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Fractal characteristics of oil shale reservoir based mercury intrusion experiment

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The storage and seepage of oil and gas in the reservoirs are controlled by pore size distribution, pore shape, pore throat and connectivity. Pore structure is of vital use for understanding and evaluating the storage and seepage properties of low-permeability reservoir. Fractal theory is considered as an effective method to describe the heterogeneity of pore structure.

Numerous models have been used to determine the fractal dimension of mercury injection data. However, these models only take into account the fractal dimension of pore space. In this paper, a new model is proposed to determine the fractal dimension of mercury injection data, which considers not only the fractal dimension of pore space, but also the fractal dimension of tortuosity. The comprehensive fractal dimension, the sum of the fractal dimension of pore space and the fractal dimension of tortuosity, is obtained from the relationship between mercury saturation and pressure. The larger the comprehensive fractal dimension, the more complex the pore structure of the reservoir.

Five mercury injection curves from Duvernay oil shale reservoirs in Canada were calculated using the new model. The relationship between fractal dimension and organic carbon content, oxygen index, and organic matter maturity were investigated. Results demonstrates that the fractal curves appear as three stages with three fractal dimension representing different pore sizes, with D1 ranging from 3.44 to 3.85, D2 ranging from 3.09 to 3.15, and D3 ranging from 3.34 to 3.50. D1 representing macropore or microfracture, is mainly influenced by the tectonism and the pore structure is more complex. D3, representing nano-scale pores, is mainly affected by organic pores formed during kerogen maturation. The fitting degree of D3 and related parameters is higher than that of D1 and D2, indicating D3 could better characterize the pore structure of reservoir. D3 shows a positive correlation with organic carbon content, vitrinite reflectance and pyrolysis peak temperature, whereas D3 has a negative correlation with oxygen index. Fractal dimension could be better to evaluate the complexity and heterogeneity of pore structure of oil shale reservoir.

Keywords: Fractal theory; Oil shale; Pore length; Pore structure; Fractal dimension

References

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