Variability of Modern Meandering Fluvial and Tidal Estuarine Systems: A Re-examination of Lithofacies Models

Derald G. Smith, Department of Geography, University of Calgary, Calgary, AB, Canada T2N 1N4, email: dgsmit@ucalgary.ca

Stephen M. Hubbard, Department of Geoscience, University of Calgary, Calgary, AB, Canada T2N 1N4

Peter E. Putnam, OSUM Oilsands Corp. Ltd. Suite 300-1204 Kensington Rd. NW, Calgary, AB. T2N 3P5

Jason R. Lavigne, Bergshrund Integrated Sedimentologic Solutions, 2104 3rd Avenue NW, Calgary, Canada, AB, T2N 0K4

Dale A. Leckie, 801-7th Ave. SW, Nexen Inc., Calgary, AB, Canada, T2P 3P7

Milovan Fustic, 801-7th Ave. SW, Nexen Inc., Calgary, AB, Canada, T2P 3P7

Abstract

Research on modern meandering fluvial and tidal estuarine channel deposits over the past 30-years has demonstrated considerable variability of lithofacies that still has not been incorporated into textbooks and other educational products. The upward grain-size fining of fluvial sandy point bar deposits (PBD) has been well documented, and is often considered as a “one size fits all” facies model for meandering channels. In contrast, an understanding of silt-dominated counter point bars deposits (CPBD) is still in its infancy (Smith et al. 2009; in review). Counter point bar deposits in low gradient rivers (e.g. 0.00004, 4 cm/km) always form downstream of point bar deposits, beyond the channel crossover or scroll pattern inflection, and may constitute up to 50% of the area in a meander lobe (Fig. 1). These heterolithic alternating thin sand and thicker silt beds form by lateral accretion, usually in the down-valley direction along regional dip. Our borehole data (Smith et al. in review) suggest these deposits vary considerably from those of point bar deposits, and thus are characterized by distinctive petrophysical properties (e.g., porosity, permeability, reservoir body connectivity, etc).

Actively meandering tidal estuary channels and their deposits are less understood. Tidal estuaries include the lowermost reaches of river systems influenced by oceanic tides, exhibiting either a flow reversal, as occurs in the lower meandering Chehalis and Willapa river estuaries of SW Washington State and Daule and Babahovo river estuaries of Ecuador (Smith 1988), or a waxing and waning regime of unidirectional flow, as occurs in the lower Fraser River, B.C. (Smith 1985) (Fig. 2). Heterolithic meandering tidal channel deposits commonly form in meso tidal settings (2-4 m spring tide range, North American classification). In rivers where flow reversals do not occur, but fluvial flow

fluctuates as a result of tidal influence, point bar deposits consist of sand; counter point bar deposits have not yet been studied (Fraser River, Fig. 2, Smith 1985). On the other hand, meandering tidal channels that exhibit flow reversals can have heterolithic (distinctive sand-mud couplets) vertical successions in both point bar and counter point bar deposits (Willapa River, Washington State and Daule and Babahovo rivers, Ecuador). Here, each sand-mud couplet likely represents one year of sedimentation, attributed to one dominant annual fluvial flood cycle responsible for the sand bed and a mud bed attributed to deposition during the remainder of the year. In some subtropical regions, two annual fluvial flood cycles in a given year may be expected. In contrast to pure fluvial meander bend deposits, both point bar and counter point bar deposits in tidally influenced meanders can be characterized by repetitive sand-mud couplets. Because of their similar heterolithic vertical sequence, it would be very difficult to separate point bar from counter point bar deposits from core only (Fig. 2). In a specific meander, mud beds tend to be thicker distally (fining distally). In the Chehalis River, which experiences flow reversals in the reach studied, we observed clean sand in the point bar, but increased heterolithics distally in the counter point bar deposits. All of the examples with tidal reversals had remarkable similarity to those exposed in the open pit mines of the Alberta Oil Sands (Smith 1988). From our experience, considerable variability exists within meandering river lithofacies, whether they be fluvial or tidally-influenced, suggesting much more field research is needed.

In the exploration and development for hydrocarbons, whether in the Mannville or Belly River groups, a more sophisticated understanding of the variability of meandering fluvial and tidal estuary channel deposits should result in better reservoir delineation, and subsequent increased drilling and extraction efficiency.

References

Smith, D.G., 1985, Modern analogues of the McMurray Formation channel deposits: sedimentology of mesotidal-influenced meandering river point bars with inclined beds of alternating sand and mud. Alberta Oil Sands Technology and Research Authority Edmonton, Alberta, unpublished Open File Report, Research Project No. 391, 78p.

Smith, D.G., 1988, Modern Point Bar Deposits: Analogous to the Athabasca Oil Sands, Alberta, Canada: in de Boer, P.L., van Gelder, H. and Nio, S.D., eds., Tidal Environments and Facies, Reidel Publishing, Dordrecht, The Netherlands, p. 417-432.

Smith, D.G, Hubbard, S.M., Leckie, D.A., and Fustic, M., 2009, Counter point bar deposits: lithofacies and reservoir significance in meandering modern Peace River and ancient McMurray Formation, Alberta, Canada: Sedimentology, v. 56, p. 1655-1669.

Smith, D.G, Hubbard, S.M., Lavigne, J.R., Leckie, D.A., and Fustic, M., in review, Stratigraphy of counter point bar and eddy accretion deposits in low energy meander belts of the Peace-Athabasca Delta, Northeast Alberta, Canada. Proceedings of the River to Rock Record conference, University of Aberdeen, January, 2009.

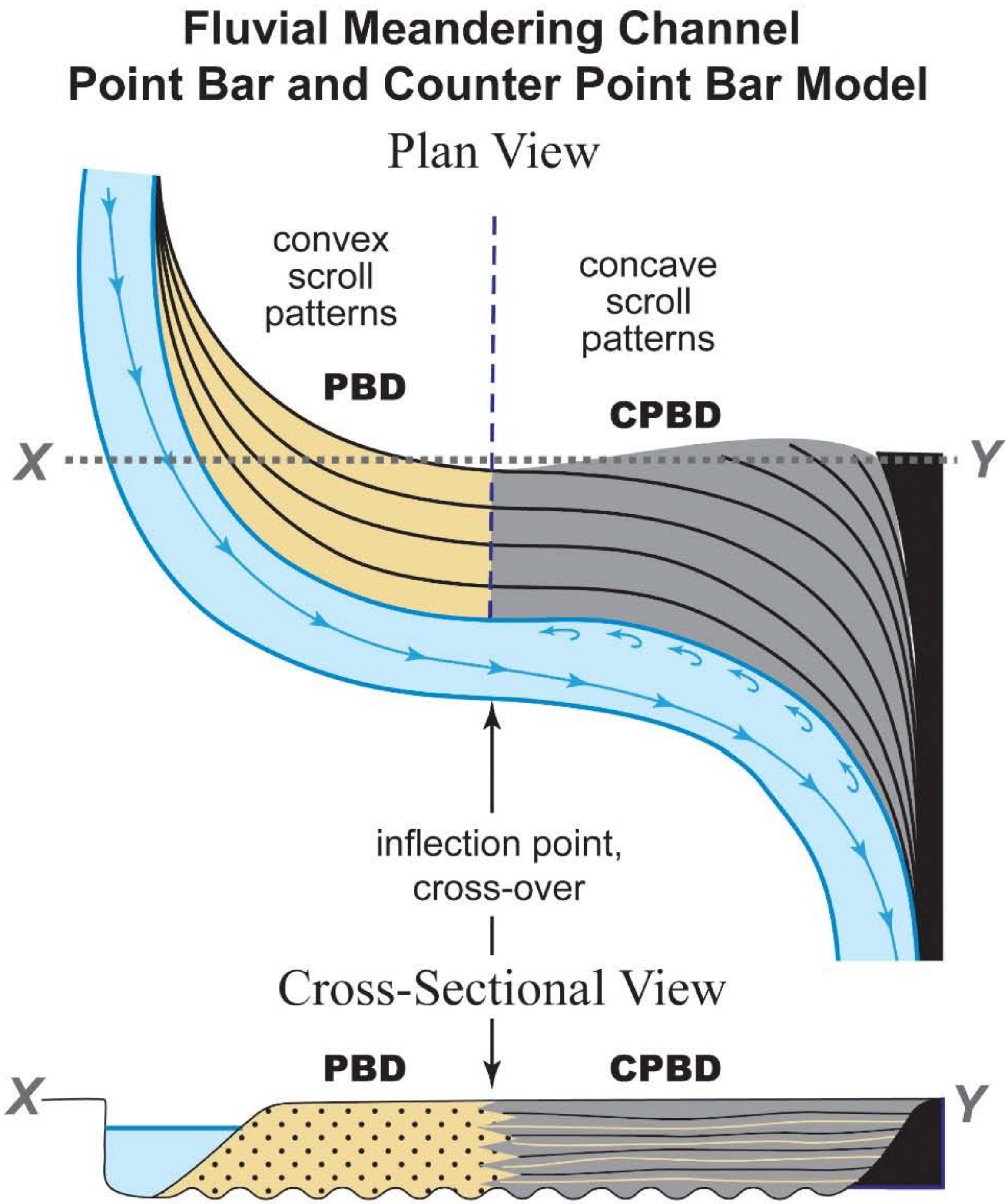

Figure 1. Schematic plan-form and lithostratographic model of a fluvial meander belt showing point bar and counter point bar deposits. Note the fining downstream direction of sediment grain size.

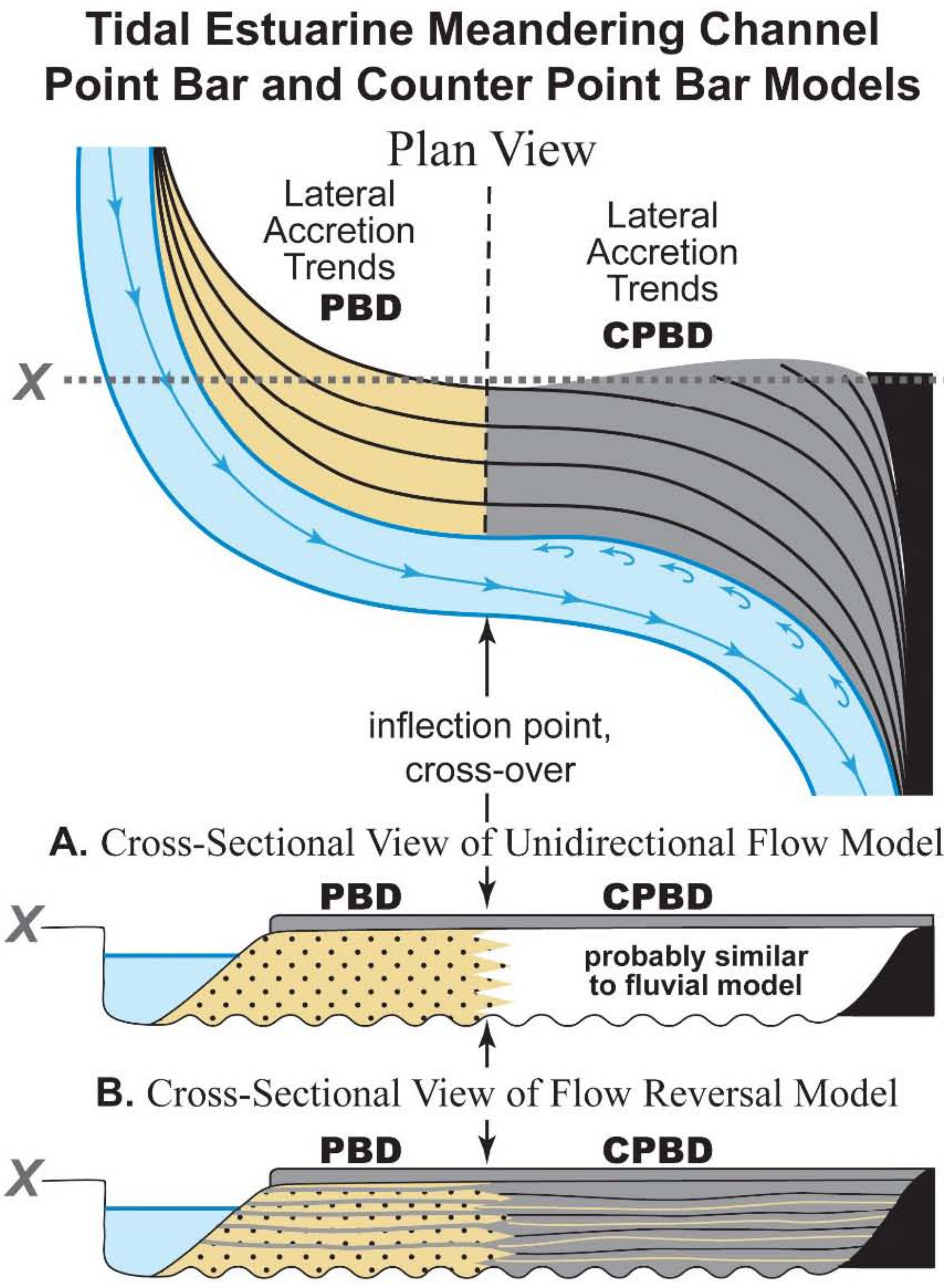

Figure 2. Schematic plan-form and lithostratographic view comparing point bar and counter point bar deposits of two different styles of meandering tidal estuarine channel deposits capped with overbank mud. **A**. Tidal unidirectional flow model. **B**. Tidal flow reversal model.