The Development of Inclined Heterolithic Stratification in a Tidally Influenced, Fluvially Dominated River, Fraser River, British Columbia

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Introduction

Predicting the lateral and vertical extent of mud beds in hydrocrabon reservoirs comprised of inclined heterolithic stratification (alternating beds of sand and mud) is necessary to ensure the economic viability of resource extraction from these deposits. However, in core it is not possible to determine the continuity of mud beds and muddy successions because of limited data. This is not the case in modern settings. To assess the continuity of mud beds and mud-dominated units, a mid-channel bar (detached point bar - South Arm Marshes [Fig.3]) in the mesotidal reach of the Fraser River, British Columbia was studied (Fig.1). The distribution of sand and mud beds across the bar, and the sedimentological and ichnological character of these deposits, were determined by obtaining a series of vibracores, box cores, and grab samples. The overall point bar succession exhibits a fining-upward profile with an increase in mud-bed thickness from the shallow subtidal to the upper intertidal zone. Conversely, sand bed thickness decreases from the base of the channel upward. A fining-downstream trend is observed around the bar, due to an increase in mud-bed thickness in the downstream direction (Fig. 5, 6). A low diversity assemblage of diminutive infauna-generated burrows characterizes the ichnology of the system (Fig. 4). Where present, bioturbated horizons tend be rhythmic in nature, reflecting annual cyclicity in environmental stresses (i.e. Box core 5). Burrowing is limited to the muddy horizons, or extend down from muddy horizons into underlying sand beds. Burrow initiation in sand beds was not observed.

Sand is mainly transported in the late spring and early summer, when river discharge increases by nearly an order of magnitude due to the flood stage freshet induced by melting snow pack in the British Columbia interior (Fig. 2). Throughout the remainder of the year, relatively low flow conditions ensue, enabling the accumulation of fine-grained (muddy) sediments, and the establishment of stable brackish-water conditions. The latter is favourable for infaunal colonization.

The depositional model presented here may prove to be a useful tool for hydrocarbon exploitation by providing an analog model for predicting lithological heterogeneities (i.e. lateral and vertical extent of mud beds). Two locales where this data may be applied include NE British Columbia and the Nechako Basin. In NE B.C., Leckie et al. (1990) report estuarine/fluvial valley fill deposits in the Paddy and Cadotte Members. For the Nechako Basin, Goodin (2008) identified extensive deltaic deposits that represent deltaic sedimentation with a marine influence. Point bars developed in the lower delta plain would be attractive hydrocarbon targets that can be more easily explored for if their distribution can be predicted. This depositional model may also apply to other tidally influenced fluvial deposits in the rock record, such as the bitumen-rich McMurray Formation of the Western Canada Sedimentary Basin, Alberta.

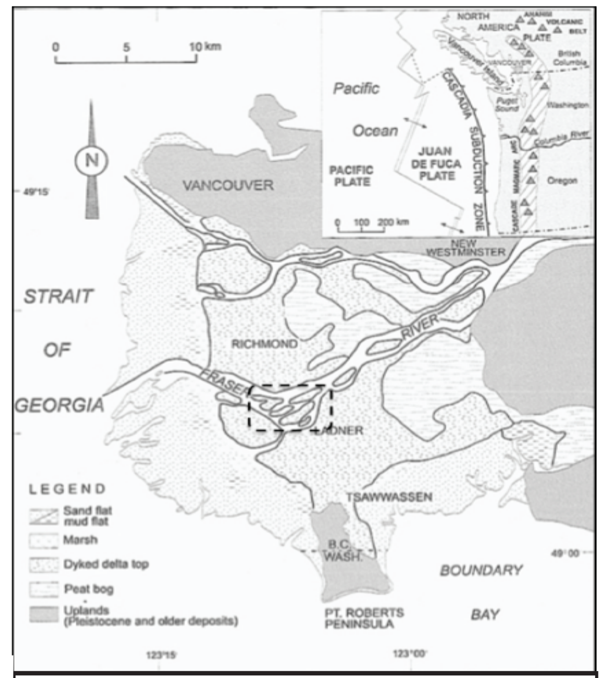


Figure 1 – Location and setting of the Fraser River Delta. Inset shows tectonic setting of western North America (triangles represent Quaternary volcanoes). Dashed box marks location of the South Arm Marshes (modified from Clague, 1998).

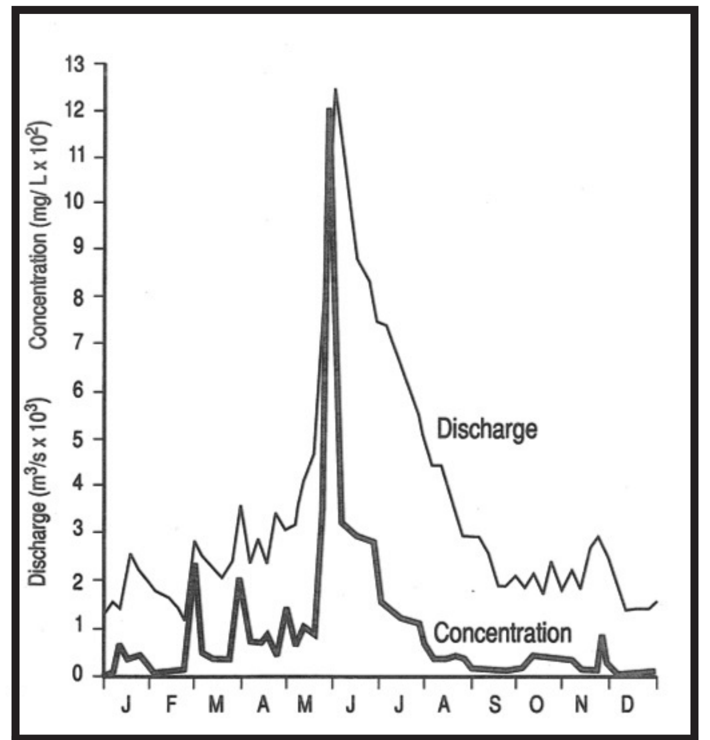
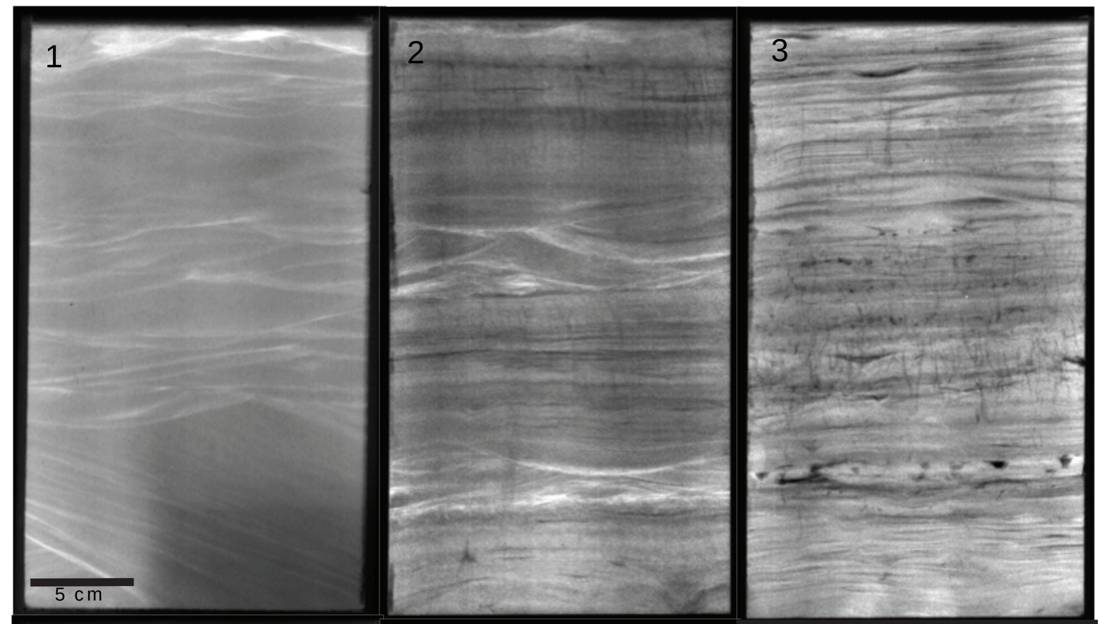


Fig. 2 – Daily mean discharge and suspended-sediment concentration for the Fraser River at Mission, 1986 (from Kostaschuk et al., 1998)

Figure 3 – Aerial view of study area. Black dots represent locations of box cores 1- 5, shown below.



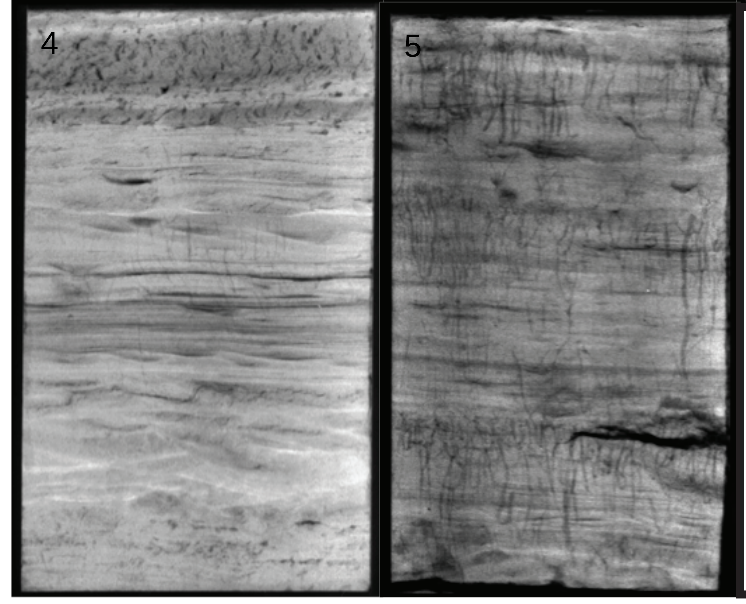


Figure 4 – X-ray images of box cores 1-5. Locations are shown in Fig. 3. X-rays are taken to provide detailed images of sedimentological and ichnological structures that would otherwise not be observable in the unlithified sediments. A transition from unbioturbated to thoroughly bioturbated is evident from box core 1 through box core 5. Box core 1, located on the upstream side of the bar, consists of sand and current generated bedforms. Box core 5 is much more heterogeneous, showing many fine mud lamina, and several bioturbated horizons.

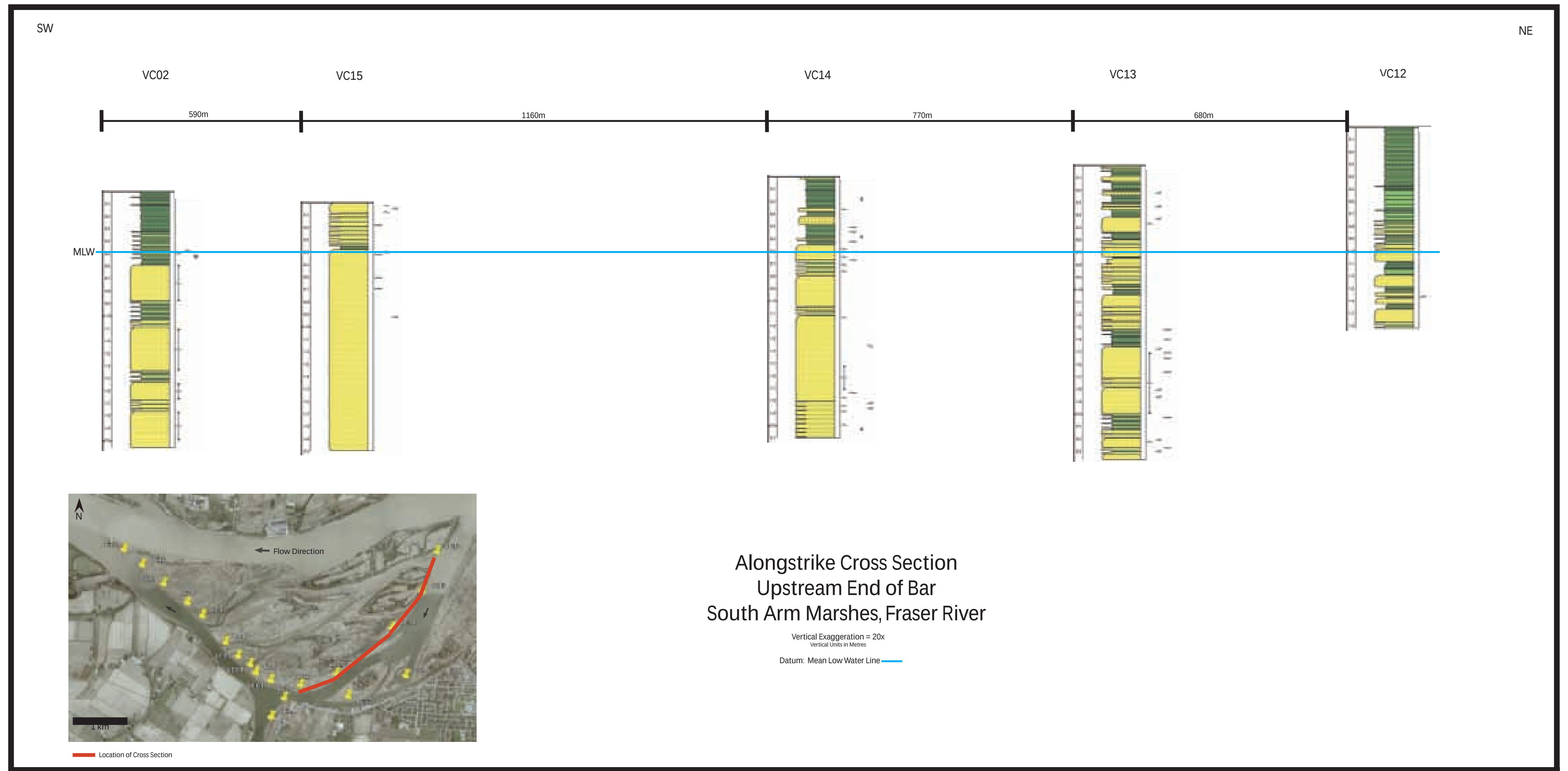


Figure 5 – Alongstrike cross section of upstream end of bar. Mud beds are shown in green, and sand beds are shown in yellow. Compared to the downstream end of the bar (below), the upstream end shows a higher proportion of sand.

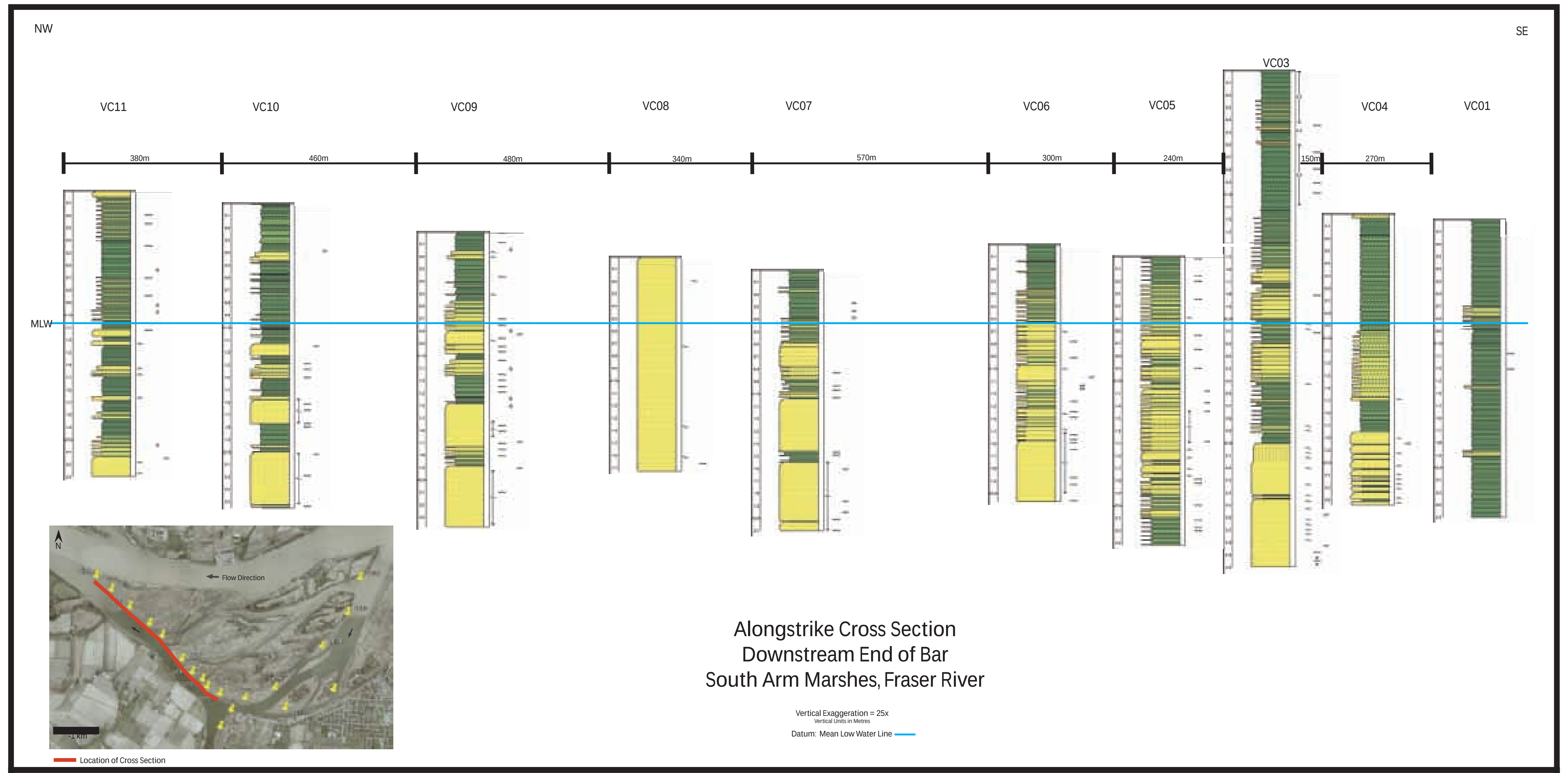


Figure 6 – Alongstrike cross section of downstream end of bar. Compared to the upstream end of the bar (above), the downstream end has a much higher mud proportion, as well as muc more laterally extensive mud beds.

References

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