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Analysis of Sedimentary Facies of the Fuyu Formation in Y Oilfield

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Abstract: This paper takes the Furuyi oil layer of Daqing Y Oilfield as the research object. By combining core observation, experimental analysis and logging data, the deposition facies characteristics of the oil zone are systematically analyzed. The study shows that the Furuyi oil layer is located in the Changyuan structural belt of the central depression area of the Songliao Basin and belongs to the fourth section of the Quantou Formation of the Lower Cretaceous. It was formed in the early stage of the depression's river-reef sedimentary environment. The source area was from the northern Nehe River-Baiquan and the western Baicheng-Baoqiang regions. The formation thickness is 150-250 meters. Sandstone and mudstone interbeds form the primary component of the rock composition. The production, storage and cover combination is good. The Furuyi oil layer mainly develops meandering river facies (including river channels, river floodplain subfacies and multiple microfacies) and delta facies (including plain, front subfacies and multiple microfacies). The rock types, sedimentary structures and logging response characteristics of each facies type are significant. Vertically, the oil layer shows a multi-cycle positive cycle structure, transitioning from meandering river facies to delta facies from bottom to top; horizontally, meandering river facies are distributed in the northern and western source areas, and delta facies are located in the central and southern areas. The sand bodies are distributed in strips or lenses along the source area, and the microfacies of beach and river mouth dam have the best reservoir performance. The study has clarified the sedimentary facies and sand body distribution patterns of this oil layer, providing geological basis for oil and gas exploration and development.

Keywords: Depositional Facies; Delta; Quantou Formation; Reservoir; Structure.

1. Overview of the Study Area

Situated in the central sag of the Songliao Basin, Daqing Oilfield has Y Oilfield as its key exploration and development zone—where the geological structures and stratal development features are critical to the formation and distribution of oil and gas resources. From the perspective of the regional tectonic background, the Songliao Basin has undergone three main evolutionary stages: the faulting stage, the depression stage, and the inversion stage. Y Oilfield is located in the secondary tectonic unit of the central depression zone of the basin, and as a whole, it presents a long-strip-shaped tectonic structure with a north-north-eastward orientation. The formation of this tectonic structure is closely related to the tectonic stress caused by the late Yanshan Movement to the Himalayan Movement, providing favorable tectonic closure conditions for the migration and accumulation of oil and gas. [1-2]

In terms of stratum development, Y Oilfield has successively developed the Lower-Cenozoic basement, Mesozoic Cretaceous, Cenozoic Paleogene, Neogene and Quaternary strata from bottom to top. Among them, the Cretaceous is the main target stratum for oil exploration in this area, and the Fuyu oil layer belongs to the fourth section of the Quan Tou Formation of the Lower part of the Cretaceous, which is one of the important oil-bearing layers of Y Oilfield. The thickness of the Fuyu oil layer is generally relatively stable, ranging from 150 to 250 meters. Affected by the ancient topography and sedimentary environment, there are certain differences in the thickness of the strata in some local areas. From the lithological characteristics, the Fuyu oil layer mainly features a set of purple-red and gray-green mudstones interbedded with gray-white and light-gray sandstones. The sandstone lithology is mainly fine sandstone and siltstone, with good sorting and moderate rounding, and the cementation material is mainly mud cement, and in some areas, calcareous cement can be seen, with a moderate degree of cementation.

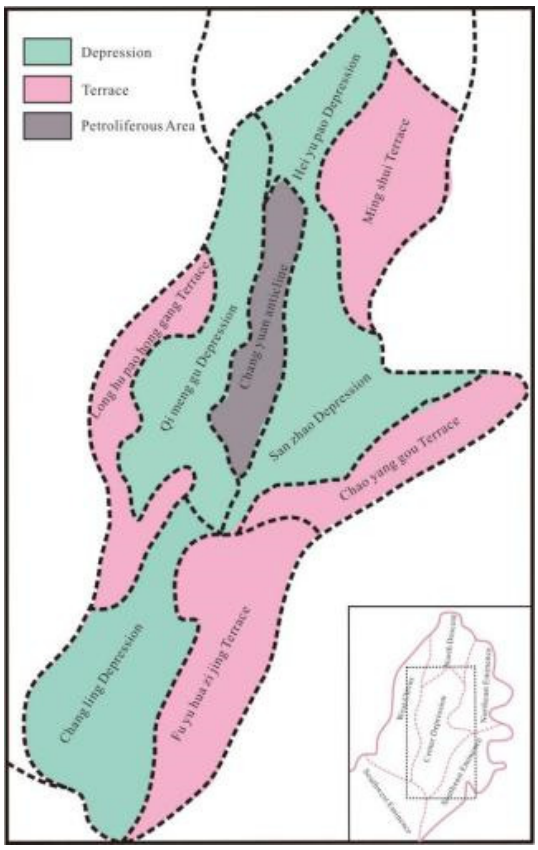

Fig 1. Study area of Y oilfield

2. Classification of Sedimentary Facies

Through the observation of a large number of core samples from the Fuyu oil layer in Y Oilfield, the indoor experimental analysis, and the interpretation of logging data, combined with the regional sedimentary background, it was determined that the Fuyu oil layer mainly develops two sedimentary types: riverine and deltaic. Among these types, the riverine one is primarily made up of meandering river deposits, while the deltaic type is mainly composed of delta plain and delta front sediments. [3]

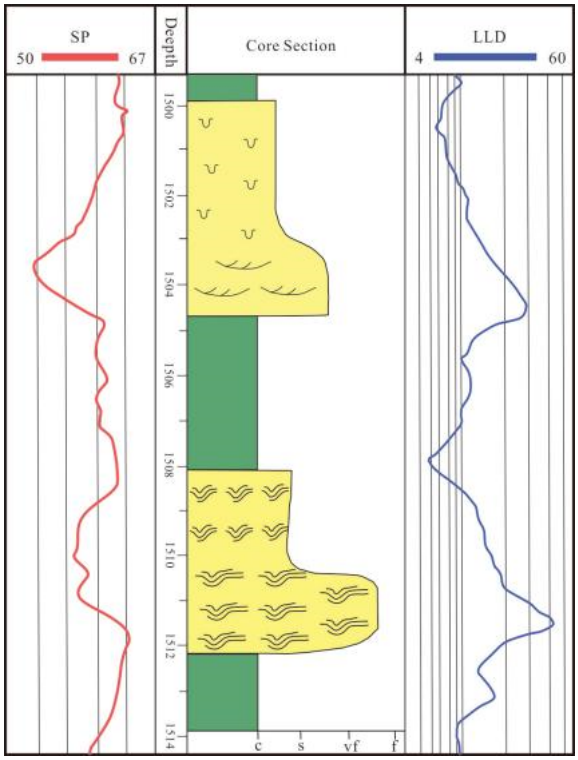

Fig 2. Integrated core log of well A

As one of the key sedimentary types within the Fuyu oil layer, meandering river deposits are predominantly distributed in the northern and western source regions of Y Oilfield. These deposits exhibit the typical "dual-structure" feature: the lower segment consists of fluvial channel sediments, while the upper segment is composed of river floodplain sediments. Serving as the core part of meandering river deposits, the fluvial channel is mainly made up of gray-white and light gray fine sandstone and siltstone, characterized by coarser rock texture, better sorting and rounding. Its sedimentary structures primarily include large tabular cross-bedding and trough cross-bedding, with local occurrences of parallel bedding—all of which indicate strong hydrodynamic conditions. In terms of logging curves, the fluvial channel presents distinct bell-shaped or box-shaped spontaneous potential (SP) curves with large amplitudes, low values on the natural gamma (GR) curve, and high values on the resistivity curve. Furthermore, the fluvial channel can be subdivided into two microfacies: riverbed lag microfacies and point bar microfacies. The riverbed lag microfacies mainly develops at the bottom of the channel, with its rock texture dominated by coarse sandstone and conglomerate; it has a small thickness (generally ranging from 0.5 to 2 meters) and a limited distribution range. In contrast, the point bar microfacies is the main component of the fluvial channel, located on the convex bank of the channel. Its rock texture is mainly fine sandstone and siltstone, with a greater thickness (usually between 2 and 8 meters) and relatively stable lateral distribution, making it one of the important reservoir microfacies in the Fuyu oil layer.

In the Fuyu Formation, deltaic facies are predominantly developed in the central and southern regions of the Y Oilfield. These facies form as river-borne sediments accumulate in areas where water flow energy diminishes.

The delta plain subfacies, representing the terrestrial segment of the deltaic system, exhibits a transitional connection with the meandering river sedimentary system. It is primarily composed of three microfacies: distributary channels, distributary bays, and marshes. The distributary channel microfacies shares similarities with the meandering river channel subfacies in terms of lithology, sedimentary structures, and logging responses, though it is smaller in scale with a typical thickness ranging from 1 to 5 meters. Situated between distributary channels, the distributary bay microfacies is dominated by mudstone and silty mudstone, interspersed with minor thin siltstone layers; its sedimentary structures are primarily horizontal and lenticular bedding, and logging curves show high natural gamma (GR) values alongside a gently sloping spontaneous potential (SP) curve. The marsh microfacies develops in low-lying parts of the delta plain, characterized by thin, discontinuously distributed carbonaceous mudstone and coal seams.

Lying beneath the delta plain, the delta front subfacies constitutes the underwater portion of the deltaic system and represents the most favorable reservoir interval within the deltaic sedimentary framework. It comprises four main microfacies: underwater distributary channels, estuary dams, distal sand dams, and underwater distributary bays. The underwater distributary channel microfacies forms the primary skeletal sand body of the delta front, consisting mainly of fine sandstone and silty sandstone with good sorting; its sedimentary structures include small-scale tabular and wavy cross-bedding, and logging curves display moderate-amplitude bell-shaped or box-shaped SP curves with low GR values. The estuary dam microfacies, located at the terminus of underwater distributary channels, is dominated by fine sandstone with a thickness of 2–6 meters, featuring reverse grading and parallel bedding; its logging signature includes funnel-shaped SP curves, often with low amplitude. The distal sand dam microfacies lies beyond the estuary dams, composed of silty sandstone in thin layers (typically 0.5–2 meters thick) with horizontal and wavy bedding, corresponding to low-amplitude funnel-shaped or finger-like SP curves. Finally, the underwater distributary bay microfacies occupies the interspaces between underwater distributary channels, consisting mainly of mudstone with occasional thin siltstone interlayers; it exhibits horizontal bedding and logs show high GR values with a flat SP curve.

2.1. Sedimentary Facies Distribution

When considering the planar distribution, the sedimentary facies distribution of the Fuyu oil layer is governed by factors including source area direction, paleotopography, and hydrodynamic conditions. Meandering river facies are predominantly found in the northern and western parts of the Y Oilfield, in proximity to the source areas. The primary sources of sediment are the Nehe-Baiquan source area to the north and the Baicheng-Baokang source area to the west. [4]

Meandering river sand bodies originating from the northern source area exhibit a north-northeast trending distribution.

These sand bodies have a relatively wide span, typically ranging from 5 to 15 km, and a fairly substantial thickness of 3 to 8 m on average. They are dominated by point bar microfacies sand bodies, which possess favorable reservoir properties.

In contrast, meandering river sand bodies influenced by the western source area extend in a northwest-southeast direction. These sand bodies are narrower, generally measuring 3 to 10 km in width, and thinner, with a thickness ranging from 2 to 6 m. While they also consist mainly of point bar microfacies sand bodies, their continuity is relatively poor due to the influence of source supply intensity.

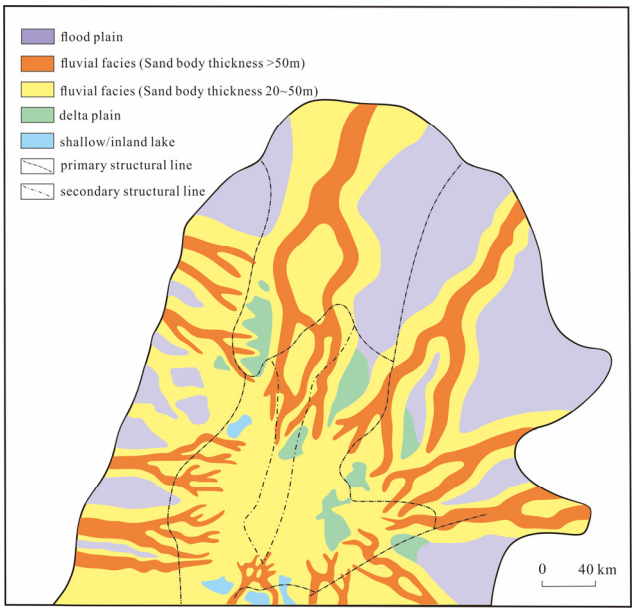

Fig 3. Sedimentary facies map of Fuyu oil zone in Y oilfield

The deltaic facies are mainly distributed in the central and southern parts of the Y oilfield, formed by the transportation and deposition of meandering river sediments to the center of the basin. The deltaic plain subfacies are mainly distributed in the northern and western parts of the deltaic facies, showing a transitional relationship with the meandering river facies. The distributary channel sand bodies are distributed in a branch-like pattern, extending from the source area to the center of the basin. The sand body width is generally 2-8 km and the thickness is generally 1-5 m. The subfacies of the delta front is mainly distributed in the central and southern parts of the deltaic facies, close to the center of the basin. The underwater distributary channel sand bodies and the estuary dam sand bodies are the main sand body types of this subfacies. The underwater distributary channel sand bodies are distributed in a strip-like pattern, connected with the distributary channel sand bodies of the deltaic plain subfacies. The estuary dam sand bodies are distributed in a lens-shaped at the front end of the underwater distributary channel, with a sand body thickness generally 2-6 m, and have excellent reservoir performance. [5]

3. Conclusion

Through a systematic analysis of the sedimentary facies of the Fuyu oil layer in Y Oilfield of Daqing Oilfield, combined with the study of geological background, sedimentary facies types, profile characteristics and planar characteristics, the following main conclusions were drawn:

The Fuyu oil layer in Y Oilfield was formed in the early stage of the depression period of the Songliao Basin during the river-delta sedimentary environment. The source area mainly came from the northern Nehe River-Baiquan area and the western Baicheng-Baoqiang area. The thickness of the strata is stable, and the lithology is mainly composed of sandstone and mudstone interbeds. The formation of the hydrocarbon reservoirs has favorable geological basis due to the good combination of source, reservoir and caprock.

The Fuyu oil layer mainly develops two sedimentary facies types: meandering river facies and delta facies. Among them, the meandering river facies include subfacies of river channel (bed retention microfacies, beach microfacies) and river floodplain subfacies (river floodplain microfacies, river floodplain lake microfacies, river floodplain marsh microfacies), and the delta facies include subfacies of delta plain (divergent channel microfacies, divergent interbay microfacies, marsh microfacies) and delta front subfacies (underwater divergent channel microfacies, estuary dam microfacies, far sand dam microfacies, divergent interbay microfacies). Different sedimentary facies types have unique lithology, sedimentary structures and logging curve characteristics, which can be used as important references for the identification of sedimentary facies.

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