Characteristics of Chang 7 shale in Qingyang area, Ordos Basin

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Abstract. Chang-7 shale is the most important source rock of Mesozoic in Ordos Basin. The characteristics of Chang 7 shale in Longdong area of Ordos Basin are analyzed from the aspects of shale thickness, distribution, sedimentation, petrology and organic geochemistry. The results show that the shale in the study area is mainly distributed in the middle and lower part of Chang-7 member. The shale is mainly composed of deep lake and semi deep lake facies, with a thickness of 10m-40m and good horizontal continuity. The lithofacies are mainly black shale facies, laminated mudstone facies and silty mudstone or silty mudstone facies. The organic matter abundance is high, and the types of organic matter are mainly type I and type II, and they are in the mature evolution stage. It has good oil-bearing property. In tight oil accumulation, shale is not only an important material source, but also provides an important reservoir forming power. Only with the existence of shale, can oil form industrial reservoir.

1. Introduction
Ordos Basin is an important petroleum basin in China. Under the influence of strong tectonic activity and warm and humid climate, thick dark mudstone was widely deposited in chang7 period, which is an important source rock of Mesozoic strata in the basin [1, 2]. Chang7 dark mudstone is widely developed in Qingyang area, southwest of Ordos Basin. In this paper, the chang7 shale in Qingyang area is taken as the research object, and its geological characteristics are mainly studied from the aspects of shale spatial distribution, petrological characteristics, mineral composition and organic geochemical characteristics.

2. Geological background
Ordos Basin is a large multi cycle superimposed continental petroliferous basin in the west of North China platform. Under the joint influence of the crustal movement in the Pacific tectonic domain and the Tethys Himalayan tectonic domain, On the basis of Archean and Paleoproterozoic crystalline basement, Ordos Basin has experienced five tectonic evolution stages: meso Neoproterozoic aulacogen, early Paleozoic shallow sea platform, Late Paleozoic coastal plain, Mesozoic inland depression and Cenozoic fault depression around the basin [3]. As a result, the Ordos Basin is characterized by multi cycle superimposition, gentle geological structure and lack of anticlines and faults. Generally speaking, it is a regional slope with the East upwarped and the West dipping.
According to the present structural form, Ordos basin can be divided into six structural units, i.e., Yimeng uplift, Jinxi flexure fold belt, Weibei uplift, Northern Shaanxi Slope, western margin thrust belt and Tianhuan depression. Qingyang area is located in the southwest of Ordos Basin, it mainly straddles two tectonic units of Tianhuan depression and Yishan slope (Fig. 1).

3. Shale thickness and distribution characteristics
Chang 7 of the study area is mainly composed of deep lake and semi deep lake facies, with lake bay alternating between delta front and pre Delta. The rapid expansion of the lake basin, continuous and stable deep-water deposition, low salinity and anoxic sedimentary environment provide good geological conditions for the large-scale development of high-quality oil source rocks in Chang 7.

According to the logging response characteristics of the black shale in the study area, such as high natural gamma, high zhongzi, high acoustic time difference and low resistivity, combined with cuttings logging data and previous research results [4], the dark shale thickness map of Chang 7 member in the study area is obtained (Fig. 2). It can be seen from the figure that the dark mudstone of Chang 7 member is widely distributed in the study area, and the sedimentary thickness is between 10 m and 40 m.

Figure 1. The study area in Ordos Basin
Figure 2. Distribution of Chang 7 shale in study area
4. Petrological characteristics

4.1. Lithofacies characteristics
The lithofacies types of organic rich shale in Chang 7 member of Qingyang area can be divided into black shale facies, laminar mudstone facies and silty mudstone facies (Fig. 3). The black shale phase is dark black, fresh and glossy with high shale content. Laminar mudstone facies is black or gray black, with pure lithology, increased sand content, and more tuffaceous lamina, sandy lamina and pyrite nodules. Silty mudstone facies is gray or light black, and sedimentary structures such as massive bedding, horizontal bedding and wavy bedding are developed.

![Figure 3. Photos of Chang 7 shale in study area](image)

4.2. Mineral composition characteristics
Microscopic observation shows that the lithology of Chang 7 shale in Qingyang area is mainly argillaceous iron bearing fine silty coarse silstone, fine siltstone and iron mudstone. The clastic composition is mainly quartz, feldspar, mica, a small amount of acidic extrusive rock, metamorphic rock and other debris (Fig. 4). The distribution of argillaceous iron is not uniform among the particles, which is layered, banded or porphyry. Mica is distributed directionally, and some carbon chips and carbonaceous stripes are found. The average content of quartz, plagioclase and clay minerals in Chang 7 shale is 27.75%, 18.46% and 42.16%, respectively.

![Figure 4. Micrograph of Chang 7 shale in study area](image)
5. Organic geochemical characteristics

The geochemical characteristics of shale affect the gas generation capacity of rocks and play an important role in controlling the reservoir capacity of shale gas [5]. The amount of natural gas generated in organic rich shale mainly depends on the content of organic carbon, the type of organic matter and the degree of thermal evolution of organic matter. The content of organic carbon and the type of organic matter mainly depend on the sedimentary environment, and the degree of thermal evolution mainly depends on the degree and duration of thermal evolution after deposition.

5.1. abundance of organic matter

Organic matter abundance is not only an important parameter for evaluating hydrocarbon generation potential of source rocks, but also organic carbon content (TOC), hydrocarbon generation potential of rock pyrolysis (S1 + S2), chloroform asphalt "a" and total hydrocarbon content (HC). On the basis of collecting and sorting out a large number of test data of Chang7 member rock samples, combined with the test results of Chang 7 core in the study area, the organic carbon content (TOC) plan of Chang 7 is drawn (Fig. 5). The results show that the organic carbon content (TOC) of Chang 7 shale in the study area ranges from 1.21% to 25.2%, with an average of 7.9%. The overall TOC content is high and belongs to high-quality source rock. At the same time, according to the pyrolysis parameter data of 5 shale samples in the target layer (Table 1), the hydrocarbon generation potential (S1 + S2) of the dark mudstone of Chang 7 in the study area is 0.67 ~ 33.53 mg / g, with an average of 15.81 mg / g.

![Figure 5. Toc and Ro contour plot of Chang 7 shale in study area](image)

**Table 1.** Pyrolysis parameters of Chang 7 shale

| Sample | Depth/m | S0/mg.g | S1/mg.g | S2/mg.g | S1+S2/mg.g | Tmax/C° |
|--------|---------|---------|---------|---------|-------------|---------|
| 1      | 2027.68 | -       | 0.66    | 0.74    | 1.40        | 317     |
| 2      | 2031.38 | 0.04    | 3.68    | 29.85   | 33.53       | 438     |
| 3      | 2035.13 | 0.20    | 3.06    | 27.48   | 30.54       | 445     |
| 4      | 2044.94 | 0.11    | 1.21    | 11.70   | 12.91       | 451     |
| 5      | 2058.44 | 0.01    | 0.17    | 0.50    | 0.67        | 457     |

|        | 0.01 ~ 0.2 | 0.17 ~ 3.68 | 0.5 ~ 29.85 | 0.67 ~ 33.53 | 317 ~ 457 |
|--------|-------------|--------------|--------------|--------------|-----------|
|        | 0.99        | 1.756        | 14.05        | 15.81        | 421.6     |
5.2. *types of organic matter*

The pyrolysis parameters of rocks can be used to evaluate the types of organic matter. Generally speaking, the hydrogen index is directly proportional to the type of organic matter in immature or immature stage [6]. According to the distribution characteristics of rock pyrolysis parameters Tmax and Hi, shale can be divided into four types: type I, type II1, type II2 and type III. The Tmax hi diagram of Chang 7 shale shows that the types of organic matter are mainly type I and type II1, and a small amount of type II2 organic matter (Fig. 6). Among them, Chang 73 type is the best, mainly type I, with good oil generation potential.

![Tmax hi diagram of Chang 7 shale in study area](image)

5.3. *maturity of organic matter*

A large number of thermal maturity studies in Ordos Basin show that the basin generally enters mature stage except for some areas on the northern and southern margins of the basin [4]. The Ro of Chang 7 shale is mainly in the range of 0.6% - 1.15%, which is in a large amount of oil generation stage [7-9]. According to the vitrinite reflectance test of different well length 7 shale in the study area, the Ro contour map of the dark mudstone of Chang 7 in the study area is compiled (Fig. 5). The measured results show that the Ro of most samples in the study area is between 0.7% and 1.2%, which has a strong ability of hydrocarbon generation and expulsion.

6. **Conclusion**

The chang7 sedimentary period is the heyday of lake basin development in the extension period of Ordos Basin. The dark mudstone of Chang 7 member is widely distributed in the study area, and the sedimentary thickness is between 10 m and 40 m. The lithofacies types of organic rich shale in Chang 7 member can be divided into black shale facies, laminated mudstone facies and silty mudstone facies. The average content of quartz is 27.75%, plagioclase is 18.46%, and the total clay mineral is 42.16%. The abundance of organic matter is high, the types of organic matter are mainly type I and type II, and the thermal evolution degree of source rocks is high. In most areas, RO is between 0.7% and 1.2%, which has a strong ability of hydrocarbon generation and expulsion.

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