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Reevaluating the Role of Over-Mature Organic Matter in the Sichuan Basin: Carbonized Kerogen as a Dual-Function Gas Source and Nanoseal

CHENZHAO QUAN[1,2], ZIQI FENG[1,2] AND HAOHAO WANG[1,2]

[1]State Key Laboratory of Deep Oil and Gas, China University of Petroleum (East China)
[2]School of Geosciences, China University of Petroleum (East China)

The functionality of organic matter in ultra-deep (>8000 m) environments remains a subject of debate. This study utilizes the Lower Cambrian Maidiping Formation oil shale as a natural analogue to decode the behavior of late-stage carbonized kerogen in the Sichuan Basin. By combining structural characterization with molecular dynamics simulations, we redefined the role of this over-mature material. Despite a low degree of graphitization, the kerogen possesses a unique nanoporous framework capable of generating significant methane (approx. 230 ml/g) even at late evolutionary stages. Crucially, the simulation results highlight its performance as a superior nanoseal, evidenced by strong methane confinement capability (high adsorption and low diffusion coefficient). Consequently, late-stage carbonized kerogen should be viewed as a dynamic component that contributes to both charge and retention in ultra-deep reservoirs, providing vital clues for exploring the Ediacaran Dengying Formation and similar deep-earth targets.

