Discussion and application of thin-layer sand connectivity of outer front facies

Lingzhi Zhang *

The 5th oil production plant of Daqing Field Ltd. China Heilongjiang daqing 163000 China

Abstract: In this paper, the microfacies of thin-layer sand of outer front facies are described by homogeneous unit thickness classification in the past, the plane distribution of single sand body and the connection relationship between different sand body types are roughly understood; From the two aspects of vertical single-stage thin-layer sand body identification and fine description of sedimentary facies belt map applying energy facies in plane microfacies, the outer front belt is divided into 6 types and 9 kinds of thin-layer sand combinations, the connectivity of sand bodies is clearer and the directionality is clearer. The application of research results not only deepens the geological understanding, but also guides the adjustment of water-driven scheme.

Keywords: Thin-layer sand, connection relationship, energy microfacies.

1. Raising questions

According to the research in 2008, for the N Ⅱ and N Ⅲ oil layers of the outer front facies in area A, from the perspective of vertical evolution, the stability of the sheet sand of the outer front facies of the delta is different. According to the genesis, it can be divided into five types of sand bodies: River controlled underwater distributary channel sand, wave controlled offshore bar sand, wave controlled distal bar sand, river lake dual control transition sand body and outer front sheet sand, N sedimentary units are classified. In the actual development and application, Gptmap software was used to classify the thickness according to the effective thickness (effective thickness > 0.5m is the main sheet sand, effective thickness 0-0.5 is the non main sheet sand, and effective thickness = 0 is the off surface reservoir) determine the microfacies of single well, generate the facies belt map of each sedimentary unit, and then guide the scheme adjustment and measure formulation. The corresponding connection relationship between oil and water wells can not be truly reflected and accurately identified, and have a rough understanding of the plane distribution of single sand body and the connection relationship between different sand body types With the oilfield entering the period of high water cut, some blocks have shown "double high" That is, the characteristics of high recovery degree and high comprehensive water cut. For group N Ⅱ and group N Ⅲ oil layers, from the perspective of sand body development thickness and scale, the number of thin sand development layers is large, but the thickness is thin; from the perspective of production status, group N Ⅱ oil layer is well produced, but there are great differences between layers, resulting in uneven production; group N Ⅲ is poor in overall production due to poor oil layer conditions; from the perspective of multi-disciplinary statistics of oil layer remaining reserves , group N Ⅱ and group N Ⅲ still have certain potential. Therefore, in order to effectively control the "double high" block, it is necessary to clarify the corresponding and accurate connection relationship between oil and water wells, use more precise and accurate static results to guide the adjustment of water drive scheme and the formulation of measures, and provide basic technical support for effectively tapping the potential of remaining oil.

2. Single stage thin sand body identification and plane characterization of energy phase units in microfacies

Through the identification of single-stage sand body of thin-layer sand, the vertical subdivision unit reaches the level of single-stage sand body; After the establishment of high-resolution stratigraphic framework, the energy change sand body in plane microfacies of each unit is identified, six types of thin-layer sand type combinations are carefully dissected, the genetic classification of each unit after subdivision is re recognized, and the sedimentary facies belt map is finely described. The connectivity and directionality of different types of thin-layer sand are clearer, which provides a basis for the

* Corresponding author: zhanglingzhi@petrochina.com.cn

analysis of remaining oil in thin-layer sand It provides a basic basis for the adjustment and formulation of measures and schemes.

2.1 Single stage thin layer sand body identification

At present, N Ⅱ and N Ⅲ oil layers are vertically subdivided into 54 sedimentary units. Although it is very fine, there are still two stages of thin sand in the same well and small layer, and two upper and lower parts of thin sand in different wells in the same small layer. Some units are not subdivided into single-stage sand bodies, and one unit contains multiple layers. When drawing according to the dominant sand bodies with gptmap software, the microfacies are determined according to the classification of effective thickness, and the actual connection relationship is not clear, Therefore, it is necessary to analyze the separability of thin-layer sand on the basis of existing sedimentary units. Firstly, the units with more than 50% of the number of single sand bodies in the unit are screened out, and then the unit separability grades are determined in the form of single well profile in the whole area according to the cycle stability characteristics of logging curve, which are completely separable, basically separable, barely separable, upper sand, lower sand and non separable. Through data statistics, combined with the classification of logging curve characteristics, it is determined that the proportion of single sand body greater than two wells in the unit is > 50%, and the classification can be determined if the classification proportion is > 80%, that is, the "four-step" method determines the further subdivision scheme of vertical thin sand, so as to identify the single-stage sand body.

Using the logging curve,the sand body can be divided into two parts in the vertical direction,the determination of separability level includes Completely separate,Basic separate,Encourage separate,Upper layer,Lower layer,and inseparable.

Subdivision scheme of thin sand determined includes "four-step method".Step1,according to data statistics,there are more than two units with single sand body in each unit;Step1,it can be divided into grades and has the cyclic characteristics of logging curves;Step3,select the primary unit and pull the whole well profile;Step4,data statistics to determine the proportion of separable wells in the unit,and then determine the divisible unit scheme.

2.2 Establishment of high-resolution stratigraphic framework

The subdivision of sedimentary time units and the comparison of the overall system are the most basic and crucial work in the study of plane sedimentary microfacies, and directly affect the fineness and accuracy of reservoir research and understanding. Firstly, select layered standard wells: the selection of standard wells and marker beds is based on the selection of representative layered backbone wells in the oilfield, which are characterized by sandstone development, many layers, many channel sand bodies, relative concentration, representative thickness and vertical separability. Such wells have stable interface markers in some layers, such as calcium tip, which are widely developed in the whole region.The distribution of stable sedimentary layers in each oil layer profile of N Ⅱ and N Ⅲ in block a oilfield is relatively obvious. According to the characteristics of logging curves, two standard layers and multiple marker layers are identified. A large set of sandstone is developed in the standard layer at the bottom, which is widely developed in the whole area.

Before comparing all wells in the block, establish a closed well connection skeleton profile according to the direction perpendicular to the source and nearly parallel to the source, and compare it to find the possible correlation marks (such as reference layer) of the block; Firstly, we can master the variation laws of formation thickness, lithology and correlation marks in all directions, which is very helpful for the comparison of wells in the block in the next step. First, close the boundary of each unit on the closed skeleton profile, and then compare the wells between them under this control. Carry out step-by-step fine comparison and step-by-step closure verification according to "oil reservoir group → sandstone group → sedimentary time unit", The well layer correlation series of the whole area is carried out, and the high-resolution stratigraphic framework is established, which lays a foundation for the subsequent study of sedimentary microfacies, sand body contact relationship and plane combination.

2.3 Characterization of planar phase band diagram of energy phase unit in microfacies

2.3.1 Identification of microfacies and energy facies in outer front zone and establishment of logging facies model and division standard

Through the analysis of rock electric relationship of logging curves, the logging facies model of energy facies in 7 types of microfacies subdivision 20 is established. The above characteristics show that this subfacies has a stable reduction environment and is a shallow water delta outer front subfacies only affected by lake energy above the wave base. The sheet sand in the outer front of the delta includes underwater distributary channel main body, underwater distributary channel normal body, underwater distributary channel edge, underwater distributary channel end, main thin-layer sand (thin-layer sand main body), non main thin-layer sand (thin-layer sand normal body), class I off surface reservoir (inner edge of thin-layer sand), class II off surface reservoir (outer edge of thin-layer sand) and main sheet sand (sheet sand main body), non main sheet sand (sheet sand normal body), class I off surface reservoir (inner edge of sheet sand), class II off surface reservoir (outer edge of sheet sand), main far sand dam, non main far sand dam, inner edge of far sand dam, outer edge of far sand dam, main offshore dam, non main offshore dam, inner edge of offshore dam, outer edge of offshore dam and mud.Microphase refinement to energy phase standard:

1 Continuous underwater distributary channel at the end of the inner front zone of the Delta
1) Underwater distributary channel microfacies
① Main body of underwater distributary channel: effective thickness ⩾ 1.5m, particle size becomes finer upward, with positive rhythm; The lower lithology is mainly brown and gray siltstone and fine sandstone, the upper part is transitional to argillaceous siltstone and silty mudstone, and the scouring at the bottom is not obvious. The micro electricity has very high amplitude, high amplitude difference, obvious negative anomaly of natural potential, and the curve shape is mostly flat bell shape and thin box shape; Abrupt change at the bottom, with positive cycle and microdentation.
② Normal body of underwater distributary channel: 1.0m ⩽ effective thickness ＜ 1.5m, the bottom is mainly fine sand, and the upper part is mainly mudstone, silty mudstone. The curve shape is mainly flat bell type, box type and finger type. The amplitude of microelectrode is high with amplitude difference, and the natural potential has obvious negative anomaly.
③ Edge of underwater distributary channel: 0.8m ⩽ effective thickness ＜ 1.0m; Typical channel characteristics of logging facies.
2) End of underwater distributary channel (small underwater crevasse channel): 0.8m ⩽ effective thickness ＜ 1.0m; It is located at the front end of a typical underwater distributary channel, and the positive rhythm is not typical.
3) Thin layer sand (referred to as thin layer sand)
① Main thin layer sand (main body of thin layer sand): effective thickness ⩾ 0.5m. It is widely distributed in the delta front in strip shape, with excellent particle size sorting and good roundness, mainly gray white and gray fine sandstone. Microelectrode curves and spontaneous potential curves generally have the characteristics of positive cycle and composite cycle, with medium amplitude, single finger or finger interbedding.
② Non main thin layer sand (thin layer sand body): 0m < effective thickness < 0.5m. Excellent particle size sorting and good rounding, mainly fine sandstone and siltstone. The curve has finger shape, the fluctuation of natural potential is small, and the amplitude difference of microelectrode curve is small.
③ Class I off surface reservoir (inner edge of thin sand): effective thickness = 0m, class I sandstone thickness > 0m. Generally fine, mainly grayish white and white well sorted siltstone. The fluctuation of spontaneous potential curve is small, and there is almost no amplitude difference in microelectrode curve.
④ Class II off surface reservoir (outer edge of thin sand): effective thickness = 0m, thickness of class I sandstone = 0m, thickness of class II sandstone > 0m.
2 Microfacies of wave controlled sheet sand mold
1) Sheet sand
① Main sheet sand (main body of sheet sand): effective thickness ⩾ 0.5m. It is sheet-shaped and massive, widely distributed in the delta front, with excellent particle size sorting and good roundness, mainly gray white and gray fine sandstone. Microelectrode curve and spontaneous potential curve have the characteristics of reverse cycle and composite cycle, with medium amplitude, single finger or finger interbedding.
② Non main sheet sand (sheet sand body): 0m < effective thickness < 0.5m. Excellent particle size sorting and good rounding, mainly fine sandstone and siltstone. The curve has finger shape, the fluctuation of natural potential is small, and the amplitude difference of microelectrode curve is small.
③ Class I off surface reservoir (inner edge of sheet sand): effective thickness = 0m, class I sandstone thickness > 0m., Generally fine, mainly grayish white and white well sorted siltstone. The fluctuation of spontaneous potential curve is small, and there is almost no amplitude difference in microelectrode curve.
④ Class II off surface reservoir (outer edge of sheet sand): effective thickness = 0m, thickness of class I sandstone = 0m, thickness of class II sandstone > 0m.
2) Mat mud: Class II sandstone, thickness = 0m. Argillaceous deposits are mainly clay deposits, containing a small amount of silt. Sandy deposits are often clay interlayer or thin lens, with horizontal bedding. The electrical measurement curve shows a low and flat straight line, and there is no amplitude difference between microelectrodes.
3 Distal bar microfacies
① Far sand dam of main body: effective thickness ⩾ 1.5m. The sediments are mainly siltstone with typical anti rhythm. The lower mudstone has obvious micro horizontal bedding and upward transition. The lithology is obviously developed, with typical funnel-shaped, middle layer, abrupt top change and gradual bottom change.
② Non main remote sand dam: 1.0m ⩽ effective thickness ＜ 1.5m. The thickness is medium, the particle size is well sorted, the particle is well rounded, and it is mainly fine-medium grained sandstone. The curve has the characteristics of reverse cycle, large amplitude difference of microelectrode, small fluctuation of natural potential, typical funnel-shaped, middle layer, abrupt top and gradual bottom.
③ Inner edge of far sand dam: 0m ＜ effective thickness ＜ 1.0m. The thickness is thin, the particle size is well sorted, and the particles are well rounded. The sediments are mainly fine sandstone and siltstone. The curve has the characteristics of reverse cycle, the amplitude difference of microelectrode is small, and the fluctuation of spontaneous potential is small.
④ Outer edge of distal sand dam: effective thickness = 0m, the curve has the characteristics of reverse cycle, the fluctuation of natural potential is small, and there is almost no amplitude difference of microelectrode.
4 Offshore dam microfacies
① Main offshore dam: effective thickness ⩾ 2.0m. The thickness is thick, with reverse cyclic grain sequence from bottom to top, good particle size sorting and good particle rounding. The lithology is mainly brown, gray siltstone and argillaceous siltstone. The electrical measurement curve has obvious funnel-shaped characteristics. The

microelectrode curve and spontaneous potential curve have medium and high amplitude, characterized by top mutation and bottom mutation, with obvious dentition.

② Non main offshore dam: 1.0m ≤ effective thickness ＜ 2.0m. The thickness is medium, the particle size is well sorted, the particle is well rounded, and the fine to medium grained sandstone is mainly gray and grayish white. It is characterized by curve saw reverse cycle, obvious toothing, large microelectrode amplitude difference and small natural potential fluctuation.

③ Inner edge of offshore dam: 0m ＜ effective thickness ＜ 1.0m. The thickness is thin and the particle size is well sorted. It is mainly fine sandstone and siltstone, mainly grayish white. The amplitude difference of microelectrode is small, and the fluctuation of spontaneous potential is small.

④ Outer edge of offshore dam: effective thickness = 0m, natural potential fluctuation is small, and microelectrode has almost no amplitude difference.

2.3.2 "Three Combinations" fine description of energy facies and sedimentary facies belt in microfacies

Through the plane combination of microfacies analysis and pattern drawing method, according to the "block environment + logging facies Standard + plane distribution characteristics" - three combinations, the outer front facies sand bodies of NII and NiII reservoir groups can be divided into three categories and seven combination types: underwater distributary channel type, river controlled thin layer sand type, river controlled wave controlled transition type, wave controlled sheet sand type, far sand dam type, offshore dam type and wave controlled surface type. The following continuous underwater distributary channel, river controlled thin sand, river controlled wave controlled transition type (River controlled mainly, wave controlled secondly), river controlled wave controlled transition type (wave controlled mainly, river controlled secondly), typical wave controlled sheet sand, far sand dam type, offshore dam edge, stable off surface reservoir type (mainly outer surface), stable off surface reservoir type (mainly mud, few off surface) Ten types of sand bodies were dissected. Determine the sedimentary environment of each unit according to the large sedimentary background of the whole block, determine whether it is river controlled, wave controlled or river controlled wave controlled transitional thin-layer sand from the overall distribution "shape" of sand body and the shape of logging curve, and determine the internal energy facies standard in combination with the reservoir standard (effective thickness 0-0.5m, 0.5-0.8m, 0.8-1m, greater than 1m, etc.) to finely depict the sedimentary facies belt map, During the drawing process, the unconnected layers are drawn into different phase zones through manual tracking, which breaks the default automatic connection mode of non pinch out microfacies in the same unit in the software, and the connection relationship is more accurate.

Plane anatomy of "continuous underwater distributary channel" in outer front zone and its energy phase in microfacies.

Underwater distributary channel sand is also developed in the sheet sand developed in a large area of the outer front facies of the delta. The underwater distributary channel is the extension of the distributary channel after it enters the lake, accompanied by sheet sand transformed laterally by lake waves. In the vertical channel direction, there is a strong regularity from underwater distributary channel to underwater distributary channel, that is, underwater distributary channel - main thin sand, non main thin sand - off surface reservoir - underwater distributary mud. It fully reflects the distribution of lithology and grain sequence with the underwater distributary channel as the center, overflowing to both sides of the channel and weakening hydrodynamic force away from the channel. The mud between the distributary channels is mostly distributed in a long strip along the extension direction of the channel. In the extension direction of the channel, from north to south, the underwater distributary channel disappears as it is far away from the material source, forming a large-area distribution of thin-layer sand at the end of the underwater distributary channel in front of it. The distribution of thin-layer sand at the end of the underwater distributary channel has a strong regularity, that is, the end main thin-layer sand, the end non main thin-layer sand, class I off surface reservoir, class II off surface reservoir and mudstone, It shows that the control effect of the river has not completely disappeared here. Along the provenance direction, this kind of sand body develops a narrow-band underwater distributary channel with a width of about 100 ~ 150m, the effective thickness of a single layer is 1 ~ 2m, and the electrical logging curve reflects the typical independent channel sand with positive rhythm characteristics, which can be tracked continuously in the extension direction of the channel.

[microfacies type] is delta front subfacies. Microfacies types include: underwater distributary channel, end of underwater distributary channel, thin sand between underwater distributary channels and mud between underwater distributary channels.

[Genesis] underwater distributary channel is often accompanied by widely distributed thin sand, mainly represented by siltstone and argillaceous siltstone. The rock thickness is thin, with typical sedimentary characteristics of underwater distributary channel, obvious positive rhythm, sudden Scouring at the bottom, and medium and high amplitude bell shape and flat toothed box shape on the electrical logging curve.

[plane distribution of microfacies] the two sides of underwater distributary channel are: main body of underwater channel - normal body of underwater channel - main thin layer sand - non main thin layer sand - off surface reservoir. This type distributes non main thin layer sand in a large area; There will also be off surface reservoirs, so it is called underwater distributary channal type.

Plane anatomy of "river controlled thin sand" in the outer front zone and its energy phase in microfacies.

The energy of the channel continues to weaken until it disappears, but the river control effect still exists. At this time, the underwater distributary channel no longer exists, but the main thin-layer sand is continuously or intermittently distributed in strips under the influence of the river control effect, and there is a strong rhythm from the main thin-layer sand to both sides, that is, the transition from the main thin-layer sand to non main thin-layer sand and off surface reservoirs. This type is also mainly affected by river control. The main energy facies types are main thin-layer sand, non main thin-layer sand, class I off surface reservoir and class II off surface reservoir. The main thin-layer sand is distributed in continuous or intermittent strips, so this type is called River controlled thin-layer sand.

[microfacies type] it is the delta outer front subfacies, which is river controlled. The microfacies types include: Main thin-layer sand, non main thin-layer sand, class I off surface reservoir, class II off surface reservoir and distributary inter mud.

[Genesis] it is the river controlled thin-layer sand in front of the end of the underwater distributary channel. Due to the weakening of river power and the deepening of lake water, the underwater channel disappears. The river controlled thin-layer sand along the source in front of the end of the channel is deposited, and the main body of the thin-layer sand can be positive rhythm. This is due to the thin layer of river controlled sand in the proximal area of the outer front of the delta.

[plane distribution of microfacies] several continuous main thin-layer sands are developed, and the logging curves are mostly positive rhythm. A large area of main thin-layer sands are distributed in a wide-band shape. Generally, it can be judged that the main thin-layer sands are distributed along the source from northeast to northeast and bifurcate towards the basin. The main thin-layer sands are mostly 400 ~ 600m wide. The main thin-layer sands are in the order of main thin-layer Sands - non main thin-layer Sands - off surface reservoirs, It is distributed in an irregular ring, belonging to the characteristics of typical river controlled thin sand.

Plane anatomy of "river controlled wave controlled transition type (River controlled mainly, wave controlled secondly)" and energy phase in microfacies in the outer front zone

When depositing, this kind of sand body is affected by both river and Lake wave action, as well as along the source and vertical source. It is located in the transition zone between river control and wave control. Therefore, it is called River controlled wave controlled transition thin-layer sand.

[microfacies type] it is the delta front subfacies, which is the transitional type of river control and wave control. The microfacies types include: Main thin-layer sand, non main thin-layer sand, off surface reservoir and distributary inter mud.

[Genesis] it is caused by the dual action of river energy and Lake wave energy. In the early stage, it was located in front of the end of underwater distributary channel, forming River controlled thin sand; After that, it was transformed by lake and wave, but the transformation was not complete, and it showed the characteristics of river control in the north and the initial characteristics of wave control in the central and south. This is due to the river controlled and wave controlled transitional thin-layer sand in the near middle end of the outer front belt of the delta front subfacies (River controlled and wave controlled).

[plane distribution of microfacies] four strip-shaped main thin-layer sands in the north are identified, which are generally distributed along the source in nne-ns direction, and the non main thin-layer sands also have the characteristics of river control along the source; The main thin-layer sand in the central and southern part is distributed near the East-West vertical source, and the non main thin-layer sand is also distributed near the East-West vertical source. The thin-layer sand in the East is characterized by intermittent distribution from north to south.

Plane anatomy of "river controlled wave controlled transition type (mainly wave controlled and secondary river controlled)" in the outer front zone and its energy phase in microfacies.

[microfacies type] it is the delta front subfacies, which is the transitional type of river control and wave control. The microfacies types include: Main thin-layer sand, non main thin-layer sand, off surface reservoir and distributary inter mud.

[Genesis] it is caused by the dual action of river energy and Lake wave energy. In the early stage, it was located in front of the end of underwater distributary channel, forming River controlled thin sand; Later, it was transformed by lake and wave, but the transformation was not complete, showing both river control characteristics and wave control characteristics. This is due to the river controlled wave controlled transitional thin-layer sand in the near middle end of the outer front belt of the delta front subfacies (mainly wave controlled and secondly River controlled).

[plane distribution of microfacies] the main non main thin layer sand disappears to the north and south of the source. The non main thin layer sand is generally distributed in the near east-west direction, and some wells are anti rhythm, which is the main wave control feature. A total of 4 intermittent strips are identified, the main thin-layer sand along the source in the near north-south direction, and the non main thin-layer sand also shows the signs of along the source in the north-south direction. Some wells have obvious positive rhythm, which is the main river control feature.

Plane anatomy of "typical wave controlled sheet sand" in the outer front zone and its energy phase in microfacies

During the formation of typical wave controlled sheet sand, the Lake wave action is relatively strong, and the clastic material is carried by the river. Due to the swing back and forth of the lake shoreline, the carried clastic material is transported to the front edge of the Delta and deposited to form sheet sand. It is lumpy in the distribution of the main sheet sand, and the center of the main sheet sand is lenticular, The long axis of the Tuo sand body is oblique to the lake shoreline, and the physical properties become worse from the center to the surrounding. The thickness of most sheet sand is between 0.5 ~ 1.0m.

[microfacies type] it is the delta front subfacies, which is wave controlled. The microfacies types include: main

sheet sand, non main sheet sand, class I off surface reservoir, class II off surface reservoir and inter sheet mud.
[Genesis] due to the action of Lake waves, the sediment carried by early underwater channels was deposited in the outer front zone, and gradually transformed into wave controlled sheet sand close to the vertical source after Lake wave transformation. This is due to the wave controlled sheet sand in the middle end of the outer front zone of the delta front subfacies.
[plane distribution of microfacies] the core of the main sheet sand is distributed near the East-West vertical source. Generally, the main non main sheet sand is distributed near the east-west direction, and the main non main thin layer sand disappears to the north of the source. Part of the logging curve shows inverse rhythm. A large number of main sheet sand and non main sheet sand are continuously distributed, and the sand thickness is relatively thin, most of which are less than 1.0m. This type of anti rhythmic main sheet sand is distributed in a large area. The repeated action of waves causes the sheet sand to be distributed in the direction of material source in a lump shape, so it is called typical wave controlled sheet sand.
Plane anatomy of "distal bar type" in the outer front zone and its energy phase in microfacies
The sedimentary period of this kind of sand body is controlled by the Lake wave action. The clastic material brought by the river swings back and forth with the lake shoreline, and the deposited sand body is brought to the front end of the delta to form a distal sand dam. The sand body of the distal sand dam is locally lumpy, the core of the dam is lenticular, the long axis is parallel to or oblique to the lake shoreline, the core becomes worse around, and the thickness of the outer edge of the distal sand dam is thin, The effective thickness of single layer of far sand dam is between 0 ~ 1.0m.
[microfacies type] it is the delta front subfacies, which is wave controlled. The microfacies types include: Main distal bar, non main distal bar, inner edge of distal bar, outer edge of distal bar and mud.
[Genesis] the far sand dam is formed in the open water at the outer front of a certain water depth by the strong wave action and the transformation of lake bottom sediments for a long time. The repeated action of waves causes the far sand dam to be distributed in parallel wave peaks. The thickness is generally greater than 0.8m, with typical anti rhythm, top mutation, bottom gradient, wave bedding, Hill shape and other sedimentary characteristics. This is due to the wave controlled distal sand bar in the middle and distal region of the outer front zone of the delta front subfacies.
[plane distribution of microfacies] the main far sand dam is distributed near the East-West vertical source. Generally, the main non main far sand dam is distributed near the east-west direction, the non main far sand dam disappears to the north of the source, and the logging curves mostly show inverse rhythm. The effective thickness of sandstone in the far sand dam is mostly greater than 1.0m, and the vertical source is distributed in a large area. From the center of the far sand dam to the surrounding, there are the main body of the far sand dam - the normal body of the far sand dam - the inner edge of the far sand dam - the outer edge of the far sand dam, which has obvious wave control characteristics, so it is called the far sand dam type.
Plane anatomy of "edge of offshore dam" in outer front zone and its energy phase in microfacies
[microfacies type] it is the delta front subfacies, which is wave controlled. The microfacies types include: main offshore dam, non main offshore dam, inner edge of offshore dam and outer edge of offshore dam.
[Genesis] the offshore dam is mostly formed in the environment with gentle slope, rich sand and strong wave action. It is a high-energy sedimentary body under the action of wave. The highest energy facies unit deposition with the highest energy, the coarsest particle size, the best sorting, the least mud content, the best physical properties and the largest thickness is taken as the main body of the offshore dam, which gradually decreases from the main offshore dam to the surrounding dam body, and the water body gradually deepens As the energy decreases, the particle size becomes finer, the separation becomes worse, the mud content becomes more, the physical properties become worse and the thickness becomes smaller. The cause is the northwest edge of the wave controlled offshore dam in the distal area of the outer front zone of the delta front subfacies.
[plane distribution of microfacies] the non main offshore dam is distributed near the vertical source in NWW direction and disappears to the north of the source. The logging curves are mostly in inverse rhythm. The non main offshore dam is mostly greater than 1.0m. The vertical source belt distribution of the inner edge of a large area of offshore dam is as follows from the center of the offshore dam to the four sides: the main body of the offshore dam - the normal body of the offshore dam - the inner edge of the offshore dam - the outer edge of the offshore dam, with obvious wave control characteristics, Therefore, it is called thin sand at the edge of offshore dam.
Plane anatomy of "stable outer surface reservoir type (mainly outer surface)" and energy phase in microfacies in the outer front zone
Because this type of sand body is far from the lake shoreline and the supply of clastic materials is insufficient, it is mainly stable outer front sheet sand, which is the delta outer front subfacies.
[microfacies type] it is the delta outer front subfacies, which is wave controlled. The microfacies types include: main sheet sand, non main sheet sand, class I off surface reservoir, class II off surface reservoir and mud.
[Genesis] it is formed in the outer front and far end environment with gentle slope, far bank, insufficient sand supply, deep water body and waves that can also touch the lake bottom. The lithology is mainly fine siltstone, silt containing siltstone and argillaceous siltstone, with wavy cross bedding, horizontal texture and massive bedding, and occasionally lenticular bedding. The physical property and oil bearing property are poor, and most of them are off surface reservoirs. This is due to the stable sheet sand in the distal region of the outer front zone of the delta front subfacies.
[plane distribution of microfacies] the surface sheet sand distributed in a large area is distributed in a near east-west

direction in some parts. The outer edge of the sheet sand is distributed in a thin layer and sharp knife shape. The sand thickness is mostly less than 1.0m, and the logging curves are mostly in inverse rhythm. From the center of the surface sheet to the periphery, it is: continuous sheet - broken sheet - irregular strip - isolated lump. This type of off surface reservoir is widely distributed, so it is called stable off surface reservoir.

Plane anatomy of "stable off surface reservoir type (dominated by mud and rarely off surface)" and energy facies in microfacies in the outer front zone

Because this type of sand body is far from the lake shoreline and the supply of clastic materials is insufficient, it is the subfacies of the outer front of the delta.

3. Application of achievements

3.1 Deepening geological understanding

According to the sedimentary facies belt map after subdivision, the scale of the main sheet sand is reduced and the connectivity seems to be poor. In fact, the underwater intermittent distributary channel is identified, the sand body scale and combination are significantly changed, the connectivity thickness is changed, and the connectivity relationship is clearer. For example ,before subdivision,two wells are main sheet sand on the plane, showing that the connecting thickness is 0.9m, corresponding to 1.3m. After subdivision, the actual connecting thickness is 0.9m, corresponding to 0.8m, and the upper part is 0.5m communication between off surface reservoir and main sand, which makes the connecting relationship more accurate.

After plane fine dissection, the internal connectivity of sand bodies with different energy phases and the same energy phase has clearer directionality, which is characterized by phase mutation, seepage mutation, phase gradient and seepage gradient.

3.2 Guide the adjustment of water polymer flooding dynamic scheme

The results of sedimentary facies belt map drawn by using the energy facies change sand body identification method in the microfacies of the outer front zone of the delta guide the adjustment of water drive scheme and the formulation of measures. For example, a total of 29 wells are planned in block Q, including 18 wells for survey and adjustment, 6 wells for hole patching and 5 wells for fracturing.

4. Conclusion

Using the "three-step" method of key parameter data statistics combined with the hierarchical characteristics of logging curves to determine the vertical separability of thin-layer sand, improve the work efficiency, and improve the method of vertically identifying thin-layer sand to single-stage sand body.

The fine characterization of energy facies of thin-layer sand unit needs to take the large sedimentary environment as the main background, combined with the "three combination" method of logging facies model and plane characteristic distribution of sand body, the outer front facies sand body can be divided into 6 types and 10 combination types in terms of Genesis. Under the guidance of model drawing, the sedimentary facies belt maps of different genetic types are finely characterized, and the connectivity and directionality are more clear.

The research results can guide the adjustment of water drive scheme and the formulation of measures, provide technical basis and direction for accurately tapping the potential of water drive.

References

1. Hu Zhicheng. Characterization of single sand body in the lower Es3 sub member of block Wei 22 [D]. Changjiang University, 2015
2. Michao. Characterization of single sand body of SA III formation in Labei block and tapping potential of remaining oil [D]. Northeast Petroleum University, 2015
3. Zhang Lei. Study on single sand body characterization of logging data in block VI of Xinli oilfield [D]. Northeast Petroleum University, 2015
4. Sun Liwei. Genetic model of delta outer front facies sand body in a basin [D]. Industrial technology, 2015
5. Dou Hongwu. Study on single sand body identification method of delta front subfacies reservoir [J]. Journal of petroleum and natural gas, 2011,05:165-167 + 340
6. Song min. single sand body identification and genetic analysis of SAII composition in block a of Lamadian Oilfield [D]. Zhejiang University, 2012
7. Li Chen. Study on single sand body identification method and remaining oil distribution of layer Pui 1-2 in Sanan District 5 [D]. Daqing Institute of petroleum, 2010
8. Liu Lingtong, Li Yunxiu, et al. Contact relationship and connectivity of sand bodies in the front of complex fault block fan delta [J]. Journal of Chengde Petroleum College, 2016