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Assessment of vertical and lateral facies variability in organic-rich mudstones at the km-scale: a case study from the Devonian Duvernay Formation of Alberta, Canada

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Summary

Organic-rich mudstone successions are known to have significant vertical and lateral heterogeneity. This has been well described in literature at the core scale and the basin scale in many unconventional reservoirs around the world. Investigating geological heterogeneity at a scale in between the two (e.g. km- to sub-km scale) is not always possible because of the dense well coverage necessary for such assessment. Therefore, facies heterogeneity assessment of organic-rich mudstones at the km-scale of investigation is poorly accounted for in literature. Using a case study from the Devonian Duvernay Formation of Western Canada, this study takes advantage of the great amount of well data available in the public domain to perform a heterogeneity assessment of organic-rich mudstone successions at the km-resolution. The five key petrofacies identified through core-to-well log tie – organic-rich black siliceous mudstones, carbonate-rich mudstones to grainstones, organic-lean clay-rich mudstones, organic-rich clay-rich mudstones, and interbedded – were displayed in cross-sections and mapped across the study area for assessment of vertical and lateral heterogeneity. Analysis reveals that the Duvernay Formation has a significant degree of vertical and lateral heterogeneity, which depends on the location of the wells with respect to the main sediment sources active at the time of Duvernay deposition. These include debris flow channels originating from carbonate reefs, carbonate platforms in the NE migrating towards the basin and ocean currents reworking and depositing detrital clays. Although the Duvernay Formation shows trends in the stacking pattern of petrofacies across the study area, this may become quite unpredictable when carbonate- or clay-rich sedimentation breaks the dominant organic-rich sediment deposition. Our analysis shows that, in this case, the Duvernay Formation radically varies in the occurrence and thickness of petrofacies at the sub-km scale, making it an extremely heterogeneous reservoir. This understanding may be applied to other shale plays worldwide which lack the well control necessary to perform a similar assessment.

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