

Stratigraphic architecture of a steeped basin-margin during an early post-rift transgression

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The syn- to post-rift transition phase is a key stage in rift basin evolution, with the establishment of narrow structural shelves prior to their evolution into sedimentary shelves on passive margins. However, little is known about the process interactions that control the distribution of sand-rich accumulations during post-rift healing of inherited stepped slope profiles. We investigate a rare example of an exhumed stepped slope system that developed during the syn- to post-rift transition in the southern Neuquén Basin, Argentina. The study area comprises three volcanic syn-rift sub-basins (5-8 km long, 3-4 km wide) filled with an Early Jurassic shallow- to deep-marine succession (Lower Cuyo Group). The subbasins were partially connected along a 27 km long proximal-to-distal slope transect, and their stratigraphic variability is constrained using 10 long (250-450 m), high-resolution (1:25 scale) measured sections, within which we identify 10 facies associations.

During the late syn-rift stage, alluvial and shallow-marine, mixed clastic-carbonate successions developed on footwall highs or growth fold limbs in proximal sub-basins, passing downdip into fine-grained mud-rich offshore transition successions in distal subbasins. In distal sub-basins, the early post-rift stage is marked by extensive calcareous carbonaceous-rich mudstone deposition (40-70 m thick), which records long-lived sand-starvation during coeval submergence of proximal sub-basins. Through time, sand-prone turbidity currents reached the distal sub-basins, depositing thick (70-230 m) sand-rich packages comprising lobes and small channel-fills, which are texturally “dirty” and immature at base and pass upward into cleaner sandstone. These are time-equivalent to more condensed, thinner (maximum 160 m), very clean and mature sand-rich lobe-prone successions in proximal sub-basins. These relationships suggest that initially immature sands was fed to distal sub-basins from flows that were able to bypass the stepped slopes, while clean mature sand remained trapped in proximal sub-basins in shallow-marine settings, and a subsequent supply of cleaner sand-rich material from proximal to distal sub-basins with establishment of routing pathways that linked the subbasins.

The Lower Cuyo Group is interpreted as a transgressive succession deposited with increasing accommodation during relative sea-level rise and high sediment supply. Analysis of sediment distribution, transport directions and retrogradational stacking pattern reveals a dominant control by physiographic changes in slope morphology inherited from subdued rift structures prior to linkage of the sub-basins. Textural and compositional characteristics of sandstone deposits highlight interactions between sediment gravity flows and inherited structural relief, which can be used as analogues to predict the location and reservoir quality of sand-rich accumulations across steeped slope systems in subsurface rift basins.