Research on Technical Difficulties and Countermeasures of Well-Seismic Combination Unit-Level Tectonic Modeling

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Abstract: Compared with the previous reservoir modeling, the well-seismic combination sedimentary unit level structural modeling is faced with problems such as large amount of data, difficulty in data loading, a large number of inclined wells, causing serious structural distortion, and the local morphology of the fault needs to be accurate to the unit level. In view of the above difficulties, this paper systematically introduces the corresponding countermeasures to solve the corresponding problems. The built model can characterize the unit level structural characteristics with high accuracy, and can guide the fine adjustment and exploration of the sedimentary unit level scale.

Keywords: Structural modeling, sedimentary unit, well-seismic combination.

1. The raising of the question

The study area has entered the ultra-high water cut stage, and the remaining oil is scattered, and the fault edge is the favorable part for remaining oil excavation [1-3]. In order to fully tap the remaining oil at the fault edge and clarify the injection-production relationship at the sedimentary unit level, the well-seismic combined with unit-level structural modeling research has been carried out since 2018.

Different from reservoir group-level modeling, well-seismic integrated sedimentary unit-level modeling is faced with many problems, such as many wells, many layers, large amount of calculation, the scale of fault feature needs to be raised to the unit level, and high structural accuracy requirements. In order to ensure the quality of the model and meet the development needs, the research on the technical difficulties and countermeasures of unit-level modeling is carried out.

2. Technical difficulties and solutions

Compared with reservoir modeling, sedimentary unit-level modeling has four major technical difficulties (Table 1).

Table1 Modeling Technical Difficulties, Countermeasures and Objectives

Number	Technical difficulties	Countermeasures	Targets
1	Inaccurate inclined well data leads to severe structural deformation	Azimuth correction Trend control	Restore the reasonable structural shape of inclined well
2	Large data volume Difficulty loading	Batch loading Dilution treatment	Establish the overall work area
3	The accuracy of fault characterization requires Promote to unit level	Well seismic fault point matching Unit boundary control	Accurate description of the fault Three-dimensional distribution shape
4	Multiple and thin units Adjacent layers are easily intersected	Stepwise constraint Thickness control	Trend of layer model Reasonable and non intersecting

(1) Inaccurate inclined well data leads to severe structural deformation

In practice work, the stratification point of inclined wells often differs greatly from the stratification trend of surrounding wells, which causes the distortion of the structural surface around inclined wells. It may be affected by the data acquisition time, instrument

difference, data processing and other factors. Therefore, it is necessary to correct the well deviation data.

The first is azimuth correction, which mainly aims to restore the reasonable position of the plane of the stratification point of the inclined well.

During the drilling process, measuring instruments measure the depth, inclination, and azimuth of each measuring point in the well trajectory. The measurement instruments of azimuth are mostly fluxgate and gyroscope[4-5]. The measurement of well inclination azimuth is usually carried out by magnetic measurement instruments, and the measured azimuth is based on the magnetic north position.

When using non-magnetic measuring instruments such as gyroscopes, the measured azimuth is based on the true north azimuth. However, because the orbit design and trajectory calculation of the directional well are both based on the Gaussian projection coordinate system, which is based on the grid north position. So it is necessary to convert the measured magnetic north as the reference for the azimuth angle of the well deviation into the azimuth angle of the well deviation based on the grid north position. This work is called "azimuth correction" and is referred to as "azimuth reference frame conversion" abroad.

Through the establishment of the model, it is shown that when the local dip angle exceeds 5°, for the directional well with a horizontal displacement of 400 m, if the magnetic azimuth angle correction is not considered, the well trajectory deviation in the X direction is 46.6m, and the deviation in the Y direction is 64.75m [6]. Therefore, it is necessary to carry out the correction work. According to the actual working situation, the correction angle in the research area is generally 10.33°.

The second is to correct the inclined well and restore the reasonable form of the structure.

The structural trend surface method is mainly adopted for correction, that is, the correction amount of inclined well coordinates is determined by analyzing the difference between distorted structural surface and reasonable structural trend surface, so as to further modify the inclined well trajectory (Fig.1, Fig.2).

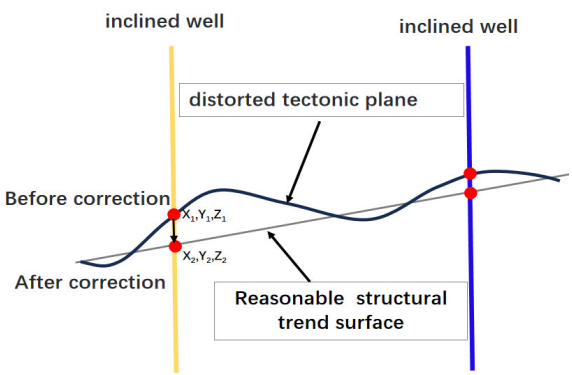

Fig. 1:Schematic diagram of correction principle

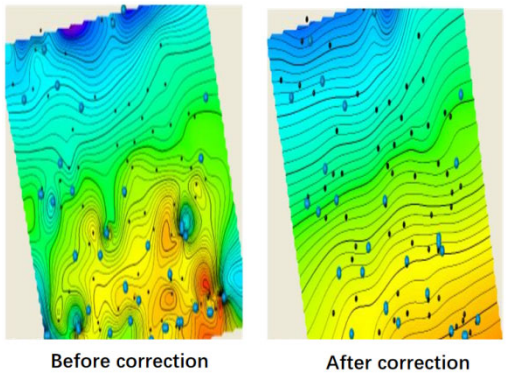

Fig. 2: Structure comparison diagram before and after correction

(2) Large data volume, difficult to load

In the study area, about 102,375 files were used in modeling, and the total number of record points exceeded 100 million, which is a hundred times of the data volume of reservoir group levelmodel. Therefore, we adopted the method of batch loading and thinning processing to reduce the pressure of large data volume and establish a unified overall work area.

One is to break it into pieces and load it in batches.

There are 17,708 wells of all types in the work area, which are loaded in 9 batches, improving the efficiency of the software operation.

The second is to conduct thinning processing on the well deviation data.

The interval of well deviation data measurement is 0.05m, and the record points of each well reach more than 20,000, which means that the record points of more than 17,000 wells reach the level of hundreds of millions, This is a great test for software and hardware. In view of the situation of excessive data volume and difficult loading, under the premise of ensuring accuracy, data extraction is processed, and the original 0.05m interval is extraction to 5m interval, which not only ensures data accuracy, but also ensures the running speed.

(3) The fault characterization accuracy should be improved to the unit level

Compared with reservoir group-level fault modeling, unit-level fault modeling requires more detailed depiction of local fault morphology. In the past, reservoir group-levelfault modeling mainly controlled the overall morphology of faults, focusing on matching breakpoints near the top surface of the oil layer group and those with larger fault spacing with the cross-section. However, it did not achieve accurate depiction of the internal morphology of faults in the oil layer group. Therefore, the trend surface display of reservoir group-level fault morphology can meet the needs. However, for the sedimentary unit-level fault morphology, the main fault point and the accessory fault point must be clearly defined, and the main fault point and the fault must be strictly matched. On this basis, it is further considered whether the unit boundary points on both sides of the fault belong to the correct fault hanging wall or footwall, and the section position is adjusted according to the structural drop between well points. Only by meeting the requirements of strict matching of the main fault point and the section and the

unit-level boundary point belonging to the correct fault plate can the section morphology be accurately depicted to the unit level (Fig. 3,Fig. 4)

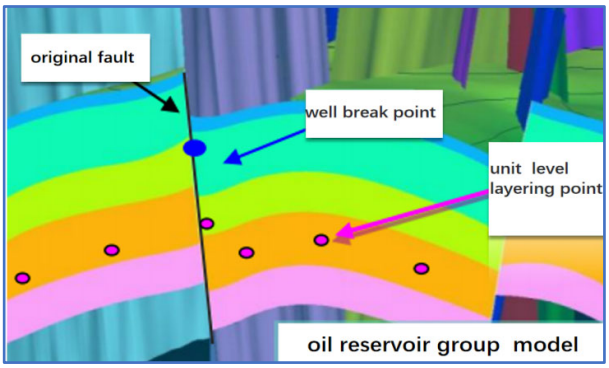

Fig. 3: Location of stratification points and layer morphology before constraint of main break points

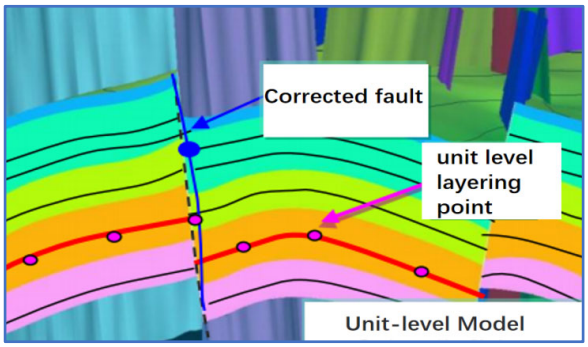

Fig. 4: Location of stratification points and layer morphology after constraint of main break points

（4） Multiple and thin units, with adjacent layers easily intersecting

There are many subdivision layers in the study area, and 195 sedimentary units can be subdivided vertically, the thinnest sedimentary unit measured thickness is less than 1m. When establishing the unit level model, adjacent layers without well control between wells are very easy to cross each other. In view of this difficulty, on the basis of well vibration combined with simulated tectonic trend constraints on the top surface of the reservoir group, the unit level modeling is established by using the method of stepwise constraint and thickness control.

3. Application Case Analysis

The establishment of the sedimentary unit-level structural model further improves the refinement of reservoir description, which can effectively guide the refined adjustment of the oilfield to tap the potential.

1. The integrated application of unit structure map and facies zone map has been realized, which can effectively guide the adjustment of injection-production relationship on both sides of the fault;compared with the reservoir group-level faults, the understanding of the injection-production connectivity of 445 injection-production well groups near 59 faults has been changed, and 49 high-efficiency wells in the fault zone have been further realized (Table 2).

Table 2 Statistical Table of Potential for Supplementary Drilling in Fault Areas

project		Number of wells		
		Oil well	Water well	subtotal
water drive	vertical well	15	14	29
	high angle well	8		8
	subtotal	23	14	37
Three mining and supplementary drilling		10	2	12
total		33	16	49

2. Quantifying the distance between logging and fault unit level, further releasing the well distribution potential of large displacement directional wells and complex structural areas;

(1) In the early stage, a total of 27 highly inclined directional wells were implemented to tap potential, with a daily oil production of 9.2t per well in the initial stage. By accurately characterizing the spatial distribution of faults, we have expanded the potential of 8 wells in the already implemented areas (Fig. 5).

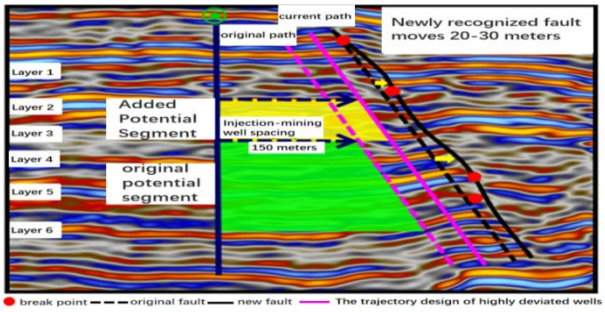

Fig. 5 Principal breakpoint constraint section curvature

(2) Re-recognize the potential of fault block area, and expand the potential of 41 supplementary drilling wells (25 oil wells and 16 water wells) (Fig. 6).

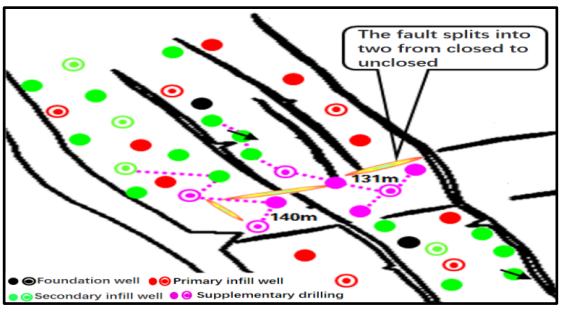

Fig. 6 Supplementary drilling in local area of fault block

4. Some Understandings

(1) Compared with reservoir modeling, four technical difficulties of unit-level modeling are clarified: four technical difficulties of unit-level modeling are clarified: ①the data of inclined wells are not accurate enough, causing serious structural deformation; ②the data volume

is large, and it is difficult to load; ③ the fault characterization accuracy needs to be improved to the unit level; ④the number of units is large and thin, and adjacent units are easy to be intersected;

(2) In view of the technical difficulties, the corresponding countermeasures are formulated. Through azimuth correction, data sampling, batch loading, main fault point constraint surface characterization of fault morphology and step by step constraint, thickness control and other methods, the research goal of establishing the unit-level structural model is realized;

(3) The establishment of the sedimentary unit-level model realizes the integration of two maps, clarifies the unit-level injection and production relationship, quantifies the distance between logging and fault unit level, deepens the understanding of the residual oil potential near the fault, and releases the well distribution potential.

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