Geophysical Research Abstracts, Vol. 8, 09609, 2006
SRef-ID: 1607-7962/gra/EGU06-A-09609

Structure of the Ecuador-Colombia convergent margin from wide-angle data modelling

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The South-Colombia — Ecuador convergent margin (3˚N-3.5˚S) represents a region of strong crustal deformations, related to the subduction of the oceanic Nazca plate beneath the South-American continental plate. In this area, the upper plate consists in Cretaceous oceanic terranes accreted to the South American continent. Several great subduction earthquakes occurred in this area during the 20th century. On the Nazca Plate, between 0˚ and 3˚S, the Carnegie Ridge testifies to the interaction between the Galapagos hotspot and the Cocos-Nazca spreading center since ∼20 My. Its subduction beneath the Ecuadorian coast induces lateral variations of seismicity, deformations, vertical motion and sediments distribution along the margin. Joint refraction/reflection travel time tomography, using wide-angle seismic data acquired on the margin during Sisteur (2000) and Salieri (2001) experiments, provides images of the deep structure of the margin. The results of this work show that morphology and crustal structure of oceanic plate and margin are set out differently from North to South, outlining a margin segmentation into three structurally contrasted zones :

(1) The North zone (South-Colombia/North-Ecuador, 3˚N-1˚N) shows a normal oceanic crust. The overriding plate is characterized by an oceanic Cretaceous substratum (Diabasico and Piñon formations) underlined by high seismic velocities (6.0-6.5 km/s). The margin appears to be controlled by a transient tectonic regime, between accretion and erosion, expressed by forearc subsidence (2-3 km thickness basins) and the subduction of the whole oceanic plate sedimentary cover (∼2 km thickness).

(2) The central zone (Carnegie Ridge subduction, 1˚N-2.5˚S) reveals an over-thickened oceanic crust (up to 19 km thick) progressively thinning toward the ridge southern flank (∼14-15 km thickness). In this zone, the margin is also composed of a well-developed Cretaceous oceanic basement (Piñon formation). The fore-arc shows no evidence of subsidence.

(3) The South zone (Gulf of Guayaquil area, 2.5˚S-3.5˚S) is characterized by a 7 km thick oceanic crust, which was slightly influenced by the Galapagos hotspot during its emplacement at 20 My. The South-Ecuadorian fore-arc shows clues of subsidence, revealed by huge sedimentary basins (up to 7 km thickness) related to normal and detachment faults ($\geq$5 My). The Cretaceous oceanic substratum characterizing the lower part of overriding plate to the North may extend toward this area, despite significantly lower seismic velocities. This might be linked to the opening of the Gulf of Guayaquil (N-S extension) and to a strong erosion tectonic regime (abrasion of the base of the overriding plate), which would have contributed to eliminate the deep part ("high velocity") of the margin basement.

Along the overall margin, we have also some evidence, from velocities at the top of the oceanic plunging crust, of fluids over-pressure.

During the last century distribution of large earthquakes shows an intense activity in the north zone, with a remarkable sequence of rupture propagation from Carnegie Ridge northern flank, which seems to act as a barrier, to the North (respectively 1906, 1942, 1958 and 1979 earthquakes). Comparing this seismological segmentation to the long wavelength structures modelled in this study suggests that the variation of interplate coupling along the margin could be influenced -at least- by the buoyancy of the plunging oceanic lithosphere, and the structure and weight of the overriding plate. In the north zone, the interplate coupling should be high, partially due to a high lithostatic pressure (mafic margin basement), and a strong compressive deformation in the overriding plate. The central zone could be associated, from north to south, to a highly locked zone in front of the Ridge axial part (maximum oceanic crust thickness), evolving to a partially locked zone along its southern flank, linked to the lower buoyancy of Carnegie Ridge from. In the south zone, the globally extensive tectonic regime, which controls the Gulf of Guayaquil opening, should tend to lower the interplate pressure. Nevertheless, presence of seamounts on the Nazca plate, basal-erosion processes and associated permeability variations could contribute to increase locally the interplate coupling.