Ichnological and Sedimentological Variability in IHS Across the Tidal-Fluvial Transition: McMurray Formation, Southern Athabasca Oil Sands

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Summary

In the southern Athabasca Oil Sands region, a large proportion of the Lower Cretaceous middle McMurray Formation was deposited by lateral accretion on large tidal-fluvial estuarine point bars. These deposits typically consist of inclined heterolithic stratification that display considerable variability in facies successions, owing to spatial and temporal fluctuations in depositional processes; mixing of marine and fresh water, and the interplay between fluvial discharge and tidal flux. Although, it is difficult to resolve and quantify the dominant controls on IHS development along the axis of the various McMurray paleo-estuaries, high-resolution ichnological and sedimentological analysis can potentially be used to resolve the relative importance of each of the parameters at specific positions along the axis of the main paleo-valleys. This is attempted for middle McMurray Formation deposits along the “Christina Valley” trend.

Initial appraisal of approximately 1400 meters of core found that three intergradational, but distinct, IHS styles recur throughout the study area; fluvial-, mixed tidal-fluvial-, and tidal-dominated IHS, which are arranged in a progressively paleo-seaward direction through the Christina Valley. Fluvially dominated deposits consist of sand-dominated IHS with rare to no bioturbation (BI 0-1). Sandstone beds are meter-scale in thickness and are unburrowed. Mudstone beds are generally centimeter-thick and display rare deposit-feeding trace fossils (e.g., *Planolites*). In the paleo-seaward direction, inferred mixed tidal-fluvial IHS consist of mixed sandy and muddy IHS displaying higher bioturbation intensities (BI 0-3, BI 2 average) and diversities. Sandstone and mudstone bed thicknesses are centimeter to decimeter-scale, and brackish-water trace fossils (e.g., *Gyrolithes, Skolithos,* Cylindrichnus) occur sporadically, often subtending from mudstone beds into underlying sandstone beds. These

characteristics suggest stronger tides relative to more paleo-landward positions in the valley, the presence of fluid mud, and higher but variable salinities. Deposits inferred to be the tide-dominated are recognized by IHS that is muddy and contains abundant rhythmic sand-mud couplets. Bioturbation is dominantly restricted to mudstone beds and muddy bedsets (BI 0-4, BI 2 average), and burrows typically subtend into or through underlying sandstone beds. The resulting facies successions reflect deposition under heightened tidal flow and reduced freshwater input (i.e., more stable salinities).

The refinement of IHS depositional models hinges on high-resolution facies analyses, and ultimately leads to improved predictions of paleogeographic position. From this analysis, it appears possible that the sedimentological and ichnological character of the sediments can, in part, determine the magnitude to which tides and salt-water affected deposition. In particular, the intensity and diversity of bioturbation and the amount of mud deposition are strongly controlled by the mixing of tidal and fluvial flow.