



## Reservoir Characteristics of Mud Shale from the Upper Permian Linxi Formation in Binbei Area of Songliao Basin

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Permian is widely developed in Songliao Basin and peripheral areas, dark mudstone from the upper Permian Linxi Formation is widely distributed, a big sedimentation thickness, secondary hydrocarbon generation exists in source rocks, it has a high prospect of oil and gas exploration and it is the most favorable oil and gas exploration horizon in the upper Paleozoic (Zhang et al., 2011; Zhao et al., 2011; Zhu et al., 2017). Shenyang Geological Survey of China Geological Survey Bureau successfully drilled a very thick dark mud shale of the upper Permian Linxi Formation of HF1 well in the west of Binbei area of Songliao Basin. In this paper, the reservoir characteristics of mud shale from the upper Permian Linxi Formation of HF1 well are systematically analyzed and discussed the prospect of shale gas from the upper Permian Linxi Formation in Binbei area of Songliao Basin.

The lithology of the upper Permian Linxi Formation of HF1 well is mainly grayish-black mudstone, silty mudstone, mudstone sandwiched with gray fine sandstone, siltstone, argillaceous siltstone, and tuff. There are 61 layers of dark mud shale in the upper Permian Linxi Formation, with a cumulative thickness of 312.91m, among them, there are 9 layers of mud shale with a single layer thickness of more than 10m, and the maximum thickness of the single layer is 47.9m. The TOC content of 26 pieces of dark mud shale samples from the upper Permian Linxi Formation of HF1 well is 0.03%–1.56%, with an average value of 1.06%, the organic matter abundance is relatively high, and the samples are mainly medium-good source rocks with good hydrocarbon material basis; the organic matter type is type-II kerogen, and the source of organic matter is mixed sources of higher plants and lower aquatic organisms such as bacteria and algae; The Ro of 17 pieces of dark mud shale is 1.50%–3.76%, with an average value of 2.53%, indicating that the source rocks are in the thermal evolution stage of high maturation– over maturation.

Mineral X ray diffraction and clay mineral X ray diffraction statistical analysis were performed on 9 dark mud shale from the upper Permian Linxi Formation of HF1 well. The brittle mineral content range from 46.5%–75.9% with an average of 55.7%, the

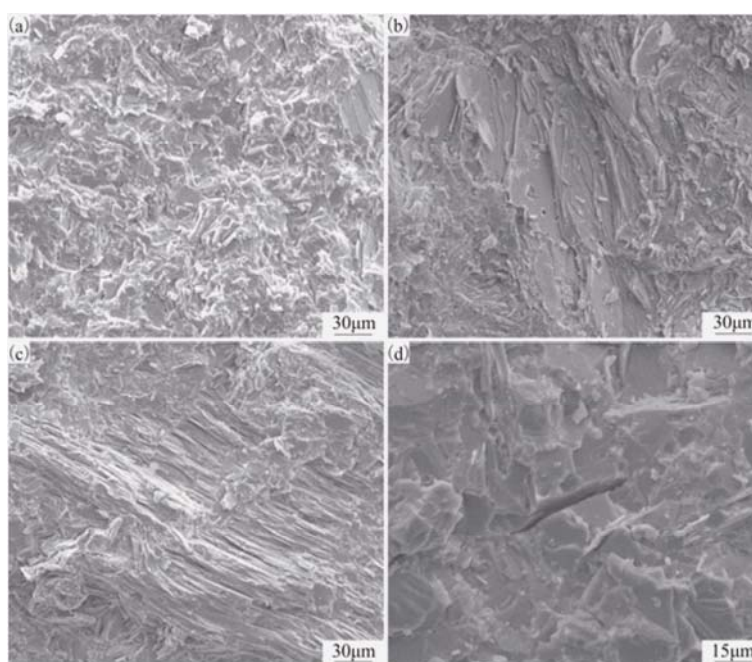


Fig. 1. Characteristics of reservoir space of mud shale from the upper Permian Linxi Formation in Binbei area of Songliao Basin.

(a) intergranular pores; (b) intragranular pores; (c) mineral interlayer fractures; (d) intramineral microfractures.

main brittle mineral is quartz, which accounts for 34.2%–49.7% of the total mineral content with an average value of 40.3%; the content of plagioclase is 8.8%–24.3% and the average value is 13.1%; carbonate minerals and authigenic minerals are relatively rare, range from 1.7%–3.1%, with an average value of 2.3%; clay minerals are mainly composed of illite, chlorite and imonicite, the content of clay minerals is 24.1%–53.5% with an average of 44.3%, illite relative content is relatively high, accounting for 42%–67% of the clay mineral content, with an average value up to 58%, high illite content is conducive to the enrichment of adsorbed gas; chlorite accounted for 18% to 42% of clay mineral content, with an average of 26%; the imeng mixed layer accounts for 11%–20% of the clay mineral content, with an average value of 16%. Dark mud shale from the upper Permian Linxi Formation with high brittleness index is easy to produce natural fractures or be fractured, thereby increasing the storage space and improving the migration channel, which is conducive to the accumulation and development of shale gas.

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It develops micron-scale and nano-scale of micro-pores and micro-fractures in dark mud shale from the upper Permian Linxi Formation in Binbei area of Songliao Basin. The micropores are mainly intergranular and intragranular pores in mineral pores. The diameter of intergranular pores is generally 1.5–4.5  $\mu\text{m}$  (Fig. 1 a); the diameter of intragranular pores is generally 1.5–6.0  $\mu\text{m}$ , with more pores around 3  $\mu\text{m}$  (Fig. 1 b). Microfractures are mainly mineral interlayer fractures and intramineral microfractures. The interlayer fractures can be up to 5–55  $\mu\text{m}$  in length and 0.5–3.0  $\mu\text{m}$  in width (Fig. 1 c); the microfractures within the mineral are long strips that cut through the mineral particles, approximately 50  $\mu\text{m}$  long and about 3  $\mu\text{m}$  wide (Fig. 1 d). The porosity of dark mud shale from the upper Permian Linxi Formation in the Binbei area is 0.21%–7.71%, with an average of 1.67%; the permeability is  $(0.0263\text{--}0.0576)\times 10^{-3}\mu\text{m}^2$ , with an average of  $0.0365\times 10^{-3}\mu\text{m}^2$ . The reservoir properties is relatively good, the porosity and permeability is positively correlated, as the porosity increase, the permeability also increase.

To sum up, the analysis show that the organic matter abundance of mud shale from the upper Permian Linxi Formation in Binbei area of Songliao Basin is relatively high, the type of organic matter is type-II kerogen, and in the thermal evolution stage of high maturation-over maturation, it has a certain gas potential. Brittle mineral content is relatively high, which is beneficial to the reservoir reconstruction in the later period; the development of micro-pores and micro-fractures in mudstone is conducive to the accumulation of shale gas and the reservoir properties is relatively good, it has a certain prospect for shale gas exploration.

**Keywords:** Songliao Basin, Binbei area, the Upper Permian Linxi Formation, mudshale, reservoir characteristics

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## References

- Zhang, Y.S., Wang, Y.B., Lu, Z.Q., Wang, J.T., Su, K., Fan, F., Cao, J., and Zeng, Y.t., 2011. Characteristics of source rock from Carboniferous-Permian in Songliao Basin and its peripheral area, northeastern China. *Geological Bulletin of China*, 30(2):214–220 (in Chinese with English abstract).
- Zhao, Z.K., Jiang, T., and He, J.L., 2011. The oil and gas exploration prospect of Carboniferous-Permian in Songliao Basin, northeastern China. *Geological Bulletin of China*, 30(2):221–227 (in Chinese with English abstract).
- Zhu, Z.H., Cheng, H.G., Zhang, M., Li J., and Li, J.Y., 2017. The Geochemical Characteristics of Source Rocks of Upper Permian Linxi Formation in Songliao Basin. *Unconventional Oil & Gas*, 4(4):55–63 (in Chinese with English abstract).

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