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2D and 3D modelling of the Linking Zone between the Iberian and the Catalan Coastal Ranges (NE Spain): Characterizing basement and cover deformation from geological and geophysical cross sections

Esther Izquierdo-Llavall (1), Concepción Ayala (2,3), Félix Manuel Rubio (2), Emilio Pueyo (4), Antonio Casas (1), Belén Oliva-Urcia (5), Adriana Rodríguez-Pintó (1), and Carmen Rey-Moral (2)

(1) University of Zaragoza, Ciencias de la Tierra, Zaragoza, Spain (estheriz@unizar.es), (2) Instituto Geológico y Minero de España (IGME)-Area de Geofísica y Teledetección. Tres Cantos - 28760 Madrid , (3) Visiting at Inst. Ciencias de la Tierra "Jaume Almera" (CSIC). C/ Lluis Solé Sabaris s/n, 08028 Barcelona, (4) Instituto Geológico y Minero de España (IGME)-Unidad de Zaragoza, Manuel Lasala 44, 50006 Zaragoza, Spain, (5) Dpto. de Geología y Geoquímica. Universidad Autónoma de Madrid. Ciudad Univ. de Cantoblanco , 28049 Madrid

New geological, geophysical and petrophysical information is presented in this work in order to improve the understanding of the Linking Zone, an E-W-trending fold and thrust system that connects the northeastern part of the Iberian Range (WNW-ESE-striking) and the Catalan Coastal Ranges (NNE-SSW-striking). It was formed during the Alpine Orogeny and it is characterized by (1) thick-skinned tectonics, partly controlled by reactivation of faults inherited from Mesozoic times and (2) thin-skinned tectonics, affecting the cover sequences above the regional detachment levels (Triassic gypsum and shales). The present study aims to obtain a 3D image of the structure of this area through the construction of balanced geological and geophysical cross sections.

In the Linking Zone scarce subsurface information is available. Therefore, we have conducted data acquisition campaigns to improve this knowledge: A) about 3000 gravity stations distributed along 8 main profiles were measured, and these new stations were complemented with gravity data from IGME databases. These data were analyzed and processed to obtain a Bouguer anomaly map and a residual gravity map with reasonably good coverage; B) a petrophysical survey was also carried out; rock samples were acquired and analyzed obtaining density and susceptibility values of the main lithologies. The statistics of these physical properties is of key importance during the combined geophysical/geological modelling. Petrophysical data indicate a weak, progressive increase of density mean values from the top to the base of the stratigraphic pile with the exception of Triassic gypsum and shales, where the lowest density was obtained.

The modelling has been made in three steps: First, a set of eight geological cross-sections based on surface geology and structural information were built, controlled and improved through gravity modelling and balanced to make them geometrically correct, consistent throughout the sections and closer to reality. Second, the cross sections were imported in Move (by Midland Valley Exploration) and GeoModeller (by Intrepid Geosciences) to create a 3D geological model in accordance with all the geological observations. Finally, a 3D gravimetric inversion using GeoModeller was carried out to obtain the lithological horizons that also honor the petrophysical and gravimetric data.

The studied area can be divided in three structural domains: (1) the eastern margin of the Aragonian Branch, (2) the Linking Zone and (3) the transition between the Linking Zone and the Catalan Coastal Ranges. In the Aragonian Branch, the main structures partly correspond to the inversion of basement faults limiting the margins of the Oliete sub-basin, Lower Cretaceous in age. The boundaries of this basin coincide with positive residual gravity anomalies. Structures in the Linking Zone belong to the northern margin of the inverted Morella basin (Upper Jurassic-Lower Cretaceous) to the South and the thin-skinned Portalrubio-Vandellòs thrust system to the North, both separated by a strongly deformed zone corresponding to inverted structures in the marginal areas of the Mesozoic basin. In the Catalan Coastal Ranges, faults affecting the basement are dominant. Positive residual gravity anomalies match with antiformal structures at the front of the range and negative gravity anomalies to Plio-Quaternary basins superimposed on the Alpine compressional structure. In the foreland of the Iberian and Catalan Coastal ranges, the slightly deformed basement of the Cenozoic Ebro Basin is characterized by positive residual anomalies indicating the location of basement uplifts. From the 3D model we obtained a faulted, deformed basement at a maximum depth of 1700 m but generally found between 350 and 1400 m.