Study on the Countermeasures for Improving Oil Recovery of Natural Water Flooding Thin Oil Reservoirs with Complex Fault Blocks

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Abstract: The shallow reservoir of Nanpu land is a typical complex fault block reservoir, according to the oil product, about 60.9% of the geological reserves which are thin oil reservoirs, and because it has an active geological bottom water as the small reservoir faults and a small oil-bearing area, it has entered the development stage of extra high water cut, and the degree of water flooding is low as well as the recovery rate. It is urgent to carry out technical research to improve oil recovery, aiming at the geological characteristics of reservoirs with the small oil-bearing area and sufficient natural energy, the NmII42 layer with high 63-10 fault block is a typical unit, and the deep flooding method is proposed to improve the reservoir volume and oil displacement efficiency and the technical advantages of a small scale, low input and flexible adjustment which provide the technical reference for the development and adjustment of the high water cut stage of similar oil reservoirs.

1. Introduction

The shallow reservoirs in the Nanpu land are complex fault-block reservoirs with boundary-bottom water layers. The oil-bearing horizons are the Minghuazhen Formation and the Guantao Formation. The reservoirs are river-phase sand bodies with good reservoir physical conditions. According to the classification of oil products, the shallow reservoir types in Nanpu land include thin oil reservoirs and heavy oil reservoirs, of which the geological reserves of thin oil reservoirs account for 60.9% of the total geological reserves in the shallow area of Nanbao land. The high-level 63-10 fault block NmII42 is a typical unit, and the deep flooding and flooding method is proposed. This technology is based on oil wells and can improve the reservoir volume and oil displacement efficiency. It has small scale, low input and flexible adjustment technology.

2. Reservoir Overview

The high-level 63-10 fault block NmII42 is a broken anticline structure with near-east-west distribution. The fault block mainly develops two south-west faults near the east-west direction. The whole layer is inclined to the north and the dip angle is 6-10°. The reservoir in the test area is loose sandstone with a wide distribution range. The average thickness of single sand layer is 6-8m, the average porosity is 33.4%, the average permeability is 2432×10-3μm2, and the physical properties are good. It belongs to ultra-high porosity and high permeability to high pore height. Seepage reservoir. In the longitudinal direction, NmII42 is divided into two sand bodies, NmII42-S1 and NmII42-S2. The interlayer between the sand bodies is unstable due to the undercut of the river channel. The pore throat value of the reservoir is a large pore-medium throat type, the rock wettability is hydrophilic, and the reservoir sensitivity is weak speed sensitivity, weak water sensitivity, and no acid sensitivity. The high-level 63-10 fault block NmII42 is a layered edge water structure reservoir with a wide distribution range of 2-10 meters and an average of 5.8m. It is a normal temperature and pressure system with a pressure coefficient of 0.96 and an average formation temperature of 65°C. The ground temperature gradient is 3.01 ° C / 100 m, as shown in Figure 1.

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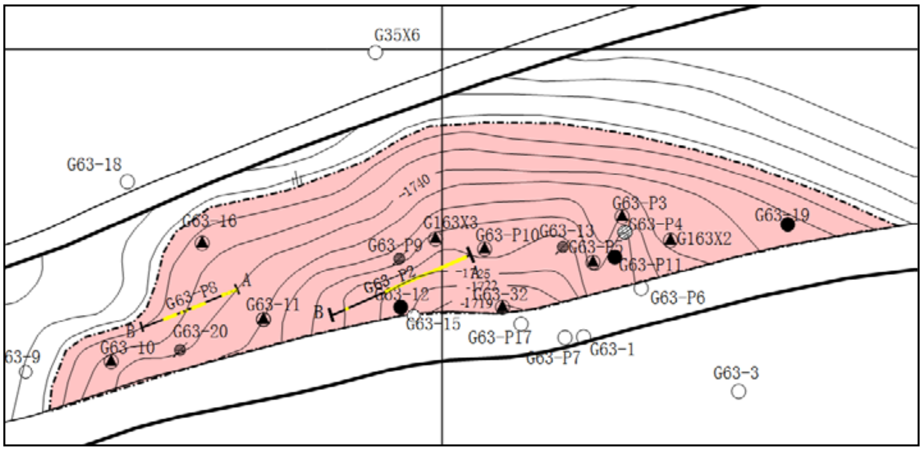

Figure 1 High-Level 63-10 Fault Block Nmii42 Small Floor Plan

3. Residual Oil Quantitative Evaluation Research

There are many research methods for residual oil. In order to improve the research accuracy of residual oil, multiple methods are needed to verify each other [1-3]. Using theoretical formula method and laboratory experiment method to study the proportion of movable oil and non-movable oil in residual geological reserves, compare with the relationship between movable oil and non-movable oil in numerical simulation, verify the accuracy of model calculation, and use numerical simulation method. Determine the remaining oil enrichment area and verify the numerical simulation results using the mine statistical method.

Based on the geological reserves, residual geological reserves and geological reserves, the relationship between residual oil saturation and original oil saturation and geological reserves recovery degree (Formula 1) is derived to calculate the remaining oil saturation of the reservoir.

$$S_o = S_{oi}(1 - R_D) \quad (1)$$

Where: Soi - original oil saturation, %;

RD - the extent of geological reserves, decimals;

So - residual oil saturation, %.

Equation (1) shows that the greater the degree of geological reserves, the smaller the remaining oil saturation. The geological reserve of the NmII4 small layer of the high 63-10 fault block is 35.8%, and the residual oil saturation is 0.39.

Closed core wells, especially in the middle and late stages of development, are direct means of observing and testing the remaining oil distribution in the layer, the inspection wells can comprehensively analyze the distribution of residual oil saturation and oil displacement efficiency in water flooding development reservoirs. The statistics of the closed coring data representing the characteristics of the reservoir are affected by the rhythm reservoir, and the bottom water flows along the high permeability section, causing strong flooding or extra strong flooding in the bottom of the reservoir. The upper part of the reservoir is mostly unflooded or Weak flooding, oil displacement efficiency is less than 10%. The remaining oil is distributed on the top of the reservoir, and the thickness accounts for 40-50% of the thickness of the whole reservoir.

The numerical simulation of fine reservoirs is an important method to quantitatively study the distribution of remaining oil. The historical fitting results show that the remaining oil saturation of the NmII4 small layer with a high 63-10 fault block is 0.39, which is consistent with the theoretical calculation results.

The numerical simulation method was used to quantitatively evaluate the remaining oil of NmII42 in the high 63-10 fault block. The retained oil accounted for 55.5% and the residual oil accounted for 44.5%. Residual residual oil is mainly distributed in the top of the structure and the high structure near the fault. This part of the remaining oil saturation is higher, close to the original oil saturation. This type of remaining oil accounts for 52.6% of the total, so the potential oil for the test area is tapped. The direction should not only expand the volume of the reservoir, but also reclaim the remaining residual oil. It should also take into account the improvement of the oil displacement efficiency and the potential residual residual oil.

4. Research on Countermeasures to Enhanced the Oil Recovery

4.1 Research Overall Ideas

There are two technical difficulties in the development and adjustment of the ultra-high water cut development stage of the shallow natural oil flooding conventional thin oil reservoirs in Nanbao Land. First, the oil content of the sand body is small, the sand body volume less than 0.2km2 accounts for 92.4%, and the reserves account for 61.7%. This makes it difficult to establish a production well network in the reservoir. At present, the commonly used polymer flooding, ternary composite flooding, carbon dioxide flooding and other enhanced recovery methods are difficult to apply [4-9]; second, the natural energy of the reservoir is sufficient and difficult. Inhibition, natural energy makes the reservoir energy sufficient in the early stage of reservoir development, and the reservoir production is high, and the development effect is good. However, when the reservoir enters the middle and late stages of development, especially in the development stage of extra high water cut, sufficient natural energy will weaken the polymerization. The concentration of substances, surfactants and other injection systems is difficult to suppress.

According to the above technical idea, three slugs are used for injection, and the first slug is a gas slug, which aims to reduce the viscosity of the crude oil by gas dissolution and extraction; the second slug is an emulsion flooding slug, the purpose is to inject The surfactant with strong emulsifying property makes it emulsified and sealed in the reservoir in situ, increases the width of action, increases the sweep coefficient, and improves the oil displacement efficiency; the third segment is a sealing slug, and the purpose is to inject self-aggregation The ball is blocked to prevent the first and second segments of the plug from directly returning after the well is opened, and the rate of returning the oil-segment plug is reduced.

4.2 Pilot Test Program Study

4.2.1 Preferred Displacement Method

According to the quantitative evaluation results of remaining oil, 5 deep flooding and flooding wells were deployed in the remaining oil enrichment areas of two single sand bodies of Sm and S_2, and one well was observed, as shown in Fig. 2.

The displacement medium of the three slugs was screened by laboratory experiments. First, the gas slug is preferred: the ability to dissolve and expand the crude oil of CO_2, hydrocarbon gas and N_2 and the ability to reduce the viscosity of the crude oil are evaluated. The experimental results show that the ability to dissolve the expanded crude oil from good to bad is CO_2, hydrocarbon gas, N_2, and the crude oil is reduced. The viscosity ability evaluation shows that the hydrocarbon gas is slightly better than CO_2, and the N_2 capacity is the worst. The comprehensive CO_2 is the throughput gas medium [10-13]. Second, the emulsion flooding slug is preferred: comprehensive evaluation of strong emulsifying capacity and low interfacial tension, using a concentration of 0.3% RA (betaine) + 0.1% AES (fatty alcohol polyoxyethylene ether sulfate) + 0.05% WT -J80Z (fine tuning additive). The third is to block the slug. Preferably, the cross-linked bulk particles and the gel are injected to block the large pores in the near-well zone.

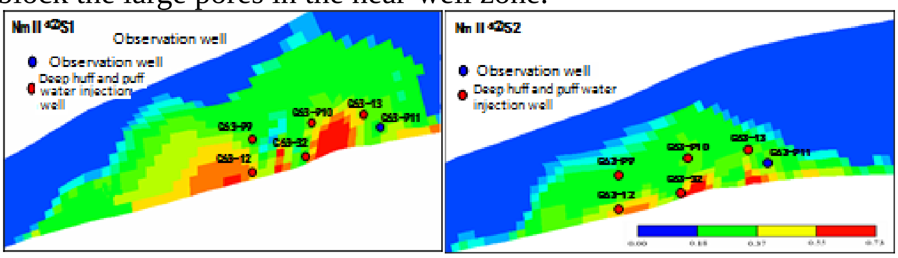

Figure 2 Nmii42 Small Layer Deep Throughput Flooding Well Network Deployment Map

4.2.2 Development technology policy optimization

Demonstrate the injection and production parameters such as well time, throughput radius, injection ratio, number of injection groups, liquid production rate, plug concentration design, injection sequence and injection round. Evaluate the oil increase and input and output corresponding to different injection and production parameters. After demonstration, the optimal injection and production parameters are finally determined, that is, the well time is 20 days, the throughput radius is 40 meters, and the ratio of the proportion of carbon dioxide to the emulsion flooding agent is injected. 1:1, the number of slug injection groups CO_2-emulsified oil-displacement agent-blocking agent 2 groups were alternately injected, the production rate was 20m3/d, and the throughput was 3 rounds.

Table 1 Single Well Injection Scale

No	CO2Injection volume (tons)	Emulsified oil displacing agent		Plugging agent					
				Pre-crosslinked expanded particles		Gel solution		Microsphere solution	
		Injection amount (square)	Injection concentration	Dosage (tons)	Particle size (mm)	Injection amount (square)	injection concentration	Injection amount (square)	injection concentration
G63-P9	626	1252	0.3% RA+0.1% AES+0.05% WT-J80Z	6	6-8	455	0.25%	341	0.15%
G63-P10	626	1252		6	6-8	455	0.25%	341	0.15%
G63-12	537	1073		5	6-8	390	0.25%	293	0.15%
G63-13	514	1028		5	6-8	374	0.35%	280	0.15%
G63-32	447	894		4	6-8	325	0.25%	244	0.15%
Total	2750	5500		25		2000		1500	

4.2.3 Development indicator forecast

After the implementation, the test area is expected to increase oil by 0.86×104t, and the oil price of $50/bbl input-output ratio is 1:1.51, effectively improving the development effect of the block.

5. Conclusion

(1) By combing the geological reservoir parameters of the shallow thin oil reservoir sandstone in Nanbao land, according to the two key factors of oil area and well pattern, the NmII42 small layer of 63-10 block is selected as a typical unit to improve the harvest. Rate pilot research program to explore the optimal way to improve oil recovery.

(2) Carry out quantitative evaluation of remaining oil, reasonably divide the remaining oil types, and clarify the remaining oil tapping potential in the ultra-high water cut stage of the shallow oil reservoir of Nanbao Land should also consider the technical direction of expanding the volume and improving the oil displacement efficiency.

(3) In view of the characteristics of reservoirs with small oil-bearing area and sufficient natural energy in the shallow sand oil reservoirs of Nanpu land, the deep flooding and flooding methods are proposed, and the gas slugs, emulsion dispersing agent slugs and plugging are designed. The combination of the three-stage plug of the agent slug has the advantages of small implementation scale, low input and easy adjustment.

(4) Carry out research on typical unit pilot test plan, optimize displacement mode, optimize injection and production parameters, and effectively improve the development effect of the block.

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