A geological cross-section of the Andean orogen at 25.5° LS

J. A. Muñoz [1], A. Amilibia [2], N. Carrera [1], R. Mon [3], G. Chong [4], E. Roca [1], & F. Sàbat [1]

[1] Dpt. de Geodinàmica i Geofísica, Facultat de Geologia UB, Martí i Franqués s/n, 08028-Barcelona, josep@geo.ub.es, nuria@geo.ub.es
[2] Dpt. of Geology, Royal Holloway, University of London, Egham, Surrey TW20 0EX.
[3] Dpt. de Geología, Facultat de Ciencias Naturales e Instituto Miguel Lillo, Universidad Nacional de Tucumán, Miguel Lillo 205 4000 Tucumán (Argentina).
[4] Dpto. de Ciencias Geológicas, Universidad Católica del Norte, Avd. Angamos 0610, Antofagasta, Ghile

The Andes is the type orogen for subduction contractional systems but many uncertainties still exist about the crustal structure and few complete cross-sections have been done and published. Estimates of shortening have been in the past years a matter of debate mainly as far as the deficit of tectonic shortening to account for the known crustal thickness is concerned. Estimates for this shortening have mainly relied on shortening calculations made on cross-sections of parts of the orogen (Baby et al.1997). It is known that along strike motion of material do occur in any mountain belt and has to be taken into account in any precise orogenic mass balance. It has also recently argued that the shortening deficit in the Andes results from plane strain calculations not considering the out of plane section motion of material (Hindle et al., 2005). However, 2D estimates of shortening on cross-section balancing are still a first valid approximation to a mass balance and construction of cross-sections across the entire Andean orogen is a priority.

A complete cross-section of the Central Andes at 25.5 LS has been constructed based mostly on surface geological data. This work has involved field mapping and interpretation of aerial and satellite images across all the main structural units at this Andean transect. Structural data have been acquired all along the cross-section. Interpretation of seismic reflection profiles has also integrated where available, mostly in the eastern part of the cross-section. Published geophysical data have used to constrain the deep crustal structure (Wigger et al. 1994, Yuan et al., 2002).

The main structural features along the cross-section from west to east are described below. The Coastal Cordillera is dominated by strike-slip fault systems which have been deformed the Jurassic La Negra magmatic arc since Mesozoic times. A significant part of the forearc may have been tectonically eroded by the subducted Nazca plate (Fig. 1). Eastwards, the Central Valley is occupied by a Late Jurassic-Early Cretaceous extensional basin, subsequently deformed during the onset of contractional deformation at Late Cretaceous times. This basin developed in a back arc tectonic setting. Synchronously, the Salta rift basin resulted from a widespread extensional deformation of the South America plate in the Argentinean side during the opening of the South Atlantic (Fig. 1). The Cordillera de Domeyko is a thick skinned basement involved thrust system which resulted from the inversion of previous Triassic and Early Cretaceous extensional basins. It is characterized by a pop-up geometry with along strike changes of the dominant vergence (Amilibia et al., 2000). A foreland basin developed east of Cordillera de Domeyko. Thick sequences of this basin have been preserved in the salares aligned between the Cordillera de Domeyko and the present magmatic arc. The Cordillera de Domeyko mostly developed during the Late Cretaceous-Paleocene as evidenced by the growth sequences at both sides of the range

(Amilibia, 2000; Mpodozis et al., 2005). However, their structures where reactivated during the Paleogene and Neogene. Shortening in the Cordillera de Domeyko was coeval with post-rift sedimentation in the Salta Basin. However, it is uncertain if the onset of shortening in Domeyko marked the transition from sin-rift to post-rift in the Salta Basin or if contractional deformation coexisted with Salta Basin rifting. The structure of the Puna is characterized by thrusts and related folds with a no defined vergence. Tertiary synorogenic rocks were deposited and preserved in the Arizaro and Pastos Grandes basins. Growth geometries observed in the lower sediments of the Tertiary succession as well as unconformities at the bottom of the preserved upper Neogene units show that Puna thrusts started to develop at Paleogene time and continued to developed until present. Thrust structures of the eastern Puna were active during the Oligocene-Early Neogene. They have produced the exhumation of Precambrian rocks and controlled the sedimentation in the foreland basin that extended at that time from the Calchaquí valleys to the present foreland (Ramos, 1999, Coutand et al., 2001). East of the Puna, N-S trending, basement involved thrusts of the Eastern Cordillera inverted the Cretaceous Salta rift basin. Structure of the Eastern Cordillera is dominated by west verging tight thrust-related folds with strongly inverted and thinned limbs. The inversion of previous extensional features is moderate because the obliquity between them and the subsequent contractional structures. However, inversion is the dominant tectonic style in the Eastern Cordillera. Extensional faults controlled the location and orientation of the main thrusts as well as interference patterns in the fault-related folds. Inversion started about 12 Ma ago in the western part of the Eastern Cordillera as evidenced by growth strata involving dated tufs. Deformation progressed eastwards into the Santa Barbara system where inversion of Salta basin extensional faults has been observed in the seismic lines across the Metán basin and the foreland.

Contractional deformation started at Late Cretaceous in the Cordillera de Domeyko and then progressively migrated eastwards to the active thrust front at present. The oldest structures have been reactivated through the Paleogene, Neogene and Quaternary. The absence of precise dating of the sedimentary sequences does not allow the definition of distinct tectonic events. Instead contractional deformation seems to have been distributed across the entire orogen as the deformation progressed eastwards. As a consequence, synchronous thrust propagation mode coexisted with a piggy back thrusting sequence. The resulting unconformities in the synorogenic strata depend on the time gap between periods of the reactivation of the structures, among other factors.

Oblique convergence resulted into strain partitioning. Orthogonal shortening occurred in all the structural units eastwards the Coast Range, whereas strike-slip displacements concentrate along the weakened magmatic arcs, mainly along the coast.

All along the studied transect the Andean structures are strongly controlled by the reactivation of previous inherited structures, mainly the Mesozoic extensional faults. Consequently inversion is the dominant tectonic style.

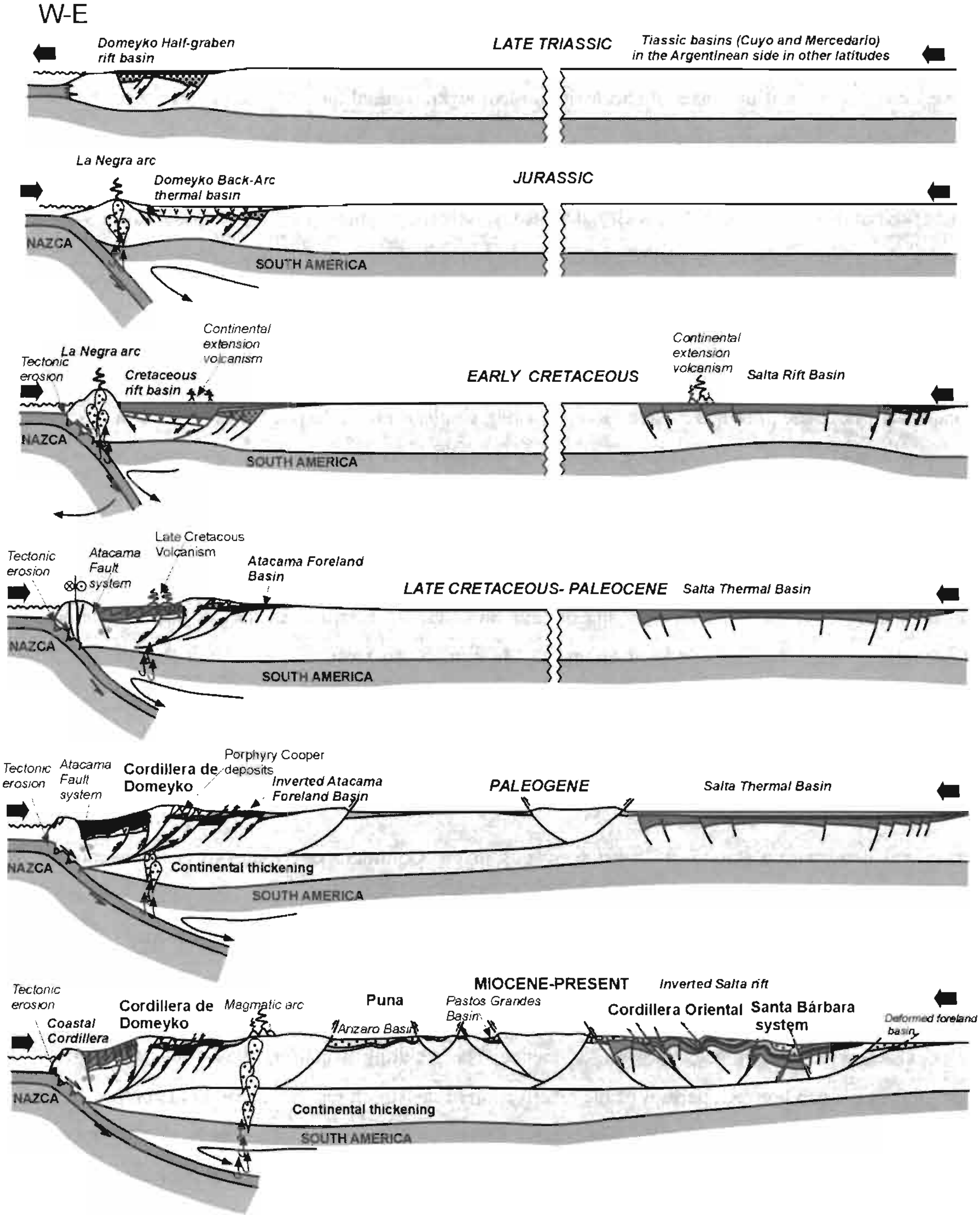

Figure 1: Schematic cross-sections showing the tectonic evolution of the Southern edge of the Central Andes at 25.5° LS.

Acknowledgements

This work have been founded by the projects DGSIC BTE2000-0571 and CGL2004-05816-CO2-01 and have been developed in the Grup de Geodinàmica I Anàlisi de Conques, 2001 SGR 0074, of the Comissional d'Universitats i Recerca de la Generalitat de Catalunya.

References

Amilibia, A., (2002). Inversión Tectónica en la Cordillera de Domeyko Andes del Norte de Chile. PhD thesis. Universitat de Barcelona.

Amilibia,A., Sàbat, F., Chong, G., Muñoz, J.A., Roca, E., Gelabert, B. (2000). Criterios de inversión tectónica: ejemplos de la Cordillera de Domeyko (II región de Antofagasta). Proc. IX Congr. Geol. Chileno, 2: 548-552.

Baby, P., Rochat, P., Mascle, G., Hérail, G. (1997). Neogene shortening contribution to crustal thickening in the back-arc of the Central Andes. Geology 25(10):883-886.

Coutand, I., Cobbold, P., de Urreiztieta, M., Gautier, P., Chauvin, A., Gapais, D., Rossello, E., López-Gamundi, O. (2001). Style and history of the Andean deforamtion, Puna plateau, northwestern Argentina. Tectonics, 20(2): 210-234.

Hindle, D., Kley, J., Oncken, O., Sobolev, S. (2005). Crustal balance and crustal flux from shortening estimates in the Central Andes. Earth and Planetary Sciences Letters, 230: 113-124.

Mpodozis, C., Arriaga, C., Basso, M., Roperch, P., Cobbold, P. Reich, M. (2005). Late Mesozoic to Paleogene stratigraphy of the Salar de Atacama Basin, Antofagasta, Northern Chile: implications for the tectonic evolution of the Central Andes. Tectonophysics, in press.

Ramos, V. (1999). Los depósitos sinorogénicos terciarios de la región andina. In: Geologia Argentina. Instituto de Geología y Recursso Minerales. Anales 29(22): 651-682.

Wigger, P.J.; Schmitz, M.; Arandea, M.; Asch, G.; Baldzuhn, S.; Giese, P.; Heindsohn, W.D.; Martinez, E.; Ricaldi, E.; Röwer, P.; Viramonte, J. 1994. Variation in the crustal structure of the Southern Central Andes deduced from seismic refraction investigation. In: Reutter, K.J.; Scheuber, E.; Wigger, P.J. eds. Tectonics of the Southern Central Andes. Springer-Verlag, 23-48.

Yuan, X., Sobolev, S.V., Kind, R.V. (2002). Moho topography in the Central Andes and its geodynamic implications. Earth and Planetary Sciences Letters, 199: 389-402.