Gas and Water Distribution in an Over-Mature Shale Reservoir and Its Implication for Gas Production

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Abstract

To better understand the mechanism of hydrocarbon accumulation and fluid migration in Chinese shales, several samples from two leading marine shales (Longmaxi and Niutitang) were collected for geochemical and mineral analysis, the characterization of pore structure, preliminary studies on fluid flow, and the distribution and investigation of different methane adsorption behaviors. The main findings for over-matured marine shales can be summarized as follows: Geochemical analyses show the Longmaxi and Niutitang marine shales were at an over-matured stage and dry gas window, with EqVRo values ranging from 2.92% to 3.31%. Both shales had abundant TOC. Quartz, calcite, and clay minerals were the main mineral compositions. FE-SEM images showed micro-fractures, interparticle pores, and organic pores, with the latter having better connectivity than intraparticle pores. SI and tracer diffusion experiments indicated that fluids in shale migrated with the network flow. In addition, shales with different pore networks had different fluid flow behaviors, and that tracers flowed mainly through connected and easily-accessible paths. The methane adsorption results showed adsorption capacity had positive correlations with TOC, and the organic matter (including kerogen and bitumen) had much greater adsorption abilities than inorganic minerals (quartz, clay, and others). Therefore, two patterns for the surfaces of organic matter and inorganic minerals were proposed. Finally, the fluid distribution patterns in over-matured marine shale were studied. Shale gas was originally generated in organic matter and then migrated out through connected pores, under differential pressure, between internal and external organic matter hydrocarbon generation areas. These hydrocarbons replaced the water in the pores. Therefore, shale gas may adsorb in organic pores and is

freely stored in connected inorganic pores, with bound water, whereas isolated pores are saturated with water. Two different adsorption patterns on mineral surfaces (organic matters and inorganic minerals) were established to explain the different shale gas adsorption behaviors in organic pores and connected pores, with bound water. We believe the shale gases may mainly be adsorbed in organic pores and the adsorption gas content calculation should focus on organic pores.