Syn-depositional tectonic controls on the internal architecture of a mid-Pleistocene depositional sequence (Mejillones Formation, northern Chile)

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Introduction

Early sequence stratigraphic models predict that the internal organisation of depositional sequences is controlled by the complex interplay of changes in accommodation at the shoreline (including eustasy and vertical tectonic movements) and sediment supply. However, while the way in which accommodation changes along the depositional dip of a subsiding basin margin has been fully documented, comparatively less attention has been paid to the effects on stratal architecture of local basin factors, such as eventual along-strike changes in accommodation in response to shoreline-perpendicular faulting (e.g., Gawthorpe et al., 1994; Hodgetts et al., 2001). The high-resolution sequence-stratigraphic analysis of young successions where all the variables influencing sequence development, such as basin-physiography, plate tectonic setting, rates and magnitudes of glacio-eustasy, and sediment supply are well constrained, provides an excellent opportunity to evaluate their effective control on stratigraphic architecture (e.g., Saul et al., 1999; Cantalamessa and Di Celma, 2004; Di Celma et al., 2005) and remains an area of broad interest in the basin analysis.

In the Mejillones Formation, a shallow-marine Pleistocene succession of the Mejillones Peninsula, northern Chile (Fig. 1), the cyclic stratigraphic record is the result of the complex interaction of regional uplift, glacio-eustasy, local tectonics, sediment supply, and sedimentary processes. Stratal geometries, characteristics of sedimentary facies, and nature of sequence-bounding unconformities have been investigated to evaluate the influence of intrabasinal, normal faulting on both along-strike variations in sequence architecture and genetic complexity of sequence boundaries.

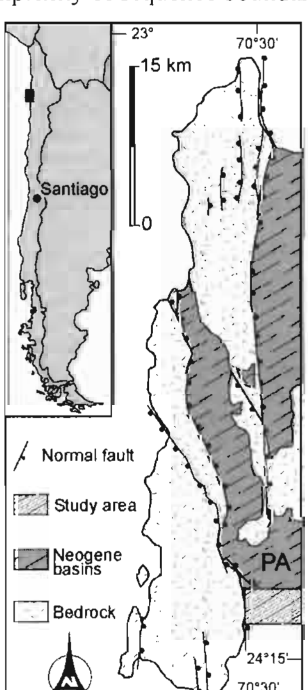

Figure 1. Schematic geological map of the Mejillones Peninsula. PA, Pampa del Aeropuerto

The Mejillones Formation has been studied at Pampa del Aeropuerto, the southern end of the Mejillones Peninsula, and particularly along the sea-cliff of the Moreno Bay where the Plio-Pleistocene infill of a halfgraben basin is excellently exposed (Fig. 2A). At this site, the sedimentary succession consists of the shallow-marine, late Pliocene La Portada Formation (Ibaraki, 2002) unconformably overlain by the mid-Pleistocene, mollusc-bearing Mejillones Formation (Ortlieb et al., 1996). In particular, based on absolute dating, Ortlieb et al. (1996) ascribed the sediments of the Mejillones Formation at the top of the sea-cliff (the object of this study) to the marine isotope stage 9. At Pampa del Aeropuerto, the entire basin fill is dissected by Pleistocene, small-displacement normal faults which strike NW-SE and NNW-SSE (Armijo and Thiele, 1990), that is obliquely with respect to the E-W and ESE-WNW oriented Pleistocene palaeo-shorelines. The high-resolution sequence stratigraphic model developed for the Mejillones Formation is based upon the recognition of key stratal surfaces, facies shifts, and facies stacking patterns derived from outcrop-based interpretation. Albeit incomplete, the sequence can be divided into a transgressive systems tract (TST) and a falling-stage systems tract (FSST), which have been erected according to the four-fold systems tract division proposed by Plint and Nummedal (2000) (i.e. the upper sequence boundary is the subaerial unconformity located at the top of the falling-stage systems tract).

Results

The sequence-stratigraphic analysis revealed that systematic variations in architecture and nature of bounding surfaces of the Pleistocene sequence exist across normal faults. Depending on position with respect to them, two basic types of internal organisation can be recognised. In hanging-wall sections the sequence consists of a lower-shoreface, siliciclastic-rich transgressive systems tract (TST), which is bounded beneath by a transgressively modified, *Glossifungites*-demarcated sequence boundary (SB/RS) and overlain by a mollusc-bearing falling-stage systems tract (FSST) developed within a beachface setting. The downlap surface that separates the TST from the FSST is the regressive surface of marine erosion (RSME). On the footwall crests the sequence lack of the TST and consists solely of the FSST. In this case the FSST rests abruptly upon the underlying Pliocene sediments and is underlain by a tectonically enhanced unconformity composed of the RSME superimposed onto the previous SB/RS (SB/RS/RSME). The prominent lateral change in component units (systems tracts) and nature of bounding surfaces within the studied sequence seems to be directly related to the presence of normal faults. If so, it suggests that sequence architecture and nature of bounding surfaces reflects not only eustasy and sediment supply, but also local fault-controlled, short-term creation and loss of accommodation space.

Figure 2B shows a model that may help to explain variations in sequence architecture across normal faults in response to locally varying accommodation. At time T1, during a rapid sea-level rise and landward migration of coastline, the subaerial surface of exposure (SB) was eroded and replaced by a *Glossifungites*-demarcated RS (coplanar SB/RS). At T2, as transgression proceeded, new accommodation was created, more sediment was added to the rock record, and a relatively thin TST was deposited. At such time, incremental fault movement resulted in uplift of footwall blocks and subsidence of hanging-wall blocks. Extensional subsidence rates exceeded regional uplift rates so that hanging-wall undergone net subsidence. During the succeeding phase of sea-level fall, accommodation was progressively destroyed in response to base-level lowering. Wave scouring in front of the advancing shoreline cut the antecedent fault-generated sea-floor morphology and the poorly

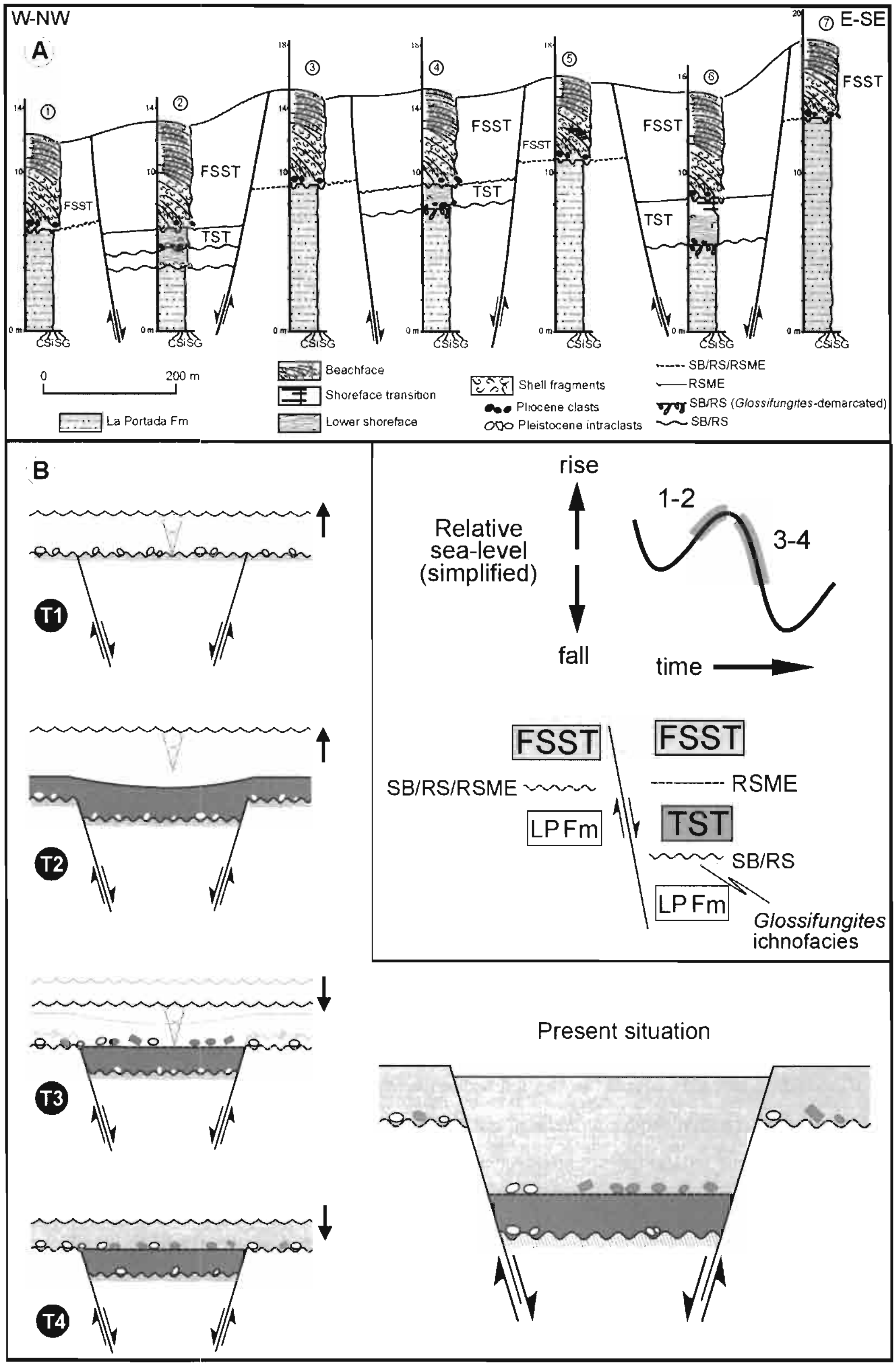

Figure 2. Depositional strike-oriented correlation panel of the studied section showing a synthesis of distribution and architecture of systems tracts both at the hanging-wall and footwall of the secondary normal fault system. B) Generalised model (not to scale) illustrating the possible sequence of events in origin of the observed along-strike variation in facies distribution. The relative sea-level oscillation and the component architectural elements are shown within the inset. See text for discussion.

consolidated, recently deposited sediments were quickly eroded, leaving a coarse pebble- to cobble-grade intraclast lag on the unconformity surface (RSME) (T3). Under these circumstances, depending on the hanging-wall or footwall setting, two different sequence architectures were generated. At the hanging-walls, because of net subsidence, wave scouring attained a position that was relatively shallower than that reached during transgression, so that only part of the TST was eroded during formation of the RSME. At the same time, the positive surface relief of footwall highs start being eroded, reworked, and removed by wave scouring until the floor was reduced to the same level as that in the hanging-walls. However, because of the relative uplift of footwall blocks, this position was deeper than that reached during transgression. Consequently, the entire TST and part of the underlying Pliocene bedrock were eroded from the crest of footwalls, forming a tectonically enhanced, coplanar regressive surface of marine erosion and sequence boundary (SB/RS/RSME). As a result, in hanging-wall sections the FSST directly overlies the TST, whereas in footwall sections the FSST rests directly on Pliocene sediments of the La Portada Formation. At T4, beachface deposits filled the new accommodation created landward of the contemporary RSME and prograded.

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