Research and application of the potential tapping method of single sand body in a high water cut period

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Abstract. This paper studies the reservoir sedimentary system of an oilfield, grasps the origin and characteristics of sand development in narrow and small river channels, and uses the method of sandstone facies determination to track and predict sand bodies, and establishes the continuous distribution mode of channel sand bodies. On this basis, combined with the dynamic monitoring data, the type and potential of remaining oil in the oilfield are analyzed by using the dynamic analysis method, and five potential tapping directions centered on the channel sand body are determined. The practice shows that the remaining oil analysis based on the anatomy of single sand body should be paid more attention to in the exploration of potential in high water cut period. Combined with various technical means such as reinjection, encryption and orientation, the injection production relationship of single sand body should be improved and the field application has achieved good results.

1. Introduction
The narrow channel of distributary plain subfacies is developed in the north of area a, and the narrow channel and sheet sand deposition of delta front subfacies are developed in the south. In the northern part of the basin, narrow channel sand is developed, inter channel sand is poorly developed, channel vertical inheritance is poor, and 80.2% of the reserves are concentrated in channel sand body.

At present, after more than 30 years of water injection development, an oilfield shows the contradiction of "three highs and one low" with high proportion of low production wells, high proportion of long shut in wells, high natural decline rate of old wells and low oil recovery rate. The comprehensive water cut of the whole area has reached 80.4%. In view of this kind of oilfield with well-developed reservoir and high comprehensive water cut, through fine reservoir description, applying high-resolution sequence stratigraphy and sedimentology principles, the sedimentary characteristics of reservoir are finely depicted, the continuous distribution mode of channel sand body and interlayer distribution mode are established, and the fine potential tapping adjustment idea is established based on improving the injection production relationship of single sand body and focusing on long shut in treatment of low production wells so as to provide technical direction for improving oilfield development effect.

2. Reservoir sedimentary characteristics of an oilfield

2.1. a certain oil field is controlled by a single water system in the East
The root of the water system is developed in well A-B area, with large hydrodynamic energy, and there are 6 secondary water systems from north to south. A certain oil field is mainly affected by the second to sixth secondary water system. The sandstone of the main water system is developed, the scale of
secondary water system becomes smaller and the sandstone becomes thinner. The regional sedimentary background is shallow water delta facies, and the river is the main sedimentary force, mainly distributed plain facies and inner front subfacies.

2.2. the sand development of narrow and small rivers is poor, and the development of inter river sand is poor, and the vertical inheritance of the river is poor

According to the modern sedimentary model, combined with the sand body anatomy of surrounding dense well network, the law of river channel extension is studied, and the reservoir tracking method is established by using sandstone facies determination technology.

At the far water end, the land-based datum is low, located below the bottom of the deposit. The river has strong cutting capacity, most of the riverbed is narrow, and interweaved in a network; from land to underwater, the datum level gradually changes from below the sedimentary surface to the sedimentary surface, and the river energy decreases gradually, and the scour ability and cutting ability of the river to the ground decreases. At the same time, due to the rapid water retreat slow water retreat, the erosion ability and cutting ability of the river to the ground are decreased. At the same time, due to the rapid water retreat and slow water retreat, the -During the process of rapid water inflow, the river bed width increases in the water land interaction zone, and it is trumpet shaped towards the opening of the lake center; after the river enters the underwater, the energy reduction speed increases after the lake water convergence, the river splits into branches and narrow strips, which increases the flow speed and reduces energy consumption by reducing the width of the riverbed.

Due to the change of river energy state and riverbed form from provenance area to Lake area, the sedimentary characteristics and styles of delta plain subfacies, delta front subfacies and sub facies sand bodies outside delta front are different: the sub facies sand bodies of delta plain are narrow net and the vertical source direction is not continuous; the sand body in the front facies water channel interaction zone of delta is thick and large in scale, and the sand body is distributed in a standard way. The sand body is thin and the lateral continuity is poor. The sand body of the delta is isolated. That is, the sand body shows a narrow net wide net, sheet branch strip isolated sedimentary pattern.

According to the change trend of the above sedimentary model, the development characteristics and reasons of sand body in an oilfield are summarized:

The sand development of narrow and small river channel is located near the lake bank line, the water body of the lake basin is shallow, and the effect of Lake wave on river diversion is weak.

The development of interbank sand is poor. Because it is far away from the source area and the hydrodynamic force is weak, fine-grained sand deposition can only be found in a few severe flood periods or local crevasses.

The vertical succession of the river is poor, because of the weak flow power of the river, there is no large deep erosion valley.

2.3. study on the identification of single sand body and the distribution mode of interlayer

Single sand body refers to the channel and related sand body deposition formed in a flood period, which is equivalent to the fourth level structure in the reservoir layer proposed by miss. The recognition method is to identify the scour surface and rhythm of the channel in the core. Through the rock electrical calibration, the natural potential curve and the microelectrode curve are used to divide the sand body.

The deposition of single sand body is controlled by different sedimentary environment. Because of the change of river cutting capacity from strong weak weak, the single sand body presents three types, namely vertical simple superposition, staggered migration cutting superposition and isolated type, among which, interlaced migration and cutting superposition and vertical simple superposition are shown in the composite channel sand body, and isolated type is mainly in narrow and small channel sand bodies.
The interlayer distribution pattern between sedimentary units and single sand layers is formed by the tracing of single sand bodies. The distribution of interlayer between sedimentary units is stable, with an average thickness of 3.1m and a large thickness; the internal interlayer of thick oil layer is mainly physical interlayer and calcareous interlayer, with a small distribution range, and the interlayer thickness is generally less than 0.6m and the thickness is smaller; the interlayer from scour surface physical interlayer to mud interlayer from the center of sand body to both sides changes from scour surface to physical interlayer to muddy interlayer. The calcareous interlayer is generally located at the top or bottom of the river channel, and the distribution is random.

3. The proportion of channel sand body reserves is high
The application of volume calculation method shows that the reserves of different sand body types account for 19.8% of the total reserves. Vertically, channel sand reserves are mainly distributed in PI3 and pi41 sedimentary units, followed by pi5 and pi7 sedimentary units.

4. Remaining oil type and direction establishment
Six batches of infill adjustment have been completed in an oilfield. With infill adjustment, the control degree of well pattern on sand body has been greatly improved, and the proportion of well points drilled in pinch out area has decreased from 53.2% to 46.4%, a decrease of 6.8%. Under the current well pattern conditions, combined with the dynamic monitoring data and applying the dynamic analysis method, the injection production relationship of single sand body is carefully dissected, and six types of remaining oil are analyzed, i.e. rhythmic interlayer type, injection production imperfect type, plane water absorption difference type, unidirectional water injection type, plane facies variable production type and interlayer interference type.

1. Rhythmic interlayer type. The multi-stage river course superimposes, the river course migrates, and the superimposed channel becomes narrow, the physical property becomes poor, and the remaining oil in the upper part is enriched.

2. Injection production is imperfect. The main reason is that the sand body of water injection well is out of the point, which results in whether there is production or not.

3. The plane water absorption difference is abnormal. The sand body development of injection wells in different directions on the plane is different, which results in the good injection in one direction and the other.

4. One way water injection type. Only one direction of water injection is injected in the production well plane, and the remaining oil is enriched away from the direction of water injection.
5. The plane phase change adopts the business trip type. Due to the influence of phase transformation, the production well encounters non main sheet sand, while the injection well encounters channel sand (main sheet sand) or the production well encounters channel sand (main sheet sand), while the injection well encounters non main sheet sand.

6. Inter layer interference type. The plane connection of each small layer of the production well is similar, but due to the thickness difference, the thick layer water injection is promoted quickly and well used, while the thin layer is relatively poor.

From the perspective of the remaining recoverable reserves of different types of remaining oil, the remaining oil mainly consists of two types: one-way water injection and imperfect injection production, and the remaining recoverable reserves account for 37.8% and 24.7% of the total remaining recoverable reserves respectively.

According to different types of remaining oil, combined with the size and characteristics of sand body, five main potential tapping directions and main technical means are established.

| Types of sandbodies          | Total floors (number) | proportion (%) | Single layer effective (m) | Remaining recoverable reserves (10^4) | Dynamic description                  | Reorientation           | Current technology          |
|-----------------------------|-----------------------|----------------|----------------------------|--------------------------------------|--------------------------------------|------------------------|-----------------------------|
| Narrow channel sand         | 359                   | 20.5           | 1.8                        | 109                                  | Plane injection production difference High water content | ① Remaining oil in plane direction ② Same floor at the bottom | Transfer notes           | Hydraulic jet, ultra short radius Hole mending |
| Composite channel sand      | 297                   | 17             | 2.3                        | 54                                   | High water content Vertical uneven flooding | ③ Edge of sand body ④ Upper part of river | Infill drilling           | Subdivision water shutoff Hole plugging |
| Thin layer sand             | 1094                  | 62.5           | 0.2                        | 33                                   | Poor utilization                      | ⑤ Dominant phase         | fracture                    |

5. field application effect

5.1. potential excavation of remaining oil in the plane direction of sand body

From the view of the relationship between sand injection and production, the effective thickness of one-way connection and non connection is 652.0m, among which the effective thickness of one-way connection and non connection of narrow channel is the largest, with the effective thickness of 416.8m, accounting for 63.9%. The main reason for analysis is that it is affected by fault cutting and narrow channel. According to the relationship between structure location and well location, the control degree of water drive of channel sand body is analyzed. The control degree of water displacement of channel sand body at the fault side is only 72.6%, while the control degree of water drive of channel sand body in well network reaches 91.4%. This determines the channel sand body at the fault side, mainly to increase the direction of water injection and reduce the non connected proportion; the channel sand body in the well network mainly increases the multi-directional connection ratio.

| Well location structure | Disconnected (%) | One-way (%) | Two-way (%) | Multidirectional (%) | Total (%) | Reorientation                  |
|------------------------|-----------------|-------------|-------------|----------------------|-----------|--------------------------------|
| Fault edge             | 27.36           | 41.18       | 25.64       | 5.82                 | 72.64     | Increase water injection direction |
| In well pattern        | 8.59            | 30.35       | 38.32       | 22.75                | 91.41     | Increase the proportion of multi direction |
| Total                  | 19.26           | 36.51       | 31.11       | 13.12                | 80.74     | /                              |
5.1.1. increase water injection direction
For different types of sandbodies, there are mainly two kinds of injection transfer methods: for the sandbodies with good contiguity, the integral injection is adopted; for the sandbodies with narrow strips, the flexible injection is adopted. After the implementation of 6 wells in the well block, the water drive reserves increased by $1.35 \times 10^4 t$, the thickness of channel sand disconnected decreased by 20.6m, the water drive control degree of the whole area increased from 78.97% to 80.68%, and the water drive control degree of channel sand increased from 80.74% to 82.34%.

5.1.2. directional tapping potential of high water cut wells
Hydraulic jetting technology was applied to excavate the remaining oil at the edge of fault. Three wells were implemented, and the daily oil increase of single well was 0.6t. If well C is shut in with high water cut, the research results of remaining oil show that due to unidirectional water injection, the edge of fault deviates from the direction of water injection and the remaining oil is enriched. After taking directional measures to tap the potential, the daily oil increase is 0.6T and the comprehensive water cut is reduced to 86%.

5.2. development of the same floor at the bottom
The oil-water layer identification chart was applied to recheck the oil-water potential of old wells in the same layer, and hole filling was carried out in the bottom of high water cut and low production wells in the same layer. For example, in well D, the spontaneous potential value of layer pi8-9 is -68mv, and the apparent resistivity value of 4m is 17 $\Omega \cdot m$, which falls in the same layer area of the oil-water layer identification plate. After the hole is filled and the upper production layer (pi1-pi5 layer) is blocked, the initial daily oil increase is 2.1t, and the water cut is 83.4%.

5.3. sand body edge tapping
It is mainly to apply infill adjustment technology to drill infill wells at the edge of sand body to improve the control degree of well pattern. This kind of potential tapping method requires the application of fine reservoir description technology to finely depict the scale of sand body, so as to effectively avoid drilling loss.

5.4. potential tapping in thick layer
Using long rubber tube and borehole plugging technology, using stable interlayer or small interlayer developed in the thick layer, plugging the high water cut part in the layer, 4 wells were implemented, and the daily oil production of single well was increased by 1.1t. For example, in well e, through casing resistivity logging results show that the water flooding in the pi7-8 layer is uneven, and the upper small interlayer in the layer is used for water plugging, with an initial daily oil increase of 1.6 t.

5.5. potential tapping of dominant phase
Some thin and poor layers connected with the sand body of the dominant reservoir are fractured to give full play to the potential of the dominant reservoir. 5 wells are implemented, and the daily oil production of single well is increased by 1.4T. For example, in well F, the thin layer connected with the dominant facies at the bottom is selected for fracturing, and the wells are connected for water lifting protection. After the measures, the daily oil production is increased by 2.0T at the initial stage, and the water cut is decreased by 36.4%.

Through the dissection of single sand body, 60 wells were adjusted, 52 wells with low production were controlled and shut in for a long time. The daily oil increase of single well was 1.2t, and the oil increase of that year was $0.35 \times 104t$. The decline of the whole area was controlled by 3.53 percentage points, and the input-output ratio was 1:2.63.
6. Some understanding

6.1. A certain oilfield is mainly composed of distributary plain facies and inner front facies. Narrow channel sand is developed, and inter channel sand is poorly developed. Channel sand reserves account for 80.2%. Effective adjustment of channel sand is the key to improve the development effect of the whole area.

6.2 under the current well pattern conditions, there are six types of remaining oil, mainly due to the injection production offset.

6.3 the five potential tapping directions based on single sand body research and remaining oil analysis are in line with the reality of oilfield development, and the injection production relationship of single sand body is improved, and the field application has also achieved good results.

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