Research on the Sealability of Interlayer Based on Numerical Simulation Method

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Abstract. Reservoir barriers and interlayers are an indispensable part of revealing the heterogeneity of oil reservoirs. Researching the plugging properties of reservoir barriers is of great significance to the recovery of remaining oil in the middle and late stages of oilfield development and the formulation of oilfield development plans. In this paper, using reservoir numerical simulation technology, based on the three types of reservoirs divided, a numerical simulation model of barrier-intercalation pluggability is established, and the influence of permeability and barrier thickness on the sensitivity of barrier-intercalation pluggability is studied and analyzed. To provide a theoretical basis for the development of remaining oil in the oilfield. Studies have shown that the trend of the permeability of the barrier on the cumulative oil production is mainly "first and then slow", and the oil production gradually decreases with the increase of the permeability; the thickness of the barrier the impact on the cumulative oil production is mainly manifested in that as the thickness of the barrier increases, the cumulative oil production gradually decreases, and the rate of deceleration changes from abruptly to a slower to stable. The permeability and barrier thickness sensitivity analysis results obtained in this study, It provides a theoretical basis for the further development of the oilfield work area.

1. Preface

The practice of oilfield exploration and development shows that the average recovery rate of only relying on secondary and tertiary oil recovery is only about 35%, which has great development potential. It is generally estimated that 20% of the movable oil is due to the heterogeneity of the reservoir so that the local area is not affected by the injected water, resulting in "remaining oil enrichment" [1]. The influx of the injected water is affected by many factors. Among them, the seepage barrier and the difference in seepage caused by the interlayer are the important factors that cause the injected water to not be affected, especially in continental oil reservoirs [2]. Therefore, it is of great significance to research the sealability of barriers and interlayers to finely characterize the geological characteristics of the reservoir, study the distribution of remaining oil, and then take effective engineering measures.

In this paper, based on the reservoir numerical simulation technology, based on the three types of reservoirs, a numerical simulation model of barrier-intercalation plugging properties is established.
Starting from the perspectives of permeability and barrier thickness, the two parameters are used for different reservoirs. Sensitivity analysis of the pluggability of different types of barriers and interlayers shows that permeability and barrier thickness have obvious effects on different types of reservoirs. With the increase of permeability, the cumulative oil production of the three types of reservoirs gradually increases. It shows an increasing trend of “first fast and then slow”. As the thickness of the interlayer increases, the reservoir shows a gradual decrease trend. The decline rate also shows first fast and then slow. Finally, the cumulative oil production tends to stabilize. The further development of the remaining oil in the oilfield is of great significance for revealing the heterogeneity of the oil reservoir.

2. Establishment of Numerical Simulation Model of Interlayer Sealability

This time the establishment of the interlayer numerical simulation model includes plane grid and vertical grid settings. The setting process should be determined by the reservoir and oil reservoir distribution in the work area and the requirements of the reservoir numerical simulation [3-4]. To make the digital and analog results as fine as possible, combined with the speed of digital and analog calculations and according to the actual parameters of the site, the design model has a length of 2000m in the X direction, 1000m in the Y direction, a design grid size of 20m×20m, a reservoir thickness of 5m, and reservoir pores. The permeability and permeability are 20% and 1000~5000mD, respectively, the thickness of the barrier is 0.5~2.5m, the porosity of the barrier is 2%, and the permeability of the barrier is 0.001~0.1mD. The specific parameters are shown in the following table:

| X Direction (m) | Y direction (m) | Grid Size | reservoir thickness (m) | Reservoir Porosity (%) | Reservoir Permeability (mD) | compartment thickness (m) | Compartment Porosity (%) | Compartment Permeability (mD) |
|----------------|----------------|-----------|------------------------|------------------------|---------------------------|--------------------------|--------------------------|---------------------------|
| 2000           | 1000           | 20×20     | 5                      | 20                     | 1000~5000                  | 0.5~2.5                  | 2                        | 0.001~0.1                 |

The schematic diagram of permeability sensitivity of Type I reservoirs is shown in the figure:

3. Sensitivity Analysis of Permeability to Interlayer Sealability

Based on the classification of different types of reservoirs, the permeability sensitivity models of three types of reservoirs of type I, type II, and type III are designed. The three models are designed as follows: the design permeability of the three types of reservoirs are respectively It is 5000mD, 3000mD, 800mD, the designed barrier permeability is 0.001mD, 0.002mD, 0.003mD, 0.004mD, 0.005mD, and the barrier thickness is 0.5m [5].

The schematic diagram of permeability sensitivity of Type I reservoirs is shown in the figure:
Figure 3. Accumulative oil production of different barrier permeability in Type I reservoirs

Figure 4. Daily oil production of different barriers in Type I reservoirs

Figure 5. The relationship curve between the permeability of the barrier and the cumulative oil production

It can be seen from the relationship curve between the permeability of the barrier and the cumulative oil production that the cumulative oil production of Type I reservoirs increases as the permeability of the barrier increases. When the permeability of the barrier is between 0.001 and 0.002 mD, the cumulative production increased the most, but after the barrier permeability reached 0.002 mD, the oil production decreased significantly, and the cumulative oil production increased slowly. The schematic diagram of permeability sensitivity of type II reservoirs is shown in the figure:

Figure 6. Accumulative oil production of different barrier permeability in type II reservoirs

Figure 7. Daily oil production of different barriers in type II reservoirs

Figure 8. Relation curve between the permeability of barrier and cumulative oil production
It can be seen from the relationship curve between the permeability of the barrier and the cumulative oil production that the cumulative oil production of Type II reservoirs increases with the increase of the permeability of the barrier. When the permeability of the barrier is 0.001~0.002mD, the cumulative production The oil volume has the largest increase. When the permeability of the interlayer is 0.002mD, the rate of increase of the cumulative oil production begins to slow down. When the permeability of the interlayer reaches 0.003mD, the oil production decreases significantly, and the cumulative oil production increases. Tends to flatten out.

The schematic diagram of permeability sensitivity of Type III reservoirs is shown in the figure:

![Figure 9. Accumulative oil production of different barriers in Type III reservoirs](image)

![Figure 10. Daily oil production of different barriers in Type III reservoirs](image)

![Figure 11. The relationship curve between barrier permeability and cumulative oil production](image)

It can be seen from the relationship curve between the permeability of the barrier and the cumulative oil production that the cumulative oil production of Type III reservoirs increases with the increase of the barrier permeability. When the permeability of the barrier is 0.001~0.002mD, the cumulative production The increase in oil volume is the largest. When the permeability of the barrier reaches 0.002mD, the increase in cumulative oil production slows down. After the permeability of the barrier reaches 0.003mD, the cumulative oil production tends to be flat.

4. Sensitivity Analysis of Interlayer Thickness to Interlayer Sealability

Design three types of barrier thickness sensitivity models for type I reservoir, type II reservoir, and type III reservoir. The three models are designed as follows: the designed permeability of the three types of reservoirs are 5000mD, 3000mD, and 800mD, respectively. Design barriers The thickness is 0.5m, 1m, 1.5m, 2m, 4m, and the permeability of the barrier is 0.001mD.

A schematic diagram of the sensitivity of barrier thickness of Type I reservoirs is shown in the figure:
Figure 12. Accumulative oil production of different barrier thicknesses in Type I reservoirs

Figure 13. Daily oil production of different barrier thicknesses in Type I reservoirs

Figure 14. The relationship between the thickness of the interlayer and the cumulative oil production

It can be seen from the relationship curve between barrier thickness and cumulative oil production that as the barrier thickness increases, the cumulative oil production of Type I reservoirs gradually decreases. The thickness of the barrier is within the range of 0~0.5m, and the cumulative oil production volume deceleration rate is faster. When the thickness of the interlayer reaches 0.5m, the oil production decreases significantly, and the cumulative oil production decreases slowly. At this time, the oil separation effect is the best.

The schematic diagram of the sensitivity of the barrier thickness of Type II reservoirs is shown in the figure:

Figure 15. Accumulative oil production with different barrier thicknesses in Type II reservoirs

Figure 16. Daily oil production of different barrier thicknesses in Type II reservoirs

Figure 17. The relationship between the thickness of the interlayer and the cumulative oil production
It can be seen from the relationship between the thickness of the barrier and the cumulative oil production that the cumulative oil production of Type II reservoirs gradually decreases with the increase of the barrier thickness. The thickness of the barrier is in the range of 0–0.7m, and the cumulative oil production is The deceleration rate is faster. When the thickness of the interlayer reaches 0.7m, the accumulative oil production decrease rate decreases. When the interlayer thickness is between 1.0m and 2.0m, the accumulative oil production decreases gradually. Therefore, the interlayer thickness is greater than 0.7 When m, the interval oil effect is the best in this area.

A schematic diagram of the sensitivity of the barrier thickness of Type III reservoirs is shown in the figure:

![Figure 18. Accumulated oil production of different barrier thicknesses in Type III reservoirs](image1)

![Figure 19. The daily oil production of different barrier thicknesses in Type III reservoirs](image2)

![Figure 20. The relationship between the thickness of the interlayer and the cumulative oil production](image3)

It can be seen from the relationship curve between barrier thickness and cumulative oil production that as the barrier thickness increases, the cumulative oil production of Type III reservoirs gradually decreases. At first, the cumulative oil production decreases slowly. When the barrier thickness is 0.2 m, the deceleration rate of the cumulative oil production begins to increase until the thickness of the interlayer begins to slow down at about 0.9m, and then gradually decreases, and the decreasing trend gradually stabilizes. Therefore, when the thickness of the interlayer is greater than 0.9m, the interval oil production within the range is lower, and the oil separation effect is the best.

5. Conclusion
The permeability of the barrier and the thickness of the barrier has a greater impact on cumulative oil production. The trend of the cumulative oil production curve is first rapid and then slow.

When the interlayer thickness of the Type I reservoir is greater than 0.5m, the thickness of the Type II reservoir is greater than 0.7m, and the thickness of the Type III reservoir is greater than 0.9m, the cumulative oil production in this interval is lower, and the oil barrier effect is the best.
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