Sedimentology and ichnology of inclined heterolithic stratification in a mixed tidal-fluvial setting: Middle Arm, Fraser River, British Columbia

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Summary

Inclined heterolithic stratification (IHS) is a common stratal architecture developed on bars in mixed tidal-fluvial channels, both in the modern and in the rock record. The dynamic interplay of hydrodynamic processes control deposition, and the sedimentological and ichnological character of IHS. This is indeed the case for the subequally mixed tidal-fluvial, Middle Arm of the lower Fraser River, British Columbia. Within the Middle Arm, three deposits were assessed, including a channel-margin deposit, an in-channel bar and a point-bar. The channel-margin deposit is located in the most upstream position, while the point bar is the furthest seaward. The dominant depositional process (e.g., tidal flow, fluvial flow) varies along strike, and is reflected in the sedimentology and ichnology of each bar deposit. The results of this study are considered as a process-response analog for IHS deposited in admixed tidal-fluvial environments.

Four sedimentological trends are identified that largely determine the character of IHS in the admixed tidal-fluvial Middle Arm. These trends can be used in concert to identify tidal versus fluvially generated IHS. (1) Grain size fines from medium- to coarse-grained sand in the middle of the channel to mainly mud on the flanks. (2) Intertidal zone and upper subtidal zone sediments are deposited in mm- to cm-scale, rhythmically alternating sand and mud beds (IHS), and this trend appears to continue to the lower bar. The distribution of sand and mud on the Middle Arm bars indicates that tidal cyclicity exerts a major control on deposition in this admixed tidal-fluvial system. (3) Surface samples from the intertidal zone indicate that mud dominates on the upstream and downstream ends of each bar and the center of each bar is sandy, such that bars exhibit a mud-sand-mud profile. (4) Muddy bedsets in the intertidal zone are laterally extensive for up to 1 km in the along-strike direction. The along-strike, lateral continuity of muddy bedsets is highest in the mixed tidal-fluvial system, where water is brackish, and decreases towards both the tide-dominated and fluvially dominated parts of the system.

In addition to the sedimentological trends defined above, the ichnology of the Middle Arm system reflect the relative salinity, and the persistence of salinity on each bar. In particular, burrow diversity and trace size increases in the seaward direction. On the landward bars, the trace assemblage consists of *Polykladichnus*, *Skolithos*, *Arenicolites*, *Siphonichnus* and *Palaeophycus*. On the most seaward bar,

large *Siphonichnus* burrows produced by bivalves are observed alongside the same traces found in more landward positions. The increase in salinity toward the marine basin is concomitant with an increase in trace diversity, degree of bioturbation, and an overall increase in burrow size. Ichnological trends must be correlated to grain size distributions, as the degree of sediment disruption from bioturbation correlates with grain size: muddier sediments display a higher degree of sediment disruption.

IHS developed on the admixed tidal-fluvial Middle Arm of the Fraser River, is a possible analog for selected McMurray reservoirs. The results from the Middle Arm indicate that it is possible to assess the degree of brackish water and tidal influence in paleo-bar deposits from the intensity and diversity of bioturbation. For reservoirs where the ichnology indicates an admixed tidal-fluvial environment, it is likely that the most sand-rich reservoir will be encountered in the middle of bars. However, mud beds were found to be mm- to dm-scale in thickness, and muddy bedsets are laterally continuous for up to a kilometer. The lateral continuity and thickness of mud beds and muddy bedsets in admixed tidal-fluvial systems suggests that these deposits are unlikely to be the best reservoirs.