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High-resolution facies analysis and sequence stratigraphy of fluvio-deltaic depositional systems in tectonically-active basins (Jean Baptiste Lamarck Medal)

E. Mutti
University of Parma, Italy

In ancient tectonically-active basins fed by relatively small and high-gradient rivers, both marine and lacustrine fluvio-deltaic systems display similar vertical stacking patterns which are primarily controlled by high-frequency variations of sediment flux to the basin. These variations are superimposed over higher-order cycles of tectonic uplift and relative quiescence recorded by changes in the source areas, basin configuration and overall style of sedimentation.Spectacular examples of these cyclically stacked successions crop out in the upper Cretaceous and Paleogene deposits of the south-central Pyrenean foreland basin. Similar stacking patterns are also common in other basins (e.g., the Jurassic-Cretaceous Nequen basin, Argentina and the Tertiary Piedmont Basin, northwestern Italy).

Sediment flux to the sea controls the high-frequency stacking pattern of ancient fluvio-deltaic depositional systems through cyclic variations in flow efficiency which is mainly a function of the magnitude and sediment concentration of river outflows during floods. These variations result in periods of inertia- and friction-dominated jet flows followed by periods during which fluvial activity dramatically decreases. These cyclic variations, which are ultimately controlled by climate and baselevelchanges (Milankowitch cycles), are recorded by m- to dam-thick facies successions that can be interpreted as the basic "building block" (in sequence-stratigraphic parlance) of larger-scale depositional sequences.

Inertia-dominated periods are characterized by large-volume highly erosive hyperpycnal flows typically containing abundant skeletal debris and mudstone clasts. These flows bypass river mouths and carry sand tonearshore and shelfal regions forming m-thick packets of tabular graded sandstone beds with HCS alternating with muddier facies. These sandstones, which extend up to several km in shelfal regions and grade distally into prodeltaic sediments, are a typical and volumetrically dominant deltaic element herein referred to as "flood-generated delta-front sandstone lobes". Their facies tracts closely resemble those observed in deep-water turbidites. Unfortunately, because of the presence of HCS, these shallow-marine sediment gravity flow deposits have been and are still commonly mistaken in most literature for "storm-dominated" shoreface deposits.

Friction-dominated periods are expressed by mouth-bar progradation produced by river outflows of limited volume and efficiency that dissipate their energy at river mouths and are thus able to carry seaward only their fine-grained sediment load through buoyant plumes and dilute hyperpycnal flows.

When rivers dramatically decrease their activity, fluvio-deltaic systems aggrade through marine mudstone facies that pass landward into flood-plain mudstones with paleosols.

Marine diffusion processes are restricted to local tidal reworking that occurs in river mouth regions and, more extensively, in large estuaries where fluvial processes mix with strong tidal action during early periods of base-level rise. Following decreased river activity, carbonate deposition may locally occur forming generally thin units at the top of fluvio-deltaic sandstones.

Several problems arise as to the sequence stratigraphic interpretation of these fluvio-deltaic systems and their cyclic stacking patterns. In particular, these problems concern the significance of the "shoreface" and "parasequence" concepts that can be misleading if not viewed within a robust framework of stratigraphic and faciesconstraints.