

Facies Architecture and Trace Fossils of the McMurray Formation: Interpreting the Depositional Setting in the MacKay Area of the Athabasca Oil Sands

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The Lower Cretaceous McMurray Formation is host to the bulk of the bitumen resources within the Athabasca Oil Sands Region. Depositional environments for the McMurray Formation have been broadly characterized as ranging from fluvial to brackish/estuarine marginal marine deposition. Point bar and tidal channel sands are generally interpreted as having filled a major northward flowing trunk system entrenched into the underlying Devonian paleo-surface, which then emptied into an estuary or tide-dominated delta. However, western reaches of the McMurray Formation (e.g. MacKay area) do not appear to conform to this generally accepted depositional framework.

In the MacKay area of the Athabasca Oil Sands Region, sedimentological and ichnological observations of more than 50 core has led to the identification of 9 major facies that are divided into two main facies associations. Facies Association 1 (FA1) is represented by massive to inter-laminated silt and silty shale, very fine-grained bioturbated sand, weak to moderately bioturbated inter-bedded to inter-laminated sand, silt, and silty shale, and IHS sand/mud couplets. Nine ichnogenera representing a mixed ethology suite were observed in FA1. Additionally, rhizoliths and non-marine ichnofossils were locally observed. Facies Association 2 (FA2) is represented by moderate to highly bioturbated mixed sand, silty shale and silt, medium-grained cross-bedded sands, and weak to moderately bioturbated sands with occasional discrete mud and shell layers. Eighteen ichnogenera were observed within facies of FA2, dominantly representing the proximal Cruziana ichnofacies. A major erosional surface, strongly burrowed by *Teichichnus* and *Thalassinoides* (representing a *Glossifungites*-demarcated discontinuity), separates the reported facies associations.

Sedimentological and ichnological evidence suggest that deposition in the MacKay area occurred within a smaller, secondary north trending paleo-valley that formed an embayment west of the main valley system. FA1 was deposited in a continental to marginal marine setting comprising paleosol and overbank deposits, tidal channel, and tidal flat deposits. The deposits of FA1 are interpreted to represent initial transgression of the valley. FA2 contains a diverse and abundant trace assemblage, which is much more marine than typical McMurray strata. The strata of FA2 are thereby interpreted to have accumulated in a marine embayment that dominantly received sand from tidal processes.