Bedforms and Stratigraphic Architecture of Colorado Group Shales as an Indicator of Shallow Shelf Depositional Setting of the Carlile and Niobrara Formations, Southeastern Alberta - Southwestern Saskatchewan

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The Carlile and Niobrara formations in southeastern Alberta and southwestern Saskatchewan are mainly comprised of shales with minor interbeds of siltstones, sandstones, and bentonites. Sandstones of the Niobrara Formation, the Medicine Hat Member, host several giant shallow gas pools. Evaluation of the shale gas potential of the shale-dominated part of the Carlile and Niobrara formations is the main long term objective of this study. As in conventional reservoirs, interpretation of the depositional setting is an important part of reservoir characterization to address reservoir continuity and variability from laminae to depositional sequence scale (millimetres to tens of metres).

The Medicine Hat sandstones have traditionally been interpreted as shallow shelf deposits, based on the very wide lateral extent of the sandstones and their micro and macro fossil content. More recently, the sandstones were interpreted as deltaic sands – a hypothesis built mainly on ichnology. In this study, sedimentary and reservoir facies have been examined in detail in a new, long, and continuous core which fully encompasses the Carlile and Niobrara formations within the Bigstick pool, in southwestern Saskatchewan. Sedimentary facies within the Carlile and Niobrara are stacked in general coarsening-upward sequences with increasing siltstone and sandstone content. The Medicine Hat Member is heavily bioturbated, with abundant ripple bedforms and mud drapes. The more shale dominated Carlile Formation and lower Niobrara are dominated by abundant centimetre thick, fining-upward beds, patchy bioturbation, minor ripples and hummocky cross-stratification. Throughout this interval, *Inoceramus* shells, fragments, and shell hash beds are common. Although both formations are dominated by shales, bedforms show deposition was mainly by traction currents, and that slow, pelagic suspension deposits constitute only a minor part of this shale-dominated succession. The presence of hummocks suggests the seafloor was above storm wave base at the time of deposition. This is consistent with the notion that a considerable amount of reworking of the seafloor would have had to occur periodically to produce the abundant shell hash beds observed. These data, together with published data on the microfauna within interbedded shales of the Medicine Hat Member indicate a fully marine, offshore depositional environment. Thus, evidence from this study, conducted in the Bigstick Pool in southwestern Saskatchewan supports the previous interpretation of the Niobrara Formation, and more shale dominated Carlile Formation, as shallow shelf deposits, in contrast to the recently proposed deltaic depositional setting of the Medicine Hat sandstones.

Detailed sequence stratigraphic correlations within the Bigstick area also support deposition within a shelfal setting of the Carlile and Niobrara formations, due to their internal, extremely

shallow, seaward-dipping clinoforms. Although the depositional settings of the Carlile and Niobrara were quite similar, there are several major differences between the two formations. Notably, the Carlile Formation is non-calcareous whereas the Niobrara is calcareous, and the orientation of clinoforms changes significantly between each depositional unit. These reflect changes in paleo-oceanography, sediment source, and subsidence during late Cretaceous time.

An understanding of the depositional processes, setting and paleo-oceanography of each formation is important for shale gas evaluation and identification of the most prospective shale gas interval and fairway. A reversion to the previous shallow shelf depositional setting interpretation holds new implications for the deposition of Carlile and Niobrara shales, based on the domination of traction current-generated bedforms in these formations, and how clinoforms affect the lateral continuity of potential target units. In addition, the results of this study will improve the understanding of clinoforms deposition and their importance in the shallow shelf depositional model.