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Influence of inherited superposed folding on back-thrusting development: a case study from the Variscan foreland fold-and-thrust belt of Sardinia

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The Variscan foreland of SW-Sardinia consists of a Cambrian to lower Carboniferous succession polydeformed under very low-grade metamorphism. It is characterized by the following superposed structures: 1) E-W-trending upright folds; 2) N-S-trending inclined folds, penecontemporaneous with 3) W-ward fore-thrusts, and 4) E-ward back-thrusts.

A peculiar feature of this sector of the Variscan foreland is the widespread occurrence of back-thrusts, apparently more common than fore-thrusts, unlike the majority of foreland fold-and-thrust belts.

Our research focuses on the role played by the folded basement in limiting extensive fore-thrusts development and how fold shape and orientation, along with litho-stratigraphic heterogeneity, influenced the back-thrust geometry.

Generally, back-thrusts occur when the shortening can no longer be accommodated by fore-thrusts, usually because of buttressing induced by fore-thrust-related thickening and duplication of the stratigraphic succession. However, in the segment of Variscan foreland outcropping in SW-Sardinia, back-thrusting seems to be activated by a different mechanism. The inherited structural setting is characterized by two perpendicular generation of superposed folds that gave rise to a type 1 interference pattern with pluri-km-scale domes and basins. In particular, in the western sector of the foreland (i.e., the farthest from the nappe zone thrusted over the foreland) domes are made up of about 500 m thick lower Cambrian sandstone and limestones formations that may have acted as a buttress, hindering fore-thrusting propagation and facilitating extensive E-ward back-thrusting. This is corroborated by the large number of back-thrusts that crop out between the buttress and the nappe front.

In this area, back-thrusts affect the folded sedimentary succession that is progressively younger and weaker E-ward. As commonly accepted in thrust faults, ramps developed in the competent stratigraphic sequence, here made up of sandstones and limestones, and flats in weak stratigraphic horizons, here consisting of marly limestones and shales. As a result, in the study area the dip of back-thrusts decreases towards the nappes front, where the weaker lithologies have been overthrusted.

The back-thrusts' surface is characterized by discontinuous antiforms and synforms that do not affect the underlaying succession; so, a later deformation phase that folded the back-thrusts can be ruled out. Therefore, the fault plane should have been deformed throughout the back-thrusts growth and development.

Interestingly, strictly relationships can be noticed between the fault plane geometry and the inherited structures in the footwall of the back-thrusts. Where the back-thrusts cut across upright limbs perpendicular to the back-thrust strike, the fault plane shows an antiformal shape; where the back-thrusts take place above the pre-existing synforms with the axis plunging towards the back-thrust dip, the fault plane takes the form of the underlying synforms. Instead, back-thrusts are uninfluenced by pre-existing folds where they cut either synforms with the axis that plunges opposite to the dip direction of the fault plane or antiforms, regardless the plunging direction of their axis.

To conclude, this research highlights the relevant role of the inherited structural setting on fold-and-thrust belt style and suggests that the strata attitude and the axes plunging directions of pre-existing folds could have a control in the back-thrust geometry.