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Long-term tectonic influence on sequence architecture and stacking pattern revealed by hiatal shell bed features: Pleistocene succession of the Canoa Basin (central Ecuador)

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Introduction

Taphonomic and paleoecological analyses of condensed shell concentrations may provide a means of identifying discontinuities and stratal surfaces where these are obscure (e.g., Beckvar and Kidwell, 1988). In recent years several authors have highlighted the importance, in conjunction with traditional lithofacies analysis, of taphonomic and paleoecological criteria in outcrop-based sequence stratigraphic studies. These allow for better resolution of sequence subdivisions of siliciclastic successions, and identification of their internal architecture at a more detailed scale than possible with sedimentary facies alone (e.g., Abbott and Carter, 1994; Naish and Kamp, 1997; Carter et al., 2002; Di Celma et al., 2002; Cantalamessa et al., 2005). This is particularly true for Plio-Pleistocene successions where, generally, a very large number of taxa recovered from the fossil assemblages are still extant and, therefore, significant and reliable details of their ecology are more easily available.

Based on outcrop data from the southern coast of Cabo San Lorenzo (Ecuador) (Fig. 1), facies, shell bed features, and sequence stratigraphic framework for the shallow-marine Pleistocene upper Canoa and Tablazo Formations are presented (Fig. 2). Sediments of this succession exhibit a distinct cyclic pattern consisting in a stack of eight depositional sequences likely developed under the main control of orbitally-induced sea-level changes. The large-scale stratal architecture of the entire succession has been strongly influenced by the continuous uplift of the Cabo San Lorenzo area. Each successively younger sequence dips to the south-southwest at a shallower angle from a maximum of 5° for the oldest to 1° for the youngest, clearly indicating synsedimentary tilting and depocentre migration. This pattern generated discernible discordances between successively younger depositional sequences and a remarkable southward expansion of the basin-fill associated with the southward divergence of sequence-bounding unconformities. As a rule, within the studied interval an idealized sequence is composed of a transgressive (TST) and a highstand (HST) systems tract, whereas deposits attributable to the lowstand and falling-stage systems tracts are missing. Transgressive lithosomes may be defined by estuarine deposits interposed between the sequence boundary and the ravinement surface (back-barrier wedge) and by upward fining shoreface to inner-shelf facies successions above the ravinement (backstepping shelf wedge). Separated by an expanded siliciclastic core, hiatal shell concentrations occur at the base (onlap shell beds, OSB) and the top (backlap shell beds, BSB) of the transgressive shelf wedges and, sometimes, at the base of the highstand systems tracts (downlap shell beds, DSB). The primary and specific aims of this study are: (1) to understand how the shoreline configuration influenced shell bed features, the nature of other architectural elements and, consequently, the internal architecture of depositional sequences; (2) to provide new insights into the control played by synsedimentary tectonic mechanisms on the shoreline configuration and the vertical arrangement of shallow-marine clastic sequences.

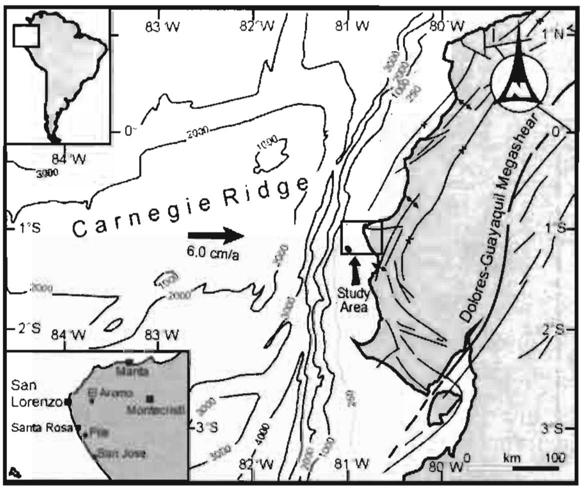

Figure 1. Structural map of the Ecuadorian coast showing position of the study area (boxed part) with respect to the place where the Carnegie Ridge impinges on the Ecuador Trench

Influence of the coastline configuration on the internal anatomy of depositional sequences

Several factors, such as rate of relative sea-level rise, coastline configuration during transgression, and the volume and grain size of sediment supplied, influence the thickness, grain size, sedimentary structure, grade of bioturbation, taphonomy, palaeoecology and other features of OSBs. Among all, coastline configuration acts as an important factor in that it controls local energy conditions on which depends the efficiency of sediment bypassing and therefore the net sedimentation rate at the shoreline. Onlap shell beds form above the storm-wave base during transgressions and, because of the high environmental energy of this setting, commonly are sedimentologic accumulations developed by the extensive reworking of autochthonous communities under sediment bypass conditions. Nevertheless, within the upper Canoa Fm OSBs are infaunal-dominated community beds associated with shoreface sediments. The absence of primary sedimentary structures, entirely removed by the intense bioturbation, and the accumulation of infaunal-dominated community shell concentrations, argues for sediment deposition within relatively sheltered shorefaces where wave action and, consequently, sediment bypass were minor. Unlike sequences of the upper Canoa Fm, those of the Tablazo Fm are dominated by OSBs formed through repeated reworking within high-energy settings and suggest accumulation within more exposed, storm-influenced shorefaces, where wave action and sediment bypass were more intense. The existence of these two well-distinguished energy regimes within the sequences of the upper Canoa and Tablazo Formations is also confirmed by the different set of component facies, and the type of vertical transition that exists, within the late transgressive sediments, between the normally supplied nearshore facies and the overlying sediment starved, inner-shelf BSBs. The gradual transition recorded within the sequences of the upper Canoa Fm reflect reduced wave energy and, possibly, higher rates of sediment supply whereas the sharp, erosive transition recorded within the cyclothems of the Tablazo Fm, reflect more energetic, stormy inner-shelf settings accompanied by formation of an erosive local flooding surface (LFS). Such vertical changes in geometric features and mode of shell concentration both in shoreface and inner-shelf settings, is clearly due to the progressive uplift of the Canoa Basin and the consequent formation of a less deeply embayed, more exposed configuration by successive interglacial coastlines.

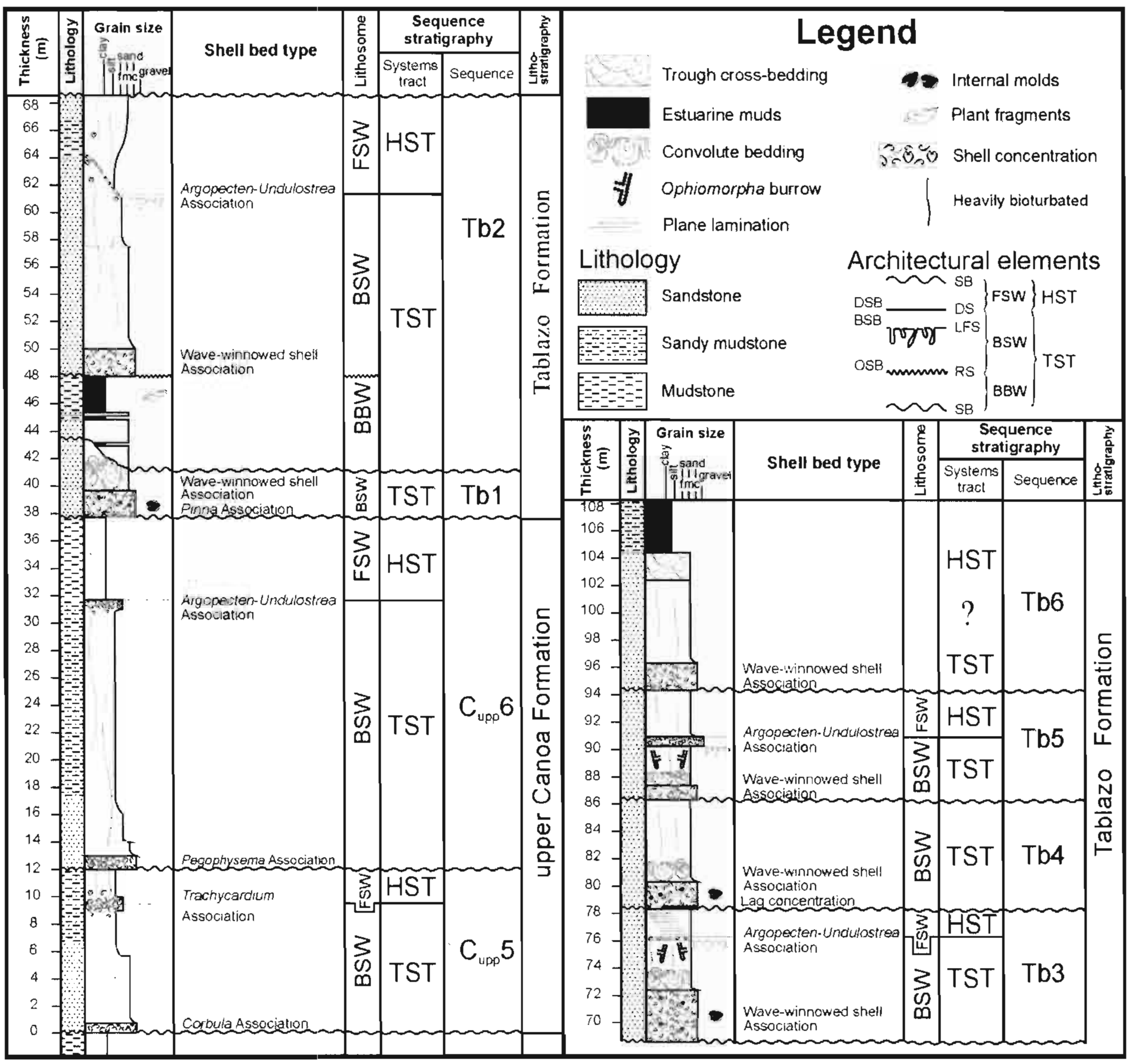

Figure 2. Composite stratigraphic section compiled for the Pleistocene sedimentary succession exposed between El Mangle (Pile) and Rio Callejon (San José). The eight depositional sequences identified are subdivided in the component systems tracts. BBW, back-barrier wedge; BSW, backstepping shelf wedge; TST, transgressive systems tract; HST, highstand systems tract.

Sequence pattern through time

The stratal architecture of the eight depositional sequences described in this paper and the way they are stacked, provide a record of the dynamic interplay of high-frequency sea-level changes, tectonism, changing shoreline configuration, and sediment supply. At a multi-cycle time scale, tectonics influenced the long-term trend of the relative sea-level changes and, consequently, the large-scale stratigraphic organization, which displays a distinctive stacking pattern. The seaward and downward retreat of successive maximum flooding shorelines, as well as the progressive increase in grain size of the sedimentary facies encasing the BSBs (i.e. compared to those of the upper Canoa Fm, BSBs of the Tablazo Fm accumulated in a more proximal setting), suggest that the sequence set represents a falling-stage sequence set. The long-term trend of relative sea-level fall that has driven the forced regression is the product of tectonic deformation in the San Lorenzo area. This requires syn-sedimentary uplift that progressively subtracted accommodation for sediments from north to south, and produced a southward divergence of sequence-bounding unconformities, the progressive rotation of the older sequences, and hence the stratigraphic expansion of the succession in this direction.

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