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Generating Reservoir Models from High Resolution Outcrop Studies: A Case Study from the Lower Cretaceous McMurray Formation, Northeastern Alberta

It is estimated that the Athabasca Oil Sands, of which the McMurray Formation is an important constituent, contain 950 bbls of bitumen in place. Because much of the resource is not amenable to surface mining, subsurface extraction is an increasingly important means of exploitation. Unfortunately, production efforts are hampered by a complex facies architecture characterized by inclined heterolithic stratification (IHS). Variability in bed thickness, lateral continuity, degree of bioturbation, and mud-bed fracturing, all contribute to complex fluid flow within these reservoirs.

Delineation of facies architecture was accomplished by combining detailed sedimentologic mapping with outcrop photo mosaics and detailed strip logs. Two-, and three-dimensional numerical models, based on the outcrop data, were generated to assess the most influential factors governing fluid flow at the outcrop scale. Parameters integrated into the models included the distribution of lithofacies, the degree of bioturbation, and the presence/absence of mud-bed fracturing. A permeability grid was populated based on statistical (deterministic and stochastic) assessment of the data. Flow simulations gauged the relative effects the various lithological parameters exerted on horizontal and vertical fluid flow. From these simulations, lithology and bed thickness were determined to be the dominant controls on both vertical and horizontal bulk permeability. Mud-lined burrows found locally within the sand member of IHS, decrease horizontal bulk permeability and have little effect on vertical permeability, whereas mud-bed fracturing increases vertical permeability but has an insignificant impact on horizontal bulk permeability.

This data is used to conduct a sensitivity analysis of the most influential parameters on fluid flow within IHS beds. These are, in descending order, lithology (primarily grain size), bed continuity, bed thickness, reservoir thickness, presence/absence of fractures, and presence/absence of bioturbation.