Heterogeneity of Lacustrine Shale and Its Implications – A Case Study of Zhangjiatan Shale in Ordos Basin, China

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ABSTRACT

The Upper Triassic lacustrine Zhangjiatan shale is an exploration target for shale oil and gas in Ordos Basin, China. Four lithofacies, including black organic-rich shale, grey black organic-rich shale, siltstone and sandstone, were recognized and among which mineral composition, total organic content (TOC), pore type and pore structure are different. The heterogeneity lead to different amount of free, solution, adsorbed oil and gas in different lithofacies. Especially, millimeter scale silty laminae, interlaminated with clayey layers, were observed in organic-rich shale. In comparison to the clayey layer, the amount of quartz, feldspar and carbonate, porosity and permeability are higher and pore diameters are larger, while clay minerals, pyrite, TOC, and S1 are less. These differences lead to the different amount of free, solution, adsorbed oil and gas and the total volume between silty laminae and clayey layers. Although the clayey layers have higher TOC and S1, the oil saturation index is lower than that in silty laminae, which indicates quite a few absorpted oil were stored in clayey layers and movable oil content is lower because of the adsorption of clay and kerogen. The clay content and TOC decreases and the brittleness increase with the increasing proportion of silty laminae in the organic-rich shales. Furthermore, subparallel fractures occur at the interface between silty and clayey layers, the shale with abundant silty laminae could be more favorable to hydraulic fracturing. The amount of movable oil and free gas increases with the increasing abundance of silty laminae. And that in the siltstone and sandstone interlayers would be higher. Thus, the shales with abundant silty laminae, siltstone and sandstone interlayers would be “sweet spot”. Silty laminae, siltstone and sandstone interlaminated or intercalated with clayey interlayer formed a sandwich structure, is favorable to primary migration. Hydrocarbon generated from organic-rich shale were firstly expelled into silty laminae, siltstone and sandstone interlayers, and then migrated to the overlying, underlying reservoirs and enhance the expulsion efficiency. The silty laminae, siltstone and sandstone interlayers, together with fractures, provide the storage and migration pathways for oil and gas, and have higher movable oil and free gas content. Understanding the heterogeneity of Zhangjiatan shale is important to “sweet spot” optimization and analyzing the mechanism of primary migration.