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Research on Fine Reservoir Description and Comprehensive Treatment Technology of G271 Chang 8 Reservoir

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Abstract

The G271 reservoir in JY Oilfield is a typical ultra-low permeability reservoir with poor physical properties, strong heterogeneity, and well-developed fractures. On the basis of the detailed description and research of the oil reservoir, we deepened the understanding of reservoir characteristics, analyzed the causes of problems, and put forward corresponding countermeasures, which achieved certain results, improved the level of reservoir development, and explored a set of stable production technology suitable for the G271 Chang 8 reservoir. Series: One is to continuously fine-tune the injection-production regulation, rationalize the injection-production parameters, and make the injection-production ratio within 2.0 through numerical simulation and mine practice; Microspheres, continuously alleviate the contradiction between plane and profile; thirdly, for plugged wells, temporary plugging fracturing and temporary plugging acidification show good adaptability, but the treatment of flooded wells still needs to continue to tackle problems; fourthly, to strengthen fracture research and conduct timely development Intensify adjustment, continuously optimize the fracture network relationship, and improve the well pattern adaptability. It is of great practical significance to enrich the development experience of ultra-low permeability reservoirs.

Keywords

Fine reservoir description development characteristics governance countermeasures.

1. Overview of the oil field

1.1. Basic overview

The G271 area is located in the Jiyuan Oilfield. The distribution of the Chang 8 oil layer is mainly controlled by the underwater distributary channel sand body in the delta front. The genesis of the trap is related to the lateral pinch-out of the sandstone and the tight lithology. In the monoclinic background, due to differential pressure As a result of the consolidation, a nose-shaped uplift with small undulations and an axial nearly east-west or north-east direction (uplift amplitude of 10-30m) is formed locally. The main oil-bearing layer is Chang 81, with a burial depth of 2600m, an effective thickness of 9.0m, a porosity of 8.6%, and a permeability of 0.38mD. The original formation pressure is 18.7MPa, the formation crude oil viscosity is 0.626mPa·s, the formation crude oil density is 0.707g/cm3, the original gas-oil ratio is 119.78m3/t, the surface crude oil specific gravity is 0.839, the surface crude oil viscosity is 6.57mPa.s, and the reservoir type is lithology In the reservoir, the original driving type is elastic dissolved gas flooding, the salinity of formation water is 13.29g/L, and the water type is CaCl2 type.

By the end of 2021, the oil-bearing area has been 52.0km2 and the geological reserves are 2670.72×104t.

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1.2. Development Overview

Block G271 has a total of 432 oil wells, 431 wells have been opened, the daily fluid production level is 701t, the daily oil production level is 430t, the daily oil production capacity of a single well is 1.03t, the daily oil production level of a single well is 1.02t, and the comprehensive water cut is 38.7%; the total number of water injection wells is 126 122 wells were opened, the daily injection level was 2086m3, the daily injection per well was 17m3, the monthly injection-production ratio was 19.2, and the cumulative injection-production ratio was 2.01. The oil recovery rate of geological reserves is 0.60%, and the recovery degree is 4.19%.

2. Research on reservoir characteristics

2.1. Research on geological characteristics

2.1.1. Characteristics of sedimentary facies

The distribution of sedimentary sand bodies in Chang 8 reservoir of G271 is controlled by the distribution of provenance and sedimentary system. The sand bodies are mainly underwater distributary channels, and they are mainly distributed in stripes from northwest to southeast on the plane, and the sand bodies are distributed along the distributary channel. Good connectivity. The sand body width of the main belt is 3-6km, and the average thickness is greater than 15m.

The sedimentary microfacies profile shows that the main layer Chang 812-1 and Chang 812-2 microfacies are mainly multi-phase superposition of underwater distributary channels. Plane distribution characteristics of sedimentary microfacies: the provenance direction is NW direction, and the main layers Chang 812-1 and Chang 812-2 develop five distributary channels extending to the southeast, mainly due to the process of water advance and water retreat.

Combined with the fine stratification results: Chang 812-1 and Chang 812-2 sublayers mainly developed underwater distributary channel microfacies and channel flank microfacies, with thick sand bodies and extremely developed massive structures: Chang 811, Chang 811 Sublayer 813 is dominated by interdistributary bay microfacies, and its lithology is dominated by argillaceous siltstone.

2.1.2. Rock and mineral characteristics

G271 Chang 8 reservoir is fine-grained detrital feldspar sandstone. According to the identification data of 24 samples from 6 wells, the reservoir rocks in this area are composed of 33.5% quartz, 29.2% feldspar, and 29.2% detritus. 21.4%, (Table 2-1).

Table 2-1 G271 crumb composition table

block	horizon	Number	number of samples	Crumb ingredient %				
				quartz	Feldspar	cuttings	other	Subtotal
Liu Maoyuan	Long81	6	24	33.5	29.2	21.4	4.1	88.1

The content of interstitials is 10.6%, and the interstitials are mainly kaolinite (2.67%) and iron calcite (2.60%), followed by siliceous (2.15%) and hydromica (1.79%) (Table 2-2).

Table 2-2 Statistical table of G271 interstitial content

block	horizon	Number	number of samples	Filler composition and content %							
				Kaolinite	water mica	Chlorite	iron calcite	iron calcite	iron calcite	other	total

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Liu Maoyuan	Long 81	6	24	2.67	1.79	0.96	2.60	0.02	2.15	0.46	10.6

2.1.3. Pore structure characteristics

From the perspective of pore structure parameters, the Chang 8 reservoir has a displacement pressure of 1.60 MPa, a median pressure of 2.16 MPa, a median radius of 0.18 μm, a maximum mercury injection saturation of 85.67%, a mercury removal efficiency of 32.15%, and good pore-throat sorting. The micro-throat is the main one, and the average coefficient of variation is 0.17.

2.1.4. Reservoir physical properties

The reservoir is highly heterogeneous. The permeability distribution is uneven on the plane, and there is a high permeability layer on the section. The high-value areas of permeability are elliptical and lenticular along the NW-SE or N-S direction, and are not connected to each other, and are mainly concentrated in the central part of the underwater distributary channel (Figure 2-1).

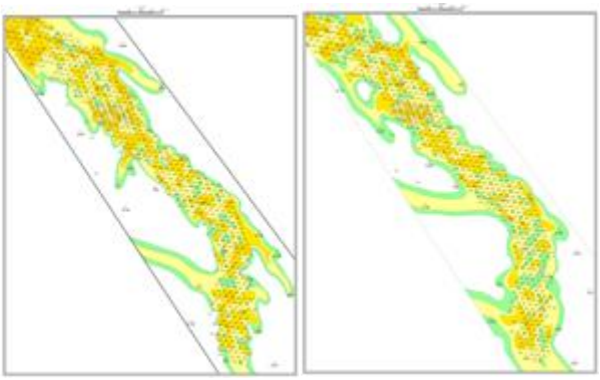

Figure 2-1 G271 Chang 8_1^{2-1}-Chang 8_1^{2-2} Permeability Equivalent Diagram

2.1.5. Fracture characteristics

Imaging logging shows that natural fractures are multi-directional, and the main fracture direction is NW, which is consistent with the water breakthrough direction of the reservoir injection-production reaction. The downhole micro-seismic artificial fracture monitoring shows that there are two groups of fractures in the block. Data such as effective water breakthrough characteristics and dynamic monitoring have verified that the dominant direction of water flooding in the reservoir is NE108°, and secondary fractures are also developed.

2.1.6. Reservoir seepage characteristics

The oil-water two-phase seepage zone in Chang 8 reservoir is narrow, and the oil-phase permeability before the intersection decreases the fastest with the increase of water saturation. The water cut rises quickly and the water-free oil recovery period is short (Figure 2-2).

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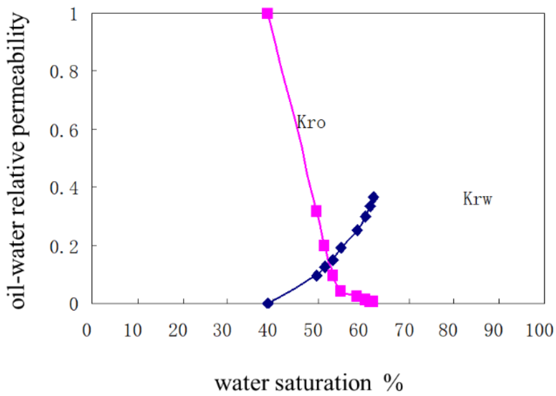

Fig. 2-2 Phase permeability curve of Chang 8 in Well J30-46

2.2. Research on development laws

2.2.1. Law of water flooding

According to the characteristic curve of type A water flooding in the G271 area, the linear relationship between cumulative oil production and cumulative water production is obvious, and the current water flooding is stable through treatment. On the plane: the G245 unit in the northern part of the reservoir mainly has the northwest-southeast dominant direction and the northeast-southwest conjugate sub-dominant direction, the east-west direction of the G269 unit is the dominant direction, and the high-permeability area of the G271 unit well group in the middle of the reservoir is the dominant direction. The effect of fractures exists in areas with complex water flooding directions. Profile: According to the injection profile analysis, the profile is affected by the high-permeability section in the layer, and the water absorption profile is mainly finger-shaped and peak-shaped, and the proportion of uniform water absorption wells is only 35.6%.

2.2.2. The law of pressure change

The pressure in the G271 area remains at a level of 89.6%, and the plane distribution is uneven, showing the characteristics of high in the north and low in the south. Affected by regional physical properties, the southern part of the reservoir has poor physical properties, high pressure in the water injection well, energy accumulation around the water well, and large injection-production pressure difference (Figure 2-3).

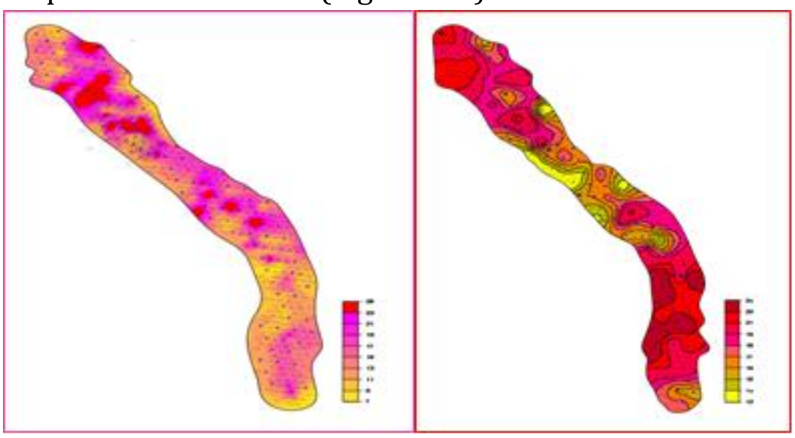

Figure 2-3 Distribution map of formation pressure and water injection pressure in G271 area in 2021

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2.2.3. The characteristics of effective water seeing

Through the dynamic analysis of single wells, 190 wells (types I and II) are effective, the degree of effectiveness is 47.6%, and the average effective period is 26.7 months. There were 141 water wells, and 62 wells showed water after a period of time.

There are currently 141 wells in G271 area, accounting for 35.3% of the total wells. There are two types of water breakthrough (porous, fractured). Pore-type water breakthrough is the main type (accounting for 76.3%). Through dynamic monitoring and production performance verification, the dominant direction of water flooding in the reservoir is NE108° and NE45°, and the water breakthrough is multidirectional. Analysis of the relationship between water wells and permeability, the direction of better physical properties, the direction of the main flow of the channel, is easy to form fracture-type and pore-type water breakthrough.

2.2.4. The law of diminishing output

After fitting analysis, the decreasing trend of the G271 area is in good agreement with the exponential decreasing. In terms of the production wells in different years, the production wells in 2010 are in line with the exponential decline. The production wells in 2011 are affected by the physical properties of the reservoir, and the daily production capacity of a single well is maintained at 0.84 after one year of production. t Stable production.

2.2.5. Change law of water content

The water cut rising law of Chang 8 reservoir shows convex characteristics, and the water cut rises rapidly in the middle and low water cut stage (Fig. 2-4~Fig. 2-5).

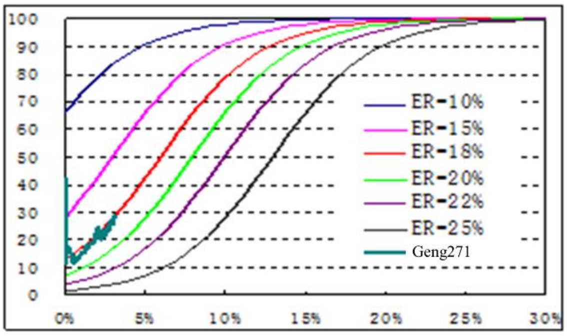

Fig. 2-4 Curve of water cut and recovery degree in G271 area (modified child template)

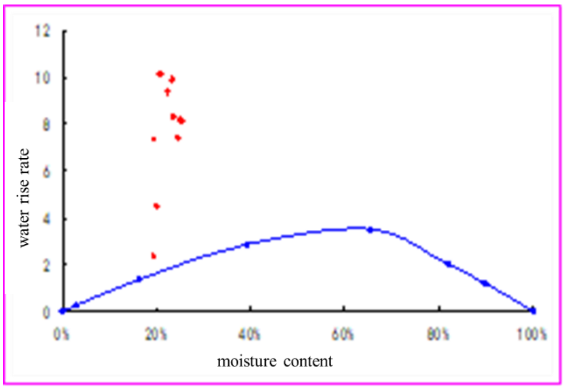

Figure 2-5 Relationship between water content and water rise rate in G271 area

2.2.6. Distribution law of remaining oil

On the plane, the main layers Chang 812-1 and Chang 812-2 have a low overall recovery degree and high residual oil saturation. The non-main layer reservoirs have poor continuity, and the residual oil is sporadically distributed.

In the pore seepage zone, the enrichment degree of remaining oil between oil wells is relatively high; in the fracture channeling zone, the oil production well is connected with the water

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injection well, the lateral displacement range of the fracture is limited, and the remaining oil is mainly distributed in the lateral direction of the fracture (Fig.2-6~Fig.2-7).

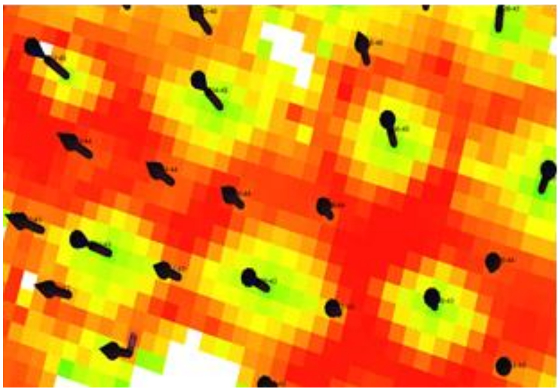

Fig. 2-6 Distribution characteristics of remaining oil on the plane of pore seepage zone

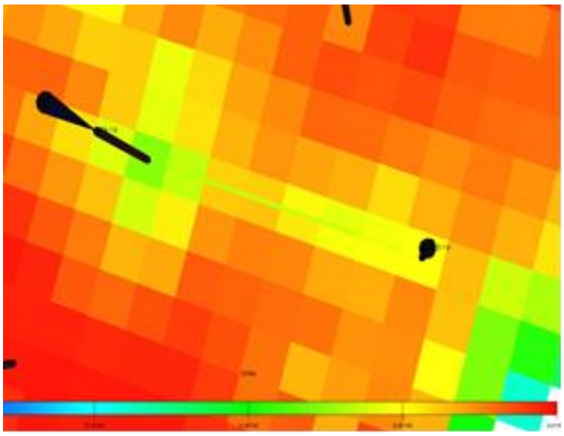

Fig. 2-7 Distribution characteristics of residual oil in fractured area

On the profile, the remaining oil is mainly distributed in the areas with relatively poor physical properties, the areas where the injected water has not been swept away, and the areas where the oil wells are not well fired, and the water-flooding reserves are less developed (Fig. 2-8).

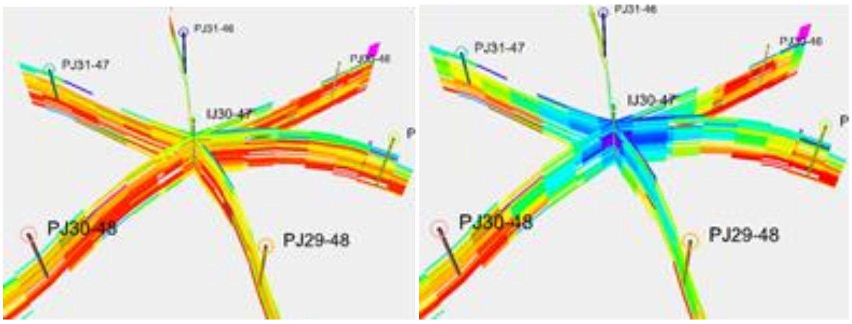

Figure 2-8 Distribution characteristics of remaining oil in the section

3. Application and effect of comprehensive management technology

3.1. Fine division of injection-production units

In order to better evaluate the oil reservoir, finely describe the regional development characteristics, and combine the geological characteristics and dynamic development characteristics, the G271 area is divided into development units. Subdivided into 6 development units (Figure 3-1).

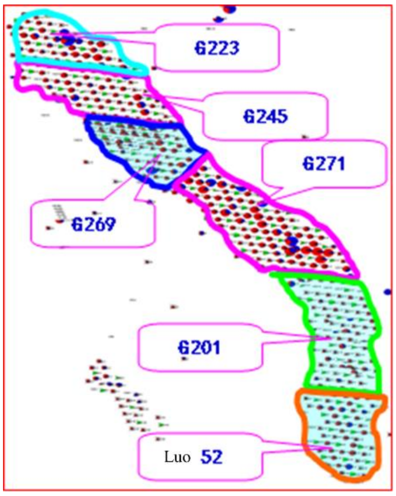

Figure 3-1 Unit division of G271 area

3.2. Optimization of water injection policy by unit

Utilize the schemes of reservoir engineering, mine statistics and numerical simulation to optimize the development technology policies of different development units, adhere to the water injection policy of "overall strengthening and local adjustment", the water injection intensity is generally controlled at 1.6-1.7m3/md, and the injection-production ratio is controlled at 2.0 (Table 3-1), the current water injection technology policy is basically within the reasonable technical policy range of numerical simulation.

3.3. Carry out unstable water injection and expand the scope of water flooding

In order to maintain a reasonable pressure level, the injection and production policies were continuously optimized, and 23 well groups in 5 reservoir positions were selected to implement unstable water injection with different policies (Table 3-1), to expand the swept volume of water flooding and to balance Energy distribution, slowing water rise. Corresponding to 136 oil wells, 23 wells are currently in effect, the daily oil increase of a single well is 0.23t, and the cumulative oil increase is 467t.

Table 3-1 Periodic water injection technology policy table

Area	Location	Physical properties and development characteristics	Adjustment system	
			Water injection cycle	Daily water injection
1	G245	The physical properties in the northern part of the reservoir are relatively good, but the interlayers are developed, and the pore type sees water.	30d	Daily allocation 10m3 note for 10 days, 16m3 note for 10 days, 22m3 note for 10 days
2	G271	High-permeability zone in the middle of the reservoir, with good physical properties, high production, and simultaneous development of pores and fractures	2d	The daily allocation is 30m3 for one day, and the betting is suspended for one day.
3	G271	The high-permeability area in the middle of the reservoir has good physical properties, high production, more water breakthrough in pore	1d	Constant water injection, note 12h, stop 12h

		type, and is sensitive to injection-production adjustment		
4	152	The physical properties of the reservoir in the southern part of the reservoir are poor, and the water injection pressure in the area is as high as 21.4MPa, and the oil well shows that water breakthrough occurs when the effect is realized.	1d	Constant water injection, note 12h, stop 12h
5		The physical properties of the reservoir in the southern part of the reservoir are poor, the overall injection-production ratio of the region is as high as 4.8, and the production is stable	30d	18 party note 15 days, 25 party 15 days

The knowledge obtained by periodic water injection: First, the physical properties of the northern part of the reservoir are better, the response after injection and production adjustment is obvious, the effective period is 2-3 months, and the maximum water injection intensity is controlled within 2.2m3/d; second, the reservoir physical properties in the southern part of the reservoir are relatively Poor, unstable water injection adaptability is better.

3.4. Continuous chemical water plugging to improve local well pattern adaptability

With the purpose of "improving the water drive efficiency of the reservoir", adhere to the prevention in advance, and implement the overall management of the block in accordance with the principle of "continuous profile control and multiple rounds of profile control". The profile control system and construction parameters were continuously optimized, and the overall profile control effect was good. 17 wells were implemented, corresponding to 91 oil wells, 19 of which were effective, the single-well oil increase was 0.49t, and the cumulative oil increase was 781t. After profile control, the water injection pressure was increased from 14.2↑18.2MPa, and the water absorption thickness of the three comparable wells was increased from 7.1↓6.47m, which was still dominated by peak or finger-shaped water absorption. The average comprehensive water cut of the 8 target wells for profile control has increased from 62.3 to 30.8%, and the average daily oil increase of a single well is 0.35t. The overall production of no wells is stable, and the profile control has improved the plane water flooding situation to a certain extent (Fig. 3-2).

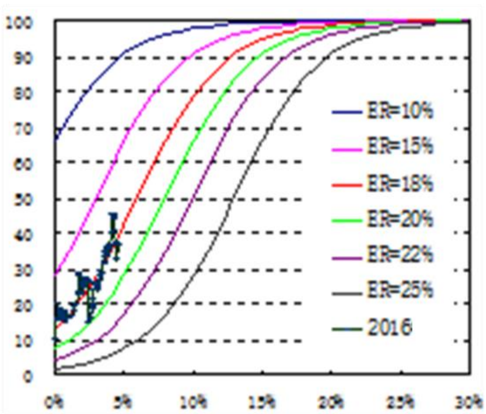

Figure 3-2 Change curve of water cut and recovery degree in profile control area

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3.5. Microsphere control flooding to expand the swept volume of water flooding

Through continuous injection, for the purpose of improving the heterogeneity of the reservoir, it acts on the larger pore throats and channels in the deep formation, diverts the injected water, expands the swept volume, and improves the recovery factor. 10 wells including J 68-23 have been carried out with polymer microspheres flooding test. By continuously optimizing the particle size of microspheres and injection parameters, the average single-well water absorption thickness of the four comparable injection wells was 10.0m↑12.1m. Among them, the swept volume of water injection in well group J66-25 increased before and after adjustment and flooding. Corresponding to 54 oil production wells, the average water cut of 16 wells with water penetration decreased from 57.5 to 51.2%, and the liquid volume from 4.85 to 4.27m3. The production of 38 wells with no water penetration was stable, and the water cut rate dropped sharply. The relationship between water cut and recovery degree is obviously skewed to the right, and the water flooding effect becomes better (Fig. 3-3).

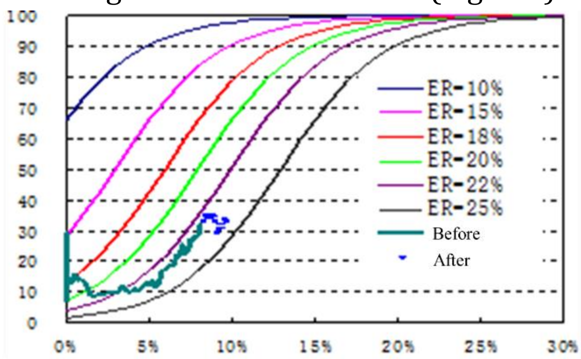

Figure 3-3 Curve of water content and recovery degree in microsphere injection zone

3.6. Treatment of low-yield wells to improve reservoir development benefits

3.6.1. Blockage removal of plugged wells

Returning to the production curve of low-yield wells, combined with well test data, to determine the plugging characteristics; in the past two years, plugging measures have been implemented for 26 wells, and the temporary plugging and acidizing measures have good adaptability in the middle of the reservoir.

Temporary plugging and acidification: For plugging in the near-wellbore area, temporarily plug the high-permeability layer and acidify the low-permeability layer to relieve the blockage. 18 wells were implemented, and the daily oil increase of a single well in the initial stage was 1.17t, and the average cumulative oil increase of a single well was 171t. After the measures, the average water cut in the initial stage decreased by nearly 10%, and the water cut in the later stage rose to the level before the measures. Some oil wells experienced periodic blockage, with an average period of 1 year. Comparing the effects of the measures in different regions, this measure has good physical properties in the middle of the reservoir, and the water injection is effective.

Temporary plugging and fracturing: The near-well fractures of the oil well are plugged, and then fracturing is used to create new fractures and tap the remaining oil. 7 ports were implemented, 6 ports were effective, and the daily increase of oil was 3.5 tons. This process has little effect on precipitation, but has obvious liquid extraction effect. On the basis of controlling fracture length and extension, the fracture width is increased, and it is effective for oil wells with high initial production and low single sand body production degree.

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3.6.2. Treatment of flooded wells

Comprehensively analyze the production history of water-flooded wells and reservoir conditions, analyze the causes of water breakthrough, and test water-flooded wells control measures such as water plugging fracturing, oil well water plugging, and conversion of ineffective water injection wells. The average daily oil increase of a single well is 0.3t, with little change after the measures and the previous period, and the water cut remains above 80%. Because the water plugging fracturing and oil well water plugging process have high requirements on the performance of the plugging agent and fracturing details, it is easy to cause the construction to be ineffective, and the water cut will continue to rise. Therefore, further tests are required for such processes.

3.7. Encryption adjustment test to improve water flooding efficiency

A total of 69 infill wells have been put into production, with an average daily fluid production of 2.22m3 per well, an average daily oil production of 1.33t and a water cut of 29.8%.

The knowledge gained by infilling: the old well has no obvious interference, and the stages are gradually reduced. The infill well has a large decline in the initial stage, and the current production is stable. After the encryption, the main lateral pressure difference decreases, and the effective displacement is gradually established. At present, the formation pressure in the infill area is 15.8MPa, and the pressure remains at 84.5%, which is 1.5MPa higher than that before the infill. Infill wells can effectively improve oil production rate and recovery. At present, the daily output of infill wells is 88t, accounting for 20% of the block production. The study of fine single sand body shows that after infill adjustment, the water drive control degree is increased by 2.4%, and the expected recovery rate is increased by 2%.

3.8. Comprehensive management effect

On the basis of fully absorbing the research results of fine reservoir description, 45 well groups will be adjusted for injection and production from 2020 to 2021. The oil and water well measures were 75 wells, and in December 2021, the natural decline was from 11.5% to 8.9% in the stage of reservoir governance, and the measures cumulatively increased oil by 4217t. The left deviation trend of the relationship between water cut and recovery degree was controlled, the development situation improved, oil stabilization and water control were good, and various development indicators met the standards.

Guided by fine reservoir description, comprehensive treatment measures are more targeted; through treatment, the decline has been greatly reduced, and the level of reservoir development has risen from Class II to Class I.

4. Conclusion and understanding

(1) The sedimentary microfacies of the Chang 8 reservoir in G271 are mainly underwater distributary channels; the reservoir sorting is good, and the heterogeneity within and between layers of the Chang 8 reservoir is strong; natural micro-fractures are relatively developed, and the fracture direction It is multi-directional, mainly in the direction of NE108°, which is inconsistent with the long diagonal direction of the original well pattern, the two-phase seepage interval is narrow, and the final oil displacement efficiency is low;

(2) Due to the development of micro-fractures, wells in the dominant direction of water flooding have quick effects but are easy to see water, and water breakthrough is mainly caused by fractures and pore fractures; the decline of old wells follows exponential decline; the reservoir pressure maintains a high level, but the plane distribution Inhomogeneous, the effective pressure system can basically be established in the areas with relatively good physical properties in the central and northern parts of the reservoir, while the establishment of an

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effective pressure system in the southern part of the reservoir with poor physical properties is slow;

(3) The numerical model of the reservoir is fully integrated with the development dynamics for grid design, and the dynamic and static parameters are adjusted to achieve the fitting of the whole area and a single well, quantify the remaining oil distribution, and divide the reservoir development unit according to the actual development dynamics;

(4) Through the practice of comprehensive reservoir management in the past three years, a set of stable production technology series suitable for the G271 Chang 8 oil reservoir has been explored. , the injection-production ratio should be controlled within 2.0; the second is to carry out unstable water injection, continuous water plugging and profile control, and microsphere injection to continuously alleviate the contradiction between plane and profile; the third is for plugging wells, temporary plugging fracturing and temporary plugging Acidification shows good adaptability, but water-flooded well treatment still needs to continue to tackle key problems; Fourth, strengthen fracture research, carry out intensification adjustment in a timely manner, continuously optimize the fracture network relationship, and improve well pattern adaptability.

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