Fractal Characteristics of Shale Reservoir Based on the High-pressure Mercury Injection Method

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1 Introduction

Shale of continental basin of east China general is a product of lake face, from shallow lake to deep lake. It is also a good cap rock to prevent oil and gas emission. The shale generally has bigger special surface area, its pore is small, its structure is complex, and it is easy to absorb water, so the general method is very difficult to accurately describe its pore structure. Domestic scholars have done much research on the marine shale structure of Sichuan Basin, but do less research on lacustrine / continental shale. It has important significance for shale oil and gas exploration to study lacustrine shale pore structure in the middle and eastern China.

2. Conclusions

Based on the high-pressure mercury intrusion data, we use fractal theory to study the pore structure of shale. According to the capillary pressure curve and “J” function curve fractal geometric formula, we can obtain shale transition pore (10-100nm) fractal dimension, and analyze the relationship between transition pore fractal dimension and the shale composition, structure (organic geochemical parameter TOC, S1, S2, and pore structure), the research results show that:

(1) lacustrine shale samples’ pore size mainly concentrated within the limitation of 3.56nm-50nm (by high pressure mercury experimental conditions, the minimum measurement value is 3.56nm), and it is mainly composed of micro-pore, transitional pore, mesopore and macro-pore’s proportion is very small, the samples’ porosity ranges from 0.21% to 7.65%, with an average porosity of 3.7525%; the specific surface area ranges from 0.695m2/g to 14.801m2/g, with an average specific surface area of 8.339m2; the specific pore volume ranges from 0.001 ml/g to 0.032ml/g, with an average specific pore volume of 0.0161ml/g; each sample’s average pore size, median pore size, most probable pore size is below 10 nm.

(2) Drawing with lgPc—lg(1-S), D1 is the fractal dimension of the bigger pores whose pore size is beyond 100nm, D2 is the fractal dimension of the pores whose pore size ranges from 10nm to100nm. D1 was significantly bigger than D2, that supposed that the mesopore and macro-pore are more complex than transitional pore, Zhao Yuji got the similar results when he studied the coal’s pore structure. Using the nitrogen adsorption method to study the shale pore fractal dimension, we can also get the similar conclusions. Because most of the pores in Shale range from 10nm to 100nm, we focus on the fractal dimension D2.

(3) Analysis on the relationship between the fractal dimension of shale and other parameters, we found that: the median pore size compared to the average pore size, most probable pore size, it has the strongest correlation with transitional pore fractal dimension; Shale samples’ correlation between fractal dimension and clay mineral content is weak, weak positive correlation with the quartz content; Because of the hydrocarbon generation in the early stage of the evolution, the shale produce a lot of large pores, in the later stage, organic matter content’s increase led to the decrease of the mineral grains’ pore support function, thus the transitional pore’s fractal dimension become significantly lower before being stable with the TOC content increases; The effect of different pore on the mercury withdrawal efficiency is different, the larger the proportion of the transitional pore is, the more conductive to the mercury withdrawal; the fractal dimension of the transitional pore is bigger , the pore structure is more complex, and the mercury withdrawal efficiency is lower; The parameters such as pore size, TOC, mineral content, mercury withdrawal efficiency, they all have correlation with D2, thus D2 can be an important parameter to measure the complexity of pore structure, it has great significance to
the quantitative evaluation of shale reservoir quality.

**References**

