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Fractal characteristics of coal pore-fissure system based on thermodynamics model-an example from North China

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To better understand the characteristics of coal pores and their influence on coal reservoirs, coal pores and fissures in eight main coalfields of North China were analyzed by using mercury porosimetry, scanning electron microscopy (SEM), electron microscope and photometer. Fractal characteristics of coal pores (size distribution and structure) were researched by using thermodynamics model. This new approach has been developed proposing the relationships between fractal dimensions and coal pore-fissure characteristics. Mercury porosimetry data indicate that the coals are fractal, with pore radius ranging from 0.1 to 50 μm. Calculated fractal dimensions of these coals range from 2.61 to 2.98, higher than those from other kinds of rocks such as sandstone, shale, and carbonate. The data suggest that coals have more complicated and inhomogeneous pore structures than other rocks. The results show that: 1) By scanning electron microscopy (SEM) imaging analysis and fractal appraisal, the coal reservoirs generally have very high heterogeneity. The coal pore-fissure system was divided into six types (including gas pores, fissures, scrap pores and their combinations). 2) Coal pore structures have fractal characteristics and fractal dimensions reflect the characterization of pore structures that controlled by the composition (e.g., ash, moisture, volatile component) and pore parameters (e.g., pore diameter, micro pores content) of coal. 3) The fractal dimensions of coal pores have good correlations with heterogeneity of coal pore structures. Bigger the fractal dimensions, higher the heterogeneity of pore structures. 4) The fractal dimensions and petrologic permeability of coals have strong negative exponent correlation. However, the fractal dimensions and petrologic permeability of coals have no obvious correlation. In this paper, the thermodynamics model was used to investigate the relationship between heterogeneity, petrologic permeability and coal rank with the fractal dimensions. A horizontal 'U-shaped' trend between fractal dimensions and coal ranks is observed, with the minimum fractal dimensions occurring at 1.0-2.4% Ro, m. The effects of coal rank upon fractal dimensions are mainly due to the variety of micropore contents and aromaticity of coals during coalification. Pore structure of coals was characterized by using the fractal theory of multiporous material. Based on the fractal theory of geometry, the fractal dimensions which tested by mercury porosimetry of pores in coal reservoirs range from 2.0 to 3.5. The situation that the value exceeds 3.0 may reflect the strong structural movement, high metamorphism and excessive pressure. Moreover, the correlation between pore characteristics and fractal dimension was gained by using SEM images assistant analysis.