismic joint interpretation fault method

4.2. Fault Identification Methods and Results

In order to explain the fault accurately, in addition to fault interpretation of the distortion, misalignment, bifurcation, merger, and weakening of the same axis, the following technical methods are mainly used in the process of section interpretation:

(1) Direct interpretation of section

In general, faults with larger fault distances are clearly reflected on the seismic profile. The misalignment of the reflected wave group, the appearance of the cross-section wave, the abrupt change of the reflection structure, the distortion, bifurcation, and merger of the same axis are very obvious (Figure 3).

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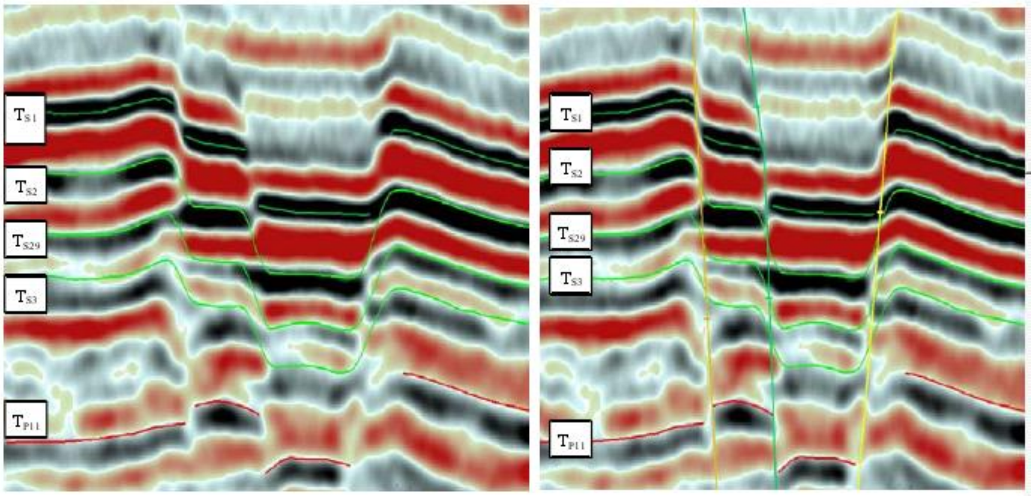

Figure 3. Direct manual interpretation using fault profiles

(2) Identifying small faults using changes in the upper and lower strata

The existence of faults is often not isolated. Corresponding changes occur in the upper and lower strata. For large faults, the faults are very obvious and easy to explain. For small faults, the corresponding changes in the upper and lower strata also exist, but they are not so obvious.

(3) Analysis of faults using multiple adjacent profiles

When a suspicious small fault is found during the fault interpretation process, it is compared with the adjacent survey line, and the existence of a fault on the adjacent section is used to determine whether the fault exists.

(4) Make full use of coherent body recognition technology

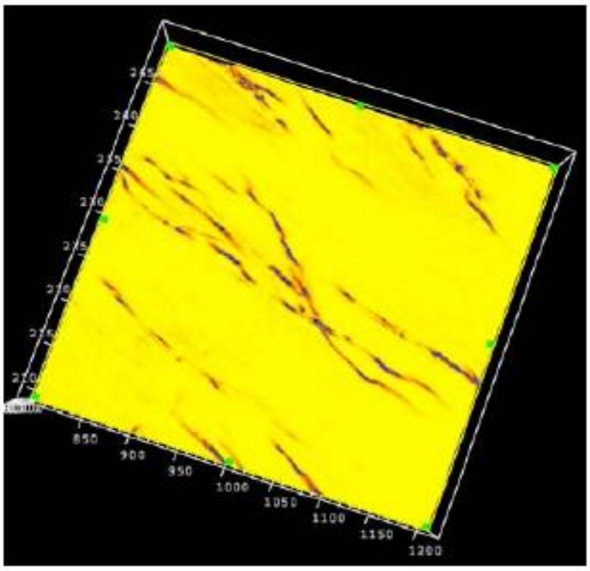

Figure 4. Perspective slice of S2 reservoir in study area

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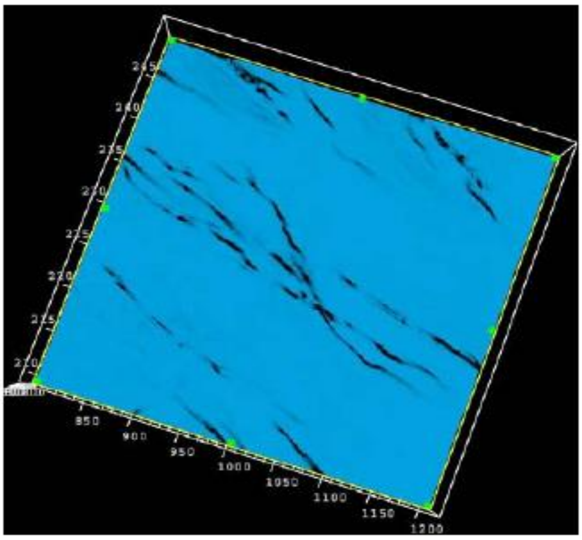

Figure 5. Coherent 3D map of flattened eigenvalues in study area

Coherent volume analysis has played a key role in solving geological problems such as faults, fractures, and lithology in recent years. It is the core technology of fault interpretation. This work uses eigenvalue coherence and volume fluoroscopy techniques to solve the problem of fault identification.

(5) Well-seism combined with interactive verification,

The faults on the seismic section show obvious misalignment of the same-phase axis, and the position of the fault plane can be roughly determined through the shifting relationship between the upper and lower in-phase axes to determine the fault information; Use the logging curve to accurately determine the position and distance of the breakpoint on the well. Synthetic seismic records are the bridge between logging and earthquakes. Through synthetic records, the wells are accurately projected on the seismic profile, so that the information about the breakpoints on the logs and the information about the faults on the earthquakes can be organically matched. After repeated verification, the spatial distribution and plane distribution characteristics of the faults in the study area were finally obtained.

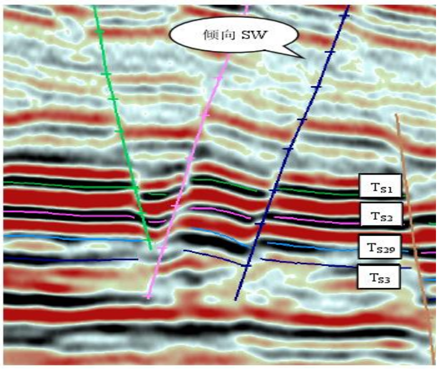

Figure 6. Over 75 # fault south Trace1087

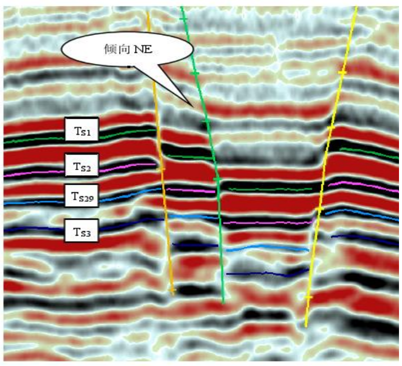

Figure 7. Over 75 # fault is Trace950

A total of 19 faults were interpreted in this single layer, with a total of 60 faults. All interpreted fault points were closed on the section, and the faults were closed in three dimensions.

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5. ANALYSIS OF STRUCTURAL CHARACTERISTICS OF WELL- SEISMIC COMBINATION

The distribution of faults reflects the characteristics of tectonic development in this area to a certain extent. The faults developed in this area show a certain regularity both in section and plane. Vertically, there are the most faults on the top surface of the S21 reservoir. The S29 and S31 faults have relatively few faults. Most of the faults are mainly trunk faults, and small faults are not developed. The fault strike in the plane is mainly NW. A total of 60 faults were explained, and there were 15 faults that interrupted the entire Sa II reservoir. The faults in this area have the following characteristics:

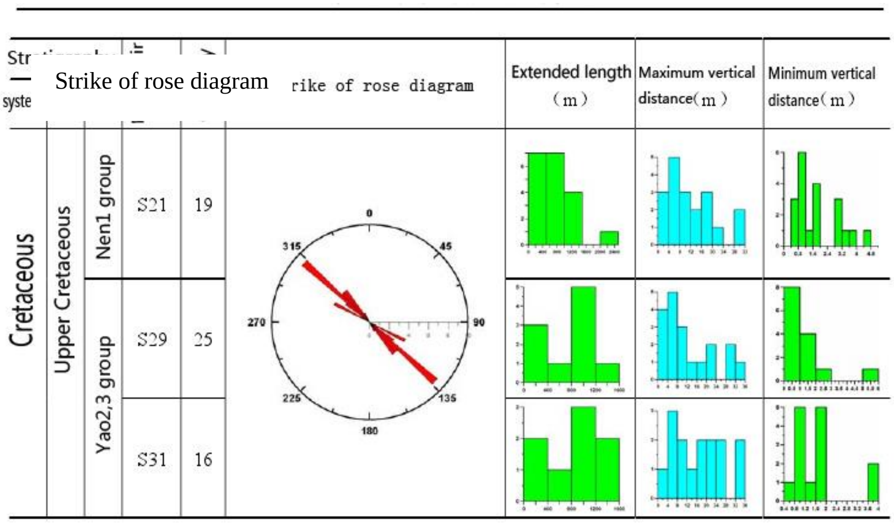

Figure 8. Statistical map of fracture geometry in BE area

(1) The trend of the fault is mainly northwest.

In the Sa II oil layer in the BE area, the distribution direction of most faults is mainly northwest (Figure 8), and the distribution direction in each reflection layer is basically the same, which has certain inheritance.

(2) Medium-scale faults, with the highest number of faults at the top of S29.

Fault scale refers to the fault plane extension length and displacement (or maximum vertical fault distance) and the relationship between them. Analyzing fault scale is helpful for studying fault formation mechanism and activity law.

From the perspective of fault extensions in the work area, faults with extensions less than 1000m account for more than 60% of the developmental faults in the Sartu reservoir, and individual fault extensions can reach more than 2000m. It can be seen from the fault distance that the maximum fault distance is mainly concentrated within 20m, but the distribution range is not obvious.

It can be known from the statistics of the number of faults on the top surface of each oil layer group that the number of faults and the density of the faults show a rule from bottom to top. The number of faults in the S29 reservoir is large and the density is large, reaching 25.

6. CONCLUSION

In this paper, the seismic interpretation of the 8.16km2 three-dimensional seismic data in the BE area and the Jason inversion of the Sa II reservoir were made, and the following conclusions and understandings were mainly obtained:

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Based on the well-seism combination, the Sa II reservoir in the study area is explained in detail, and the horizon interpretation is as fine as the sedimentary unit. 19 structural faults were identified at the top of the Sa II reservoir through a tectonic trend method combined with other interpretation techniques, and superimposed analysis studies were conducted to ensure that the faults were closed in space and implemented one by one. This has a very important guiding role in further improving the injection-production relationship and improving the degree of water flood control in the study area.

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