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Twenty years of progress in studying inversion tectonics in the Northern Apennines and Adriatic foreland, Italy

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The Northern Apennines of Italy is a classic example of a fold-and-thrust belt developed at the expense of a formerly rifted continental margin that later experienced post-orogenic extensional reworking. The change in polarity of the stress fields from the Paleozoic-Mesozoic extension to Paleogene-Pleistocene compression affected both the advancing sector of the chain and the adjacent Adriatic foreland producing different styles and degrees of positive inversion. In addition, the inner sector of the chain was also affected by subsequent Miocene to Present day extension, triggering an additional episode of negative inversion.
In the outer sector of the Northern Apennines, following the development of the ’90s inversion tectonics concepts remarkable examples of both pre-orogenic faults modified by subsequent compression and orogenic thrusts that were reactivated as post-orogenic normal faults have been reported and analysed. Therefore due to the spectacular exposures and mild overprint of both compression and extension, the Northern Apennines represent a natural laboratory to analyse the different styles of inversion tectonics. In addition, the access to seismic reflection data imaging the deformed Adriatic foreland provides additional clear evidence for positive basin inversion with anticlines cored by upwards-extruded syn-rift wedges.
Field and interpretation of seismic data documented different styles of interaction between the extensional and the compressional structures; these commonly include short-cut thrusts and positive inversion anticlines. Their occurrence appears controlled by the orientation of pre-existing, hinterland-dipping normal faults with respect to the subsequent compressive stress axis, with short-cut thrust trajectories dominating in case of dip-slip inversion and positive anticlines cored by reverse-reactivated normal faults in case of oblique-slip inversion, respectively. In case of inherited foreland-dipping normal faults, subsequent compression sometimes controls fold hinge location, fault rotation, giving rise to local mild positive reverse fault reactivation with buttressing effects in the footwall blocks.
New field data observation allowed us to recognize the effect of positive basin inversion both at local scale (e.g., a single anticline) and within different sectors of the fold-and thrust belt. Numerous structural field evidence highlight a limited amount of contraction that contrasts with the strong structural elevation and suggest reworking of deep-seated reverse-reactivated normal fault sets under the Apennines chain. Using constrains derived from seismic interpretation and validation by gravimetric-magnetic modelling, thick ?Paleozoic-Mesozoic basins have been imaged underneath the most elevated sectors of the chain. Balanced cross-section restoration constrained by these new data indicates for these sectors the partial positive inversion of graben-boundary normal faults and the consequent vertical extrusion of the basin infills. This model of inversion tectonics at regional scale has resulted in a even more conservative estimates of orogenic contraction, associated with lower shortening rates.
Finally, fieldwork investigation coupled with subsurface data and the hypocentral depth of the recently recorded seismicity corroborated the model of negative inversion during the last post-orogenic extensional event.