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Paleo-Environmental Interpretation and Depositional Process Classification of Allomembers D and E, Lower Horseshoe Canyon Formation, Alberta

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Summary

Three-dimensional outcrop exposures of the lower Horseshoe Canyon Formation near Drumheller, Alberta provide an excellent opportunity to study facies variability in a mixed-influence marginal-marine system. High-resolution sedimentological and ichnological data from 30 sections through allomembers D and E, exposed in outcrops along the Red Deer River Valley and along Willow Creek, are integrated with data from 4 cored wells and 75 wireline logs within a four township area.

Allomember D contains three Element Complexes (EC; equivalent to facies associations). EC-D1 is dominated by 0.5-1.2 m thick, organic-rich mudstone, interpreted as an Onshore EC. EC-D2 comprises a 1-6 m thick fining-upward succession, interpreted as a tide-dominated, fluvial-influenced (**T**f) Tidal Flat EC. Sandstones in EC-D2 are current rippled and trough-cross bedded, commonly draped by rhythmic laminae of mudstone and carbonaceous debris. The rhythmic mud laminae reflect evidence of tidal deposition. Bioturbation intensities range from BI 0-1, likely due to stresses imposed by freshwater (fluvial) conditions and high sedimentation rates (fluvial and tidal). Where bioturbation is present, the suite contains *Planolites* and *Thalassinoides* with rare *Palaeophycus* and *Rosselia*. EC-D3 is composed of sediments deposited in a 5.5 m deep, fluvial-dominated, tide-influenced (**F**t) Channel EC. EC-D3 is dominated by trough cross-bedded sandstones with common mudstone drapes. No visible bioturbation is present, probably due to the freshwater stress, high sedimentation rates, and/or high-energy conditions experienced by organisms in the fluvially dominated channel.

Allomember E comprises three ECs. EC-E1 comprises a coarsening-upward, wave-dominated, tide-influenced (**W**t) Beach EC characterized by hummocky cross-stratified, trough cross-bedded, and plane-bedded sandstones with common mudstone drapes. BI values range from 0-4, and the trace-fossil suite includes *Ophiomorpha*, *Rosselia*, *Thalassinoides*, *Planolites*, *Palaeophycus*, Macaronichnus, *Conichnus*, and *Skolithos*. This suite is consistent with the *Skolithos* Ichnofacies. EC-E2 forms a 1-4.5 m thick, fining-upward succession of sandstones and mudstones, interpreted as a tide-dominated, fluvial-influenced, wave-affected (**T**f*w*) Tidal Flat EC broadly similar to that of EC-D1. Sandstone units commonly contain current ripples with abundant mud and carbonaceous laminae, as

well as rare trough cross-bedding and combined flow ripples. BI values within the sandstone units range from 0-2, with a trace-fossil suite containing *Ophiomorpha*, *Thalassinoides*, *Planolites*, *Palaeophycus*, *Siphonichnus*, *Skolithos*, *Diplocraterion*, and *Rosselia*. Oyster beds are present with an apparent trend of NNE-SSW, roughly perpendicular to the Red Deer River Valley and approximately parallel to the shoreline. The majority of the shells are disarticulated and fragmented, likely representing transport over short distances. Nevertheless, a significant number of oyster shells are articulated and oriented vertically, probably preserved in their growth positions. EC-E3 comprises a 6.5 m deep, fluvial-dominated, tide-influenced (**F**t) Channel EC, filled with inclined heterolithic stratification (IHS). BI values range from 0-1, and the trace-fossil suite contains *Planolites,* with rare *Skolithos* and *Thalassinoides*. The ichnological character of EC-E3 is consistent with the brackish-water trace fossil model. The presence of both IHS and a brackish-water ichnological suite is taken as evidence of both tidal and fluvial influence, and is consistent with an estuarine channel interpretation.

The element complexes in Allomembers D and E are characterized and interpreted on the basis of the relative proportions of the depositional processes (i.e., fluvial, wave, and tidal) responsible for their deposition. By classifying the ECs by depositional processes, it is possible to recognize important changes in depositional conditions, enabling high-resolution reconstruction of the paleoenvironment and the architecture of potential reservoir units. This study examines the intra-parasequence level of stratigraphy to improve the understanding of reservoir architecture and compartmentalization within a mixed-influence, marginal-marine system.