XV Congreso Peruano de Geología. Resúmenes Extendidos.
Sociedad Geológica del Perú, Pub. Esp. N° 9 (2010), Cusco p. 364-368

DATING THE LATE NEOGENE ANDEAN SHORTENING TRANSFER IN THE CAMISEA SUBANDEAN ZONE (PERU, 12°S): IMPLICATIONS FOR GROWTH OF THE NORTHERN ANDEAN PLATEAU

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INTRODUCTION AND GEOLOGICAL SETTING

Precise knowledge of timing of deformation in the Subandean zone of the Andean Plateau is a prerequisite to decipher the Late Neogene growth of the Andean Plateau (Espurt et al., accepted). In this study, we report a regional balanced cross section, new apatite fission-track (AFT) and vitrinite reflectance (Ro) data of the Camisea basin in the central Peruvian Subandean zone, adjacent to the northern Andean Plateau.

The Camisea basin is located in the central Peruvian Subandean zone, north of the northern edge of the Andean Plateau (12°S, Fig. 1A). This basin constitutes the second largest gas/condensate province of South America. The surface geometry of the basin is dominated by E–W thrust-related anticlines deforming thick Cenozoic foreland basin strata. The deformed sedimentary cover ranges from Ordovician to Pleistocene in age. In the southern Camisea basin, the sedimentary pile reaches a cumulative stratigraphic thickness of ~10 km that thins northward above the Brazilian crystalline basement (Gil Rodriguez et al., 2001). Ordovician/Silurian rocks are only exposed in the southern Camisea basin border, south of the Pongo de Mainique. The overlying Devonian to Cenozoic sedimentary series are only exposed in the Pongo de Mainique area where strata are vertical (Fig. 1).

SAMPLING AND METHODOLOGY

To illustrate the structure of the Camisea Subandean zone, we constructed a balanced cross section (Fig. 1B) partly based on the previously published interpretation of Gil Rodriguez (2002). The cross section is of about 90 km-long from the Vilcabamba Cordillera to the Ucayali foreland. The cross section orientation is orthogonal to the fold axes, i.e., parallel to the N-S tectonic transport direction to minimize out-of-the-plane transport. Surface data were obtained from 1:100,000 INGEMMET (Instituto Nacional Geológico, Minero y Metalúrgico del Peru) geologic maps, PERUPETRO S.A. geologic data, digital elevation models from SRTM data, LANDSAT images, and also from several field surveys. Surface data combined with subsurface data provided by PERUPETRO S.A. were used to precisely constrain the geometry of the thrust systems at depth. The section was balanced and restored using Midland Valley "2DMove" software on the basis of a flexural-slip algorithm.. The cross section was restored at the top of the Cretaceous deposits, assuming that they were horizontal at deposition, and pinned in the foreland.

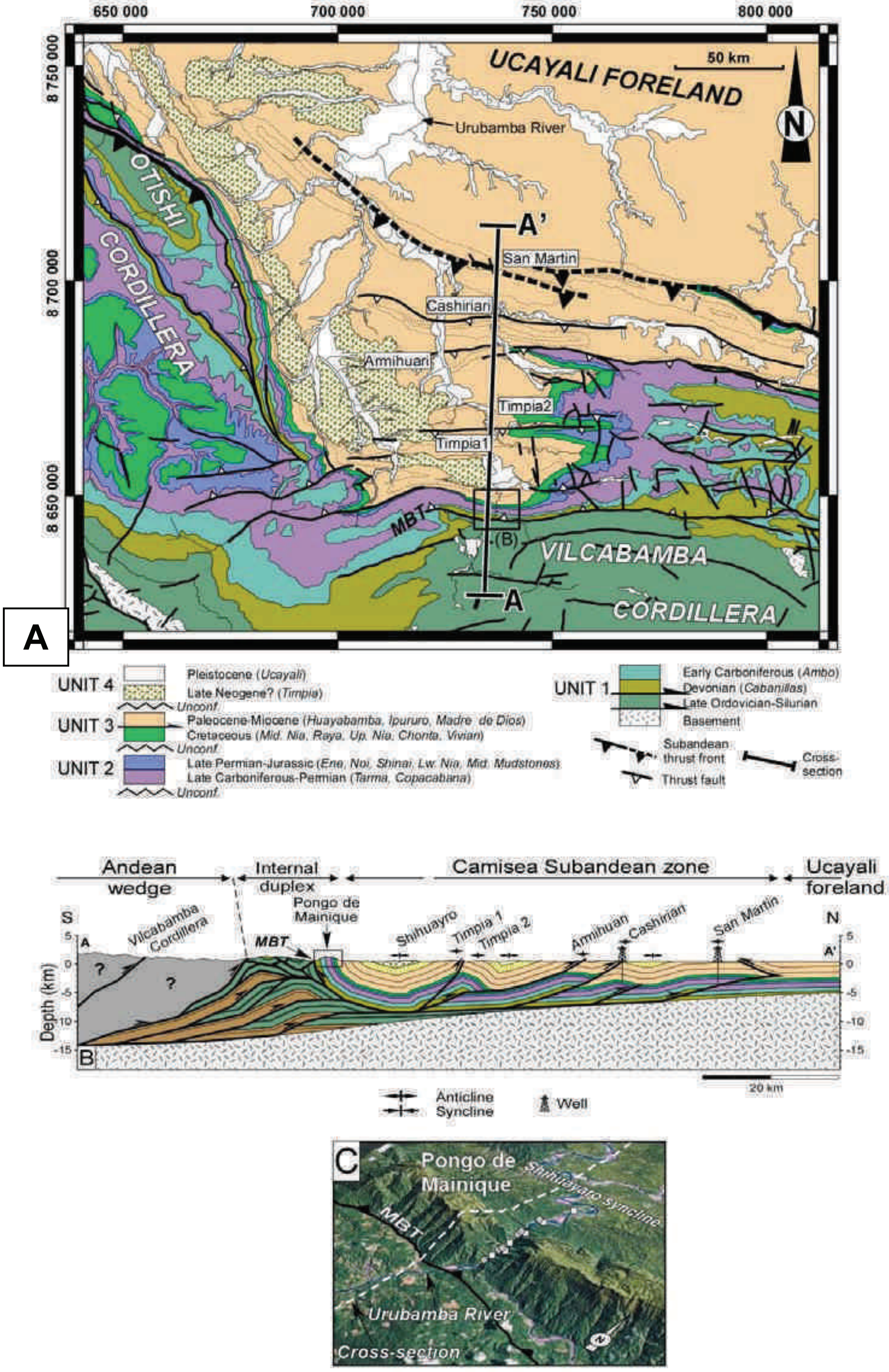

Figure 1 : A. Geological map of the Camisea basin (modified from Espurt et al., 2008, in press) Names of the anticlines (white rectangles). MBT: Mainique back-thrust. B : Balanced cross section through the Camisea basin from the Pongo de Mainique to the Ucayali (modified from Espurt et al., accepted). MBT: Mainique back-thrust. C: A: Three-dimensional view (Landsat image) of the Pongo de Mainique area (see location on A). The Landsat image has been draped on the SRTM 90-m digital elevation model from NASA. Location of AFT (grey diamonds) and Ro (white squares) samples are shown. These samples have been projected on the balanced cross section (dashed white line).

The vertical sedimentary section of the Pongo de Mainique lies in the hanging-wall of the Mainique back-thrust and includes strata from the Devonian to the Paleogene. We collected six sandstones for AFT analyses and six samples for Ro analyses in rich-organic matter stratigraphic levels (coal or black shales) (Fig. 1C).

RESULTS AND DISCUSSION

The restoration of the cross section shows that horses h1, h2 and h3 of the internal duplex accommodate 53 km (i.e., 39%) of total horizontal shortening. ~23 km of the duplex shortening were transferred to the north into the Camisea thrust systems. The remaining ~30 km would have been accommodated by the Mainique back-thrust (Fig. 1B).

The youngest AFT components are plotted versus paleo-depth (Fig. 2) (Fitzgerald et al., 1995).

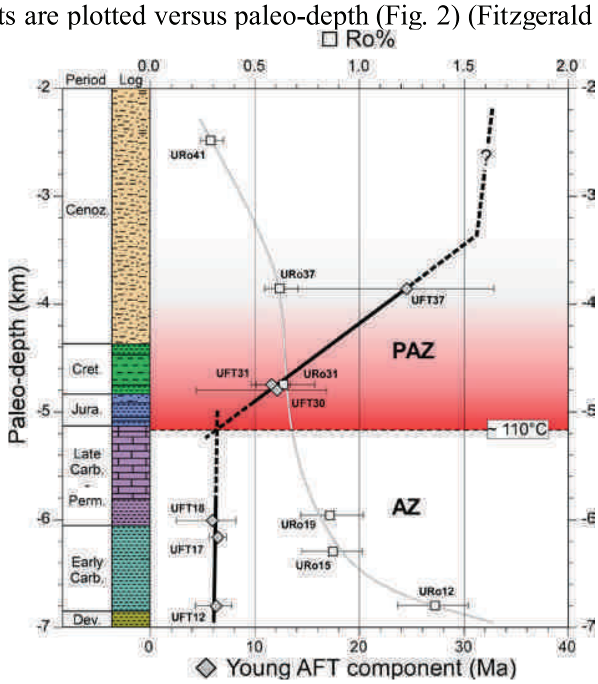

Figure 2 : Plots of the young AFT component (grey diamonds) and Ro data (white squares) versus paleo-depth. PAZ: Partial annealing zone. AZ: Annealing zone. (modified from Espurt et al., accepted).

The paleo-depths are taken from the restored cross section (Fig. 3A). The obtained profile can be divided into two parts: the upper part in which the young AFT components decrease with the paleo-depth and the lower part in which all ages are invariant (5.9-6.5 Ma, or ~6 Ma). We interpret the upper part of the profile as the lower portion of the fossil Miocene partial annealing zone (Fig. 2). In contrast, similar invariant young AFT components (~6 Ma) for the three deepest samples (UFT18, UFT17 and UFT12) as well as higher Ro values (0.86-1.37%) suggest complete annealing during Cenozoic reburial (Fig. 2). This distribution characterizes the presence of a "break in slope" in the apatite age profile which marks the base of the fossil Miocene partial annealing zone and is associated with a rapid uplift (Fitzgerald et al., 1995). The "break in slope" indicates the onset of cooling sampled rocks of the Mainique back-thrust at ~6 Ma. Ro values were also plotted versus paleo-depth (Fig. 2). The thermal-depth evolution trend is consistent with a progressive temperature increase of the basin during the Cenozoic reburial that precedes exhumation.

Sequential restoration calibrated by AFT and Ro data indicates that the last ~23 km horizontal shortening was accommodated by the Camisea thrust system over the past ~6 Ma giving a mean shortening rate of 3.8 mm/yr (Fig. 3). Using this shortening rate for the first ~30 km horizontal shortening, we calculate that the Andean shortening transfer into the Peruvian Subandean zone initially started at ~14 Ma. This result suggests that the transfer of shortening from the northern Andean Plateau to the Subandean zone occurred prior to the removal of dense lithosphere event previously reported between ~10 Ma and ~7 Ma (Garzione et al., 2008 and references therein). We rather propose that the Late Neogene growth of the northern Andean Plateau mostly results from a continuous crustal shortening combined with possible lower crustal flow (Espurt et al., accepted).

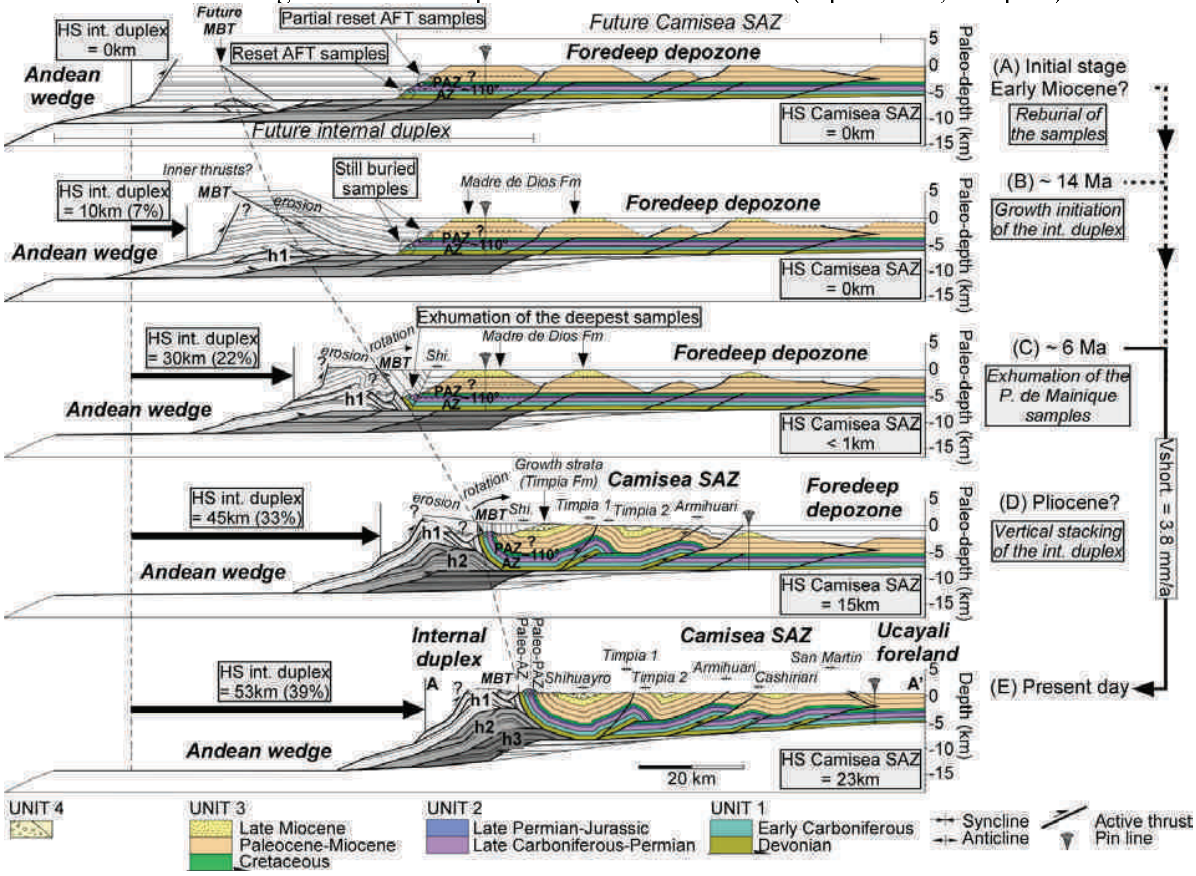

Figure 3 : Sequential restoration of the balanced cross section illustrating the history of the Andean shortening transfer from the Andean wedge in the Camisea Subandean zone. The restoration is calibrated using AFT, Ro and additional sedimentary data. HS: total horizontal shortening. Vshort.: shortening velocity. AZ: annealing zone. PAZ: partial annealing zone. (modified from Espurt et al., accepted).

ACKNOWLEDGMENTS

This study was led thanks to the Institut de Recherche pour le Développement (IRD) – PERUPETRO S.A. – PLUSPETROL E&P S.A. research agreement, and supported by IRD (UR 154) and French INSU – CNRS programs DyETI and ECLIPSE II. Midland Valley is acknowledged for providing ''2DMove'' for kinematic structural modeling.

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