The effects of tidal currents on asymmetric distributions of sediment, infauna and burrows along the Fraser River delta front, B.C.

K. Ayranci*, Applied Research in Ichnology and Sedimentology (ARISE) Group, Department of Earth Sciences, Simon Fraser University, 8888 University Drive, Burnaby, British Columbia, Canada, V5A 1S6

kayranci@sfu.ca

and

S. E. Dashtgard, Applied Research in Ichnology and Sedimentology (ARISE) Group, Department of Earth Sciences, Simon Fraser University, 8888 University Drive, Burnaby, British Columbia, Canada, V5A 1S6

Summary

The Fraser River delta is a tide-influenced, river-dominated delta that exhibits distinct asymmetry in the sedimentological, biological and neoichnological character between the updrift (south) and downdrift (north) delta front (< 150 m water depth). The updrift portion consists of heterolithic sand and mud beds and bedsets with low infaunal diversities and low bioturbation intensities (BI 0-3). Preserved sedimentary structures include parallel and low angle laminations, gas-escape structures, and soft-sediment deformation. The downdrift portion is composed of continuous muddy layers with more diverse infauna and a higher intensity of burrowing (BI 3-6). Where preserved, muddy sediments are parallel laminated, and show some soft-sediment deformation. This asymmetrical distribution of sediments and infauna is strongly controlled by the net northward flow of tidal currents on the subaqueous delta front and by seasonal variations in fluvial discharge.

The updrift and downdrift delta fronts are subject to different physical processes. Depositionally, the updrift delta front (UDF) is mainly an area of net erosion whereas the downdrift delta front (DDF) is an area of net sediment accumulation. The UDF experiences periodic slope failures due to erosion and over-steepening of the depositional slope. Sand material eroded from the UDF is transported to the prodelta via the main submarine canyon at the mouth of the main Fraser distributary, and does not reach the DDF. River-derived fine-grained sediment (silt and clay and lesser fine-grained sand) is either transported to the prodelta, or is carried north, downdrift, by strong tidal currents. The DDF is an area of net sediment accumulation where mud accumulates mainly by suspension settling (Hart and Barrie, 1995). This sediment is nearly exclusively derived from the Fraser River.

Compared to the UDF, the DDF shows a remarkable increase in biodiversity and trace diversity, indicating that the downdrift portion is more hospitable to infauna. The dominant control on trace-makers appears to be grain size, muddy substrates are more bioturbated, and possibly food resources, where finer grained sediment and organic matter is delivered by suspension settling. UDF sediments are mainly colonized by polychaetes and bivalves, and exhibit a low diversity suite of traces consisting of sporadically distributed simple vertical and horizontal burrows (e.g., *Planolites*, *Skolithos*, *Palaeophycus*, and *Cylindrichnus*), attributable to the *Skolithos* Ichnofacies. Holothurians, spatangoid sea urchins, polychaetes and bivalves are the main infauna on the DDF, and the neoichnology is characterized by a suite of robust, fully marine traces (e.g., *Rosselia*, *Asterosoma*, *Gyrolithes*, *Teichichnus*, *Scolicia*, *Artichnus*, *Arenicolites*, *Polykladichnus*, *Thalassinoides* and *Phycosiphon*), attributable to the *Cruziana* Ichnofacies.

The physical and chemical oceanographic properties, such as current velocity and salinity, suggest that the Fraser River discharge is dominantly hypopycnal and is restricted to the upper 5-10 m of the water column (within the zone of wave mixing). Given the dominant wind (and wave) direction is from the northwest, the river-derived stresses are typically effective on the updrift delta plain, and potentially on the updrift UDF to 15 m water depth. However, below storm-wave base, sediment deposition is highest on the DDF, and appears to mainly result from suspension settling. The DDF, below storm wave base, is well supplied with both fine-grained sediment and terrestrially deriver organic matter, and is not affected by the high turbidity and low salinity water concentrated in the zone of wave mixing and in the hypopycnal plume. This differs significantly from wave-dominated asymmetric deltas, particularly those that occur in shallow seas where wave activities can affect the entire delta front, and / or where the river discharge is homopycnal or hyperpycnal.

The asymmetry of the tide-influenced Fraser River delta is sedimentologically similar, but neoichnologically distinct from wave-dominated asymmetric deltas. In the wave-dominated asymmetrical delta model, the net longshore transport direction controls sediment dispersion, such that the DDF is dominated by river-derived sediment, and the UDF is dominated by alongshore transported sediment that is trapped updrift of the main distributary mouth (Bhattacharya and Giosan, 2003). Ichnologically, the UDF of asymmetric wave-dominated deltas is characterized by a relatively high density and diversity suite of trace fossils, and the DDF is characterized by a low density and diversity of trace fossils. For the tidally asymmetric Fraser delta, the UDF is sand dominated, experiences and has a limited diversity and density of bioturbation. The DDF is an area of net sediment accumulation of river-derived mud, and shows higher trace diversities and densities than the UDF. The sedimentological trends of the tidally asymmetric Fraser delta are similar to those of wave-dominated asymmetric deltas, but the ichnological character is reversed. In this case, the reversal of the ichnological trend is likely a function of the hypopycnal conditions of the river and the significant water depth into which the Fraser builds. The water depth is an order of magnitude greater than storm-wave base, and hence is mostly affected by tidal flows and not waves. The importance of this study lies in the fact that tide-influenced asymmetrical deltas are not restricted to any particular water depth; they can potentially develop in deep-water settings and therefore, may be more common than the wave-dominated asymmetrical deltas. Moreover, the nature of asymmetric delta must also account for the density contrast between the river discharge and the water in the receiving basin, as asymmetric deltas built at the mouths of hypopycnal rivers differ from homopycnal and hyperpycnal ones. In fact, it is possible that in settings, where the vertical thickness of an asymmetric delta exceeds storm-wave base, it is entirely possible that the upper and lower deltas front could exhibit distinctive sedimentologic and / or ichnologic trends.

References

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