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Paleo-ocean environments before and after the Ordovician glaciation and the correlation with heterogeneous marine black shale: a stratigraphic case study of Wufeng-Longmaxi formation in Fuling, Sichuan basin, SW China

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The discovery of Fuling gas field in the Sichuan basin led China shale gas exploration to an unprecedented boom. The most important shale gas plays are the upper Ordovician Wufeng formation and Lower Silurian Longmaxi formation which demonstrate intriguing characteristics which are comprising of stable regional distribution, high abundance of organic matter, high thermal maturity and high brittle mineral content etc. As the Ordovician-Silurian transition was a critical interval in Earth's history marked by dramatic climatic, oceanic, and biological turnovers; these two advantageous organic rich shale deposited before and after Hirnantian glaciation are showing differences in many aspects. In this study, the stratigraphy and lithofacies within the stratigraphy framework of the upper Ordovician Wufeng formation and Lower Silurian Longmaxi formation in Fuling were quantitatively analyzed based on outcrops, cores, well logs data, and geochemical proxies. A total of three third-order sequences were divided based on the recognition of four third-order boundaries. The Wufeng Formation is equivalent to a third-order sequence and is subdivided into a transgressive system tract (TST) (black shale of lower Wufeng Formation) and a highstand system tract (HST) (Guanyinqiao Member of upper Wufeng Formation). Long-1 Member is equivalent to a third-order sequence and is subdivided into a TST, an early highstand system tract (EHST) and a late highstand system tract (LHST); Long-2 and Long-3 Member are combined to be one third-order sequence and is subdivided into a lowstand system tract (LST), a TST and a HST. Sequence development and sedimentary environment characteristics were analyzed within each system tract unit. TOC% was correlated to V/Cr and EF-Ni respectively within each system tract unit, suggesting paleoproductivity and water redox condition are the main controlling factors of organic enrichment and its preservation. The heterogeneity in shale lithofacies throughout the stratigraphic frame work reflects the vertical evolution of the paleo-climate and paleo-ocean environment across the Ordovician-Silurian transition. We suggest that the high primary productivity of Wufeng formation was due to the boom of diatom triggered by large scale coverage of volcanic ash before Hirnantian glaciation. Marine anoxia may have been a kill mechanism that cause the mass extinction of marine macro-organism during the glacial period. And the up sequence TOC deterioration of Longmaxi formation is likely subjected to influence of ocean bottom flow and slow recovery of marine organism after the glaciation.