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Fine Interpretation Method and Genetic Analysis of Segmented Growth Fault

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Abstract: *Based on accurately well small layer contrast recognition breakpoint results and the accurate results of 3D seismic fine interpretation, and the main fault plane and the secondary fault plane of the segmented growth fault is fine split, to carry out the faults in the fine 3D characterization. According to the location of the breakpoint and the break separation of the breakpoint, accurately matched breakpoints on the well with seismic interpretation of fault surfaces. In the process of work, the factors which affect the matching precision of the breakpoint and the fault plane are analyzed. Based on the accurate logging and seismic interpretation results of the target horizons in the study area, the growth index and thickness coefficient of the layer nearby the fault are analyzed, and the genetic mechanism of the fault segment growth is revealed. The research results show that: (1) The combination precision of the breakpoint is mainly affected by two factors: 1) the accuracy of the well seismic calibration, the breakpoint is not matched is due to the error of the well seismic calibration. 2) Deviation data affects the accuracy, slope sections due to measurement errors, resulting in deviation data is not accurate, is unable to obtain the real and effective well hierarchical data, well breakpoints' vertical depth information. 3) As the recognition accuracy of seismic interpretation is limited, cannot match multiple breakpoints appear in the short distance of the broken belt.*

Keywords: *The north of Xingshugang in the Songliao basin; Breakpoints combination precision; Segmented growth fault*

In recent years focused on the role of fracture in hydrocarbon accumulation is in the majority, with combination of well logging and seismic interpretation further develop the work of structural description , fault description precision improvement, some difficult and important problems appears. In accordance with the existing modes of fault interpretation, one well through a fault can only drilled one breakpoint and in practical work there are a large number of wells in the short distance drilling in case of multiple breakpoints. This phenomenon is fully illustrated, the fault interpretation accuracy needs to be improved. Therefore, it is necessary to carry out the research on the model of fault segment growth and evolution. Fault segment growth in the rift basin is universal, and it is an indispensable stage in the formation and evolution of the fault basin **Error! Reference source not found.**. Fault growth is a dynamic process, dry differences due to rock, fault to the propagation, generally in the plastic layer formation of force folds, overall performance for monoclinal structure characteristics **Error! Reference source not found.**. Therefore, fault propagation fold is vertical faults to the initial stages of growth. With the cumulative fault activity and upper fault system began to form, plastic layer leads to under the vertical fault to piecewise growth **Error! Reference source not found.**; when accumulated to a certain fault distance, segmented growth fault in the plastic layer is connected by faults. Scholars put forward application "Figure 4 peel" technology to analysis the formation and evolution law of transition zone**Error! Reference source not found.Error! Reference source not found.**, and made many helpful discussions of causes for the Sanzhao sag vertical fault to segmented growth. But through the literature research found that there is a problem in the sectional growth: the research is mainly from the process of large tectonic evolution, through the seismic interpretation method to complete. Because of the limited recognition precision of seismic interpretation methods, some of the fault horizon which can be identified by the small layer contrast would be avoided, which leads to the lack of detailed understanding of the fault. This article wants to take faults in Songliao Basin in Xingbei area as an example, put forward to small layer contrast recognition well fault horizon based on the detailed fault interpretation method, according to well breakpoint location and the separation of well breakpoint, fine splitting main fault level and secondary fault plane, back to the fault' fine three-dimensional characterizations. In the process of fine interpretation of faults in the study area, the factors that affect the precision of the breakpoint combination are analyzed. Because the accurate well logging and seismic interpretation, statistical and analysis growth index of formation which nearby faults and formation thickness coefficient, to reveal the mechanism of fault segmentation growth characteristics.

I. General Situation Of Study Area

The study area is located in Daqing Xingshugang six-seven district in the East. Songliao Basin, located in the middle of Northeast China, basin surrounded by mountains, between basin and mountain to deep faults is

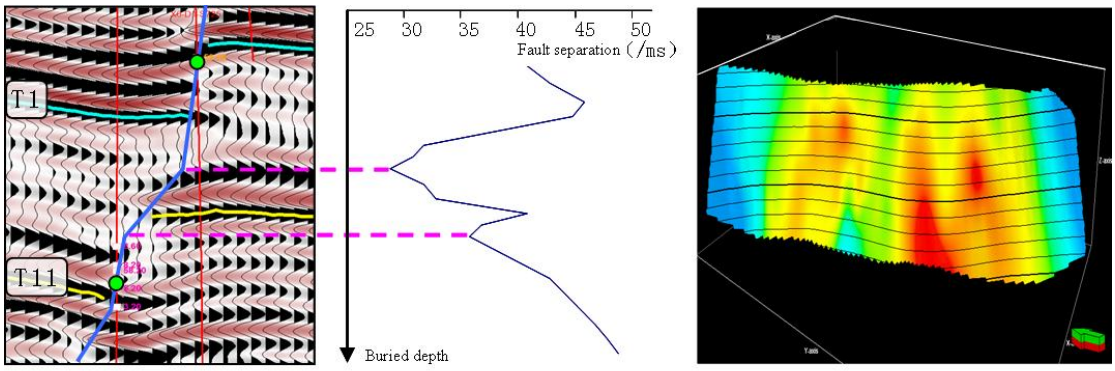
bounded on the West sector for Nenjiang[Error! Reference source not found.], fracture Baicheng and mountains, east of Yilan-Yitong fault and Zhang Guangcai ridge, south of Chifeng-Kaiyuan fracture and the Yin mountain-Yan mountain orogenic belt, North Xunke-Tieli fracture and Xiaoxinganling Songliao basin from bottom to top can be divided for basement tectonic layer, fault depression layer, depression layer and inversion structural layer of the four layer structure. Depression layer includes a lower Cretaceous Quantou Formation (K1q) and the upper Cretaceous Qingshankou group(K2q), Yao Jia group(K2y), Nenjiang group (k2n), mainly of large depression deposited in lacustrine basin fluviolacustrine facies clastic rock, during a brief period of transgression and weak volcanic activity, intensity of fault activity also has been greatly weakened. After the deposition of Nenjiang group, Songliao Basin underwent several times pulse type extrusion, among them the extrusion at the end of Nenjiang group Stage and Mingshui group has a great influence on the basin. Due to the influence of the tectonic movement of Songliao Basin, section of the study area is multi ladder type or graben. Along the strike direction on the fore part of the overlay, the fault dips didn't end closer to each other, the fault throw in overlapping section there is a mutual relation of growth. The stratigraphy in the study area can be divided into three structural layers: rift structure, tectonic depression layer and tectonic inversion layer. Corresponding formation, and three sets of faults system: lower fault system developed in faulted period Huoshiling group-Yingcheng group, which controlled the formation of sedimentary rift [Error! Reference source not found.]; central fault system developed in Denglouku group-Nenjiang group; upper fault system was formed in Nenjiang group-Mingshui group, and the central fault system interface T06 is fewer in number [Error! Reference source not found.]. Three sets of fault systems in the vertical upward connectivity is poor, the number of faults that run through the upper and lower is not much. Fault zone in the study area with cable-stayed in North West-east direction, connected to form a side column overlap zone [Error! Reference source not found.]. The six-seven area fracture in the plane has obvious directivity, through the statistics, it is concluded that the fault strike with NW, NWW to the main, NE to a small part; tend to NE, NEE to the main, a small portion of the fault is in the NW direction.

II. Fine Fault Interpretation Under The Combination Of Well Logging And Seismic Data

The fine interpretation under the combination of well and seismic is the key and difficult point in this work. Based on the previous study and understand of fault evolution mechanism , this time we will fine descript the fault under the piecewise model of overlapping faults on the three-dimensional spatial distribution patterns to coordinate well and seismic data to fit each other, eventually improve the fault description precision. In view of the fault interpretation of the particularity, in strict accordance with the "with the well and seismic data to rely on, take model theory as guidelines," principle, and the technical scheme for the "macro control, grasp the overall, general the first" carry out.

2.1 Fine interpretation of main fault.

Main fault refers to the telophase of fault evolution; paragraphs of small faults overlap through and come into major energy channels, are the main part with the largest separation for the entire fault. First analysis of well logging and seismic data, in seismic data analysis phase axis in the continuous seismic profile wrong fault features, the reasonable boundary of judgment in the hanging wall and footwall; on the well logging data analysis well breakpoint location and phase calibration shaft fracture characteristics of consistency, choice the breakpoint with the biggest fault separation for the well with multi breakpoints, and take it as the basis of analysis. Then, the fault separation of the fault is analyzed, and the Fault separation distribution contour map and the buried depth-fault separation diagram are drawn, to judge the fault segment location.



a. Buried depth -Fault separation diagram b. Fault separation distribution contour map

Figure.1 Analysis of well seismic data and break distance of break point

On the basis of the above work, combined with the fault evolution mechanism, the basic configuration

mode of the fault is determined. Mainly based on stratigraphic plastic difference conditions of fault evolution mechanism, fault flat is develop in the brittle layer dip of fault is small(such as PuI1-3 quality sandstone) , fault slope is develop in the fault dip large formation between the brittle layers, the whole is fault slope-fault flat combined fault pattern. Finally, the faults' 3D characterization is the result of successive interpretation of seismic profile.

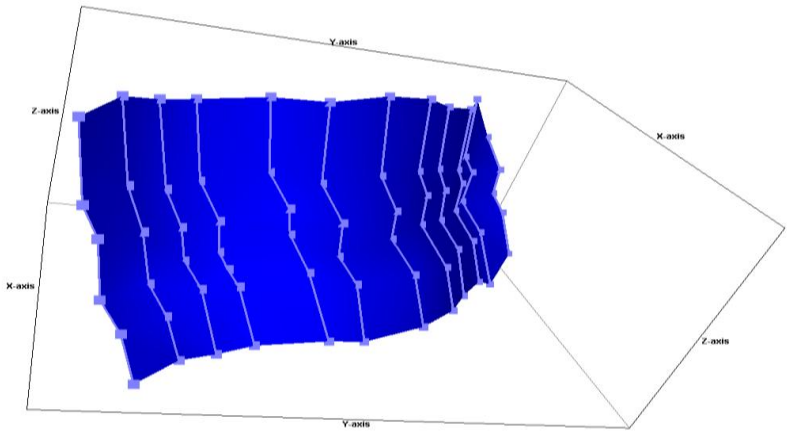
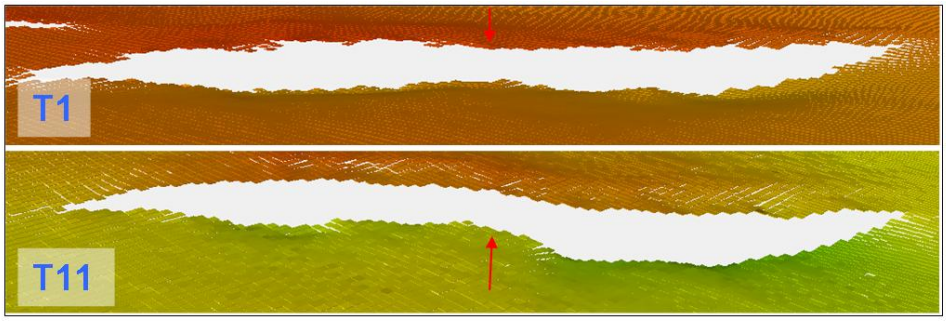


Figure.2 3D interpretation of main fault

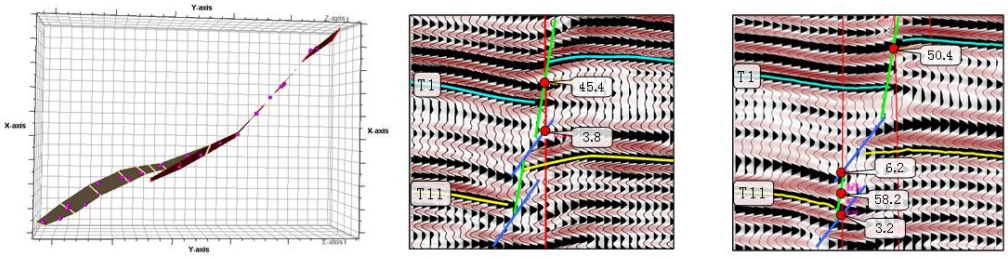
2.2 Secondary section decomposition.

According to the fault evolution model, the main fault is decomposed. The section is generally located at the position of Dip conversion or the low value zone of the fault separation. After the decomposition of the secondary section, there are overlapping relations, Branch small faults formed in the lap joint, matching with breakpoint on the well with small fault separation.

In the transverse direction, based on the distance between the fault separation distribution contour map and the equal T0 map of the seismic standard layer, the segmentation growth point is identified, and the fault segment is overlapped with the location of the breakpoint. In vertical direction, based on the plastic difference of the strata and the formation mechanism of the multi period evolution, the main fault is divided into several sections. According to fault the formation mechanism of the multi period evolution, the fault can be divided into two segments, in Qingshankou group below PI4, this period of Xingshugang North Fault universal angle smaller, generally less than 50 degrees; in Yaojia group above PI4, dip of fault overall larger and generally more than 50 degrees. According to the theory of stratigraphic plastic differential fault evolution, the faults in the formation of the Yaojia group can be subdivided further, and the segments are generally located in the transition region between the brittle layer and the plastic layer.



a. The T0 map of the seismic standard layer shows that the fault distance is reduced.



b. Transverse decomposition effect of fault c. Vertical decomposition effect of fault

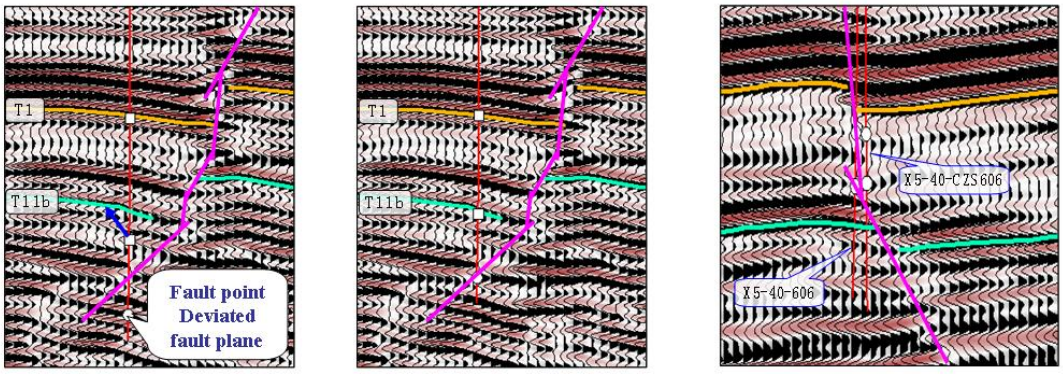
Figure.3 Effect of fault decomposition

2.3 Analysis of precision of break point combination.

The analysis of the situation of combination and matching of the break point and the fault plane is an important means to verify the accuracy of the fault characterization, the degree of well logging and seismic correspondence and the correctness of the fault pattern. Mainly analysis from two aspects: the matching situation of the break point position and the fault separation of the well break point.

In aspect of matching the position of the break point, firstly, we can identify the fault in the 3D space and the corresponding seismic profile to identify the well break points which are not completely matched with the fault plane. And divided into two categories of treatment, one is a well with multi breakpoints in broken belt, is characterized by fault separation is relatively small, generally within 5m, wells drilled encountered multiple breakpoints spacing within 40m, is reasonable phenomenon; another is non fracture zone well breakpoints, is the phenomenon of breakpoints is not matched with the fault plane under the condition of a single breakpoint for one well or with a big breakpoint distance. According to breakpoint position mismatch of the second kinds of condition, the analysis and processing are carried out from the following three aspects:

①Analysis of well seismic calibration accuracy, adjust the synthetic seismic records and time depth relationship. Can identify and correct the breakpoint mismatch caused by the error of the well seismic calibration. For example well X5-4-128 drill meets a well breakpoint, and there is difference with seismic interpretation of fault plane about three phase axis, according to the standard layer position calibration time depth relationship was found to have obvious mistakes, after adjusting the correction, the break point is in good correspondence with the fault characteristic of the seismic event..②Analysis of deviation data accuracy, part of the inclined shaft due to measurement errors, resulting in deviation data is not accurate, real and effective well stratified, well breakpoints vertical depth information cannot be obtained. Such as X5-40-CZS606 well for side slope of the X5-40-606 well, two wells were drilled in case of two well breakpoints, but slant hole deviation due to data mistakes lead to well breakpoints deviate from the fault surface. Methods ignore for such cases by inclined wells' breakpoint.③To modify the fault interpretation results in the range of the contradiction between the formation mechanisms of fault, so that the break point of the well is in agreement with the fault plane. If there is still a serious problem of low combination precision, we need to correct the basic evolution of the fault and configuration mode, and return to the interpretation and characterization of the main part of fault. After the above process, 23 faults in the study area have been explained. Three dimensional characterization results of multi section and overlapping patterns are formed for the 14 major faults.



a. Well seismic calibration error b. Corrected well seismic correspondence c. Deviation data error and fault plane does not match the breakpoint

Figure.4 Breakpoint combination precision influencing factors

683 wells breakpoints of reservoir site are divided into three kinds and are combined homing. ①well break point of the main section: the separation is relatively large, corresponding to the main part of fault; ②well break point of branch section: the break distance is relatively small, and it is relative to the branch fault; ③break point in broken belt: the distance is relatively small, and close to the main part of fault, and the fault zone is relatively small. After the fault interpretation, the combination rate of break point of oil reservoir is 98.4%, and the combination rate of multiple break points in a well is 97%.

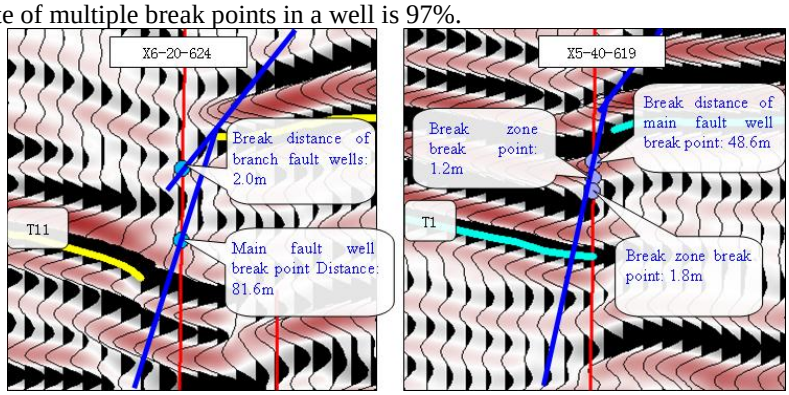


Figure.5 wells breakpoint classification and combined homing

Table.1 Statistical table of the combination of 14 major faults in the study area

Fault ID	The hole			One well with multiple breakpoints		
	Total	combination	Combination rate （%）	Total	Combination	Combination rate （%）
257	112	110	98.2	78	76	97.4
260	98	96	98	45	44	97.8
261a	27	25	92.6	15	13	86.7
275	35	34	97.1	10	9	90
276	3	3	100	/	/	/
278	201	198	98.5	126	123	97.6
272	8	8	100	/	/	/
277	6	6	100	/	/	/
280	7	7	100	2	2	100
259b	66	66	100	30	30	100
274	22	21	95.5	11	10	90.9
274-1	20	20	100	12	12	100
286	14	14	100	5	5	100
273	4	4	100	/	/	/
合计	623	613	98.4	334	324	97.0

III. Conclusion

(1)Proposed to accurately even well small layer contrast recognition breakpoint results and accurate 3D seismic fine interpretation results based segmented growth fault fine description method, clearly the main fault level and secondary fault plane and the lap relationship between them.

(2)Through the analysis of the breakpoint combination accuracy are mainly the following two factors: 1) well seismic calibration accuracy, well seismic calibration error does not match the breakpoint. 2) Deviation data affects the accuracy, slope sections due to measurement errors, resulting in deviation data is not accurate, is unable to obtain the real and effective well stratified, well breakpoints vertical depth information.3) As the recognition accuracy of seismic interpretation is limited, cannot match multiple breakpoints appear in the short distance of the broken belt.

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