

The Pore Size Distribution and Oil Storage Mechanism in the Wolfcamp Mudstone, Midland Basin

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Abstract

Wolfcamp (WFMP) mudrocks in the Permian Basin have, in the past few years, become one of the primary targets for mudrock oil production. However, high water cut in oil production is a challenged issue, and the reason remains unclear. Pore fluids, including gas, water and oil are stored in both organic matter-hosted pores and mineral-hosted ones. Does the distribution of pore fluids in mudrocks depend on variations in pore sizes or mineralogy? Total of 28 core samples, including 8 from a meter-scale WFMP A lithofacies cycle of the R. Ricker No. 1 core well, 5 from WFMP A and 4 from WFMP B from Greer #1 core well, 6 from WFMP C and 5 from WFMP D from Greer #2 core well, were selected for low temperature N₂ adsorption. All core wells are located in Reagan County, Texas. The difference in pore size distribution among four WFMP units, changes in porosity and pore size distribution before and after oil removal with CH₂Cl₂ solvent extraction, and the key factors (TOC, lithology, and thermal maturity) to oil storage are investigated in this study. Porosity and pore-size distribution varies in a meter-scale lithological cycle in WFMP A, and is highly dependent on lithofacies variation. The porosity of organic-rich siliceous mudstone and calcareous mudstone is twice as large as that of organic-lean thin carbonate beds because of the presence of organic-matter pores. The absence of organic-matter pores and clay-mineral pores in organic-lean carbonate facies leads to a smaller BET surface area and larger average pore size. Intergranular pores according to SEM pore images are dominantly in the organic-lean carbonate facies, and pores greater than 10 nm in size contribute 48% to 72% of the total porosity. The organic-lean carbonate facies are favorable to migrated oil storage and flow and serve as reservoirs in meter-scale cycles in WFMP A. A comparison of

pore size distributions for siliceous mudstone under as-received, dried with oven at 110°C, pentane extraction, and CH₂Cl₂ extraction sample treatment conditions shows no obvious differences in pore size distributions for the pores larger than 20nm. After drying, 3-20nm pores are exposed, indicating those pores are associated with clay minerals. After removing both mobile and immobile oils, the volume of pores less than 5nm increases, indicating that those pores are filled with oil. There is slight increase in total pore volume after oil cleaning in organic matter-rich siliceous mudstones, and the pores smaller than 10nm in diameter, in particular the pores less than 5nm contribute to the increased pore volume. About 80% of the total pore volume was occupied by gas, light oil and connate water in organic matter -rich mudstones, and abundant light oil might be evaporated in the course of core storage, handling and transportation. The high concentration of light oil may be the result of mixing of Type II and Type III organic matter in WFMP Formation.