Sedimentological and Neoichnological Trends in a Microtidal Barrier Island / Embayment System, New Brunswick, Canada

Tyler Hauck*
University of Alberta, Edmonton, AB
thauck@ualberta.ca

S. George Pemberton and Murray Gingras
University of Alberta, Edmonton, AB, Canada

and

Shahin Dashtgard
Simon Fraser University, Burnaby, BC, Canada

Summary

In the last half-century there has been a marked increase in the understanding of the facies architecture, stratigraphy, and sequence stratigraphy of transgressive incised-valley fill systems. This understanding has, in part, stemmed from and increase in the number of studies undertaken in recent estuarine environments along the world's coastlines. These studies facilitate the understanding of the distribution of facies in estuaries, and the physical and chemical processes by which these facies were deposited. Understanding the distribution of facies, and more specifically those of reservoir potential, is important in the search for hydrocarbons in estuarine deposits. This is especially critical considering that estuarine deposits within incised-valley fills account for an estimated 25% of off-structure petroleum plays in clastic reservoirs worldwide (Boyd et al., 2006).

In addition to recent sedimentological and geomorphological advancements to estuarine models, significant advances in the delineation of estuarine strata have been accomplished through ichnological and neoichnological studies. Estuaries comprise a distinct set of environmental conditions (i.e., those conditions associated with brackish-water settings) that act as significant limiting factors to infaunal colonizers. Through work in both ancient and modern estuarine deposits, it was recognized that brackish-water conditions result in distinct, recognizable, and recurring trace-fossil assemblages (Pemberton et al., 1982; Frey and Howard, 1986; Pemberton and Wightman, 1992; Wightman and Pemberton, 1997; Gingras et al., 1999; Pemberton et al., 2001). The studies resulted in the establishment of the brackish-water ichnological model that greatly aided in the predictability of estuarine facies in the subsurface, and has proven to be a very powerful tool in paleoenvironmental analysis of estuarine strata (MacEachern et al., 1999; Zonneveld et al., 2001; Buatois et al., 2002; Hubbard et al., 2004; Bann et al., 2004).

Modern neoichnological work has largely aimed at furthering the use of ichnology in paleoenvironmental analysis in settings characterized by large tidal ranges (i.e., meso- to

macrotidal regime; 2-4 m and >4 m respectively). This is because high amplitude tides expose large areas of intertidal substrate during low tides. In contrast, relatively few studies exist describing the distribution and type of bioturbation observed in microtidal systems (tide range less than 2 m). This has important implications, as microtidal wave-dominated environments are distinct geological phenomena, and thereby merit further neoichnological study.

This study focuses on microtidal wave-dominated brackish-water deposits in Kouchibouguac Bay, New Brunswick, Canada. Two field seasons involved the collection of tube and box cores taken from depositional sub-environments throughout the system. The cores were X-rayed to determine the types of burrows present and to estimate their relative abundances. In addition to the core data, burrow diameters and trace diversities were recorded throughout the bay (at fixed-station transects). Sediment was collected from each station for textural analysis and the assessment of total organic carbon. Resin casts provided three-dimensional burrow data.

The estuaries residing within Kouchibouguac Bay contain many elements that are typical of the wave-dominated end-member of Dalrymple et al. (1992). However, there exists variation in both the sediment texture and morphology of the estuary in comparison to the wave-dominated end-member, resulting primarily from low fluvial discharge (Fig. 1).

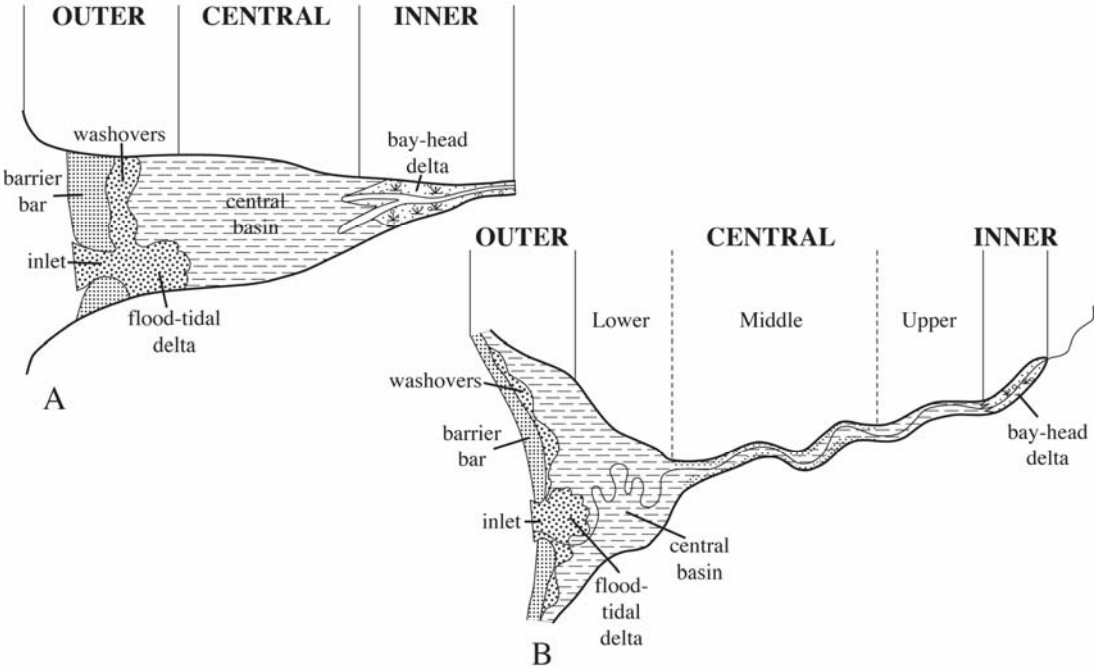

Figure 1: Morphological components typical of wave-dominated estuarine settings. A) Typical wave-dominated estuarine zonation consisting of a tripartite sand-mud-sand distribution. Modified from Dalrymple et al. (1992). B) Distribution of facies from estuaries in the wave-dominated Kouchibouguac Bay. The central estuary is further subdivided into the lower, middle, and upper due to significant textural variations therein.

Microtidal brackish-water deposits in Kouchibouguac Bay are complex, exhibiting a wide variety of subenvironments that contain characteristic bioturbate fabrics. Analysis of the distributions of sediments, TOC (total organic carbon), and infauna reveal that sediment texture and associated TOC levels are a strong control on the distribution of infauna, and, consequently, on the distribution and type of bioturbation observed in the system. In areas where salinity is mostly stable and relatively close to that of marine levels (such as the outer estuaries and lower central estuaries; Fig. 1), the distribution of infauna is dominantly affected by these two parameters. Further up the

estuaries additional parameters including lowered and fluctuating salinities, in addition to sediment texture and TOC content, control the distribution and diversity of infauna.

The activity of infauna typically destroys all primary sedimentary structures in the central estuary (Fig. 2). In the outer estuary the barrier complex, most notably the tidal inlets and flood-tidal deltas, experience strong currents, attributable to waves and tides. The inner estuary near the bay-head deltas experiences riverine currents and freshwater influences. As a consequence, primary sedimentary structures are preserved in these two areas. In the outer estuary, hydrodynamics limit infauna colonization, whereas lack of bioturbation in the inner estuary is predominantly the result of reduced and fluctuating salinities.

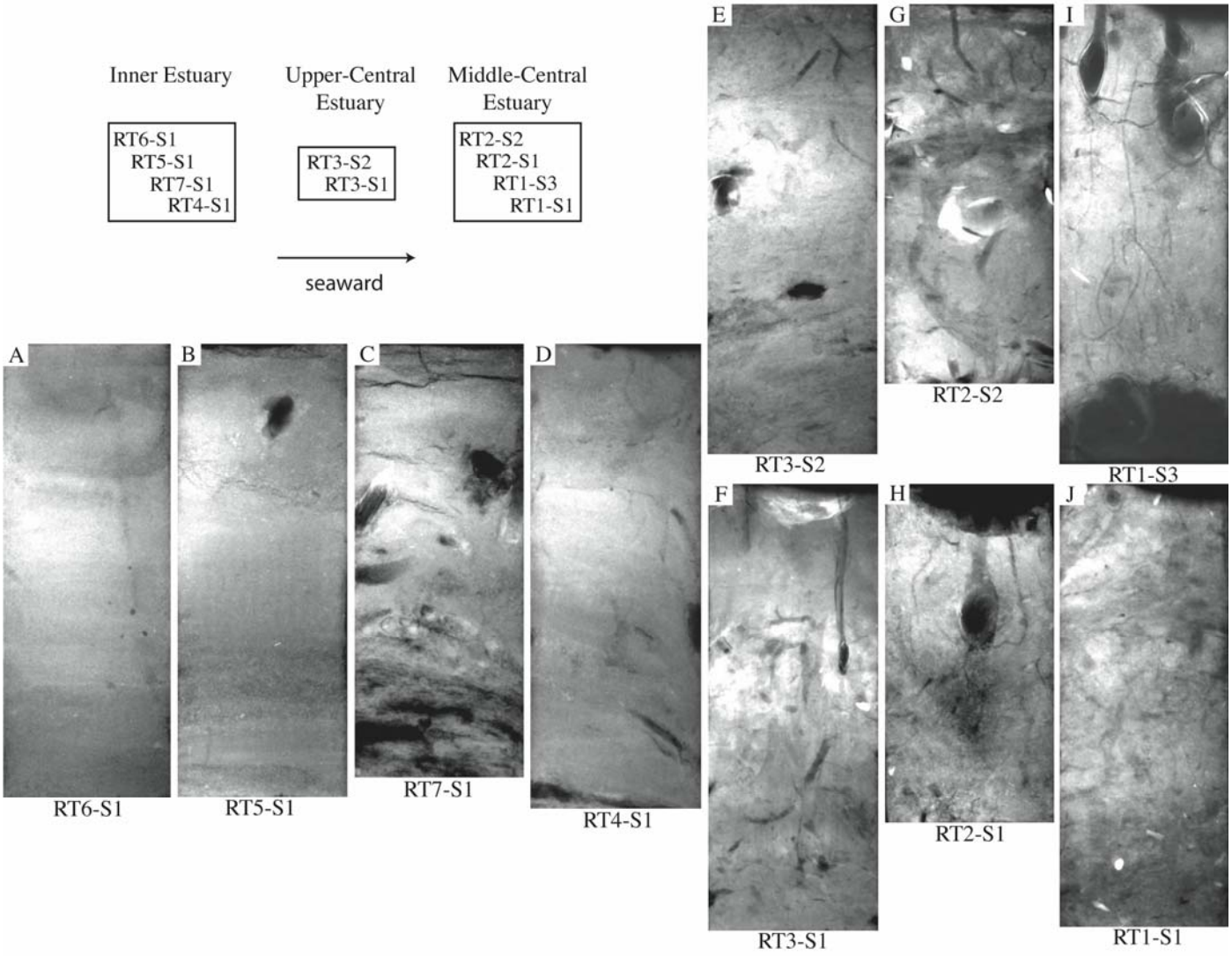

Figure 2: Subaqueous tube cores taken from the estuary funnel (middle-central estuary to inner estuary) of one of the estuaries in Kouchibouguac Bay. Notice the gradual decrease in bioturbation, and the concomitant preservation of primary sedimentary structures.

Notable trends within the system include: 1) benthic invertebrates in the system comprise a low diversity of mostly marine faunas with locally very high densities of individuals; 2) deposit feeding is the dominant behavior in the system, with an increase in filter feeding in subenvironments characterized by substantial sand fractions; 3) the diversity of benthic organisms and vermiform size

decreases gradually in a landward direction; and, 4) primary sedimentary structures are best preserved at the landward (inner estuary) and seaward (outer estuary) extremes of the system.

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