Pliocene to Quaternary retro-arc extension in the Andes at 35° - 37°30´s

Andrés Folguera [1], Víctor A. Ramos [1], Tomás Zapata [2], Mauro Spagnuolo [1], & Fernando Miranda [3]

[1] Laboratorio de Tectónica Andina, Universidad de Buenos Aires and CONICET, Argentina; folguera@gl.fcen.uba.ar
[2] Repsol-YPF and Universidad de Buenos Aires, Argentina
[3] Segemar, Buenos Aires, Argentina

Introduction

The Southern Central Andes are mainly the result of shortening imposed during the last 20 to 12 Ma (Ramos et al., 2004). However, field studies reveal that this picture is more complex than previously thought. The retro-arc area between 37° and 40°S is flanked by recent extensional basins (Muñoz and Stern, 1988) associated with lithospheric attenuation (Kind et al., 2002) and profuse volcanic activity, active since at least Early Pliocene times (Ramos and Folguera, 1999; 2005; García Morabito et al., 2003; Melnick, et al., 2003). Three main depocenters are controlled by extensional structures superimposed to the inner sectors of the Andean fold and thrust belt (Agrio and Chos Malal fold and thrust belts) formed mainly during Middle to Late Cretaceous times with mild reactivations in Eocene and Late Miocene periods (Ramos, 1998): the Loncopué, Bío-Bío Aluminé and Lago del Laja troughs (Fig. 1). The origin of this phase of extension at 37°-40°S seems to be linked to the steepening of the subducted oceanic slab (Muñoz and Stern, 1988; Stern, 2004; Ramos and Folguera, 2005), evidenced by westward moving and narrowing of the arc front during the last 5 Ma. Contrastingly, north of 37°S the inner retro-arc is being uplifted by dextral-transpressional strike-slip faults, the northernmost-known extreme of the intra-arc Liquiñe-Ofqui fault system (Lavenu and Cembrano, 1999) developed in the eastern side of the Andes (Folguera et al., 2004). The prolongation of these faults into the Argentinian side has been recognized as the Antiñir-Copahue fault system (ACFS). It is responsible of the closure of the northern part of the Loncopué trough (Fig. 1). As a result of that a very recent fold and thrust belt (Guañacos fold and thrust belt) is rapidly growing in an out-of-sequence order respect to the external fold and thrust belt, whose orogenic front is the ACFS (Folguera et al., 2005). This segmentation in the retro-arc seems to be related to the intersection of the long Liquiñe-Ofqui fault system (38°-46°S) across the Main Andes, at the latitude of the Copahue volcano (Fig. 1). A new Plio-Pleistocene extensional retro-arc basin, the Las Loicas trough, is not involved in the young Guañacos fold and thrust belt, and it is located immediately to the east (35°-37°30´S). Las Loicas trough is the northernmost-known expression of this broad area of extension at the retro-arc (Figs. 1 and 2), which includes the Loncopué, Bío-Bío Aluminé and Lago del Laja troughs, and the most prominent basin developed between 5 and 3 Ma ago.

Las Loicas trough

Profuse bimodal volcanism fills this trough for more than 250 kilometers with a NNW trend, from the Planchón Azufre caldera (35°S) at the Andean water divide to the Tromen volcano (37°30´S) more than 100 kilometers east of the volcanic arc (Fig. 2). As established by petrological and geochemical studies (Drake, 1976; Hildreth et al., 1984; 1991, 1999; González Ferrán, 1995) silicic products have crustal affinities with no mantle connection. Hildreth et al., (1999) conclude that such a scenario could only be related to a change in retro-arc compressive

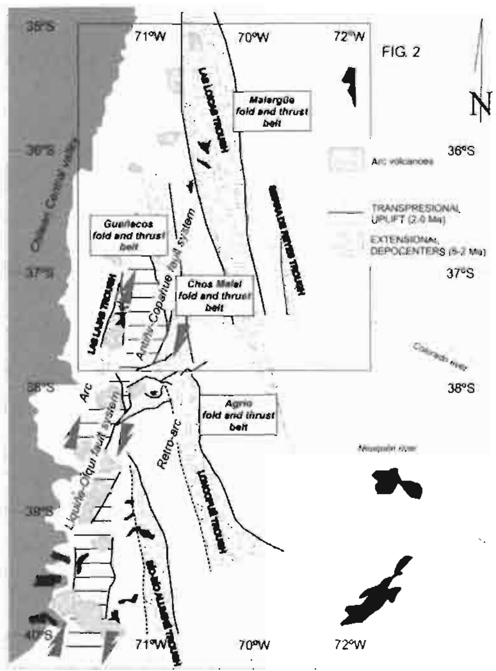

Figure 1. Regional map between 35° and 40°S, where the main NNW extensional basins along the arc and retro-arc zone are represented, as well as the area of recent (2-0 Ma) transpressional uplift controlled by the northern extreme of the Liquiñe-Ofqui fault zone. The square shows the location of figure 2, corresponding to Las Loicas trough.

conditions, well constrained up to Late Miocene times (Manceda and Figueroa, 1995; Ramos et al., 1996), to an extensional or neutral regime that would favor mantle underplating and consequent crustal melts. Present field work in the region has identified extensional faults affecting Late Pliocene-Quaternary volcanic rocks, which confirms the proposal of Hildreth et al. (1999). Based on structural evidence and volcanic rock types the Las Loicas basin can be divided in two sectors. The northern sector coincides with the río Grande valley, which is interpreted as a half-graben structure, east-bounded by west-dipping normal fault. Its filling corresponds to andesitic lava flows, ignimbritic and ash fall deposits derived from three major volcanic complexes: Planchón-Azufre caldera, Calabozos Caldera and Puelche volcanic field, all of them located near the water divide. This northern part is more closely related to the volcanic arc front, even though bimodal calderas and volcanic fields are defining a separate chain respect to the volcanic arc. At 35°S the arc front intersects Las Loicas trough at the Planchón-Azufre caldera, where the extensional axis could be crossing the water divide.

The southern sector of Las Loicas trough comprises a series of normal faults that affected Late Miocene to Pliocene-Quaternary volcanic rocks. The normal faults which have frequent jumps in polarity are associated with discrete transfer faults and broad folds that define the slip-accommodation zones. The geologic maps show that extensional panels are right-laterally rotated, which suggests a regional dextral component associated with extension along mainly NS faults. This southern part of the trough is located entirely in retro-arc positions and offers an exceptional opportunity to study the relation of volcanic products to the extensional structure. The main extensional faults are located between the Pliocene silicic intrusives associated with calderas to the west, and the Wayle and Tromen volcanoes to the east (Fig. 2). If it is accepted that the silicic domes are products of crustal anatexis Main extensional faults were found northwest of Wayle and Trómen volcanoes, while Late Pliocene silicic intrusives associated with calderas are located east of them (Fig. 2). Assuming that the lasts are products of crustal anatexis (Hildreth et al., 1999) and the volcanoes are more evolved mantle-derived products in the area (Kay, 2001), an east dipping detachment may be inferred for Las Loicas trough (Wernicke and Burchfield, 1982). The geometry of this Neogene extensional basin is compatible with a late reactivation of the underlying Lower Jurassic extensional depocenters. This geometry is correlated with the inverted Los Chihuidos High depocenter, which was controlled by an east dipping lithospheric discontinuity as inferred by the geometry of syn-rift sequences (Zapata and Folguera, 2005).

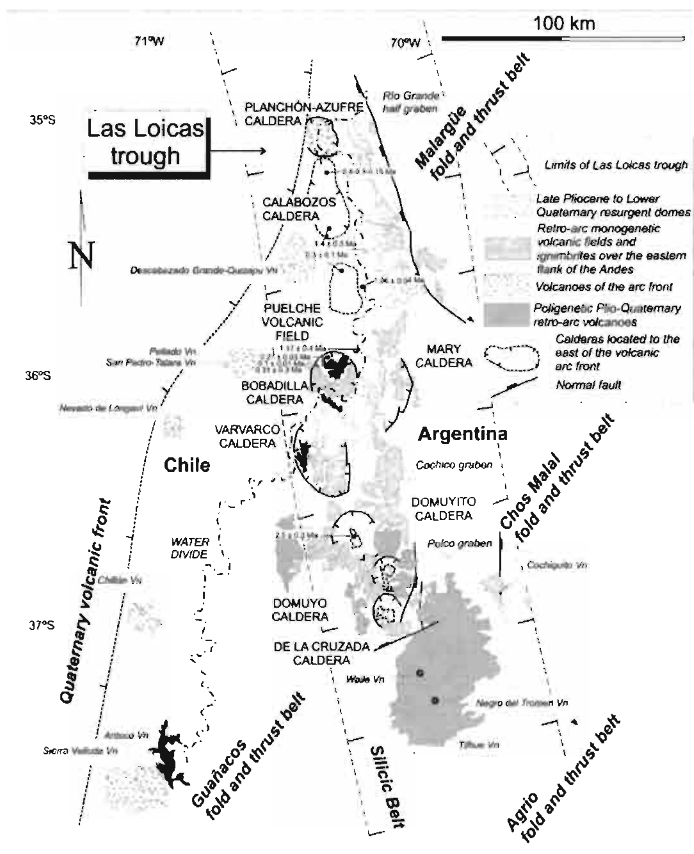

Figure 2. Las Loicas trough at the inner parts of the Andean fold and thrust belt between 35° and 37°30´S. Note an inflection of the arc front to the north at the intersection with the area of extension in the retro-arc. Based on Hildreth et al., (1984, 1991, 1999); González Ferrán (1995), Miranda (1996).

Las Loicas trough is the Plio-Quaternary basin with higher volumes of silicic volcanic products. On the other hand the Bío-Bío Aluminé and the Loncopué troughs are dominated by mantle derived rocks. A plausible explanation for these differences is that Late Miocene crustal thickening was much more important in the north at the Malargüe fold and thrust belt than in the Agrio and Chos Malal fold and thrust belts (Fig. 1). These contrasting crustal thicknesses, north and south of 37°S were develop at 12 Ma. Mantle upwelling related to the steepening of the oceanic slab could have enhanced this basaltic underplating and consequent crustal melting.

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