Application of research based on fine geology in oilfield development

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Abstract. As the oilfield development enters a high water-bearing stage, the water content of the main oil layer gradually increases, the inefficient and ineffective circulation is serious, and the remaining oil distribution is scattered. It is difficult to select the well and reservoir. Through comprehensive development of high-density 3D seismic work, the study area further elaborates the sedimentary microfacies of the reservoir, making the development of the reservoir and the connectivity between the oil and water wells clearer. At the same time, applying the well-seismic combination technology to the fault understanding, further clarifying the relationship between injection and production, the understanding of the underground situation is becoming more and more clear. Based on the comparison and application of the fine geological research results in the study area, this paper expounds the role of fine geological research results in the remaining oil potential tapping in the extra high water cut period.

Keywords: Fine-geology; Well-seismic-combination; Reservoir-anatomy; Fault; residual-oil.

1. The purpose and significance of fine geological research

The fine geological research method is relative to the traditional oilfield geological description method. It is formally refined to make the research object more detailed than before, but essentially emphasizes the understanding of reservoir characteristics from the cause, from the reservoir longitudinal and plane. The most basic genetic unit is identified to maximize the restoration of the paleo-deposit reservoir prototype. In order to deepen the underground structure and development, high-density 3D seismic work was carried out, and the sedimentary microfacies of the seismic attributes and the single channel sand body division technology were used to improve the inter-well reservoir description accuracy, so that the oil layer development status and between the oil and water wells The connectivity is more clear; at the same time, the faults are accurately described by the well-seismic combination technology, and the small faults between the wells are identified, and the relationship between injection and production is further clarified[1]. On the one hand, the remaining oil of the oil well can be excavated by measures. The targeted adjustment of the wells has broadened the excavation space of the remaining oils, provided a reliable basis for perfecting the injection-production relationship of the fault zone and the fine description of the sand bodies between the wells, and has certain guiding significance for the remaining oil potential in the extra high water cut period.
2. Basic overview of the study area

There are 688 oil and water wells in the study area, including 403 oil wells and 285 wells with a development area of 18.5 km$^2$. The mining horizons are Saertu, Grape Flower and Gaotaizi oil layers, with geological reserves of $13098 \times 10^4$ t and recoverable reserves of $4924.85 \times 10^4$ t. The injection-production ratio is 1:40, and the geological reserve is 40.57.

![Fine geological oil layer distribution map in the study area](image)

**Figure 1.** Fine geological oil layer distribution map in the study area

In the longitudinal direction of the study area, three sets of oil layers, such as Saertu, Grape Flower and Gaotaizi, were developed, and 7 oil layer groups, 27 sandstone groups and 92 sedimentary units were drilled. According to the results of well-seismic combined reservoir description, considering the genetic characteristics of the sand body, the geometric shape, the combination of different micro-phase plane lithology units, the sand body drilling rate, the permeability difference and other factors, by subdividing the sediment in the vertical direction. The distribution characteristics of microfacies and lithologic physical units are described finely on the unit and plane, and divided into four sedimentary facies and four sub-facies[2]. The faults in the study area are relatively developed, the regional structure is relatively flat, the dip angle of the stratum is 1~3°, and the fault is relatively developed. According to the research results of sedimentary unit level structure, there are 49 faults in the oil layer, all of which are normal faults. The strikes are mostly north-northwest, the fault dip angle is 39-81°, the fault extension length is 0.2-2.7 km, and the maximum fault distance is 93.2 m. Minimum breaking distance 0.8 m.
3. Re-recognition of fine geology

3.1. Carry out research on the combination of well and earthquake, and deeper understanding of structure

The well-seismic combination technology is applied to accurately identify various faults. Compared with the original well-seismic combination, the fault strike and dip angles are not changed, the combination relationship and the plane position are changed, and some faults have large changes in the horizon, and the structure is more aware. Clearly, the relationship between injection and production is more clear [3].

The original wells of the Saertu oil reservoir combined with the interpretation of 47 faults, and the present fine structure explained 45 faults, of which 4 faults were merged into 2, 1 fault fragmentation was 2, and 1 new fault was added; Interpretation of 36 faults, the current fine structure explained 44 faults, of which 4 faults were merged into 2, 1 fault fragmentation was 2, and 1 new fault was added; the Gaotaizi oil layer original well earthquake combined with the interpretation of 27 faults, now fine The structure explained 33 faults, of which 4 faults were merged into 2, 1 fault was broken into 2, and 7 new faults were added (Fig. 2). Through the completed fine interpretation of the sedimentary unit level, using the fine contrast of the seismic section, the well breakpoint is strictly controlled, and the length and plane position of the fault plane of the study area are finely adjusted. Compared with the original sandstone group-level structural interpretation, the following changes are made.

First, the plane change: the length and position of the 9 fault planes change, the maximum extension length of the fault is shortened from 2.9km to 2.7km; the four faults are merged into two faults; one fault is split into two faults.

The second is the longitudinal change: the longitudinal change mainly refers to the change of the fault layer of the fault. Through the interpretation of the fine structure of the deposition unit level, the fault layer is lost to the small layer. After reinterpretation, a total of 16 faults were changed. Taking the 74-2# fault as an example (Fig. 1-2), the original 74-2# fault is lost in the S, P, and G oil layers. After the fine structure is explained, the fault is lost to the SI1-PI5+6 layer.

3.2. Finely dissect various reservoirs and deepen understanding of reservoir configuration

Through the fine anatomy of the reservoir under the condition of the well network in the study area, the reservoir microfacies of 92 sedimentary units were finely characterized, and nine sedimentary models of I, II and III reservoirs were established to define the internal configuration of the braided river. The subdivision of the water diversion channel dam sand body and the underwater estuary dam deposit is subdivided, and the reservoir understanding is clearer.

The Portuguese I3 sedimentary unit in the study area belongs to the fine-grained sandy braided river sediment. The main feature is the development of large-scale braided waterways and heart beaches. The river channel is wide and shallow, and the sand body thickness is 4-9 m. The stability is poor, the braided channel is divided into a network by a diamond-shaped or a spinning-shaped heart beach, and the plane is in a north-south direction. The sand body develops a cross-layered layer of 2 to 10 cm.
the sedimentary characteristics, sand body anatomy, curve shape recognition, etc., refine the four sedimentary microfacies of the heart beach, the braided channel, the overflow sand and the inter-channel mud; at the same time, the sand body anatomy of the six unit sedimentary units such as Sa II1+2b and Sa II7+8a, combined with logging The curve clearly identifies the microchannels of abandoned rivers, identifies the side-point dams, and re-recognizes that the six sedimentary units in the study area belong to the sediments of large-scale water-distributed river channels. The river channels are distributed in a near-south-north direction, and the sand bodies are large in scale and single channel sand bodies. The stacking, the internal dam and the abandoned river channel are developed; in addition, the sedimentary environment of the sedimentary units of the Gaotaizi oil layer is deepened, and the I+3b, high I4+5, high I6+7 and high I8 deposition units are identified in the Gaotaizi oil layer. The estuary dam deposits, and the high I1+1, high I3, and high I4+15 sedimentary units identify the underwater distributary channel sediments in the delta inner front, and identify the delta in the high I1+2b and high I12+13 sedimentary units. Yuanyuan sand dam The product has updated the geological understanding of the estuarine dam and the high I9 unit below the development of the delta outer leading sand body, which provides a reliable basis for the remaining oil potential.

4. Application of fine geological research results

4.1. Defining the connection between wells and guiding the adjustment of wells

It can be seen from the well map of the 55# fault zone that the original 55# fault separates the production well A1 from the injection well, and the oil well A1 belongs to the condition of no injection. However, from the historical monitoring data of Well A1, the formation pressure of the well is gradually increasing, indicating that there is an injection well to supplement the energy of the well. In addition, from the case of the tracer in the A2 well group, the tracer was found in all the monitoring wells of the SI4+5(1)~SI4+5(3) section of the A2 well group, of which the A3 well and the injection well were On the same side of the fault, the A1 well is on the other side of the fault, and the oil-water wells are connected from the dynamic angle. With the improvement of the seismic interpretation accuracy, the 3D earthquake re-recognizes the 55# fault, indicating that the 55# fault intermediate part Elimination, static data prove that oil and water wells are also connected.

Figure 3. Fine geological research results analysis fault

At the same time, combined with the newly explained sedimentary facies map, the development and connectivity of the oil and water wells are carefully analyzed. After comparison, the sand deposits are developed in the original sedimentary facies map of the A2 well in the SI2 small well, and the well A1 in the well is developed. In the main body-like sand deposit, in the new sedimentary facies map, the A2
well develops the main-seat sand deposit, and the A1 well develops the mat-like sand deposit. In the SI3 small-layer well A2, the original sedimentary facies belt map shows the formation of braided sand deposits, and the well A1 well develops the sand-like sediments. In the new sedimentary facies belt map, the A2 well develops in the river channel, and the A1 well develops the main-seat sand deposit. From the comparison before and after, it can be found that the new sedimentary facies map shows the outer reservoir of the oil-water well in the middle interval, and the connectivity of the oil-water well becomes worse. In the SI4+5 small well water well A2, the original sedimentary facies belt map develops the sand-like sedimentation, and the well A1 well develops the non-main body-like sand deposit. In the new sedimentary facies map, the north 2-21-426 well develops on the edge of the river. The A1 well develops the main body sand deposit. From the comparison before and after, it can be found that the connectivity of the oil and water wells is getting better. Through the combination of dynamic and static, the relationship between injection and production is further clarified, so that we can make targeted adjustments to the well A1. Combined with the new understanding of fault and sedimentary facies maps, it is decided to subdivide the A2 wells, alleviate the inter-layer conflicts, and subdivide the original SI1~SI4+5(3) intervals into SI1~SI3(3), SI4+ 5 (1) ~ SI4 + 5 (3) two layers, and simultaneously raise water, the corresponding water is also raised for SI4--SI5+6, the whole well water volume is increased from 30m³ to 70m³, from the effect before and after the adjustment, the oil well A1 daily oil production increased by 0.4t. In addition, as the well pressure in the well is gradually increasing, in order to further enlarge the production pressure difference, the well is pumped up, and the daily oil is increased by 3.5t compared with the data before and after the pump change, and a better oil-increasing effect is obtained.

4.2. Defining the fault distribution, guiding measures to tap the potential

Using the well-seismic combination technology, the No. 81 fault is re-recognized. The extension length of the 81st fault in the southeast direction of the Portuguese group 2 is shortened. The fault near the A4 well is broken into two unconnected faults, which are closer to the original fault. The A4 low-efficiency well cannot be treated with stimulation measures. Through the re-recognition of the fault, the well and fault distance have the space for reform; at the same time, combined with the results of fine geological research, the re-anatomy of the interfacial sedimentary microfacies. In the PI18+9 sedimentary unit, the river channel is distributed in the shape of a scorpion and a branch. The internal structure of the sand body is better. The inter-river sand body is distributed along the river channel, and the connection is good. The outer reservoir is distributed in pieces, the thickness is thin, and the connection is poor. A sporadic tip-out zone is exposed in the sand between the rivers. The former A4 well was developed as a sand-sand sediment. The new results of the well-seismic combination indicate that the A4 well is located at the edge of the river. The surrounding new wells are shown as medium-low flooding, and the oil-water wells are connected in the second type.

![Figure 4. Fine geological study of fault areas and oil and gas production](image-url)
The GI4+5 sedimentary unit is from the original. The sedimentary facies map explains that the well is mainly developed with more than one meter of sand-like sand deposits, connected with the braided channel sand, and the river sand is highly flooded. After re-recognizing the sedimentary unit, the sedimentary facies sand around the well has a larger change. The adjacent braided channel sand body is not developed, replaced by a strip-shaped channel sand body, and the well is separated from the surface of the reservoir. The location of the well belongs to the river channel deterioration, with a certain amount of remaining oil. By analyzing the low-efficiency cause of the well and combining with the new understanding of the sedimentary facies map and the distribution of remaining oil, it is considered that there are residual water in the river and the residual oil in the narrow river channel, and it is determined that the well is multi-cracked. The three-stage PII8+9-GI4+5(1), GI17-18-GI18-19, GI1+2-GII10 have better fracturing effect, the daily production liquid increases by 42.6t in the initial stage of fracturing, and the daily oil production increases by 5.1t. The water content decreased by 3.21 percentage points.

Because some wells in the fault zone cannot be modified, the new results of fine geological research are applied, and the injection-production relationship and connectivity of oil-water wells are analyzed in detail, so that some low-yield and low-efficiency wells that did not meet the fracturing conditions have fracturing potential and new results of fine geological research provide new potential directions and strong technical support for the treatment of low-yield and low-efficiency wells in fault areas.

5. Conclusion
(1) The results of fine geological research provide a reliable basis for re-recognizing reservoir sedimentary characteristics, finely characterizing reservoir sedimentary microfacies and tapping potentials for oilfield development.

(2) The results of fine geological research provide guidance for re-recognizing faults, clarifying the relationship between injection and production, and adjusting the wells in the later stage.

(3) The comprehensive application of dynamic monitoring and static data can verify the rationality of new results in fine geological research to a certain extent.

References
[1] Qian Jie Fu Youchun et al. Application of fine geological research in water injection adjustment. Foreign Oilfield Engineering. (2001).
[2] Hu Yongle, Wang Yanling et al. Adjustment of technical guidelines for the development of high water cut in the water injection field. Petroleum Journal. (2004).
[3] Chen Huijun Wan Xinde et al. New technology and new understanding of Sabei Development Zone in Daqing Oilfield. Petroleum Industry Press. (2003).
[4] Hu Juan. Application of crosswell tracer monitoring technology in Yaoyingtai Oilfield. Science and Technology and Engineering, (2012).