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RECOGNIZING TIDE-DOMINATED VERSUS TIDE-INFLUENCED DELTAS: MIDDLE DEVONIAN STRATA OF THE BALTIC BASIN

KATI TÄNAVSUU-MILKEVICIENE AND PIRET PLINK-BJÖRKLUND
Department of Geology and Geological Engineering, Colorado School of Mines, Golden, Colorado 80401, U.S.A.
e-mail: ktanavas@mines.edu

ABSTRACT: **This paper examines the differences between tide-dominated and tide-influenced deltas, as well as tide-dominated deltas and tide-dominated estuaries. The deltaic deposits of the Middle Devonian Kernave and Aruküla formations were documented in cores and outcrops in the Baltic Basin and interpreted as tide-dominated delta deposits. These tide-dominated deposits consist of three vertically stacked progradational to aggradational packages, 20–40 m thick. Each package consists of two stratigraphic intervals. The lower upward-coarsening interval contains seaward-accreting prodelta to distal tidal-bar and proximal tidal-bar deposits. The upper upward-fining interval consists of tidal-flat deposits and minor tidal gully, distributary-channel, supratidal muds, and paleosol deposits. The overall character of these delta deposits indicates a subaqueous delta with no river-dominated delta-plain. Comparison of these successions with modern and ancient tide-dominated and tide-influenced deltas suggests that tide-dominated deltaic deposits tend to form in conditions of relative sea-level rise succeeding transgressions, when tidal currents are strong enough to redeposit most river-derived sediments. Tide-dominated deltas form subaqueous deltas, where the bulk of the deposits are tidally reworked. In contrast, tide-influenced deltas contain tidal indicators in delta-front and lower-delta-plain deposits, whereas the upper delta plain is river-dominated. Our data suggest that tide-dominated deltas may change into tide-influenced deltas during delta evolution when they prograde to the mouth of the restricted or funnel-shaped bay, given the rate of fluvial sediment supply exceeds the rate of accommodation increase.**

INTRODUCTION

Most of the largest modern rivers feed tide-dominated or tide-influenced deltas (e.g., Saito et al. 2001; Hori et al. 2002a, 2002b; Lambiase et al. 2003; Roberts and Sydow 2003). Tide-dominated and tide-influenced deltas are also described in the ancient record (e.g., Mellere and Steel 1996; Willis et al. 1999; Kitazawa 2007); however, some ancient tide-dominated deltas have been interpreted as estuary deposits (see Walker 1992; Willis and Gabel 2003) or as shelf sand ridges (see Nio and Yang 1991a; Willis et al. 1999). In recent years, details of tide-dominated delta depositional systems and deltaic architecture have been documented (Hori et al. 2002b; Dalrymple et al. 2003; Dalrymple and Choi 2007), but most data on tide-dominated deltas have been derived from modern environments.

The term tide-dominated delta has been more widely used only during the last decade, especially in modern deltaic successions (e.g., Harris et al. 1993; Saito et al. 2001; Hori et al. 2002a, 2002b; Dalrymple et al. 2003; Choi et al. 2004; Heap et al. 2004), and less frequently applied to interpret ancient deltaic deposits (e.g., Mellere and Steel 1996; Willis and Gabel 2003; Kitazawa 2007). Differentiation between modern tide-dominated and tide-influenced deltas is based on deltaic morphology. Modern tide-dominated deltas possess a straight, funnel-shaped geometry such as the Fly River delta in Papua New Guinea (Dalrymple et al. 2003), or in the Changjiang (Yangtze River) delta in China (Hori et al. 2002b). Modern tide-influenced deltas form morphological features that are generally more similar to river- or wave-dominated deltas than tide-dominated deltas, as in the Song Hong delta in Vietnam (Hori et al. 2004) or the Mahakam delta in Indonesia (Storms et al. 2005).

In ancient deposits, differences between tide-dominated or tide-influenced deltas can be difficult to recognize. In this paper, deltas are called tide-dominated when tidal facies dominate, and tide-influenced when fluvial or wave-generated facies dominate and tide-generated facies are subordinate. However, this definition is not widely accepted.

The Kernave and Aruküla formations of the Middle Devonian Baltic Basin documented here are dominated by gradationally based tidal-bar and tidal-flat successions that fine seawards into prodelta muds. Only in rare places do channel deposits and paleosols occur. This is in contrast to the earlier documented, younger tide-influenced Gauja Formation deltas from the Baltic Basin, where fluvial facies dominate and consist of different types of distributary-channel fills that grade seaward into tide-influenced mouth bars and prodelta muds (see Pontén and Plink-Björklund 2007). Although tidal influence has been documented throughout the Gauja deltaic succession, only in a few places do tide-dominated facies associations occur. The documented Kernave and Aruküla formations are also distinctly different from the older Pärnu Formation tide-dominated estuarine deposits of the Baltic Basin, where the sediments fine into the estuarine system from both ends, the tidal bars are sharply based, and the prodelta muds are lacking (see Tovmasyan 2004).

In this paper, we contrast tide-dominated and tide-influenced deltaic successions and document the specific criteria for recognizing tide-dominated deltas from other tide-dominated deposits, such as estuaries. We discuss whether the tide-dominated and tide-influenced deltas may represent different stages of deltaic development and what conditions are likely to cause the transition from tide-dominated to tide-influenced deltas. This study is limited to tide-dominated, tide-influenced, and river-influenced deltas only.

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