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Threefold dynamics of delta progradation revealed by the Holocene record of the Po River plain, Italy

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The Middle to Late Holocene sedimentary evolution of the Po River plain, in Northern Italy, records a complex pattern of coastal progradation and delta upbuilding that took place following sea-level stabilization, starting around 7.7 cal ky BP. During this period, the Po River delta prograded approximately 60 km seawards, reaching 30 m in thickness. Above a condensed offshore succession, individual parasequences stack and shingle to form a complex aggradational to progradational (highstand) systems tract that exhibits a characteristic coarsening-upward pattern from muddy prodelta facies to heterolithic and sandy, delta-front deposits. Unique sedimentological, paleoecological and geochemical features were used to distinguish and diagnose environments within predominantly muddy successions (proximal prodelta, mudbelt, sediment-starved shelf. Sedimentological changes in homogenized muddy intervals were tracked using changes in the meiofauna (benthic foraminifers and ostracods) and mollusk content. Geochemical proxies were used to constrain changes in sediment dispersal pathways through time.

A characteristic three-stage progradation model was reconstructed for the Po Delta system. At the turnaround from retrogradation to progradation, between 7.7 and 7.0 cal ky BP, thin (< 5 m) sand bodies with a mixed, freshwater and brackish fauna reflect bay-head delta progradation into shallow estuarine environments (Stage 1). The filling of the estuary took place following a 5 km-long bay-head delta progradation. Po Delta progradation initially occurred in relatively shallow waters, less than 10 m deep (Stage 2 – 7.0–1.5 cal ky BP). The early phases of Po Delta progradation were driven by autogenic factors, including shifting of distributary channels, local subsidence and sediment compaction. Multiple flooding surfaces in delta-plain facies successions reflect the development of wide, flat embayments, with frequent salinity oscillations. Po River was the main sediment delivery agent supplying sand to the bay-head delta and to early delta development. The abrupt shift of the delta in a southward position, between 2.8-1.5 cal ky BP, is constrained by the development in the study area of wave-dominated parasequences, with strong evidence of longshore (Alps supplied) sediment delivery and fossil assemblages diagnostic of nearshore settings. With continuing subsidence, the final stages of progradation saw the upbuilding of the faster prograding, modern, river-dominated Po Delta into significantly deeper (up to 25 m) waters (Stage 3 – 1.5 cal ky BP–Present). River-dominated deltaic parasequences indicate very high sedimentation rates and are typified by fossil assemblages indicative of highly-stressed conditions.

Through genetical subdivision, compositional characterization, and stratigraphic correlation of a variety of muddy facies, we reconstructed an evolutionary scenario of coastal progradation that reflects the heterogeneity of the offshore environment and its relation with more proximal depositional environments (i.e, estuary). The implications of this threefold progradation model can be prospecting for shale hydrocarbon resource development of mud-dominated systems.