Microscopic Analysis of Organic Matters from Key Shale Reservoirs in China

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Shale oil, preserved in shale rock which is previously regarded as source rock, if successfully exploited, would give another boost to unconventional oil resource exploration and development in China. Organic matter (OM) in shale plays the crucial role in both generation and rentation of hydrocarbons, while the research of microstructure remains insufficient. In this work, focused ion beam – scanning electron micrscope (FIB-SEM) with scanning transmission electron microscopy (STEM) detector and energy dispersive spectrometer (EDS), transmission electron microscope (TEM), and Raman spectroscopy are applied to analyze the microsctructure difference of shale oil samples from highly potential shale plays in Sichuan, Songliao, Erdos, Bohai Bay and Jungar basins.

The STEM imaging results indicate that, high matured and over matured OM (kerogen Ro>2.33%) in shale gas shale shows either highly porous or granular morphology and carbonization effect; The oil- generating OM (kerogen Ro~0.73%, in the oil-window) in shale oil shale exhibits an uniform nonporous structure with no visible pores exist, and this may enventually lead to a “bad source rock” or “bad shale oil rock”, while the sample is proved to be a good source rock based on the geochemical analysis. TEM imaging was applied to reveal the internal structure under much higher resolution, and the inside of OM particle exhibits a heterogeneous structure. Partial of the OM particle is highly porous with the pore size less than 10 nm, and the other zones are solid.

Based on the high-resolution TEM imaging and 3D FIB-SEM pore system analysis, a 2-level oil expulsion pathway system is proposed. The mesopores (<10 nm) in OM makes the primary oil expulsion pathway, and the macropores (10 ~ 1000 nm) both formed by OM particles and mineral particles, together with the microcracks, make the sencondary oil expulsion pathway. In the past, researchers usually focused on the sencondary oil expulsion pathway using 3D digital rock technique, while underestimate the primary oil expulsion pathway, which is of great importance for shale oil. The microscopic electron imaging would will provide a novel perspective in evaluating shale oil rocks.