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Sedimentary characteristics of Chang 2 and its relationship with sand body superimposition in Resiwan oil region

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Abstract: *On the basis of core observation, logging interpretation and previous research results, the sedimentary microfacies characteristics of each sub layer of the Chang 2 oil-bearing formation in the Resiwan oil area of Zichang Oilfield and the superimposed relationship of sand bodies are studied. The results show that the Chang 2 member in the Resiwan oil area of Zichang oilfield belongs to braided river deposits, and the study area mainly develops sedimentary microfacies such as river island, channel lag deposits and floodplain. The vertical superimposition types of sand bodies in Chang 2_2 oil-bearing formation are multilayer superimposition sand bodies and massive thick sand bodies, which are also the dominant sand body combination of oil-bearing reservoirs in the study area. Chang 2_1 oil-bearing formation is dominated by thin interbeds. Flood plains are developed at the top of Chang 2_3 oil-bearing formation, and massive thick sandstone is developed at the middle and lower parts, but the horizontal continuity is poor. Horizontally, the sand bodies of Chang 2_2 oil-bearing formation are mainly overlapped horizontally and cut laterally, which improves the connectivity of the sand bodies to a certain extent. Chang 2_1 and Chang 2_2 are mostly isolated sand bodies, and the sand bodies are wrapped in mud, resulting in poor oil and gas display. The contact pattern of sand bodies in the study area is mainly affected by sedimentary microfacies and river water volume.*

Keywords: *Resiwan; Chang 2; Braided river; Sandbody superimposition relationship*

1. Introduction

With the continuous improvement of the recovery degree of the Chang 2 reservoir in the Resiwan oil region, it is found that the stable production time of the reservoir is short and the liquid production decreases significantly, so it is necessary to seek other development methods. Combined with years of exploration and development experience, previous research results, core observation and comprehensive analysis of logging data, it is believed that braided river sediments are mainly developed in Chang 2 Member. For braided river sedimentary reservoirs, braided channel and river island are the main oil and gas reservoir sand bodies. [1-3] Braided river sedimentation has the advantage of high sand to ground ratio, and it often presents the characteristics of "sand wrapped with mud" on the plane. However, its river channel swings frequently, which makes the sand bodies of different stages cut and stacked vertically and horizontally, making the braided river reservoir have strong spatial heterogeneity. [4-5] For the study block, the large-scale development of Resiwan Chang 2 block began in 2015, mainly relying on formation energy. The initial liquid production is high, but the retention time is short. Therefore, it is necessary to clarify the characteristics of sedimentary microfacies and the superimposition relationship of sand bodies to understand the distribution and connectivity characteristics of underground reservoirs, so as to provide a reference basis for later water injection production and tapping the potential of remaining oil. [6-8]

2. Regional sedimentary background

Ordos Basin is the second largest continental sedimentary basin in China, which is rich in energy resources. [9] The Triassic Yanchang formation is the main oil-bearing layer of the basin. According to the current situation of exploration and development and the results of resource evaluation, it still has great potential for development.[10] Yanchang formation is mainly a low and ultra-low permeability reservoir controlled by sedimentation and diagenesis. [11] Resiwan area of Zichang Oilfield in the study area is located in the east of Zichang Oilfield, and its structure belongs to the middle eastern part of

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northern Shaanxi slope of Ordos Basin (Fig.1).[12] In Chang 2 period, the lake basin of Ordos Basin contracted more and more, and most of the northern part of the area became alluvial plain. The study area Chang 2 mainly developed braided river sediments, which had typical braided river sedimentary characteristics, mainly manifested in the rapid migration and poor stability of the river channel, resulting in the characteristics of "sand wrapped mud" in both plane and profile. The sand bodies are distributed in the NE-SW direction, and the braided interchannel argillaceous deposits are distributed sporadically. The lithology of Chang 2 reservoir in the study area is mainly gray and light gray medium-sandy fine-grained feldspar sandstone with the characteristics of low porosity and low permeability. According to the available data, the geological conditions of the study area are complex, horizontal and vertical heterogeneity are very strong, which limit the development effect of the oil field.

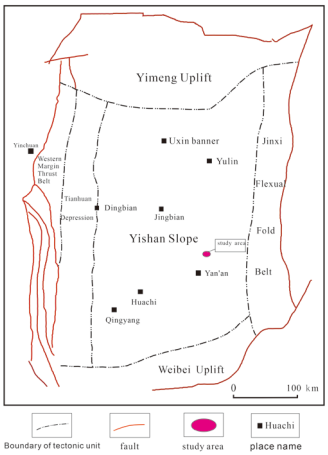

Figure 1: Geographical location of the study area.

3. Characteristics of sedimentary microfacies

3.1. Types and characteristics of sedimentary facies

Braided river subfacies deposits are developed in the study area, mainly including three microfacies: river island, riverbed detention deposits and floodplain.

3.1.1. River island

The river island is the main microfacies type in braided river sedimentary reservoirs. The river island sand body is generally thicker, and the thickness of the river island in the study area is mostly 10-20m. Lithology is mainly gray feldspathic fine sandstone (Fig.3b). In the river island lithofacies association, the plate cross bedding is the main one (Fig.3c), followed by the trough cross bedding (Fig.3d) and parallel bedding(Fig.3e) and the erosion surface is visible at the bottom(Fig3.f), indicating that there is a strong hydrodynamic condition during the deposition period, with a strong scouring effect. In the sedimentary sequence of the river island, there is a positive rhythm or a compound rhythm in which the grain size gradually becomes finer upward. On the whole, from the bottom to the top, the bedding scale gradually becomes smaller and thinner, and the lithofacies gradually changes from medium sandstone to fine sandstone and silty mudstone . The natural gamma curve and resistivity curve of the river island show typical smooth or micro toothed medium high amplitude box type, or bell plus box type. The former logging curve has sudden changes at the top and bottom, while the latter has sudden changes at the bottom and gradual changes at the top (Fig.2a), reflecting stable hydrodynamic conditions and sufficient material sources. [13] In addition, SP curve is slightly reversed in the river island, indicating that there is interlayer in the river island, which can be used as the physical barrier in the sand body, and is an important part to pay attention to for tapping the potential of remaining oil in the later period.

3.1.2. Channel lag deposit

Riverbed detention is another common sedimentary microfacies type of braided river sedimentary reservoir. It mainly develops trough cross bedding (Fig.3d), followed by plate cross bedding (Fig.3c). Its scale is smaller than that of the river island, and its thickness is mostly between 2-6m, with scour surface (Fig.3f). The natural gamma curve or resistivity curve of river bed detention sedimentation mainly shows medium high amplitude micro dentate bell shape, sudden change at the bottom, gradual change or sudden

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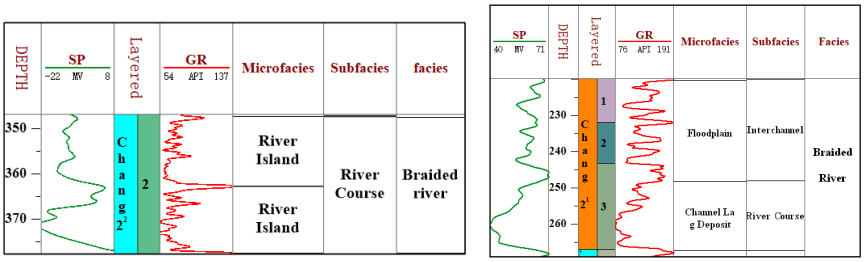
change at the top, showing a positive rhythm (Fig.2b), reflecting that the hydrodynamic conditions gradually weaken or suddenly weaken upward during sedimentation.

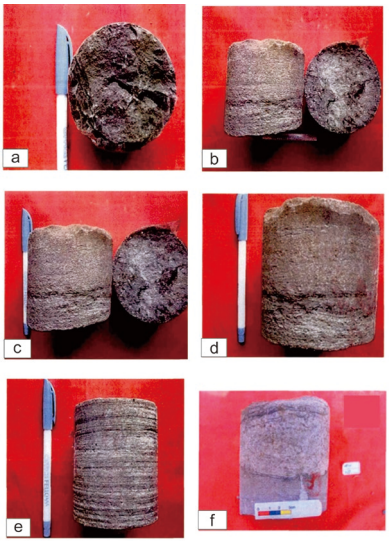
3.1.3. Floodplain

The floodplain microfacies are composed of gray and dark gray mudstones (Fig.3a) with thin layers of fine sandstone and siltstone. The spontaneous potential curve of the floodplain microfacies is obviously positive, and the natural gamma curve is obviously high. Most of the curves are in the shape of micro teeth and fingers (Fig.2b), with wavy bedding. It indicates that the river hydrodynamic conditions are weak or absent in this sedimentary period. The floodplain sedimentary microfacies in the study area are mainly developed in Chang 2_1 and Chang 2_3, and are rarely found in Chang 2_2.



(a) 8825-2 well *(b) 269 well*

Figure 2: Sedimentary microfacies type and logging curve response.



a. black mudstone, 144 well, 383m; b. gray fine sandstone, 7488 well, 412m; c. plate cross bedding, 144 well, 375m; d. trough cross bedding, e. parallel bedding, 6202 well, 427m; f. Scour surface ,423.76m, 966 well.

Figure 3: Identification mark of sedimentary structure of Chang 2 oil layer formation

4. Superposition characteristics and styles of sand bodies

4.1. Overlay Type

Generally speaking, the superimposed type of sand bodies is divided according to two aspects, namely, the genetic type of sand bodies and the contact relationship between single sand bodies. Through the analysis and description of these two aspects, the superimposed type of braided river sedimentary sand bodies of the Chang 2 oil-bearing formation in the Resiwan area of the Zichang Oilfield is summarized.

For the contact relationship between sand bodies, vertically, for a single well point, the way of sand body superimposition is relatively simple. The separated sand bodies can be clearly identified. The cut and stack type can be divided into identifiable and difficult to identify. The identifiable cut and stack type presents a composite bell or box shape on the logging curve. The difficult to identify cut and stack type has only a single cycle box shape response on the logging curve due to the serious mutual erosion of the two sand bodies. [14] The thick sand body formed by it has good connectivity, it can become a favorable

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place for oil and gas accumulation. In the horizontal direction, the separation and stacking of sand bodies can be divided by integrating the response of logging curves.

4.2. Sandbody superimposition type

4.2.1. Superposition type of river island sand body

The river island sand body is usually in the form of very thick sand body and multilayer superimposition in vertical direction, with good continuity in vertical direction (Fig. 4 (a) (b)). The thickness of single sand body is generally greater than 8m, and the maximum can be more than 20m. The sand to ground ratio is generally greater than 50%, and the maximum can be 90%. The natural gamma ray curve shows a smooth or slightly dentified box type (or bell shaped plus box type), with little or no interlayer visible. It shows that there is little change in the single stage river channel, the sedimentation time is long, the provenance is sufficient, and the accommodation space is large. In the horizontal direction, the extension of the extremely thick sand body is short and the continuity is poor. It can be seen that the channel sand is horizontally overlapped with it. It is mainly distributed in the Chang 2_2 oil layer in the study area, and the Chang 2_3 oil layer can also see the development of the central beach, but its scale is much smaller than that of Chang 2_2, and its southwest direction is more developed than the northeast direction (Fig.5).

4.2.2. Overlapping pattern of channel lag deposit sand bodies

The channel lag deposits are generally formed at the bottom of the river channel, and the particles are relatively coarse. Its sand body thickness is smaller than that of the river island, and is developed in Chang 2_1, Chang 2_2, and Chang 2_3 oil layers.

Vertically, Chang 2_1 and Chang 2_3 oil layers are mainly distributed in isolation or exist in thin interbeds. The sand body thickness is mostly 2-4m, and the sand to ground ratio is generally less than 40%. The log curve response is mostly flat bell shaped, and the curve has a tooth shape formed by obvious return (Fig. 4 c). The isolated sand body is usually formed in the floodplain with short single stage river course time, few sediment sources, little or no river course swing, and is wrapped by argillaceous deposits. Thin interbeds are mostly formed in the case of short single stage channel time and multi stage swing of the channel. Horizontally, the continuity is good, and lateral cutting and stacking can be seen, which improves the connectivity between sand bodies to a certain extent . In Chang 2_2, the channel lag deposits are longer 2_1 and longer 2_3, which are more developed, and the thickness of the sand body is also longer 2_1 and longer 2_3. In the vertical direction, most of them are isolated in different periods (Fig.5), which has better continuity in the vertical direction. In the horizontal direction, the channel lag deposit and the river island have lateral overlap and horizontal overlap, which improves the poor continuity of the river island sand body in the horizontal direction.

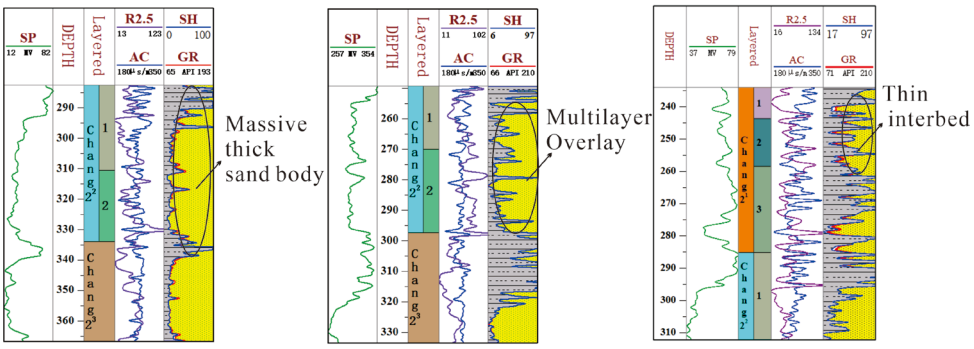

Figure 4: Vertical sand body overlay.

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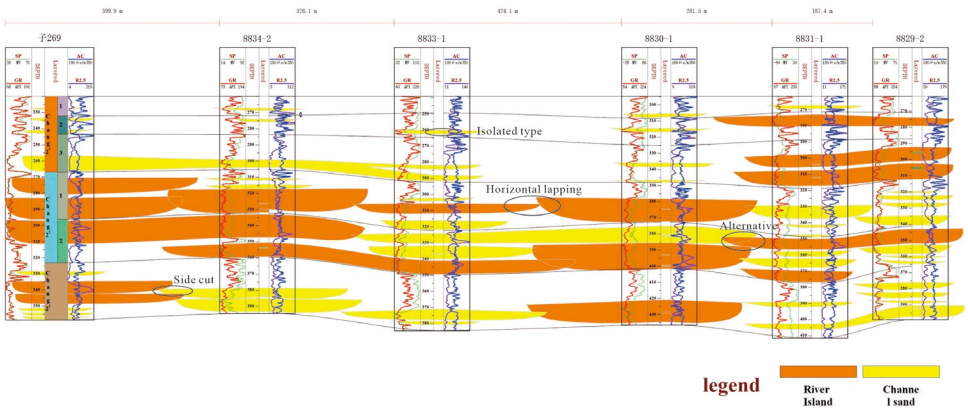

Figure 5: Superposition relationship of lateral sand bodies.

4.2.3. Influencing factors

The contact pattern between sand bodies can reflect the position relationship of single sand bodies on the plane. The influencing factors of the superimposition relationship between sand bodies mainly include ancient landform, sedimentary facies type, tectonic movement, river flow, climate conditions and changes in sedimentary base level. [15] The study area is located in the northern slope of the Ordos Basin. Its geotectonic background is a large, multi cycle cratonic basin with simple structure and stable structure, In addition, there is almost no fault in the area, and the ancient landform is relatively flat, so the influence of structure and ancient landform can be ignored.

5. Conclusions

1) Fluvial facies are mainly developed in Chang 2 in Resiwan area of Zichang Oilfield, and braided river deposits are mainly developed, and sedimentary microfacies such as river island, channel lag deposit and floodplain are developed. Among them, the river island and channel lag deposit are the main sand body deposits in the study area. The river island is mainly developed in the Chang 2_2 oil-bearing formation, with the maximum thickness of more than 20m, and has good correspondence with the oil and gas interpretation. The channel lag deposits are developed in three small layers of Chang 2, and the largest scale is in Chang 2_2, with the thickness of 6-8m. The sand/ground ratio of Chang 2_2 is more than 50%, and the maximum is 90%. Chang 2_2 oil formation is the main oil producing interval in the study area.

2) The vertical stacking relationship of sand bodies in Chang 2_2 oil-bearing formation is dominated by multi-layer stacking and thick massive sand bodies. Isolated sand bodies and thin interbeds are mostly developed in Chang 2_1 and Chang 2_3 oil-bearing formations. Horizontally, the sand body is mainly horizontally overlapped, which is mainly developed in the Chang 2_2 oil-bearing formation. Multilayer superimposed sand bodies and thick massive sand bodies are high-quality sand body combinations for oil and gas distribution in the study area. Horizontal overlapping or sidecutting of sand bodies improve the poor continuity of thick sand bodies in the transverse direction to some extent.

3) The contact pattern of sand bodies in the study area is mainly controlled by sedimentary microfacies and river water volume.

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