Black shale of Wufeng-Longmaxi Formation in southeast Chongqing pore type of reservoir

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Abstract: On the basis of previous research results, a series of studies on black shales of the Upper Ordovician Wufeng Formation and Lower Silurian Longmaxi Formation in southeastern Chongqing have been carried out with thin sections and scanning electron microscopy. The results show that the pore types of black shale reservoirs in Wufeng-Longmaxi Formation in southeastern Chongqing include intergranular pore, intragranular dissolution pore, organic pore and fracture.

1. Introduction

As a new energy source, shale gas has attracted great attention at home and abroad. At present, the exploration and development of shale gas in China is still in the basic stage. Shale strata in China are mainly distributed in marine shale, continental shale and marine-continental alternative shale. And the domestic research on shale gas is mainly concentrated in the marine shale of the Paleozoic in South China[1-3]. Many experts and scholars have done a lot of research on the classification of shale pore types. Correspondingly, there are many classification schemes. In the study of Barnet and Woodford shales, Roger et al. considered that the pore can be mainly divided into lamellar clay intergranular pore, organic pore produced in burial and maturation process, pore inside the organic matters, intergranular pore of mineral particles, microchannel and fracture [4]. According to the experimental results of scanning electron microscopy analysis and testing in southeastern Chongqing (Figure 1), the reservoir space types are classified into intergranular pore, intragranular pore, organic pore and micro-fracture on the basis of the classification scheme proposed by Robert G. et al[5].

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2. Stratigraphic characteristics

According to the description of geological map and regional geological survey report of Chongqing, combined with outcrop, etc. The Lower Paleozoic is well developed in research area. Among them, the Wufeng Formation develops black carbonaceous silty shale and siliceous shale with siltstone, and thickness is 2-12m. The overlying stratum Longmaxi Formation, is composed of black, grey-black shale, silty shale, the bottom is carbonaceous shale and carbonaceous siliceous shale, and the top usually develops thin to medium-thick siltstone, contains abundant graptolite, the whole formation with a thickness of 20-110m.

3. Pore type of reservoir

3.1 Intergranular pore

During the sedimentary period, interstitial pore can occur between rigid and plastic particles. The common plastic mineral particles are clay aggregates, mica minerals, feces aggregates, organic matter, etc. The common rigid particles are quartz, feldspar, authigenic pyrite, etc. During the burial, plastic particles became deform and flowed into the intergranular pore, thus blocking the intergranular pore and throat. Downhole of Longmaxi Formation in Southeast Chongqing. The average content of clay minerals in core samples is 47.62%, and illite is about 70% of it, chlorite is about 25%. There are usually nano-scale micro-pore between sheet chlorite. In the outcrop samples of the study area, chlorite and I/MML clay mineral content can account for 40% of the total clay content. In these flaky chlorite and I/MML clay deposits, a large number of nano-scale interlayer pore can be formed (Figure 2-1, 2-2).
3.2 Intragranular pore

The pore sources in grains are various, mainly from the interior of mineral particles. The pore shapes are various, including flake, strawberry and dissolution pore. Because of the preservation of primary pore and the change of diagenesis, the intragranular pore mainly develops in the stable quartz, feldspar and pyrite, which has the characteristics of poor connectivity and different pore sizes. The intragranular dissolution pore is also Longmaxi Formation.

A well-developed pore type in shale. On the one hand, quartz particles can dissolve under the action of diagenetic fluids, and then form intragranular dissolution pore. Calcite minerals in black shale of Wufeng-Longmaxi Formation are often associated with clay minerals. When the rock fluid is acidic and the fluid is suitable for calcite dissolution, granular dissolution pore remaining in clay minerals can be formed. In addition, the granular dissolution pore can be seen under the microscope (Figure 3-1, 3-2).

3.3 Organic pore

Due to the influence of organic matter and mineral composition, the pore of shale has undergone complex hydrocarbon generation process besides matrix pore, and a certain amount of pore has been generated by the aggregation of organic matter hydrocarbon generation process. These pores can greatly increase the storage space of shale gas. The results show that if organic matter in rocks accounts for 7%, after hydrocarbon expulsion, pore systems accounting for 14% of rock volume can be generated; if 35% of carbon in rocks is lost due to hydrocarbon generation, the porosity of rocks will increase by 4.5%[6]. The black shale of Wufeng-Longmaxi Formation has a high organic carbon content and an average TOC content of 2.05%. Meanwhile, the maturity of organic matter is relatively high, with an average Ro of 2.68%. Most of the samples are in the stage of high maturity and over maturity, indicating that organic matter has undergone hydrocarbon expulsion. Because organic matter is usually adsorbed by clay mineral particles, hydrocarbon generation of organic matter among clay minerals will leave residual
pore, which can be used as potential shale gas reservoir space (Figure 4-1, 4-2).

3.4 Microcracks
For the tight shale as shale gas reservoir, besides pore, fracture is also a very important reservoir-forming factor. The development of fractures can not only increase the storage space of free gas, but also provide enough analytical space for adsorbed gas. In addition, fractures can also be as the migration channel of shale gas during the shale gas exploitation, which is favorable to the production of shale gas. In short, the development degree of fracture is positively correlated with the quality of shale gas reservoir, that is, the better gas reservoir quality is, the well developed fracture is. Fractures are well developed in both downhole core and outcrop in study area. According to the observation of core and outcrop in the field, it is found that most of the fractures developed in the Wufeng-Longmaxi Formation shale in the study area are filled and semi-filled, and the filling materials are mainly quartz and calcite. For the reservoir space of shale gas, although these fractures are completely filled or semi-filled, and can hardly be used as the storage and migration channel of shale gas, it is found that all the fractures are filled with brittle minerals such as quartz, calcite and pyrite, which is very conducive to pressure transformation and artificial fractures in the process of shale gas development. Gas accumulation is very advantageous (Figure 5-1, 5-2).

4. Conclusion
Black shale reservoir space can be divided into intergranular pore, intragranular dissolved pore, organic pore and fracture. The pore size of the intergranular pore is mainly micron or nanometer. The pore size of intragranular solution is mainly nano-scale. These pores are favorable for shale gas reservoir.

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