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Characteristics of Sandbody and Sedimentary Facies of Yan 8 Reservoir of Yan'an Formation in X Area

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Abstract: To foster the exploration and exploitation of oil reservoirs in Northern Shaanxi, an investigation into the attributes of sand bodies and depositional facies within the Yan 8 oil layer formation in Area X was conducted, utilizing core samples, mud logs, and well-logging data. Building upon core descriptions, an analysis was performed on individual-well depositional facies, continuous-well depositional facies, as well as areal depositional facies. It is postulated that the Yan 8 interval in the study region represents a fluvially-dominated delta plain setting, characterized by three primary developments: distributary channels, natural levees, and inter-channel swamps as micro-environments. Vertically, the sand bodies of the Yan 8 oil layer formation are discontinuous, primarily comprising distributary channels and inter-channel swamps. Horizontally, the Yan 8 oil layer formation features 10 river channels, which are arranged in a linear fashion on the plane, extending in a northwest-southeast direction. These channel deposits form the principal framework of the sand body structure and also serve as the main zones for oil and gas accumulation.

1. Introduction

The X area is located on the northern slope of Shaanxi in the Ordos Basin, a loess hilly area. The development layer is the Yan 8-Yan 10 oil group of the Jurassic Yan'an Formation, with a deposition thickness of about 130 m. At the end of the Triassic, under the influence of the Indosinian tectonic movement, the Ordos Basin as a whole uplifted, and the top of the Yanchang Formation was subjected to geological effects such as strong weathering and river erosion, forming a paleo-landform with extensive water systems, vertical and horizontal ravines, and undulating hills [1, 2]. At this time, the ancient river valleys of Ganshan and Shaanxi, the ancient river valleys of Ningshan, Qingxi, Mengshan and Shaanxi, and the branch river valleys developed on the slope divided the southern part of the basin into Jiyuan Highland, Yanwu Highland, Ziwuling Highland and Northern Shaanxi Plain. In the Jurassic, the basin as a whole declined. The Yan'an Formation exhibited a sequence of coal-bearing strata, pertaining to fluvial-swamp depositional environments.

Vertically, it consisted of sandstone, mudstone, coal, and carbonaceous mudstone, featuring numerous cycles of deposition. During the initial depositional phase, it was predominantly characterized by thick, multi-stage braided river systems, with coarse clastic sediments filling the area [3, 4].

The depositional environment not only dictates the reservoir's production characteristics, encompassing its horizon, capping conditions, size, and distribution pattern, but also influences the internal configuration and lithology of the reservoir, ultimately governing the distribution of oil and gas [5, 6]. Nonetheless, the present comprehension of the micro-environments and the arrangement of sand bodies within Zone X remains uncertain. Therefore, on the basis of previous studies, the author uses core, thin section, logging and production performance data to classify sedimentary microfacies, and describes in detail its spatial distribution and its relationship with oil and gas enrichment, with a view to follow-up Provide basis for development.

2. Stratigraphic characteristics

In the X region of Northern Shaanxi, the Yan 8 oil layer formation underwent detailed subdivision and comparison utilizing the marker bed technique, the equal thickness principle, and sedimentary cycle analysis. Based on the outcomes of the stratigraphic subdivision, a map depicting the thickness of the substrata (see Figure 1) and a structural diagram of the stratum tops (see Figure 2) were generated. It is postulated that the stratum corresponding to depositional period 8 is relatively intact across the entire area and has not undergone erosion. The overall thickness of the formation remains fairly consistent, with an average thickness of approximately 25 meters. The formation's top is characterized by the dense development of nose-like structures, arranged in multiple rows in a nearly east-west orientation. These structures exhibit a structural relief of less than 25 meters, and their distribution displays some variability. These nose structures offer favorable trapping conditions for the accumulation of hydrocarbons.

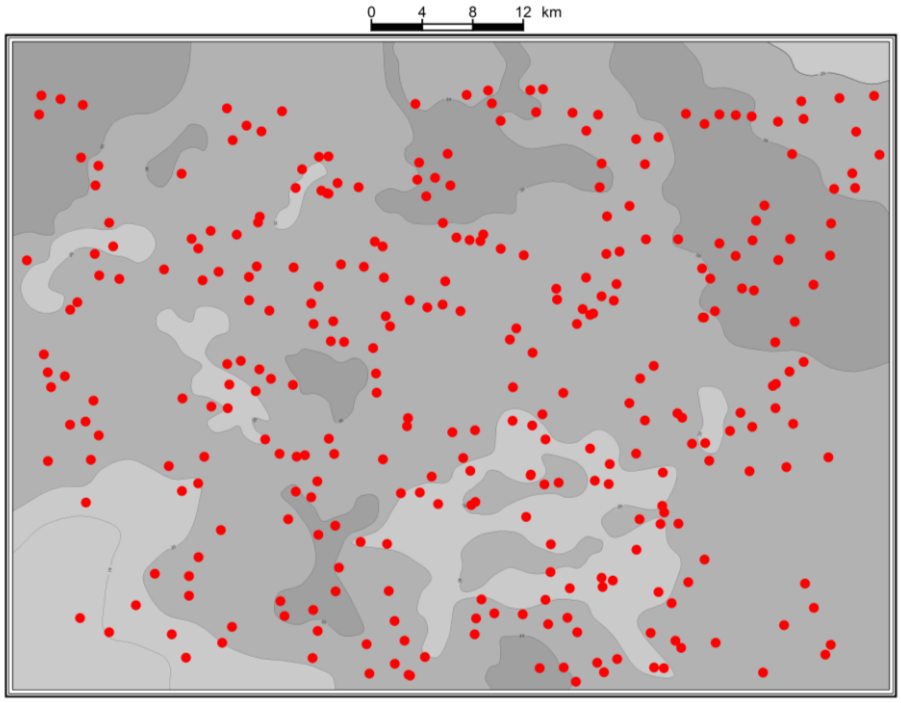

Figure 1: Plan of thickness of Yan 8 formation in X area

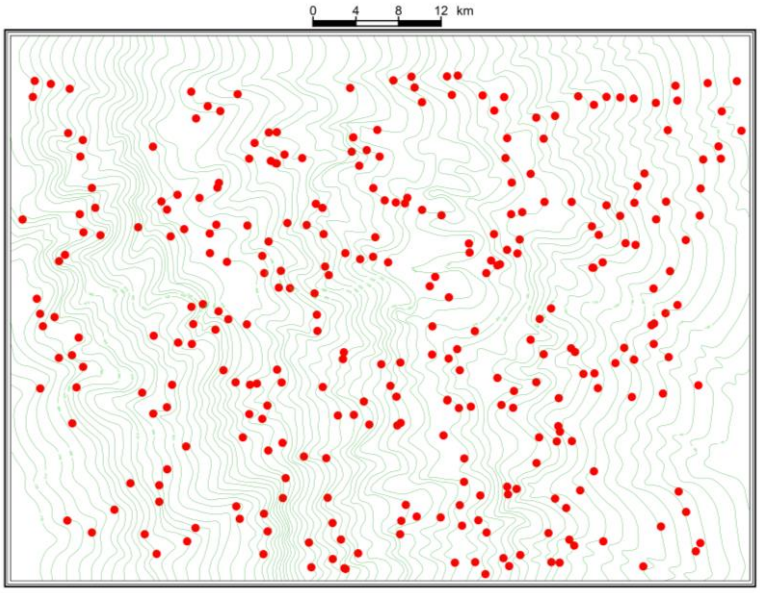

Figure 2: Top structure diagram of Yan 8 formation in X area

3. Sedimentary Facies Characteristics

3.1 Types of Sedimentary facies in the Study Area

Located within the northern Shaanxi region of the Ordos Basin, the X area is characterized by the Yan 8 oil layer group of the Yan'an Formation, which is classified as a delta plain subfacies. Through a comprehensive analysis of existing research findings and regional data, it has been determined that the primary sedimentary microfacies in this area consist of distributary channels, natural levees, and interdistributary swamps (see Table 1).

Table 1: Sedimentary facies classification of Yan 8 oil layer group in X area

Sedimentary facies	Sedimentary subfacies	Sedimentary microfacies
Delta	Delta plain	Diversion channel
		Branch swamp
		Natural embankment

(1) Diversion channel

The distributary channel, also called the branch channel, is the frame part of the delta plain. A large amount of mud and sand forming the delta are transported to the estuary and deposited through them. The distributary channel sedimentation is dominated by sandy sediments (see Figure 3), and the sequence features gradually tapering upwards. However, they are finer than the sediments in the middle and upper reaches of the river, and the sorting becomes better. Generally, the bottom is medium-fine-grained sand, which often contains residual sediments such as gravel and stems of plants. Upward, it becomes silt, argillaceous silt, and silty mud. The sandy layer has trough or plate-shaped cross germanium bedding and wavy cross bedding, and its scale becomes smaller upwards, and its bottom boundary and the underlying rock layer are often in erosion and erosion contact.

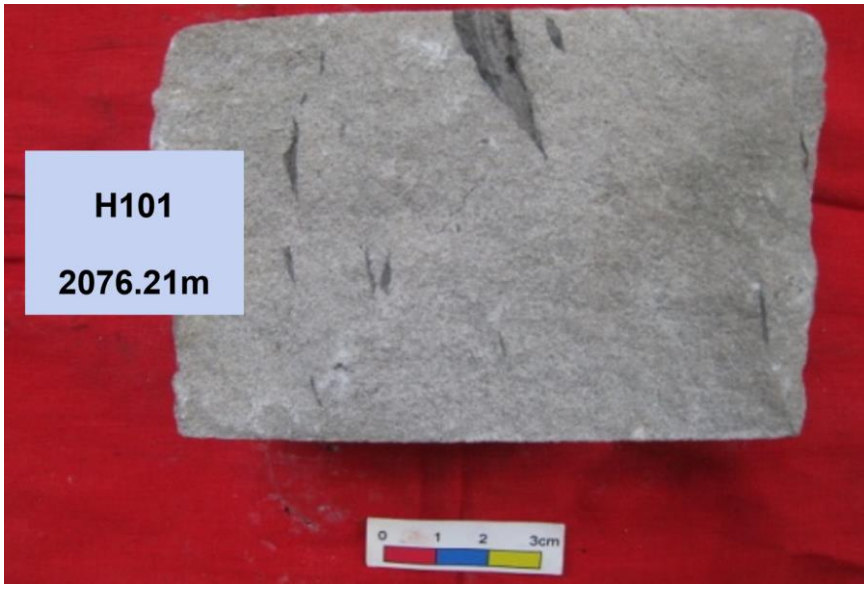

Figure 3: Well H101, extension 8, 2076.21m, blue-gray sandstone

(2) Natural embankment

This kind of natural embankment is formed by overflowing and silting out of the flood carrying mud and sand during the flood period. Natural dikes are well developed in the upper part of the delta plain, but their height, width, grain size and stability are gradually reduced in the downstream direction. Its grain size is finer than river deposits and coarser than marsh deposits. It is dominated by silt and silty clay. It becomes finer and thinner from the river channel to both sides. The horizontal texture and the cross-shaped texture are developed. The water is more wavy and planted. Chips, stems and roots and burrows are more common.

(3) Branch swamp

The surface of the swamp is close to the average high tide surface. It is a low-lying area that is periodically submerged by water. Its water body is mainly fresh water or brackish water. The plants in this swamp are luxuriant, all of which are reeds and other herbaceous plants, which is a stagnant weakly restored or restored environment. The lithology is mainly dark-colored organic mudstone, peat or lignite deposits, which often contain thin layers of siltstone deposited by floods. It is common to have massive uniform bedding and horizontal texture. The biological disturbance has a strong effect, and sometimes burrows are seen. It often contains plant debris, charcoal debris, roots, ostracods and edulis, siderite, etc.

3.2 Single-well Facies Analysis in the Study Area

To uncover the patterns of vertical evolution and lateral distribution of sedimentary facies within the Yan 8 oil layer group in the X area, a single-well analysis of sedimentary facies was conducted on two wells within the study region.

(1) Analysis of Yan 8 oil layer group facies in Well C33

Well C33, situated in the northern part of the study area, exhibits frequent overlapping of distributary channels, interdistributary swamps, and natural levees from the base to the upper delta plain. The primary deposits consist of distributary channels and interdistributary marshes, with some areas classified as natural levee microfacies.

(2) Analysis of Yan 8 oil layer group facies in Well G137

Located in the central part of the study area, Well G137 displays frequent interleaving of distributary channels, interdistributary swamps, and natural levees across the delta plain from

bottom to top. The deposition is predominantly characterized by distributary channels and interdistributary swamps.

3.3 Examination of Sand Body Connectivity in the Study Region

Facies profiling is a method employed to analyze sedimentary facies, utilizing electrical logging data to establish phase sequences between neighboring wells and ascertain their two-dimensional distribution characteristics.

Taking into account the structural position and geological evolution of the study area, along with extensive exploration and development experience, two continuous well profiles have been established to reflect the region's sedimentary facies. These profiles reveal that the Yan 8 oil-bearing formation exhibits minimal undulations and primarily features distributary channels and interdistributary swamps. Fine sandstone dominates the channel deposits, with sand bodies distributed in a lenticular shape within the channels. The interdistributary swamps are mainly composed of siltstone and mudstone. Vertically, there is frequent interleaving of sand and mudstone, forming thin interbeds.

3.4 Sedimentary Microfacies and Distribution Characteristics of Sand Bodies

After identifying the sedimentary facies, subfacies, and microfacies, a systematic approach was adopted, progressing from the analysis of individual well facies diagrams to inter-well comparisons, and ultimately examining the planar characteristics of sedimentary microfacies and sand body distributions.

The deposition of the Yan 8th stage occurred in a river-dominated delta plain environment. By generating a thickness map of the Yan 8th stage sand bodies (see Figure 4) and a planar map of sedimentary microfacies (see Figure 5), it is evident that 10 river channels were developed during this stage in the study area. These channels appear as elongated strips on the map, oriented in a northwest-southeast direction. The maximum width of these channels reaches approximately 6.28km, while the narrowest section measures around 0.80km.

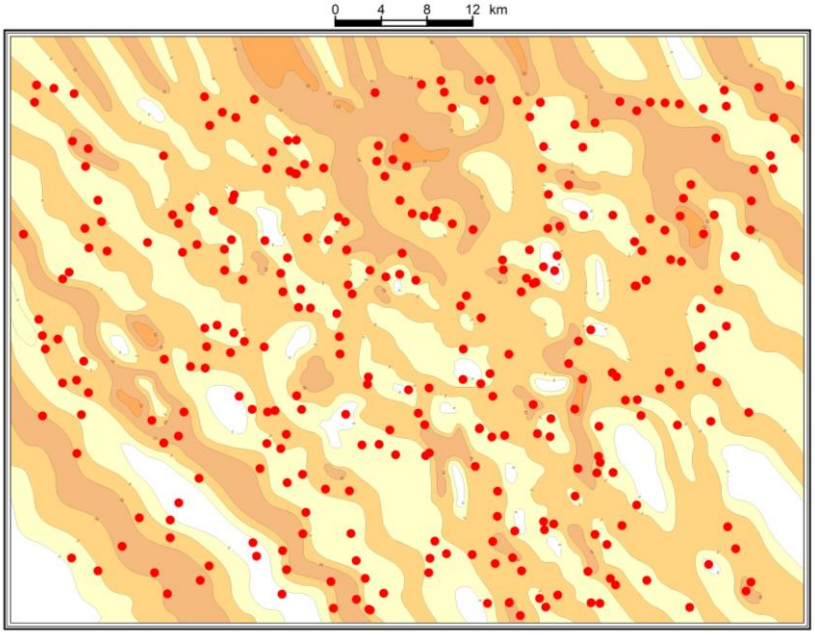

Figure 4: Plan view of thickness of Yan 8 sand body in X area

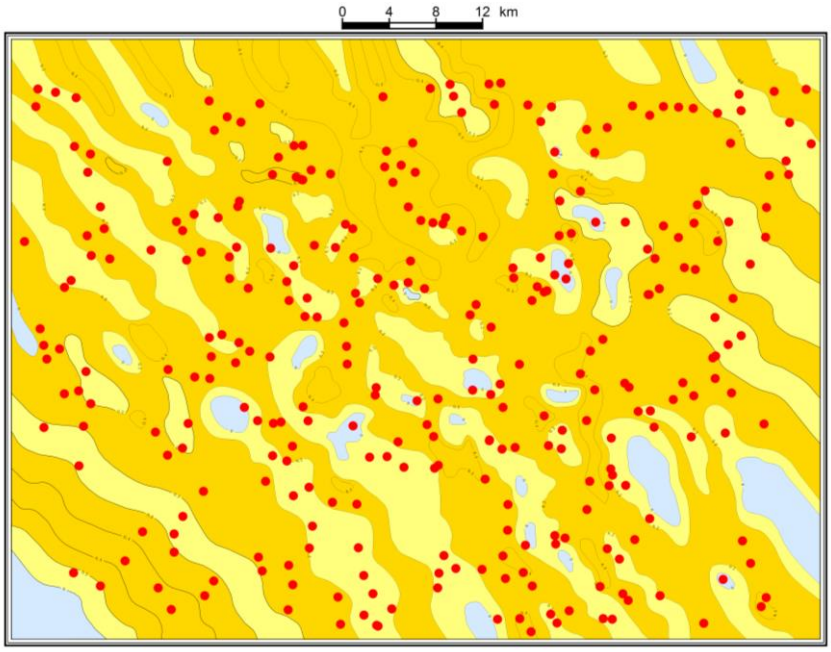

Figure 5: Plan view of sedimentary microfacies of Yan 8 in X area

On the planar map, the rivers enter from the northwest and exit towards the southeast. Within the study area, regions with a sand ratio ranging from 0 to 0.2 are characterized by inter-channel swamps, while areas with a sand ratio between 0.2 and 0.4 feature natural levees. Zones with a sand ratio exceeding 0.4 exhibit channel deposition, and a significant portion of the study area has a sand ratio of 0.4 or higher. The channel sediments form the primary framework of the sand body and represent the main areas favorable for enrichment.

4. Conclusions

(1) The Yan 8 oil layer group within the study region is characterized as a subfacies of the delta plain, where the formation of sand bodies is largely governed by sedimentary microfacies. It predominantly features diversion channels, natural levees, and inter-channel swamp microfacies.

(2) In the vertical profile, from base to top, the distributary channels, inter-channel swamps, and natural levees of the delta plain frequently intertwine. The primary deposits consist of distributary channels and inter-channel marshes, with some areas belonging to natural levee microfacies. Fine sandstone dominates the channel deposits, forming lenticular sand bodies. The inter-channel swamps are mainly composed of siltstone and mudstone, and the vertical sequence reveals frequent interbedding of sand and mudstone layers.

(3) Spatially, the eighth stage of sedimentation occurred in a river-dominated delta plain environment, with ten distributary channels primarily developing as elongated strips oriented in the northwest-southeast direction. The channels range in width from approximately 0.80km at their narrowest to 6.28km at their widest. Channel deposits form the core of the sand body structure and are the primary zones for oil and gas accumulation.

Acknowledgement

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