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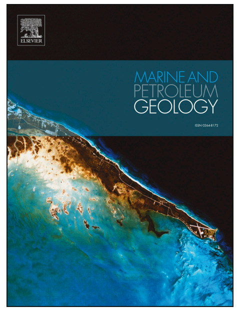

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Multi-fractal distribution analysis for pore structure characterization of tight sandstone—a case study of the Upper Paleozoic tight formations in the Longdong District, Ordos Basin

Zezhang Song [a,b], Guangdi Liu [a,b,*] [1], Weiwei Yang[c], Huayao Zou [a,b], Mingliang Sun [a,b], Xiaolong Wang [a,b]

[a] State Key Laboratory of Petroleum Resources and Prospecting, China University of Petroleum, Beijing 102249, PR China

[b] College of Geosciences, China University of Petroleum, Beijing 102249, PR China

[c] Research Institute of Petroleum Exploration and Development, Changqing Oilfield Company, PetroChina, Xi'an, SX 710021, PR China

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Abstract

With proven gas potential, the gas charging and accumulation mechanisms for the Upper Paleozoic tight gas reservoir in the Longdong District of the Ordos Basin remain controversial. Pore structure is the most direct and critical factor that affects gas charging and accumulation in the reservoir. However, the pore structure characterization of tight sandstone is far more difficult than that for conventional reservoir rocks due to significant heterogeneity. The present work aims to introduce a new quantitative method for pore structure characterization that integrates multi-fractal distribution analysis, an effective and profitable method for quantitative heterogeneity analysis, and high-pressure mercury intrusion porosimetry (HPMIP). Twenty-one samples from targeted tight formations with different gas-bearing status were obtained for analysis.

The results show that the best formations for gas charging and accumulation in the Upper Paleozoic tight sandstone formations in the Longdong District are the formations with more large pores, more homogeneous small pores, and well-developed micro-fractures. The existence of micro-fractures is the key factor that affects gas charging and accumulation. Tight sandstone samples were categorized into three types in accordance with the HPMIP curve configuration. Due to the high heterogeneity of pore structures, analyses based solely on HPMIP curve configuration has its shortcomings, which can be compensated by multi-fractal distribution analysis. The multi-fractal distribution of target tight formations could be interpreted as two linear segments, representing large pores and small pores. The separating points of the two segments vary from 0.1 μm to 0.5 μm in different samples due to different pore structures. Large pores are not ideal fractals in gas-bearing formations due to the existence of micro-fractures, whereas they are fractals in dry formations where micro-fractures are not developed. Small pores are all ideal fractals, with the highest heterogeneity in type γ samples and the lowest heterogeneity in type α samples. A conclusion was made in this work: if the slope of segment one in the multi-fractal distribution of mercury saturation (S_{Hg}) versus capillary pressure (P_C) is larger than 1, this measure could be accepted as an empirical indicator for the existence of micro-fractures.

* Corresponding author. State Key Laboratory of Petroleum Resources and Prospecting, China University of Petroleum, Fuxue Road No.18,Changping, Beijing 102249, PR China.
E-mail addresses: guangdiliucupb@gmail.com (G. Liu).