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Modeling of Hydrocarbon Generation and Conduction in Organic Rich Shale System Under Complicated Tectonic Setting: A Case Study of Sangzheping Syncline, Pengshui County, Southern China

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The lower Paleozoic organic rich shales in the southern China have experienced substantial buries, multiple significant uplifts and erosions as well as strong deformations, which highlights the characteristic differences to the black shales in the northern America. All kinds of high-steep structures are widespread due to the intensive horizontal compression. Significant anisotropy of the permeability in the shales and the potential differences in the high-steep structures lead to the horizontal conduction-accumulation-retention/dissipation process of the natural gas, which has been proven by numerous shale gas exploration cases in the southern China.
The Sangzheping Syncline was selected, and 2D basin modeling equipped with the modules for the unconventional petroleum systems was used to the quantitative research of the hydrocarbon (HC) generation and conduction process within the organic rich shale system. Based on the reconstruction of the tectonic evolution, the HC generation and conduction histories were modeled. The modeling results suggest: 1) During the early stage, crude oil was the main product due to the oil-prone organic matter in the shales. Despite a slight vertical dissipation, most of the oil remained in the shale system, since the vertical permeabilities of the shales was extremely low. The geotherm rose while the burial depth increased, and the oil had been cracking into gas until the oil depleted at 137 Ma. The gas content increased dramatically since 300 Ma, and peaked when the greatest burial depth was reached at 125 Ma. Affected by subsequent deformations, uplifts and erosions, the natural gas diffused from the core of the syncline to its flanks, and has been dissipating after the shales exposed at the surface. Current gas content at the syncline core is much higher than the ones at the flanks; 2) Modeled gas contents were consistent with actual exploration results when the orders of vertical permeabilities in the shale system were set on $\sim$ 0.1 nano darcy. The horizontal diffusion of gas was intensifying as the permeability anisotropy increased to $\sim$ 100 $\times$, and did not have noticeable change when the permeability anisotropy continued to increase.
Based on these results, the HC generation and conduction process within the shale system of a syncline can be drawn: HC generation and cracking led to a significant overpressure in the well-sealed shale system during the early stage, which reduced the formation effective stress and increased the permeability of the shale. Controlled by the subsequent complicated tectonic setting, natural gas diffused horizontally from the syncline core to the flanks. The gas dissipation led to the decreasing of formation pressure, which made the formation effective stress return to the normal status. The gas diffusion and dissipation were then blocked when the horizontal permeability was too low to support further conduction. The residual natural gas was preserved in and adjacent to the syncline core.