NEOTECTONICS OF THE COASTAL REGION OF ECUADOR : A NEW PLURIDISCIPLINARY RESEARCH PROJECT

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KEY WORDS : Ecuador, Plio-Quaternary, Neotectonics, Marine terraces, Geomorphology,

INTRODUCTION

The coastal margin of Ecuador, 150 to 200 km wide onshore, comprises oceanic terranes accreted onto the Andes during the Paleocene and emerging after the Late Eocene (Benitez 1995, Jaillard et al. 1995). Presently, this area is in the position of a fore-arc ridge and basin, mostly emerged, in relation to the subduction of the Nazca plate beneath the South American plate (Lonsdale 1978), that proceeds with a N80°E convergence and at a rate of 8 cm/year (Daly 1989, DeMets et al. 1990).

The main features of the geodynamic pattern are (fig.1) : i) an oblique subduction (15° to 25°), that favors transcurrent movements, evidenced for instance by the dextral Dolores-Guayaquil Megashear (Winter and Lavenu 1989) ; ii) the opening of the Gulf of Guayaquil, related to the motion along the Dolores-Guayaquil Megashear ; iii) the subduction of the Carnegie Ridge between 0° and 2°S, that causes the trench to lift up by about 1500m.

At the scale of the whole South American continent, the margin of the South American plate is broadly convex near the Peru-Ecuador boundary, and the geometry of the slab changes from a nearly flat subduction south of 3°S to a more normally dipping one to the north.

Regarding the seismic activity, few strong historical earthquakes are reported in the southern part of the coastal block, but several major earthquakes shook the northwestern Ecuador and southwestern Colombia since the beginning of the century. Nishenko (1989) considers the Esmeraldas area in northwestern Ecuador as an area of high seismic risk.

In order to understand the relations between the subduction system and the present tectonic evolution of the Ecuadorian coastal block, we started a neotectonic study focused on the various manifestations of recent deformations (uplift, subsidence and strike-slip). A pluridisciplinary approach including detailed stratigraphy of marine terraces, fault kinematics, and geomorphologic studies of drainage anomalies, will be used.

MARINE TERRACES

An important feature of the coastal region of northern Peru and Ecuador is the occurrence of emerged Quaternary marine terraces, called "Tablazos" (De Vries 1988, Macharé and Ortlieb 1994). In Ecuador, such terraces are observed up to an elevation of 320 m in the Manta area, and up to 90 m in the Santa Elena area. Several intermediate levels are observed. The lowermost well preserved and extensive terrace, observed at up to +20 m in the Manta and Chanduy areas, was likely formed during the last major high stand of sea level, i.e. stage 5e of the last interglacial period, about 125 ka BP. Assuming that this high sea level was +6 m above present sea level, an uplift of the terrace by some 14 m is calculated and a mean uplift rate of about 110 mm/ky is evaluated.

Lower, younger terraces are observed west and east of Manta, between 3 to 10 m above present mean sea level : they may correspond to later episodes of the last interglacial period (stages 5c and 5a, respectively 105 and 80 ka) and to the Holocene period. Higher and older terraces of Middle and Early (?) Pleistocene age are preserved at various elevations, up to +300 m.

The Tablazo Formation overlays Eocene and Pliocene deposits in the Manta area (San Mateo and Canoa Formations respectively), and the Eocene Ancón Formation in the Santa Elena area. The Pliocene Canoa Formation is deposited in shallow environment. In the Esmeraldas area, erosion surfaces overlay the Pliocene Onzole Formation, deposited in a lower middle bathyal deposition environment (Bianucci et al. 1993). The different depositional environment of Pliocene formations suggest that the Quaternary terraces take place after a relatively complex Pliocene history.

Controversial hypotheses have been made in the past regarding the tectonic significance of the terrace sequences in the region (Marchant 1961). A flight of three or more terraces exists, but local or regional faults make the feature more or less complicated. For instance, a lineament observed on radar image in the Santa Elena neighborhood suggests the fault duplication of a terrace, with an upthrow of up to 40 m. Moreover, near this place, a fault plane gives evidence of an extensional displacement contemporaneous with the deposition of the basal conglomerate of a Santa Elena equivalent terrace.

FAULT ANALYSIS

The preliminary results of fault analysis from random sites along the coastal area are consistent with a NS extension. Such deformations are observed in fan conglomerates of the Western Cordillera piedmont, as well as in terraces in the Santa Elena and Esmeraldas areas. An extensional tectonic event probably represents the most recent stage of deformation, and just pre-dates or is contemporaneous of the deposits of terraces estimated to be of Late Pleistocene age. The Pliocene beds display more complex fault systems, especially in the Esmeraldas area. The important uplift of the Pliocene of Onzole Formation at Esmeraldas (Bianucci et al. 1993) cannot be explained by the moderately developed normal faulting resulting from the extensional event. More complex fault motions are to be expected in the coastal area, close to the upper part of the internal wall of the trench.

GEOMORPHOLOGIC MARKERS

Because of the coastal range relief, the drainage issued from the Andes in Ecuador reaches the Pacific Ocean in only two points, the Gulf of Guayaquil through the Daule-Babahoyo Basin to the south, and the Esmeraldas area to the north, the former being the most important. The Daule and the Babahoyo Rivers follow respectively the western and eastern margins of the Daule-Babahoyo Basin. In the SE part of the basin, the Babahoyo River flood plain morphology suggests that it is an area of active subsidence superimposed over the northern branch of the Dolores-Guayaquil Megashear.

Some observations made on topographic and radar SAR images show that the NE-SW trend of the rivers inside the basin is related to recent fault motion. The fault movement deduced from morphological evidences is partly normal, with ria lakes or swampy lands sharply separated from dry lands, and drainage deflected along this morphological separation line. This suggests a transtensional tectonic system, but the close relation between plate motions and the Dolores-Guayaquil Megashear remains speculative.

CONCLUSIONS AND PROJECT OUTLOOK

The neotectonic evolution of the coastal area of Ecuador includes several types of deformations, such as uplift and accretionary tectonics on the coast side, or subsidence of wide flood plains involving probably normal as well as strike slip faults on the Andean side. Therefore, the understanding of the geodynamic evolution during the Quaternary up to present time can only be obtained by a pluridisciplinary approach involving specific study methods according to the style of deformation and the morphology. As far as the relation with active deformation is concerned, local seismic studies are planned to constrain the seismotectonic activity, specially in the Esmeraldas and Manta areas.

A comprehensive approach will be applied first to the different areas using remote sensing approach (by means of Spot and ERS1 images principally). At a further stage of analysis, correlation between the various neotectonic data will be made combining thematic documents with satellite images and digitized topography.

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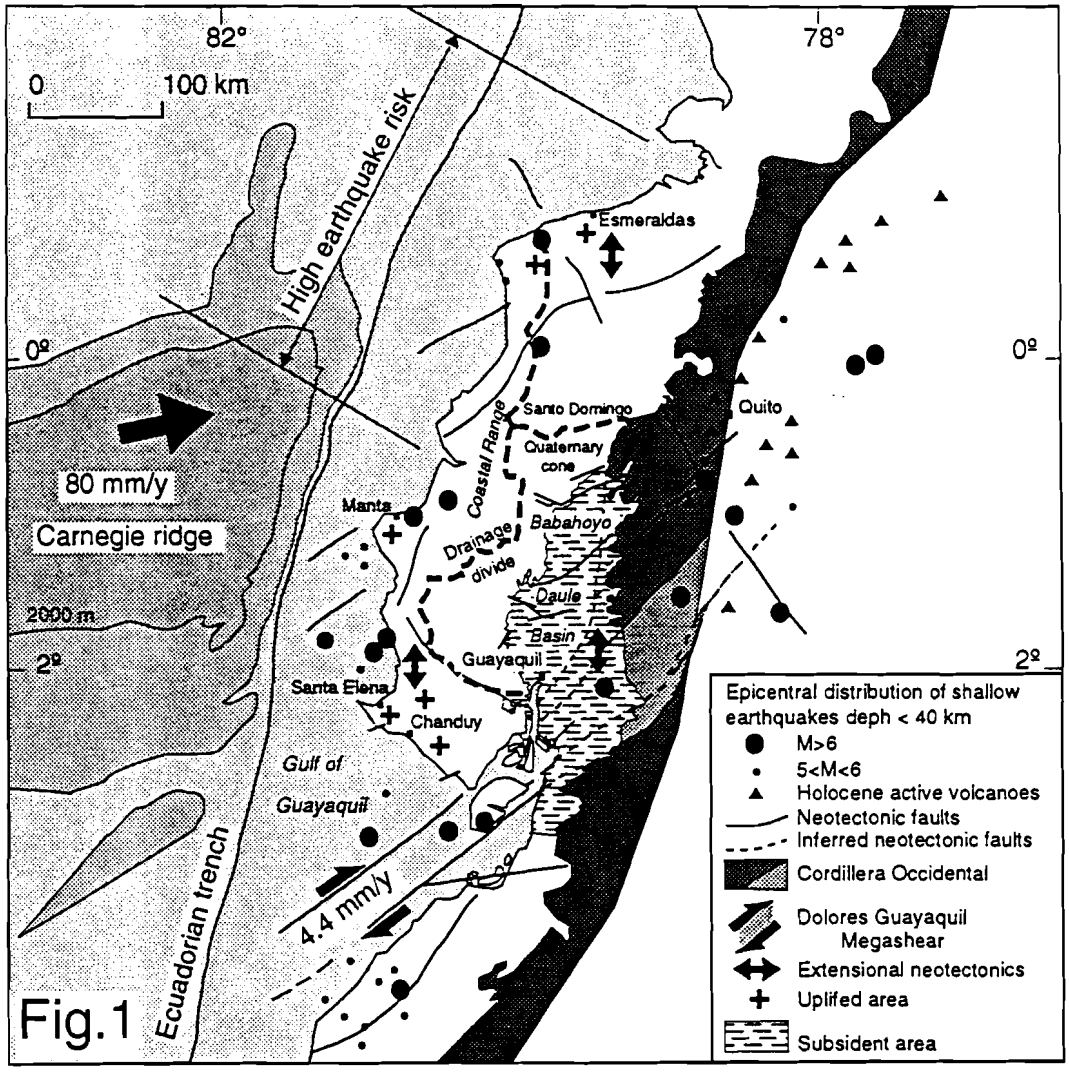

Neotectonic scheme of the coastal block of Ecuador.