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Mechanisms of Differential Organic Matter Enrichment in the Permian Dalong Formation Shale in the Middle-Upper Yangtze Platform, China: Insight from geochemistry evidence

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The Permian Dalong Formation in the Middle-Upper Yangtze region is an increasingly important strategic target for shale gas exploration, yet the mechanisms controlling spatial heterogeneity of organic matter (OM) enrichment between adjacent trough systems remain insufficiently resolved. To address this gap, we carried out a systematic comparative study of the Kaijiang-Liangping (K-L) and Western Hubei (W-H) troughs using integrated outcrop observations and representative well data, combined with petrography, X-ray diffraction (XRD), total organic carbon (TOC), and trace-element geochemistry within a tectono-sedimentary analytical framework. The results show a pronounced inter-trough differential enrichment pattern: the W-H Trough is characterized by a wide-trough, deep-depocenter architecture and significantly higher source-rock quality, with shale thickness locally reaching 50 m and mean TOC of 6.26%, compared with 15 - 30 m and 4.06% in the K-L Trough. This contrast is fundamentally linked to distinct tectonic evolution histories, with K-L Trough jointly affected by Mianlue Ocean extension and Emei taphrogenesis, whereas W-H Trough was mainly controlled by basement-fault reactivation associated with interaction between the North China and South China blocks. These contrasting structural settings led to different depositional and geochemical conditions: in W-H Trough, OM enrichment developed under persistently oxygen-deficient to euxinic waters (U/Th > 1.25; V/Cr > 4.25; coherent Mo_{EF}-U_{EF} covariation), higher paleo-productivity (Cu_{XS} = 0.96 - 7.19; mean Ni/Al = 24.68; Ba(bio) > 100), and generally warm-humid weathering regimes (Rb/Sr > 1; CIA = 52.12 - 91.76), while Member A in K-L Trough records relatively more oxic, less productive, and comparatively arid depositional conditions. From a hydrocarbon exploration geochemistry perspective, the dominant enrichment triggers also differ, with ELIP-related volcanic forcing more significant in K-L and nutrient recycling associated with upwelling more important in W-H. We therefore propose a tectono-sedimentary-geochemical coupling model in which tectonic setting governs redox stratification, productivity structure, and climate-sensitive weathering fluxes, thereby controlling source-rock quality and the spatial distribution of shale gas sweet spots, providing a robust geochemical basis for play de-risking and favorable area prediction in the Dalong Formation.



