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Characterization of Microscopic Pore Structures in Shale Gas Reservoirs of the Southeast Chongqing

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Unlike traditional resources, mud shale has the characteristics of low porosity, low permeability, small pore structure, nanoscale pore as the main body. The microscopic pore structures of mud shale can not only influence the occurrence state of shale gas and gas content, but also influence the hydrocarbon expulsion efficiency of source rocks, which makes the study of shale gas reservoir necessary. As traditional pore structure characterization technology can not satisfy the study of the microscopic pore structure of mud shale reservoir, we must adopt the experimental technologies of high precision (Jiang Yuqiang et al., 2014). At present, field-emission environmental scanning electron microscope (SEM), highmercury injection, adsorption-desorption pressure isotherms, nuclear magnetic resonance (NMR) technology, focused ion beam scanning electron microscopy technology(FIB-SEM) and micro/nano CT scan technology are general technologies to characterize the pore nanoscale structure of density reservoirs. In order to fully describe the microscopic pore structure characteristics of the shale, we analysis the organic geochemical and mineralogical characteristics of mud shale based on the pyrolysis, organic carbon, clay mineral and rock X - ray diffraction analysis. And using the field-emission environmental scanning electron microscope to observe the shale sample surface morphology and classify the shale gas reservoir types. Using high pressure mercury intrusion method and nitrogen adsorption method to obtain the pore structure parameters of shale samples. Try to qualitative and quantitative describe the microscopic pore structure characteristics of areas of Pengye 1 well in the Southeast Chongqing area.

1 The Components of the Shale

The mud shale of Pengye 1 well in the Southeast

Chongqing is generally in high thermal evolution degree, and the vitrinite reflectance (R_0) value distributes between $2.59\% \sim 2.59\%$ with an average of 2.73%, which shows that hydrocarbon source rocks is in the over mature phase. The TOC value of shale sample distributes between 0.61% $\sim 1.1\%$ with an average of 0.87%. The mineral composition quantitative analysis results show that the shale mineral composition of the Longmaxi group is complex, and the inorganic heterogeneity is strong. In general, the clay mineral content is the highest, followed by quartz, and there are some feldspar and carbonatite. And it also contains a small amount of pyrite and a small amount of barite mineral. Clay minerals mainly develop the illite mixed layer, followed by illite, and it also contains a fair amount of chlorite, does not contain kaolinite, which reflects that the interval has reached high diagensis evolutionary stage.

2 The Microscopic Pore Characteristics of Shale

2.1 The shale gas reservoir space types

Combining with the previous research, the author found that the interval mainly develops microcrack, microtunnel, flocculus pore, intracrystalline pore, intercrystalline pore, organic pore and pore within fossils(as shown in figure 1) through the scanning electron microscope. According to the pore origin, the pore can be divided into two categories, namely, organic and inorganic pore. Inorganic pore develops in the inorganic part or matrix of shale. The organic pore is due to the hydrocarbon generation of organic matter. Among them, microcrack, microtunnel, flocculus pore, and intracrystalline pore belong to inorganic pore, while organic pore and pore within fossils belong to organic pore.

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Fig. 1 Reservoir space types of Longmaxi group shale in Pengye 1 well

(a), The organic full in the microcracks, low porosity, a large number of framboidal pyrite;(b), The organic is zonal distribution, micropores development; (c), Microchannel; (d), Flocculus pore exists between clay minerals; (e), Enrichment of pyrite, a small amount of intergranular pore; (f), A small amount of organic microporous develops between framboidal pyrite crystal; (g), The intracrystalline pore; (h), (i), A lot of nanoscale pores develop in the organic; (j), Mica interlaminar crack filling of organic matter, which develops some nanoscale pores; (k), Fossile pores develops in diatom body cavity; (l), Graptolite fossils.

2.2 The pore structure characteristics of the shale

Compared with sandstone reservoir, shale has the characteristics of low porosity, low permeability, and the micro-nanoscale pore development, which influences the enrichment of shale gas. According to the IUAPC standard, we can divided the shale gas pore into three types, namely, micropores (<2 nm), mesopores ($2\sim50$ nm), macropores

(>50 nm) (Rouquerol J et al., 1994). In this paper, we use nitrogen adsorption and mercury intrusion to describe the pore structure of Longmaxi group in the Southeast Chongqing. Nitrogen adsorption method shows that the shale develops from micropores to macropores, which is very complex. Pore size distribution with bimodal characteristics, the pore less than 4 nm in diameter contributes to the entrance. The specific surface value of shale is between 8.68 m^2 / g \sim 10.3 m^2 / g with an average of 9.38 m^2 / g, which is greater than the specific surface of density sandstone. This may be associated with clay minerals, fine particles, and the large specific surface area is available for shale gas adsorption. High pressure mercury injection curve type characterized by sudden drop, suggests that the fine bottle-neck shape pore develops in the shale. Micropores, mesopores and macropores serial configuration, small pore throat and poor connectivity reflects small aperture and strong heterogeneity, and this pore structure is conducive to the accumulation of the shale gas but bad for gas migration.

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Reference

- Jiang Yuqiang, Chen Lin, Jiang Chan, Tan Mingyou, Wen Xiu, Gan Hui, Wang Meng and Hu Zhaoyang, 2014. Characterization techniques and trends of the pore structure of tight reservoir. Wuhan: Geological Science and Technology Information, 33(03): 63-70 (in Chinese).
- Rouquerol J, Avnir D, Fairbridge C W, Et Al., 1994. Recommendations for Characterization of Porous Solida. Great Britain: Pure & Applied Chemistry, 66(8): 1739-1785.