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Sedimentary Characteristics of Chang 8_1 Sub-Member of Yanchang Formation in M Area of the Ordos Basin

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Abstract: *The Ordos Basin is a significant oil and gas basin. Region M is located southwest of the Ordos Basin. Its Chang 8_1 sub-member is primarily delta front, with abundant oil, and is the primary exploration and development target series. Deep research into the sedimentary facies of the Chang 8_1 sub-member has implications for oil and gas exploration. The study area is primarily delta facies, which is further subdivided into four microfacies: underwater distributary channel microfacies, underwater distributary channel inter-facies, estuarine bar microfacies, and sheet sand microfacies, based on core observation, logging interpretation results, and other data, combined with previous understanding and regional sedimentary background and other research results. During the Chang8_1 period, the entire area is dominated by multi-phase underwater distributary channel sand that is superimposed vertically and distributed in nearly east-west strips.*

Keywords: *The Ordos Basin, Yanchang Formation, Sedimentary Characteristics*

1. Introduction

The sedimentary environment and sedimentary facies determine the reservoir's rock type, structure, and vertical and horizontal combination, as well as the genetic type, geometric shape, and spatial distribution of the reservoir sand body. They are also an important factor in the distribution of heterogeneous remaining oil in the reservoir. The heterogeneity of the reservoir can be explained by the sedimentary mechanism through the analysis of sedimentary microfacies, and the distribution of remaining oil can then be predicted.

2. Regional Geological Outline

M area is located in the southwest section of the northern Shaanxi slope, and the local structure is located in the Qingyang nose fold belt. The structural form is a monocline with a western slope The top structural slope of Chang 8 member is gentle, and the dip angle is about 0.5°~0.7°[1] . It has no obvious control effect on oil and gas. There are weak nose structures in some areas[2-3]. The M area belongs to the southwest sedimentary system, which is controlled by the southwest prov-enance during the Triassic, and has developed a set of braided river delta-lake facies sedimentary systems dominated by clastic rocks. After the expansion of the lake basin in Phase 7, it began to contract, and the lake basin in Phase 3 contracted rapidly. Its sedimentary environment evolved from large areas of underwater deposition to underwater deposition, until deep lake facies disappeared, and all evolved into shallow lake facies deposition[3-6]. During the Jurassic period, due to the overall uplift of the basin, the Chang 2 and Chang 1 strata were largely missing in the M region (Figure 1).

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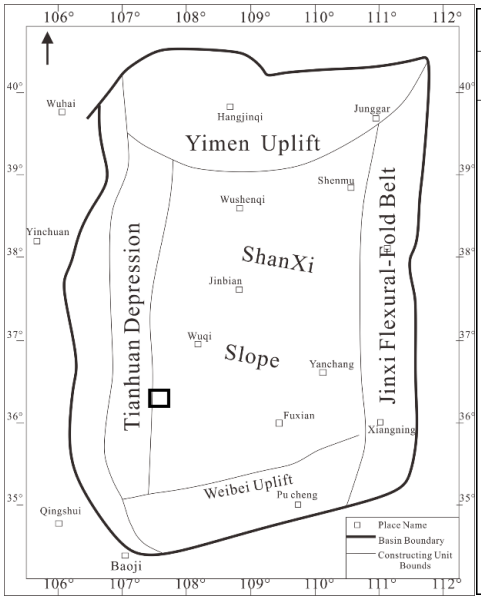

Geologic Era						Layer Thickness (m)
Age	Period	Series	Group	Formation	Sub-formation	
Mesozoic	the Triassic period	Upper series	Yanchang	Chang1	Chang1	0-90
				Chang2	$Chang2_1$	45-60
					$Chang2_2$	45-60
					$Chang2_3$	40-55
				Chang3	$Chang3_1$	30-40
					$Chang3_2$	30-35
					$Chang3_3$	30-35
				Chang4+5	$Chang4+5_1$	45-50
					$Chang4+5_2$	45-50
				Chang6	$Chang6_1$	40-50
					$Chang6_2$	25-35
					$Chang6_3$	35-50
				Chang7	$Chang7_1$	30-40
					$Chang7_2$	30-35
					$Chang7_3$	30-35
				Chang8	$Chang8_1$	45-50
					$Chang8_2$	40-45

Figure 1: Structural division area and stratigraphic column of Yanchang formation in the M area.

3. Method

On the basis of understanding the regional geological background, the sedimentary environment and subfacies of the work area are analyzed by using outcrops, cores, and logging facies indicators. According to the different sedimentary environment characteristics of each small layer of Chang8 member, the point (single well facies analysis), line (profile facies analysis), and plane (plane sedimentary microfacies analysis) are carried out step by step. Among them, the most basic research work is single well facies analysis, which comprehensively applies lithology Lithofacies and electrical characteristics can be divided into facies, subfacies and microfacies. On this basis, cross-well correlation facies are analyzed step by step, and the sedimentary microfacies profile and plan of each small layer in the study area are drawn.

4. Identification Mark of Sedimentary Facies

4.1. Sedimentary Identification Indicat

4.1.1. Color Mark

By observing the core images, it is found that the color of Chang 8_1 sub-member in the study area is mostly gray and dark gray, and lithology is the interbedding of fine grained lithology. If the color of a rock is dark, it indicates that it is in the condition of strong reduction or reduction for a long time; when the color is lighter, it reflects a condition of weak oxidation and reduction. It can be seen that the sedimentary environment of $Chang8_1$ sub-member in this area is mostly continental underwater conditions (Figure 2).

4.1.2. Sedimentary Structural Characteristics

Core observations show that $Chang8_1$ sub-member in the M area has a variety of sedimentary structures. It includes scouring structure, parallel bedding, wavy bedding, lenticular bedding, plant fossils, syngenetic deformation structure, etc., and is rich in carbonaceous clasts and coal lines. A layered structure generated under a high flow regime of the scouring surface, usually in a concave-convex distribution. The scouring surface is mostly distributed at the bottom of the distribution channel and underwater distribution channel. It is these sedimentary structures that indicate that the water body in this period is unstable or in a shallow water environment. Parallel bedding is mainly composed of medium and fine sandstones, which are mostly formed under the hydrodynamic conditions of shallow water and rapid flow, and are commonly found in estuarine sandbars with strong hydrodynamic forces and underwater distribution channels and distribution channel deposits. Wavy bedding and lenticular bedding are mainly developed in the stratum of siltstone, argillaceous siltstone, mudstone, siltstone and mudstone interbedding, which indicates that there is sand and mud supply in the sedimentary

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environment, and the period of water flow activity and water flow stagnation occur alternately, which are mostly seen in the sedimentary environment of natural embankments, river mouth dams and far sand dams (Figure 2).

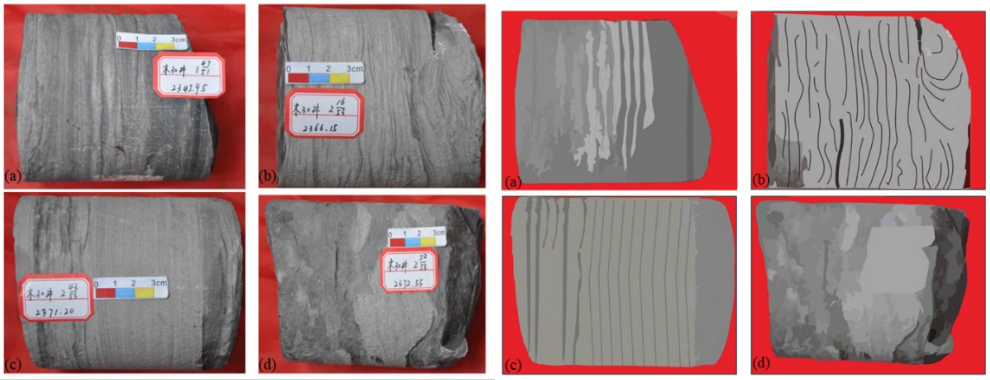

Figure 2: Part of sedimentary structure types and sketch of Chang81 sub-member in the M area.

4.2. Logging facies sign

From logging curves of several wells in the study area, it can be seen that GR curves are well characterized by fine sandstone, siltstone and mudstone, which can be used to judge shale content. GR values of mud and shale in the study area are relatively high, while GR values of sandstone in the study area are relatively low. Based on this, different types of sedimentary facies can be identified by logging response characteristics[7-8]. The logging curves of different sedimentary microfacies in the study area have the following characteristics: the underwater distribution channel often develops muddy gravel sandstone, the bottom is the scouring surface, and the SP curve and GR curve are often bell-shaped and box-shaped. The underwater distribution channel is dominated by suspended sediment. The lithology is mostly argillaceous siltstone and silty mudstone. It is often developed alternately with the underwater distribution channel. The electrical survey curve is smooth as a straight line or straight line, and the amplitude of the curve anomaly is very low or no anomaly. The shape of the microfacies electrical survey curve of the estuary sandbar is mostly funnel-shaped or funnel-shaped and box-shaped composite type, the amplitude of the curve anomaly is medium to medium-high, and the curve can contain microtooth or be smooth. The SP amplitude of sheet sand is low to medium, the curve is smooth or slightly dentate, the middle line of the tooth converges inward, the curve shape is small funnel finger shape or blunt finger shape or tongue shape, and the top and bottom are generally in gradual contact (Figure 3).

Sedimentary Microfacies	Logging Curve Shape
Distributary Channels Subfacies	
Estuary bar	
Interdistributary bay microfacies	
Sheet sand microfacies	

Figure 3: Mapping of logging curve characteristics and sedimentary microfacies of Chang81 sub-member in the M area.

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5. Sedimentary type and microfacies division

Based on lithology, sedimentary structure, grain size change and other characteristics of the coring well, combined with previous understanding and research results of the regional sedimentary background, it is considered that the delta front subfacies developed in the M area are further subdivided into four microfacies: underwater distribution channel microfacies, underwater distribution channel interfacies, river mouth sandbar microfacies and front sheet sand microfacies (Table 1).

Table 1: Sedimentary facies division scheme of Chang81 sub-member of Triassic in the M area.

Sedimentary System	Sedimentary Subfacies	Sedimentary Microfacies
Delta	Delta front	Underwater distribution channel
		Interdistributary bay
		Estuary bar
		Sand sheet

5.1. The distribution channels subfacies

Underwater distribution channels play an important role in delta deposition. The microfacies lithology of the underwater distribution channel in Block M mainly includes small fine-grained conglomerate, medium-coarse-grained sandstone, medium-fine sandstone, etc., with medium sorting. The vertical sequence is similar to the onshore distribution channel, but the sandstone color is darker, and is dominated by small cross bedding. At its top, it can be modified later by water flow and waves, and sometimes vein bedding and horizontal bedding appear. The natural potential is mostly box and bell shaped with abrupt changes at the top and bottom, and the curve is mostly toothed, corresponding to medium amplitude resistivity (Figure 4).

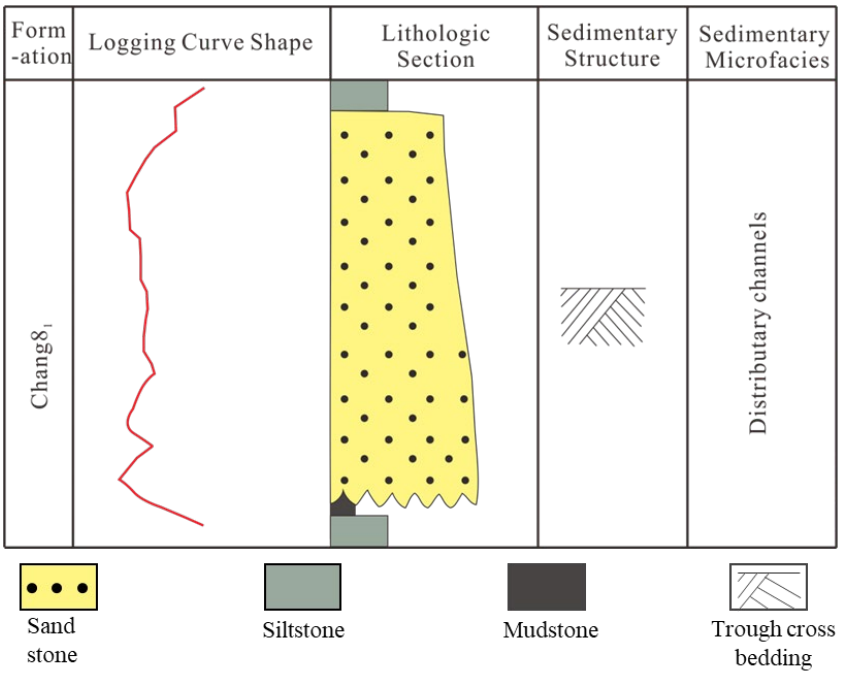

Figure 4: Core column of underwater distributary channel of Chang81 sub-member in the M area.

5.2. Estuary bar microfacies

The estuary bar in Area M is mainly composed of argillaceous siltstone and siltstone, which is generally less than 0.5m. It is generally coarsened from top to top, and develops low angle cross bedding, vein bedding and laminated bedding. The biological disturbance is strong, and the logging curve is funnel-shaped (Figure 5).

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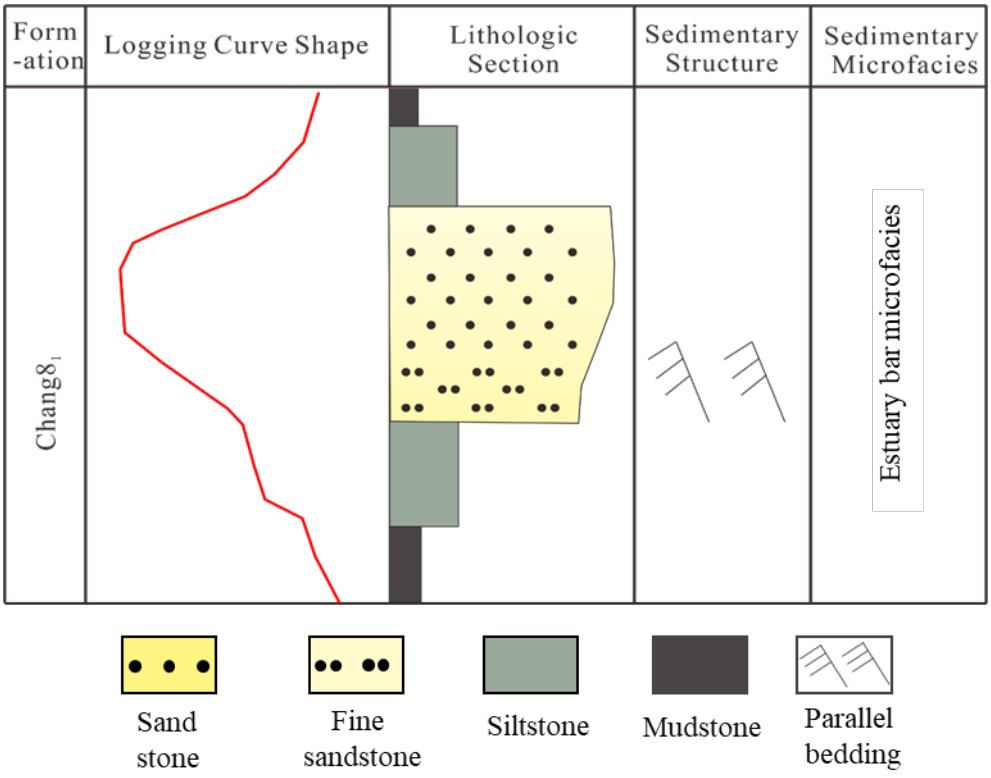

Figure 5: Core column of estuary bar of Chang81 sub-member in the M area.

5.3. Sheet sand microfacies

Sheet sand microfacies in the study area are mainly grey siltstone, the sand body thickness is 1~2m, the curve is finger-shaped, the amplitude of resistivity curve is higher than the overflow sand microfacies, and the finger-shaped characteristics are obvious, generally located in front of the underwater distribution channel, and distributed in leaf shape (Figure 6).

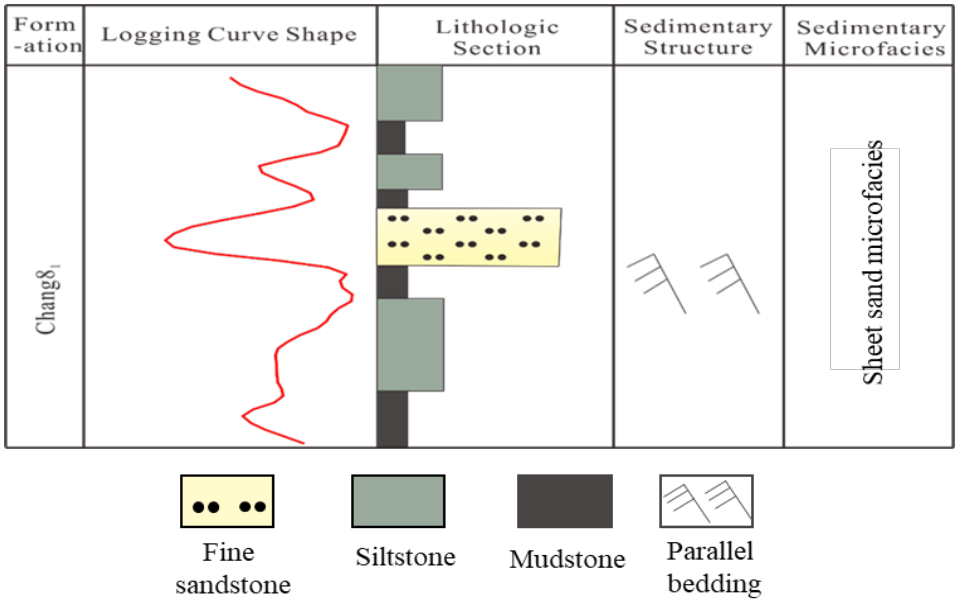

Figure 6: Core column of sheet sand of Chang81 sub-member in the M area.

5.4. Interdistributary bay microfacies

The underwater distributed interchannel microfacies are composed of gray, light gray fine sand, silty

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sand, gray-green mudstone and other lithology, with horizontal bedding, wavy bedding and lenticular bedding developed. The spontaneous potential curve is straight or funnel shaped with medium and low amplitude (Figure 7).

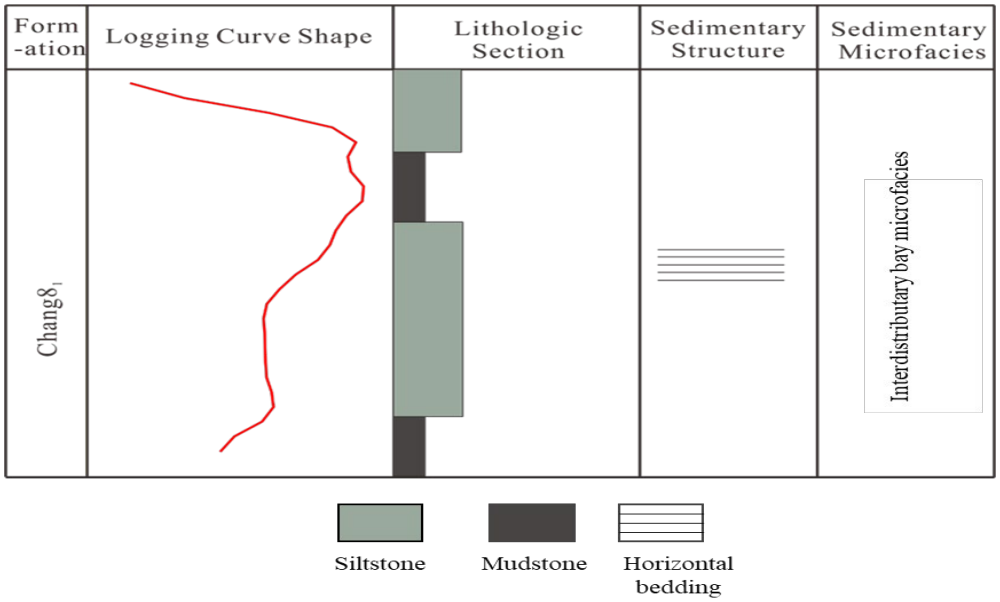

Figure 7: Core column of interdistributary bay microfacies of Chang81 sub-member in the M area.

6. Sedimentary Characteristics

The Chang8$_1^1$ small layer in the study area is mainly composed of multi-phase underwater distributary channel sand, which is superimposed longitudinally and distributed in the nearly east-west strip on the plane. The underwater distributary channel and estuarine bar are relatively developed, which indicates that there is poor terrain in the area, the river continues to flow forward under inertial action, and there is a lot of coarse debris in the river flow, which is easy to deposit to form the estuarine bar, and the distributary channel is large in scale and has good connectivity. The development of sheet sand also shows that the provenance is rich and the hydrodynamic force is low (Figure 8).

The underwater distributary channel of Chang8$_1^2$ is slightly developed with estuarine bar, but there is a gap compared with Chang8$_1^1$ and Chang8$_1^3$, which indicates that the terrain difference in this area is not as good as that of Chang811. The river continues to flow forward under inertial action, and there is a lot of coarse debris in the river, which is easy to deposit to form estuarine bar, and the distributary channel is large in scale and has good connectivity. The development of sheet sand also fully indicates that the source of matter is rich, and there are many mudstones, indicating that the hydrodynamic force is weak (Figure 8).

The Chang 8$_1^3$ small layer is the main sand body development horizon in the study area. The sand body is widely distributed throughout the entire area. It is basically full of sand in the basin. The sand body is stacked in multiple stages, which is a concentrated reflection of the accommodation space less than the sediment supply rate. The low accommodation space leads to the late sand body cutting and stacking on the early sand body, forming a pan-connected body, thus laying a solid material foundation for the formation of high-quality reservoirs. The small layer Chang8$_1^1$ in the study area is mainly composed of multi-phase underwater distributary channel sand, which is superimposed longitudinally and distributed in nearly east-west strip on the plane. The underwater distributary channel and estuarine bar are relatively developed, which indicates that there is poor terrain in the area, the river continues to flow forward under inertial action, and there is a lot of coarse debris in the river flow, which is easy to deposit to form the estuarine bar, and the distributary channel is large in scale and has good connectivity. The development of sheet sand also shows that the provenance is rich and the hydrodynamic force is low (Figure 8).

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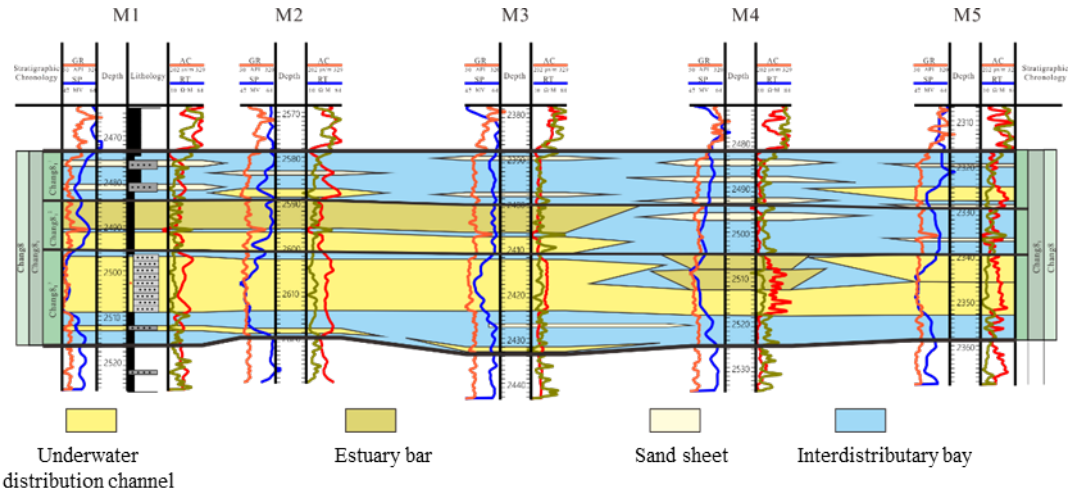

Figure 8: M1-M5 Connected well facies section of Chang8_1 sub-member in the M area.

7. Results

On the basis of core observation and log curve morphology observation, and through the analysis of facies indicators, it is considered that delta deposits are mainly developed in area M, including underwater distributary channel, estuarine bar, sheet sand, interdistributary bay and other sedimentary microfacies. During the Chang8_1 period, the lake basin gradually began to expand. The whole lake basin was dominated by multi-period underwater distributary channel sand, which was superimposed on each other in the longitudinal direction, and distributed in strips in the east-west direction in the plane. In the Chang8_1 period, the whole area is dominated by multi-phase underwater distributary channel sand, which is superimposed vertically and distributed in strips in nearly east-west direction. During the period of Chang 8_1^3-Chang 8_1^1, the sedimentary lake water gradually expanded, the hydrodynamic conditions became weaker, and the sand body thickness gradually became thinner.

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