Reservoir characteristics analysis of Upper Paleozoic Permian He 8 formation in Qingyang area

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Abstract. Through field geological survey, combined with outcrop and drilling data, the reservoir characteristics of Upper Paleozoic Permian He 8 formation in Qingyang area are comprehensively analyzed. The results show that the He 8 formation in Qingyang area is mainly composed of medium and coarse grains. The reservoir porosity is 5% ~ 14%, and the permeability is 0.05×10^{-3}um^2 ~ 0.7×10^{-3}um^2. The study on reservoir characteristics of He 8 formation is not only of great geological significance, but also provides important data for oil and gas exploration in Qingyang area.

1. Introduction
With the development of oil and gas exploration and development in the world, the development and accumulation characteristics of oil and gas reservoirs and the physical properties of reservoirs have become the focus of research. However, the characteristics of accumulation and physical properties of oil and gas reservoirs are controlled by their formation environment. The reservoirs formed in different sedimentary systems have different distribution rules and heterogeneity characteristics [1, 2]. Therefore, it is necessary to study reservoir characteristics from the perspective of oil and gas geology, discover high-quality reservoirs and improve the development efficiency of oil and gas resources. This paper discusses the petrological characteristics, pore structure and physical properties of He 8 formation reservoir in Qingyang area of Ordos Basin, which provides a preliminary basis for subsequent oil and gas development.

2. Regional geological background
Ordos Basin is a multicycle sedimentary cratonic petroliferous basin and the second largest onshore sedimentary basin in China [3]. According to the structural morphology of the basin, especially the difference of geological structure characteristics since Mesozoic and the structural evolution history of the basin, Ordos basin can be divided into six first-order regional structural units, including Yimeng uplift, Weibei uplift, Jinxin flexure fold belt, Yishan slope, Tianhuan depression and thrust fault structural belt. Qingyang area is located in the east of Gansu Province, and its regional structure is located in the southwest of Yishan slope of Ordos Basin, adjacent to the Tianhuan depression on the western edge of the basin (Figure 1).

The Paleozoic land in Qingyang area was uplifted from the ocean and deposited into the largest lake basin in Northwest China in Mesozoic. In the Pleistocene, the Loess Plateau with a thickness of more than 100 meters was formed due to the continuous uplift of the land in the Quaternary. In the Holocene,
the Loess Plateau was eroded and cut by rivers and floods, forming the existing landform of plateau, gully, ridge, valley, plain, mountain and slope.

The Paleozoic land in Qingyang area was uplifted from the ocean and deposited into the largest lake basin in Northwest China in Mesozoic [4, 5]. In the Pleistocene, the Loess Plateau with a thickness of more than 100 meters was formed due to the continuous uplift of the land in the Quaternary. In the Holocene, the Loess Plateau was eroded and cut by rivers and floods, forming the existing landform of plateau, gully, ridge, valley, plain, mountain and slope.

The lower Paleozoic Ordovician strata in the study area were developed in the Pingliang Formation and beiguoshan formation, but the thickness was thin or suffered erosion. The Benxi Formation and Taiyuan formation are partly deposited and partially missing in the area, and they are in continuous or unconformity contact relationship with the upper and lower strata, or unconformity. The strata from Shanxi formation to Shihe formation are continuous deposition and contact with conformity (Table 1).

Table 1. Stratigraphic table of Shihezi formation of Permian in the study area.

| Horizon          | code   | thickness (m) | Lithological                                    |
|------------------|--------|---------------|------------------------------------------------|
| Upper Shihezi Formation | P2h1   | 30～50        | Light gray argillaceous siltstone, fine sandstone, medium sandstone |
|                   | P2h2   | 30～50        |                                                 |
|                   | P2h3   | 30～50        |                                                 |
|                   | P2h4   | 30～50        |                                                 |
|                   | P2h5   | 30～50        |                                                 |
| Lower Shihezi Formation | P2h6   | 30～50        | Light gray siltstone, light gray fine sandstone and medium sandstone |
|                   | P2h7   | 30～55        |                                                 |
|                   | P2h8   | 40～56        |                                                 |
3. Petrological characteristics of reservoir

The outcrop of He 8 formation in the study area is mainly grayish white and pink medium fine sandstone (Fig. 2). The thickness of single sand layer can reach 1m, and the accumulated thickness of sand formation is more than 10m. According to the statistical analysis of sandstones in the study area, it can be concluded that the sandstone types of He 8 formation of Shihezi formation in Qingyang area are mainly lithic quartz sandstone and lithic sandstone, followed by quartz sandstone (Table 2). The quartz content of He 8 formation ranges from 60% to 90%, with an average of 78.6%. The cuttings content ranges from 5% to 60%, mainly from 20% to 30%, with an average of 22.4%.

![Figure 2. Field outcrop of He 8 formation in the study area](image)

Table 2. Stratigraphic table of Shihezi formation of Permian in the study area.

| Horizon | Quartz sandstone | Lithic quartz sandstone | Lithic sandstone |
|---------|------------------|-------------------------|------------------|
| He 8    | 11.6             | 48.3                    | 40.1             |
| He 8    | 6                | 56.1                    | 37.9             |

4. Reservoir pore characteristics

The main reservoir space of He 8 formation in Qingyang area is pore [6]. According to the study, there are three types of pores in the reservoir: residual primary intergranular pore, secondary dissolution pore and kaolinite intergranular pore. In Qingyang area, intergranular pores and secondary dissolution pores are dominant, while a small amount of residual primary intergranular pores are developed (Table 3). In the actual reservoir, there are not only a single pore type, but also a large number of composite pores (such as intergranular pore + intergranular pore + dissolved pore, intergranular pore + intergranular pore, intergranular pore + dissolved pore, etc.).

5. Reservoir physical properties

The statistical analysis of coring data of He8 member in Qingyang area shows that the porosity of reservoir in the study area is mainly distributed in the range of 5 ~ 15%, with an average of 9.22% (Fig. 3); the permeability is mainly distributed in the range of $0.05 \times 10^{-3} \text{um}^2$ ~ $0.7 \times 10^{-3} \text{um}^2$, with an average of $0.54 \times 10^{-3} \text{um}^2$ (Fig. 4). In the study area, the porosity of He 8 reservoir is generally less than 10%, and the permeability is generally less than $0.60 \times 10^{-3} \text{um}^2$, which belongs to low porosity and low permeability reservoir rock; and the correlation between porosity and permeability is good.
6. Conclusion
The He 8 formation is mainly composed of medium and coarse-grained sandstone with good structural maturity and quartz as the main clastic component. The main reservoir space of the reservoir is pore, which is mainly composed of residual primary intergranular pore, secondary dissolution pore and kaolinite intergranular pore. The porosity of He 8 reservoir is generally less than 10%, and the permeability is less than $0.60 \times 10^{-3} \text{um}^2$, which belongs to low porosity and low permeability reservoir.

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