Vertical Changes in Shale Sedimentary Facies, Organic Content and Composition, Carbonate Content, and Clay Mineralogy of a Thick Shale-Dominated Succession of the Carlile and Niobrara Formations, Southwestern Saskatchewan and Southeastern Alberta - Paleo-Oceanographic Circulation and Depositional Setting Controls

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Search and Discovery Article #50450 (2011)
Posted July 31, 2011

*Adapted from poster presentation at AAPG Annual Convention and Exhibition, Houston, Texas, USA, April 10-13, 2011

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Abstract

Detailed core studies and geochemical analysis of the 230-metre thick shale-dominated deposits of the Carlile and Niobrara formations, Bigstick Pool area (southeastern Alberta and southwestern Saskatchewan), have revealed significant changes in shale sedimentary facies, organic and carbonate content, and clay mineralogy. Sequence stratigraphic correlations show the succession is characterized by gently basinward-tapering units. This, and the abundance of interbedded silt and sand ripples, suggests the shales were deposited in a shallow water basin characterized by ramp-style morphology, with no significant shelf break or deep water deposits present.

Within the Carlile and Niobrara formations, the presence of ripple bedforms and basal scour surfaces in mudstone and sandstone laminae/beds indicate traction current was a prevalent transport mechanism. These currents may have been generated by storms, tides and/or geostrophic circulation. Depositional setting of these formations is a matter of debate, as both prodeltaic and shelf settings have been proposed. In a shallow-water ramp-style basin, both settings have similar bedforms, ichnofacies, and diminutive ichnofauna due to stressed conditions from frequent dysoxia and/or storm/wave reworking. Thus, facies boundaries in a ramp setting between the offshore prodeltaic and shelf environments become non-distinct.

The Carlile and Niobrara formations are both characterized by similar bedforms, ichnofacies and strata geometries, indicating deposition in a relatively similar setting. However, both formations are characterized by unique geochemical characteristics. These may reflect significant changes in depositional setting, climate, ocean circulation, seaway width and connection to the Boreal and Tethyan seas. For instance, the change from non-calcareous Carlile shales to calcareous nannoplankton-rich Niobrara shales likely reflects the introduction of warm Tethyan waters into the basin. The influx of Tethyan water likely also caused a change in water circulation, chemistry, salinity and nutritional levels of the seawater.
The fabric and geochemistry of the Carlile and Niobrara shales and thus their shale gas prospectivity are likely more influenced by changes in paleo-oceanography and basin scale processes than changes in depositional setting. Observations from this study provide insight on the understanding of deposition of thick shale units and distribution of shale-dominated reservoirs, which is applicable to other shale gas reservoirs.

References


Website

The Carlile and Niobrara formations are both characterized by similar bedforms, ichnofacies and strata geometries, indicating deposition in metre thick, shale-dominated deposits of the Carlile and Niobrara formations. Laminae/beds indicate traction current was a prevalent transport mechanism. These currents may have been generated by storms, tides or changes in paleo-oceanography and basin scale processes than changes in depostional setting. Observations from this study provide insight on the understanding of deposition of thick shale units and distribution of shale-dominated reservoirs, which is applicable to other shale gas reservoirs.

The fabric and geochemistry of the Carlile and Niobrara shales and thus their shale gas prospectivity are likely more influenced by changes in paleo-oceanography and basin scale processes than changes in depositional setting. Observations from this study provide insight on the understanding of deposition of thick shale units and distribution of shale-dominated reservoirs, which is applicable to other shale gas reservoirs.
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7. 2- and 3-Dimensional Geometry of the Carlile and Niobrara Formations

8. Bulk Mineralogy and Clay Mineralogy

10. TOC and Organic Matter Type

11. TOC Variation and Maturity

Acknowledgments

Thanks are extended to Nexen Inc., ConocoPhillips, Imperial Oil, and Lundin Energy for their financial support and permission to publish these results. Thanks are also extended to the Alberta Energy Regulator and the Western Canada Sedimentary Basin Speckle Project (WCSBP) for permission to publish results that were obtained using their data. Special thanks are extended to the Canadian National Energy Board for the funding of the project and to the Alberta Research Council, Special Report 4.

References