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A Reconstruction and Discussion of the Effect of Diagenetic Environment on Hydrocarbon Generation Based on Diagenetic Mineral Assemblage in Mudstone

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Abstract

Inorganic minerals in mudstone are composed of clay minerals, carbonate and detrital minerals. Detrital minerals (such as quartz and feldspar) are mainly original deposit. However, clay minerals (kaolinite, illite, and chlorite) and carbonate (calcite and dolomite) are mostly diagenetic minerals. Furthermore, conversion of the four kinds of clay minerals are common. The formation of clay minerals and carbonate is controlled by temperature, pressure, pH, Eh and type of cations during diagenesis. Therefore mineral assemblage can indicate the characteristics and change of diagenetic environment. In addition to inorganic minerals, there are also organic matter of different sources and chemical properties in mudstone. Traditionally, it is considered that evolution of organic matter is controlled by thermal effect. Now studies show that inorganic and organic matter can interact with each other and form clay-organic complexes. This suggest that attention should be paid to the influence of diagenetic mineral assemblage and diagenetic environment on the evolution of organic matter

Samples of mudstone from 1500-4500m of the Palaeogene in the Dongying Depression, China, were collected to investigate the changes of mudstone diagenetic environment. XRD, thin section and SEM were used to detect diagenetic minerals and assemblage characteristics. Results showed that content of detrital minerals, which are floating in mud matrix or preserved as silt laminae, is basically unchanged from shallow to deep strata. Clay minerals which are gathered as argillaceous matrix or preserved as argillaceous laminae have growth and decline relation to carbonate which mainly appear as micropoikilitic ferriferous calcite and ferriferous dolomite. All these characteristics indicate that detrital minerals are exogenetic, whereas carbonate is diagenetic minerals. Based on the SEM analysis of the clay minerals, it was found that smectite present honeycomb and reticulate structure, while illite present filiform and schistose structure and there are growth and decline relationship between them. Nevertheless, hexagonal tabular and stratified kaolinite has the highest content from 2400m to 3300m. Rosette and stratified chlorite shows increase trend when the burial depth is deeper than 3300m. These characteristics indicated that clay minerals are diagenetic minerals and there are conversions among the four types. Therefore form shallow to deep, three diagenetic mineral assemblage zones can be divided based on the characteristics of carbonate and clay minerals in mudstone. Namely, smectite + illite/smectite zone in the depth of 2000-2500m; kaolinite + illite/smectite zone in the depth of 2500-3300m and illite + chlorite + carbonate zone below 3300m. Previous studies showed that kaolinite is stable under acidic conditions, while other clay minerals and carbonate are stable under alkaline conditions. Hence according to mineral assemblages feature, it was inferred that diagenetic environment of mudstone has undergone the change of alkaline-acid-alkaline. For the organic matter with different chemical properties in mudstone, the hydrocarbon generation will be different in the acidic and alkaline diagenetic environment even if the conditions of temperature and pressure are the same. Therefore, for hydrocarbon generation we should not only focus on thermal effect, but also pay more attention to the differences of diagenetic environment which have great significance for the understanding of hydrocarbon generation, hydrocarbon expulsion and reservoir formation in mudstone.

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