The Effect of Sediment Cohesion on Delta Morphology

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Among the variables thought to control the morphology of deltas, sediment size and vegetation type have received less attention than waves, tides, and river discharge. Here we investigate the effect of sediment cohesion on the shapes, number of active distributaries, and wetland areas of river-dominated deltas using Delft3D v. 3.28, a morphodynamic model. Thirty experiments simulate self-formed delta growth from a sediment-laden river entering a standing body of water devoid of waves, tides, and buoyancy forces. At the inlet boundary a steady, uniform discharge of 1000 $m^3 s^{-1}$ carries both cohesive silt and noncohesive sand grains, each in equilibrium concentrations. To test the effect of cohesion on delta morphology we varied the cohesiveness of the sediment, or its resistance to erosion, and the relative flux of cohesive to noncohesive sediment.

Results show a variety of self-formed deltas are generated by the same three processes observed in field-scale deltas: 1) channel bifurcation around stagnant river mouth bars; 2) subaqueous dissection of the mouth bar and the levees; and 3) subaerial channel avulsion. Furthermore, the partitioning of discharges down distributary arms by bed adjustments at bifurcations produces discharge ratios between bifurcate channels that are similar to field deltas. Bird's foot-like deltas with rugose shorelines and rough floodplains are created at high total cohesion because levees aggrade rapidly, confining the flow, leading to rapid channel progradation. Fan-like deltas with smooth shorelines and floodplains are created at low total cohesion because levees are easily incised and the flow is more uniformly distributed over the delta topset. Deltas with a high number of simultaneously active distributary channels are created at intermediate total cohesion because that maximizes the number of channel-creating processes. Because vegetation generally acts as a cohesive agent, our results imply that Martian deltas and Earth's deltas deposited prior to the Devonian should exhibit more fan-like characteristics with fewer channels. Furthermore, current efforts to restore wetland habitat by diverting flows and sediment should consider sediment cohesion as an important variable. The resulting sediment mixture will control the shape of the deposit, its length of shoreline, and the number of channels.