SALIENT AND RECESS DEVELOPMENT IN THE AGRIO - ALUMINÉ FOLD AND THRUST BELT. INFLUENCE OF A PRE-ANDEAN FORELAND OBSTACLE 1-50

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Curved traces are recurrent features of structural map-view patterns on different fold and thrust belts (FTB) of the world (Marshak, 2004). Although curving FTB frequently reflect pre-deformational thickness of the sedimentary basin fill (Aitken and Long, 1978; Macedo and Marshak, 1999), other causes are also common. These include interaction of the growing orogenic wedge with foreland obstacles or promontories, and intersection between two non-coaxial (and possibly diachronic) belts, among others (Marshak, 2004). In such cases, a recess is expected to form against the basement high or where non-coaxial belts overlap, and a salient away from it. These map-view curvatures are commonly accompanied by significant morphological, structural and stratigraphic changes (Marshak, 2004).

The Agrio and Aluminé fold and thrust belts occur along the Andean foreland region between 37° and 40°30'S. They involve several thousands of meters of a Mesozoic succession accumulated under variable tectonic and sedimentary conditions in the Neuquén basin (Vergani *et al*., 1995). Different lines of evidence indicate that both portions of the fold and thrust belt developed in at last two discrete periods of progression of deformation toward the foreland. The first occurred in Late Cretaceous times, and the last one between the Middle Miocene and the Lower Pliocene (Cobbold and Rossello, 2003; Zamora Valcarce *et al*., 2006; García Morabito *et al*., 2011; García Morabito and Ramos, 2012).

There is a striking difference in the degree of progress of the deformation towards the east between both belts, delineating a wider northern portion that defines a salient (Chiuhuidos salient), and a narrower southern portion that becomes a recess (Laguna Blanca recess) (Fig. 1a). Significant morphological, stratigraphic, and structural changes occur around 38°30'S, on the transitional area between both segments.

In the north, the Agrio FTB propagates hundreds of kilometers towards the foreland by the incorporation of rift and post-rift deposits into the orogenic wedge. This system consists of a series of large, axial-extended folds of variable wavelengths developed through a combination of thick and thin-skinned tectonics (Zapata *et al.,* 2002; Cobbold and Rossello, 2003; Zamora Valcarce *et al.,* 2006). South of 38º30'S, the Aluminé FTB is much narrower. The forward growth of the belt would have been inhibited by the presence of the east-west oriented Huincul High (Fig. 1a). The integration of structural data and detrital zircon ages from its exposed portion document that this system was already a positive element by the time of inception of Andean deformation (Naipauer *et al.,* 2012). Therefore, it may have acted as a foreland obstacle, limiting the progression of deformation towards the east, and confining it to a narrow region where the FTB and the Huincul System interact. Important basement blocks uplift and exhumation took place along this inner segment giving rise to the Southern Neuquén Precordillera, an independent mountain system that grew separately from the main Andean chain. This system exhibits the deepest levels of exposure of the entire belt, providing good exposures of the basement, the synrift, and the early post-rift successions. NNW-trending inverted normal faults coexist here with a series of NE and east-west oriented folds and faults with evidences of a persistent Jurassic activity. Northwards, it is replaced by partially inverted depocenters preserved in subsurface, documenting a dramatic change in the structural relief as a consequence of differential regional uplift.

To test the feasibility of these ideas, a series of sandbox models have been performed. They were analyzed with the GEODEF, a numerical method originally designed to get a 2D high-resolution strain monitoring

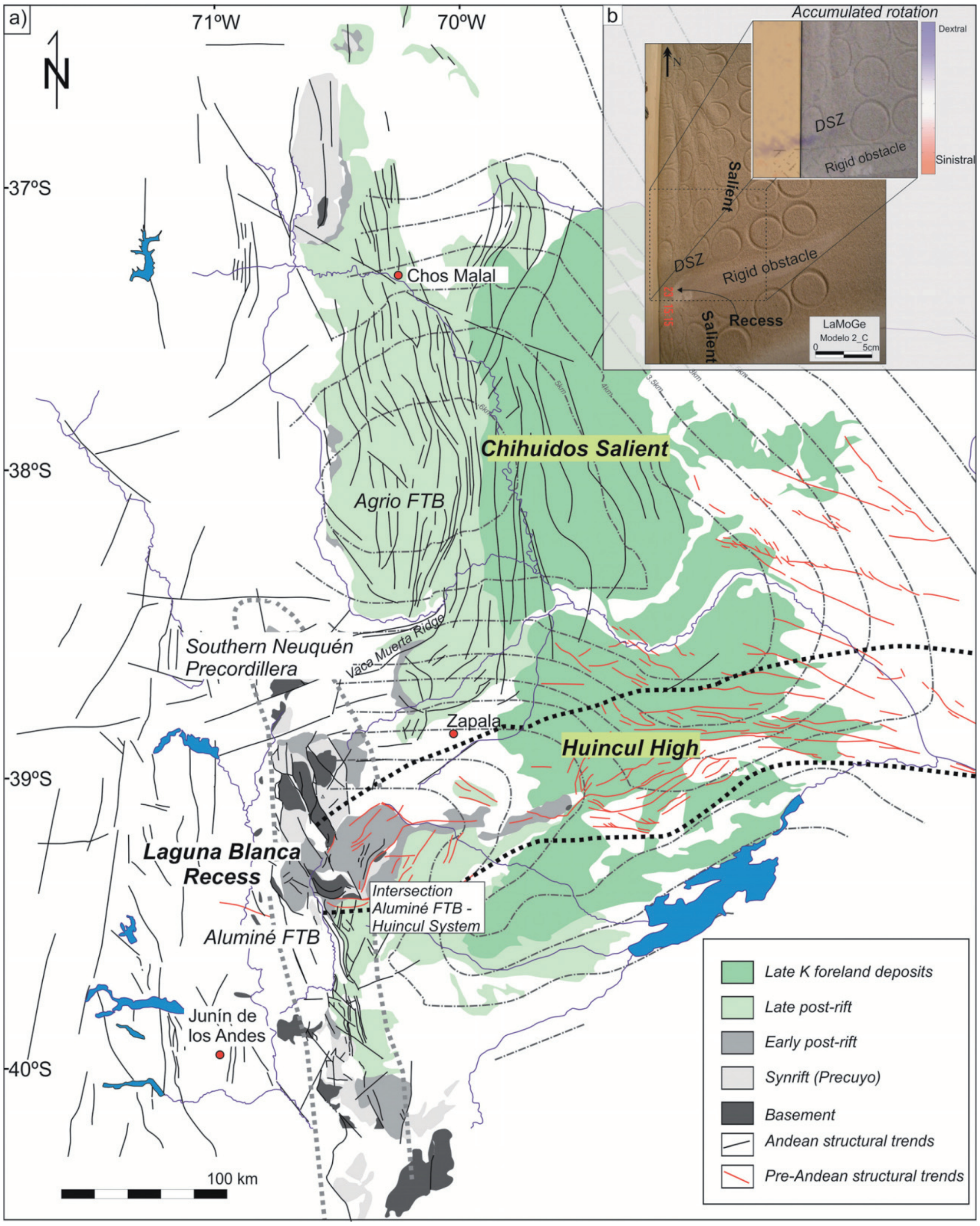

Fig. 1 - a) Structural map of the Agrio-Aluminé FTB, illustrating the contrast between the Agrio salient and the Aluminé recess. The recess exhibits a much narrower width, and the basement has been exposed defining the Southern Neuquén Precordillera. It reflects the interaction between the eastward propagating Aluminé FTB and the western portion of the Huincul High. Structural features from the Huincul High based on Silvestro and Subiri (2008). b) Map-view of analogue model final stage. Note the salient-recess geometry obtained after the advance of the moving-wall from left to right. The inset shows the calculated cumulative rotation; DSZ= dextral shear zone.

of the deformation fields from sequential digital photos obtained throughout the evolution of sand models (Yagupsky *et al.,* 2008; Yagupsky, 2009; Yagupsky and Cristallini, 2011). The corresponding displacement fields are computed by an optical image cross-correlation technique (Particle Image Velocimetry, PIV). The software allows establishing the pattern of incremental strain, much earlier than scarps become visible over the surface of the model. It also computes and maps the accumulated rotation over each sector of the studied surface (Fig. 1b).

The good agreement found between the experimental results and first order features of the belt supports the hypothesis that the Huincul High acted as an obstacle for the Andean deformation progress. In our models, the relative amount of deformation is greater behind the rigid element than near the apex of the advancing wedge. Furthermore, the imposed obstacle induces the salient to be laterally bounded by strike- slip faults (Fig. 1b). This compares well with the dextral kinematics observed along Sierra de la Vaca Muerta ridge during the Terciary (Repol, 2006). This fault system, striking sub-parallel to the transport direction, would be responsible for accommodate the contrast in the position of the thrust front between the Chihuidos salient and the Laguna Blanca recess. We argue that this is an expectable response to the interaction between the advancing deformation and the already formed rigid obstacle represented by the Huincul High.

Concluding remarks

Between 37º and 40º30'S a differential propagation of the deformation towards the foreland delineates a curving fold and thrust belt. Along-strike variation in width is accompanied by significant latitudinal morphological, topographic, and structural changes. Structural data and detrital zircon ages from the exposed portion of the Huincul High confirm that this E-W feature was already uplifted by the time of inception of the Andean deformation. This structural setting is supported by analogue models, suggesting the following two factors as the origin of the curved geometry of the Agrio-Aluminé fold and thrust belt: 1) a higher pre-deformational sedimentary sequence involved in the Agrio FTB generated the Chiuhuidos salient; and 2) the interaction of the Aluminé FTB with the Huincul High induced the Laguna Blanca recess. Therefore, the Huincul High would have acted as a transverse foreland obstacle that inhibited the forward growth of the Andean belt, increasing the deformation and uplift in a narrow region where the two system interacted.

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