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Sedimentary facies characteristics and oil/gas accumulation research of Fuyu Formation in Zhaoyuan area

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Abstract: By comprehensive utilization of core, logging and seismic data, sedimentary facies are characteristics studied in Fuyu Formation in Zhaoyuan area. Fuyu Formation is in delta sedimentary system, including delta plain and delta front subfacies. The microfacies types are mainly distributary channel, flood plain, mud outside river, natural levee, distributary bay and estuary dam, et al. Through single well facies and linked well facies analysis, the sedimentary facies distribution characteristics of Fuyu Formation were studied in the Zhaoyuan area. The river development scale is different in each layer group of Fuyu Formation. Channel development increases from FⅡ to FⅢ, showing the water gradual shrinking progradation sedimentary formation, and after water jump greatly， the sedimentary facies transformed from delta plain to delta front deposition above FI, showing the internal channel development gradually decreased from bottom to top in FI. Sediment source came from the southwest, delta distributary channel microfacies is the main sand pattern. The hydrocarbon accumulation research shows that channel sand is the main hydrocarbon accumulation sand body type in the study area and the hydrocarbon accumulation pattern is in Zhaoyuan area long distance lateral migration and keeping out at fault and sand body boundary.

Key words*: Zhaoyuan area; sedimentary characteristics; accumulation model; Fuyu Formation*

I. INTRODUCE

Zhaoyuan area locates in western nose-like structure of Chaoyanggou terrace in Songliao basin. It is adjacent to Qijia and Gulong sag and just opposite to Daqingchangyuan in northwest. In the late period of Mingshui group, Zhaoyuan nose-like structure reached the peak of oil producing and the formation of the structure is earlier than the peak period of hydrocarbon expulsion in hydrocarbon source rock[1]. In Qijia-gulong depression QingI period, hydrocarbon source rock has a large thickness and the organic matter maturity is moderate, so it has the good condition of hydrocarbon generation, and oil and gas resource potential is obvious[2]. Gulong sag is located in the northwest of the study area. In the perspective of the hydrocarbon generation and expulsion, the southwest of study area is favorable range of oil and gas[3-4]. Therefore, the study area has great exploration potential and broad development prospect.

Sedimentary facies determines the rock composition, structure and physical properties of formation, and controls the formation and distribution of reservoir, thus further affecting oil and gas feature [5]. Therefore, starting from the study for the cause of sand, recovering the ancient environment of sand sedimentary period and identifying the type of sedimentary facies is the basis of correct understanding for reservoir characteristics and its development dynamic[6-7]. Predecessors have researched the sedimentary and reservoir characteristics in QuanⅢ-Ⅳ period in Daqingchangyuan and its east [8-9], but the related study for Zhaoyuan area has not been worked yet. The fast sand thickness variation on plane, the complex space distribution of, strong heterogeneity, unclear distribution rule and thin interbedding reservoir lead to the great difficult for favorable zone division in Fuyu oil layer of study area. Therefore, this article starts from the Fuyu reservoir sedimentary characteristics in Zhaoyuan area in, defining the sedimentary facies types and distribution rule of fuyu reservoir and study fuyu reservoir hydrocarbon accumulation mechanism to provide idea for searching for favorable reservoirs, determining the favorable oil and gas zone for development and laying the foundation for further development plan.

II. GEOLOGICAL CONDITION

Zhaoyuan area is located in Zhaoyuan county territory of Heilongjiang province. The area is in Songhuajiang flood area with a relatively low terrain. The elevation is 127.0 to 139.0m. Tectonic position is located in Zhaoyuan nose-like structure region of the western section of Chaoyanggou terrace in central depression area in the songliao basin. The topography is low in the north and the south is high. Formation of the structure was mainly affected by fault. Structure number is locally proportional to number of fault. Zhaoyuan nose-like structure that the study area is located in formed in before the Sifangtai group sedimentary and the nose structure background is the main factor that induced secondary oil migration accumulation. In Fuyu reservoir

sedimentation, there are six major depositional systems in the east of Daqingchangyuan. The Mesozoic and Cenozoic strata are mainly developed in the study area. Fuyu reservoir is located in the Mesozoic cretaceous Quantou Ⅲ, Ⅳformation and is a set of purple mudstone and purple, gray and incanus coarse grain continent clastic sediment.

III. SEDIMENTARY FACIES TYPE AND IDENTIFICATION MARK

3.1 Sedimentary background

The constructive delta deposition is the representative sedimentary characteristics of Songliao basin. This kind of delta can form in water withdrawal and stable period, as well as the significant water advance period. In the middle-late period of early cretaceous, songliao basin had developed into a large depression basin. Meandering river, braided river, delta, alluvial fan and lacustrine mud filling patterns appeared in turn along the long axis of the basin, forming river-delta sedimentary system inside the basin. This period is in late stage of Qingshankou formation water back and early stage of Yaojia to Nenjiang formation water forward. The period is an obvious filling period in the process of the whole depression. The terrain is very flat in the delta deposition scope. The lake is wide and has very shallow water. The large river-shallow water delta system with unique style is developed under the condition[10]

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3.2 Core analysis

In this study five cores were observed, including Yuan15 Wells, Yuan151 Well, Yuan154 Wells, Yuan156 well and Yuan358 well. By rock core, rock debris and adjacent well data, The upper part of Fuyu oil layer is greyish-green, purple mudstone with obvious characteristics of positive rhythm. The middle and lower parts is taupe oil stain, oil immersion and siltstone containing oil with purple and green gray siltstone, presenting interbed with different thickness. It reveals the delta sedimentary environment of Fuyu reservoir in the study area.

3.3 The sedimentary facies types

On the basis of the comprehensive utilization of well drilling, logging and seismic data, according to the rock lithology, color, structure features, rhythm combination, microscale element and palaeobios characteristics, This paper researchs Fuyu oil layer sedimentary facies in Zhaoyuan area. The logging facies model of Fuyu reservoir is established, and the single well sedimentary microfacies are divided in the study area. Fuyu formation is in delta sedimentary system in the study area, growing the delta plain and delta front subfacies, and delta plain subfacies are priority, and microfacies type has mainly distributary channel,flood plain, mud between channels, natural levee, distributary bay and estuary dam.

3.3.1 Distributary channel microfacies

Sedimentary characteristics are basically same with the bed deposition of river system. Giving priority to sandstone sedimentary, granularity is relatively coarse. The wash surface is obvious at the bottom. The Sedimentary shifts gradually from sandstone to mudstone upward, presenting positive rhythm characteristics overall in vertical. Logging curve shows as tooth bell and box shape.

3.3.2 The flood plain microfacies

The waters overflow natural levee in flood period, and flow into distributary interchannel in crevasse. Flood plain is sedimentary body that sand and mud accumulation forms after overflowing natural levee, usually locating in outside of channel. Lithology is mainly fine sandstone and siltstone. The logging curve characteristics show as isolated peak and small funnel shape.

3.3.3 Mud between channel microfacies

Lithology is given priority to dark purple, celadon mudstone and silty mudstone, being occasionally mingled with thin argillaceous siltstone that the water overflowing forms in flood period. Logging curve characteristics shows as low-rising flat shape.

3.3.4 Natural levee microfacies

Natural levee microfacies are sedimentary body in edge of distributary channel in delta phase. Natural levee microfacies is mainly made of aubergine, purple, green and gray-green mudstone. Logging curve shows as the dentation.

3.3.5 Distributary bay microfacies

Distributary bay microfacies are generally located in low-lying area between branch channels in the delta front. The water power is relatively weak. Distributary bay is mainly made of mud, silty mud and clay deposit.

3.3.6 Estuary dam bar microfacies

In the late period of Fuyu oil layer sedimentary in Zhaoyuan, the wave energy has strong transformation to distributary channel sand body, Estuary dam bar sedimentary characteristics show that particles becomes fine, large scale cross-bedding is rare and lithology is sandstone with green mudstone. the logging curve shows as dentation, single finger and multiple finger.

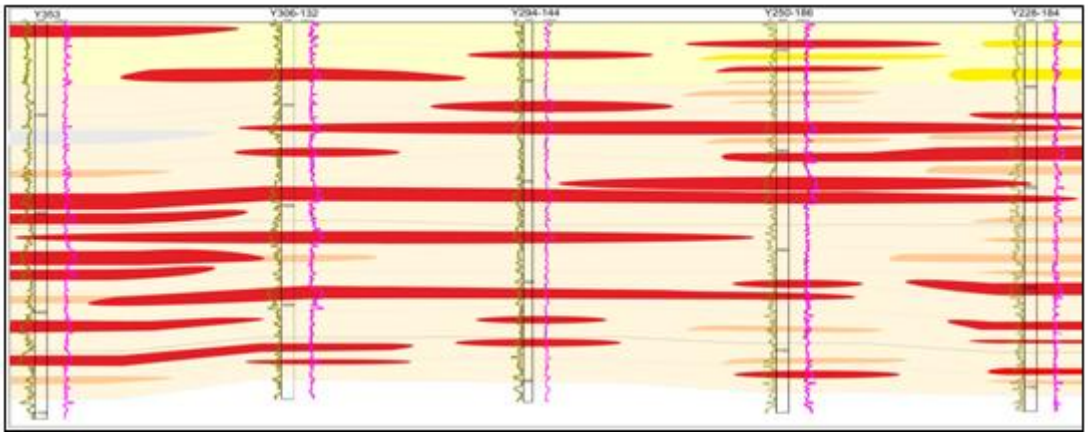

Fig.1 Linked well phase diagram

IV. DISTRIBUTION CHARACTERISTICS OF SEDIMENTARYFACIES AND HYDROCARBON ACCUMULATION ANALYSIS

4.1 Distribution characteristics of sedimentary facies

On the basis of single well sedimentary facies model establishment, conbining with the correlation and division result of strata and regional data, selecting representative wells profile in research area carries out analysis of spatial distribution characteristics of sedimentary facies (Fig 1).

Based on the above analysis and combining with seismic attributes and inversion section data, Fuyu reservoir distribution characteristics of sedimentary facies are studied in Zhaoyuan area. Channel is developed in each small layer of Fuyu formation. Channels extend from southwest to northeast have better continuity. In FⅠ3, FⅠ5, FⅠ7, FⅡ1, FⅡ, channel is continuously developed in the interwell. The channel development scale is different in FⅠ, FⅡ, FⅢ. The channel development is gradually increasing from FⅡ to FⅢ, showing as progradation strata sedimentary characteristics that the water gradually shrink. However, the sedimentary facies transform into delta front deposition after water rises significantly, showing channel development scale gradually decreases on the top of FI formation. Sediment source comes from southwest. The Sediment is given priority to delta distributary channel microfacies, and natural levee microfacies scatteredly develop on both sides of distributary channel. The sedimentary sand body is usually discontinuous ribbon or sheet distribution. Because of difference of source supply, water range and wave transformation effect in each formation sedimentary period, the sedimentary characteristics of each formation is different. In general, the channel is developmental and planar phase changes fast and heterogeneity is strong in Fuyu reservoir.

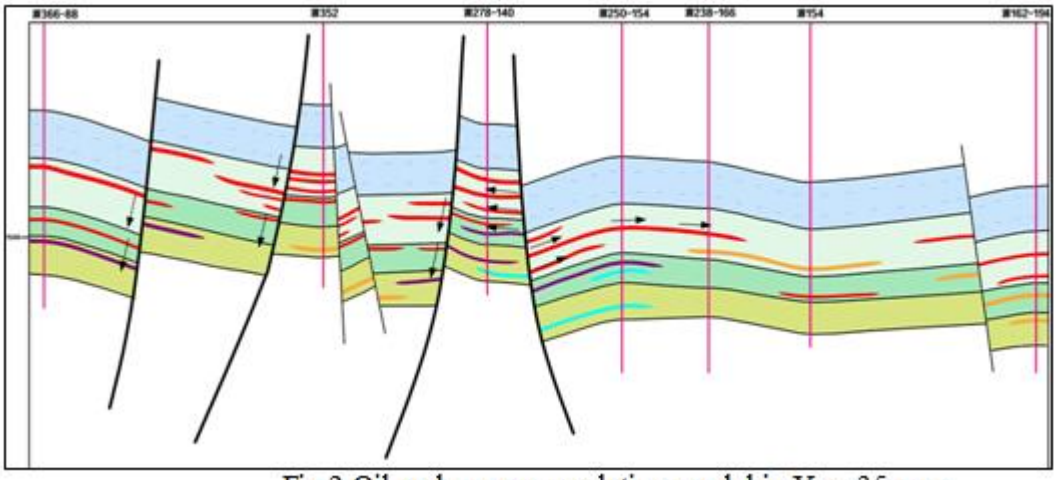

Fig.2 Oil and gas accumulation model in Yuan35 area

4.2 Oil and gas accumulation analysis

Oil and water distribution of Fuyu formation is complex and oil and water are mainly distributed in FI and FII formation in study area. The channel sand is advantage sandbody for oil and gas enrichment. At present, most of wells producting oil or gas of Fuyu formation that have been found are concentrated in fluvial facies in the study area. On the basis of test conclusion, logging interpretation result and sedimentary facies research in work area, the paper thinks the accumulation model in this area is long distance lateral migration and obscuring in sand body border and fault reservoiring pattern (Fig 2).

The oil and gas generated from Qing Ⅰ formation hydrocarbon source rock in Sanzhao sag and Chaoyang ditch terrace laterally migrated along the unconformity surface and sand body to the study area. Because of fracture vertical conduction, lateral sealing and fault and lithologic barrier, the oil and gas gathered into reservoir. The reservoir type is given priority to lithology, tectonic lithology and fault lithology. The characteristic of accumulation pattern is that the channel and natural levee are the main body. The sand body plate and strip in plan and is lenticular in profile. The fracture is complex and the fault trend is basically same with dip direction, which is advantageous to the lateral migration of oil and gas. Oil and gas mainly gathered in sand body development district, and migrated to tectonic high position through the sand body communication fracture zone.

V. CONCLUSION

5.1Fuyu formation is in delta sedimentary system in the study area, including delta plain and delta front subfacies, giving priority to with delta plain subfacies deposition. The sedimentary microfacies types are mainly distributary channel, flood plain, mud between channels, natural levee, distributary bay and d estuary dam.

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