Geophysical Research Abstracts, Vol. 9, 09872, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-09872

Diachronous rotational movement along the Southwestern Pyrenean thrust front

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The spatial and temporal development of a thrust front depends on numerous variables including shortening rates, geometry of the sedimentary bodies, mechanical behavior of the involved materials and the occurrence (or not) of syntectonic sedimentation, etc. For those reasons fold-and-thrust-belt fronts are typically diachronous along strike as has been demonstrated when reliable chronologic data allows an accurate dating of the deformation. Depending upon the scale, the diachronism implies the occurrence of confined (local) or widespread (regional) lateral gradients of shortening and therefore rotations are common, in different magnitudes, in most orogenic fronts.

Several balanced cross-sections suggest important differences of shortening along strike bounding the Southwestern Pyrenees. Numerous paleomagnetic investigations have been developed to characterize the expected vertical-axis rotations during the last four decades in the External and Internal Sierras and in the Jaca-Pamplona, Aínsa and Graus-Tremp basins. At present there exist more than 700 sites to control rotations and 41 kilometers of magnetostratigraphic profiles (mostly Cenozoic sections) including, in total, more than 9.000 demagnetized samples. This frame converts the Southwestern Pyrenees in an excellent example to fully understand processes of lateral transference of deformation.

The External Sierras front represents the southernmost expression of the western Pyrenean thrust. A rotational emplacement has been extensively characterized and quantified by paleomagnetic data by several researchers (Bentham, 1992, PhD University of Southern California; Dinarés-Turell, 1992 PhD Universitat de Barcelona; Hogan, 1993 PhD University of Southern California; Pueyo, 2000 PhD Universidad de Zaragoza;

Fernandez, 2004 PhD Universitat de Barcelona). The rotation magnitude, age and even velocity have been accurately constraint in two sectors: rotation ages seem to be younger westwards and have been identified as Lutetian in the Boltana anticline (Fernandez, 2004) and Bartonian in the Pico del Aguila anticline (Pueyo, 2000). In this contribution 36 new paleomagnetic sites (more than 300 samples) are presented and interpreted together with three existing magnetostratigraphic profiles (Hogan, 1993) all of them located in the Jaca molassic basin (fluvio-lacustrine Campodarbe Fm. Priabonian-Rupelian in age). The main goal is accurately dating the onset and cessation of the rotational movement in different portions along-strike the Pyrenean sole thrust.

Detailed progressive thermal demagnetization (steps every 25-50˚C) was performed to unravel the NRM components in the University of Michigan by means of a 2G cryogenic magnetometer and an ASC TD-SC oven. Together with low-temperature records of the present magnetic field only one paleomagnetic direction has been characterized unblocking gradually between 250˚ up to $\approx$ 500˚ (in a few cases) and unblocking sharply around 650 and 675˚ (most cases). Low temperature analyses (MPMS) and thermo-magnetic runs (MVSM) carried out in the IRM (University of Minneapolis) confirm the occurrence of magnetite and hematite respectively. High-temperature components, as previously described in magnetostratigraphic studies (Hogan, 1993), display two polarities (N:15 010,43 a95:9˚ k: 21; R:21 187,-37 a95:9˚, k:14). The wide distribution of sites with different bedding attitudes allows performing the fold test at different scales confirming the pre-folding condition. Therefore the Campodarbe formation seems to hold a reliable record of the Oligocene magnetic field.

Comparison of local data with Eocene - Oligocene references (Ebro basin) gives robust values of rotations, ranging between non significant to almost 40˚ CW. The excellent exposures and the magnetostratigraphic data allows an accurate dating of the studied sites, all comprised between chrons C17r and C11n (GPTS). Evaluation of rotation values, in combination with other Bartonian data (Arguis Fm.), in three different N-S sections (from East to West are Monrepós, Anzáñigo and Salinas) allows reaching key observations: 1) The rotation reach 40˚ at the base of Bartonian (Arguis Fm) and is probably larger during Lutetian times (Guara Fm.) in the Pico del Aguila anticline (Monrepós). 2) The rotation undoubtedly finishes by the end of Bartonian (C17n) in the area. 3) Significant values of rotation ($\approx$ 20˚ CW) are found 25 km to the west in the lower Priabonian (Anzañigo sector). 4) Rotations disappear during Rupelian times (maybe C12r) in this region. 5) Rotations are significant ($\approx$ 30˚ CW) in the westernmost section (Salinas 15 km westwards from Anzañigo) at this time. 6) Rotations are significant until upper Rupelian times (at least C10r) in this profile.

Despite the onset of rotation is only partially established, a well-defined diachronism

has been demonstrated for the end of the rotational movement. The rotation laterally vanishes at an averaged rate of $\approx$ 5 km/M.a. although this velocity may be faster if a non-steady scenario is considered, for example if some oblique structures (v.g. lateral thrusts terminations) articulate zones with and without rotation. Comparable values could be expected for the rotation onset as regards of the remarkable similarities found with the lateral migration of the deformation along the External Sierra front (Millán et al., 2000; Rev. Soc. Geol. España 13[2], 279-300) or the westwards onlap of the turbiditic trough (Labaume et al., 1985; Tectonics 4 [7], 661-685).