Application of 3D Seismic Data in Structural Research of Oilfield Development Area

Chunrui Wang
crwang01@petrochina.com.cn

No.3 Oil Production Plant of Daqing Oilfield Company Ltd, 163113, China

Abstract. The northern part of the oilfield has entered the development stage of ultra-high water cut period. With the increase of well pattern density, the mining objects gradually become worse, which puts forward higher requirements for development adjustment and fine potential tapping. The research block is cut into relatively independent parts by extended faults, resulting in irregular well pattern distribution and imperfect injection production, which has a great impact on the development effect. It is difficult to clearly understand small faults, micro amplitude structures and fracture zones by relying solely on logging data. At present, the development of seismic data is widely used in the old area of Changyuan. Therefore, we must use three-dimensional seismic technology to re understand faults, improve the injection and production system in fault areas, further excavate remaining oil and improve the development effect of fault areas. The existing data have conducted a detailed study on the fault, and the three-dimensional structural geological modeling has found that the overall structural shape has little change, but relatively small faults have been found and re recognized. In this paper, through the new interpretation of infill wells, it is difficult to combine, and there may be small faults between wells. The self well seismic combination technology has re recognized the faults, and found many small intestines between wells. At the same time, it has a clearer understanding of the occurrence, morphological development and combination relationship of large faults.

Keyworks: Cementing Quality Evaluation by Acoustic Variable Density Logging Curve

1 Introduction

Oil is one of the most important resources in China, which is of great help to China's overall economic development and scientific and technological development. At the same time, oil resources are also the lifeblood industry of a country. In recent years, with the continuous acceleration of the overall development of China's economy, the intensity of oil exploitation has become greater and greater. At present, 3D seismic interpretation technology has been widely used in China, and the effect is ideal. It is a technology of three-dimensional interpretation of geological conditions by using points, lines and planes. This paper analyzes and discusses the practical application of this technology in China. In the research of oilfield development and deployment, the application of 3D seismic interpretation technology is an essential content The complex geological conditions and scale of the oil field and the application of horizontal wells determine that only by using dense information such as earthquake, it is possible to accurately characterize underground geological bodies and implement micro structures and small faults; When the seismic inversion results can not

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accurately predict the lateral change of thin reservoir, it is possible to realize thin reservoir prediction, carry out reservoir tracking and guide horizontal well drilling The examples of thin reservoir prediction and small fault identification using seismic interpretation technology fully show the value of fine seismic interpretation technology With the continuous development of seismic interpretation technology, especially earthquake, it is widely used in oilfield development Combining seismic with geology, logging and development to form comprehensive research technology is the development trend of technology required for oilfield development [1].

2 The necessity of 3D seismic deepening structural research

At present, the northern part of the oilfield has entered the development stage of ultra-high water cut stage. With the increase of well pattern density, the mining objects gradually become worse, which puts forward higher requirements for development adjustment and fine potential tapping. The research block is cut into relatively independent parts by extended faults, resulting in irregular well pattern layout and imperfect injection production, which has a great impact on the development effect. At present, there are mainly the following problems in the structural description of fault area: first, there is no clear understanding of small faults and cross well small faults near large faults in complex fault area; Second, the micro amplitude structure is difficult to identify and characterize. However, it is difficult to clearly understand small faults, micro amplitude structures and fracture zones by relying solely on logging data. At present, the development of seismic data is widely used in the old area. Therefore, we must use three-dimensional seismic technology to re understand faults, improve the injection and production system in fault areas, further excavate remaining oil and improve the development effect of fault areas.

The identification of large faults is relatively easy, whether using well data or seismic data interpretation, but the identification of small faults is very difficult. Three dimensional seismic work has not been done in the initial and middle stage of oilfield development. There are certain accuracy problems in interpreting and combining faults by using early collected two-dimensional data and infill well data. Many breakpoints of well interpretation are difficult to combine, and there may be some small faults between wells that have not been found. Well seismic combination technology can give full play to its advantages between wells and accurately identify and predict small faults that block the enrichment of remaining oil laterally. Faults play an important role in shielding the enrichment of remaining oil. It is necessary to carry out well seismic combination technology, give play to its advantages of data between wells, and effectively identify and combine faults to guide oilfield development and dynamic analysis [2].

3 Recognizing faults by combining well with earthquake

According to the geological characteristics of thin sand mudstone interbedding in the north of Songliao Basin, combined with the advantages of 3D seismic and high-resolution seismic, the research work of high-resolution 3D seismic is carried out On the premise of ensuring the signal-to-noise ratio of data, broaden the effective frequency band; The high-resolution processing based on high signal-to-noise ratio is realized, so that the seismic data can more accurately and reliably reflect the underground geological conditions in vertical and three-dimensional space The seismic interpretation adopts the advanced three-dimensional fine structure interpretation and comprehensive seismic lithology interpretation technology of multi information and multi method, which improves the accuracy of small fault, small amplitude structure and reservoir prediction. It has been verified by development wells and achieved good geological and economic benefits.

Taking advantage of the favorable opportunity of 3D seismic exploration in Daqing placanticline, the well seismic combination technology was carried out in 2009, and various methods were used to identify faults. In order to accurately interpret the fault, in addition to the fault interpretation of the distortion, dislocation, bifurcation, merging and weakening of the event axis, the following technical methods are mainly adopted in the process of profile interpretation.

Generally speaking. Faults with large fault distance are clearly reflected on the seismic profile: the dislocation of reflected wave group, the emergence of section wave, the sudden change of reflection structure, the distortion, bifurcation and merger of event axis are very obvious. The fault track can be directly drawn and small faults can be identified by using the changes of upper and lower strata. The existence of faults is often not isolated, and the upper. The lower strata will change accordingly. For large faults, the fault horizon is very obvious and easy to explain; For small faults, this corresponding change of upper and lower strata also exists, but it is not obvious.

The seismic section is locally enlarged to explain the small changes of small faults and stratigraphic occurrence; Overall reduction is used to explain the overall change of large faults and stratigraphic occurrence Multiple adjacent sections are used to analyze and determine the fault. When a suspicious small fault is found in the process of fault interpretation, it is compared with the adjacent survey line, and whether there is a fault in the adjacent section is used to judge whether there is a fault. Make full use of the flexible display function of the interpretation system. According to the actual situation of the interpretation horizon, the display mode can be changed, such as changing the gain, changing the vertical and horizontal proportion, etc. Making full use of coherent body recognition technology, coherent body analysis has played a key role in solving geological problems such as faults, fractures and lithology changes in recent years. It is the core technology of fault interpretation [3].

At present, the development of coherent body technology has mainly experienced three stages. The first stage, similarity coherence; In the second stage, the inclination, slope and azimuth are coherent; The third stage is eigenvalue coherence and volume perspective. In terms of fault function, it evolves and develops from identifying large faults to small faults. The principle of eigenvalue coherent volume technology is complex, but in general, it is still to calculate the dip value at each sampling point in the vertical and horizontal directions of seismic data volume by analyzing the correlation between channels to form dip data volume, Then, the partial differential equation is transformed from vector domain to scalar domain, which is similar to the three-dimensional data volume of sequence field composed of infinite interpretation horizons composed of sedimentary sequence information, so as to provide detailed sequence information for the production of low-frequency model.

Sandstone gas reservoirs are widely distributed in various types and have great potential Sulige gas field in Ordos Basin is a typical low permeability tight sandstone gas field with the characteristics of low permeability, low porosity and low abundance The stacking mode of effective sand bodies in the reservoir of the gas field is complex, the reservoir thickness is thin, and the resolution of seismic data is low; Large spatial variation of lithology and strong reservoir heterogeneity; The wave impedance of sandstone is close to that of mudstone after gas bearing, so it is difficult and multi-solution to use conventional P-wave technology for effective reservoir prediction (advantage) multi wave seismic data increases the S-wave information collected by multi-component geophone. Non AVO fitting S-wave reflects the rock skeleton information and generally does not change with the change of fluid Compared with traditional P-wave exploration, multi wave seismic exploration technology has outstanding advantages in the following aspects: improving structural imaging under fault, salt and gas reservoir; Oil and gas detection; True and false flat points, highlight analysis; Lithology prediction, fracture detection, estimation of formation lithology, porosity and anisotropy analysis Therefore, the combined application of P-wave and S-wave data has more advantages for reservoir prediction than a single conventional P-wave (current situation at home and abroad) in foreign countries, multi wave data have seen good exploration and development results in the North Sea of the United Kingdom, the Gulf of Mexico of the United States and Alberta of Canada In recent years, multi wave research has also been carried out in many oilfields such as Daqing Oilfield, Qinghai Oilfield and southwest oil and gas field. Multi wave data has also achieved obvious results in lithology prediction, gas bearing enrichment area prediction and fracture prediction Compared with foreign multi wave seismic technology, there are still gaps in petrophysical research, joint interpretation and inversion of three-dimensional multi wave data, reservoir prediction and so on

In order to stabilize the estimation process of dip volume, additional smoothing and a function of depth are used as constraints in the calculation process. Then, according to the calculated data volume, operations such as slicing along the layer, volume perspective slicing and coherent slicing along the layer can be carried out, so as to guide the identification and judgment of small faults and assist in the determination of the strike and tendency of small faults. Coherent data volume is the estimated value of three-dimensional seismic coherence. Seismic channels near the fault usually have different seismic characteristics from adjacent props, so there will be sudden changes in coherence between local channels. On the slice of coherent data volume, regular low coherence values near the fault plane can be obtained, which can truly reflect the distribution law of faults. Coherent body can well establish the overall structural pattern and the distribution characteristics of controlled faults on the plane, and the rationality of faults can be checked after interpretation.

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The well seismic correlation model is established through the location relationship between well and fault and the location relationship between well and fault plane. Based on the well seismic correlation model, using the obvious dislocation of the same phase axis on the seismic profile, the position of the fault plane can be roughly determined through the dislocation relationship between the upper and lower same phase axes, so as to determine the existence of the fault, the horizon through which the fault passes, the strike and extension direction of the fault, vertical fault offset, dip angle and other information; The location and distance of breakpoints on the well can be accurately determined on the logging curve. Synthetic seismic record is a bridge between logging and earthquake. Through synthetic record, the well is accurately projected on the seismic profile, so that the information on logging can be organically matched with the fault information on earthquake, which can be verified interactively and repeatedly. After determining the attributes of the fault through the combination of well and earthquake, the spatial distribution and plane distribution characteristics of the fault in the study area are finally obtained after interactive comparison and repeated modification with the previous research results.

4 New understanding of faults from seismic data

Reservoir structure and sedimentary characteristics, 3D seismic geological fine interpretation technology, fine structure interpretation, sand body and reservoir prediction and Application Research of seismic interpretation results in development, the following understandings and results are obtained: structure in the study area is a dome anticline with gentle dip angle, the structural axis, and the long axis of the structure is 46km and the short axis is 23km There are 17 faults in the oil-bearing area of the whole oilfield, all of which are low angle normal faults. The fault dip angle is generally 40 ° ~ 50 °, and the fault strike is mostly NW The deposition of Pui oil formation of oil layer belongs to the sedimentary system in the north of Songliao basin. The lithology of the lower part gradually coarsens from 11 to 10 small layers, and the thickness of single sand layer becomes larger. To the middle part, 9 to 6 layers are mainly massive superimposed sandstone, the lithology of the upper part gradually becomes thinner from 5 to 1 layers, and the thickness of single layer of sand body becomes thinner [4].

The seismic interpretation is basically consistent with the original understanding of the strike of large faults, but the development of faults interpreted by 3D seismic data is more real and complex; The interpretation changes of small faults are relatively large.

In the study of small faults, the main difference between seismic interpretation and original understanding of faults lies in small faults. Since the infilling and adjustment in the Northern Development Zone of the oilfield, the recognition of faults has gradually deepened and the recognition results have been refined. At present, the occurrence and shape of large-scale faults have been basically determined, but the understanding of small offset faults is not accurate and perfect. Under the guidance of seismic interpretation faults, the formation principle and distribution characteristics of the remaining scattered small breakpoints after the combination of large faults are systematically analyzed. Through the three-dimensional display of breakpoint data in the modeling software and the analysis of structural cross-section, the best combination method of small fault distance breakpoints is discussed, so as to more accurately identify small faults and draw the actual data map of faults

Associated small faults produced during the formation of anticlines. In the process of anticline, a series of faults with different sizes and occurrence are associated, among which some faults with relatively small scale are mostly distributed between the two wings or some large faults in the core of the anticline, which are similar to the occurrence and shape of large faults, but the extension range and fault distance are small. Most of them do not intersect with large faults and are limited by large faults, The formation period of these small faults is later than that of large faults.

The formation modes of small offset faults can be divided into two types: associated small faults generated in the formation of anticlines. In the process of anticline, a series of faults with different sizes and occurrence are associated, among which some faults with relatively small scale are mostly distributed between the two wings or some large faults in the core of the anticline, which are similar to the occurrence and shape of large faults, but the extension range and fault distance are small. Most of them do not intersect with large faults and are limited by large faults, The formation period of these small faults is later than that of large faults. Derived small faults generated during the formation of main faults. In the same period or later stage of the formation of large faults, due to the up and down dislocation of the two walls of the fault, the internal stress field in a certain area changes, resulting in a series of derived small faults and small folds. Such small faults are mostly located in shallow strata. Most of them are concentrated near the main fault on the plane, sometimes in groups, and most of them are connected with the main fault on the section.

A new example of small fault breakpoint combination was identified in the earthquake. The 78# fault located in the study area is composed of 228 breakpoints of new and old wells, with a fault distance of 1.0 ~ 73.0m, and the horizontal extension length of SA2 group is 3200m, belonging to the large fault developed in the early stage. The number of breakpoints is large, and the size difference of break distance is obvious. According to the seismic interpretation results, a new derived small fault is found at the tail of 78# fault, which forms a "herringbone" shape with 78# main fault and is temporarily named 781#. It is analyzed from two aspects: 3D geological structure modeling and display of scattered breakpoints and attributed breakpoints and structural section 781#.

According to the original understanding of the fault, the breakpoints of the four wells located near the 781# small fault are classified as the 78# main fault section, while from the three-dimensional display of structural modeling, it can be seen that the breakpoints of the four wells are not on the 78# main fault section, and the breakpoints of the four wells can be combined into another fault plane as the derivative fault of fault 78, that is, the 781# small fault section [5].

From the analysis of the seismic interpretation profile, according to the fault shape interpreted by the seismic profile, when combining the breakpoints on the well, it is suspected that a well located in the hanging wall of the fault should be broken at the top of Sa 2. Only after the combination can the fault shape be consistent with the fault shape interpreted by the earthquake, but the existing breakpoint library has no breakpoints displayed here. After re comparison, it is found that there is a fault at the depth of 941.6m and the fault distance is 1.6m in the lower part of sii1 + 2 of the well. Because the break distance is too small, this breakpoint is ignored in the comparison of electric measurement curves. Recognizing the breakpoint again reasonably verifies the 781# small fault of seismic interpretation.

Based on briefly presenting the basic principle of 3-D seismic volume visualization, this paper gives us some results using the kit of Open Inventor of SGI. The results include four aspects:

One is the rendering of three kinds of slices (Inline, Xline and horizontal one);Second is translating, rotating and scaling the slice geometry image; Third is we can change color and transparency from seismic data in order to reach some kinds of effect; The last is the realization of seismic movie. Additionally, the results mentioned above are encapsulated into ActiveX control with ActiveX technique and this control is imported into PowerPoint. So we can render the seismic data and have control of rendering as we want in geological report application.

The combination of breakpoints under the guidance of seismic interpretation should be reassigned to scattered breakpoints in the three-dimensional display of modeling software; In the structural profile, when the reconstructed fault is inconsistent with the seismic interpretation, it is necessary to re compare the small layers of the electrical logging curve and re understand the breakpoint. If the previously interpreted breakpoint is correct, it is necessary to re interpret the fault and confirm that the fault finally belongs to the combination.

5 Conclusion and understanding

Reservoir development is an important part of the work of oilfield enterprises, and the application of seismic exploration technology plays a very important role in finding favorable reservoirs and efficient reservoir development Seismic data interpretation is an important part of seismic exploration technology, and 3D seismic data interpretation technology is an interpretation method and technology for 3D data volume. It can more truly, accurately and clearly reflect various geological information of underground strata, so that oilfield developers are looking for small sand bodies and small amplitude structures, Small fault block reservoirs and various complex and subtle reservoirs have played an important role in greatly improving the development efficiency.

(1) Improve the well seismic combination technology and give full play to its advantages between wells. Understand the occurrence and morphological development complexity of larger faults more clearly, and accurately identify small faults that block the reservoir.

(2) Under the guidance of seismic interpretation of faults, through the three-dimensional display of data in modeling software and structural profile analysis, combined with dynamic verification, small faults can be identified more accurately, and then the actual data map of faults can be drawn to guide the development and dynamic analysis of oil fields.

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