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# Seismic evidence of the rebound of the Adria foreland and the current geodynamics of the Central and Southern Apennines (Italy)

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ABSTRACT

The sedimentary wedge of the Apennines foredeep in the Central Adriatic Sea provides evidence of westward tilting of the foreland during the Lower Pliocene. The wedge was covered by an Upper Pliocene-Lower Pleistocene sequence of parallel and horizontal strata that onlapped onto the pre-wedge sediments. The Southern Apennines contain younger foredeep growth strata because the chain front migrated until the Lower Pleistocene.

Seismic profiles from the Central and Southern Apennines foredeep show a regional, apparently contrasting eastward-dipping set of post-growth parallel layers that are covered by a Middle/Upper Pleistocene Prograding Sedimentary Wedge (PSW), which is particularly thick in the Central Adriatic basin.

In accordance with the “Law of Original Horizontality” and by excluding possible exceptions to this law (inclined depositions in several specific frameworks), the observed geometric setting can be explained as an effect of post-deposition inversion of the previous orogen-ward tilting. We infer that the driving mechanism of uplift was the regional isostatic rebound of the Adria foreland, which started in the Middle Pleistocene and is still active as indicated by the current uplift of Adria and by the passively raised chain. Under the same conditions, the greater the tilting of the foredeep during the chain migration, the greater the degree of isostatic rebound. The rheology of the foreland and sedimentary loading are also key elements of these crustal-scale vertical movements. Furthermore, normal faults and greater foredeep uplift of the foreland can play local roles in short-wavelength deformations.

The current axis of the chain, which was affected by imbrication of the Apennine and Apulia units, is now subject to higher rates of rebound and erosion. We infer that inversion of some of the previous faults that originated the buried western margin of the Apulia carbonate platform (AP) triggered the extensional seismicity that is recorded along the chain.

The rapid uplift of the foreland and of the overlying thrust belt since the Middle Pleistocene caused a change in the drainage network on the Adriatic side of the chain from a longitudinal pattern to a transverse pattern. In addition, erosion of the uplifted units contributed to the high rate of deposition of the PSW in the Adriatic foreland basin.

The regional rebound process that is proposed in this work implies a primary role of the AP buoyancy and rejects the hypothesis of its current passive sinking, which is often regarded as the primary source of Apennines tectonics.



## 1. Introduction

The Pleistocene uplift of the Central and Southern Apennines has been studied and discussed by many authors (e.g., Bordoni and Valensise, 1998; Amato and Cinque, 1999; Amato, 2000; Schiattarella et al., 2003; Pizzi, 2003; Ferranti and Oldow, 2005). However, the driving force of the current tectonics is still a subject of debate and different opinions. In particular, the NE–SW alignment of the extensional focal mechanisms along the axis of the Apennine Chain (Montone et al., 1999; Pondrelli et al., 2006) implies that the regional uplift of the chain is no longer related to the original compressional domain. This has been mainly interpreted as being due to two possible causes: the presence of a mantle wedge that extends from the Tyrrhenian back arc system to the axial belt

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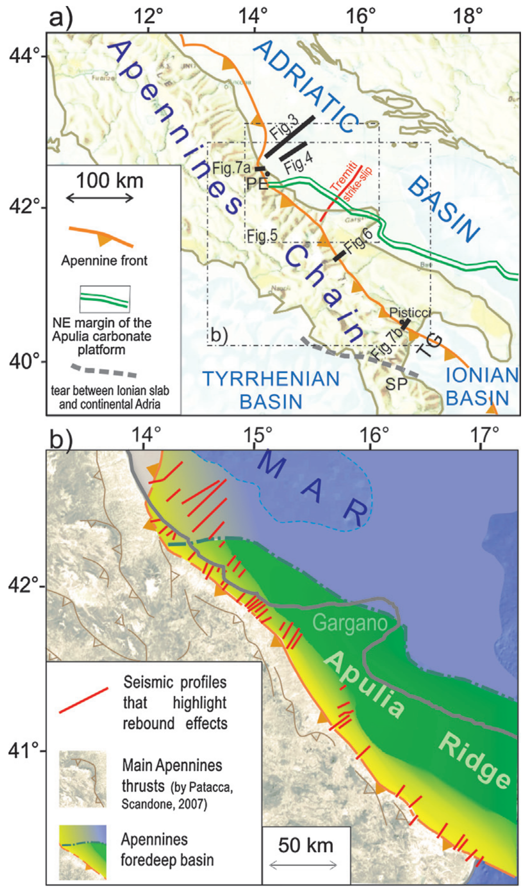


**Fig. 1.** a) Map of the study area. The Apennines front is from Bigi et al. (1992), the NE Apulia platform margin is from Nicolai and Gambini (2007), and the tear between the Ionian slab and continental Adria is from Del Ben et al. (2008). The locations of the profiles are referred to the figures. PE: Pescara, SP: Sibari Plain, TG: Taranto Gulf. b) Location map of seismic profiles that show evidence of eastward tilting. The foredeep basin is depicted between the Apennines front and its eastern boundary, which is recognized as the beginning of the westward thickening of the basin. MAR: Mid Adriatic Ridge.

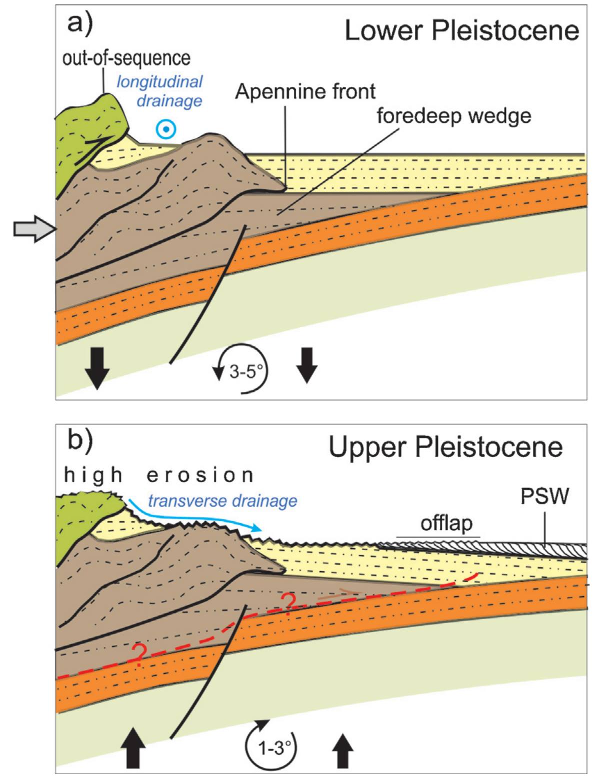


**Fig. 2.** Schematic geometries for the Central Adria foreland (not to scale, the amounts of rotation are only indicative). a) At the end of the Lower Pleistocene, a package of parallel layers (yellow) had onlapped onto the inactive external front of the chain and the eastern pre-foredeep sediments (orange) that are overlaid by the Lower Pliocene foredeep wedge (brown). In addition, the compressional stress in the out-of-sequence imbrication of the Apulia units (green) was ending. b) The rebound began after the end of compression. The eastward tilting of the foreland passively uplifted the chain, which was affected by high erosion rates; the uplift and erosion supported each other. The large amounts of erosion products contributed to the deposition of the Prograding Sedimentary Wedge (PSW) in the foreland. The foredeep sediments and the western PSW were uplifted and partially eroded, as is shown by their offlap terminations. In some cases, a blind thrust (red dashed line) that affected the foredeep sequence could be hypothesized. Because these cases can produce local folding that results in similar tilting to that caused by the uplift, in this paper only clearly unfolded foredeep sequences have been considered as evidence for rebound. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

(Doglioni, 1991) or the isostatic rebound of a different detached lithosphere (Cinque et al., 1993; Westaway, 1993; Hippolyte et al., 1994; Amato and Montone, 1997). Buiter et al. (1998) investigated the flexural downbending of the Adriatic plate and concluded that the lateral migration of slab detachment is not clearly supported by modelling of lithospheric flexure and gravity data.

In the study area (Fig. 1), the Middle/Upper Pleistocene uplift of the axial belt is coeval with the uplift of the Apulian Ridge, which is generally ascribed to a lithospheric bulge due to the flexure of the Adria foreland below the Apennines (Doglioni, 1991). Moretti and Royden (1988) suggested that the asymmetric deflection on the two sides of the Apulia Ridge toward the Apennine and Dinaric belts would reflect the transition of a gradually less prominent compression from north to south along the Apennine/Calabrian front and younger subduction along the Dinaric/Hellenic chain. Conversely, the Pleistocene uplift of the Apulian Ridge was interpreted by Ricchetti et al. (1988) as being due to elastic rebound following the progressive attenuation of the Apennine compression.

In this framework, evidence of the eastward tilting of the Pliocene to Recent deposits in the undeformed Adria foreland does not appear to have been considered. The aim of this paper is to highlight the regional presence of eastward deepening, which is interpreted as a counter-tilting of the Central/Southern Apennines foreland. The results of our analysis support the idea that regional rebound, which started after the last compressional stage of the chain, has been the main tectonic feature since the Middle Pleistocene. The rebound has involved the foreland sector, which was previously tilted towards the chain, and has passively lifted the overlying belt. The effects of this process can be recognized in a variety of features, such as the typical geometrical setting of the sediments (Fig. 2), changes in the drainage networks and the high erosion and sedimentary rates, which formed a thick prograding wedge in the Adriatic Sea. All of these features have been analysed and related to the rebound process.

The hypothesis that the unbending of the Adriatic lithosphere be associated to the diminished thrusting within the Apennine thrust belt is not new in the literature; it was first proposed by Kruse and Royden (1994), who interpreted the uplift of the Adriatic lithosphere as the Quaternary release of elastic strain energy that was stored in the lithosphere during the Pliocene compressional stage. The concept of lithospheric rebound as the driving factor of foreland uplift has been identified in several chains and foreland basins (e.g., the Karoo basin in Southern Africa and the Western Interior foreland basin in North America by Catuneanu et al., 1998; the North Alpine foreland basin in Switzerland by Cederbom et al., 2004; the Lachland Fold Belt in Southeastern Australia by Stephenson and Lambeck, 1985). The model that has generally been consid-