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Coeval gravity-driven and thick-skinned extensional tectonics in the mid-Cretaceous of the western Pyrenees

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The Mesozoic Basque-Cantabrian Basin in the western Pyrenees constitutes a peri-cratonic basin originated by rifting related to the Cretaceous opening of the Bay of Biscay. During the mid-Cretaceous the basin experienced important extensional/transtensional tectonics, which controlled the deposition of thick sedimentary successions. Many extensional structures have been documented in the basin but their thin-skinned/thick-skinned character is an unresolved question. In this field-based study, we characterize contemporaneous thin-skinned and thick-skinned deformations that took place during the filling of the mid-Cretaceous Lasarte sub-basin, located in the northeastern margin of the Basque-Cantabrian Basin (western Pyrenees). Most of these extensional structures and associated growth strata are preserved and allow us to characterize and date different deformation phases. Moreover, verticalization and overturning of the successions during Tertiary compression allow mapping the geometry of the extensional structures at depth.

The Lasarte sub-basin constitutes a triangular sag bordered by three major basement-involved faults, which trend N, E and NE, respectively. These trends, common in the Variscan fault pattern of Pyrenees, suggest that they are old faults reactivated during the mid-Cretaceous extension. Stratigraphy of the area shows very thin to absent Aptian-Albian (and older) deposits above the upward border blocks, whereas on the downward blocks (sub-basin interior) contemporaneous thick successions were deposited (up to 1500 m). The sub-basin fill is composed of different sedimentary systems (from alluvial to siliciclastic and carbonate platforms) affected by syndepositional extensional faults (and related folds). These faults die out in a southwestward dipping ($\sim$4º) detachment layer composed of Triassic evaporites and clays. A NE-SW cross-section of the sub-basin shows NW- to N-trending six planar and two listric extensional faults and associated folds, which define a horst and graben system. Rollovers (unfaulted and faulted), hangingwall synclines and central domes are present in the hangingwalls of both listric and planar faults. Also, a fault-propagation fold, a forced fold and a roller have been interpreted. Synkinematic depositional systems and sediment-filled fissures are parallel to the NW- to N-trending tectonic structures. Based on the trend of tectonic structures, the orientation of sediment-filled fissures and the paleocurrent pattern of growth strata, a thin-skinned NE-SW to E-W extension has been deduced for the interior of the Lasarte sub-basin. Both the coincidence between the directions of extension and dip of the detachment layer and the characteristics of the deformation suggest a thin-skinned gravity-driven extensional tectonics caused by the dip of the detachment layer. Recorded extensional deformation event in the Lasarte sub-basin is contemporaneous with and would have been triggered by the extreme crustal thinning and mantle exhumation processes documented recently in both the Basque-Cantabrian Basin and the Pyrenees.