Andean transpressive tectonics at the eastern edge of the Cordillera Oriental, Colombia (Chivor-Guavio area)

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Introduction

The Cordillera Oriental of Colombia is considered to be an asymetric bivergent fold and thrust belt resulting from the Neogene inversion (Andean phase) of a thick Mesozoic and Tertiary back-arc basin with a predominant southeastward transport (Colletta *et al.*, 1990; Cooper *et al.*, 1995). The tectonic style of the chain implies both thick-skinned (e.g. compressional inversion of the Boyacá paleonormal fault) and thin-skinned tectonics. At present time, two important questions are debated : 1) the pre-Andean deformations and related unconformities that have been recognized from the Magdalena valley to the Llanos foothills (Casero *et al.*, 1997; George *et al.*, 1997; Schamel, 1991) ; 2) the role of strike-slip tectonics, recently evidenced in the southern domain of the chain (De Freitas *et al.*, 1997).

The Chivor-Guavio area we studied, located in the eastern edge of the Cordillera Oriental, provides good opportunities to answer these questions. In this area, field works and seismic interpretation have been untertaken in order to realized a cross-section from the « Las Juntas » crossroads in the Cordillera Oriental to the Llanos plain (Fig. 1).

Geometric and facies analysis along the cross-section Las Juntas-Llanos

Along the section from NW to SE we observe :

1) Along the Chivor dam, kinked folds with N30E axial trends and thrusts affecting the Early Cretaceous series ; 2) Hanging-walls of major basement-involved faults present series of en-echelon N50E-trending folds. En-echelon folding also affects the paleozoic rocks of the Quetame massif ; 3) NW-verging thrusts occur in the sedimentary cover but also transports westward the Quetame massif over Valanginian black shales ; 4) The western side of the Quetame massif shows dramatic eastward thickening and westward wedging in the Valanginian shales that suggests fault-controlled deposition above hanging-wall of basin-bounding master faults ; 5) The eastern part of the Quetame massif corresponds to a steep E-dipping panel of paleozoic sediments. Overlying this panel, a steeply dipping reverse sequence of pre-Oligocene sediments is limited eastward by a SE-verging

major accident (the Teasalia fault) that separates the Cordillera Oriental s.s. from the subandean Guavio foothills ; 6) The Guavio foothills are structured by the symetric Guavio anticline between the Nazareth and Rio Amarillo synclines. The eastern boundary of the foothills is the Agua Clara thrust, SE-verging ; 7) East of the Agua Clara thrust, the undeformed Llanos plain forms the western part of the Orinoco Quaternary drainage area.

Seismic interpretation

The seismic lines we studied show evidence of basement-involved NW-verging thrusts and well-individualized basement pop-up limited to the east by convex-upward reverse faults splaying off toward the surface. The bivergent transport, the pop-up, the downward convergence and the upward convex shape of faults stongly suggest basement-involved positive flower structure. Some of the kink and box-folds in the Early Cretaceous sediments correspond to fault-bend folding formed above decollements and ramps. The lower decollement is the contact between the basement and the Early Cretaceous sedimentary cover. The upper decollement would be located within black shales, limestones and evaporites forming the Berriasian Guavio formation. The ramps are thought to be parts of Early Cretaceous normal faults that are twisted and segmented during the basement-involved thrusting and folding. From the NW to SE, huge thickness variations of the Early Cretaceous series indicate important degree of fault-controlled sedimentation. The Tesalia fault appears as an anastomosed fault system, the faults converging downward. Steep reverse faults are implicated in the Agua Clara thrust system suggesting a basement-involved structure that is burried by a ramp linked to a major decollement at the base of the Turonian Chipaque (or Gacheta) formation.

Interpretation and discussion

Evidences of present-day dextral wrench tectonics are numerous (shallow-focus earthquakes, rivers shifting). The general morphology of the Cordillera Oriental also suggests that the Borde Llanero is a « dextral lateral ramp » of the chain, the frontal ramp being the thrusting front of the Sierra Nevada del Cocuy over the Llanos (Fig. 1). Moreover, the southward wedging of the Cordillera Oriental present important dextral wrench tectonics affecting the Garzon and Quetame massifs (Fig. 1).

In the Chivor-Guavio area, based on our observations, we propose that dextral transpressional tectonics is not only limited to present-day deformation but also occured during the entire Andean uplift of the Cordillera Oriental eastern edge. We interpret the Quetame massif as a serie of en-echelon basement pop-ups uplifted during transpressional Andean deformation. These pop-ups are linked to the en-echelon pattern of the Early Cretaceous normal faults which can be either segmented, or twisted, or then inverted (e.g. Tesalia fault) during the Andean transpression. This

transpressional thick-skinned tectonics is accomodated at the basement-cover interface and in the sedimentary cover by thin-skinned deformation.

Some of the en-echelon folds affecting the Paleozoic basement and its sedimentary cover suggest a sinistral strike-slip component. We interpret these folds as inherited folds from Paleozoic deformations, that were reactivated during Andean transpression. Because the developpement of these reactivated folds is controlled by some of the NW-verging thrusts, these thrusts are also thought to be reactivated Paleozoic thrusts. This is in accord with the Paleozoic history of the Borde Llanero that acted as a suture zone between the Guiana shield and an allocthonous continental microplate at the Ordivician-Silurian times (Suarez, 1990).

Conclusion

The Chivor-Guavio area is a key zone to understand the thick-skinned tectonics implied along the Colombian Borde Llanero. In this area, along a cross-section through the whole Borde Llanero, we identified basement-involved pop-ups related to a dextral transpressional inversion of an Early Cretaceous megahalf graben. This megahalf graben formed the eastern passive margin of the Colombian Cordillera Oriental back-arc basin. This transpression occured essentialy during the Andean orogeny (Middle Miocene to recent). Inherited structures from Paleozoic to Early Cretaceous are reactivated. The Early Cretaceous normal faults are reactivated in transpression and some of them were reused as ramps during Andean thin-skinned tectonics. The transpressional inversion of deep and steep basin bounding-master faults as the Tesalia fault is responsible for the upthrusting of the Cordillera Oriental above its eastern foothills. So, at least the southern part of the Borde Llanero can be regarded as a NNE-SSW-trending dextral transpressive belt.

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