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Tides and deltaic morphodynamics

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Tide-dominated and tide-influenced deltas are not widely recognized in the ancient record, despite the numerous modern and Holocene examples, including eight of the twelve modern largest deltas in the world, like the Ganges–Brahmaputra, Amazon, Chang Jiang, and Irrawadi. Furthermore, tide-dominated or tide-influenced deltas are suggested to be more common in inner-shelf or embayment settings rather than close to or at a shelf edge, primarily because wave energy is expected to be higher and tidal energy lower in outer shelf and shelf-edge areas. Thus, most shelf-edge deltas are suggested to be fluvial or wave dominated. However, there are ancient examples of tide-influenced shelf-edge deltas, indicating that the controls on tidal morphodynamics in deltas are not yet well understood.

This paper asks the following questions: (1) How do tides influence delta deposition, beyond creating recognizable tidal facies? (2) Does tidal reworking create specific geometries in delta clinoforms? (3) Does tidal reworking change progradation rates of deltas? (4) Is significant tidal reworking of deltas restricted to inner-shelf deltas only? (5) What are the conditions at which deltas may be tidally influenced or tide-dominated in outer-shelf areas or at the shelf edge? (6) What are the main morphodynamic controls on the degree of tidal reworking of deltas?

The paper utilizes a dataset of multiple ancient and modern deltas, situated both on the shelf and shelf edge. We show that beyond the commonly recognized shore-perpendicular morphological features and the recognizable tidal facies, the main effects of tidal reworking of deltas are associated with delta clinoform morphology, morphodynamics of delta lobe switching, delta front progradation rates, and the nature of the delta plain. Strong tidal influence is here documented to promote subaqueous, rapid progradation of deltas, by efficiently removing sediment from river mouth and thus reducing mouth bar aggradation and fluvial delta plain construction rates. Such subaqueous progradation of the delta front is decoupled from shoreline progradation. The delta plain of such tide-dominated deltas consists of a few distributary channels and tidal flats on top of the emerged tidal bars. The delta front clinoforms become gentler and longer, as ebb tidal currents together with river effluent efficiently transport sediment to the basin. Tide-dominated deltas tend to maintain a funnel shape and show low lobe switching rates, compared to fluvial-dominated and tide-influenced deltas. The funnel and thus river mouth position is further stabilized by fine-grained sediment accumulation on marginal tidal flats due to the flood current sediment transport. However, all these effect weaken as the deltas prograde to the shelf edge, due to the loss of vertical (and lateral) restriction and tidal amplification. Here significant tidal reworking tends to be restricted to topographic irregularities, caused by incision, delta-lobe or mouth bar deposition and avulsions, or tectonic processes. The role of such topographic restrictions is twofold, by reducing wave energy and amplifying tidal energy.