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Utilizing planform reconstructions to constrain anomalous point bar heterogeneity

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Point bar models developed from the Athabasca Oil Sands Region (AOSR) are characterized by several common trends, including an upstream-to-downstream increase in intervening mudstone beds. However, not all point-bar deposits exhibit these trends, which can manifest as uncertainty in conventional stochastic modelling approaches. The most effective method to understand anomalous facies distribution patterns is to reconstruct the planform architecture and analyze the evolutionary history of meander bend migration. Imperial Oil's Kearl Mine offers an excellent opportunity to utilize dense borehole spacing and 1000s of mine-face photographs to reconstruct the planform architecture of meander-belt deposits to constrain anomalous heterogeneity trends. Results demonstrate that point-bar and counter-point-bar heterogeneity and morphology are influenced by the lithology of upstream cutbank material.

A 2.0 x 1.5 km study area contains over 200 boreholes with well logs and core photos, weekly LiDAR scans, and 2D seismic data that are supplemented by thousands of mine-face photographs as excavation advances. Planform reconstructions rely on dipmeter data to constrain accretion and flow direction as well as mine-face photographs that provide critical linkages between 1D borehole data. Results of this study document a mudstone-dominated abandoned channel that encompasses a northward expanding point-bar deposit. The abandoned channel was subsequently laterally incised by a younger meander bend that was translating downstream. This resulted in time-equivalent counter-point-bar and adjacent expanding point-bar deposition immediately downstream from the incision of the older abandoned channel deposit. Anomalous facies distributions documented include several slumped and deformed mudstone bodies, mud-clast-dominated breccias, and lower-point-bar, mud-dominated inclined heterolithic stratification (IHS); all of which were misinterpreted, to varying degrees, with conventional modelling methods. These deposits are bound upstream and downstream by typical upward and downstream fining point-bar deposits that were modelled to a higher degree of accuracy.

Relating the distribution of anomalous heterogeneity to the planform evolution reveals that cut-bank lithology played a role in meander bend evolution and local sediment supply to an adjacent point bar. Abandoned channel deposits along the cut-bank limited lateral expansion and promoted downstream translation, which led to counter-point bar deposition. Erosion of the cut-bank also supplied mudstone that was deposited immediately downstream as slumped blocks, breccia, and mud-dominated IHS on the upstream end of the point bar. The breccia and slump blocks are to be expected in such a scenario, but the presence of mudstone-dominated IHS may suggest that in some instances, erosion of mudstone along the cut-bank may be a local source of mud-sized sediment. This finding is a direct example of the process-to-product relationship that can be gleaned from detailed planform reconstructions. Our results inform well log and core recognition criteria for anomalous point bar heterogeneity that can be used to constrain geologic modelling in analogous deposits.