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Multi-scale influence of topography on shallow-marine successions associated with long-term transgressions

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Thick shallow-marine successions associated with long-term transgressions are less well known than their thin, well-sorted counterparts, widely studied due to their potential to form good reservoirs. In these successions, particularly in storm-dominated examples, bioturbation can obliterate primary sedimentary characteristics, making stacking patterns and sequences difficult to define, and challenging our understanding of the main controls in their resulting depositional architecture. This study presents an example from the Jurassic of the Neuquén Basin (Argentina), with the aim to: a) refine the depositional model of a thick, shallow-marine succession associated with a long-term, early post-rift transgression, b) constrain multi-scale controls on stratigraphic architecture and lateral facies variability, and c) discuss their preservation and response to post-depositional processes. To do this, a <300 m-thick succession has been studied along a >10 km continuous exposure, with mapping, sedimentary logging and correlation of stratigraphic units, integrated with subsurface, biostratigraphic and ichnological data. The succession shows an overall retrogradational-aggradational-retrogradational stacking pattern, with several higher frequency regressive units (parasequences and parasequence sets, PSS). The lower part (PSS I) comprises laterally-discontinuous (10's of m) mouth-bars and distributary channel fills, dominated by several m-thick coarsening- and fining-up sandstone packages and m-scale erosive conglomeratic lenses. Above these, the succession (PSS II-IV) is composed by laterally-continuous (>100's of m) storm-dominated lower-shoreface to upper-offshore deposits, dominated by <1m-thick fine-grained and highly bioturbated tabular muddy sandstones and sandy mudstones, with rarely-preserved HCS and bioclastic-rich limestones; their internal characteristics and bed boundaries are diffuse due to pervasive bioturbation, suggesting overall low sedimentation rates and recurrent periods of colonization. The coarse-grained nature and lithology of the mouth bars and channel fills in the lower succession (PSS I) are consistent with a proximal sediment source, associated with erosion of intra-basinal highs. Its variable thickness, lateral distribution and onlap against underlying syn-rift deposits demonstrates partial infill of localized higher-accommodation areas. The well-sorted and finer-grained nature of the shoreface-offshore strata the middle and upper succession (PSS II-IV) indicates a more mature, distal source, with sediment redistributed by longshore currents, and then intensely bioturbated. These deposits display well-defined parasequences internally composed of laterally-continuous bedsets (<5 m-thick). They extend along the entire study area, but show a significant vertical thickness variability. The integration of outcrop and subsurface data mapping (well and seismic) reveals this variability records the stratigraphic response of transgression over a complex, regional-scale ramp-step and underfilled rift topography, which controlled the location of main thickness and facies changes, and promoted areas of favored biogenic reworking. This study offers new insights in how to interpret thick transgressive successions based on primary depositional mechanisms and postdepositional processes, and provides useful tools to understand and predict the nature and potential preservation of these deposits in limited subsurface datasets.