Sedimentary characteristics of Yan 6 oil layer of Yan'an Formation in X area of Ordos Basin

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Abstract. Using core, mud logging and logging data, the study on the sedimentary characteristics of the Yan 6 oil layer of the Yan'an Formation in the X area of the Ordos Basin was carried out. It is believed that the Yan 6 oil layer in X area mainly develops delta deposits, and the subfacies is delta plain. The sedimentary microfacies are mainly diversion channels, inter-branch swamps and natural dikes. According to coring well data, sand body shape analysis, and logging facies analysis. Vertically, the sand bodies in the Yan 6 oil layer group are discontinuous, and there are mainly distributary channels and inter-branch swamps. Horizontally, the Yan 6 oil layer group develops 7 river channels, which are distributed in a strip on the plane, and the extension direction is northwest-south east. The comprehensive characterization of the sedimentary microfacies and the distribution of reservoir sand bodies in Yan 6 oil layer provides a reliable basis for the oil field to adjust the oil production plan in time.

1. Introduction

The Ordos Basin is one of the earliest basins in my country where oilfields have been discovered, and it is also the second largest petrolierous basin in my country[1~3]. It is rich in oil and gas resources. The main oil-bearing strata are the Triassic Yanchang Formation and the Jurassic Yan'an Formation[4]. In the process of exploration and evaluation in recent years, the Jurassic Yan'an Formation oil production well points have been discovered in the study area. The oil test and production yield are good, showing a good prospect for increasing reserves and production. The distribution characteristics of Jurassic reservoirs are mainly restricted by the sedimentary facies and the distribution of sand bodies in the Yan'an Formation [5,6]. Therefore, on the basis of sedimentary background research, it is particularly important to select appropriate research methods to finely characterize the sedimentary characteristics of the Jurassic Yan'an Formation.

The X area is located on the northern slope of Shaanxi in the Ordos Basin, a loess hilly area. The Yan 6 oil-bearing group of the Jurassic Yan'an Formation is the main development strata. In the process of exploration and evaluation in recent years, Jurassic oil production well points have been discovered in Area X. The production test and production are good, showing a good prospect for increasing reserves and production. However, there is still a lack of systematic geological understanding. Further evaluation and development of the region are restricted. Therefore, it is necessary to study the reservoir sedimentary characteristics of Yan'an Formation in Yan'an Formation in X area, screen favorable target areas for production and provide a solid geological basis for production and construction.
2. Stratigraphic characteristics
For the X area, the Yan 6 oil layer group was finely divided and compared by the marker layer method, the principle of equal thickness, and the sedimentary cycle analysis method. According to the results of the stratigraphic division, the plan view of the thickness of the small strata (Figure 1) and the top structure map of the strata are drawn (figure 2). It is believed that the stratum of the extension period 6 is relatively complete in the whole area and has not suffered denudation. The overall thickness of the formation does not vary much, with an average thickness of about 34m. The nose-like structure at the top of Yan 6 is densely developed, forming multiple rows of nearly east-west nose-like structures, with a structural amplitude less than 25m, and the distribution of rhinoplasty has a certain difference, with the distance of the rhinoplasty being 3-8km. The 6-layer nose-like structures are relatively developed. These nose-like structures cooperate with the main sandstone belt and the updip direction pinch-out shielding, providing favorable trap conditions for oil and gas accumulation.

Figure 1 Plan of thickness of Yan 6 formation in X area

Figure 2. Top structure diagram of Yan 6 formation in X area
3. Sedimentary facies characteristics

3.1 Types of sedimentary facies in the study area

Based on previous research results and comprehensive analysis based on actual regional data, it is believed that the Yan 6 reservoir of Yan’an Formation in X area is a delta plain subfacies, and its main sedimentary microfacies include distributary channels, natural dikes and inter-branch swamps (Table 1).

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

(1) Diversion channel

The distributary channel microfacies is located in the main part of the river bed, dominated by fine sandstone. The thickness of the sand layer is relatively large. During the active period, the water body is deeper and the hydrodynamic force is strong. The AC and GR logging curves show a typical box shape with low shale content. It is relatively stable and has abrupt contact at the bottom. According to the above phenomenon, it can be judged that the river channel in the study area has a certain undercutting erosion effect on the underlying sediment.

The rock color is mainly gray-yellow, gray-brown, light gray, dark gray, gray-black, etc. The lithology is mainly composed of coarse sandstone, gravelly coarse sandstone, medium sandstone, fine-grained sandstone, and thin siltstone, Mudstone constitutes a sequence of river deposits. The thickness of the lower coarse-grained sediments is much greater than that of the upper fine-grained sediments. The bottom has channel retention sediments, and the vertical grain size gradually changes from coarse to fine. The top contact sometimes presents a gradual transition, sometimes a sudden change process type. Sedimentary structures include cross bedding, parallel bedding, block bedding, wavy bedding, vein bedding, etc. The typical bedding structure sequence is mostly from the bottom scouring surface-medium and small plate cross bedding (Figure 3), a combination of grooved cross bedding-parallel bedding-sand bedding. From the perspective of sequence integrity, braided rivers in this area are mainly composed of multi-phase channel sequences superimposed on each other. The spontaneous potential and natural gamma logging curves of single well phases are in the form of large toothed boxes with top and bottom. Often presents a sudden contact relationship.

Figure 3. Well H124, extension 6, 1824.20m, plate-like cross bedding
2) Natural embankment

The natural embankments of the delta plain are located on both sides of the distributary channel. The side toward the channel is steeper and the outer side is slower. The lithology is dominated by light gray fine sandstone with fine grain size. The regular characteristics of the sand body in the vertical direction have similar characteristics to the channel sediments below it. Due to the morphological control of channel sandbodies, the sandbodies of this sedimentary microfacies also present a strip-like structure distribution law on the plane. Analysis and research found that the response characteristics of the channel side sedimentary microfacies in this area on the corresponding AC curve are intuitively visible, mainly showing finger-like structure characteristics, but also bell-shaped, and the sediments are mainly fine powder and silt sand. Far away from the riverbed, the grain size becomes finer, wavy bedding and flowing water wave marks are developed.

3) Branch swamp

Sedimentary microfacies of inter-branch swamps generally occur in relatively low terrain, and can also be formed in the sinking parts of the oxbow lake. During the flood period, it was the main sedimentary area, and the main sediment was muddy suspended matter. Mainly use dark gray mud as sediments, that is, it is in a weak hydrodynamic environment, with parallel bedding, rich plant fossils, flowing water sand grain bedding, etc. can be seen. Research and analysis show that the microfacies of the swamp between branches developed in this area have a good response on the spontaneous potential logging curve, and the main curve characteristics are nearly linear and serrated.

3.2 Single-well facies analysis in the study area

In order to reveal the vertical evolution and planar distribution of the sedimentary facies of Yan 6 oil-bearing group in X area, single-well sedimentary facies analysis was carried out on 2 wells in the study area.

1) Single-well facies analysis of Yan 6 oil layer group in Well G213

Well Geng 213 is located in the eastern part of the study area. There are 3 ~ 5m thick thin coal seams on the top 6 of this well. There are some thin interbeds of fine sandstone, siltstone and mudstone, which are sedimentary products of alternate microfacies between branch swamps and natural dikes on water. The sedimentary microfacies as a whole, Yan 6 mainly consists of distributary channel and marsh deposits between branches, and part of it belongs to natural embankment microfacies deposits.

2) Single-well facies analysis of Yan 6 oil layer group in Well G79

Well Geng 79 is located in the southern part of the study area, and there is a thin coal seam of 3 to 5 m in the middle of this well. There are some thin interbeds of fine sandstone, siltstone and mudstone, which are sedimentary products of alternate microfacies between branch swamps and natural dikes on water. On the whole, sedimentary microfacies mainly consist of distributary channel and inter-branch marsh sediments, and some of them belong to natural dike microfacies.

3.3 Analysis of the connected profile of the sand body in the study area

Combining the structural location and geological evolution background of the study area, based on a large number of exploration and development practices, two continuous well profiles that can reflect the sedimentary facies of the area have been established. The two profiles show that the Yan 6 oil-bearing group has little undulation, and mainly develops distributary channels and interbranched swamps. The channel deposition is dominated by fine sandstone, and the sand bodies are distributed in the channel in a lens shape. The swamps between branches mainly deposit siltstone and mudstone. The vertical direction shows that sand and mudstone frequently overlap each other to form thin interbeds.
3.4 Sedimentary microfacies and distribution characteristics of sand bodies

On the basis of determining sedimentary facies, subfacies, and microfacies, follow the point-line-plane research method, starting from the analysis of single-well facies diagrams, and then analyze the inter-well facies diagrams, and finally conduct sedimentary microfacies and sand bodies. The study of the plane characteristics.

The 6th stage sedimentation was formed in the river-controlled delta plain environment. Drawing the 6th stage sand body thickness map (Figure 4) and the sedimentary microfacies plan (Figure 5) shows that there are 7 river channels developed in the study area in this stage, which are strips on the plane. It is spread out in a shape of a northwest-south east direction. The widest part of the river is about 9.47km, and the narrowest part is about 0.61km.

In plane, these rivers flow in from the northwest direction and flow out from the southeast direction. The area of the study area with a sand ratio of 0 to 0.2 develops inter-branch swamps, the area with a sand ratio of 0.2 to 0.4 develops natural dikes, and the area with a sand ratio of more than 0.4 develops channel sedimentation, and most of the study area has a well-sand ratio of 0.4 or more. Channel sediments constitute the main body of the sand body skeleton and are also the main favorable enrichment area.

![Figure 4 Plan view of thickness of Yan 6 sand body in X area](image1)

![Figure 5 Plan view of sedimentary microfacies of Yan 6 in X area](image2)
4. Summary
The Yan 6 oil layer in the X area of the Ordos Basin mainly develops delta plain subfacies. The sedimentary microfacies are mainly divided into distributary channels, natural dikes and inter-branch swamp microfacies. Facies of the three sedimentary microfacies. The interaction formed a strip of sand-shale deposits on the plane, and it is easy to form uplifts on the west-dip monoclinic background, which provides favorable conditions for later hydrocarbon accumulation.

The sand body color of Yan 6 oil layer in X area is mainly gray, grayish white, and a small amount of light green, indicating that the sedimentation occurred in a relatively shallow water environment, and the main development is the onshore sedimentary facies. Vertically, it mainly develops distributary channel and marsh deposits between branches, some of which belong to natural dike microfacies deposits. The channel deposition is dominated by fine sandstone, and the sand bodies are distributed in the channel in a lens shape. The swamps between branches mainly deposit siltstone and mudstone. The vertical direction shows that sand and mudstone frequently overlap each other to form thin interbeds. On the plane, the six-stage sedimentation was formed in a river-controlled delta plain environment, with 7 distributary channels mainly developed in strips, extending in the northwest-south east direction. The widest part of the river is about 9.47km, and the narrowest part is about 0.61km. Channel deposits constitute the main body of the sand body skeleton and are also the main oil and gas enrichment area.

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