

Pore Structure and Fractal Characteristics of a Lacustrine Low-Maturity Shale: A Case Study from the Second Member of Kongdian Formation in the Cangdong Sag, Bohai Bay Basin, East China

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Recent hydrocarbon exploration shows the second member of Eocene Kongdian Formation (Ek_2) of the Cangdong Sag in Bohai Bay Basin, East China has great shale oil potential, but there is still a lack of studies of the reservoir evaluation of the Ek_2 shale. In this study, twelve core samples of the Ek_2 shale were collected from one well to investigate their pore structure and fractal characteristics by using Cold-Field Emission Scanning Electron Microscope (CFESEM) observation and low-pressure N_2 adsorption-desorption (LPN2AD) test. The results show that the Ek_2 shale has high-abundance of total organic carbon (TOC) ranging from 0.56 wt% to 5.56 wt% and low-maturity characteristics with vitrinite reflectance (R_o) of 0.51%-0.73%. Specific surface area (SSA) and total pore volume (TPV) are much lower in the range of 0.870-9.829 m^2/g and 0.0025-0.0240 cm^3/g , respectively. CFESEM observation demonstrates that the Ek_2 shale with a small number of organic pores mainly developed intraparticle pore within clay aggregates and dissolution pores. TOC does not play a key role in the pore development during low-maturity stage. Using Frenkel-Halsey-Hill (FHH) model, the fractal dimensions (D_1 , D_2) were identified at the relative pressure (P/P_o) of 0.01-0.50 and 0.5-1.0, respectively. D_1 values representing shale pore surface roughness with a range of 2.010-2.813 increase when clay content increases, which leads to an increasing number of micropores and complicates the pore surface. D_2 values denoting shale pore structure complexity, varying from 2.442 to 2.906, show a positive relationship with the contents of feldspar and analcime, but a negative relationship with the content of carbonate minerals. Feldspar and analcime are easily corroded to produce more irregular dissolution pores, resulting in an augment of shale pore structure irregularity. The presence of carbonate minerals serving as the main cement in the Ek_2 would cause a decrease of pore volume and pore structure irregularity.