6th International Symposium on Andean Geodynamics (ISAG 2005, Barcelona), Extended Abstracts: 15-18

Curved geometries in a transfer zone, Quebrada del Toro, Salta Province, NW Argentina

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Introduction

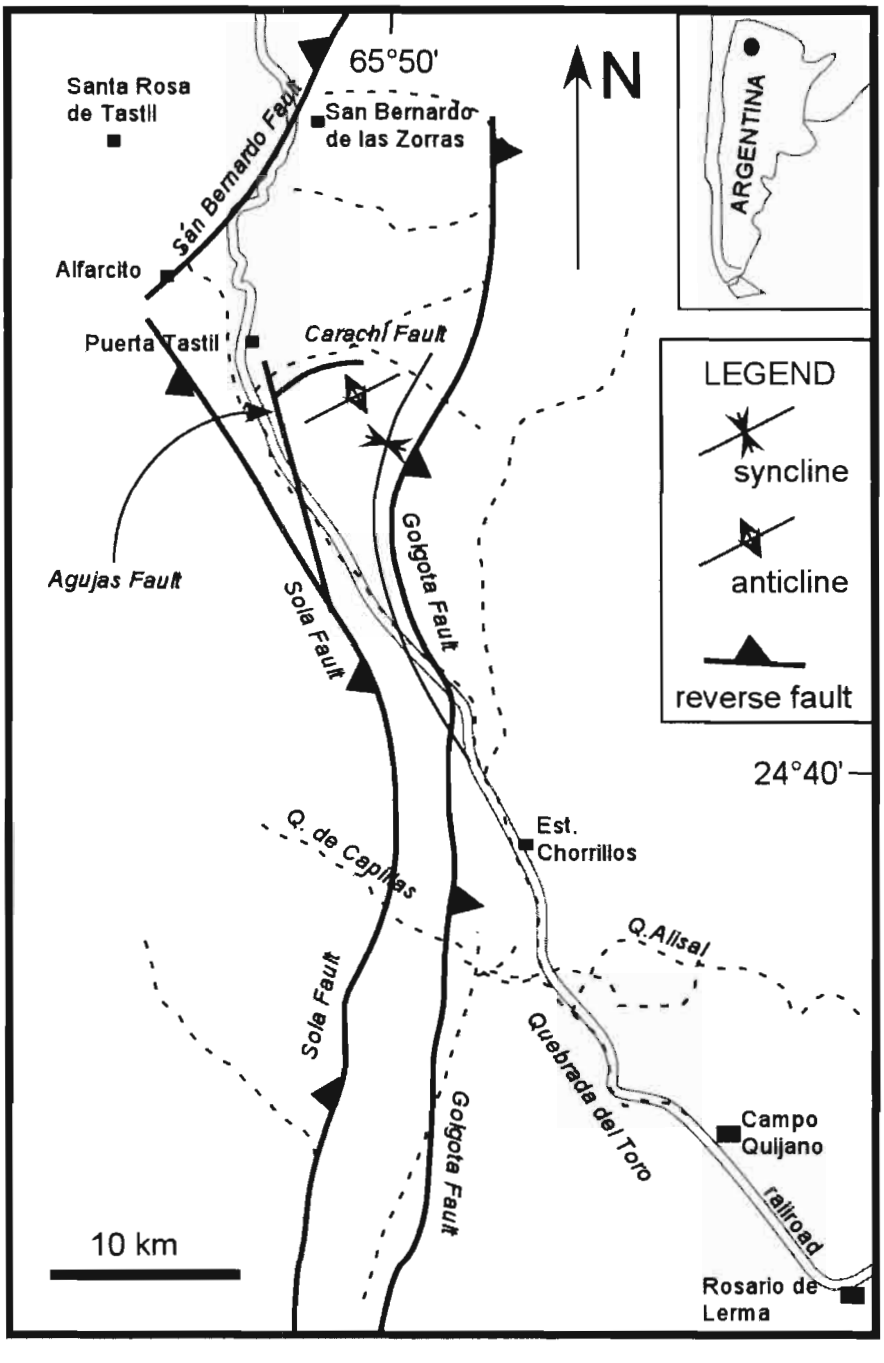
The Quebrada del Toro, or Toro Canyon, is a first-order geomorphic feature in the Central Andes of northwestern Argentina (Fig. 1). The canyon initiates at the eastern border of the Puna, near the Santa Rosa de Tastil Batholith, and descends with a WNW-ESE, then NNW-SSE, orientation, traversing the western half of the Cordillera Oriental up to where it debouches into the structural depression forming the Lerma Valley. The Toro Canyon, to a large extent, follows the trace of the Toro Lineament, one of the most widely cited geological features in northwestern Argentina, postulated almost simultaneously by Salfity et al. (1975), Baldis et al. (1976), and Mon (1976), and christened by Mon (1976). The Toro Lineament marks the southern limit for Paleozoic exposures in northwestern Argentina; farther south Mesozoic and Cenozoic strata rest unconformably on metamorphic basement. The Toro Lineament has been compromised in numerous geological hypotheses for northwestern Argentina, such as: (a) that it marks internal boundaries in the Puna and Cordillera Oriental geological provinces (Alonso et al. 1984; Ramos 1999). (b) that it reflects Paleozoic or older structural features, (c) that it exerted a strong control on Cenozoic magmatism (Petrinovic et al., 1999, 2001; Hongn et al. 2002), (d) that it presently is an active intraplate fault zone, judging from recent seismic events along its trace. There exist, as well, divergent opinions regarding the intensity and timing of tectonic activity of the Toro Lineament: significant activity in the Miocene compensating structural shortening of the Andes (Seggiaro y Hongn, 1999), minor activity in the Miocene and a sinistral strike-slip offset of 20 km in the Quaternary (Marrett, 1990; Marrett y Strecker, 2000), and also that its strike-slip behaviour is due to north-south differential shortening of the Andes in the Cenozoic (Riller and Oncken, 2002).

The present summary suggests that curved structures associated to the Toro Lineament reflect its activity as a transfer zone. This interpretation is based on a comparison between the mapped structural geometries and similar geometries obtained in analogic modelling (Calassou et al., 1993; Baby et al., 1994).

Geology and tectonics

The study area is comprised by 65°30'-66°00'W and 24°15'-24°45'S (Fig. 1). Exposures comprise Precambrian-Cambrian metasedimentary rocks of the Puncoviscana Formation (Omarini, 1983; Jezek et al., 1985), granitic rocks of the upper Proterozoic Santa Rosa de Tastil Batholith (Kilmurray and Igarzabal, 1972; Omarini et al., 1985), lower Paleozoic marine quartzites and shales in the Meson and Santa Victoria Groups (Vilela, 1956; Turner, 1960; Schwab and Schäfer, 1976; Sanchez, 1999; Moya, 1999), Cretaceous-Paleogene continental sedimentary strata of the Salta Group (Reyes and Salfity, 1973), and Neogene and Quaternary synorogenic, mostly coarse-grained, continental deposits (Schwab and Shäfer, 1976). The latter sequence,

totalling about 2 km in thickness, conforms a complex syncline within the downfaulted structural block bounded by high-angle reverse faults that lodges the Quebrada del Toro.



The tectonic style in the Quebrada del Toro is defined by two sets of structures oriented NW-SE and NE-SW (Fig. 1; Schwab and Schäfer, 1976; Marrett and Strecker, 2000). To the northwest the Toro canyon is bounded by the San Bernardo reverse fault, with vergence to the southeast; this fault brings up Santa Rosa de Tastil granitoids against Neogene-Quaternary strata. The reverse Sola Fault, oriented NS, constitutes the western margin of the Toro canyon south of Alfarcito, and upfaults rocks of the Puncoviscana Formation and Salta Group. The reverse Golgota Fault bounds the Toro canyon along the east, showing a marked variation in

orientation from NE-SW in the north, to NS in the south. The hanging wall of the Golgota Fault shows Paleozoic sedimentary rocks. In between these major bounding faults develop the Carachi and the Agujas faults. The Carachi Fault shows a curved trace, concave to the SSE, and with vergence to the NNW and N. The Agujas Fault splays from the Sola Fault with a NW-SE orientation. Marrett and Strecker (2000) postulated that movement along the NE-SW-oriented faults (San Bernardo, northern Golgota, and Carachi faults) initiated in the early to late Miocene and concluded after 0.98 Ma, and that the NW-SE-oriented faults (Sola and Agujas faults) moved initially between the late Miocene and 4.17 Ma and are still active.

Conclusions

Surface geology allows separation of the pre-Cenozoic basement rocks in the hangingwalls of the Sola, Golgota, and San Bernardo faults, from the Neogene-Quaternary syntectonic fill in the footwalls. This spatial distribution generated mechanical conditions that yielded the observed structural geometries. The present structural arrangement in the Toro Canyon area, with two sets of curved fault and fold traces with opposing vergence, resulted from Cenozoic compression. The origin of these geometries is herein related to the Toro Lineament acting as a transfer zone. This postulate is based on analogies observed among field data and the results of analogic modelling experiments by Calassou et al. (1993) and Baby et al. (1994). Transfer zones commonly are oblique to the direction of structural transport and are characterized by a complex deformation. During Andean tectonics the Toro Lineament would have behaved as a structural ramp oblique to the direction of maximum shortening. Associated curved structures may have been related to the presence of rheologically constrasting structural levels.

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