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Detailed Anatomy and Evolution of a West African Channel-Levee System: Response to Changing Bathymetry and Gravity Flow Processes

A large 3-D seismic volume was used to dissect a 55 km segment of the Benin-major channel-levee system located on the mid-slope of the western Niger Delta. The system consists of a prominent erosive base (erosional fairway) bordered by outer levees that developed during the passage of large, erosive flows. Although older and much smaller, a 38 km segment of the adjacent Benin-minor channel-levee system shows remarkable similarities in its early history. Both systems responded in similar ways to down-slope changes in the gradient profile, regardless of differences in scale and age. The depth of incision of the erosional fairways increases across bathymetric highs and decreases within intervening lows. Correspondingly, the crest thickness of contemporaneous outer levees shows an inverse linear relationship with the depth of incision of the erosional fairway (i.e. where the erosional fairway is most deeply incised, the outer levees are thinnest, and vice-versa). At Benin-major, these elements confine a channel-belt consisting of stacked sinuous channels bordered by inner levees that developed during the passage of smaller, under-fit confined flows. The aggradation rate of these stacked channels varies through time and with distance along the system. For example, the youngest channels in the proximal study area aggraded rapidly with a progressive increase in sinuosity through time. In contrast, time-equivalent channels in the distal study area show an abrupt decrease in aggradation rate and sinuosity, accompanied by incision. The change in channel behaviour in the distal study area probably reflects late movement on a structural high accompanied by an up-dip migrating knickpoint that created 3 meander cut-offs.