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Fold geometry and foliation development in the western area of the Central Pyrenees

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The present study deals with alpine compressional structures in the hangingwall of the Gavarnie thrust sheet, located in the western area of the central Pyrenees. The main goal of this study is to determine the precise relationship between folding, regional foliation development and the emplacement of the alpine Gavarnie thrust. The Gavarnie nappe has been previously interpreted both as the result of fault-bend folding and ductile uplift. Here we present the integration of both geometrical and foliation datasets in order to give an overall interpretation for the kinematics of structures in the western sector of the Axial Zone.

Alpine compressive deformation with foliation development can be observed in four main units with different rheological behaviour. From North to South these units are: the variscan Axial Zone, the Permian late-variscan cover, the Internal Sierras and the northern sector of the Eocene turbiditic basin. The Axial Zone includes Paleozoic materials, and shows a complex structure due to the superimposed variscan and alpine orogenic cycles. Contribution of alpine deformation in this part of the orogen is not a solved question yet. However, the existence of E-W dominant magmatic foliation and lineation in variscan intrusions suggests that reactivation of an E-W variscan foliation can be an important deformational mechanism during alpine convergence.
Alpine deformation analysis is easier in the Stephanian to Eocene cover materials. They are intersected by several fluvial valleys that favor the outcrop of an approximately 2000 m. vertical section. A structural study has been performed along these valleys, paying special attention to S0/S1 relationship and S1 attitude variation.

The western sector of the Pyrenean Axial Zone is affected by an inhomogeneous alpine foliation, that in general terms becomes weaker towards the East. It has a generally uniform attitude, with a WNW-ESE strike, and variable dips towards North. A lithological control on the foliation can be observed: it is inexistent or scarce in Cenomanian-Santonian and Paleocene massive limestones, and pervasive in Permian sandstones and shales, Santonian-Maastrichtian sandstones and marls and Eocene siliciclastic turbidites.

Post-variscan materials are affected by WNW-ESE trending, South-verging asymmetric folds associated with foliation. Folds show different geometries depending on the lithology and rheological profile of the sedimentary units. Permian sandstones and shales and Eocene turbidites (with a strong anisotropy defined by alternating competent and non-competent strata) present generally tight, metric-scale folds, with frequent subvertical to overturned limbs, and are associated with axial plane foliation. Conversely, in Cenomanian to Paleocene materials, folds are usually gentler. Foliation attitude suggests a syn-folding origin, but post-folding foliation can also be recognized.

At the map scale, foliation has a general trend parallel to the main structures. However, in some areas, there is a small angle between foliation and fold axes, that could be the result of variations in the displacement of the underlying Gavarnie thrust. Foliation dip changes locally, without a North-South variation trend. Hence, it seems to reflect smaller structural scale variations more than to be linked to a range-scale structure. The attitude of bedding in the hangingwall of the Gavarnie nappe shows also local changes along North-South sections. Geometrical relationships, especially the dips of beds at the backlimb of the hangingwall anticline cannot be explained by a single fault-bend folding mechanism and point to a complex origin for deformation, with processes involving shear, flattening and thrust-related folding.

The described structures can be considered to be associated with the emplacement of the Gavarnie thrust-sheet, during a long-lived process in which foliation related to thrusting and crustal shortening took a dominant role in mountain building.