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Relationship between the stress sensitivity and pore structure of shale

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Abstract

The pore structure of shale changes with variations in the effective stress, greatly affecting the gas production of shale. The relationship between pore structure and stress sensitivity has remained unclear to date. The porosity sensitivity exponent and pore compressibility are two crucial parameters for describing the stress sensitivity and relate to the pore structure of shale. In this study, expressions of the porosity sensitivity exponent and pore compressibility were deduced based on a dual-porosity model. The results show that the scale and quantity of the micro-fractures and matrix pores play an important role in determining the porosity sensitivity exponent and pore compressibility. Regarding the pore structure of shale, a low ratio of the porosity of the matrix pores to the porosity of the micro-fractures causes the porosity sensitivity exponent to be low and the pore compressibility to be high; consequently, the shale shows strong stress sensitivity. The results regarding the porosity sensitivity exponent and pore compressibility indicate that the pore compressibility is the dominant factor influencing the stress sensitivity. The pore compressibility is affected by not only the pore structure of shale but also the mechanical properties of shale. Young's modulus is negatively correlated with pore compressibility, while Poisson's ratio shows a positive relationship and can be neglected. The effect of tortuosity on the stress sensitivity was also studied. The fitting results for the Walsh model illustrate that the tortuosity increases the degree of stress sensitivity. The results of this study identified the relationship between stress sensitivity and pore structure of shale, which will enable reservoir engineers to accurately predict stress sensitivity and investigate the permeability and porosity of shale based on its pore structure.

Key words: shale; stress sensitivity; pore structure; pore compressibility;

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Highlights:

1. The expressions of the porosity sensitivity exponent and pore compressibility were deduced to determine the relationship between the stress sensitivity and pore structure of shale.
2. The scale and quantity of the micro-fractures and matrix pores play an important role in determining the porosity sensitivity exponent and pore compressibility.

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