High frequency sequence stratigraphic framework and sedimentary characteristics of P oil layer in the southern part of A area

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Abstract. Based on the high resolution sequence stratigraphy theory, 42 wells and 2745 well logging curves are used to study the evolution of all levels of base level cycles and the development pattern of high-resolution sequence in the P reservoir in the southern part of Songfangtun area. The results show that the 4 sequence interface of the grape flower beds in the Songfangtun area can be divided into 2 medium-term, 5 short term and 12 ultra short term sequences. On this basis, the sedimentary microfacies type and distribution evolution law have been carried out. It is considered that the shallow water delta depositional system is developed in P reservoir in the Songfangtun area. The main development of delta front subfacies is to identify 8 kinds of microfacies such as subwater distributary channel, inter channel, inter channel, slime, overflow sand, mouth fan, estuarine dam, far sand bar and mat sand. The underwater distributary channel sandbodies are widely developed at the front of the delta. Due to frequent bifurcations and diversions, the underwater distributary channel sandbodies cut and overlap each other, forming branches and striped sand bodies. The sandbody reservoir has good physical property and is the main reservoir sand body with oil and gas enrichment. The detailed study of sedimentary microfacies provides a reference for further exploration and development of lithologic reservoirs in this area.

1. Geological background
An Oilfield is located in the south-central part of Sanzhao sag in Songliao Basin, on a nosing structure which is in NE-SW direction overturned. The strata are mainly Cretaceous: Huoshiling formation, Shahezi Formation, Yingcheng Formation, Denglouku formation and Quantou Formation, Qingshankou formation Yaojia formation, Nenjiang Formation, Sifangtai formation and Mingshui formation from bottom to top[1-3]. The P reservoir located in the first member of Yaojia formation is the main exploration and development target layer. During the first Yaojia Formation deposition period, the basin settle slowly, the topography is gentle, lake water is shallow, and the supply of material sources is sufficient[4]. Large river controlled shallow water delta sand body develops along the north long axis direction. The sand body has good physical properties, which is the main reservoir of P reservoir in A oilfield[5].
2. Division and correlation of high resolution sequence stratigraphy in P reservoir

Braided river can be divided into three subfacies: braided channel, overflow bank and flood plain. Braided channel subfacies can be divided into two configuration elements: core beach and braided channel. Overflow bank can be divided into inter channel, natural dike, crevasse fan and other configuration elements. However, due to the frequent swing of braided channel and the underdevelopment of overflow bank sandbodies, the braided channel and core beach are the focus of the study on braided river reservoir configuration.

The sedimentary structure of the central beach in the study area is not obvious in vertical rhythm, and large and small trough cross bedding is developed; The sedimentary characteristics are that the lithology is dominated by medium sandstone ~ fine conglomerate, with argillaceous interlayer developed inside, and the thickness of sand body is relatively thick, generally 5-8m; The characteristics of SP and GR logging curves are high amplitude box shape, toothed box shape and funnel shape.

The sedimentary structure of braided channel is vertical positive rhythm with small trough cross bedding, oblique bedding and parallel bedding; The sedimentary characteristics are that the lithology is mainly fine to medium sandstone, the bottom interface is often an obvious scouring surface, the distribution of mud and gravel, and the thickness of sand body is 4-6m; The curve features are SP and GR curves with middle and high amplitude finger shape, bell shape and compound bell shape, for example: Under the top boundary of P reservoir is grayish green massive mudstone, and on the interface is gray black mudstone. The secondary marker bed can be traced and compared in several third-order structural zones in the depression, and the stability degree is more than 60%. By using the first-class marker beds comparing the long-term cycles just like unconformity surface at the top and bottom of P reservoir, the top of P reservoir widely developed thick mudstone with high gamma and low resistance mutated into low gamma and high resistance,and three sets of marker beds of thick mudstone with high gamma and low resistance widely developed at the bottom of oil layer P; The short-term cycles are compared by using the third and fourth grade marker beds such as local lake flooding surface and the top of large river channel;

The core of configuration characterization is to restore the distribution of configuration units in different phases. The vertical identification of configuration units in different phases is essentially the identification of corresponding configuration interfaces. Generally, sedimentary discontinuities are
used to identify 5-level configuration interfaces. Three methods can be used to identify the configuration interfaces between single sand bodies, such as argillaceous interlayer, electrical mutation and adjacent well constraint. (Fig. 2).

![Diagram of sedimentary characteristics controlled by stratigraphic framework]

**Figure 2.** High resolution sequence stratigraphic division of P oil layer in Songfangtun area (J136)

3. Sedimentary characteristics controlled by stratigraphic framework
Based on the observation of core wells, it is determined that shallow water delta facies develops in reservoir P of the study area, and delta front subfacies mainly develops, which can be subdivided into underwater distributary channel, sheet sand, crevasse fan, overflow sand, estuary bar, distal bar, inter-channel and inter-mat. There are 8 kinds of sedimentary microfacies (Fig. 4). Among them, the underwater distributary channel microfacies sand content is high, with the positive rhythm characteristics of coarse in the bottom and fine in the upper. The channel cross bedding is developed, and the scouring surface can be seen at the bottom. The logging curve is box shaped or bell shaped; the lithology of the distributary Bay is fine, mainly composed of gray mudstone and argillaceous silt, with horizontal bedding and common plant debris. The microfacies lithology of Hekou bar is mainly composed of siltstone, argillaceous siltstone and mudstone, with the reverse rhythm of fine in the bottom and coarse in the upper part, with the development of wavy bedding and slump deformation bedding, and funnel-shaped logging curve; the sheet sand is mainly interbedded with argillaceous siltstone and mudstone, mainly developing wavy cross bedding, and the curve is mainly finger shaped.
Figure 3. Microfacies types of P reservoir in Songfangtun area

Figure 4. Plane evolution diagram of sedimentary microfacies in P reservoir in Songfangtun area

The evolution of sedimentary system is controlled by base level cycle. P9-p6 is a half cycle of mid-term base level descent, which is a progradational sequence. In this period, due to the decrease of base level, the sand bodies of underwater distributary channel began to develop and continuously pushed towards the lake basin. In P9 ultra short term cycle period, the sedimentary microfacies are mainly composed of underwater distributary channel and sheet sand in delta front, with crevasse fan
and mouth bar microfacies developed locally. The product also increases gradually and distributes irregularly at the edge of underwater distributary channel (Fig. 4). The overall p9−p6 ultra short-term cycle sedimentary sequence reflects the process that the base level drops, the water body becomes shallower, and the underwater distributary channel sand body gradually progradates into the lake.

P52−p1 is a half cycle of mid-term base level rise, which is a retrogradation sequence, and can be divided into 3 short-term cycles and 8 ultra short-term cycles. In this period, the sediment level gradually increases to a deeper level. In the period of p52 ultra short-term cycle, underwater distributary channels extend far away, and four underwater distributary channel sandbodies are developed in the southwest. In the ultra short-term cycle period of p42 and p41, the activity of underwater distributary channel is weak, while the overflow sand microfacies and their development in the edge of the channel are mainly distributed around it. In the P3 ultra short term cycle period, the activity of underwater distributary channel was enhanced again, and the extended distance was longer. In the P22 ultra short term cycle period, the underwater distributary channel activity continued to increase; in the p21 ultra short-term cycle period, the river activity is weakened. However, in P1 period, the river activity is weaker. In the front of the river channel, the estuary bar microfacies are relatively developed, and the coastal shallow lake microfacies are developed in the Southeast.

4. Conclusion
(1) There are 4 types of sequence boundaries in P reservoir, which can be divided into 2 medium-term base level cycles, 5 short-term base level cycles and 12 ultra-short-term base level cycles. The high-frequency sequence stratigraphic framework is composed of short-term cycles and ultra-short-term cycles as single sand body level correlation unit. The formation thickness is controlled by paleogeomorphology and base level changes, and the source strata are thinned layer by layer. The stratigraphic development model is "thick in the north and thin in the South".

(2) Shallow water delta depositional system is developed in oil layer P of area a, and delta front subfacies are mainly developed in study area. Eight microfacies sand bodies, such as underwater distributary channel, sheet sand, crevasse fan, overburden sand, estuary bar, distal bar, inter channel and inter sheet mud, are identified.

(3) During the period of p9−p6, the base level decreased, the accommodation space narrowed, and the source supply was sufficient. The underwater distributary channel sand body began to develop and moved towards the lake basin, and the distribution range was relatively small; in the period of p52−p1, the base level continued to rise, the accommodation space gradually increased, and the distribution range of sedimentary sand body was large. The sandbodies of subaqueous distributary channel in delta front are widely developed with a long extension distance. Due to frequent branching and diversion, underwater distributary channel sandbodies are vertically overlapped and horizontally connected, and are distributed in branches and strips on the plane. The sandbodies have good physical properties and are the main reservoir.

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