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Storage Space Characterization & Reservoir Potential of Terrestrial Shale in China

ZHU R.K., WU, S.T., CUI J.W., and BAI B.
Research Institute of Petroleum Exploration and Development, PetroChina, No. 20 Xueyuan Rd., Beijing; wust@petrochina.com.cn

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The micro-structure and micro-porosity evolution have become the important aspects in unconventional reservoirs evaluation. This paper is focused on the typical terrestrial shale system in China and samples are from Chang 7 shale in Ordos Basin, Lucaogou Fm. in Junggar Basin, Jurassic shale in Sichuan Basin and Qingshankou Fm. in Songliao Basin. Nano-CT and FIB-SEM are used to characterize the storage space and to reconstruct 3D porosity model. The pore size is analyzed based on image analysis, mercury injection and gas adsorption data. The porosity evolution of terrestrial shale is studied based on the reservoir diagenetic modeling system which is designed by CNPC Key Laboratory of Oil & Gas Reservoir.

The lacustrine shale in China has the potential to produce industrial oil and gas. The characteristics are as follows,

(1) Shale is deposited in semi-deep/deep lacustrines and Type Ⅰ and ⅡA dominate the kerogen. Ro is 0.7~1.2%, TOC is 1.4%～25.6%, S1 is 1.15～21.6mg/g rock, and Chloroform bitumen A is 0.25~1.5%, indicating great resource potential in shale system.

(2) The brittleness index of shale is relatively high. XRD data suggest that the content of brittle mineral including quartz, feldspar, calcite and dolomite is 41% in average and that of clay mineral is less than 50%, which is good for the further hydro-fracturing based on the experiences from unconventional oil & gas projects in North America.

(3) Typical 3-element structure is developed in terrestrial shale. Brittle minerals, clay minerals and organic matter are inter-bedded from bottom to top. Nano-pores and micro-fractures diametered in 50~300nm dominate the storage space. The percentage of inter-clay mineral pores and OM pores is 50% and 30% respectively. Also, there are some isolated pores at micrometer scale. The pore-throat system is connected as a whole.

(4) The shale porosity is controlled by maturity, clay mineral content and compaction. The evolution of pore volume per kilogram of macro-pores, meso-pores and micro-pores is different. The pore volume per kilogram of macro-pores increases firstly and decreases later with increasing temperature & pressure, while that of meso-pores and micro-pores suggesting the opposite tendency. The content of HC in shale shows the same tendency to macro-pores and reaches its maximum value of 150 mg/g TOC at 350 ℃.