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Sedimentary processes and depositional environments of the Horn River Shale in British Columbia, Canada

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The Horn River Basin in the northeastern British Columbia, Canada, is one of the largest unconventional gas accumulations in North America. It consists mainly of Devonian shales (Horn River Formation) and is stratigraphically divided into three members, the Muskwa, Otterpark and Evie in descending order. This study focuses on sedimentary processes and depositional environments of the Horn River shale based on sedimentary facies analysis aided by well-log mineralogy (ECS) and total organic carbon (TOC) data. The shale formation consists dominantly of siliceous minerals (quartz, feldspar and mica) and subordinate clay mineral and carbonate materials, and TOC ranging from 1.0 to 7.6%. Based on sedimentary structures and micro texture, three sedimentary facies were classified: homogeneous mudstone (HM), indistinctly laminated mudstone (ILM), and planar laminated mudstone (PLM). Integrated interpretation of the sedimentary facies, lithology and TOC suggests that depositional environment of the Horn River shale was an anoxic quiescent basin plain and base-of-slope off carbonate platform or reef. In this deeper marine setting, organic-rich facies HM and ILM, dominant in the Muskwa (the upper part of the Horn River Formation) and Evie (the lower part of the Horn River Formation) members, may have been emplaced by pelagic to hemipelagic sedimentation on the anoxic sea floor with infrequent effects of low-density gravity flows (turbidity currents or nepheloid flows). In the other hand, facies PLM typifying the Otterpark Member (the middle part of the Horn River Formation) suggests more frequent inflow of bottom-hugging turbidity currents punctuating the hemipelagic settling of the background sedimentation process. The stratigraphic change of sedimentary facies and TOC content in the Horn River Formation is most appropriately interpreted to have been caused by the relative sea-level change, that is, lower TOC and frequent signal of turbidity current during the sea-level lowstand and vice versa. Therefore, the Horn River Formation represents an earlier upward shallowing environmental change from a deep basin (Evie) to shallower marginal slope (middle Otterpark), then turning back to the deeper marine environment (Muskwa) in association with overall regression-lowstand-transgression of the sea level. (This study is supported by "Research on Exploration Technologies and an Onsite Verification to Enhance the Fracturing Efficiency of a Shale Gas Formation" of the Korea Institute of Energy Technology Evaluation and Planning (KETEP), granted financial resource from the Ministry of Trade, Industry & Energy, Republic of Korea.)