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Microscopic pore structure characterization of shale rock based on fractal theory and its application in the prediction of permeability

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Hard pellet model and capillary model as two types of physical models for porous media, can't accurately describe the microscopic pore structure features of porous media. Shale rock porosity is dominated by nanometer and micron scales [1], the traditional models and methods can not accurately describe the pore structure of shale reservoirs. Numerous studies have shown that real porous media in nature have fractal features over a range of scales [2]. Based on fractal theory, this paper provides new ideas and methods for the characterization of pore structure in shale reservoirs. SEM scanning electron microscopy, nanometer CT and focused ion beam (FIB) and other techniques used to describe the micro-pore structure of shale reservoirs [3], Based on the imaging technology, remarkable achievements have been made in the analysis of shale pore formation, pore type classification and organic matter nanometer pore characterization. The fractal dimension can quantitatively describe the complexity of shale pore structure [4-5].

Fractal theory can be applied to predict the permeability of porous media. Domestic and foreign scholars have made some progress in predicting the permeability of porous media. Domestic and foreign scholars have made some progress in predicting the permeability of porous media. Based on the fractal theory, fractal characteristics of shale reservoir pores were studied by image analysis, and the expression of shale permeability was derived. The influence of maximum pore radius, minimum pore radius and fractal dimension on shale permeability was analyzed [6]. In this study, the pore of shale reservoir was taken as the research object. Based on the shale reservoir skeleton, the Sierpinski carpet model was used to study the distribution of shale porosity. Through the statistics and analysis of the pores in shale raw binary image, the relationship between the number of pores larger than the pore size and the pore size in the double logarithmic coordinate system. The negative of the slope of the stable straight line in the data is the fractal dimension of the porosity. Fractal dimension calculation of pore structure should be based on the distribution of data points and pore size range of regression, which can not only ensure data integrity, but also a true reflection of pore distribution.

Shale permeability is a parameter that characterizes shale seepage capacity, and its size is related to porosity, geometry of the pores in the liquid infiltration direction, particle size and arrangement. Because the fractal dimension of porosity is a parameter that reflects the change of the number of pores under different pore sizes, the fractal dimension of porosity is negatively correlated with the porosity. Therefore, the larger the fractal dimension of porosity and the smaller the porosity, the more the shale permeability small. The permeability of shale decreases with the increasing fractal dimension of the pores because when the fractal dimension of tortuosity increases, the pore channels become more tortuous and the permeability decreases. The maximum pore radius, inflection point radius, fractal radius fractal dimension and tortuosity fractal dimension all have a great influence on the permeability of shale. Shale permeability has a significant positive correlation with the maximum pore radius and inflection point radius, and the pore radius Fractal dimensions and tortuosity fractal dimension showed a significant negative correlation, and pore radius fractal dimension of the correlation is small.

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