An overview of black shales through the Ordovician–Silurian transition in South China: stratigraphy, distribution, and environment

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Abstract

From late Katian (Late Ordovician) to early Telychian (Llandovery, Silurian), the Wufeng and Longmaxi (Lungmachi in Wade-Giles) black shales were widely distributed on the Upper Yangtze Platform, South China. They are the main intervals for shale gas production in China at the present stage. The stratigraphic research about these two formations started from the early 20th century, and after several decades of work, the graptolite biozonation sequence has been established and can be correlated globally. The Wufeng Formation includes four biozones, i.e., the *Dicellograptus complanatus*, *Dicellograptus complexus*, and *Paraorthograptus pacificus* biozones of upper Katian, and the *Metabolograptus extraordinarius* Biozone of lower Hirnantian. The Longmaxi Formation includes nine biozones, i.e., the *Metabolograptus persculptus* Biozone of upper Hirnantian, the *Akidograptus ascensus*, *Parakidograptus acuminatus*, *Cystograptus vesiculosus*, *Coronograptus cyphus* biozones of Rhuddanian, the *Demirastrites triangulatus*, *Lituigraptus convolutus*, *Stimulograptus sedgwickii* biozones of Aeronian, and the *Spirograptus guerichi* Biozone of lower Telychian. In recent years, with the exploration and production of shale gas from these two formations, biostratigraphic subdivision and correlation have been widely applied to many drilling cores in the Sichuan Basin. Meanwhile, three positive excursions of the organic carbon isotope are recognized, respectively in Hirnantian (HICE), around Rhuddanian and Aeronian boundary, and in late Aeronian. In addition, some preliminary cyclostratigraphic studies are carried out. The lithofacies paleogeography map, strata isopach map and paleotopography map for each graptolite biochrone of these two black shales were quantitatively reconstructed. The paleogeographic reconstructions revealed the circumjacent distribution pattern in the border area of Chongqing, Hubei, and Hunan provinces in the middle of Upper Yangtze Platform, and the stage-progressive distribution pattern from Guizhou to Chongqing in the south of Upper Yangtze Platform. Moreover, the migration routes of black shale depositional centers are described for exploring the preferred areas for shale gas. Comprehensive analysis shows that the formation of the Wufeng black shale was controlled by the regional restricted and stagnant marine environment formed by the connection of the southern old lands in South China during late Katian, while its disappearance resulted from the change of the global seawater circulation system due to the middle Hirnantian glaciation; the deposition of the Longmaxi black shale resulted from the anoxic environment at the bottom of the ocean due

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to the global sea level rise from the end of Ordovician to the earliest Silurian, and its diachronous facies change was controlled by the shallowing of seawater and the input of a large number of terrigenous clasts from middle Aeronian to early Telychian.

Keywords: Wufeng Formation, Longmaxi Formation, Biostratigraphy, Paleogeography, Shale gas