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Influence of organic matter on smectite illitization: A comparison between red and dark mudstones from the Dongying Depression, China

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Abstract

Interactions between organic matter (OM) and clay minerals have received considerable attention in previous studies. The influence of OM on smectite illitization has been analyzed primarily in simulation experiments rather than in diagenetic studies. The present study explores the influence of OM on smectite illitization during diagenesis. Thirty red and dark mudstone samples from the Dongying Depression were analyzed. X-ray diffraction (XRD) analyses revealed that the illite percentages in mixed-layer illite-smectite (I-S) of both types of samples were dispersive above 3100 m and more convergent below this depth. The stacking mode of I-S in dark mudstones above 3100 m remained primarily at R0–R0.5 ordering with the average number of layers (N_{ave}) dispersively distributed between 2 and 4.5. In red mudstones, the I-S changed from the R0 to R0.5 mode with the N_{ave} increasing from 2 to 5. Over this range, the smectite illitization in dark mudstones was slower than that in red mudstones. Below 3100 m, the I-S stacking mode of dark mudstones changed from R0.5 to R3 ordering with the N_{ave} increasing sharply from 4 to 8. In red mudstones, the I-S displayed R1.5 and R3 ordering with the N_{ave} varying between 4.5 and 6.5. Over this range, the smectite illitization in dark mudstones accelerated rapidly, whereas the process in red mudstones was retarded. Additionally, the red mudstone samples contained little OM, whereas the dark mudstone samples contained abundant total organic carbon (0.17–4.43%). Thermo-XRD, near-infrared (NIR) as well as mid-infrared (MIR) spectroscopy analyses suggested that the OM in dark mudstones exhibited a significant transition at 3100 m, coincident with the illitization change. Above 3100 m, the smectite illitization in dark mudstones was delayed due to the OM pillar effect in the interlayer spaces of smectite. Below 3100 m, the interlayer OM became varied and desorbed, discharging organic acid. This led to the dissolution of smectite structural layers. Consequently, illitization in the dark mudstone was accelerated. This study revealed that the existence and occurrence of OM could influence the smectite illitization in diagenesis. Further study on the interactions between OM and clay minerals is needed to facilitate our understanding on the mechanism of smectite illitization as well as its geological applications.

Keywords: Smectite illitization, dark mudstone, red mudstone, organic matter, Dongying Depression, reaction mechanisms