THRUST KINEMATICS AND FORELAND BASIN DYNAMICS OF THE SOUTHERN SUBANDEAN ZONE OF BOLIVIA: NEW INSIGHT FROM APATITE FISSION TRACK ANALYSIS

Stéphane BRUSSET (1), Philippe ROCHAT (2), Patrice BABY (1,3), Joan FLINCH (4)

(1) LMTG, Geodynamics, UMR 5563, 38, rue des 36 ponts, 31400 TOULOUSE, FRANCE, stephane.brusset@cict.fr
(2) TOTALFINAELF CSTJF avenue Larribau, 64000 Pau, France philippe.rochat@totalfinaelf.com
(3) IRD UR104, LMTG, Geodynamics, UMR 5563, 38, rue des 36 ponts, 31400 TOULOUSE, FRANCE, patrice.baby@cict.fr
(4) TOTALFINAELF CSTJF avenue Larribau, 64000 Pau, France joan.flinch@totalfinaelf.com

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INTRODUCTION

It is now well-known that the subandean zone of Bolivia (fig.1) is structured by thrust-related folds (Baby et al., 1992). Such structures are controlled by two main décollement levels located in the Silurian Shales and in the Devonian Los Monos Fm. Several balanced-cross sections have been proposed for the studied area. The aim of this paper is to discuss the geodynamics evolution of the thrust-wedge using Apatite Fission Track Analysis on samples collected on each structure and to combine this analysis with a sedimentary facies study of Neogene deposits. The evolution of the thrust-wedge controls the foreland basin system configuration, so a step-by-step reconstruction will give good information about the propagation of the Neogene Subandean retroforeland basin system.

METHODOLOGY

The information obtained from AFTA allows deducing a maximum burial history for each anticline-syncline pair. The combination of this information with source rock maturity analysis defines precisely these burials. The kinetic parameters used to constrain the deformation sequences are: i/the dating of the cooling of the apatites (rising); ii/two new ages obtained in tufaceous strata; and iii/ages of youngest grain population of apatites located in the basal part of Neogene series and resulting from recent volcanic explosion. The sedimentologic and morphologic analyses allow relating the facies associations and the relevant surfaces recognized in the Neogene series to depozones of a modern foreland basin system.

The interpretation of new seismic sections allows a better geometric definition of the deep structures. This new information is used for the construction of balanced cross-sections.

RESULTS

Between 20.9±2.7 and 9.9 ±1.3 Ma, the distribution from west to east of the ages obtained in the base of the Neogene series shows the diachrony in the foreland basin system structure development. The burial computation using temperature constraints on apatite samples allows constructing the pre-thrusting configuration of the foreland basin system. Thickness variations can be interpreted as the result of a bending of the foreland lithosphere determining distal foreland system depozones. These depositional areas are distributed from west to east as follow: the foredeep depozone in the present day Domo Oso and west-Iñiguazu anticlines; the forebulge depozone from west-San Alberto to west-Aguarague and the backbulge depozone from Aguarague to the Chaco plain. During this period, the southern Subandean zone was submitted to large wavelength tectonic tied to the flexion of the Brazilian shield owing to the load of an orogenic prism located westward in the Camargo area.

The facies records that the studied area was in the part distal of such a system (foredeep - forebulge - backbulge depozones).

From 9.6 ± 0.8 Ma, thrust-related folds propagated eastward with two décollements one at the very base of the wedge (Silurian - Kirusillas Fm) and other within the wedge itself (Upper Devonian –Los Monos Fm). Link thrust developed between the décollements and involved Kirusillas, Icla and Huanapama Fms in a hinterland dipping duplex associated with large structures. From the second décollement (Los Monos Fm) merged thrusts with associated box folds (antiformal stack).

The décollement at the base of Los Monos Fm authorizes a decoupling between the most top structures and the lowest structures. Therefore the shortening of Aguarague's structure gets accommodated partly in the antiformal stack of the San Alberto anticline. On the other hand, in the more internal structures (Domo Oso, Iniguazu), the shortening of the lowest duplex gets accommodated directly in surface by the development of a transported syncline. The deformation sequence corresponds globally to forward thrust propagation. This type of spread is obvious well in the lowest duplex, and registered by the sedimentary sequences near the structures Aguarague and La Vertiente. On the other hand, the geometry of the most top units seems to show a more anarchic organization. The existence of several décollement levels and the shortening are characterized by the synchronous development of the thrusts (Boyer, 1993). This synchronism is proved by the ages of cooling of the apatites.

CONCLUSIONS

Several conclusions can be pointed out (fig. 2)

1- the classical stratigraphy of Neogene rocks based on facies recognition is inconsistent with stratigraphic implication of apatite fission track analysis. For example the basal part of Neogene strata is eastward younger and younger. This trend agrees with the progressive onset of flexural subsidence controlling the first stages of foreland system occurrence;

2- two radiometric ages (K/Ar) have provided by tuffaceous layers interbedded in Neogene formations. One gives 3.3 ± 0.1 Ma at the very base of the wedge-top depozone I sequence in the eastern part of the Chaco plain the other is dated at 5.3 ± 0.2 Ma in the eastern syncline of San Alberto in the basal part of the wedge-top depozone II sequence.

3- to interpret this new stratigraphic constraints, the propagation of a typical foreland basin system is required. The first stage corresponds to the occurrence of distal depozones (distal foredeep, forebulge and backbulge) with an axis of the forebulge located in the present day San Alberto area.

4- as demonstrated by the cooling ages of apatites, thrust reached the Iñiguazu area between 9.6±0.8 Ma and 6.7±0.6 Ma and developed throughout the study area until around 6 Ma, the latest cooling of one sample occurred around 3 Ma at the western rear of the wedge suggesting out-of-sequence thrust reactivation;

5- geomorphologic observations (terrace tilting; growth onlaps) evidence the ongoing of thrust-related deformation.

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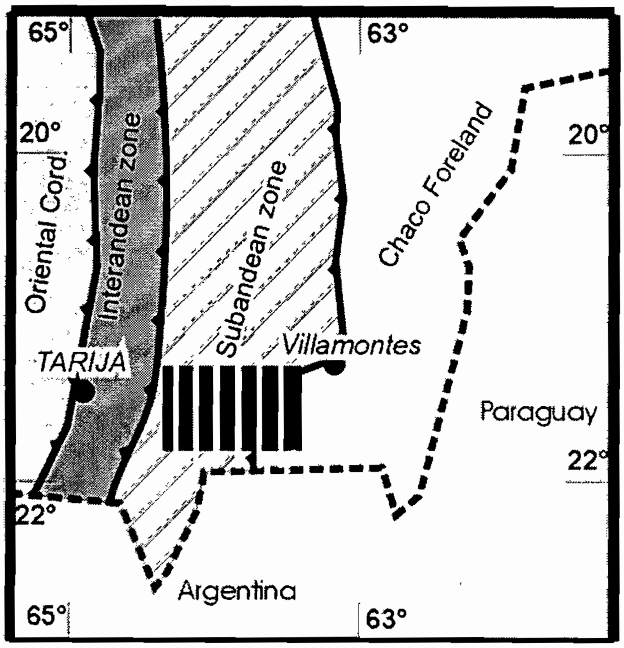

Figure 1: Schematic map of Bolivia. Strip area corresponds to the studied zone

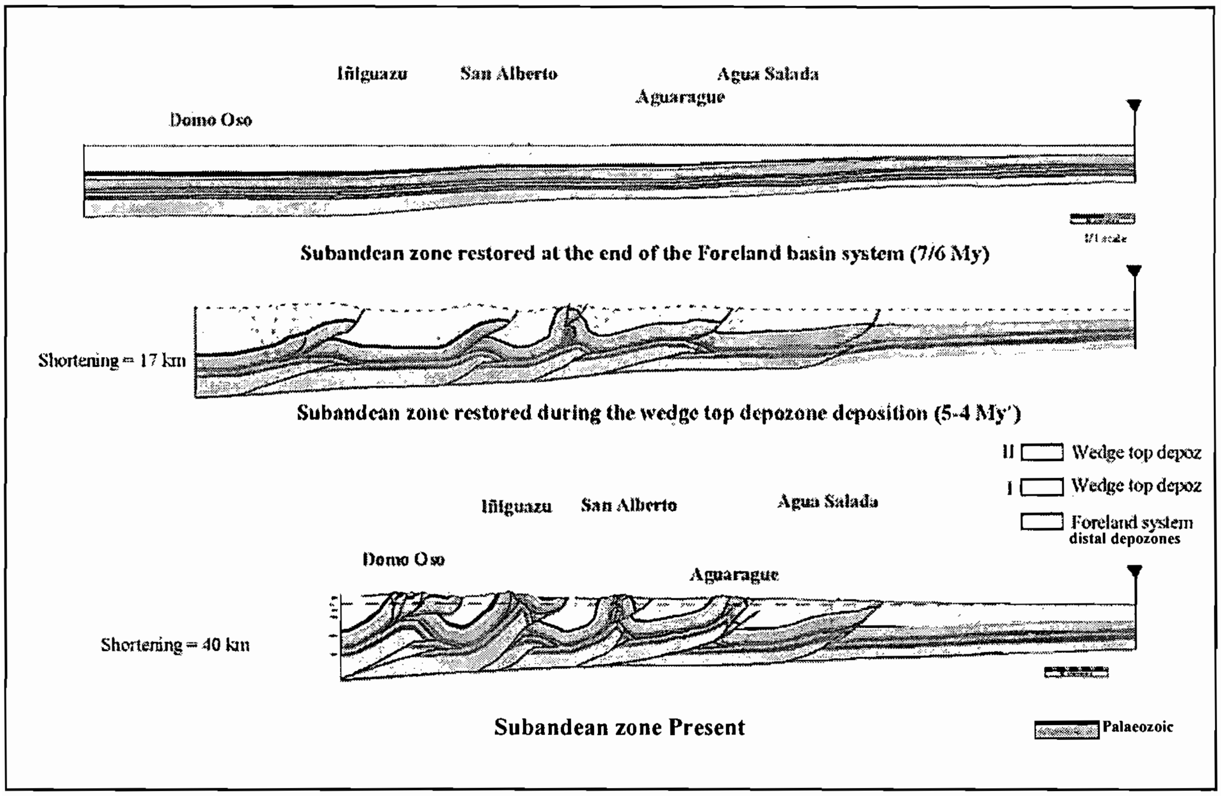

Figure 2: Sequential restoration of the studied cross-section displaying the eastward progression of the thrust wedge in the southern Subandean zone.

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