The Thermal Evolution of Clay Minerals and Organic Matter in Shales

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Abstract

The Thermal Evolution of Clay Minerals and Organic Matter in Shales are the two important components of shale. Organic matter (OM) and clay minerals are usually thought to strongly influence the hydrocarbon generation, enrichment and exploitation. Three representative shales with different maturities in China, i.e., Yanchang (T3y) shale, Longmaxi (S1l) shale and Niutitang (Є1n) shale, were collected to investigate the microstructure characteristics of OM and clay minerals. The three shales (T3y, S1l, Є1n) represent low maturity (0.5-1.2 %), high-over maturity (2.0-3.2 %), and over maturity (3.0-5.0 %), respectively. Taking the three shales as examples, this study examined the microstructure evolution of OM and clay minerals in shale.The results showed that both OM and clay minerals have strong effects on pores. The differences among the three samples are embodied in the distribution of pore size and the location. For the T3y shale, clay minerals are loosely arranged and develop large amounts of pores, and fine OM grains often fill in intergranular minerals or fractures. Widespread OM pores distribute irregularly in S1l shale, and most of the pores are elliptical and nondirectional. The Є1n shale is characterized by the preferred orientational OM-clay composites, and lots of pores in the composites are small than those in S1l shale, suggesting that over maturity lead to the collapse and compaction of pores under huge pressure of strata. In addition, the evolution of clay minerals includes mainly the dehydration and microstructural change (such as reduction of interplanar spacing), as well as the transformation of mineral type (typically smectite to illite). For the three shale samples, there is some smectite in T3y and none found in S1l and Є1n. Possibly, the over-high maturity of S1l and Є1n shales has transformed smectite to illite. From the FE-SEM images, clay

minerals are loosely arranged and are nondirectional in T3y. However, in S1l and Є1n, clay minerals have encountered more serious compaction, so that clay particles integrate with each other more tightly. To sum up, with increasing maturity, OM pores would increase at first and then gradually disappear, and the pores in clay minerals tend to decrease in size and number, which may be attributed to the burial and thermal histories. The evolution of OM-clay composites has a directional trend, and in over-maturity, the pores developed in the composites are more numerous than the pores in OM or clay minerals, possibly because of the protection of clay layers on the OM. Consequently, thermal evolution, as one of the most important factors to affect microstructure of OM and clay minerals, has shown great significances in better understanding diagenetic process and hydrocarbon generation of shale.