Discussion on the comprehensive adjustment potential of the Sabei transition zone

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Abstract: This paper is based on the current situation of poor development effect of the Sabei transition zone. According to the practical adjustment countermeasures, using the data of core wells, the flood data and numerical simulation methods are updated. The residual oil is analyzed, and the adjustment potential and genetic types of the Sabei transition zone are studied, which provided a reference for further digging potential.

The area of Sabei transition zone accounts for 45% of the total area of Sabei development area, the geological reserves account for 24.6%, the comprehensive water cut is up to 95%, but the recovery is obviously lower than the pure oil area, and the calibration recovery is 2~3 percentage points lower than that of the pure oil area. Therefore, only a clear adjustment of the potential distribution can be made to put forward the targeted measures and ultimately improve the development effect of transition zone.

1. Analysis of water washing in coring well

Based on the data of coring wells, the utilization and the characteristics of remaining oil in various types of reservoirs and oil reservoirs in the transitional zone are analyzed and evaluated.

The B4-90-J255 is an obturated coring well drilled in 1995. It is located in the second strip-type in the Sabei transition zone, and the B2-20-JB279 is an obturated core well drilled in 2006. It is located in third strip-type of the eastern transition zone. The washing condition showed that 28% of the effective thickness was not washed (Table 1), and the thickness of the unwashed layer in the thick oil layer accounted for more than 60% of the total unwashed thickness. But the water washing condition of the B4-90-J255 well is obviously higher than that of the B2-20-JB279, which indicates that the one or two belts have been used well after the encryption of the well network.

1.1 Analysis of the current situation and potential of various oil layers

Table 1 water washing condition of the Sabei transition zone

| Well name | effective thickness(m) | unwashed thickness(m) | Proportion (%) | Low washed thickness(m) | Proportion (%) | Moderate washed thickness(m) | Proportion (%) | high washed thickness(m) | Proportion (%) |
|-----------|------------------------|-----------------------|----------------|-------------------------|----------------|-----------------------------|----------------|--------------------------|----------------|
| B1-90-J255 | 37.8                   | 7.11                   | 18.81          | 7.37                    | 19.50          | 17.58                       | 46.51          | 3.74                     | 15.19          |
| B2-20-JB279 | 19.7                   | 8.99                   | 45.63          | 2.93                    | 14.87          | 7.44                        | 37.77          | 0.3.4                    | 1.73           |
| total     | 57.5                   | 16.1                   | 28.09          | 10.30                   | 17.91          | 25.02                       | 43.51          | 6.08                     | 10.53          |

The first is that water can be found in all the thick reservoir layer, and the remaining oil is mainly distributed in the inner layer. The statistical results of the core well show that the oil layers with effective thickness of more than 1m has almost produced water, and the remaining oil is mainly...
distributed in the inner layer, and the proportion of the unwashed thickness is 22.81%, mainly formed by the permeability differences among the layers, intercalation or gravity.

Table 2: Wash condition of thick layers of core well in Sabei transition area

| Reservoir | Effective Layer | Water Washing | Water Washing Condition |
|-----------|----------------|---------------|-------------------------|
|           | Layers         | Effective Thickness (m) | Water Washing Percentage (%) | High Washed Thickness (m) | Moderate Washed Thickness (m) | Low Washed Thickness (m) | Flooding Efficiency | Recovery Degree (%) |
| Saertu    | 9              | 27.1          | 17.92                   | 66.13                    | 3.74                      | 10.93                     | 40.33                 | 3.25                 | 11.90               | 43.77               | 29.22               |
| Putahua   | 1              | 17.6          | 16.85                   | 95.94                    | 2.1                       | 11.93                     | 10.25                 | 38.24                 | 4.5                  | 25.57               | 41.00               | 29.20               |
| Subtotal  | 10             | 44.7          | 34.77                   | 77.79                    | 5.84                      | 11.06                     | 21.18                 | 47.38                 | 7.75                 | 17.34               | 42.68               | 33.15               |
|           | 10             | 44.7          | 34.77                   | 77.79                    | 5.84                      | 11.06                     | 21.18                 | 47.38                 | 7.75                 | 17.34               | 42.68               | 33.15               |

Second, the remaining oil and inefficient inefficiency exist in thick reservoirs. Although all the thick oil layers produce water, but there are 22.81% unwashed thickness, 19.73% low water washed thickness, 45.22% moderate water washed thickness, 12.24% high water washed thickness in the layer (Table 2).

The average displacement efficiency of the high water washing layer is 63.13%. From the relationship between the effective thickness of the high wash oil layer and the distribution of oil displacement efficiency, for the oil displacement efficiency of more than 63%, the thickness percentage is 42.6%.

Third, thin layers appears low level of use, the proportion of layers produce water is only 42.11%, washing thickness proportion is only 39.18%, 9.08% thickness is low water washed, 35.20% thickness is moderate water washed, only 2.45% thickness is high water washed. In addition, the data of core wells also show that as long as the water is produced from thin layer, the proportion of water washing...
and oil displacement efficiency are high, the proportion of water washing thickness of the oil layer with more than 0.5m effective thickness is only 44.93%, the oil displacement efficiency is 39.87%, and the water wash thickness proportion of the reservoir with effective thickness less than 0.5m is only 20.43%, and the oil displacement efficiency is high up to 30.41% (Table 3).

### Table 3: wash condition of thin layers in Sabei transition area

| Effective thickness classification | Effective layer washed | Washed condition | Flooding efficiency (%) | Recovery degree (%) |
|-----------------------------------|------------------------|------------------|-------------------------|---------------------|
| layers effective thickness (m)    | effective thickness (m) | washed percentage (%) | high wash thickness (m) | proportion (%) |
| 0.5m ≤ h < 1m 11 7.5 3.37 44.93 | 0.24 3.20 3.25 43.33 | 8.27 8.27 39.87 21.83 |
| < 0.5m 8 2.3 0.47 20.43 | 0.20 8.70 11.74 30.41 | 30.41 5.92 |
| Total 19 9.8 3.84 39.18 | 0.24 3.45 3.45 35.20 | 9.08 37.65 37.65 18.10 |

1.2 Analysis on the develop situation and potential of each reservoir layers

Compared with the water washing situation in each reservoir group, the oil layer of S1 group is less used, the thickness of water washing is only 33.9%, and 40% of unwashed thickness is unwashed in the whole layer; Putaohua oil layer is well used, all the layers produce water, and the thickness of the unwashed is only 4.26%. In the Saertu reservoir, the SIII layer is better used, and also produce water from all levels, and the water washing degree reaches 73.21%.

1.3 Potential analysis of remaining oil in various oil layers

Oil displacement efficiency is an index to describe the production status of oil reservoirs, and oil saturation is the index to describe remaining oil in reservoirs. According to the remaining oil saturation obtained from the relative permeability curve and the range of oil saturation of various oil layers, the limit of oil saturation is ensured, that is, oil saturation less than 30% is residual oil, oil saturation is between 30 and 40%, the remaining oil is low saturation, and the oil saturation is between 40 and 50% as the middle saturation remaining. The oil saturation is more than 50%, which is high saturation remaining oil. According to this criterion, the remaining oil potential of various types of oil layers in transitional zone is given, and the proportion of remaining oil with high saturation is 52.2% (Table 4).
### Table 4: Remaining Oil Distribution in Various Reservoir in Sabei Area

| Wash Degree       | Thickness Proportion (%) | Remaining Oil Proportion in Various Reservoir (%) | Proportion of All Remaining Oil (%) |
|-------------------|--------------------------|--------------------------------------------------|------------------------------------|
|                   | So≤30                    | 30≤So<40                                         | So≥50                              |
| High washed       | 10.6                     | 37.2                                             | 62.8                               | 0.0                  | 0.0                     | 3.9                  | 6.6                  | 0.0                | 0.0                    |
| Moderate washed   | 43.5                     | 0.0                                              | 7.0                                | 74.9                               | 18.1                   | 0.0                  | 3.1                  | 32.6               | 7.9                    |
| Low washed        | 17.9                     | 0.0                                              | 0.0                                | 5.6                                | 94.4                   | 0.0                  | 0.0                  | 1.0                | 16.9                   |
| Unwashed          | 28.0                     | 1.1                                              | 0.0                                | 1.1                                | 97.8                   | 0.3                  | 0.0                  | 0.3                | 27.4                   |
| Washed Layers in Total | 72.0                     | 4.2                                              | 9.7                                | 33.6                               | 24.8                   |                          |                      |                    |                          |
| Total             | 100.0                    | 2.0                                              | 9.7                                | 33.9                               | 52.2                   |                          |                      |                    |                          |

2. Analysis of Water Flooded Data in Replaced and Lateral Inclined Wells

The water flooded data of the replaced and lateral inclined wells show that (Table 5) the reservoirs with effective thickness more than 2.0m have all produced water. The low and the unflooded proportion in northern transitional zone with oil layers thicker than 1m is 46.8%; for oil layers thicker than 1m in the eastern transitional zone, the unflooded proportion is 46.4%.

### Table 5: Water Flooding Condition of Incline Wells in Transition Area of Sabei

| Area                | Effective Thickness Classification | Water Found Between Layers | Water Found in Layer |
|---------------------|-----------------------------------|-----------------------------|----------------------|
|                     |                                   | High Water Content          | Moderate Water       | Low Water Content    | No Water Found         | High      | Moderate | Low     | None    |
|                     |                                   | Sandstone (%)               | Effective (%)         | Sandstone (%)        | Effective (%)          | Sandstone | Effective (%) | Sandstone | Effective (%) | Sandstone | Effective (%) | Sandstone | Effective (%) | Sandstone | Effective (%) |
| North Transition Area | Effective thickness ≥ 2.0m       | 94.05                       | 94.90                 | 4.71                 | 4.23                  | 1.24                  | 0.88          | 38.0          | 47.0          | 13.6          | 1.4          |
|                     | Effective thickness ≥ 1.0m       | 19.58                       | 18.05                 | 19.79                | 67.34                 | 20.61                 | 18.41          | 21.3          | 59.3          | 19.4          | 5.4          |
|                     | Effective thickness ≥ 0.5m       | 34.30                       | 28.69                 | 64.30                | 42.62                 | 31.40                 | 28.69          | 21.3          | 59.3          | 19.4          | 5.4          |
|                     | Effective thickness < 0.5m       | 4.17                        | 6.19                  | 33.85                | 42.27                 | 56.23                 | 46.39          | 5.15          | 8.2           | 20.6          | 54.6          | 18.6         |
| Subtotal            |                                   | 67.80                       | 73.20                 | 16.98                | 18.40                 | 10.55                 | 8.11           | 10.67         | 0.29          | 31.1          | 47.3          | 18.7         | 2.9          |
| East Transition Area | Effective thickness ≥ 2.0m       | 86.66                       | 86.63                 | 10.11                | 10.40                 | 3.23                  | 2.97           | 16.6          | 44.4          | 17.4          | 1.7          |
|                     | Effective thickness ≥ 1.0m       | 64.99                       | 67.28                 | 28.88                | 26.91                 | 4.60                  | 3.96           | 1.53          | 1.85          | 21.0          | 51.7          | 25.5         | 1.8          |
|                     | Effective thickness ≥ 0.5m       | 21.48                       | 23.22                 | 67.61                | 66.35                 | 11.11                 | 10.43          | 17.1          | 57.3          | 24.6          | 0.9          |
|                     | Effective thickness < 0.5m       | 50.95                       | 40.94                 | 51.80                | 51.18                 | 17.18                 | 7.87           | 8.0           | 61.5          | 41.5          | 25.2         |
| Subtotal            |                                   | 44.33                       | 68.95                 | 23.77                | 22.63                 | 11.62                 | 7.47           | 20.28         | 0.95          | 31.6          | 46.6          | 18.6         | 3.3          |

3. Numerical Simulation of Area Remaining Potential and Distribution Characteristics

The multidisciplinary research model is set up. By using the results of multidisciplinary research, we found that the remaining oil potential of the transition zone is mainly distributed in the oil layer of more than 1 meters through the statistics of the low and unwashed thickness and the proportion of the thickness levels. This part of the thickness accounts for 42.08% of the total residual thickness, followed by 0.5 to 1 meters, accounting for 39.64%. Only 18.28% of the less than 0.5 meters. The results are basically the same as those water content statistics obtained from core wells and sidetracking wells.
4. Characteristics of potential adjustment and types of causes

Synthesizing above all outcomes, in the transition zone in the Sabei development area, Saertu and Putaohua oil layers are extracted, mainly including the distributary plain facies, the inner front margin facies and the outer front margin and other sand body sedimentary types, and the various inter river sand bodies occupy a large proportion in the non-main oil layers. Because its distribution is scattered and complex, and its lithology and physical properties are poor. Moreover, there are fewer large channel sand bodies, mainly distributed in the PI group. The main oil layer is PI3, which belongs to large river sand body. Its size is large, the width is more than 4km, PI1 and PI5+6 are low bend distributary sand bodies, the width of sand body is 500-900m, the channel is continuous and the thickness changes small, and the thrid strip with most oil layers appear in oil and water. Layer. The proportion of low bend channel sand body and straight channel sand body is not very large in this area, while the net channel sand body is the main sand body sedimentary type in the region, and the area of the matting sand body is larger and the use degree is poor in this area.

According to the analysis, the remaining oil distribution in the area has the following characteristics: first, the distribution of remaining oil is scattered. Two, the remaining oil is distributed in imperfect injection to production and detention areas. Third, there is a certain residual oil at the edge and top of the river.

The remaining oil can be classified into five types: imperfect injection to production, thick oil reservoir layer, poor oil reservoir, detention zone and well pattern. From the result of the study, the remaining oil is mainly due to incomplete injection production and well network control, which accounts for about 40% of the remaining oil, 30% of the differential oil layer and the stagnant zone, and 30% in the thick oil layer. Therefore, the effective water flooding adjustment measures should be applied on the transition zone, such as encryption adjustment, injection production system adjustment, etc. The problem of imperfections and well pattern cannot be controlled. Secondly, the effective utilization of remaining oil in thick oil layers can be improved by effective means such as tertiary oil recovery.

5. Conclusions

(1) The water washing condition of the core well shows that the unwashed thickness in the thick oil layer of the transition zone accounts for more than 60% of the total unwashed thickness, and is the remaining oil enrichment area; the proportion of the high saturation remaining oil is over 50%.

(2) Water flooding data show that the reservoirs with effective thickness more than 2.0m all contain water, and the proportion of unflooded oil reservoirs thicker than 1m and is more than 45%.

(3) The results of numerical simulation show that the remaining oil potential of the transition zone is mainly distributed in the oil layer over 1 meter, which accounts for more than 40% of the total remaining thickness.

(4) The remaining oil is summed up into five types: imperfect injection to production, thick oil layer, poor reservoir type, retention zone type and incontrollable well type, among which the main types are imperfect injection to production and incontrollable well type.

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