

Study on Sedimentary Environments and Implications for Shale Reservoirs in the Permian Longtan Formation, Southeast Sichuan Basin

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Marine-continental transitional shale is one of the most promising targets for shale gas exploration in the Lower Yangtze region. To investigate the sedimentary environments and the enrichment regularity of Longtan shale, multiple techniques, including core and thin section observations, geochemical and elemental analyses, X-ray diffraction, scanning electron microscopy (SEM) and low-pressure nitrogen adsorption (LPNA), were used to analyze the sedimentology, mineralogy, and pore structure of the Longtan shale. Core descriptions and thin section observations show Longtan shale was deposited in marine-delta transitional environments, including delta-front, shore swamp, mixed tidal flat, and shallow shelf facies. The Sr/Cu, V/Cr, CIA, EF (Mo), EF (U) and other major and trace elements results indicated warm and moist climates and water in reducing conditions in the Longtan period. Both the climate and water conditions are favorable for organic matter production and preservation. Additionally, the paleoenvironment and depositional model for the Longtan Formation was reconstructed. Geochemical results show that Longtan shale is in over-matured stage (R_o ranging from 2.4–3.57%) with II2-III kerogen type. The shale from shore swamp facies exhibits a high content of total organic carbon (TOC; avg 5.76%). The organic geochemistry of Longtan shale is mainly determined by sedimentary facies. The pore system of Longtan shale consists of inorganic pores with a small number of organic pores and microfractures. In the shore swamp and shallow shelf sedimentary system, pores are well developed. Porosity and specific surface area are mainly affected by TOC and clay minerals. An effective combination of brittle mineral particles and organic matter, clay minerals provide necessary conditions for pore preservation. The organic pores, clay mineral intergranular pores, and brittle mineral pores form the main network system for Longtan shale. In summary, the lithological combinations, organic geochemistry, and pore structure system were all affected by sedimentary environments.