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Experimental and modeling study of multi-scale gas flow in shale Micro-Nano pores

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The shale gas flowing in the Nano-scale pore structure in shale formation has the properties of over scale and over flow region. It is difficult to describe the flow pattern by using the conventional flow theory. In this study, a physical modeling test of depletion development and the flowing model of gas flow in the micro-nano pores of shale matrix were studied. Through the pore size testing, the full-scale distribution of matrix pores was determined. Based on the high-pressure isothermal adsorption experiment and the adsorption potential energy function, the difference of adsorption layer in different pores was clarified. A new method was proposed to calculate the flow in the Boundary layer near the wall. The physical model of shale gas exploitation was established, and the law of gas production of gas well depletion development was studied. The validity of coupled flow model was also verified by experimental results. The results show that the porosity of shale matrix is dominated by micropores (<2nm) and mesopores (2-50nm). The thickness of the boundary layer influenced by the wall is about 2nm, and the adsorption and Knudsen diffusion mainly occur within this area. The established apparent permeability model considering the boundary layer effect can describe the flow pattern in shale pores. This model can distinguishes the repeated calculation of gas slip flow and the Knudsen diffusion flow, which both caused by the gas-solid intermolecular forces. The results of depletion development experiment show that the producing degree of gas is related closely to the pressure. Adsorbed gas can be produced effectively, but only when the reservoir pressure is below the critical desorption pressure. During the production process of gas well, in zones near the borehole the pressure drops greatly and the producing degree of adsorbed gas is high. The results are consistent with the model calculations. The research can provide theoretical and model support for the production model and recovery prediction of shale gas reservoirs.

References

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