

Structural evolution of the Argentine Precordillera—the Rio San Juan section: Discussion

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THE SEGMENTATION OF THE PRECORDILLERA

WE APPRECIATE very much the paper of von Gosen (1992), as it is a valuable contribution to the understanding of the Argentine Precordillera (the name Cuyo Precordillera is preferred as there is another Precordillera in Southern Argentina, cf. Zambrano 1981, Gonzalez Bonorino & Gonzalez Bonorino 1991). However, some first-order corrections to the work can be made mainly on topics related to the Precordilleran segmentation, based on research carried out by local and other investigators. Much of the work of von Gosen is based on the recent structural segmentation of the San Juan section. He concludes that there is a western area ("western continental slope" p. 643) a central area ("flat-lying Early Paleozoic platform", p. 665), and an eastern area (a "back thrust zone", p. 653).

This segmentation has long been recognized by geologists that worked in this area: all papers since 1981 distinguish three well-defined subprovinces: Western, Central and Eastern Precordillera (cf. Ortiz & Zambrano 1981, Baldis *et al.*, 1982). This division is due to clear differences in stratigraphy and structure, but we do not see how von Gosen's (1992) division fits with this widely known division of the Cuyo Precordillera. Moreover, we did not find citations to work that pointed out that subprovincialism, or a discussion of why he placed different boundaries between subprovinces instead of those traditionally recognized. This omission leads to an incorrect evaluation of several main characteristics (stratigraphic and structural) throughout the paper, of which we have selected two for detailed discussion.

(1) Stratigraphic subprovincialism

The first point of discussion is related to the stratigraphic synthesis of the author. The stratigraphic chart of von Gosen (fig. 2, p. 645) is erroneous, as the same

Lower Cambrian to Argenigian stratigraphy of the Eastern Precordillera areas (Villicum & Rinconada) is ascribed also to some Central Precordillera areas (W Punta Negra). The La Flecha, Zonda and La Laja Formations do not crop out in the area named "W Punta Negra", because these are developed only in the Eastern Precordillera subprovince. The possibility that these formation exist in the subsurface of the Central Precordillera is not a sound basis to put them in a stratigraphic chart. This mistake is translated to the structural section, in which this uncertainty is not considered. Only the carbonates of the San Juan Formation have been carried up by the Central Precordillera thrusts in the Rio San Juan section. These carbonates should not reach more than 500 m thick in outcrops (sometimes duplicated by tectonics), and there are no indications of the presence of older platform carbonates in this area of the Central Precordillera.

It should also be noted that as the location "W Pachaco" remains in the Central Precordillera, the stratigraphy presented by von Gosen is far different from the stratigraphy that can be seen west of the Pachaco location. Particularly, there are widely known outcrops of the San Juan, Tambolar and Punta Negra Formations in that area (cf. Beresi 1977, Baldis *et al.* 1982). Moreover, stratigraphic and sedimentological research so far have not given any indication of the presence of the Cambrian Los Sombreros Formation in the transect analyzed by von Gosen (fig. 7, p. 651; cf. González Bonorino 1975, Banchig 1992). In the same stratigraphic chart, the Jejenes Formation (Late Carboniferous) is represented as present in the Villicum area, where no Carboniferous sedimentary units have been recognized.

(2) Structural subprovincialism

The second point of discussion is related to von Gosen's structural interpretation of the boundary be-

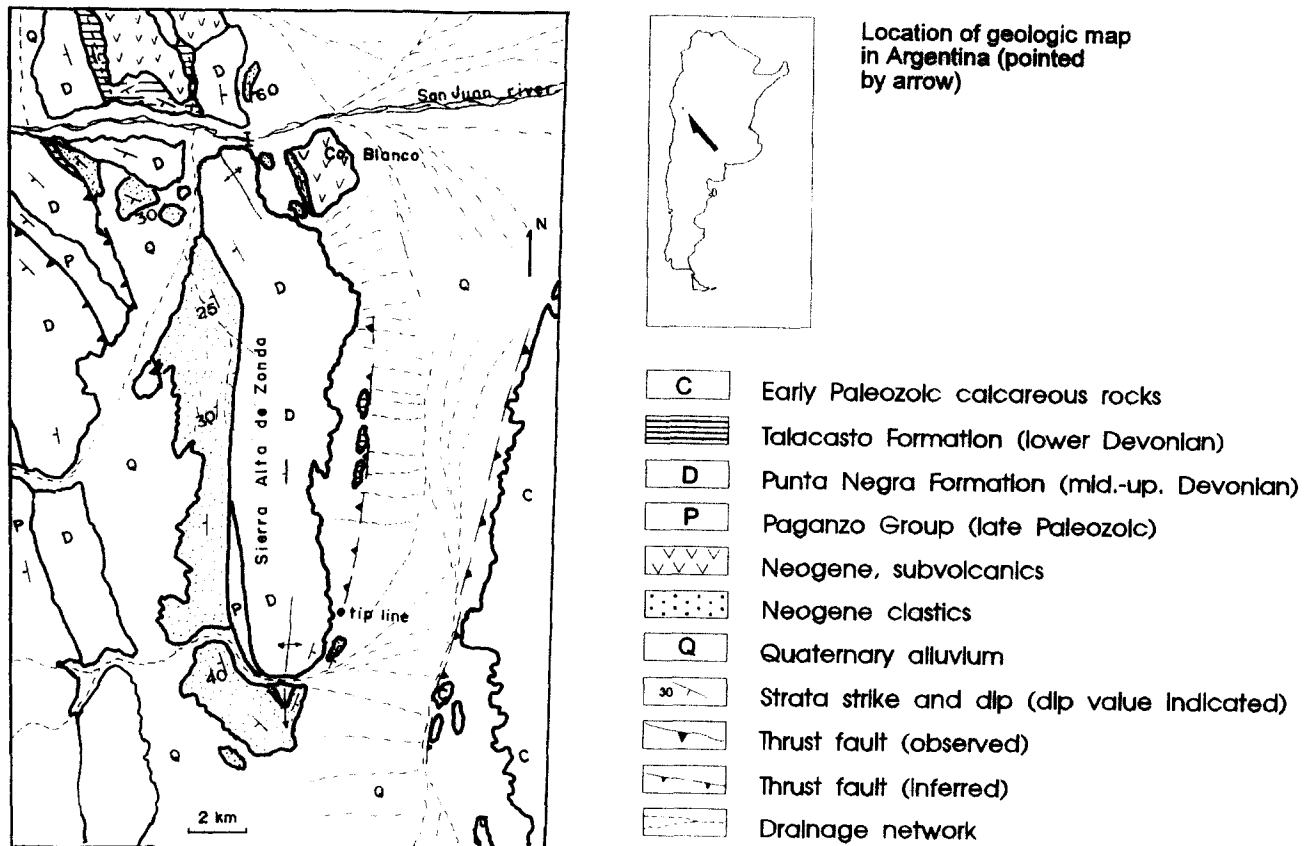


Fig. 1. Geological map of the Sierra Alta de Zonda range, Argentina, based on LANDSAT imagery and field surveys of Torres (1980), Figueroa (1987) and the authors, to show its relation to a W-dipping thrust. Note outcrops of Talacasto Formation in the east side of the range.

tween W-dipping thrusts and the 'back thrust zone' (E-dipping thrusts). As explained earlier, these different styles of deformation (plus differences in stratigraphy) led Ortiz & Zambrano (1981) to separate both areas into two subprovinces called Central and Eastern Precordillera. The structural composition of the triangular zone formed between both subprovinces is now under discussion (Uliarte *et al.*, 1987, Ruzycski *et al.* 1989, Perucca *et al.* 1990, Milana 1991). This triangular zone has been considered traditionally as coincident with the Ullum-Zonda depression, but von Gosen puts it between two widely accepted (up to now) W-dipping Central Precordillera thrusts. He interpreted that a minor E-dipping fault found in the Rio Albarracin (von Gosen's figs. 3 and 4) was responsible for the Sierra Alta de Zonda anticline (located immediately eastward of Rio Albarracin). This is a very important point to resolve, and requires a more detailed analysis.

As shown by von Gosen (1992), it is accepted that the deformation and thrusting migrated eastwards (cf. also Johnson *et al.* 1986, Jordan *et al.* 1988, Beer & Jordan 1989, Milana *et al.* 1990, among others). This caused the older western thrusts to be more deeply eroded, and consequently the original front cannot be observed. However, in the frontal parts of the younger imbricate faults of the Central Precordillera, well-developed frontal anticlines associated with these faults are common (e.g. Huaco anticline, Talacasto anticline and, as discussed here, Sierra Alta de Zonda anticline). Although

it is not very common to see, some faults laterally disappear but continue as anticlines (cf. also, Allmendinger *et al.* 1990). The presence of these 'tip lines' (Fig. 1) associated with the frontal thrusts indicates that the observed folds are more likely related to fault-propagation folds rather than to fault-bend folds as postulated by von Gosen (p. 648).

The Sierra Alta de Zonda anticline is one of the best examples of these fault-propagation folds. Figure 1 shows the distribution of rocks related to this structure. The more obvious proof of the presence of an E-verging thrust is the outcrop of the Talacasto Formation on the eastern side of the range (Banchig & Milana 1985). It has to be noticed that the Talacasto Formation is cited by von Gosen (1992, p. 646 "incompetent sand- and siltstones of the Upper Silurian to Lower Devonian") as composing one of the main décollement planes. It is evident that because of the location of the tip lines, where this structure is profiled along the road, only an anticline can be seen. However, in von Gosen's geological map this fault is ignored in spite of being widely known by other workers.

Additionally, electric resistivity surveys in the Ullum-Zonda valley (Zambrano 1978) indicate nearly 1000 m thick Quaternary deposits some hundreds of meters east of Cerro Blanco (our Fig. 1; compare also with von Gosen's fig. 4). This, as well as surface features, such as sedimentary dips, geomorphologic features, etc. (Zambrano 1982) also indicate that at this latitude, the Ullum-

Zonda valley is bounded at its western margin by a W-dipping thrust.

We would like to have read a more detailed discussion on this important point on the profile. Considering that this Precordillera is the Argentine geological province with perhaps the highest degree of investigation, our opinion is that von Gosen's data are not enough to justify such important changes in the structural geometry of this well-exposed fold-thrust belt.

In conclusion, we cannot accept the interpretation of von Gosen (1992) of the triangular zone centered in Rio Albarracin, because of its incomplete view of the entire structure, called here the Sierra Alta de Zonda anticline. Our mapping clearly indicates its affinity with the E-verging Central Precordillera thrusts.

REFERENCES

- Allmendinger, R. W., Figueroa, D., Snyder, D., Beer, J., Mpodozis, C. & Isacks, B. L. 1990. Foreland shortening and crustal balancing in an amagmatic orogen: the Andes at 30°S latitude. *Tectonics* **9**, 789–809.
- Baldis, B. A. J., Beresi, M., Bordonaro, O. & Vaca, A. 1982. Síntesis evolutiva de la Precordillera Argentina. *V Congr. Latinoamer Geol. Act.* **4**, 399–445.
- Banchig, A. L. 1992. Secuencia sedimentaria clástica-carbonática en paleoambiente de cañón submarino, de Quebrada de los Ratones, Precordillera Occidental, San Juan. *4a. Reun. Argent. Sedim. Act.* **1**, 17–24.
- Banchig, A. L. & Milana J. P. 1985. La presencia de la Formación Talacasto en el pie oriental de la Sierra Alta de Zonda. *Reun. Comunic. Paleont. San Juan Act.*, 47–48.
- Beer, J. A. & Jordan, T. E. 1989. The effects of Neogene thrusting on deposition in the Bemejo Basin, Argentina. *J. sedim. Petrol.* **59**, 330–345.
- Beresi, M. 1977. La Formación San Juan en el área de Pachaco. Tesis de Licenciatura, FCEFyN, Univ. Nac. de San Juan.
- Figueroa, G. J. 1987. Estudio litológico de la Formación Albarracin en la Quebrada homónima. Tesis Licenciatura, FCEFyN, Univ. Nac. San Juan.
- Gonzalez Bonorino, G. 1975. Sedimentología de la Formación Punta Negra y algunas consideraciones sobre la geología regional de la Precordillera de San Juan y Mendoza. *Asoc. Geol. Argent. Rev.* **33**, 223–246.
- Gonzalez Bonorino, G. & Gonzalez Bonorino, F. 1991. Precordillera de Cuyo y Cordillera Frontal en el Paleozoico Temprano: terrenos bajo sospecha de ser autóctonos. *Rev. Geol. Chile* **18**, 97–107.
- Johnson, N. M., Jordan, T. E., Johnsson, P. A. & Naeser, C. W. 1986. Magnetic polarity stratigraphy, age and tectonic setting of fluvial sediments in an Eastern Andean Foreland Basin, San Juan Province, Argentina. In: *Foreland Basins* (edited by Allen, P. A. & Homewood, P.). *Spec. Publ. Int. Ass. Sedim.* **8**, 223–235.
- Jordan, T. E., Flemings, P. B. & Beer, J. A. 1988. Dating thrust-fault activity by use of foreland basin strata. In: *New Perspectives of Basin Analysis* (edited by Kleinspehn, K. L. & Paola, C.). Springer, New York, 307–330.
- Milana, J. P. 1991. Sedimentología y Magnetoestratigrafía de Formaciones Cenozoicas en el área de Mogna, y su inserción en el marco tectosedimentario de la Precordillera Oriental. Doctoral thesis, Univ. Nac. de San Juan.
- Milana, J. P., Bercowski, F. & Jordan, T. E. 1990. El análisis composicional de gravas como indicativo tectogenético de las áreas de aporte, cuenca Terciaria de Precordillera Oriental, San Juan, Argentina. *3a Reun. Argent. Sedim.*, 199–204.
- Ortiz, A. & Zambrano, J. J. 1981. La provincia geológica de Precordillera Oriental. *VIII Congr. Geol. Argent. Act.* **3**, 59–74.
- Perucca, L. P., Sanchez, A. & Uliarte, E. 1990. Morfotectónica en la zona norte del corredor tectónico Matagusanos–Maradona–Acequión, San Juan, Argentina. *XI Congr. Geol. Argent. Act.* **2**, 435–438.
- Ruzycki, L. R., de, Paredes, J. & Uliarte, E. R. 1989. Neotectónica e inversión de estructuras de Precordillera en la zona “El Mocho”, Dpto. Sarmiento, San Juan. *1a Reun. Fallas. Activ. Noroeste Argentino Act.*, 68–70.
- Torres, C. A. J. 1980. Estudio geológico en el extremo suroccidental de la Sierra Negra de Zonda, Pcia. de San Juan. Tesis Licenciatura, FCEFyN, Univ. Nac. San Juan.
- Uliarte, E. R., Bastias, H. & Ruzycki, L. R., de. 1987. Morfología y neotectónica en el Cerro La Chilca, Pedernal, San Juan. *X Congr. Geol. Argent. Act.* **1**, 227–230.
- von Gosen, W. 1992. Structural evolution of the Argentine Precordillera: the Rio San Juan section. *J. Struct. Geol.* **14**, 643–667.
- Zambrano, J. J. 1978. Descripción geológica de los terrenos aflorantes en el sistema hidrográfico del Rio San Juan. Centro Reg. de Aguas Subterráneas Public, 212.
- Zambrano, S. J. 1981. Distribución y evolución de las cuencas sedimentarias en el Continente Sudamericano durante el Jurásico y Cretácico. In: *Cuencas Sedimentarias del Jurásico y Cretácico de América del Sur, Vol. 1*. Comité Sudamericano del Jurásico y Cretácico, Buenos Aires, 9–44.
- Zambrano, J. J. 1982. Actualización geológica del Valle de Ullum-Zonda. Centro Regional de Aguas Subterráneas. San Juan, Report p. 261.