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Application of Multidisciplinary Oil Reservoir Research Technique in Complex Fractured Oil Reservoir -- Taking Xinzhan Oil Field as an Example

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Application of Multidisciplinary Oil Reservoir Research Technique in Complex Fractured Oil Reservoir -- Taking Xinzhan Oil Field as an Example

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Abstract. Xinzhan Oil Field is a complex fractured oil reservoir. Due to the influence brought by natural fracture, after water breakthrough, water content moved upward quickly in those oil wells, thus causing the obvious contradiction between layers and an increasingly high natural decline rate. This paper focuses on the research of fracture distribution and remaining oil, taking geologic model building and numerical modeling as the main research means. By describing regularities of distribution about fractures as well as remaining oil in a quantitative and qualitative way, this paper designs a flexible adjustment scheme aiming at the encryption and injection-production of complex fractured oil reservoir so as to improve the results of oil field exploration.

Key words: Multidisciplinary; Fracture; Remaining Oil; Exploring Potential.

1. Introduction

Xinzhan Oil Field is a complex fractured oil reservoir. Due to the influence brought by natural fracture, after water breakthrough, water content moved upward quickly in those oil wells, thus causing the obvious contradiction between layers. The natural decline rate reached as high as 25.45%. In order to decline the negative influence brought by fractures, Xinzhan Oil Field takes water injection under constant pressure as the basis and overall profile control as the core adjustment countermeasure. Although the natural decline rate gradually declined to 17% after management, it is still relatively high, thus being unable to solve the essential problems existing in oil field exploration. Therefore, this paper is going to take multidisciplinary oil reservoir research technique [1], understand the regularities of distribution about fractures as well as remaining oil and explore the application value of multidisciplinary oil reservoir research technique in complex fractured oil reservoir [2].

2. Study on the regularity of the development of fracture in Xinzhan Oil Field

2.1. The analysis of fracture in conventional log

According to the characters in conventional log in fractured oil field as well as its development in fractures, this paper analyze the development of fractures in sand stone by using microspheres focus with a relatively high longitudinal resolution and difference log response curve with a high resolution acoustic time. When slipping over a fracture of the area of fractures, statistics in microsphere focused



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resistivity log always declines because of fractures [3]; however, high precision compensated acoustic logging will make the statistics larger. By using sampling site, the rate of upward and downward changes can be calculated. By combining the data collected from 15 core wells as well as 47 samples in Xinzhan Oil Field, interpretation chart can be made. Therefore, we can reach the conclusion that the upward gradient value of microsphere focus in Putaohua oil layer is 0.42, while the upward gradient value in interval transit time is 0.18 (Figure 1), downward gradient value in microsphere focus 0.46 and downward gradient value in interval transit time 0.16 (Figure 2).

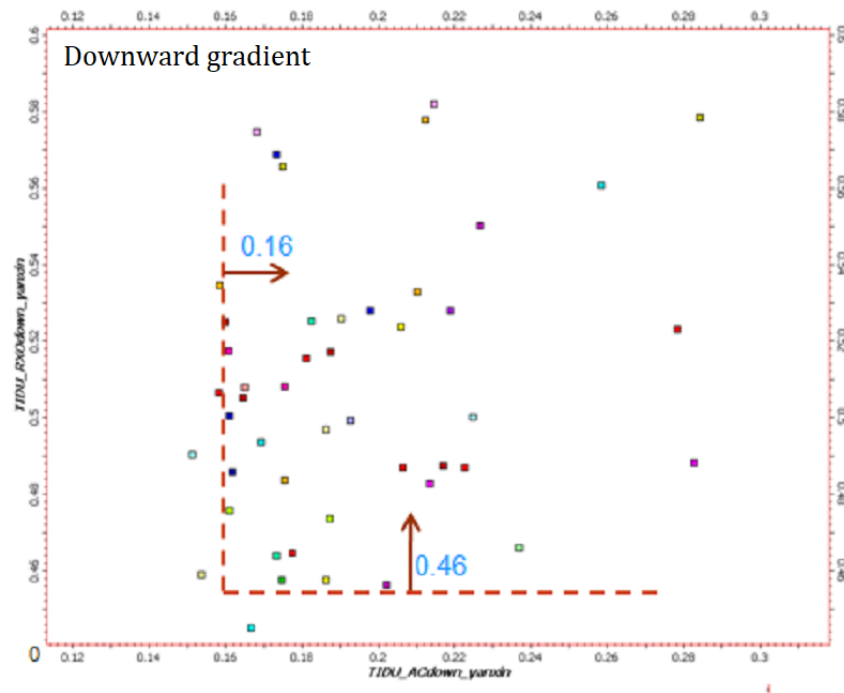


Figure 1. Microsphere focusing and acoustic time difference upward gradient map

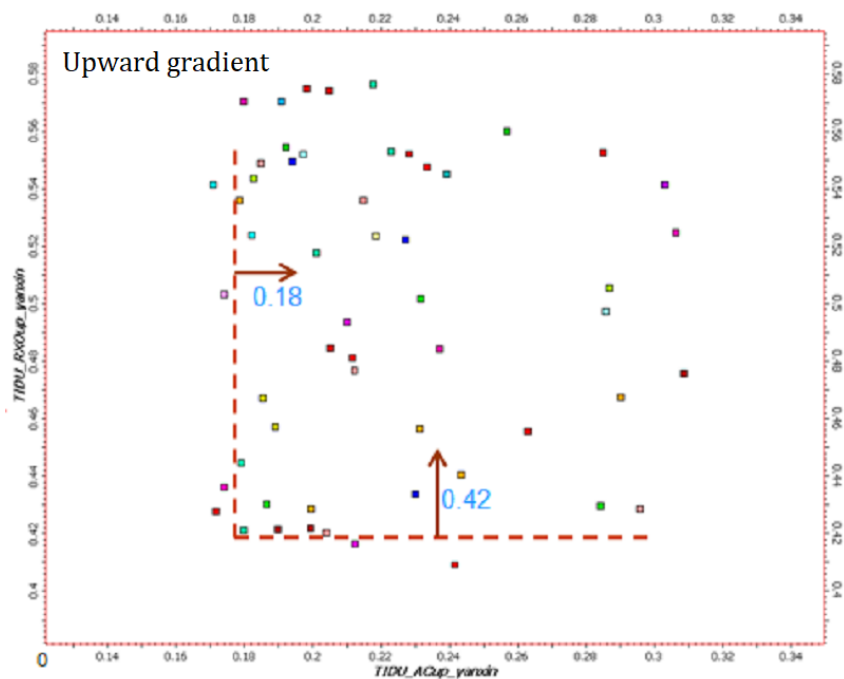


Figure 2. Microsphere focusing and acoustic time difference descending gradient map

With the above methods, 598 wells in Xinzhan Oil Field are all analyzed. The average fracture density is 0.92 point/m. Horizontally, there are most fractures in the axis of anticline, which consists with the results from the organization results drawn from fracture development. Vertically, fractures in sandstone in PI6-2 forms the most fractures, with a statistic of 1.1 point/m.

2.2. Research on Fracture Models

Taking fracture intensity models as an important constraint condition, Petrel helps to set up fracture model modules by designing geometrical parameter, dip angle of fractures, the length and the direction. Accordingly, these are fracture models for 12 sedimentary areas.

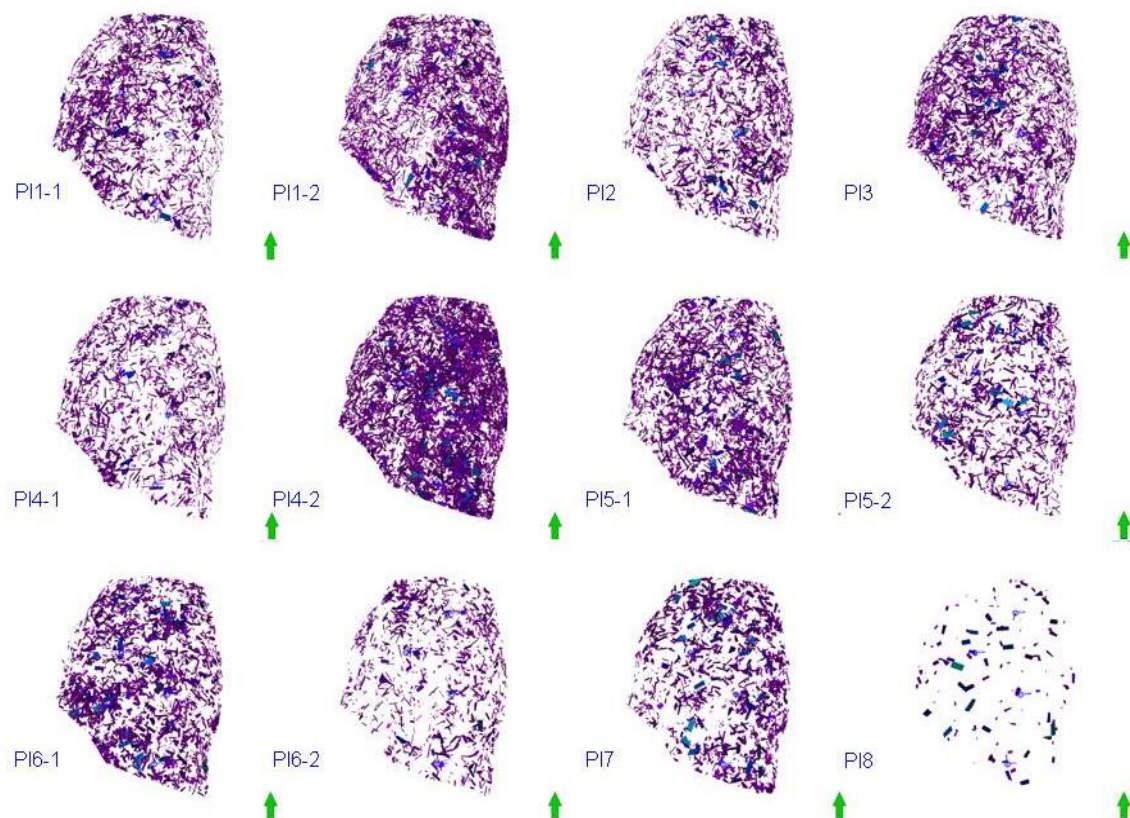


Figure 3. Fracture models of sedimentary units in block W401, Xinzhan oilfield

3. Study on the distribution of remaining oil

3.1. Residual oil distribution in a single well with static and dynamic conditions

The distribution of remaining oil was analyzed by combining dynamic and static analysis with residual oil. The first is to calculate the geological reserves of each sedimentary unit by combining statics and statics; Second, the injection and output of each sedimentary unit can be judged by combining logging curve, fracture development status and dynamic data; Third, the water drive characteristic curve is used to predict the recovery of single sand body and calculate the remaining recoverable reserves; Fourth, drop the remaining oil onto the single well point and single sand body, and draw the distribution map of the remaining oil.

Table 1. Longitudinal remaining oil distribution of sedimentary units in block W401 of xinzhan oilfield

Sedimentary unit	The original effective thickness distribution of the block				Using the differential case					
	≥1.0m	0.5-1.0m	0-0.5m	Sum (m)	≥1.0m	0.5-1.0m	0-0.5m	Sum (m)	Remaining recoverable reserves (10 ⁴)	Percentage of remaining recoverable reserves (%)
PI1-1	22.3	27.3	9.2	58.8	13.2	13.6	2.2	29.0	3.9694	13.1
PI1-2	29.2	37.9	7.9	75.0	20.0	20.5	1.7	42.2	2.3843	7.9
PI2	2.3	22.4	16.9	41.6		15.9	5.8	21.7	2.4561	8.1
PI3	16.0	39.7	9.2	64.9	6.6	22.6	3.0	32.2	2.6899	8.9
PI4-1	4.7	17.0	3.9	25.6	2.4	11.8	1.9	16.1	1.0264	3.4
PI4-2	72.6	41.2	6.9	120.7	45.8	19.2	1.3	66.3	5.7368	18.9
PI5-1	25.7	16.9	9.1	51.7	12.7	13.8	3.1	29.6	2.8399	9.4
PI5-2	9.1	16.7	7.8	33.6	2.8	12.0	1.7	16.5	1.9302	6.4
PI6-1	50.8	14.4	5.0	70.2	15.3	9.0	0.7	25.0	3.8087	12.6
PI6-2	18.5	17.6	7.4	43.5	8.4	6.5	2.3	17.2	1.9401	6.4
PI7	19.0	14.8	3.9	37.7	12.8	5.9	2.2	20.9	1.4976	4.9
Sum	270.2	265.9	87.2	623.3	140.0	150.8	25.9	316.7	30.2791	

As can be seen from table 1, the remaining oil in block W401 is mainly distributed vertically on PI1-1, PI4-1 and PI6-1, and the remaining oil in the three sedimentary units accounts for 44.6% of the total well.

Table 2. Table of plane distribution of remaining oil in putaohua layer in block W401 of xinzhan oilfield

Distribution type	Single layer original effective thickness range (m)			Original effective thickness		The remaining recoverable reserves		Distribution unit
	≥1.0	0.5-1.0	0-0.5	Sum (m)	The proportion (%)	Remaining recoverable reserves (10 ⁴ t)	The proportion (%)	
Scattered distribution	51.3	66.1	23.0	140.4	22.53	10.2545	26.03	PI4-1, PI5-2, PI6-2, PI7
Local distribution	146.3	158.6	57.3	362.2	58.11	23.2528	59.02	PI1-1, PI1-2, PI2, PI3, PI5-1, PI6-1
Large-area distribution	72.6	41.2	6.9	120.7	19.36	5.8876	14.95	PI4-2
Sum	270.2	265.9	87.2	623.3	100	39.3949	100	

As can be seen from table 2, the remaining oil in block W401 is mainly distributed in the PI4-2 deposition unit.

3.2. Numerical simulation of residual oil distribution

The numerical simulation results show that the residual oil distribution is mainly affected by the fracture and the reverse nine-spot water injection mode, and the residual oil gradually increases from the injection well to the oil well, and there is an accumulation zone of residual oil in the oil well row and row. From the oil saturation figure (Figure 9), seven sedimentary units in block W401, including PI1-1, PI1-2, PI2, PI3, PI4-2, PI5-1 and PI6-1, have high oil saturation and large remaining geological reserves,

which are the main objects of encryption and adjustment. Although the remaining small layers also exist residual oil rich area, but the area is small.

4. Conclusion

On the basis of reservoir fine description, fracture distribution rule qualitative and quantitative description and residual oil distribution rule research, according to the formation reason of residual oil, carry out the demonstration research of five modes, select the irregular infilling and injection and production system adjustment mode, and work out the infilling and adjustment plan of the north block of xinzhan oilfield.

First, in view of the residual oil formed by the east-west fracture development in the local area, the interlayer and plane conflicts between the fractures, the infill Wells were deployed in the residual oil rich area in the lateral direction of the fractures, and at the same time, the fractures were transferred into wells, forming a linear injection well network with local small row spacing and large well spacing. 29 infill wells were distributed, and 15 wells were transferred; Second, regarding the development of sand in the local south-to-north channel, the injected water rapidly enters along the hypertonic belt of the main channel, resulting in water breakthrough and flooding of oil wells in the direction, The residual oil formed by the lateral variation due to the plane contradiction is used to deploy the infill wells in the residual oil rich area, and the water-flooded wells in the main channel are transferred to improve the efficiency of oil wells on both sides, 11 infill wells were distributed, and 3 wells were transferred; Third, regarding the remaining oil formed by the poor efficiency of water injection, the irregular infilling injection and production system was adjusted, and 58 infilling wells were distributed and 14 wells were transferred; Fourth, according to the distribution of remaining oil at the well point and the production status of oil and water wells in the well group, the high water-cut oil wells around the infill wells were transferred, 13 infill wells were distributed, and 5 wells were transferred; Fifth, in areas where reservoir development is stable and fractures do not develop, single well single poor production, remaining recoverable reserves and large remaining geological reserves, it is preferred to select the horizontal well infilling method, 5 infilling wells are distributed, and 3 wells are transferred.

The remaining oil in block W401 of xinzhan oilfield is mainly distributed in three sedimentary units, PI1-1, PI4-2 and PI6-1. Planar residual oil distribution is dominated by local distribution type and large area distribution type.

On the basis of reservoir fine description, fracture distribution rule qualitative and quantitative description and residual oil distribution rule research, according to the formation reason of residual oil, 116 infill Wells were distributed in xinzhan oilfield, including 111 vertical wells, 5 horizontal wells and 40 transfer wells.

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