Gondwanic and Andean structure in the Argentine central Precordillera: The Río San Juan section revisited

J.L. Alonso [1], L.R. Rodríguez-Fernández [2], J. García-Sansegundo [1], N. Heredia [3], P. Farias [1], & J. Gallastegui [1]

[1] Departamento de Geología, Universidad de Oviedo, C/ Jesús Arias de Velasco s/n, 33005 Oviedo, Spain
[2] Instituto Geológico y Minero de España, C/ La Calera 1, 28740 Tres Cantos, Madrid, Spain
[3] Instituto Geológico y Minero de España, Parque Científico de la Granja, Avda. Real 1, 24006 León, Spain

Introduction

The Argentine Precordillera is a fold-and-thrust belt, about 80 km wide, which involves Paleozoic and Tertiary sediments (Bracaccini, 1946; Heim, 1952). The Precordillera has classically been divided into Western, Central and Eastern domains based on stratigraphic and structural features. The Central and Eastern Precordillera represent a stable carbonate platform during Cambrian to Lower Ordovician times (Bordonaro, 1999). The Western Precordillera is characterized by olistostrome or melange deposits, related to extensional tectonics during Cambrian-Ordovician times, in a continent-ocean transition (Astini, 1997; Keller, 1999) and ocean floor sediments with pillow basalts in the westernmost part (Kay et al, 1984). This continental margin remained stable until Late Devonian or Early Carboniferous. Regarding the structure, the Central and western Precordillera form an east-verging imbricate thrust system, detached in the Cambro-Ordovician carbonates, while the Eastern Precordillera consist of west-verging structures.

Up to now, the Precordillera has been interpreted as a typical thin-skinned structure developed during the Andean orogeny (Baldis and Chebli, 1969; Allmendinger et al, 1990; Von Gosen, 1992; Cristallini and Ramos; 2000). The deformation age is considered to be Miocene to Recent, with west to east progression of thrusting (Jordan et al, 1993; Zapata and Allmendinger, 1996). However, the existence of pre-Andean deformation within the Paleozoic sedimentary strata in the Precordillera, has been largely known (Furque, 1979); evidences of pre-Carboniferous deformations are well known in the Western and Eastern Precordillera, where Carboniferous deposits known as El Ratón Formation (Azcuy et al, 1981) and Jejenes Formation (Amos, 1954) overlie older Paleozoic rocks with a strong angular unconformity. In contrast to the Western and Eastern Precordillera, no pre-Tertiary deformation has been described in the Central Precordillera, where Carboniferous deposits (Paganzo group) overlie Devonian sediments with an erosional disconformity (Von Gosen, 1992). Thereby, the Central Precordillera has usually been considered a stable area until Miocene times and published cross-sections show parallelism between Tertiary and Paleozoic beds.

In this study we present new data on the structural relationships between the Tertiary and Paleozoic units in the Central Precordillera. A significant angular unconformity between the Paleozoic and the Tertiary beds occurs in most of the thrust sheets. This has very important implications in the identification of the Andean and pre-Andean structures and in the shortening estimates in the Argentine Precordillera.

Tertiary-Paleozoic structural relationships in the Central Precordillera. Implications on the structural evolution of the Argentine Precordillera.

Structural analysis of the Rio San Juan section and surrounding valleys has shown that the Paleozoic beds usually dip 20°-30° more steeply than the Tertiary strata. That occurs in several Tertiary "intra-mountainous basins" (Río Uruguay, Talascasto, Pampa Bachongo-Puesto Papagallos) located as patches on different thrust sheets in the Central Precordillera (Fig. 1). The unconformity angle ranges from 0° to 90° in the westernmost part (Pachaco Basin), because Tertiary beds truncate previous minor folds of decametric to hectometric scale. Only at the frontmost part (eastern end) of the Central Precordillera (Albarracin and western border of the Ullum basin) the unconformity angle is very low, ranging from 0° to 10° (Fig. 1).

The patches of Tertiary sediments in the Precordillera are remains of a foreland basin, which initially extended all over the Precordillera (Ramos, 1999), in which the basal part of the Tertiary sequence represents the response to the emplacement of the Cordillera Frontal to the west. As the basal strata of the basin has been dated between 21 and 18 MA (Jordan et al, 1993; Vergés et al, 2001; Milana et al, 2003), the angular unconformities between the Paleozoic basement and the Tertiary cover evidence that the Palaeozoic units were tilted westwards about 25° in the Central Precordillera before the Middle Miocene formations were deposited.

The Tertiary sequence is thrusted by several faults and preserved in their footwalls. However, when we reconstruct the eroded sector of the San Juan section, based on field mapping and structural data (Fig. 1), the estimated displacement for the Tertiary unconformity is much smaller than the one for the Ordovician limestones. This implies the reactivation of previous (pre-Miocene) thrusts, but for the Zonda Anticline where Paleozoic and Tertiary beds are nearly parallel.

We suggest that pre-Miocene thrusting in the Central Precordillera may be of Gondwanic age, because no stratigraphic record of previous Tertiary deformations has been found in this part of the Andes. It can be attributed to the Lower Permian Sanrafaelic deformation phase (Ramos, 1988) identified in the Mendoza area to the south of the Precordillera.

Andean and pre-Andean structures are shown in figure 1. The classical imbricate thrust fan detached at the Ordovician carbonates and cutting up the stratigraphic section eastwards (Von Gosen, 1992), would be of Gondwanic origin and reactivated in Andean times. The deformation that uplifted the Paleozoic basement and rotated westwards the Tertiary beds in the Central Precordillera may be due to a deeper thrust, probably detached at the bottom of the Cambrian succession. The Zonda Anticline (Fig. 1) is interpreted as a fault-propagation fold related to that deep Andean thrust ramp. This model is consistent with the geological map, because Cambrian carbonates are exposed further to the north in the frontmost part of the Central Precordillera (Cumillango, La Silla-Potrerillos Sierras, Guandacol) (Bordonaro, 2003). Wide anticlines at the level of Cambrian-Ordovician carbonates are present in these ranges, in contrast to the smaller hangingwall ramp anticlines developed in the Ordovician limestones of the Central Precordillera (Fig.1). That implies a deeper level of décollement in the frontmost structure. The inferred displacement (about 16 km) and the depth of décollement of the Zonda structure in Fig. 1 is close to the values obtained for the frontal thrust by Zapata and Allmendinger (1996) in the Rio Jachal section, 100 km to the north.

The tilting of Paleozoic units above the ramp presumably caused the reactivation of previous thrusts by flexural-slip mechanisms. For instance, bedding faults cutting across the Tertiary basal unconformity with minor displacements (a few tens to hundreds of meters) can be seen in the Albarracin Basin.

The uplift of the Western Precordillera can also be explained as a result of a thrust faults detached at 10-15 km deep. An Andean total displacement of about 45 km in the Precordillera suffices to explain the uplift and structural relationships between the Tertiary beds and the Palaeozoic basement in the Rio San Juan section. That displacement is substantially smaller than the previously estimated (Allmendinger et al, 1990; Von Gosen, 1992; Cristallini and Ramos, 2000) and is consistent with the amount of shortening (about 30 km) found in the southern Precordillera or the Cuyo Basin, south of the Precordillera (Ramos et al, 1996). If we restore the post-Miocene deformation, previous thrust sheets record a larger displacement, probably of Gondwanic age. The Central Precordillera may represent the non-metamorphic part of the Gondwanic foreland thrust belt, whereas the Western Precordillera may represent the low metamorphic grade internal parts.

The Andean deformation implies the eastwards propagation of a décollement lower than the Gondwanic one in the Central Cordillera. This may be due to the thinning related to pre-Miocene erosion of the Gondwanic orogenic wedge.

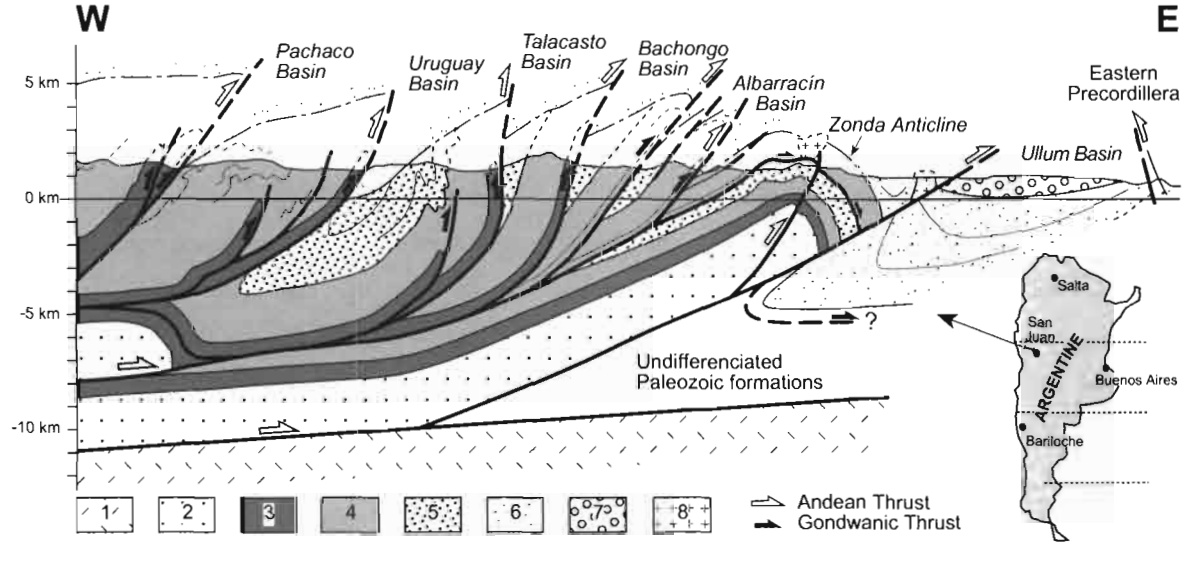

Figure 1. Cross-section of the Argentine Central Precordillera along the Río San Juan. 1) Precambrian basement, 2) Cambrian rocks, 3) Ordovician rocks, 4) Silurian and Devonian rocks, 5) Carboniferous rocks, 6) Tertiary rocks, 7) Quaternary sediments; 8) Tertiary Volcanics.

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