

Along-Strike Ichnological and Sedimentological Variations in a Mixed Wave- and River-Influenced Delta Lobe, Upper Cretaceous Basal Belly River Formation, Central Alberta

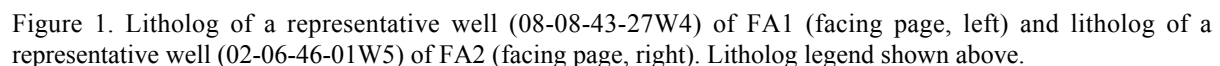
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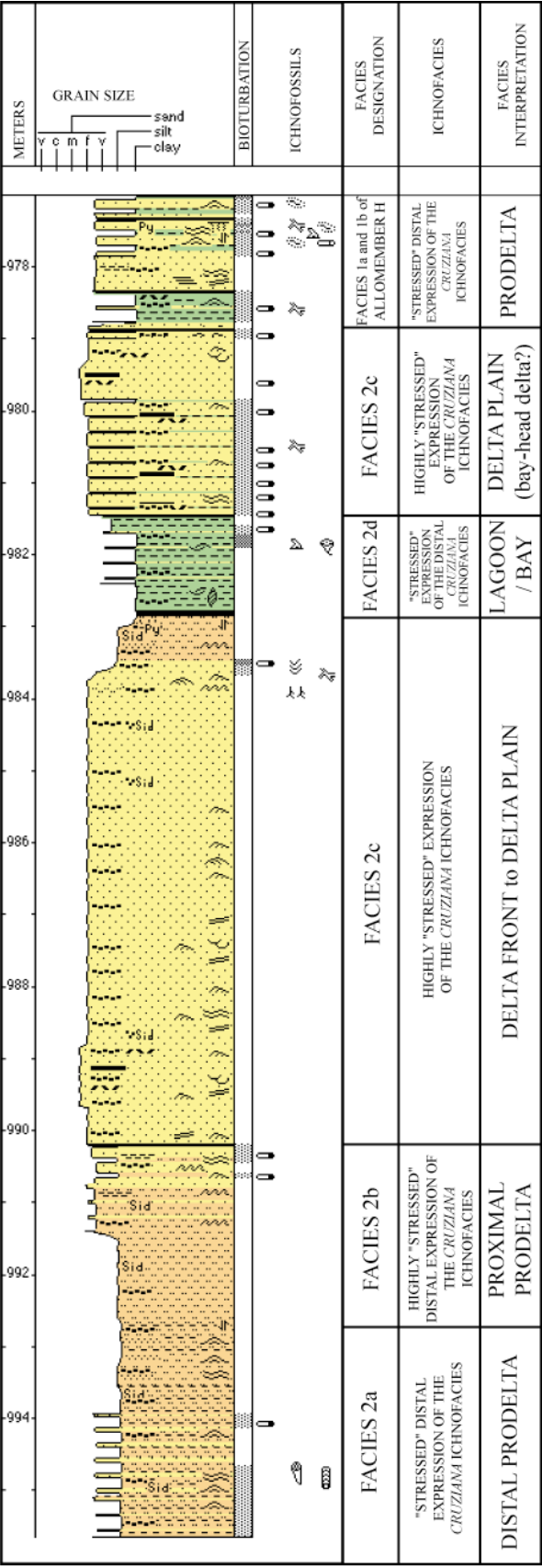
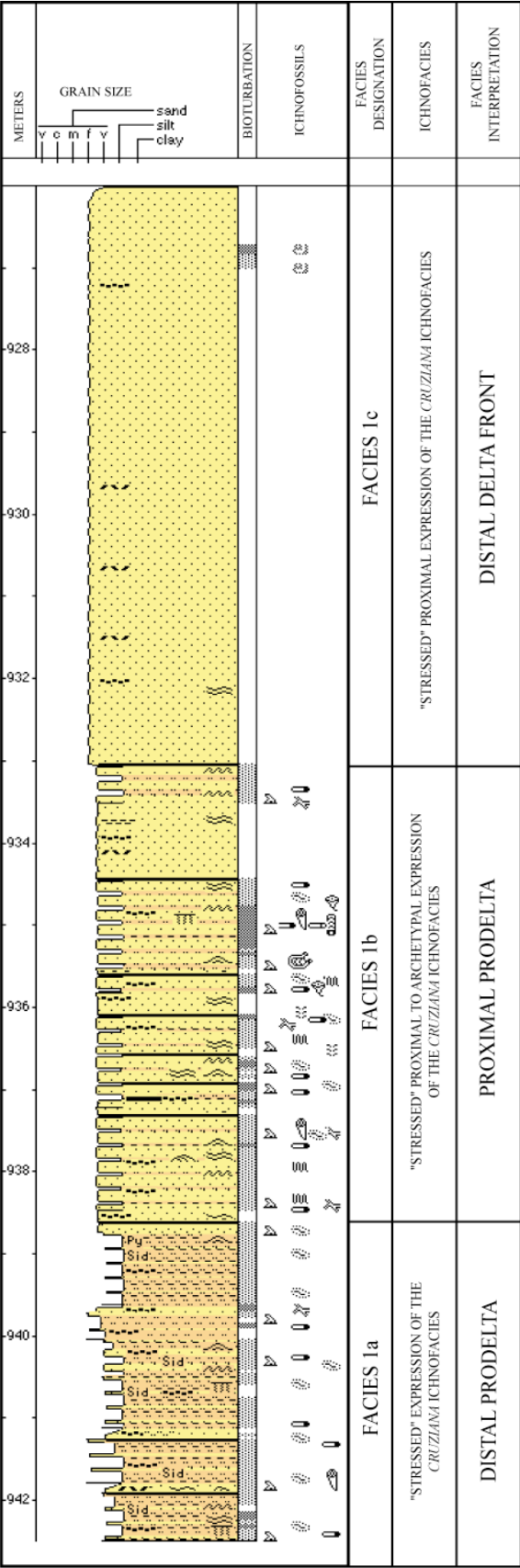
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The early to mid-Campanian Basal Belly River Formation in the Ferrybank, Keystone, and eastern Pembina fields of central Alberta, records a mixed wave- and river-influenced deltaic succession with strong storm overprinting. The deposits are separable into two distinct facies associations (Fig. 1). Facies Association 1 (FA1) comprises a recurring, coarsening-upwards succession consisting of intercalated siltstone and thinly bedded sandstone units of Facies 1a, overlain by heterolithic sandstone and sandy siltstone units of Facies 1b, and capped by sandstones of Facies 1c. The FA1 succession is characterized by an abundance of wave- and storm-generated physical sedimentary structures, very rare to moderate numbers of syneresis cracks, and convolute bedding, in addition to sporadic, low abundance, and low- to moderate-diversity trace fossil suites. Despite the availability of sandy substrates, trace fossil suites record a paucity of *Skolithos* Ichnofacies elements; such scenarios are indicative of turbid water conditions near the sediment-water interface. Collectively, the physical and biogenic sedimentary structures indicate that the depositional environment of FA1 was subjected to numerous environmental stresses, including a strong wave climate, high sedimentation rates, slumping and/or liquefaction, freshet-induced salinity fluctuations, fluid mud deposition resulting in soupground conditions, and heightened water turbidity. Facies 1a, 1b and 1c are characterized by “stressed” expressions of the archetypal to proximal *Cruziana* Ichnofacies. The facies association records trace fossil suites that depart from the “unstressed” archetypal *Cruziana* Ichnofacies ascribed to offshore environments and the *Skolithos* Ichnofacies typical of shoreface settings. Based on the integration of ichnological and sedimentological characteristics, FA1 is interpreted to record distal prodelta (Facies 1a), proximal prodelta (Facies 1b), and distal to proximal delta-front deposits (Facies 1c), representing the progradation of a mixed river-, wave- and storm-influenced delta (Fig. 2).

Facies Association 2 (FA2) also comprises a recurring, overall coarsening-upwards succession; however, FA2 is characterized by greater facies variability than FA1 (Fig. 1). The succession consists of intercalated clayey siltstone and thinly bedded sandstone units of Facies 2a at the base, overlain by heterolithic intervals of clayey to sandy siltstones and thin sandstones of Facies 2b, which are in turn overlain by sandstones capped by deformed sandy siltstone units of Facies 2c. Facies 2d, comprising variable, though typically mud-dominated, heterolithic units overlies or is intercalated between units of Facies 2c. FA2 is characterized by an abundance of current-generated structures and very sporadic, very low- to low-abundance, very low- to moderate-diversity trace fossil suites. Facies 2a and 2b consist of intercalated clayey siltstone and sandstone units that display abundant graded beds in wavy bedded composite bedsets, convolute bedding, and dark, organic-rich mudstone beds with syneresis cracks, suggesting that salinity reductions may have been concomitant with phytodetrital pulses and hyperpycnal-emplaced turbidites. Facies 2c consists of typically unburrowed sandstones that are commonly overlain by deformed, intercalated sandstones and siltstones. Spherulitic siderite is abundant throughout the basal, medium-grained, trough cross-stratified units; these grains were likely liberated from soils of the delta plain during flood inundation. Adhesive meniscate back-filled burrows are common within the upper portions of the facies, and are consistent with extended periods of subaerial exposure. The mud-prone heterolithic claystone and sandstone units of Facies 2d commonly contain abundant oyster shell fragments and low diversity trace fossil suites dominated by

Ichnological and sedimentological analysis of more than fifty cored wells through the same delta lobe reveals prodelta and delta-front deposits that vary markedly along depositional strike. The along-strike variations fit well with the recently proposed asymmetric delta model (Fig. 3). The physical sedimentology of FA1 is compatible with updrift positions of an asymmetric delta lobe, whereas the physical sedimentary structures and lithologic accessories of FA2 correspond to environments downdrift of distributary channels. The integration of ichnological analysis corroborates the asymmetric delta interpretation. Organisms are exceedingly sensitive to the physico-chemical stresses associated with fluvial influence, and thus it would be expected that infaunal organisms in downdrift locales would experience even greater degrees of environmental stress than those in updrift settings removed from direct fluvial influx. The ichnological expression of downdrift deposits records more sporadically distributed bioturbation, with lower abundances and diversities compared with updrift deposits.





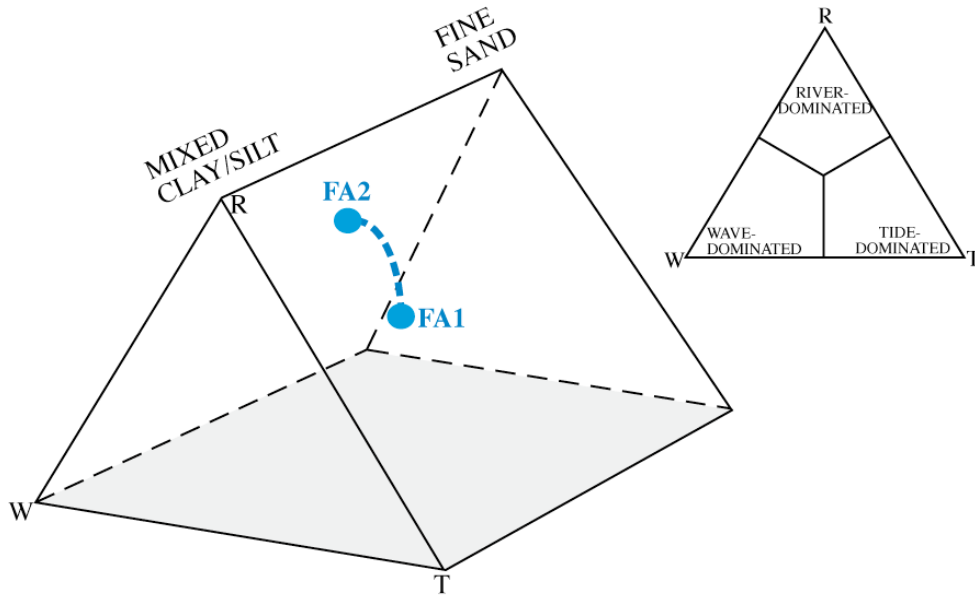


Figure 2. FA1 and FA2 are plotted on a 3-D ternary diagram of delta classification. FA1 plots as a sand-rich, wave-influenced to wave-dominated delta, whereas FA2 plots as a finer-grained, river-influenced to river-dominated delta.

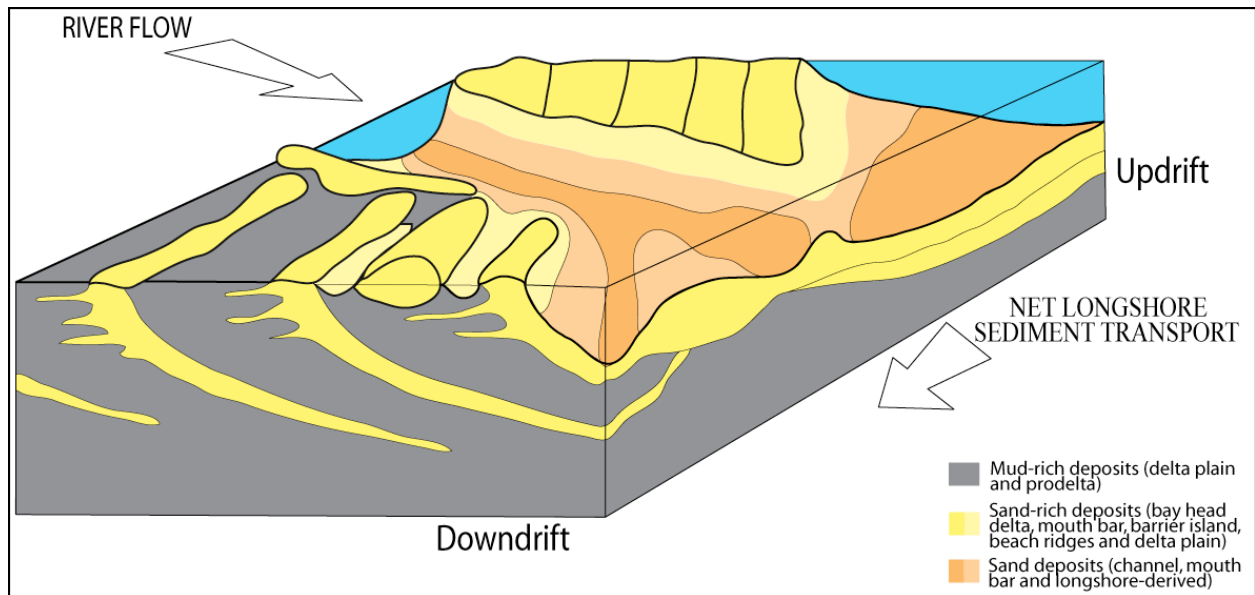


Figure 3. Block diagram illustrating the inferred three-dimensional facies architecture of an asymmetric delta lobe. A sandy beach-ridge plain characterizes the updrift side of the distributary channel(s), whereas more complex heterolithic environments preferentially form downdrift. FA1 is interpreted to have been deposited in wave-dominated locales lying updrift of distributary mouths. FA2, on the other hand, represents the more highly “stressed”, heterolithic environments located in downdrift, river-influenced to river-dominated locales. (Figure modified from Bhattacharya, J.P. and Giosan, L., 2003, Wave-influenced deltas: geomorphological implications for facies reconstruction: *Sedimentology*, v.50, p.187-210.)