LATE CRETACEOUS TO EOCENE TECTONIC-SEDIMENTARY EVOLUTION OF SOUTHERN COASTAL ECUADOR. GEODYNAMIC IMPLICATIONS.

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RESUMEN : La parte Sur de la Costa de Ecuador (Península) experimentó dos fases tectónicas mayores en el Paleoceno superior y Eoceno inferior respectivamente, desconocidas más al Norte (Costa s.s.). La primera corresponde a la colisión de la Péninsula contra la margen continental, mientras que la segunda representaría su acreción con la Costa. Luego, el conjunto cabalga la margen andina en el Eoceno superior. Dichos eventos acrecionarios coinciden con fases tectónicas conocidas en todos los Andes.

KEY-WORDS : Late Cretaceous, Paleogene, Andean margin, Oceanic terranes, Accretion.

INTRODUCTION

Coastal Ecuador is interpreted as an oceanic terrane accreted to the Andean continental margin by Late Cretaceous or Early Tertiary times. This has been confirmed by paleomegnetic studies that evidenced a 70 ° clock-wise rotation of its Northern part (Roperch et al. 1988). As a consequence, the sediments of Coastal Ecuador must have recorded the main geodynamic events occurring along the subduction zone. The sedimentologic and tectonic study of these series has been undertaken, in order to understand the subduction and accretion history of the Andean margin during Late Cretaceous and Paleogene times, and to attempt correlations between the early Andean tectonic phases and the geodynamic processes.

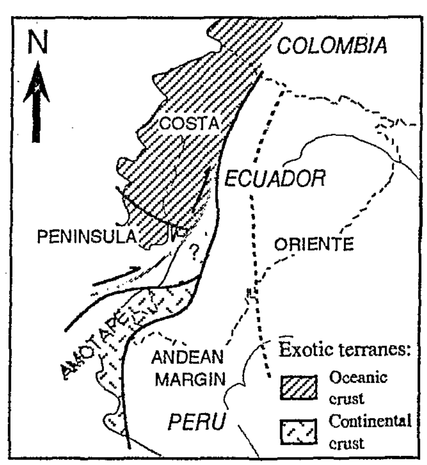

Fig. 1: Location sketch.

GEOLOGICAL SETTING

Southern Coastal Ecuador is usually subdivided into two zones separated by the Chongón-Colonche Fault (C-C Fault), thus considered as a major paleogeographic feature. North of the C-C Fault, the Chongón-Colonche Cordillera (C-C Cordillera) is characterized by the lack of late Paleocene-early Eocene deposits, whereas the Santa Elena Peninsula (Peninsula) is marked by a thick turbiditic sedimentation of Paleocene age. Coastal Ecuador is considered as having been accreted to the Andean margin by early Tertiary times (Feininger & Bristow 1980).

At the beginning of this century, the discovery of small Oil fields in the SE Peninsula motivated the paleontological study of the Late Cretaceous-Paleogene sediments of Southern coastal Ecuador. These works, combined with the well data obtained in the 30-40s by different Oil Companies, led to the statement of local, often contradictory stratigraphic models. Some stratigraphic synthesis were then attempted (Marchant 1956, Canfield 1966). In the 70s, in the light of the Plate Tectonics concepts, the age contradictions, the scarcity of the outcrops and the tectonic complexity led some authors to interpret this zone as the result of a giant olistostrome of late Eocene age, involving all kind of older rocks (Colman 1970, Bristow & Hoffstetter 1977, Feininger & Bristow 1980). More recently, ecuadorian geologists interpreted these series, again regarded as a normal stratigraphic succession, as a stack of thick turbiditic sequences (Benitez et al. 1986).

SEDIMENTARY AND TECTONIC EVOLUTION OF SOUTHERN COASTAL ECUADOR

Late Cretaceous- Early Late Paleocene. The basement of Coastal Ecuador is made up of early Cretaceous basalts (Piñon Fm), interpreted as an oceanic floor. It is overlain by Cenomanian (?) to Coniacian siliceous shales, pelagic limestones and fine-grained turbiditic grauwackes (≈ 200 m, Calentura Fm, Amoco 1991). These are followed by a thick series of coarse-grained volcaniclastic turbidites of Santonian to Campanian age, that would result from the erosion of an Eastern volcanic arc (≈ 2000 m, Cayo Fm, Benitez 1990-91). These formations crop out in both sides of the C-C Fault. The Cayo Fm grades upward into fine-grained pelagic black shales, cherts and tuffs, with few limestones beds of Maastrichtian to early Thanetian age (≈ 500 m, Guayaquil Fm, Amoco 1991, fig. 2).

South of the C-C Fault, the Santa Elena Fm, dated as Maastrichtian and Paleocene (Jaillard et al. 1992), is stratigraphically equivalent to the Guayaquil Fm (fig. 2). It is affected by roughly E-W trending tight overfolds (fig. 3), associated with penetrative E-W-trending, S-dipping axial plane cleavage, and with numerous shear plane indicating Northward thrust movements. Although no relative chronology has been firmly established, it seems that these structures comprise early 110-trending folds and later N 70-trending ones (fig. 3). The lack of any deformations North of the C-C Fault indicates that the two domains were still far from each other at this time (Jaillard et al. 1992).

The nature of both the basement and the sedimentary cover indicates that Coastal Ecuador was an oceanic basin during this period.

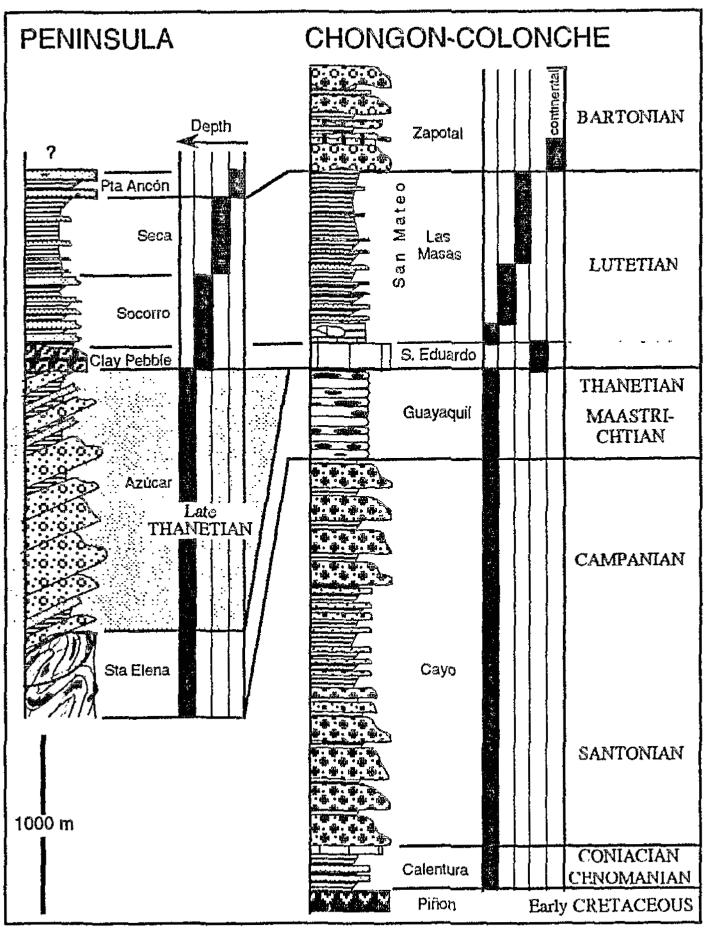

Fig. 2: Stratigraphy of the series of Southern Coastal Ecuador.

Late Paleocene-Early Eocene. Deposits of late Paleocene age are known only South of the C-C Fault. The deformed Santa Elena Fm is capped by a thick series of coarse-grained high-density turbidites (≈ 1500-2000 m, Azúcar Gp, fig. 2), which contains clasts of Quarz, metamorphic rocks, and of the Santa

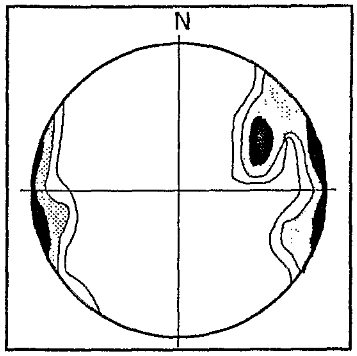

Fig. 3: Fold axis of the early deformations of the Peninsula.

Elena and Guayaquil Fms. Part of the deformation thus occurred during Late Paleocene times. The irruption of continent-derived clastic material in the oceanic basin indicates that the Late Paleocene phase is the result of the collision of the Peninsula with the Andean continental margin (Jaillard et al. 1992).

The widespread early Eocene sedimentary gap in Coastal Ecuador is most probably due to a new tectonic phase of latest Paleocene to earliest Eocene age. As a matter of fact, the report of early Eocene fauna (Small 1962) within lignite-bearing sandstones and shales (Atlanta Fm) in wells of the Ancón Oil field (Marchant 1956) suggests that this time-span is a period of erosion and local subaerial deposition. Moreover, the late Paleocene turbidites (Azúcar Gp) are often deformed by N 70-trending tight folds with steep-deeping axial planes, which are unknown in the Eocene deposits. Finally, in the Talara Basin of Northwesternmost Peru, coarse-grained polygenic conglomerates of early Eocene age disconformably overly fine-grained Paleocene marine black-shales. Note that on the Eastern part of the C-C Cordillera, late Paleocene and early Eocene deposits are locally represented by a few meters of transition beds between the Paleocene pelagic cherts (Guayaquil Fm) and the mid-Eocene transgressive limestones.

The early Eocene tectonic phase could correspond to the acretion of the Peninsula to the C-C Cordillera, since the subsequent deposits are rather comparable at both side of the C-C Fault (see below).

Lutetian. On the C-C Cordillera and North of it, the Lutetian transgression is diachronous and the erosion of the substratum incrases westward. Toward the East, early Lutetian calciturbidites and limestones containing algae and benthic foraminiferas (≈ 100 m, San Eduardo Fm, fig. 2) disconformably overly the paleocene cherts (Guayaquil Fm). Farther West, the transgression is of middle to late Lutetian age, and is associated with a rapid subsidence related to extensional tectonics, that provokes the reworking (Javita Fm) of the early Lutetian and Paleocene sediments, or the deposition of olistolites of Maastrichtian rocks within pelagic limestones and cherts (≈ 200 m, Cerro, lower San Mateo Fms). These unconformably overly the late Cretaceous volcaniclastic turbidites (Cayo Fm). These pelagic deposits are overlain by a shallowing-upward sequence of mud to clastic shelf environment comparable to that of the Peninsula (see below).

South of the C-C Fault, the Lutetian cycle begins with slumped shales and sandstones (0 to ≈ 200 m, Clay Pebble Fm), that express a tectonic activity. The presence of reworked blocks of early Lutetian calciturbidites suggests that the whole area was submitted to extensional tectonic subsidence. Middle to Late Lutetian times are then mainly represented by a shallowing-upward sequence of mud-clastic shelf environment (fig. 2). The lower part (≈ 1000 m, Socorro Fm) is characterized by the abundance of turbidites and slumpings indicating a NW- slope. The upper part (≈ 500 m, Seca Fm) is marked by the increase of the bioturbations and of the carbonate contain, the diversification of the fauna, the vanishing of the tectonic activity and the appearance of tempestites

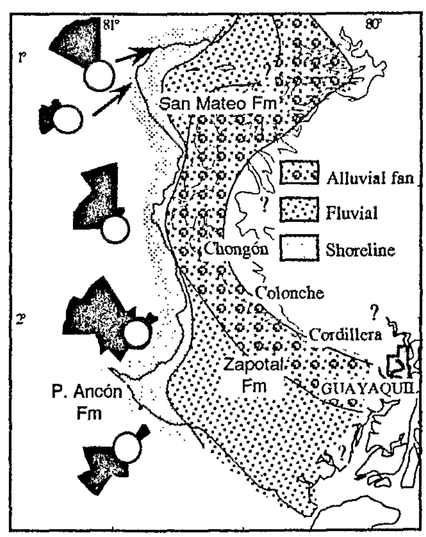

Fig. 4: Paleogeographic interpretation of the Bartonian (and early Priabonian?) deposits of Southern Coastal Ecuador.

Bartonian. Along the Southern and Western coast of Southern Coastal Ecuador, the Lutetian cycle is abruptly overlain by coarse-grained sandstones and conglomerates deposited in a shoreline environment, which exhibit a noticeable enrichment in volcanic clasts and plant fragments (≈ 100-400 m, Punta Ancón, upper San Mateo Fms, fig. 2). These deposits presents abundant small-scale, synsedimentary tectonic features. Paleocurrents are roughly perpendicular to the present-day coast (fig. 4), thus suggesting that its morphology was grossly similar to the present-day one, and comprised a central source-area. In the Peninsula, these deposits are mainly made up of shales and sandstones (Punta Ancón Fm), whereas farther North (upper San Mateo Fm, fig. 4), they include thick lenses of coarse-grained conglomerates of alluvial fan type, and abundant blocks suggesting the presence of coastal cliffs. These deposits seem to laterally grade eastward into fluvial conglomerates and coarse-grained fanglomerates nammed upper San Mateo Fm on the Northern part of the C-C Cordillera, and Zapotal Fm on its Southern part and in the Peninsula (fig. 4). The latter undated formation has been ascribed either to the late Eocene (Canfield 1966), or to the late Oligocene (Bristow & Hoffstetter 1977). Though no reliable paleontological data are yet available, our observations support the former hypothesis (fig. 2).

The emergence of the whole Coastal Ecuador by early Late Eocene times, is regarded as the result of its collision or, more likely, its thrusting on the Andean continental margin (Bourgois et al. 1990).

Late Eocene. In the studied area, this time-span seems to be characterized by a widespread sedimentary gap, which will follow up to Late Oligocene, and corresponds to the early Late Eocene major Incaic phase. However, in the Northern part, the upper San Mateo Fm could reach the early Late Eocene (Bristow & Hoffstetter 1977). In the Peninsula, the late Eocene deformation is only marked by gentle folds exhibiting a N-S to NNE-SSW axial plane, associated with reverse faults, that dip gently toward the E or SE.

GEODYNAMIC IMPLICATIONS

The evolution of Coastal Ecuador presents two periods. Late Cretaceous to early Late Paleocene times are characterized by an oceanic basin evolution. The late Late Paleocene-late Eocene time-span is marked by its progressive tectonic accretion to the continental margin. From then on, it constitutes the forearc basins of the Andean margin.

Untill now, Southern Coastal Ecuador have been considered as a single accreted oceanic terrane. The discovery in the Peninsula of two major deformation events unknown North of the C-C Fault, indicates that these areas are characterized by different accretionary histories and constitute two different oceanic terranes.

These early tectonic phases, of Late Paleocene and Early Eocene age, respectively, together with the late Eocene, Incaic phase, are the major deformational events recorded in Coastal Ecuador, and are of decreasing intensity with time. Surprisingly, in spite of its location very close to the subduction zone, Coastal Ecuador did not undergo subsequent important deformations, and virtually all the subsequent tectonic shortening has been accounted for by the more distal continental crust.

The tectonic phases of late Paleocene-earliest Eocene age coincide with a major geodynamic reorganization. Between 56 and 50 Ma, the convergence direction of the paleoPacific plate changed from N or NNE to NE (Pilger 1984, Gordon & Jurdy 1986, Pardo-Casa & Molnar 1987). As a consequence, the formerly mainly dextral transform margin of Ecuador might have changed to a chiefly convergent regime at that time. If so, the oceanic or continental microplates, formerly submitted to a Northward shift along the Andean margin, were successively accreted to the continent, due to this new convergence direction, that must have triggered the formation of a new Ecuadorian subduction system, along the continental margin and the newly accreted terranes.

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