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Influence of syn-sedimentary faults on orogenic structures in a collisional belt: Insights from the inner zone of the Northern Apennines (Italy)

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A B S T R A C T

This paper discusses the possible influence of syn-sedimentary structures on the development of orogenic structures during positive tectonic inversion in the inner Northern Apennines (Italy). Examples from key areas located in southern Tuscany provided original cartographic, structural and kinematics data for Late Oligocene-Early Miocene thrusts, organized in duplex systems, verging in the opposite direction of the foreland propagation (back-thrusts), which affected the Late Triassic-Oligocene sedimentary succession of the Tuscan Domain, previously affected by pre-orogenic structures. These latter consist of mesoscopic-to cartographic-scale Jurassic syn-sedimentary normal faults and extensional structures, which gave rise to effective stratigraphic lateral variation and mechanical heterogeneities. Structural analysis of both syn-sedimentary faults and back-thrusts were therefore compared in order to discuss the possible role of the pre-existing anisotropies in influencing the evolution of the back-thrusts. As a result, it can be reasonably proposed that back-thrusts trajectories and stacking pattern were controlled by relevant syn-sedimentary normal faults; these latter were reactivated, in some cases, if properly oriented. Such an issue adds new inputs for discussing the potential role of structural inheritance during tectonic inversions, and helps to better understand the processes suitable for the development of back-thrusts in the inner zones of orogenic belts, as it is the case of the inner Northern Apennines.

1. Introduction

It has long been documented that syn-sedimentary faults affecting basinal successions can variously influence the structural deformation patterns of orogenic structures during tectonic inversion (Butler, 1989; Hayward and Graham, 1989; Williams et al., 1989; Coward et al., 1991; Tavarnelli, 1996; Scisciani et al., 2002; Khudoley and Guriev, 2003). For example, syn-sedimentary normal faults can produce mechanical heterogeneities within the stratigraphic succession, which may effectively control the nucleation of thrust ramps (Wiltschko and Eastman, 1983; Laubscher, 1977). If this is the case, the neoformational structures inherited the structural and geometric features of the pre-existing ones, being mechanically controlled. Structural inheritance, therefore, is one of the most important causes determining the development of structures with "anomalous" geometric and kinematic features in orogenic belts. In particular, pre-existing faults can give rise to thrusts that have displacements in the opposite direction to that of the main thrusts: the back-thrusts that are directed back, in the opposite direction of foreland propagation (Vann et al., 1986; Eisenstadt and De Paor, 1987). The role of structural inheritance is, therefore, crucial to explain the development of back-thrusts, although their origin by reactivation of pre-existing structures is not generally easy to demonstrate.

Examples of structural inheritances have been described for several orogenic belts around the world (i.e., Alps, Pyrenees, Atlas … Davies, 1982; Hayward and Graham, 1989; De Graciansky et al., 1989; Butler, 1989; Coward et al., 1991; Coward, 1994, 1996; Beauchamp et al., 1996; Vergés et al., 2002; Butler et al., 2006), where the important role of pre-existing structures in controlling the thrusts trajectories has been strongly documented. Contractional reactivation of inherited normal faults has also been verified through experimental models (i.e. Bonini et al., 2012), by which the role of the pre-existing faults in triggering back-thrust developments has been investigated.

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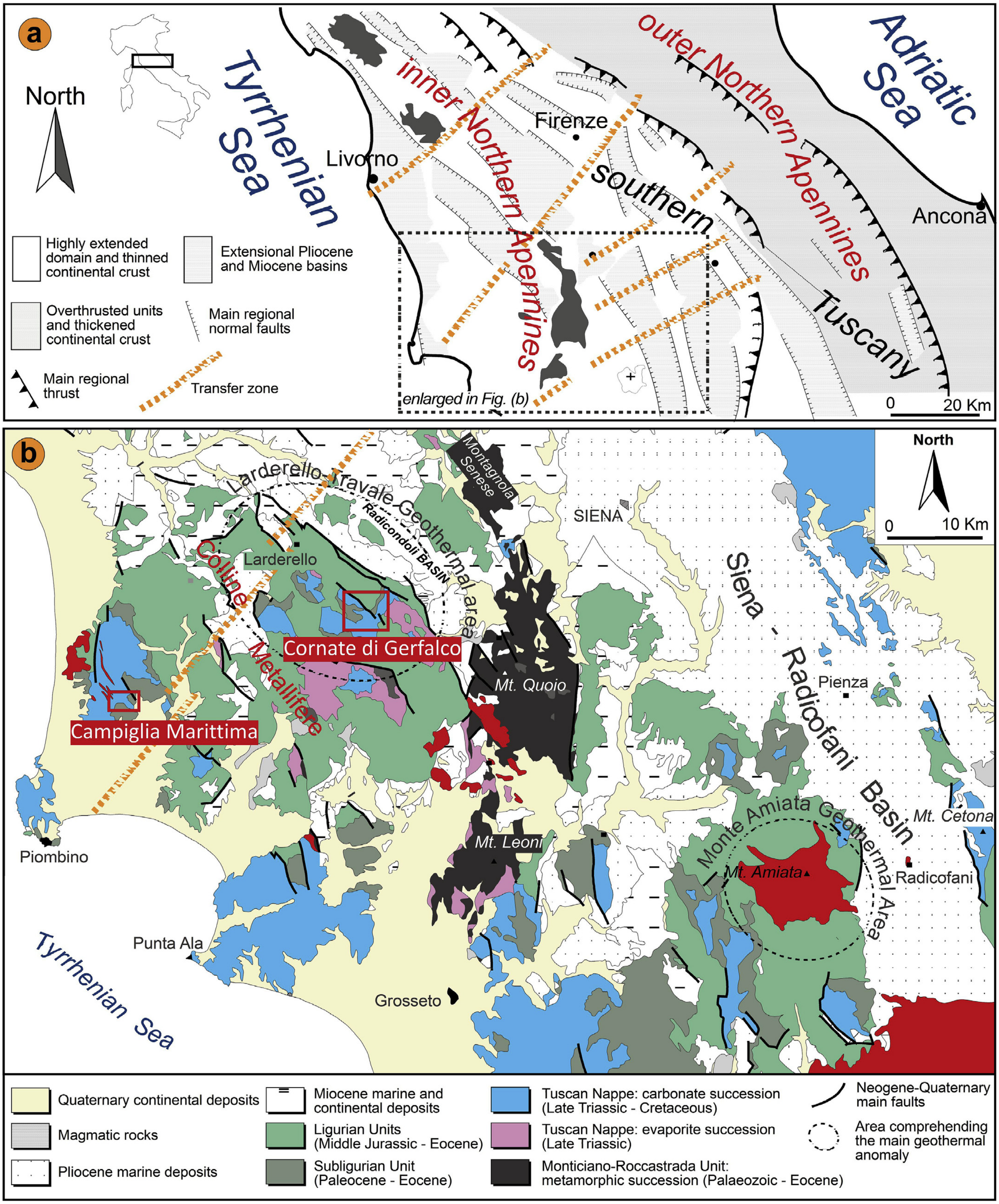

Fig. 1. a) Tectonic sketch of the Northern Apennines with the main structural features; b) Geological map of the inner Northern Apennines; the Larderello-Travale and Monte Amiata geothermal areas are also highlighted. Red rectangles (with indicated the names) are the study areas. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)