Analysis of influence factors of oil and gas reservoir description accuracy

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Abstract. The control degree of the sand body and the coincidence rate of the microfacies prediction are statistically analyzed by using the post test well, and the main factors affecting the reservoir description accuracy are analyzed. The effects of the well density, the reservoir plane heterogeneity and the well seismic combination technology on the reservoir description accuracy are qualitatively and quantitatively evaluated, and the sand body changes before and after the well encryption are summarized. This paper clearly points out that two methods are the main way to improve the description accuracy under the condition of well pattern. First, the application of coring wells to deepen the understanding of sand body plane transformation. Second, deepen the well seismic combination reservoir description technology.

1. Introduction
With the increase of well density, the understanding of sand bodies will be more and more close to the true appearance of underground. However, it is impossible to increase the density infinitely. It is difficult to accurately describe the reservoir using the existing well conditions. In this paper, the control degree of the sand body and the coincidence rate of the microfacies prediction under the different well density are counted. The main factors that affect the accuracy of reservoir description are analyzed and deeply studied.

The reservoirs in the A block are mainly distributed in flood plain facies, distributary plain facies and delta front and outer leading edge. According to the developmental subfacies, the reservoirs are subdivided into three types. The first type of reservoir is the meandering river and braided river deposits of flood plain facies; the second type of reservoir refers to the onshore distributary channel deposition of the distributary plain facies; the third type of reservoir is the underwater distributary channel deposition of the delta front facies.

2. The influence of the well density on the description accuracy
In order to study the influence of well density on sand body description accuracy. For different well density facies maps, statistically analyzed the sand body control degree and microfacies prediction coincidence rate.

The method is used to calculate the control degree of the sand body. According to the understanding of sand body in dense well, the facies map of sparse well is compiled with the same drawing method, and the sand body of the facies is superimposed. According to the situation of overlapping and changing of the distribution state of sand bodies, the control range of sand body under the different well density obtained by filling out the form (1-1). Degree (Table 1).
The method is used to calculate the coincidence rate of the microfacies prediction. After the well is encrypted, load the drilling microfacies data of the post test well on the different batch facies map, compared drilling microfacies by the well by layer, the coincidence rate is calculated (Table 2).

The control degree of sand body and the coincidence rate of the microfacies prediction of 20 typical sedimentary units selected in the different types of A block are statistically analyzed by using the uniform and dilute posterior well.

Table 2. Comparison between sand control degree and microfacies prediction coincidence rate.

| Reservoir type | Sparse well (density 57.3 /km²) | Dense well (density 100.6/km²) | D-value |
|----------------|---------------------------------|---------------------------------|---------|
|                | Control degree of sand body    | Coincidence rate of microfacies prediction | Control degree of sand body    | Coincidence rate of microfacies prediction | Control degree of sand body    | Coincidence rate of microfacies prediction |
| The first type | 99.3                            | 88.2                            | 100.0               | 92.7                            | 0.7                            | 4.5                             |
| The second type| 81.0                            | 59.8                            | 87.6                | 72.6                            | 6.6                            | 12.8                           |
| The third type | 81.7                            | 50.4                            | 86.2                | 63.6                            | 4.5                            | 13.2                           |
| Total          | 87.3                            | 66.2                            | 91.3                | 76.3                            | 4.0                            | 10.2                           |

2.1 The first type reservoir
In sparse well, the control degree of sand body can reach 99.3%, the coincidence rate of microfacies prediction is 88.2%, and the precision of description is high. When the dense well, the control degree of sand body is 100%, the coincidence rate of microfacies prediction is 92.7%, and the precision is very high. When the density of well is 57.3 /km², it is well controlled to the first type reservoir sand body. The density of well pattern increased by nearly one time, and the control degree of sand body increased by only 0.7%. The accuracy of microfacies prediction has a certain effect, and the prediction coincidence rate has increased by 4.5%.

2.2 The second type reservoir
In sparse well, the control degree of sand body is 81%, the coincidence rate of microfacies prediction is 59.8%, and the precision of description is low. When dense well, the control degree of sand body is 87.6%, and the coincidence rate of microfacies prediction is 72.6%. Contrast found that the density of well increases by nearly one times the control degree of sand body by 6.6%, and about 12.4% of the sand body is out of control, it is floodplain sediments far away from the channel mainly. The rate of prediction for microfacies is increased by 12.8%. The increase density of well has great influence on the control degree and description accuracy of the second type reservoir.

2.3 The third type reservoir
In sparse well, the control degree of sand body is 81.7%, the coincidence rate of microfacies prediction is 50.4%, and the precision of description is low. When the dense well, the control degree of sand body is 86.2%, the coincidence rate of the microfacies prediction is 63.6%, and the description
precision is still low. In contrast, the control range of the well density is increased by 4.5%, and 13.8% of the sand body is out of control. The main features are underwater distributary channel and underwater flow sand with less width than well distance, and the coincidence rate of microfacies prediction is increased by 13.2%. The increase of well density has great influence on the control degree and the description accuracy of the third type reservoir.

According to the above analysis, it can be found that under the condition of sparse well, the first type reservoir can be described accurately, and the description precision of the second type reservoir and the third type reservoir are low. The effect of well encryption is not much affected to the first type reservoir, the accuracy of the second type reservoir and the third type reservoir are raised by 12~14 percentage points, but the prediction error is still 30 ~ 40%, it still have large space can be promoted.

3. **The influence of reservoir heterogeneity on the accuracy of description**

In view of this problem, the development of the second type reservoir and the third type reservoir are studied. From the heterogeneity of the reservoir, the influence of the reservoir plane heterogeneity on the description accuracy is emphatically analyzed, including the geometric shape, scale and continuity of the sand body, as well as the plane changes of porosity and permeability in the sand body.

The relationship between the plane heterogeneity of the 20 typical sedimentary units in block A and the coincidence rate of the microfacies prediction is made (Table 3).

| Reservoir type     | The plane of sandstone drilling rate (%) | Channel sand drilling rate (%) | River course | Coefficient of variation of plane permeability | Coincidence rate of The prediction (%) |
|-------------------|-----------------------------------------|-------------------------------|-------------|---------------------------------------------|--------------------------------------|
| The first type    | 98.1                                    | 85.0                          | 2500~3000   | 450~1200                                    | 1~2                                  | 0.61                                 | 92.7                                 |
| The second type   | 77.3                                    | 42.0                          | 300~1800    | 150~700                                     | 3~5                                  | 0.72                                 | 72.6                                 |
| The third type    | 72.6                                    | 19.7                          | 150~500     | 60~250                                      | 1~3                                  | 0.82                                 | 63.6                                 |

3.1 **The first type reservoir**

The drilling rate of sandstone is as high as 98.1%, the channel sand drilling rate is about 85%. The width of the single channel width is between 450 and 1200m, the inter channel sediment is less, the horizonted continuity and the longitudinal continuity are very good. The variation coefficient of the plane permeability is only 0.61, the plane heterogeneity is weak. The coincidence rate of the microfacies prediction is very high, up to 93.9%.

3.2 **The second type reservoir**

The drilling rate of sandstone is 77.3%, the channel sand drilling rate is 42%. The channel size is smaller than that of the first type reservoir, the width of the single channel width is between 150 and 700m, the spilled sand is distributed along the riverway, the mud between the channels increases and the longitudinal continuity of the channel sand is better, the facies change frequency is higher. The permeability coefficient variation coefficient is 0.71, the plane heterogeneity is relatively strong. The coincidence rate of microfacies prediction is 72.6%.

3.3 **The third type reservoir**

The drilling rate of sandstone is 72.6%, the channel sand drilling rate is only 19.7%. The river channel size is further reduced, the width of the single channel is about 100m, and the narrow channel less than the well distance is often developed, and the longitudinal continuity is poor. The channel ends are
mostly banded and discontinuous distribution, the sheet sand development surface is larger, the transverse phase change frequency is high, and the permeability is high. The coefficient of variation is 0.82, the plane heterogeneity is very strong. The coincidence rate of microfacies prediction is only 63.6%.

Through the analysis of the statistical results, it is found that the stronger the plane heterogeneity is, the lower of the reservoir microfacies prediction accuracy, especially the third type reservoir, the smaller size of the sand body and the complex plane facies transformation, which is the main factor affecting the prediction accuracy.

4. The influence of well seismic combination reservoir prediction technology on the accuracy of description.

Compared with the well density of 100 /km², the 3D seismic data surface element is 10m x 10m, which has the advantage of lateral coverage. It can effectively identify the interwell sand body, and combine the seismic plane resolution with the vertical resolution of well logging, and can realize fine characterization of small scale and face change fast sand body. At present, widely used well seismic prediction combined reservoir prediction technology is mainly composed of three single attribute slice prediction, multi-attribute fusion prediction and geostatistics inversion prediction. Three methods are applied to reservoir description of 20 typical sedimentary units in the block A.

4.1 The first type reservoir

Due to weak plane heterogeneity of sand body and weak response of seismic to plane facies transformation, single attribute prediction, multi attribute fusion prediction and geostatistical inversion prediction have been used to improve the coincidence rate of microfacies prediction by 1.4%, 2.1% and 2.7% respectively. Well seismic combined precision has little influence on the of the first type reservoir.

4.2 The second type reservoir

The plane heterogeneity of sand body is stronger than that of the first type reservoir, but the thickness of the sand body is much smaller than that of the first type reservoir. The seismic data reflect the interlayer interference with the plane phase change, and the prediction of the single attribute, the multi attribute fusion and the geostatistics inversion, the coincidence rate of the microfacies prediction is increased by 2.2%, 6.3% and 12.4% respectively. Well seismic combined precision has little effect on the microfacies prediction of the second type reservoir, while the multi attribute fusion prediction and the geostatistical inversion prediction can greatly improve the accuracy of the second type reservoir microfacies prediction.
4.3 The third type reservoir
The sand body is thin, the plane heterogeneity is strong, the response of seismic data to the sand body is weak, the single attribute slice prediction and multi attribute fusion prediction are very strong, the sand body is not ascertain and the sand body distribution is predicted accurately, and the geological statistics inversion prediction solves this problem well, and makes the microfacies preview. The coincidence rate was increased by 13.1%.

According to the statistical results, we can find that the well seismic combination prediction technology has little effect on the first type reservoir description accuracy. However, it have great guiding significance for the second type reservoir and the third type reservoir prediction which have strong heterogeneity and low control degree under the current well density, the accuracy of reservoir description can be increased by more than 10 percentage points on the whole.

5. Summary of the characteristics of sand body change
Based on the statistics of the coincidence rate of microfacies prediction, 2 types and 4 main positions of microfacies prediction are summarized.

5.1 Two types
(1) The proportion of non controlled type is 42.9%, there is two kind of sand in this condition. One is floodplain sediments far away from the channel in the onshore distributary channel deposition; the other is the narrow channel in the underwater distributary channel deposit. The main reason is that the well density is small, the control degree of the small channel and the out channel sand between the river is low.

(2) The proportion of overforecast is 57.1%, there is also two kind of sand in this condition. One is the width of the single channel in the complex channel sand in the onshore distributary channel deposition; the other is the the continuity of the channel sand in the underwater distributary channel deposit. The main reason is that the understanding of the sedimentary model is not perfect, and the prediction of the sediment size and continuity is deviant.

5.2 Four positions
(1) The opening and end of the river channel refers to the beginning and end points of a river in the study area. Due to the lack of well point control, it is difficult to predict the direction of the river, and a certain degree of migration will occur after encryption. The distribution of the river sand should be predicted according to the source and the main direction of the development of the other river channels.

(2) The straight section of the river is that when the two wells with close distance are all channel facies, the prediction is usually combined in a straight line. After encrypt, it is found that the straight channel is a stage product of the development of the river, and the deposition process is short, the quantity is less. It should be taken into consideration.

(3) The river bifurcation merger refers to the well area of merging and branching in a number of rivers. In the river confluence, the river channel becomes wider, the channel of the fork is narrowed, the prediction of the width of the channel is difficult, and the appropriate extension should be made to the bifurcation part according to the scale of the distributary channel.

(4) In order to predict the narrow channel sand body between wells, if the prediction distance is too far away, the prediction part of the river will be interrupted, the direction or boundary of the river is out of control. The prediction should adjust the continuity of the river according to the sedimentary model.

6. Conclusion
(1) Under the current well density, the first type reservoir description can be accurately described. The second type reservoir and the third type reservoir microfacies prediction is relatively low, and the accuracy of the description can be greatly improved.
(2) Reservoir heterogeneity is an important factor affecting the accuracy of description. The stronger the heterogeneity is, the lower the accuracy of description.

(3) Well seismic combination technology can effectively improve the accuracy of microfacies prediction, especially the description accuracy of the second type reservoir and the third type reservoir can be increased by more than 10 percentage points.

(4) There are two main ways to improve reservoir description accuracy under well pattern condition. The first is the comprehensive application coring wells and 3D seismic data to improve the understanding of heterogeneity. The second is to improve the well seismic combination reservoir description technology.

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