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Dispersed organic matter from pre-Devonian marine shales: A review on its composition, origin, evolution, and potential for hydrocarbon prospecting

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The pre-Devonian shales can provide important natural archives which maintain a wealth of information on palaeobiology, palaeoenvironment, and palaeoecology, and are important hydrocarbon source rocks for the unconventional and conventional petroleum systems. In China, the pre-Devonian shales are mostly postmature, resulting in the gradual convergence of the chemical composition and structure of organic matter (OM), which increases the difficulty of OM identification under an optical microscope. Thus, it is difficult to trace OM's genesis and evolution in these shales because of their similar optical characteristics. These shales are characteristically lacking true vitrinite particles, complicating the evaluation of thermal maturity of these formations, a task which has been challenging for decades. Vitrinite-like maceral (VLM) and graptolites generally have higher reflectance and stronger anisotropy than in-source solid bitumen (SB), and their reflectances are indicators to evaluate OM maturity in these marine shales. VLM is thought to be a product of early diagenetic anaerobic biodegradation of lamalginite/bituminite in the Precambrian shales, however, its source in the Cambrian shales remains unclear. In-source SB is from the transformation of liptinites or the cracking of the residual petroleum or their mixture. The graptolites show high TOC, S_1, S_2, and HI contents, and their kerogen type is mainly II-III, indicating its significant hydrocarbon generation potential. The in-source SB plays a significant role in the gas generation. OM in the early mature pre-Devonian shales mainly consists of lamalginite and bituminite; however, in-source SB is the dominant OM in the post-postmature pre-Devonian shales. Non-granular graptolites are widely observed in the Ordovician-Silurian Wufeng–Longmaxi shales and significantly contribute to OM. According to the comparison of the naturally and artificially-matured samples, OM compounds in the low-maturity Mesoproterozoic, Cambrian, and Ordovician graptolite-bearing shales are low-maturity analogues to the postmature Precambrian, Cambrian and Ordovician-Silurian graptolite-bearing shales at the primary state, respectively. This finding is of a key importance for assessing original composition and hydrocarbon potential of these economically valuable marine shales.