Palynological Analysis of the Late Ordovician To Early Silurian Black Shales in South China Provides New Insights For the Investigation of Pore Systems in Shale Gas Reservoirs

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Abstract

Microscopic fossils (micro-fossils), which include large numbers of taxonomically unrelated organic- and inorganic-walled fossil groups, have an important geological value due to their minute size, large quantity, and wide distribution. The late Ordovician Wufeng and early Silurian Lungmachi formations are primary targets for shale gas exploration in the southeastern marginal area of the Sichuan Basin, Southwest China. In this research, different groups of micro-fossils were analyzed in order to provide new insights for the investigation of pore systems in shale gas reservoirs. Distinctive autologous micro-nano pores are observed in micro-fossils, including radiolarians, sponge spicules, acritarchs, conodonts, chitinozoans, and scolecodonts. Most pores are densely and randomly distributed with honeycomb or irregular shapes. Although the samples are over mature and were deeply buried, micro-fossils remain a large number of biological micro-nano pores. Pore diameter commonly varies from 20 to 4000 nm but differs among micro-fossil groups. The widely distributed siliceous micro-fossils, such as radiolarians and sponge spicules, could enhance the brittleness of shales. They could probably promote the development of natural fractures during diagenesis or artificial fractures during stimulation. When fractures are connected with micro-nano pores in the shale, they could provide effective storage space and improve the overall

connectivity. In most of the analyzed shale samples, micro-fossils commonly show positive correlation with high TOC strata. There are two reasons for this phenomenon. On the one hand, micro-fossils are critical contributors to hydrocarbon generation material. On the other hand, the micro-fossils yield a large number of biological micro-nano pores that conduce to the accumulation of oil and gas. Considering the importance of micro-fossil pores for the accumulation and production of shale gas, they should be included in the classification system. In our new separation system, shale pores should be classified into micro-fossil pores, mineral matrix pores, and organic matter pores, in terms of the significance of micro-fossil pores in hydrocarbon generation, storage, and migration. The wide distribution of micro-fossil pores in shales, in fact, significantly increases the complexity and heterogeneity of pore structure. In addition to the influences on the pore systems, deposited micro-fossils can actually enhance the hydrocarbon generation potential of shales.