Trabajos de Geología, Universidad de Oviedo, 29 : 142-145 (2009)

Structure and thrusting evolution of the southern Cordillera Oriental (N Argentine Andes)

N. CARRERA[1*] AND J. A. MUÑOZ[1]

[1]*Departament de Geodinàmica i Geofísica. Facultat de Geología. Universitat de Barcelona. Martí i Franquès s/n 08028 Barcelona.*

[*]*e-mail: nuriacarrera@ub.edu*

Abstract: Detailed mapping of several areas of the southern Cordillera Oriental revealed an important role of the inversion tectonics for the structural evolution of this part of the Andes. The inversion is only moderate but the compressional Andean structures are strongly controlled by the geometry and the location of previous cretaceous extensional structures. The study of growth strata and unconformities in the Cenozoic synorogenic sediments provides evidence for the eastward migration of the Andean deformation from the Puna to the Santa Bárbara System independently of the vergence of the structures.

Keywords: inversion, thrusting evolution, growth strata, Cordillera Oriental, Andes.

The structure of the southern Cordillera Oriental consists of a system of N-S-trending Andean thrust and folds structures superimposed on an oblique Cretaceous rift system (Salta Rift). The inversion of this rift has been documented from surface data in the Cordillera Oriental (Grier *et al.*, 1991; Kley *et al.*, 2005; Carrera *et al.*, 2006; Carrera and Muñoz, 2008) and few unconformities and growth geometries have been described in the synorogenic sediments related to this inversion in the southern Cordillera Oriental, in the study area (Carrera and Muñoz, 2008) and northwards (Hongn *et al.*, 2007). Moreover, thermochronological studies in the basement uplifted blocks as well as in adjacent basins have constrained timing of exhumation events (Coutand *et al.*, 2006; Deeken *et al.*, 2006).

The aim of this paper is to describe and discuss the inversion structures of the southern Cordillera Oriental, their tectonic evolution and the role played by previous Cretaceous extensional structures on the location and geometry of the Andean structures.

Methodology

The main source of information used in this study has been the detailed mapping of the area (seismic data are scarce). This field-based study makes use of the excellent outcrops of the area and of satellite images and aerial photographs. These maps together with detailed cross-sections revealed a large number of inversion structures as well as unconformities and growth geometries in the synorogenic sediments (Fig. 1). To construct the cross-sections, 2DMove software (Midland Valley Exploration©) has been used.

Stratigraphy

The basement rocks are thin-bedded sandstones and shales, Precambrian-Lower Cambrian in age, which have been deformed, metamorphosed and intruded during the Early Paleozoic. The Cretaceous-Eocene Salta Group unconformably overlies the basement and comprises the Pirgua Subgroup, the Balbuena Subgroup and the Santa

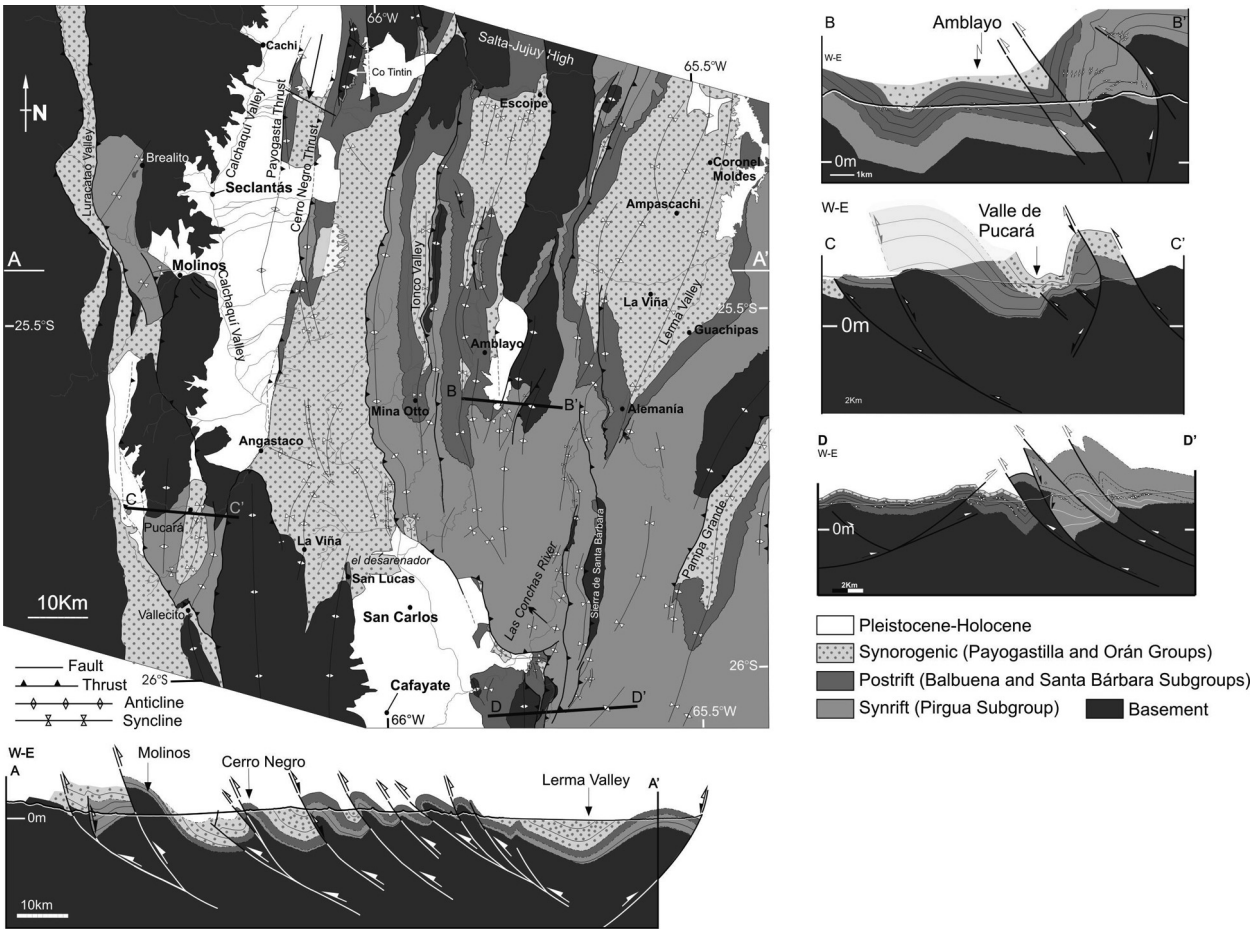

Figure 1. Geological map and cross-sections of inversion structures of the southern Cordillera Oriental. Modified from Carrera *et al.* (2006).

Bárbara Subgroup. The Cretaceous Pirgua Subgroup (synrift) consists of alluvial and fluvial deposits strongly controlled by the extensional faults of the Salta Basin. The Maastrichtian-Paleocene Balbuena and Santa Bárbara Subgroups correspond to the postrift sequence and are characterized by stromatolitic limestones and greenish shales (Balbuena rocks) and fluvial sediments (Santa Bárbara rocks). The Neogene Oran Group (syronogenic) consists of a very thick sequence of fluvial and aeolian sediments that unconformably overlay all the previously described units and exhibits unconformities, which document the evolution of the structures in this area during Andean times.

Results and discussion

Inversion

The Andean structure in the southern Cordillera Oriental is clearly related to the inversion of previous extensional faults, always with a low to moderate degree of inversion (Fig. 1). Different kinds of inversion structures have arisen from detailed mapping of the study area. Extensional faults dipping to the east (foreland) have been the most favourable to be inverted. They have been incorporated into the hangingwall of major thrusts and short cut structures have been developed in the footwall of the former extensional faults. On the contrary, W-dipping extensional faults tend to be partially inverted and folded to overturned (Fig. 1). The explanation for these geometries is far to be understood yet, but these features crop out widely in the study area (Carrera *et al.*, 2006; Carrera and Muñoz, 2008).

Timing of Andean deformation

The study of facies, unconformities and growth geometries in the syronogenic sediments allows dating the onset and timing of the Andean deformation (Fig. 2). An angular unconformity has been observed

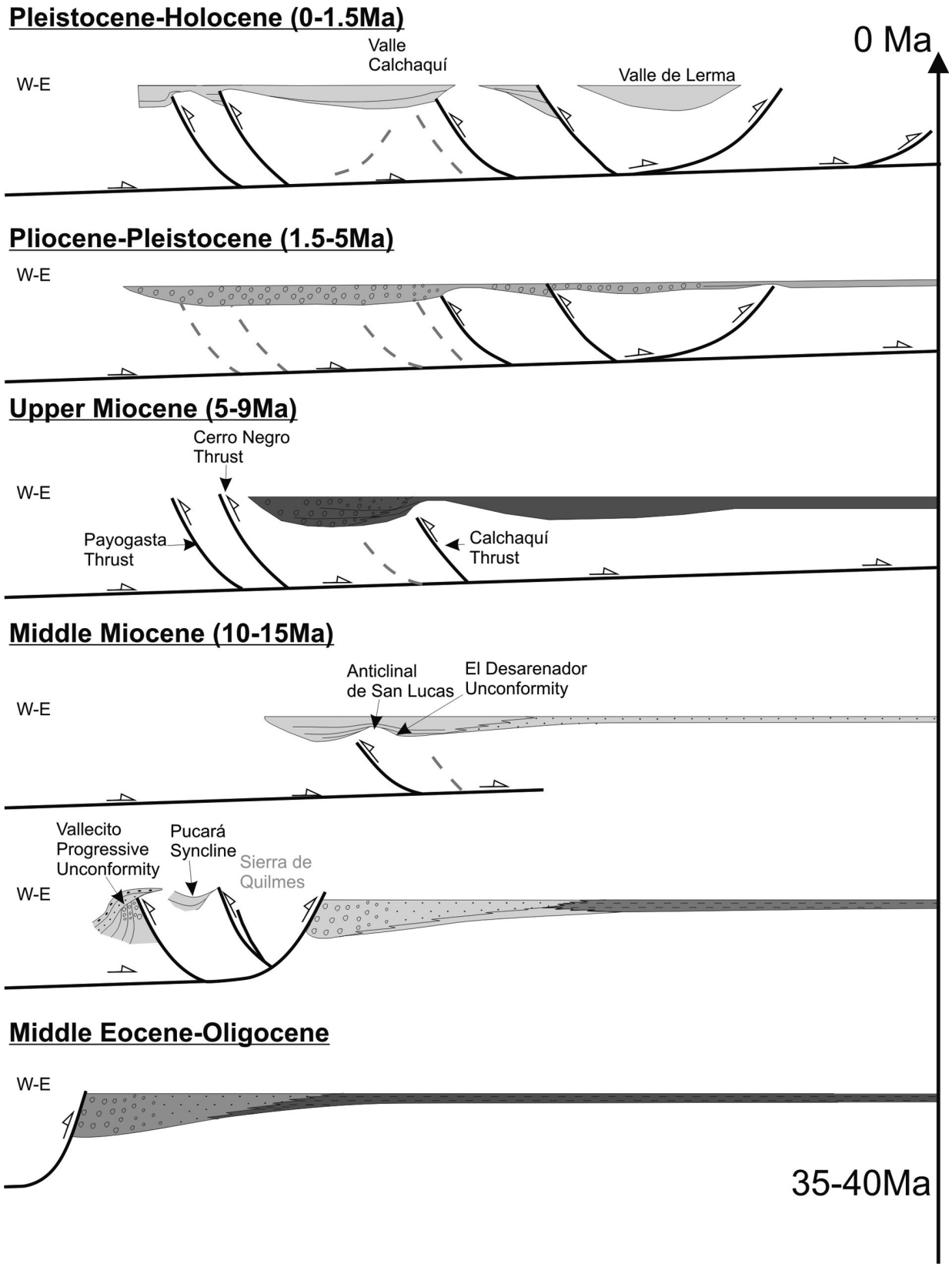

Figure 2. Tectonic evolution of the Andean deformation of the southern Cordillera Oriental based on the facies distribution and on growth geometries of the synorogenic sediments. Modified from Carrera and Muñoz (2008).

between the Oran Group and the Santa Bárbara Subgroup suggesting the onset of the Andean deformation in the area at Late Paleogene- Early Miocene times (Hongn *et al.*, 2007). In the lower part of the Oran Group (Middle Miocene) growth geometries observed in the Calchaqui Valley showed a shift of deformation eastwards (Fig. 2). In the upper part of the Oran Group, a Pliocene formation presents a basal high angle angular unconformity in the western area whereas in the east it is involved in the structures but resting parallel to the lower Oran Group. Growth geometries are observed in the Quaternary sediments evidencing deformation until nowadays (Fig. 2).

Conclusions

The Inversion of the Cretaceous extensional structures of the southern Cordillera Oriental is only moderate but the geometry and location of Andean structures are strongly constrained by the geometry and location of previous extensional structures.

The onset of the Andean deformation in this area occurred at Late Paleogene-Early Miocene times and progressed from west to east independently of the dip of the structures, which was largely controlled by the inversion of the previous extensional faults.

Acknowledgements

This work have been founded by the projects, CGL2007-66431-C02-01/BTE and have been developed in the Grup de Geodinàmica i Anàlisi de Conques, 2001 SGR 0074, of the Comissionat d'Universitats i Recerca de la Generalitat de Catalunya.

References

Carrera, N., Muñoz, J. A., Sàbat, F., Roca, E. and Mon, R. (2006): The role of inversion tectonics in the structure of the Cordillera Oriental (Argentine Andes). *J. Struct. Geol.*, 28, 11: 1921-1932.

Carrera, N. and Muñoz, J. A. (2008): Thrusting evolution in the southern Cordillera Oriental (northern Argentine Andes): constraints from growth strata. *Tectonophysics*, 459, 1-4: 107-122.

Coutand, I., Carrapa, B., Deeken, A., Schmitt, A. K., Sobel, E. R. and Strecker, M. R. (2006): Propagation of orographic barriers along an active range front: Insights from sandstone petrography and detrital apatite fission-track thermochronology in the Intramontane Angastaco basin, NW Argentina. *Basin Res.*, 18: 1-26.

Deeken, A., Sobel, E. R., Coutand, I., Haschke, M., Riller, U. and Strecker, M. R. (2006): Development of the southern Eastern Cordillera, NW Argentina, constrained by AFT-thermochronology: from early Cretaceous extension to middle Miocene shortening. *Tectonics*, 25: TC6003.

Grier, M. E., Salfity, J. A. and Allmendinger, R. W. (1991): Andean reactivation of the Cretaceous Salta rift, northwestern Argentina. *J. S. Am. Earth Sci.*, 4, 4: 351-372.

Hongn, F., del Papa, C., Powell, J., Petrinovic, I., Mon, R. and Deraco, V. (2007): Middle Eocene deformation and sedimentation in the Puna-Eastern Cordillera transition (23º-26º S): Control by preexisting heterogeneities on the pattern of initial Andean shortening. *Geology*, 35, 3: 271-274.

Kley, J., Rossello, E. A., Monaldi, C. R. and Habighorst, B. (2005): Seismic and field evidence for selective inversion of Cretaceous normal faults, Salta rift, northwest Argentina. *Tectonophysics*, 399, 1-4: 155-172.