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High Resolution Sequence Stratigraphy and Applications of Forward Stratigraphic Modelling; A Case Study from the Devonian Horn River Basin, BC, Canada

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Summary

The Devonian Horn River group in northeast British Columbia, Canada represents a deep-water restricted shale basin dominated by organic-rich mudstones that has been a target for gas exploration for the past decade. With our detailed and extensive core-based analysis, this group provides a unique opportunity to test sequence stratigraphic approaches in shale basins. Application of sequence stratigraphy is limited in most shale basins mainly due to the difficulties in determining major surfaces such as sequence boundaries. However, integration of sedimentology, ichnology, wireline logs and geochemistry allowed us to construct a high resolution sequence stratigraphic framework for the Horn River Basin. Ten systems tracts, including falling-stage and lowstand systems tracts, and nine major stratigraphic surfaces were identified. Sedimentological and ichnological characteristics were used determine subtle changes in the depositional conditions indicating major surfaces, such as sequence boundaries while geochemical characteristics were used to identify more gradual changes indicating long-term fluctuations in the relative sea level and sediment input. This sequence stratigraphic approach allowed us to understand the fundamental architecture of the reservoir and to characterize the depositional settings.

In order to test the accuracy of important parameters such as fluctuations in the relative sea level, and to generate observed stratigraphic patterns, we applied forward stratigraphic modelling. Modelling is a powerful tool to predict reservoir potential in sedimentary basins, but it has rarely been applied to shale basins. Although the Horn River Basin has a complex basin morphology and depositional history, we successfully generated a 3D stratigraphic model for the basin utilizing various parameters. Even though each parameter played critical roles in this model, sediment supply, water discharge and eustatic sea level variation were the main controlling parameters. Similarities in the simulated model and observed sequence stratigraphic patterns allowed us to (1) visualize a realistic history of the basin evolution, (2) understand physical parameters that controlled sediment distribution and accumulation, (3) determine relative sea level fluctuation and accommodation space (4) predict sediment input which provides insight into dilution or enrichment of organic material (5) explain local depositional processes where limited core coverage is available, and (6) demonstrate that high resolution sequence stratigraphic approaches in shale basins are possible and can aid to better understand reservoir potentials. Therefore, the results presented in this study show applications of forward stratigraphic modelling, specifically to the resolution of complex reservoir heterogeneity issues in this and other shale basins.