EVOLUTION OF THE CRETACEOUS CELICA-LANCONES FOREARC BASIN (NW PERU-SW ECUADOR)

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INTRODUCTION

The Celica-Lancones Basin is located in the present-day forearc zone of Southern Ecuador and Northern Peru (Fig. 1). It is characterized by unusual turbiditic series of Cretaceous age. According to the authors, this basin has been interpretad as an extensional basin (Kennerley 1973), an aborted marginal basin (Aguirre 1992), or a transcurrent forearc Basin (Jaillard et al. 1999). New observations presented here support the latter interpretation and suggest that the evolution of this forearc zone was controlled by the convergence regime.

STRATIGRAPHY AND GEOCHEMISTRY

The Celica-Lancones Basin is bounded to the Southeast by a volcanic arc (Celica Fm, San Pedro Gp), and to the Northwest by the Amotape-Tahuin Paleozoic Massif. Two series may be distinguished (Fig. 2).

To the Southeast, the Celica-San Pedro volcanic rocks are mostly of Albian age, but their upper part yielded Early Cenomanian faunas (Reyes and Caldas 1987, Carlier pers. com.). Their geochemistry is marked by depletion in Nb, Ta and Ti, and concentrations in Th, which indicate a volcanic arc affinity (Reynaud 1996, Fig. 3). These volcanic facies laterally grade NW-ward into volcaniclastic, high-density turbidites (Lancones, Alamor Fms, Reyes & Caldas 1987, Jaillard et al. 1999). Intercalated volcanic rocks exhibit volcanic arc affinity, and include dacites marked by high LREE and high Sr/Y relation, suggesting an adakitic nature (Reynaud 1996, Fig. 3). In the northeastern part of the Basin, thin-bedded alternations of black shales and fine-grained greywackes yielded Late Cenomanian-Turonian inoceramids (Jaillard et al. 1999).

This deformed and eroded Albian-Turonian series is unconformably overlain by a transgressive marine series (marls, limestones, sandstones), the base and top of which yielded Early Campanian, and Late Campanian ammonites, respectively (Jaillard et al. 2002). It is overlain by coarse-grained fan conglomerates ascribed to the Late Campanian-Early Maastrichtian (Fig. 2). They are unconformably overlain by latest Maastrichtian to Paleocene subaerial volcanic rocks (Sacapalca Fm, Hungerbühler 1997, Fig. 2) of continental volcanic arc affinities (anomalies in Nb, Ta and Ti, Reynaud 1996, Fig. 3).

To the Northwest, the Paleozoic Amotape-Tahuin Massif is unconformably overlain by transgressive beds, which are, from base to top : (i) undated sandstones and conglomerates, (ii) massive, fossiliferous shelf limestones, locally interbedded with volcanic tuffs and conglomerates, grading into black laminated limestones of Middle Albian age, (iii) laminated black shales and fine-grained volcanogenic turbidites of Middle to Late Albian age (Huasimal Fm), (iv) a coarsening upwards turbiditic sequence of arkosic to volcaniclastic composition (Copa Sombrero Gp, Olsson 1934), the top of which yielded an ammonite of Late Albian age (Fig. 2). Volcanic tuffs are locally known between (i) and (ii) (Puyango). Although reflecting heterogeneous sources (MORB to EMII types), scarce lava flows interbedded in the Copa Sombrero Gp exhibit volcanic arc affinity (Ethien 2000, Fig. 3). Since fossils of Early Coniacian age have been mentionned (Reyes & Caldas 1987), deposits of that age may be locally preserved beneath the overlying unconformity.

Along the Basin axis, from Chiclayo to Chaguarpamba, and West of Lancones, this series is intruded by large volumes of gabbros and minor diorites of Santonian-Campanian age (86-82 Ma, Mourier 1988, Alemán pers. com.). Geochemical and isotopic data (Pb, Sr, $\varepsilon Nd \approx 0$) indicate a depleted source contaminated by continental crust or sediments, suggesting that they result from partial melting of the forearc mantle (Ethien 2000).

The deformed and partly eroded turbidites and gabbros are unconformably overlain by a latest Cretaceous marine series which comprises, from base to top : (a) transgressive, shallow marine arkosic or calcareous beds overlain by black shales and siltstones of Middle to Late Campanian age (Jaillard et al. 2002), (b) undated, thick quartz-conglomerates of shoreline environments (Monte Grande Fm, Olsson 1934), and (c) black shales and medium-bedded quartz-turbidites of Early Maastrichtian age (Fig. 2). In the Pazul area (NW Peru), these are overlain by marine fossiliferous beds of Paleocene age (Balcones Fm), and the succession ends up with unconformable, coarse-grained quartz-conglomerates of latest Paleocene-Early Eocene age (Mogollón Fm), overlain by the Eocene marine deposits of the Talara Forearc Basin (Morales 1993).

TECTONIC EVOLUTION AND GEODYNAMIC INTERPRETATION

The Early Albian is marked by the beginning of the Celica-San Pedro volcanic arc activity. Therefore, the Cretaceous Celica-Lancones Basin can be unequivocally interpreted as a Forearc Basin (Fig. 1).

Scattered, **bimodal** volcanic manifestations of Early Albian age (Puyango) may be related to the extensional opening of the Celica-Lancones Basin. Subsidence of the Basin increased in the Middle Albian. Unpublished seismic lines (Alemán pers. com.) indicate that WNW-trending, S-ward dipping normal faults controlled the extension and turbiditic sedimentation (102-96 Ma). This evidence of a roughly trench-parallel extension, together with the rhombic shape of the Celica-Lancones Basin, strongly suggests that it is a pull-part basin, related to the NNE-ward, trench-parallel migration of the Amotape-Tahuin forearc sliver.

Remnants of Cenomanian-Turonian fine-grained deposits suggest that tectonic activity significantly decreased between 96 and 89 Ma. Around 84 Ma, basic intrusions emplaced in the center of the basin and along a suture line joining its NE and SW tips. They are regarded as resulting from the adiabatic partial melting of the forearc mantle (Ethien 2000), due to significant crustal thinning in the center of the Basin, and to the play of the Cross-Basin Fault Zone (suture) that achieves the evolution of pull-apart basins (Dooley & McClay 1997).

The Campanian unconformity (≈84-80 Ma) seals the Late Cretaceous deformations. In the northern part of the basin, the deformation is dominated by NNW-ward thrustings, associated with ENE-trending isoclinal to cylindrical folds. In Peru, seismic data suggest that the Albian normal faults were slightly inverted, provoking the formation of mild, basin-scale, ENE-trending folds. Progressive discordances in the overlying deposits indicate that similar mild deformations continued during the Late Campanian-Maastrichtian (80-69 Ma). Moreover, the Pazul area is a WNW-trending syncline, which results from the Late Paleocene deformation phase, since it involves Paleocene beds and is sealed by unconformable conglomerates of Early Eocene age.

These observations suggest that the Late Cretaceous-Paleocene evolution of the Celica-Lancones Basin was dominated by trench parallel stress regimes, *i.e.* in Albian-Santonian times, NNE-trending extension related to wrench motions, and NNE-trending compression during Campanian-Paleocene times. Conversely, Paleocene-Eocene deposits are only deformed by NNE-trending folds, indicating that post-Paleocene deformations are dominated by an East-trending, trench-normal contractional regime, without significant wrench movements.

This change in the stress regime of the forearc zone coincides with a drastic change in the oceanic convergence in the Late Paleocene. About 58 Ma ago, the convergence of the oceanic plate abruptly changed from a North- or NNE-ward direction, to a NE-ward direction (e.g. Pardo-Casas & Molnar 1987).

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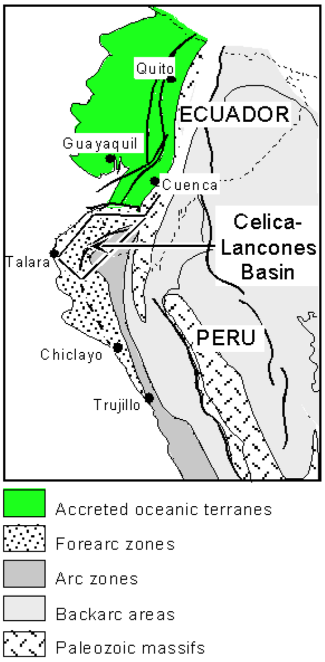

Fig. 1: Location of the Celica-Lancones Forearc basin

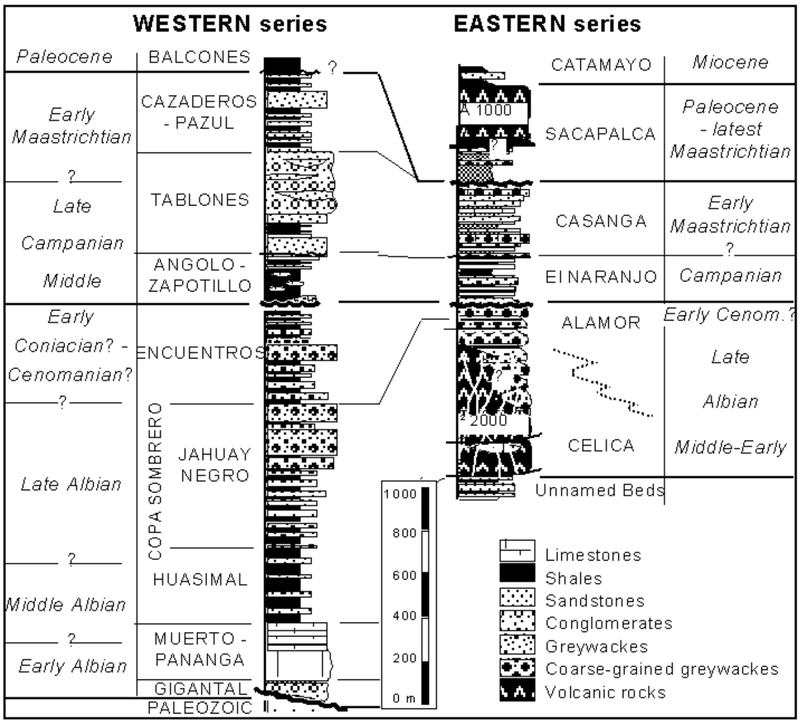

Fig. 2: Stratigraphic successions of the Celica-Lancones Basin (after Jaillard et al. 1999)

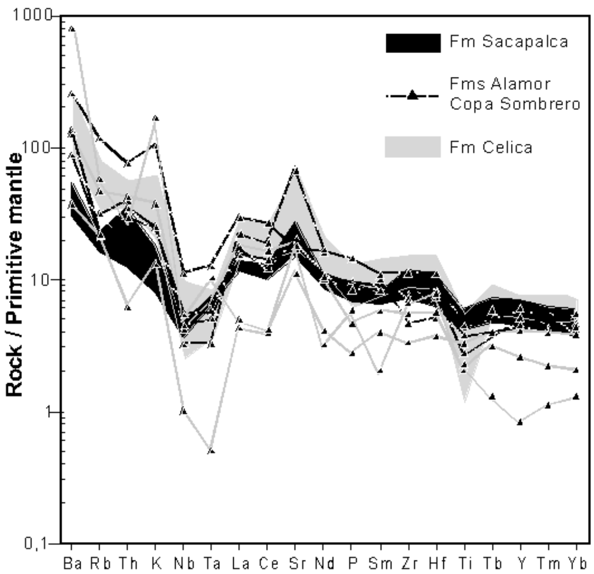

Fig. 3: Spiderdiagram of the Cretaceous-Paleocene volcanic arc rocks of the Celica-Lancones Basin (after Mamberti unpubl., Reynaud 1996, Ethien 2000)

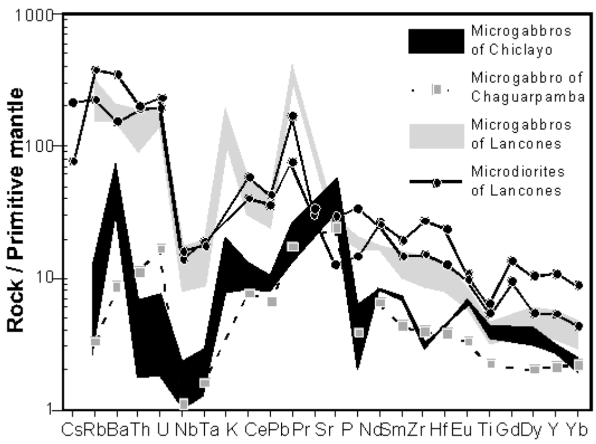

Fig. 4: Spiderdiagram of the Santonian-Early Campanian plutonic rocks of the Celica-Lancones Basin (after Ethien 2000)