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The role of receiving basin substrate cohesivity in delta morphodynamics

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Deltas are home to hundreds of millions of people worldwide and form a key part of many coastal environments. Due to their low elevation, many deltas are threatened by sea level rise as well as direct human influences on flow, sediment delivery and subsidence. The calibre and cohesivity of river sediment have both been shown to be important factors in determining the erosion, deposition and stability regimes within a delta system. However, the influence of the receiving basin substrate characteristics is poorly constrained. It has been shown that basin substrates composed of finer sediment lead to more incisive channel. However, the exact controls of substrate characteristics on delta morphology and morphodynamics has not been quantified.

This paper presents an investigation of the effects of receiving basin's grain size and cohesivity on the morphodynamics of evolving deltas, especially the ability of distributary channels to migrate or avulse after incising into the substrate as the delta progrades. Numerical experiments were conducted where the evolution of deltas was modelled in the Delft3D modelling suite. Fluvial discharge was varied between 10^2 and $10^5 m^3 s^{-1}$ and basin floor cohesive sediment fraction was varied from 0 to 100%. In further modelling, the volume of sediment fluxed to the delta is systematically reduced from an initial state to assess the relative effects of sediment flux and basin substrate characteristics. Results suggest that increasing cohesive sediment fraction of the receiving basin substrate leads to lower numbers of bifurcations (a reduction of approximately two thirds between 13% and 87% cohesive sediment). Data on bifurcation mobility were extracted from model outputs to explore 1) how higher cohesive sediment fraction in the basin substrate leads to a change in the behaviour of the delta distributary network and 2) how this affects the morphodynamic and sedimentological evolution of deltas. The results also show how a reduction in sediment input to the delta exacerbates the influence of the receiving basin characteristics on the size and shape of the delta system.