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Effect of High Pore Water Content on the Catalytic Mechanism of Montmorillonite in Organic Matter Pyrolysis in Shale at High Temperature

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Clay minerals play a crucial role in the generation and evolution of oil and gas by catalyzing hydrocarbon formation from organic matter in organic-rich shales. Shale typically contains pore water, which may inhibit the catalytic efficiency of montmorillonite. However, the mechanism by which pore water affects montmorillonite's catalytic efficiency remains controversial. To investigate the inhibitory mechanism of high pore water content on montmorillonite catalysis, we performed high-temperature thermal simulation experiments using a gold capsules system. Different amounts of deionized water or hydrochloric acid solution were added to the montmorillonite-organic matter reaction system. We examined the evolution of reactants, as well as the types and yields of pyrolysis products, under different experimental conditions. The results show that adding liquid H^+ in the water-bearing system does not enhance the carbocation mechanism; only H^+ on the surface of solid acids can trigger this mechanism. The introduction of external water reduces the contact between organic matter and montmorillonite, leading to the deactivation of some B acid sites, thereby decreasing the catalytic cracking efficiency of clay minerals. The catalysis of organic matter pyrolysis by montmorillonite and other clay minerals is an interfacial chemical reaction, which requires direct contact between the minerals and organic matter to proceed effectively.