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# Neotectonic transpressive zones in the Precordillera Sur, Central Andes of Argentina: a structural and geophysical investigation

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With 6 figures

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**Abstract:** On the flat-slab segment of the Central Andes of Argentina, the southern portion (31º30' – 33º SL) of the Precordillera is characterized by a singular Late Cenozoic tectonic style related to the tectonic inversion of paleotectonic anisotropies. Different scale, neotectonic NW trending deformation zones are described at this area. All these belts show the same structural style, defined by an en échelon array of morphotectonic features which indicate a left-lateral component of displacement under a transpressive regime. Oblique paleotectonic features seem to play a major role in the geometry and kinematics of Late Cenozoic deformation of the northern Precordillera Sur. In agreement with geological data, a tomography of electrical resistivity survey across one of these zones suggests a Quaternary reverse reactivation of a NW trending extensional paleotectonic fault.

**Key words:** Neotectonics, transpressive zones, paleotectonic controls, Precordillera sur, Central Andes, tomography of electrical resistivity, Argentina

## Introduction

The Precordillera of western Argentina constitutes a N-S trending morphotectonic unit that extends along the Pampean flat-slab subduction segment of the Nazca plate (Jordan et al. 1984), located between 28º and 33º S in the Central Andes of Argentina. It is regionally composed by an east-verging foreland fold and thrust belt bounded by a Precambrian basement to the east (Sierras Pampeanas) and the hinterland to the west (represented by the Cordillera Frontal, Fig. 1 and 2).

The central region of the Precordillera (at San Juan province, Fig. 1) is mostly formed by N-S parallel ranges and longitudinal valleys of about 150 km length (Fig. 1). The whole system is controlled by the contractional Late Cenozoic deformation and forms a thin-skinned fold and thrust belt.

However, the southern region of the Precordillera (31º30' – 33º SL) shows different morphotectonic characteristics which are controlled mostly by older (i. e. Triassic) extensional structures generated during the development of the Cuyana basin (Kozlowsky et al. 1993; Cortés et al. 2005a; Fig. 1). From its peculiar tectonic behaviour this region has been considered as a separate morphotectonic subunit, i. e. the Precordillera Sur (at the southern end of Precordillera; Cortés et al. 2005a). A geological and structural map of the central and southern regions of the Precordillera including the Precordillera Sur is shown in figure 2.

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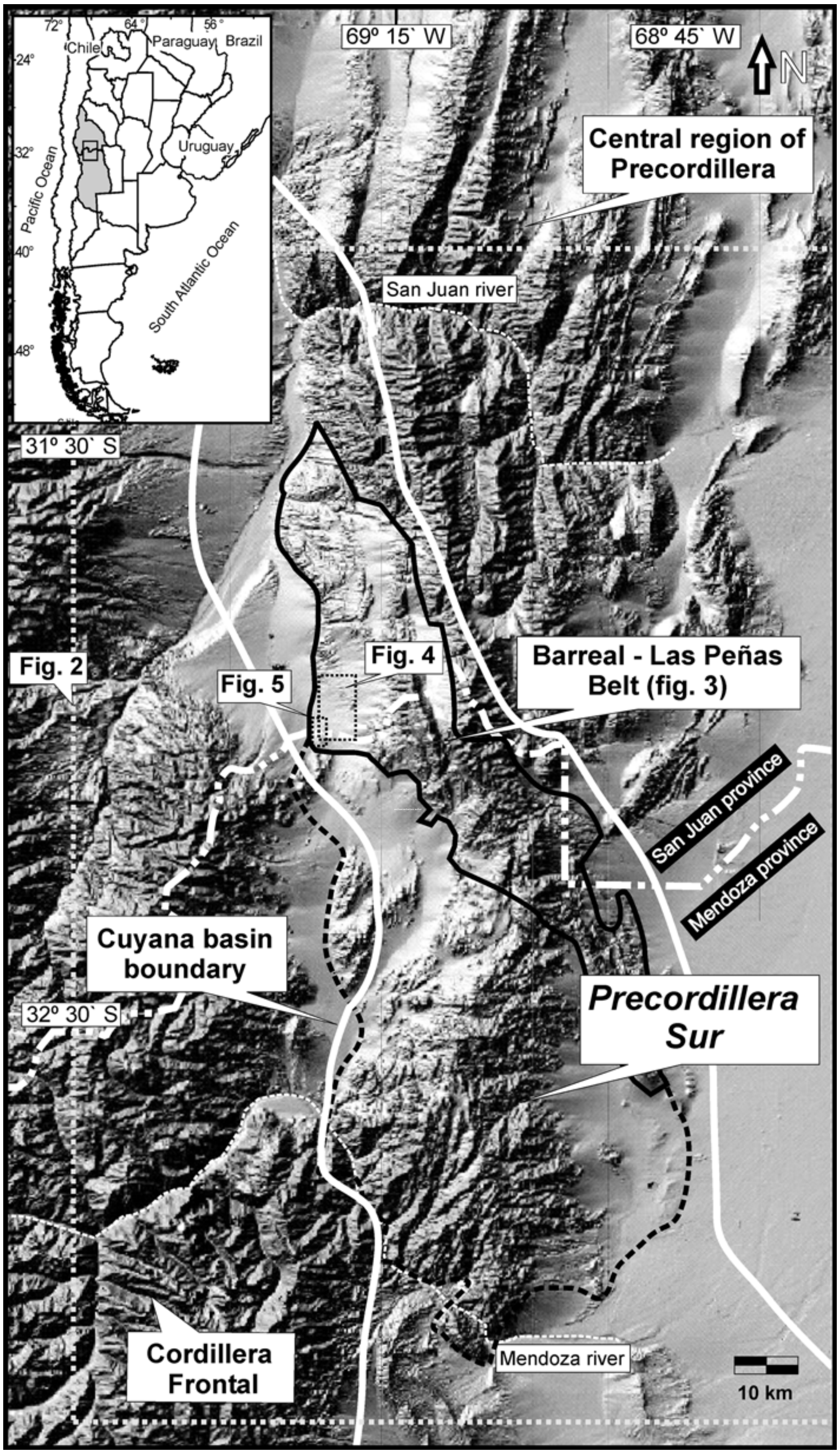


**Fig. 1.** Location of the morphotectonic units of Precordillera, Precordillera Sur and Cordillera Frontal on a Digital Elevation Model shaded relief. **Black line =** boundary of the Precordillera Sur. **White line =** boundaries of the Triassic Cuyana basin.

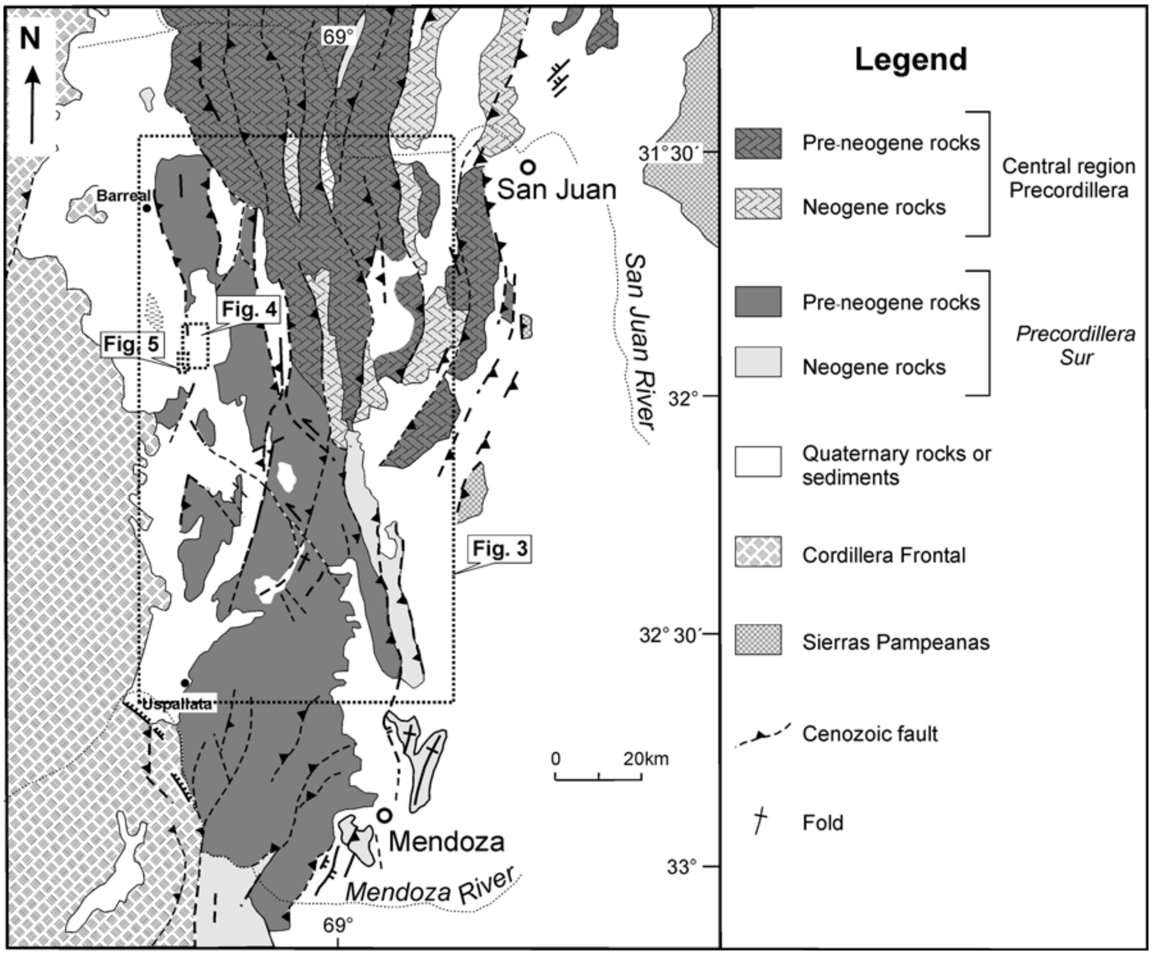


**Fig. 2.** Geological map of the Precordillera and the Precordillera Sur. Adjacent morphotectonic units (Cordillera Frontal and Sierras Pampeanas) are also shown.

The northern zone of the Precordillera Sur is characterized by a left-stepping arrangement of mountainous blocks which has been interpreted as a NW-trending left-lateral transpressive shear zone that is known as the Barreal-Las Peñas belt (CORTÉS et al. 2006).

Morphotectonic analysis highlights the same geometric and kinematic pattern at different scales within the Barreal-Peñas belt, which has been interpreted as evidence of the fractal nature of the Late Cenozoic structures in this zone (following TURCOTTE 1992).The aim of this article is to report the presence of Quaternary sinistral transpressive belts of different sizes in the northern region of the Precordillera Sur and to provide geoelectrical interpretations of paleotectonic controls on present-day compressive structures. The field investigation of structures has been completed by both the morphotectonic study of aerial photograph and a geoelectrical survey across one of the Quaternary structures.

## Tectonic framework

A brief overview of the tectonic history of the region is necessary since the deformation zones, which are analyzed in the present contribution, seem to be controlled by older structures.

The Central Andes ranges (including the Precordillera) have been originated during the latest orogenic cycle (Andean orogenic cycle) in Neogene times. However, at least two compressional and one extensional pre-Neogene events have printed the characteristics of the basement in which the Andes are built. The major pre-

Andean deformation events are the following: 1. compressive Early to Middle Paleozoic deformation (Devonian, Chanic deformation), 2. compressive Late Paleozoic deformation (Lower Permian, San Rafael phase), and 3. Upper Permian to Triassic extension (Choiyoi magmatic cycle and Cuyana basin development).

The western margin of South America has an earlier collisional history (Ramos et al. 1986). The Precordillera, considered as an allochthonous terrane derived from SE Laurentia (Astini et al. 1996; Astini & Thomas 1999; Ramos et al. 2001) has collided during the Early Paleozoic against the southwestern margin of Gondwana. As a result of such collision, the terrane has been amalgamated leading to the Early Paleozoic basement in which the following deformation stages were developed.

The first major deformation episode within the amalgamated terrane of the Precordillera took place during Middle to Late Devonian times as a consequence of a crustal shortening related to the collision of the Chilenia terrane (Ramos et al. 1984, 1986) against the Gondwana margin (Chanic deformation). Outcrops of mafic and ultramafic rocks located along the western margin of the Precordillera have been related to an ophiolite complex and subsequently to a suture zone (Haller & Ramos 1984, 1993). Furthermore, the Chanic deformation is represented in the Early Paleozoic basement by west-verging NW to NE trending metamorphic foliation (von Gosen 1995).

Evidences of an Early Permian deformation (San Rafael phase; Ramos & Ramos 1979) have been described at the Precordillera Sur (von Gosen 1995; Cortés et al. 1997, 1999; Cortés & Kleiman 1999). As a consequence of these movements, large scale N-S to NNE-SSW running folds and thrusts associated with NW strike-slips faults were developed (von Gosen 1995; Cortés et al. 1997). The San Rafael deformation phase was widely documented over the Central Andes, at the Bloque de San Rafael (Azcuy & Caminos 1987; Cortés & Kleiman 1999; Kleiman & Japas 2002; Japas & Kleiman 2004), at the Cordillera Frontal and Principal (Ramos 1988; Llambias et al. 1993), as well as at the Barreal region in the north-western edge of Precordillera Sur (Furque & Cuerda 1984). The wide distribution of this contractional event suggests that it is not a local phenomenon but the result of a major change along the subduction zone west of the Gondwana margin (Ramos et al. 1984; Ramos 1988).

After a wide extensional magmatic cycle (Choiyoi cycle), mostly developed during Middle to Upper Permian times, an extensional Triassic phase built wide scattered NNW trending rift basins all over the western margin of Gondwana (Uliana et al. 1989). The Barreal-Las Peñas belt matches up with the northern end of one of these Triassic rift basins, called Cuyana basin (Strelkov & Alvarez 1984; Fig. 1).

Different authors interpreted the Cuyana basin as a set of distinctive depocenters with opposite polarity (Kokogian & Mancilla 1989; Ramos & Kay 1991; López Gamundí 1994) and transtension areas located at the transference zones between rift segments. From the analysis of seismic lines, sedimentary facies and paleocurrents, the Cuyana basin has been described as a linked fault system with alternating polarities (Legarreta et al. 1993). Strelkov & Alvarez's (1984) maps show a NNW striking Cuyana basin with NNW to NW and NNE to NE trending normal faults. Microtectonic structures indicate a sinistral component during this extensional event (Japas et al. 2005).

The Neogene and Quaternary deformation is related to the Andean contractional orogenic cycle. At the Central Andes, the evolution of the flat slab subduction and the crustal anisotropies have conditioned the Late Cenozoic development of morphotectonic units during the last 15 Ma. The Andean contractional deformation is associated with the Cuyana basin inversion (Ramos & Kay 1991; Kozlowski et al. 1993; Legarreta et al. 1993; Cortés et al. 1997).

Oblique Paleozoic deformation zones in the Precordillera Sur were reactivated during Triassic (Cortés et al. 1997; Giambiagi & Martínez 2005) and Neogene times (Cortés 1998). The paleotectonic anisotropies have probably played an important role in the geometry and kinematics of the Neogene to Recent deformation and the consequent morphotectonic segmentation of the Precordillerean ranges. Usually, the Precordillera was considered as a unique morphotectonic unit with a single geologic history. However, it has been observed that its deformation style changes longitudinally (Ortiz & Zambrano 1981; Baldis et al. 1982; Baldis & Vaca 1986). Whereas the central region of the Precordillera (San Juan province) is a thin-skinned fold and thrust belt, with longitudinal (N-S) ranges and intermontane basins, the southern region shows evidence of tectonic inversion of the Cuyana basin (Ramos & Kay 1991; Kozlowski et al. 1993; Legarreta et al. 1993; Cortés et al. 1997; Cortes et al. 2005a). Distinctive features of the southern portion of Precordillera (in contrast with the central region), such as its different structural style and morphotectonic design were used by Cortés et al. (2005a) to define a new morphotectonic unit called Precordillera Sur. According to these authors, the Precordillera Sur is characterized by shorter NNW to NNE blocks of up to 30 km length, restricted by high angle reverse faults which sometimes are associated with oblique (NW) and transverse (WNW) strike-slip structures. These oblique and transverse structures are recognized as a distinctive feature (CORTÉS et al. 2005b) which controls the end and subsequently the segmentation of the mountain fronts.

## Different orders of transpressive shear zones

Different orders of en échelon folds and reverse faults related to oblique and transverse strike-slip faults within the northern region of the Precordillera Sur are described below. These structures, recognized from field work and aerial photographs, were outlined in Digital Elevation Model (DEM) images. All of them preserve evidence of Quaternary to Recent deformation.

## Barreal-Las Peñas belt (1st order structure)

The whole northern region of the Precordillera Sur corresponds to the Barreal-Las Peñas belt (CORTÉS et al. 2005a). This is a 130 km long and 10 – 20 km wide belt trending SE (130º). It is made up of five NNW trending blocks with a left-stepping arrangement named, from west to east, Barreal, Ansilta, Peñasco, Santa Clara and Las Peñas (Fig. 3a).

Each of these blocks reaches about 20-40 km length and is integrated by one or more ranges. Each block is laterally bounded by longitudinal (NNW- to N-S) reverse or oblique-slip faults. Their northern and southern edges are commonly marked by NW trending left-lateral strike-slip faults or deformation zones. The longitudinal faults are east- or west-verging. The NW oblique faults

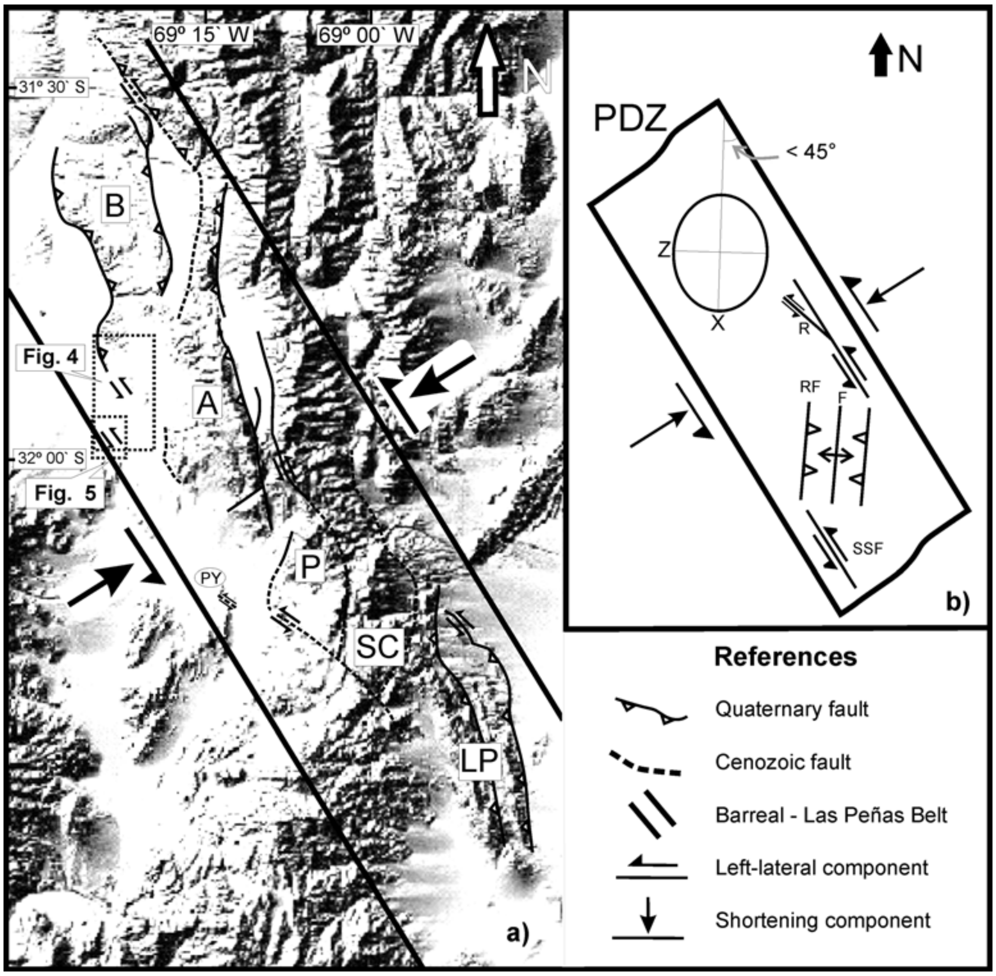


**Fig. 3.** The Barreal-Las Peñas belt (first-order structure). **a.** On a Digital Elevation Model shaded relief. **B** = Barreal block; **A** = Ansilta block; **P** = Peñasco block; **SC** = Santa Clara block; **LP** = Las Peñas block; **PY** = Pampa Yalguaraz. **b.** Kinematic model, under a transpressive regime, for the Barreal-Las Peñas belt structures. **R** = Riedel shear; **RF** = Reverse fault; **F** = Fold; **SSF** = Strike-slip fault; **PDZ** = Principal deformation zone.

work as left lateral transfer faults between some of the adjacent blocks.

On the basis of their stratigraphical relations, as observed in the field, it is interpreted that these structures are of Neogene age and could even be Quaternary to Recent in age (Fig. 3a).

The combination of these afore-mentioned structural features has been interpreted as a sinistral transpressive pattern (Cortés et al. 2006). The Barreal-Las Peñas belt corresponds to a first-order Neogene to Recent oblique deformation zone in the interior of the Precordillera of western Argentina.

## Pampa de los Burros deformation zone (2nd order structure)

The Barreal block is situated at the north-western edge of the Barreal-Las Peñas belt. Its western boundary is a 15 km long NW-trending deformation belt of Late Cenozoic age. This last belt penetrates towards the SE into the piedmont developing folds and a set of left stepping structural highs of about 5-8 km length. The most important of these highs are called Lomas del Inca, Pampa de los Burros and Lomitas Negras (Fig. 4). They have a NNW or NNE trend and show evidence of neotectonic deformation such as bending of Quaternary deposits, uplifted alluvial levels and fault and fold limb scarps developed in Quaternary sediments (Cortés & Cegarra 2004).

The Lomas del Inca high shows a folded surface. Its western uplift front is a west- verging fault propagation fold which is related to smaller oblique folds. This deformation involves Paleozoic and Cenozoic rocks (Basile 2004; Vallejo 2004). Along its western mountain front the Quaternary alluvial deposits are tilted reaching anomalous dips of up to 25º towards the west, whereas Quaternary deposits of the eastern limb dip against their original slope. The Pampa de los Burros high, located close to the Lomas del Inca high, corresponds to a double plunging anticline, slightly asymmetric to the west and with a sigmoidal axial trace (Fig. 4), which suggests the influence of a strike-slip component. At the surface, its limbs show piedmont fault scarps and fold limb scarps. The fold limbs show also growth strata (Cortés & Cegarra 2004) which can be considered as an evidence of synchronous deformation and deposition.

The Lomitas Negras high is about 3.5 km long and is situated towards the SE of the Pampa de los Burros anticline. Although its core is formed almost entirely by the Paleozoic bedrock, it preserves a Pleistocene folded and faulted sedimentary cover. Like the Pampa de los Burros anticline, the Quaternary deposits of the Lomitas Negras high exhibit syntectonic growth strata.

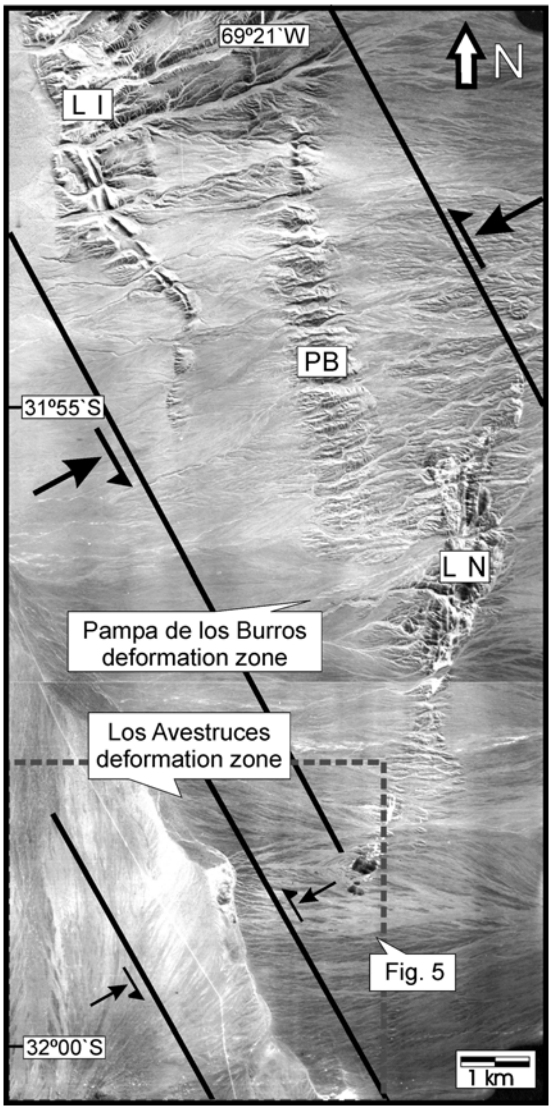


**Fig. 4.** Aerial photograph of the Pampa de los Burros and the Los Avestruces deformation zones. **LI =** Lomas del Inca high; **PB =** Pampa de los Burros high; **LN =** Lomitas Negras high.

Drainage anomalies at the north and south ends make it possible to infer strain propagation in those directions (Terrizzano 2006).

This left-stepped arrangement of structures permit us to infer a second order zone of Neogene to Recent age within the Barreal-Las Peñas first order belt.

## Los Avestruces deformation zone (3rd order structure)

Within the first order Barreal-Las Peñas belt and towards the SW of the second order Pampa de los Burros belt

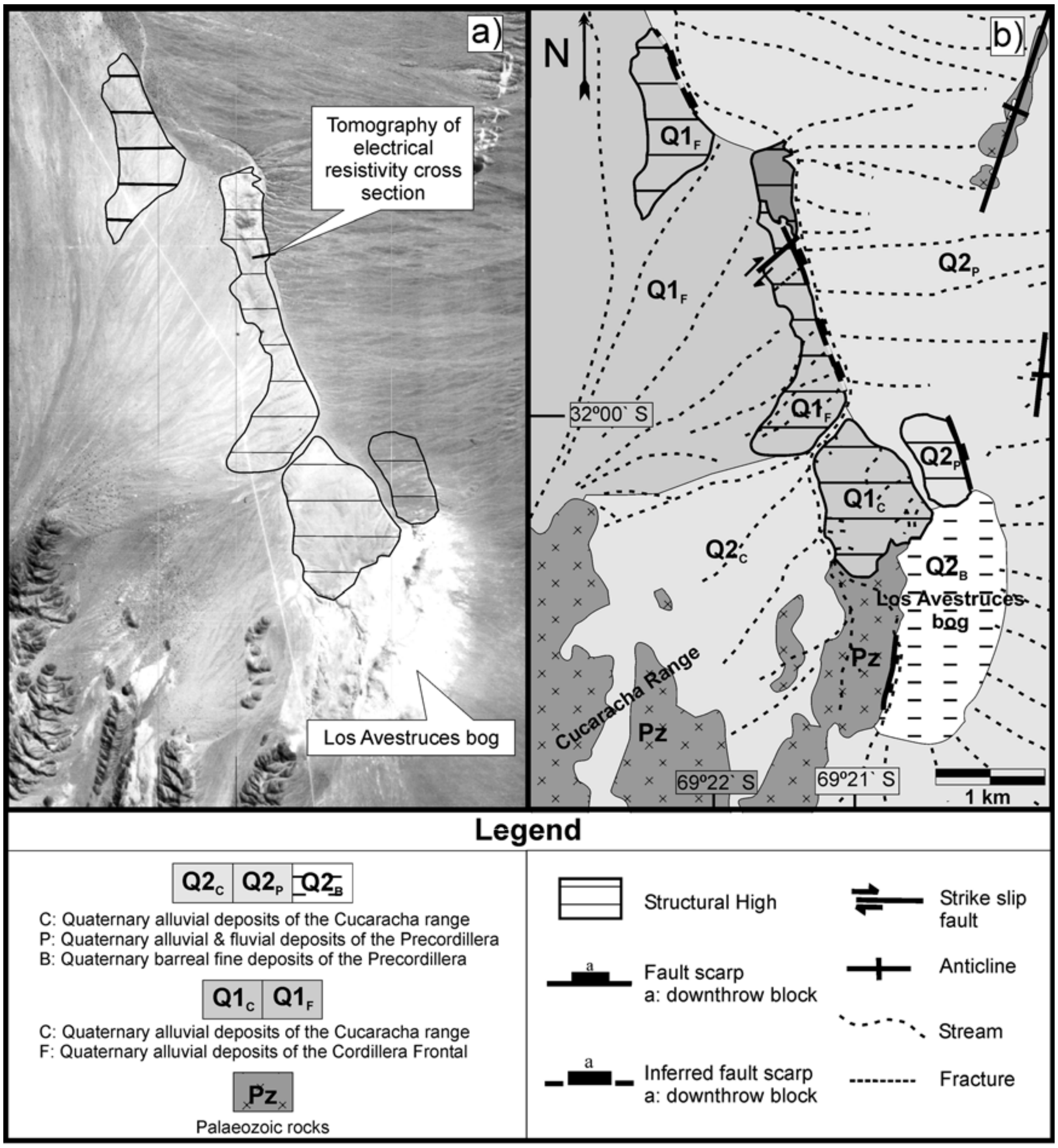


**Fig. 5.** Los Avestruces deformation zone. **a.** Structural highs, Los Avestruces bog and the location of the tomography of electrical resistivity section on an aerial view. **b.** a geological and structural sketch.

(Fig. 4), a group of 1 to 2.5 km long, NNW-trending Quaternary to Recent structural highs has been recognized. These highs constitute a 5 km long, NW- trending belt or zone which is developed in the Pleistocene sedimentary cover. They have a left-stepping arrangement and are associated with oblique and longitudinal fault scarps (Fig. 5 a and b).

Close to the southernmost high and to the east lies the Los Avestruces bog (Fig. 5 a). The fine bog sediments were likely deposited there as a consequence of tectonic damming of alluvial streams on the Precordillera piedmont. The southernmost Quaternary to Recent high apparently works as an obstacle to the drainage in that area.

Therefore, these left-stepped structural highs define a narrow and small third-order structure called Los Avestruces deformation zone.

## Los Avestruces deformation zone: geophysical observations

A pilot tomography of the electrical resistivity profile was carried out across one of the Los Avestruces highs in an E-W direction, in order to get information about the subsurface geometry of the structures recognized in the structural and geomorphic study of these pressure ridges.

A 470 m long Dipole-Dipole array (see Telford et al. 1990 for basic details on the methodology) was used in this site, with 48 electrodes separated by 10 meters. 545 quadrupoles were determined with dipole lengths of 10 m (n = 1 to 6) and 20 m (n = 3 to 12). A maximum penetration of 60 m was modelled. Injection time was 1 s, and 2 to 6 repeated measurements were performed at each quadrupole. The survey was carried out with a Syscal Junior Resistivity meter (Iris Co.) that allows automatic current input, voltage records and selection of dipole pairs.

The resistivity survey aimed at determining and modelling the distribution of electrical resistivity in the subsurface. This, in turn, can be interpreted in terms of lithology, structure and fluid content. Application of this kind of surveys to map active faults has proved successful (e. g. Storz et al. 2000; Demonet et al. 2001; Colella et al. 2004), although it has yet to be adopted as a standard practice in neotectonic studies. Areas with a high secondary porosity are frequently developed around active faults, allowing the increase of fluid content which is generally accompanied by a significant decrease in the electric resistivity.

One of the Los Avestruces ridges was selected for a transverse tomography of the electrical resistivity profile (Fig. 5 a). The profile crosscuts the westernmost edge of the structural high in Pleistocene deposits, a fault scarp facing to the east and a small outcrop of Paleozoic clastic metasediments exposed at the pressure ridge. The profile included the eastern edge of this ridge in order to decide whether or not it was a structural boundary.

## Tomography of electrical resistivity cross section: results and interpretation

Figure 6a shows the selected inverse model for the subsurface resistivity. According to the obtained resistivity values from the selected model, those of rocks and alluvium (Loke 1996-2002) and in association with field geological data, an interpreted geological cross section was built for this site (Fig. 6b). The scarp has a small topographic relief (less than 1 m) and is located at distance 220 m, showing an uplifted western block. The inverse model is consistent with the presence in the field of Quaternary alluvial fans beds ($\rho < 325$ ohm.m) both to the west ($d < 180$ m) and to the east ($d > 330$ m) of the scarp. Beds on the western and on the eastern side apparently dip west and east respectively, opposing the regional and original slope and suggesting that the Quaternary infill has been tilted as a consequence of compressional deformation.

A conspicuous resistivity discontinuity is evident in the subsurface coincident with the location of the scarp. This may suggest that the scarp is associated to a west-dipping high-angle fault. Exposures of Paleozoic rocks to the East of the scarp ($d = 320$ m) permit to assign the high resistivity zones in the subsurface ($\rho > 900$ ohm.m) to these rocks. A significant throw of around 25 m is suggested by the resistivity distribution across the fault. Since the distribution of the Paleozoic rocks indicates that the hanging western block is downthrown, it must be concluded that the fault worked as a normal fault after the Paleozoic, most probably during the Triassic. This is opposite to the reverse movement indicated by the Quaternary sediments displaced along the scarp. A possible reconciliation to these observations is to interpret this fault as a likely previous extensional fault (Triassic, associated to the development of the Cuyana basin?) that has been reactivated and inverted in the Quaternary. The significantly larger throw allowed us to depict the original normal character of the fault. This small-scale survey confirms the tectonic pattern of the area characterized by the Andean reactivation of Late Paleozoic - Early Mesozoic structures (Cortes 1998).

As a secondary observation, no evidence is shown by the electrical survey of a fault bounding the eastern limb of the Avestruces high.

## Discussion

At the northern portion of the Precordillera Sur, NW-trending deformation zones at different scales are pointed out. Within the major zone, called Barreal-Las Peñas belt (130 km length), the Pampa de los Burros belt (15 km length) and the Los Avestruces zone (5 km length) were recognized. All these Late Cenozoic zones show the same structural style, characterized by blocks, structural highs, small basins and folds with a left-stepped arrangement. The en échelon array of structural elements and morphotectonic features indicates a left-lateral component of displacement along these zones.

From theoretical and experimental basis (see Sylvester 1988 and Woodcock & Schubert 1994) en échelon arrays of structural elements and morphotectonic features in narrow elongate zones usually indicate a lateral component of displacement along them.

The direction of the horizontal movement on the strike-slip fault zone is revealed by the stepping direction

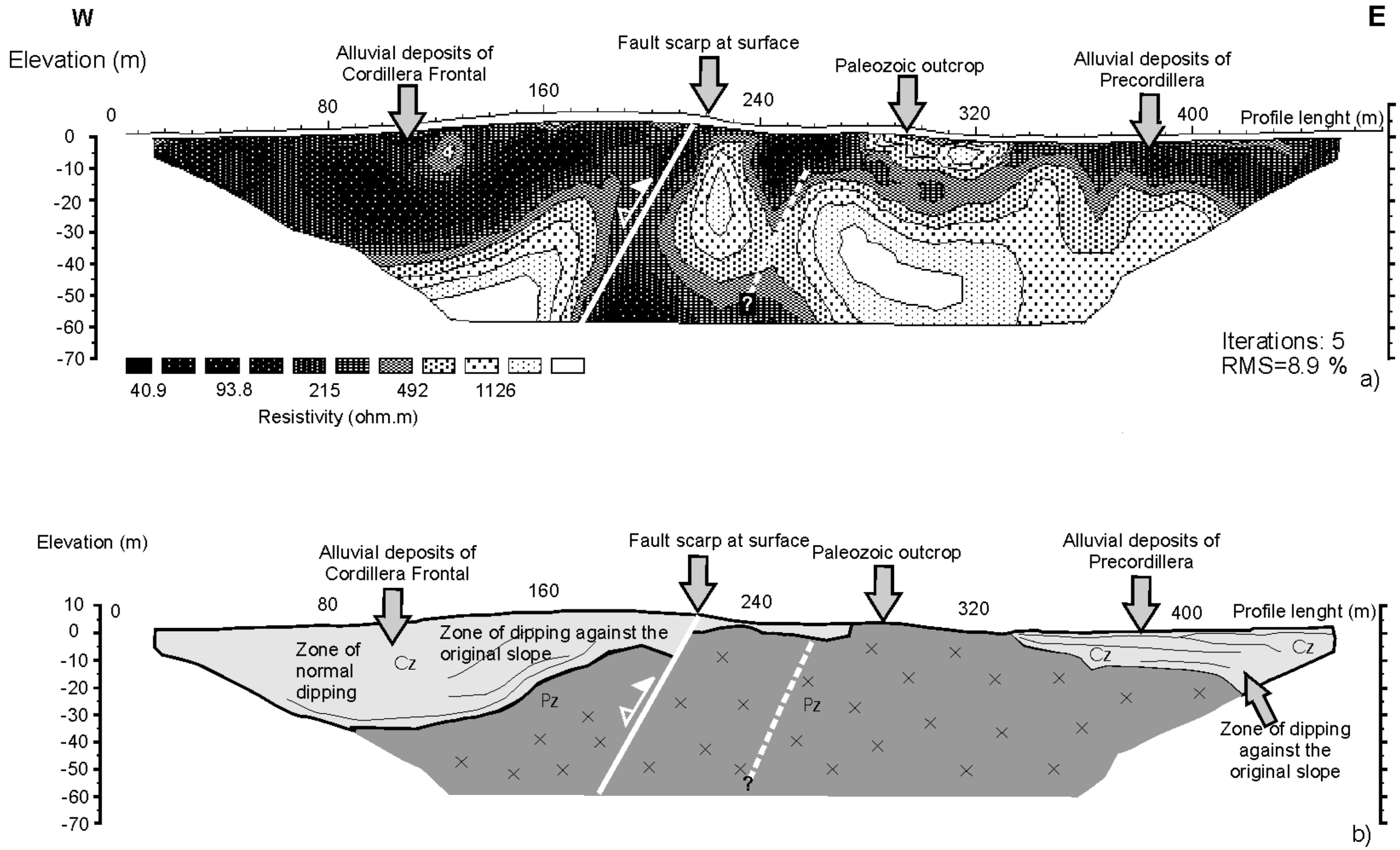


**Fig. 6.** Tomography of electrical resistivity. **a.** Selected inverse model performed in Los Avestruces highs. A DD array was used with a unit electrode spacing of 10 m (smooth-constrained inversion). Maximum penetration depth was 60 m. **b.** Interpreted geological cross section.

of the folds and/or thrusts: Right-stepping folds form in right slip; left-stepping folds form in left slip. The same pattern is followed by the thrusts. Thus, from the geometry of the strain pattern in simple shear, it is possibly to deduce the slip direction of the strike-slip fault zone (Sylvester 1988).

However, the presence of en échelon structural elements in a deformation zone is not only restricted to strike-slip faulting (Sylvester 1988). A stepped arrangement of folds or faults may also reflect the complex influence of basement structures at depth, or they may represent the superposition of differently oriented folds in time and space (Harding 1988). An example of en échelon basement-involved folds, which work as oblique structures predating strike-slip deformation, has been described from the Death Valley area by Christie-Blick & Biddle (1985). But such kind of predating en échelon structures have not been described in the pre-Cenozoic substratum in the Precordillera Sur region. On the other hand, evidence of Late Cenozoic strike-slip faulting in northern Precordillera Sur was reported by Cortés et al. (1997, 1999, 2006).

The neotectonic left-lateral deformation zones in the northern region of Precordillera Sur are interpreted as developed under a transpressive regime because their complex en échelon design is characterized by a horizontal strain ellipse which has its long axis (X axis in Fig. 3b) at a lower angle (< 45º) with respect to the principal displacement zone (PDZ) boundaries (Fig. 3b), than in a simple strike-slip deformation (Sanderson & Marchini 1984).

In the central region of Precordillera, where the Lower Permian structures (San Rafael phase) and Triassic extensional faults of Cuyana basin are absent, the Late Cenozoic contractional deformation under oblique convergence (Az 80º-85º) between the Nazca and the South American plates has built an east-verging thin-skinned belt with a general N-S trend of thrust sheets and intermontane basins. On the other hand, the Precordillera Sur, where paleotectonic events and oblique structures have been documented, shows a different tectonic style characterized by tectonic inversion of Cuyana basin structures and by sets of oblique NW fractures which were reactivated as simple or transpressive strike-slip faults or fault zones (Cortés et al. 2006). At the northern region of the Precordillera Sur, Late Cenozoic to Recent NW-running strike-slip fault zones have already been described at the Barreal block (Yamín 2007) and the Pampa Yalguaraz area (Cortés et al. 1997; Fig. 3a). Late Cenozoic to Recent strike-slip rejuvenation of Palaeozoic NW-running strike faults in this area was also studied by Cortés (1998). Furthermore, the small scale tomography of electrical resistivity survey at the Los Avestruces deformation zone has proved the case of older extensional structures being inverted as a reverse fault by the Andean orogeny.

## Conclusions

At the northern portion of the Precordillera Sur, NW-trending deformation zones at different scales are pointed out. In the interior of the major zone, called Barreal-Las Peñas belt (130 km long), the Pampa de los Burros belt (15 km long) and the Los Avestruces zone (5 km long) were recognized. All these Late Cenozoic to Recent deformation zones show the same structural style characterized by blocks, structural highs, small basins and folds with a left-stepped arrangement. The en échelon array of structural elements and morphotectonic features indicates a left-lateral component of displacement along these zones. These neotectonic left-lateral deformation zones are interpreted as having developed under a transpressive regime.

Oblique paleotectonic features seem to play a major role in the geometry and kinematics of Late Cenozoic deformation of the northern Precordillera Sur. In agreement with geological data, a tomography of an electrical resistivity profile in the Los Avestruces zone suggests the presence of an NW extensional paleotectonic fault which was reactivated as a reverse fault during the Quaternary. The presence of Quaternary fan layers tilted against their original slope, as suggested by the geophysical survey, further confirms the important tectonic deformation affecting the piedmont sediments of the western edge of the Precordillera Sur.

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## References

Astini, R., Ramos, V. A., Benedetto, J. L., Vaccari, N. E. & Cañas, F. L. (1996): La Precordillera: un terreno exótico a Gondwana. – 13º Congreso Geologico Argentino y 3º Congreso de exploracion de Hidrocarburos, Actas **5**: 293-324, Buenos Aires.

Astini, R. & Thomas, W. (1999): Origin and evolution of the Precordillera terrane of western Argentina: a drifted Laurentian orphan. – In: Ramos, V. A. & Keppie, D. (Eds.): Laurentia-Gondwana connections before Pangea.

– Geological Society of America, Special Paper, **336**: 1-20.

Azcuy, C. L. & Caminos, R. (1987): Diastrofismo. – In: Archangelsky, S. (Ed.): El Sistema Carbonífero en la República Argentina. – Academia Nacional de Ciencias: 239-251; Córdoba.

Baldis, B., Beresi, M., Bordonaro O. & Vaca, A. (1982): Síntesis evolutiva de la Precordillera Argentina. – 5º Congreso Latinoamericano de Geología, Actas **4**: 399-445; Buenos Aires.

Baldis, B. & Vaca, A. (1986): Megafracturas relacionadas con el sistema precordillerano. – Primeras Jornadas Geologia de Precordillera, Actas **1**: 204-208; San Juan.

Basile, Y. A. (2004): Estudio geológico y geofísico del sector sur de las lomas del Inca, provincia de San Juan. – 126 pp; unpubl. Trabajo final de licenciatura (Universidad de Buenos Aires).

Christie-Blick, N. & Biddle, K. T. (1985): Deformation and basin formation along strike-slip faults. – In: Biddle, K. T. & Christie-Blick, N. (Eds.): Strike-slip deformation, basin formation, and sedimentation: SEPM Special Publication, **37:** 1-35.

Colella, A., Lapenna, V. & Rizzo, E. (2004): High-resolution imaging of the High Agri Valley Basin (Southern Italy) with electrical resisitivity tomography. – Tectonophysics, **386**: 29-40.

Cortés, J. M., González Bonorino, G., Koukharsky, M. L., Pereyra, F. X. & Brodtkorb, A. (1997): Hoja 3369-03, Yalguaraz, Provincias de San Juan y Mendoza. – 119 pp.; Servicio Geológico Minero Argentino (unpublished).

Cortés, J. M. (1998): Tectónica de desplazamiento de rumbo en el borde sur de la depresión de Yalguaraz, Mendoza, Argentina. – Revista de la Asociación Geológica Argentina, **53** (2): 147-157.

Cortés, J. M. & Kleiman, L. E. (1999): La Orogenia Sanrafaélica en los Andes de Mendoza. – 31 pp.; 14º Congreso Geológico Argentino, Salta, Actas, **1**.

Cortés, J. M., González Bonorino, G., Koukharsky, M. L. Brodkorb, A. & Pereyra, F. (1999): Hoja Geológica 3369-03 Yalguaraz, Mendoza. Carta Geológica de la República Argentina Escala 1:100.000. – Servicio Geológico Minero Argentino, Boletín 280, published map and unpublished preliminary text, Buenos Aires.

Cortés, J. M. & Cegarra, M. (2004): Plegamiento Cuaternario transpresivo en el piedemonte suroccidental de la Precordillera sanjuanina. – Asociación Geológica Argentina, Serie D, Publicación Especial, **7**: 68-75.

Cortés, J. M., Yamín, M. G. & Pasini, M. M. (2005a): La Precordillera Sur, Provincias de Mendoza y San Juan. – 16º Congreso Geológico Argentino, La Plata, Actas **1**: 395-402.

Cortés, J. M., Casa, A., Pasini, M. M. & Yamín, M. G. (2005b): Fajas de estructuras neotectónicas asociadas a rasgos paleotectónicos en Precordillera Sur y Cordillera Frontal (31º30′-33º 30′ LS). – 16º Congreso Geológico Argentino, La Plata, Actas **4**: 463-466.

Cortés J. M., Casa, A., Pasini M., Yamín M. & Terrizzano, C. M. (2006): Fajas oblicuas de deformación neotectónica en Precordillera y Cordillera Frontal (31º30′-33º30′LS): Controles paleotectónicos. – Revista de la Asociación Geológica Argentina, **61** (4): 639-646.

Demonet, D., Renardy, F., Vanneste, K., Jongmas, D., Camelbeek, T & Megharaoui, M. (2001): The use of geophysical prospecting for imaging active faults in the Roer Graben, Belgium. – Geophysics, **66** (1): 78-89.

Furqué, G. & Cuerda, A. (1984): Estilos tectónicos de la Precordillera. – 9º Congreso geológico Argentino, San Carlos de Bariloche, Actas, **2**: 368-380.

Giambiagi, L. & Martínez, A. (2005): Extensión oblicua permo-triásica durante el desarrollo del grupo Choiyoi. – 26 pp.; Resúmenes 13º Reunión de Tectónica, San Luis, Argentina.

Gosen, W. v. (1995): Polyphase structural evolution of the southwestern Argentine Precordillera. – Journal of South American Earth Sciences, **8** (3/4): 377-404.

Haller, M. & Ramos, V. A. (1984): Las ofiolitas famatinianas (Eopaleozoico) de las provincias de San Juan y Mendoza. – 9º Congreso Geológico Argentino, San Carlos de Bariloche, Actas, **2**: 66-83.

Haller, M. & Ramos, V. A. (1993): Las ofiolitas y otras rocas afines. – In: Ramos, V. A. (Ed.): Geologia y Recursos Naturales de Mendoza. – 12º Congreso Geologico Argentino y 2º Congreso de exploracion de Hidrocarburos, Mendoza, Relatorio **1**: 31-39.

Harding, T. P. (1988): Criteria and pitfalls in the identification of wrench faults with exploration data (abs). – 193 pp.; American Association of Petroleum Geologists Bulletin, **72**.

Japas, M. S. & Kleiman, L. E. (2004): El ciclo Choiyoi en el bloque de San Rafael: de la orogénesis tardía a la relajación mecánica. – Revista Asociación Geológica Argentina, D, Publicación Especial, **7**: 89-100.

Japas, M. A., Cortés, J. M. & Pasini M. M. (2005): Tectónica extensional triásica en el sector norte de la cuenca Cuyana, Precordillera Sur: primeros datos cinemáticos. – Resúmenes 13º Reunión de Tectónica: 31-32.

Jordan, T., Ramos, V. A., Allmendinger, R. & Isacks, B. (1984): Andean tectonics related to geometry of subduced Nazca plate, Discussion and reply. – Geological Society of America, Bulletin, **95** (7): 877-880.

Kleiman, L. E. & Japas, M. S. (2002): The Lower Choiyoi volcanic sequence at 34º-35º30’, San Rafael, Mendoza, Argentina: Evidence of active plate convergence. – IGCP Symposium 436: Pacific Margin of Gondwana, Gondwana XI, abstracts.

Kokogián, D. A. & Mancilla, O. A. (1989): Análisis estratigráfico de la Cuenca Cuyana. Secuencias depositacionales continentales. – In: Chebli, G. A. & Spalletti, L. A. (Eds.): Cuencas sedimentarias Argentinas. – 10º Congreso Geologico Argentino Simposio, Tucumán: 169-201.

Kozlowski, E. E., Manceda, R. & Ramos, V. A. (1993): Estructura. – In: Ramos, V. A. (Ed.): Geología y recursos naturales de Mendoza. – 12º Congreso Geológico Argentino y 2º Congreso de Exploración de Hidrocarburos, Mendoza, Relatorio, **1** (18): 235-256.

Legarreta, L., Kokogian, D. A. & Dellapé, D. A. (1993): Estructuración terciaria de la Cuenca Cuyana: ¿cuánto de inversión tectónica?. – Revista Asociación Geológica Argentina, **47** (1): 83-86.

Llambías, E. J., Kleiman, L. E. & Salvarredi, J. A. (1993): El magmatismo gondwánico. – In: Ramos, V. A. (Ed.): Geología y recursos naturales de Mendoza. – 12º Congreso Geológico Argentino y 2º Congreso de Exploración de Hidrocarburos, Mendoza, Relatorio, **1**: 53-64.

Loke, M. H. (1996-2002): Tutorial, 2-D and 3-D electrical imaging surveys. – Geotomo Software.

López Gamundí, O. (1994): Facies distribution in an asymmetric half graben: the northern Cuyo basin (Triassic), Western Argentina. – 14º International Sedimentology Congress, Recife, Abstracts, **1**: 6-7.

Ortiz, A. & Zambrano, J. (1981): La provincial geológica de Precordillera Oriental. – 8º Congreso Geológico Argentino, Actas, **3**: 59-74.

Ramos, V. A. (1988): The tectonics of the Central Andes: 30º to 33º S latitude. – In: Clark, S. & Burchfield, D. (Eds.): Processes in continental lithospheric deformation. – Geological Society of America, Special Paper, **218**: 31-54.

Ramos, E. D. & Ramos, V. A. (1979): Los ciclos magmáticos de la República Argentina. – 7º Congreso Geológico Argentino, Actas **1**: 771-786.

Ramos, V. A., Jordan, T. E., Allmendinger, R. W., Kay, S. M., Cortés, J. M. & Palma, M. A. (1984): Un terreno alóctono en la evolución paleozoica de los Andes Centrales. – 9º Congreso Geológico Argentino, San Carlos de Bariloche, Actas, **2**: 84-106.

Ramos V. A., Jordan, T. E., Allmendinger, R. W., Mpodozis, C., Kay, S. M., Cortés, J. M. & Palma, M. A. (1986): Paleozoic terranes of the central Argentine-Chilean Andes. – Tectonics, **6** (6): 855-880.

Ramos V. A. & Kay, S. M. (1991): Triassic rifting and associated basalts in the Cuyo basin, central Argentina. – In: Harmon, R. S. & Rapela, C. W. (Eds.): Andean magmatism and its tectonic setting. – Geological Society of America, Special Paper, **265**: 79-91.

Ramos, V. A., Escayola, M., Mutti, D. & Vujovich, G. I. (2001): Proterozoic – early Paleozoic ophiolites in the Andean basement of southern South America. – In: Dilek, Y. & Moores, E. (Eds.): Ophiolites and oceanic crust: new insights from field studies and ocean drilling program. – Geological Society of America, Special Paper, **349**: 331-349.

Sanderson, D. J. & Manchini, W. R. D. (1984): Transpression. – Journal of Structural Geology, **6**: 449-458.

Storz, H., Storz, W. & Jacobs, F. (2000): Electrical resistivity tomography to investigate geological structures of the earth's upper crust. – Geophysical Prospecting, **48**: 455-471.

Sylvester, A. G. (1988): Strike-slip faults. – Geological Society of America, Bulletin, **100**: 1666-1703.

Strelkov, E. & Álvarez, L. (1984): Análisis estratigráfico y evolutivo de la cuenca triásica mendocina – sanjuanina. – 9º Congreso Geológico Argentino, San Carlos de Bariloche, Actas **3**: 115-130.

Telford, W. M., Geldart, L. P. & Sheriff, R. E. (1990): Applied geophysics. – 790 pp; second Edition; Cambridge (Cambridge University Press).

Terrizzano, C. M. (2006): Deformación cuaternaria en las Lomitas Negras, cinturón Barreal - Las Peñas, provincia de San Juan. – Resúmenes de la XIII Reunión de Tectónica, San Luis: 57.

Turcotte, D. L. (1992): Fractals and chaos in geology and geophysics. – 221 pp.; First Edition; Cambridge (Cambridge University Press).

Uliana, M. A., Biddle, K. T. & Cerdan, J. (1989): Mesozoic extension and the formation of Argentine sedimentary basins. – In: Tankard, A. J. & Balkwill, H. R. (Eds.): Extensional tectonics and stratigraphy of the North Atlantic margins. – American Association of Petroleum Geologists, Memoirs, **46**: 599-614.

Vallejo, M. D. (2004): Geología y Geofísica de sector norte de las lomas del Inca, barreal del Leoncito, San Juan. – 88 pp.; unpubl. Trabajo final de licenciatura (Universidad de Buenos Aires).

Woodcock, N. H. & Schubert, C. (1994): Continental strike-slip tectonics. – In: Hancock, P. L. (Ed.): Continental deformation; Oxford (Pergamon Press): 251 - 263.

Yamín, M. G. (2007): Neotectónica del bloque Barreal, margen noroccidental de la Precordillera Sur. – 281 pp.; unpubl. PhD thesis (Universidad de Buenos Aires).

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