

Preliminary Study on the Pore Characterization of Different Marine Shale Reservoirs Using Low Pressure Adsorption Method: A Case Study of the Lower Cambrian and Upper Ordovician-Lower Silurian, Yangtze Area, China

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Abstract

In this study, the pore structure of marine shale samples from the Low Cambrian Hetang Formation (XY1 Well) and the Upper Ordovician-Lower Silurian Wufeng-Longmaxi Formation (PY1 Well) in Yangtze area of China were investigated by organic geochemistry, carbon dioxide (CO₂) and nitrogen (N₂) low-pressure gas adsorption methods. The Low Cambrian and Upper Ordovician-Lower Silurian samples had typical type I kerogen, total organic carbon (TOC) contents ranged from 0.67 to 11.23 wt.%, 0.93-3.72 wt.%, respectively. The equivalent thermal maturity of the Low Cambrian samples were higher than that of the Upper Ordovician-Lower Silurian samples, while both were in the stage of postmature phase. In all samples, N₂ isotherms were of type IV (IUPAC) with hysteresis being noticeable, and CO₂ isotherms were of type I. The surface area of the Low Cambrian samples ranged from 0.73 m²/g to 6.45 m²/g, much less than that of the Upper Ordovician-Lower Silurian samples (7.47-17.29 m²/g). The micropore and mesopore volume of the Lower Cambrian samples were 0.28-5.92 times; 10⁻³ cm³/g, 1.82-5.81 times; 10⁻³ cm³/g, respectively, less than that of the Upper Ordovician-Lower Silurian samples, which were 1.89-3.30 times; 10⁻³ cm³/g and 5.55-9.16 times; 10⁻³ cm³/g, respectively. While the macropore volume of the Lower Cambrian samples were bigger than the Upper Ordovician-Lower Silurian samples. The BJH model with adsorption branch of the N₂ isotherms were used to calculate the pore size distributions (PSD) to avoid the tensile strength effect (TSE) phenomena which would appear a narrow distribution of pores centered around 4 nm. The PSD curves were multimodal for all samples. The micropore volume and mesopore volume had a positive correlation with surface area, while it existed a negative relationship between macropore volume and surface area. These indicated that the surface area were mainly dominated by micropores and mesopores. In the Lower Cambrian samples, compared with the micropore volume, the mesopore volume had a weaker positive correlation with TOC. While there was a stronger positive relationship between micropore volume and TOC compared with the mesopore volume, in the Upper Ordovician-Lower Silurian samples. The reason might be that the Upper Ordovician-Lower Silurian samples had higher thermal maturity than the Lower Cambrian samples, which resulted in the transformation from micropore to mesopore during the increase of the thermal maturity.