NEOGENE STRESS PATTERN IN SOUTHERN ECUADOR

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Resume

Results of microtectonic, structural and sedimentologic analysis of the deposition of Mio-Pliocene continental basins permit to describe the Neogene stress pattern in Southern Ecuador. These three kinds of data show that this region was submitted to a continuous compressive stress pattern, from Upper Oligocene to Pliocene time.

Introduction

Intracontinental basin deposition is a characteristic of Andean geodynamics. Basins formed after the Upper Cretaceous emersion of the Andes. These elongated basins are located in or along the High Andes. In the Ecuadorian Andes, a great continental sedimentation occured during Late Cenozoic time.

Tectonic and volcanic events which occured during and after sedimentation are recorded by the deposits. Sedimentologic and tectonic analysis is one way to retrieve orogenic mechanisms. In this paper we compare results obtained in a microtectonic analysis of Mio-Pliocene continental basins of Southern Ecuador with sedimentologic and structural data.

General sedimentary evolution of tertiary basins of Southern Ecuador

The tertiary deposition of the intramontane basins of Cuenca, Nabon, Loja, Malacatos and Zumba crop out between the Eastern and Western Cordilleras, along N-S and NNE-SSW trending major faults, at elevations ranging from 1600 to 3000 m.

The deposition of these basins (1500 to 4500 m thick) consists of continental deposits with several intercalations of volcanic deposits. It is always organized in two megasequences. The first one (fining- and thinning-upward), which shows an evolution from proximal to distal facies (alluvial fan, braided river, lacustrine facies), characterizes the opening of the basins. The second one (coarsening- and thickening-upward), which presents an inverse evolution, characterizes their closing. This last megasequence begins with megaturbiditic, deltaic and/or distal alluvial deposits and follows with a prograding alluvial sedimentation in the whole of the basin area.

In Cuenca basin, a maximum basin life of about 20 My may be estimed. Assuming a ratio of sediment decompaction of about 2.0 for the deep lacustrine sediments and about 1.5 for the rest of the basin deposits, a thickness of about 6000 m may be estimated and a sedimentation rate of 300 m/My may be deduced.

Microtectonic analysis

Microtectonic studies permit us to characterize the state of stress in this region using numerical methods to compute it. Most of microtectonic station studies revealed faults bearing several generations of slikensides (2 or 3) and a relative chronology was observed.

A N-S trending compression: Five sites, measured in the Saraguro Formation (U. Oligocene) and at the base of the Biblian Formation (L. Miocene) in the Cuenca and Nabon basins reveal a roughly N-S to N140E trending compression.

A NE-SW trending compression: Six sites, measured in the same formations in the Cuenca, Nabon and Malacatos basins, permit to characterize a roughly NE-SW trending compression. But the maximum principal stress varies in trend from N31E to N59E.

A E-W trending compression: Ten sites, measured in the same formations (Cuenca and Nabon basins) and in Middle Miocene deposits (Loja, Malacatos and Catamayo basins) reveal compression striking between N81E and N107E.

A NW-SE trending compression: In Cuenca, Nabon and Catamayo basins microtectonic results clearly show a N120E to N135E trending compression.

Comparison between microtectonic, synsedimentary folds and sedimentologic data

Two major fault systems trending N30E and N-S controlled the Tertiary basins after the deposition of the Saraguro Formation. The deposition and filling of basins in South Ecuador is affected by synsedimentary tectonic structures on kilometric scale. Systematic detailed studies of these structures were made in all the basins deposits but especially in the Cuenca basins deposits.

The fining- and thinning-upward of the first megasequence characterizes an increase in the tectonic subsidence (Lower Miocene opening basin). This opening is marked by a sedimentary wedge, which affected all the first megasequence. This synsedimentary progressive tilting is suggestive of a normal component of motion along the NE-SW trending boundary fault, induced by Lower Miocene trending compression.

The coarsening- and thickening-upward of the second megasequence characterizes the progressive closing of the basin (Middle Miocene and Pliocene time). The E-W Middle Miocene compressive event initiated the closing of the basin inducing right-lateral motions along N30E trending fault system and probably reverse motions along the N-S trending fault system.

The E-W and the NW-SE trending compressions caused the formation of progressive erosive unconformities, suggestive of synsedimentary folding with reverse beds.

The analysis of the progressive unconformities suggests, more, that variations in tectonic intensity occured during the sedimentation.

Thus, microtectonic and synsedimentary fold data attest to a strike-slip component of the movement along the boundary faults from Lower Miocene to Middle Miocene, and mainly reverse kinematics from Middle Miocene to Pliocene.

The shortening axis deduced from microtectonic analysis must furthermore have experienced an indirect rotation from NNE during the Lower Miocene, to SE during the Pliocene, and are consistent with synsedimentary folds and sedimentologic data.

Discussion and conclusions

Microtectonic studies indicate several successive tectonic events. These events may be ascribed either to one or several "instantaneous" deviatoric stress tensors, which could correspond to deformational climaxes (1 to 2 My) or to a mean deviatoric stress tensor derived from slikensides produced "continuously" during the lifetime of the basins. The convergence of results derived from microtectonic data is more agreement with the first solution. Thus, we infer that the states of stress derived from orientations of slikensides reflect compressional deformation climaxes similar to those which are at the origin of both the synsedimentary folding and the progradation of proximal facies onto more distal facies.

Sequential analysis of basins deposits clearly shows tectonic deepening, then shallowing of the basins

Synsedimentary deformation which affected all deposits in the basins attests for continuous compressive tectonics during the length of deposition.

So, these three kinds of data (sedimentologic, structural and microtectonic) indicate one conclusion: southern ecuadorian continental basins were under continuous compressive stress from Upper Oligocene to Pliocene time. Intensity of the deformation varies in time and space, and attests to deformational climaxes within a deformational compressive continuum.

In the Ecuadorian margin, this Tertiary tectonic continuum appears to be in agreement with the steady-state dynamic behaviour of subduction, which controlled Tertiary Andean orogeny.