Washed core and tracer tests data guide the characterization of single sand body in Low Permeable Reservoir

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Abstract. A Oilfield is Fluvial Facies Low Permeable Reservoir, main layer is Low bend distributary channel sand body deposition, In order to better understand the distribution of single sand body and remaining oil in the reservoir, inspection well coring and tracer tests have been carried out successively in the same well area of the oilfield, based on these data, it is found that, the actual distribution of single sand body is very different from the original description in both vertical and plane. Discovered by the inspection well core data, the scale of the vertical single-phase body was too large. It was originally considered to be the mudstone interlayer inside the 0.2m single sand body, which is actually the interlayer between different single sand bodies, and this situation was confirmed by the trace data five years later. The distribution position and scale of single sand body on the plane are also different from the original description. It was thought that the oil and water well sand body with good internal connection in the same single sand body is actually not connected. Therefore, the experience of these data on vertical and horizontal single sand body identification is summarized to guide the subsequent single sand body characterization of the oilfield, so as to better guide the oilfield to describe the remaining oil and adjust and tap the potential.

Key words: Low Permeable Reservoir; Single sand body; Fluvial Facies.

1. Preface

In order to find the remaining potential in the next step of oilfield A, according to the sedimentary characteristics of the main oil layer of oilfield A is the low-bend distributive channel facies, the flood surface is mainly used as the reference standard layer, the elevation difference is compared, and the correlation methods such as sedimentary microfacies orientation are used [1-6]. For the deposited complex meander sand body, the single sand body identification methods [6-12], such as abandoned channel, sand body thickness change and log curve shape change, are mainly used to characterize the single sand body. On this basis, the core water washing data and tracer data of A closed core inspection well located in the same well area of A main block in oilfield A were analyzed. It was found that some single sand bodies were either not divided in the previous vertical comparison or not characterized in the previous identification of flat single sand bodies. Therefore, this paper further discussed the vertical and plane characterization of single sand bodies.

2. Core water washing and trace data guide vertical characterization of single sand body in low permeability reservoir

Well J1 is A closed coring inspection well drilled in one of the main blocks of Oilfield A. In the C1 layer of the well, there is a weakly washed sand body (FIG. 1) separated by about 0. 2 m of argillaceous rock above the unwashed sand body. The mudstone thickness of about 0. 2 m is consistent with the mudstone intercalation between the lateral deposits of the point dam, which was originally classified as such. Reference 6 points out that "mudstone interlayers between the lateral deposits usually only develop in the middle and upper part of the point dam, namely the upper two-thirds of the point dam thickness, which has a strong blocking effect on the fluid flow. Due to the non-presence of late flood peak erosion in the lower part, the connected body is formed in the lower part, which is an important channel for fluid migration "[6]. This indicates that the lateral interlayer only blocks the displacement in the middle and upper part of the sand body, but does not block the displacement in the lower part of the sand body, and the lower part of the sand body should be washed first. The above condition is inconsistent with the condition of washing the upper part of C1 sand body and not washing the lower part of C1 sand body in well J1, indicating that the argillaceous rock is not the lateral mudstone inside the single sand body, but the interlayer between different single sand bodies.

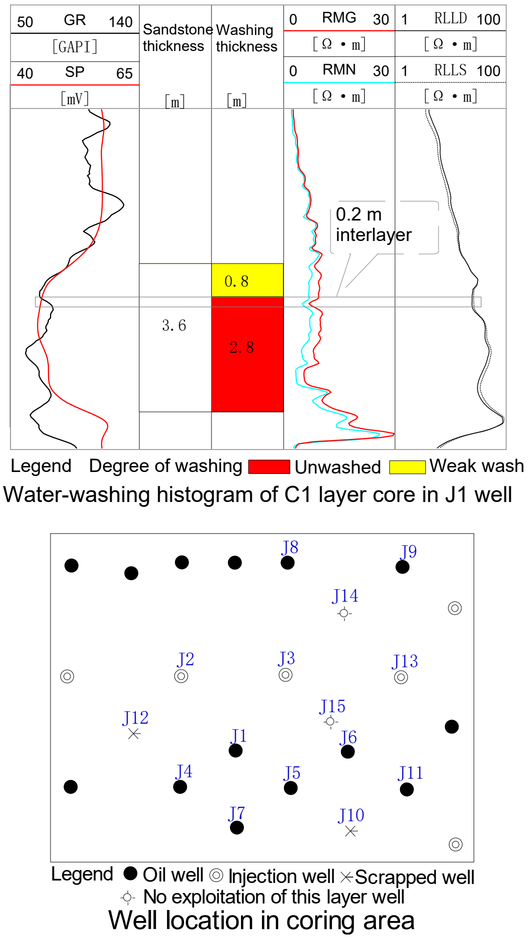

Fig. 1 Water washing histogram of C1 layer core in J1 well and well location in coring area

After J1 was drilled, J5 was injected and J1 was used as an oil well for production. Five years later, tracer was injected into two Wells J3 and J5 in J1 well area of C1 formation, and there were 6 directions for detection (see Figure 2). The detection time in 5 directions ranged from 8. 3 hours to 92 hours, and the detection time from J3 well to J1 well was 878 hours. The time of seeing agent in Yuanda and other directions is consistent with the weak water washing condition of the upper sand body of C1 during coring in well J1. Meanwhile, it is confirmed that the argillaceous rock between the upper sand body and the lower sand body of C1 in well J1 is not the lateral mudstone inside the single sand body, but the interlayer separating the upper and single sand body. Otherwise, if it is the lateral mudstone inside the single sand body, the tracer percolates through the bottom of the sand body of C1, and the maximum time is 92 hours according to other direction of agent detection in the same well area. In particular, the detection time from J5 to J1 is 14. 3h, which is similar to the injection-production distance from J3 to J1. The target direction of the tracer is the C1 sand body of J1, and the detection time from J3 to J1 is not much longer than 14. 3 hours but 878 hours.

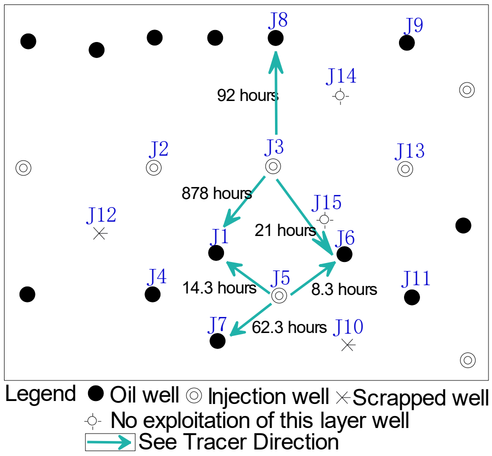

Fig. 2 Well location and tracing time diagram of J 1 well after coring five years

For the sand bodies of Wells J1, J2, J3, J4 and J5 in the C1 layer, according to the existing interpretation criteria of sand bodies in oilfield A, the degree of silt return is not enough to divide them into two independent single sand bodies in the C1 layer. Therefore, they are initially classified as one single sand body in the vertical comparison (see Figure 3). A number of literatures have emphasized the problem that reservoir correlation may be too finely divided [2, 5]. The overview of literature 7 is as follows: "In the process of small-bed correlation, if the series gully associated locally with the point dam, or even every bank overflow in the natural dike or fracture fan is taken as a single sand body and the main sand body is forcibly split, then the seepage barrier inside the main sand body will be forcibly split. It will seriously impede the later research on the law of oil and water movement "[7]. The core washing data of C1 layer and the tracer data of this well area show that the upper sand body and the lower sand body in C1 have completely different seepage barriers. J1 is based on this barrier, and the rest of the Wells are based on the flood surface closest to the barrier on the logging curve (see Figure 3). It is necessary to subdivide the argillous return near the top boundary of layer C11 and layer C12 (see Figure 3) into layers C11 and C12, so as to more accurately describe the true displacement seepage relationship, and thus more accurately guide the subsequent description of remaining oil and adjustment of excavation potential.

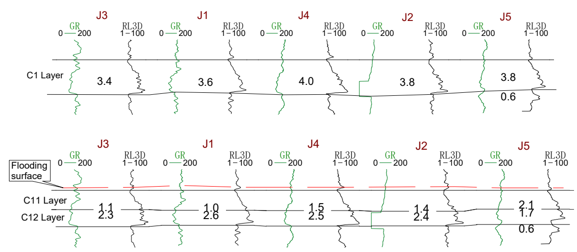

Fig. 3 Stratigraphic correlation before and after subdivision of C1 layer in J1 well area

3. Core water washing and trace data guide the plane characterization of single sand body in low permeability reservoir

Before subdivision of C1 layer in J1 well area, sand bodies were distributed in several Wells in the lower right area (see Figure 4-C1 layer). After subdivision into layers C11 and C12, multiple Wells in the lower right part of layer C12 have sand body distribution (see Figure 4-C12), while multiple Wells in the lower right part of layer C11 have sand body distribution (see Figure 4-C11). It shows that sand bodies only develop in the C12 layer, but not in the C11 layer, which further proves that the C1 layer in well J1 is subdivided into different single sand bodies in the C11 layer and the C12 layer.

In the initial vertical comparison of C1 layer, the division of single sand body was too large, and the different single sand bodies in the upper and lower stages were divided into the same single sand body. Compared with other well sand bodies, the sand body of J12 was the same as the bottom of other well sand bodies, and the sand body only developed at the bottom, with mud at the top and small thickness (see Figure 4-C1 layer). The well sand body is considered to be the abandoned channel sand body of the bar sand body at the point of Wells J1, J2, J3, J4 and J5 on the right (see layer 4-C1). After C1 layer is subdivided into lower C12 layer and upper C11 layer (see Figure 4-C12 layer and Figure 4-C11 layer), the average thickness of single well sandstone in C11 layer is 1. 0m, and that in C12 layer is 2. 0m. The average thickness of single well sandstone in C11 layer is 1. 0m smaller than that in C12 layer, and the hydrodynamic force in C11 layer is weaker than that in C12 layer during deposition. Accordingly, the porosity and permeability of layer C11 is weaker than that of layer C12, and the fluid preferentially passes through the well-permeated channel. Except for the longer 878 hours of observation time, which is the percolation time of layer C11 (the C11 layer of J1 core was washed and the C12 layer was not washed), the observation time of other tracers should be its percolation time in layer C12, otherwise it should also be the same as that of layer C11. The direction of the absence of agent indicates that C11 and C12 layers are absent of agent.

Layer C12 is completely based on core washing data and tracer data, and the direction without data is regarded as sand body connectivity. Single sand body of this layer is described (see Figure 4-C12 layer). During coring, the core of J1 was not washed, and the tracer injection occurred in 14. 3 hours from J5 to J1, so J3, J2 and J1 were not connected. The abandoned channel of C1 was added to C12 in this direction. J5 and J1 were connected, and the two Wells were located in the same point dam. After 8. 3 hours from J5 to J6, J5 and J6 are connected. The abandoned channel predicted by C1 in this direction is cancelled in C12. After 21 hours from J3 to J6, J3 and J6 are connected. The abandoned channel predicted by C1 in this direction is cancelled in C12. From well J5 to well J4, there is no fluid, and the unpredicted abandoned channel of C1 layer is added to layer C12 in this direction. The predicted abandoned channel in C1 between J3 and J8 was cancelled in C12. No fluid was found from J3 to J9, and the direction of abandoned channel in layer C12 was different from that predicted in layer C1.

The single sand body of layer C11 is characterized mainly based on core washing data and tracer data, and the direction shown in no data is based on the thickness change of sand body (see Figure 4-C11 layer). During coring, the core of well J1 was washed, and the agent was found from well J3 to well J1, so there was no abandoned river channel between well J3 and well J1. Three abandoned channels were identified based on the absence of agent in Wells J5 to J4, J5 to J11 and J3 to J9. Five abandoned channels were predicted based on thickness changes in the other directions.

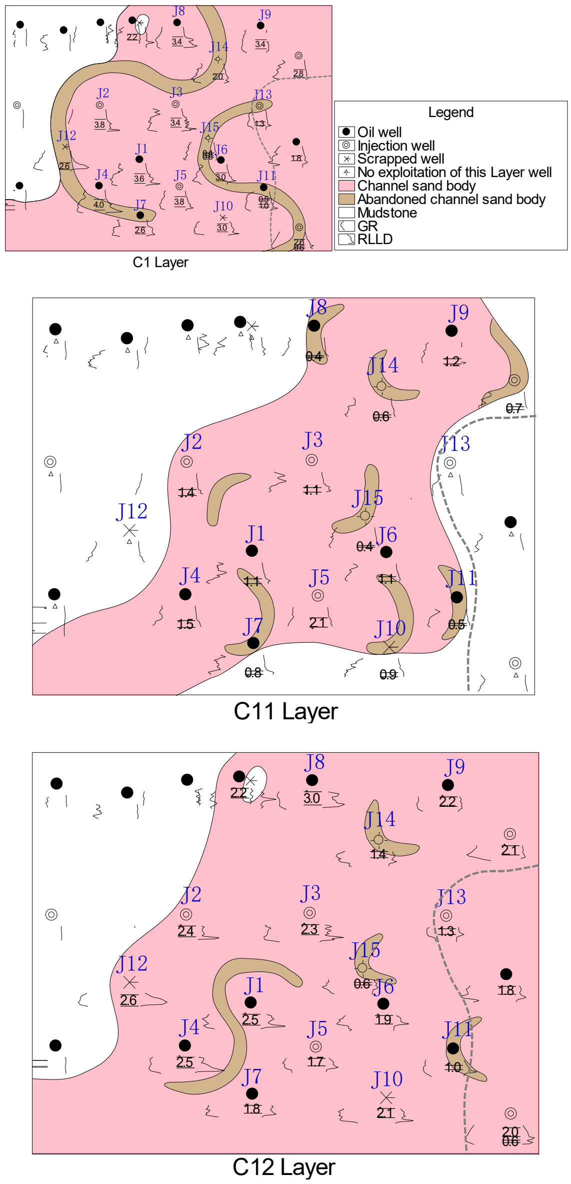

Fig. 4 Facies maps of C1 layer and C11 layer and C12 layer in J1 well area

In general, after vertical redivision and plane recharacterization, the vertical thickness and plane width of single sand body became smaller. In fact, many of the previously predicted abandoned river channels did not exist, many of the previously predicted abandoned river channels did exist, and the distribution direction of many of the previously predicted abandoned river channels changed.

The distribution of single sand bodies in fluvial facies is complex and variable. Based on the characterization results of single sand bodies guided by the above core and tracer data, it is found that the following points should be paid attention to when logging data of well area is used alone to characterize single sand bodies:

First, when the spacing between different vertical single sand bodies is too small, it is easy to be mistaken as the interlayer inside the single sand body, which will lead to the wrong judgment of the vertical seepage relationship, and also lead to the subsequent plane single sand body characterization errors based on the division of vertical single sand bodies.

Second, when the well is drilled into the abandoned channel sand body (the abandoned channel sand body is obviously thinner than the normal sand body, and the sand body is developed at the middle bottom or bottom, and the top is mud), it is easy to determine the existence of the abandoned channel in the well, but it is difficult to determine the distribution direction of the abandoned channel. If the wrong judgment is made, the understanding of the connectivity relationship of the sand body will be wrong, and the adjustment of potential excavation will be misleading. For example, J6 is closest to J15, and the curve is bell shaped. It is easy to predict J6 as the downstream end sand body of the point dam near the abandoned river channel [7], that is, it is predicted that the abandoned river channel bends towards J6, and it is considered that J6 and J15 belong to the same point dam, and J15 and J3 belong to different DAMS. In this way, J3 well and J6 well will be separated by abandoned river channel and not connected, which is inconsistent with J3 well to J6 well. Therefore, J15 well should be bent to J13 well so as not to block the communication between J3 and J6 well. Another example is the abandoned river channel at J11 well in the C12 layer. If J5 well bends to the left instead of to the right, then J5 well and J11 well become connected, which is inconsistent with the lack of agent from J5 to J11 well. Another example is the abandoned river channel of well J14 in the C12 layer. When it bends to well J9, well J14 is connected to well J9, but not to well J3. In this way, well J9 is not connected to well J3, which is consistent with well J3 to J9. If the abandoned channel bends to well J3, well J14 is connected to well J3 and is not connected to well J9, then well J9 is also not connected to well J3. Although it is consistent with well J3 to J9, a little extension of the abandoned channel spreading in this direction will block the communication between well J3 and well J8, which is inconsistent with well J3 to J8, so it is not depicted in this direction. If the abandoned channel bends towards well J13, just as the abandoned channel of J15 does not block the connection between well J3 and well J6, the abandoned channel has no blocking effect on well J3 to J9, which is not consistent with the absence of agent from well J3 to well J9. If the abandoned river bends to well J8, it is more likely to block the communication between well J3 and well J8, which is inconsistent with the detection of agent between well J3 and well J8. The abandoned channel may also have other bending directions. Only with tracer data can we determine that the abandoned channel of well J14 bends to well J9, which is the most consistent with the actual direction. If we only rely on well logging data of the well area, without tracer data, it is difficult to determine that the abandoned channel bends to well J9, which is the most consistent with the actual direction.

Third, when the sand body thickness of three adjacent Wells in the same straight line in the region presents thick-thin-thick distribution, and the sand body of the middle well becomes thinner. The thin sand body does not correspond to the middle bottom or bottom of the thick sand body on both sides, but to the middle top or top of the thick sand body on both sides, and the bottom is mud, then the middle well is not abandoned river channel sand body. There may be intact mudstone near the intermediate well sand body, which has not been washed out by the river and is another sand body boundary to prevent the effect of water flooding. It is necessary to carefully predict the location, distribution direction, extension length, and even the presence or absence of the boundary of the single sand body. If the prediction is wrong, the actually connected direction will be judged as disconnected, or the disconnected direction will be judged as connected. For example, in the connection direction of Wells J1, J5 and J10 in the C12 layer, the thickness of the three Wells is 2. 5 meters, 1. 7 meters and 2. 1 meters respectively. If it is predicted that the boundary of single sand body is between J5 and J1, it is inconsistent with the detection of agent from J5 to J1. If the boundary of single sand body extends between J5 and J6, it is inconsistent with the detection between J5 and J6. If the boundary of single sand body extends between J5 and J7, it is inconsistent with the detection from J5 to J7. When J10 is shut in, the connectivity between J5 and J10 cannot be determined. It can only be predicted that there may be a single sand body boundary between J5 and J10, and the direction is more likely to bend to J10, so as to avoid the contradiction between J5 and J6, J5 and J7, as well as between J5 and J6 and J7. Only with tracer data can it be determined that the single sand body boundary does not exist between J5 and J1. Without the tracer data, it is difficult to determine whether the single sand body boundary does not exist between J5 and J1, and whether the single sand body boundary exists between J5 and J10, depending on the well logging data of the well area. It is difficult to determine whether the single sand body boundary extends between J5 and J6 and between J5 and J7.

Fourthly, the sand bodies of oil and water Wells in different DAMS are not absolutely disconnected, but also well connected. For example, in layer C12, the connection line of well J7, well J5, well J6, well J3 and well J8 is followed. Assuming that the reverse flow time of the tracer is equal to the original flow time, the total flow time of the tracer in this route is 183. 3 hours. The connection between any adjacent Wells on this route is good. The length of the line is far beyond the width of a single point dam in the same area, so there must be some adjacent Wells located in different dam sand bodies.

Fifth, when the thickness of each local well sand body is the same, it is difficult to determine whether and where the boundary of single sand body exists, and its distribution direction and extension length between these Wells based on logging data alone. For example, the abandoned river channel between well J1, J2 and J3 in layer C12 was determined only under the instruction of checking well core water washing data and tracer data. It is difficult to predict it, as well as their distribution direction and extension length, based on logging data alone without checking well core water washing data and tracer data.

4. Conclusion

The correct characterization of vertical single sand body in low permeability reservoir is the basis for the correct characterization of single sand body on the plane. It is necessary to avoid the vertical division of single sand body. When the vertical division of single sand body is conducted according to the logging curve, it is necessary to realize that the small argillaceous return of about 0. 2m can also be used as the separation layer of upper and single sand body and become the seepage barrier of upper and single sand body.

(1) In the well area of low permeability reservoir, according to the well logging data, argillus return occurs simultaneously in the position with the same elevation difference between a part of Wells in a small layer and the nearest reference standard layer. In the other part of Wells that can be connected together, only the sand body below the argillus return develops, but not above the argillus return. It is necessary to recognize the possibility that the upper and lower argillaceous sand bodies in the previous part of the well are different single sand bodies.

(2) The comparison between the single sand body characterized by combination of logging, core and tracer data and the single sand body characterized by single logging data shows that the distribution of single sand body in low permeability reservoir is complex and changeable, and there are many uncertainties in the characterization of single sand body in low permeability reservoir by single logging data.

References

1. Yu Xinghe. Existing problems and sedimentogenesis-based methods of reservoir characterization during the middle and later periods of oil-field development[J]. Earth Science Frontiers, 2012, 19(2): 1-14.
2. Qiu Yinan, Zhang Zhisong, Tang Meifang, et al. The detailed correlation of fluvial sandbody reservoirs[J]. Petroleum Exploration and Development, 1987, 14(2):46-52, 9.
3. Zhao Hanqing. Formation correlation of fluvial-deltaic deposition in Daqing oil field[J]. Petroleum Geology & Oilfield Development in Daqing, 1988, 7(4):25-31.
4. Deng Hongwen, Wang Hongliang, Yan Weipeng, et al. Architecture model of sequence stratigraphy in fluvial facies[J]. Acta Sedimentologica Sinica, 2004, 22(3):373-379.
5. Qu Fang, Chen Qinghua, Lian Chengbo. Discussion on the method for the subdivision and comparison of fluvial reservoir[J]. Journal of Xi’an Shiyou University(Natural Science Edition), 2008, 23(1):17-21.
6. Zhang goodwill Research on point dam identification and building structure of Fuyu oil layer in Chang 43-39 block [D] Northeast Petroleum University, 2011.
7. Chen Xinkai, Liu Jingyan, Chen Cheng, et al Single sand body identification of meandering river under subdivision of main configuration elements [J] Acta sedimentologica Sinica, 2020, 38 (1): 205-215.
8. Ma Shizhong, Yang Qingyan Sedimentary model, three-dimensional configuration and heterogeneous model of meandering point dam [J] Acta sedimentologica Sinica, 2000, 18 (2): 241-247.
9. Yan Baiquan, Ma Shizhong, Wang long, et al Physical simulation of formation and distribution law of residual oil in meandering point dam [J] Geoscience frontier, 2008, 15 (1): 65-69.
10. Wang Mingchuan, Zhu Weiyao, Dong Weihong, et al Internal configuration of point bar type thick reservoir unit in meandering river and its influence on remaining oil distribution [J] Oil and gas geology and oil recovery, 2013, 20 (3): 14-17.
11. Ma Shizhong, Wang Yibo, Li Shikui, et al Internal building structure of single sand body and its control mechanism on residual oil [a] Abstracts of the 8th Academic Conference on paleogeography and sedimentology [C]. 2004.
12. He Miao, Jin zhenkui, Li Tingdong, et al Characterization of fluvial facies single channel sand body -- Taking the Triassic Kexia formation in the first middle area and the third 4 area in the northwest margin of Junggar Basin as an example [J] Science and technology Herald, 2014, 32 (6): 17-24.