Multiscale Characterization and Flow Mechanisms for Shale Oil/Gas Recovery

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ABSTRACT: A systematic investigation of multiscale pore structure in organic-rich shale by means of the combination of various imaging techniques is presented, including the state-of-the-art Helium-Ion-Microscope (HIM). The study achieves insight into the major features at each scale and suggests the affordable techniques for specific objectives from the aspects of resolution, dimension and cost. The pores, which appear to be isolated, are connected by smaller pores resolved by higher resolution imaging. This observation provides valuable information, from the microscopic perspective of pore structure, for understanding how gas accumulates and transports from where it is generated. A comprehensive workflow is proposed based on the characteristics acquired from the multiscale pore structure analysis to simulate the gas transport process. The simulations are completed with three levels: the microscopic mechanisms should be taken into consideration at level I; the spatial distribution features of organic matter, inorganic matter, and macropores constitute the major issue at level II; and the micro-fracture orientation and topological structure are dominant factors at level III. The results of apparent permeability from simulations agree well with the values acquired from experiments. Other flow mechanisms important for shale oil/gas recovery are also discussed. Some realistic industrial examples at the field scale are presented in the end.