Quaternary kinematic evolution of the Southern Apennines. Relationships between surface geological features and deep lithospheric structures

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Abstract
The post-collisional Neogene Southern Apennines thrust belt presents a complex Pliocene-Quaternary kinematics, closely controlled by the roll-back of the sinking foreland lithosphere. Integration of field geology, stratigraphy, structural analysis, geomorphology and sub-surface data set allow one to outline the present-day geological configuration and the recent evolution of the Southern Apennines in order to investigate the possible relationships between surface tectonic features and deep lithospheric structure.
Three main morpho-structural features (outer, axial, inner) have been identified in the Campania-Lucania segment of the Apenninic arc, that has been largely involved into very young tectonic transport till Lower Pleistocene times. Out-of-sequence thrusting and counterclockwise rotations strongly characterize this last compressive event at the outcrop scale too. At the same time the Tyrrhenian margin of the Southern Apennines has been affected by normal block faulting due to the progressive advancing of the back-arc extension.
The post-orogenic Brandano deposits (Sicilian) show no evidence of compressive features around the Apulian region, while along the Calabrian arc the same Sicilian deposits are largely involved in the orogenic transport. A N120° left-lateral strike-slip fault system developed starting from Sicilian because of the differential flexure retreat between Apulian and Ionian area. This Cilento-Pollino shear zone should represent the surface expression of a major lithospheric tear and it is probably also responsible for the differentiation of the Southern Apennines into axial and inner belts. Block-faulting rotations along vertical axes, caused by the Cilento-Pollino shear zone, seem to be very common all along the Tyrrhenian margin.
Finally a complex geodynamical evolution model based on roll-back of the foreland lithosphere, differential flexure retreat, lithospheric left-lateral tear fault and viscous-elastic rebound is discussed.

1. Introduction

The Apenninic chain is a post-collisional, Neogene segment of the Mediterranean Africa-verging mountain system. It is well known from the geological literature (see Elter *et al.*, 1975; Patacca *et al.*, 1991) that compression in the Apennines and extension in the Tyrrhenian basin have coexisted from late Tortonian to Quaternary times. Thrust propagation in the mountain belt and progressive opening in the back-arc basin appear to have been closely controlled by the roll-back of the sinking foreland lithosphere (Malinverno and Ryan, 1986; Patacca and Scandone, 1986, 1989; Patacca *et al.*, 1991; Doglioni *et al.*, 1990). The evaluated rate of the hinge retreat in the flexured lower plate ranges from $(1.0 \div 1.5)$ cm/y in the Padan-Adriatic segment to more than 6 cm/y in the Ionian one. This differential sinking may be considered responsible for the arrangement of the mountain chain into two major arcs (Northern Apenninic Arc and Southern Apenninic Arc), as well as for the bipartition of the back-arc basin into two distinct portions (Northern and Southern Tyrrhenian basins) characterized by different amounts of shortening/extension (see Patacca *et al.*, 1991). Due to more severe extensional processes in the Southern

Tyrrhenian basin, the latter is floored by a thin (about 10 km, Nicolich, 1989), new-generated oceanic crust. The calculated amounts of extension in the Tyrrhenian basin, shortening in the Apennines and flexural retreat in the foreland areas appear to be comparable.

The pile of nappes forming the Apennines mostly consists of Mesozoic-Tertiary sedimentary sequences detached from their original basament during the Tyrrhenian extension and commonly geometrically-arranged as duplex systems. Thrust sheets including pre-Alpine crystalline rocks, Jurassic ophiolites and Mesozoic-Tertiary metasediments, piled up during the Europe-Africa collision and during the Corsica-Sardinia rotation, form the highest units of the tectonic building. Deep seismic sounding results (Nicolich, 1989) show no evidence of crustal roots beneath the mountain chain, the maximal depth of the Moho discontinuity (35÷40 km) being consistent with the expected flexural deflection of the foreland lithosphere. Along the Tyrrhenian margin of the Apennines, a crustal doubling has been recognized, with a «Tyrrhenian Moho» at a depth of (20÷25) km and an «Adriatic Moho» reaching about 60 km of depth (see Giese and Reutter, 1978; Nicolich, 1981). We interpret the body intervening between the two discontinuities as uprised astenospheric materials which penetrated like a wedge between the top of the sinking foreland lithosphere and the bottom of the Apennine orogenic stack. The existence of a lithospheric slab beneath the Northern Apenninic Arc is suggested by some intermediate earthquakes, by sharp lateral variations of the seismic-wave velocities and by long-wave gravity anomalies (Amato *et al.*, this volume; Della Vedova *et al.*, 1991; Panza *et al.*, 1980). A real Wadati-Benioff zone beneath the Southern Apenninic Arc is well evidenced by several intermediate and deep-focus earthquakes (see Anderson and Jackson, 1987 and references therein).

In this work we shall outline the present-day geological configuration and the uppermost Pliocene-Quaternary evolution of the Southern Apennines in order to discuss the possible relationships between surface tectonic features and deep lithospheric structures in a time interval in which important changes in the geodynamic behaviour have occurred within the study area.

2. Geological framework of the Southern Apennines

The investigated Apennine sector (fig. 1) consists of a pile of thrust sheets forming a complex duplex system orogenically transported over the flexured south-western margin of the Apulia foreland. The deepest tectonic units underlying in the roof-thrust are represented by Mesozoic-Tertiary shallow-water carbonates stratigraphically overlain by upper Messinian and Pliocene terrigenous marine deposits. These carbonate units form a buried thrust belt identified by seismic investigation (see Mostardini and Merlini, 1986; Casero *et al.*, 1991) and explored by several commercial boreholes. Above the roof thrust, three groups of nappes have been distinguished:

– thrust sheets derived from a relatively deep basinal domain originally located between two shallow-water carbonate platforms, the eastern one (Inner Apulia Platform of the geological literature, see Mostardini and Merlini, 1986) being represented by the buried carbonate thrust belt;
– thrust sheets derived from the western carbonate platform and from the associated marginal areas;
– thrust sheets derived from more internal domains, piled up before the birth of the Tyrrhenian basin and presently forming the highest units of the duplex system.

The age of the last orogenic transport is late Pliocene in the northern part of the study area (Molise-Sannio segment) and early Pleistocene in the southern part (Campania-Lucania segment). The two segments join north of the Ofanto synform; in this area WNW-ESE lower Pleistocene compressional structures belonging to the Campania-Lucania segment cut across the NNW-SSE–trending structures of the Pliocene Molise-Sannio segment. From the Vulture region to the Taranto Gulf, the frontal ramp of the Campania-Lucania thrust belt directly overlies upper Pliocene-lower Pleistocene deposits stratigraphically covering the flexured Apulia carbonates. Behind the frontal ramp, out-of-sequence embricates are widespread along the whole Apenninic margin. Both the front of the Apenninic nappes and the foreland deposits are finally overlain by

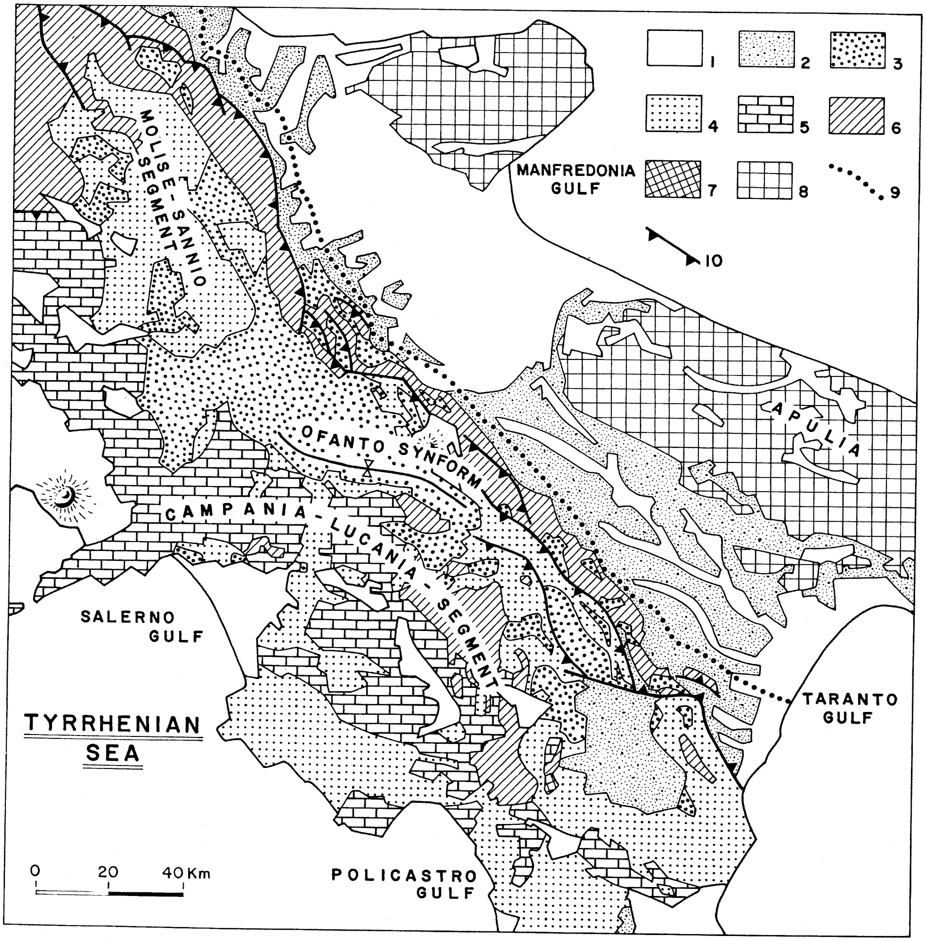

Fig. 1. Simplified geological sketch of the Southern Apennines. 1) Continental and paralic Middle Pleistocene to Holocene deposits; Quaternary volcanoes. 2) Upper Pliocene-Lower Pleistocene marine to continental deposits, including the Brandano cycle. 3) Upper Tortonian to Upper Pliocene clastic deposits accumulated in piggy-back basins formed on top of the advancing nappes. They include Lower Pliocene chaotic complexes produced by widespread landslides. 4) Apenninic nappes derived from internal paleogeographic domains, originally located between the European plate margins and the western corbonate-platform system. They include Mesozoic-Tertiary basinal sequences and ophiolite suites (Pennine, Ligurian and Sicilide nappes), subordinate pre-Alpine crystalline rocks (Calabrian nappes), metamorphosed and unmetamorphosed Mesozoic-Tertiary carbonate sequences (San Donato and Verbicaro nappes) and Lower Miocene clastic deposits related to ancient piggy-back basins (Albidona formation). 5) Apenninic nappes derived from the western carbonate-platform system and related marginal areas. They include shallow-water and deep-water Mesozoic-Tertiary carbonates, as well as Upper Tortonian-Messinian siliciclastic flysch deposits. 6) Apenninic nappes derived from a basinal realm originally located between the western platform and the eastern platform(«Inner Apulia Platform») domains. They include the Mesozoic Tertiary Lagonegro (whose paleogeographic pertinence is still uncertain) and Molise sequences (Frosolone, Agnone, Tufillo-Serra Palazzo and Daunia units.) The upper portion of the Molise sequences consists of Messinian siliciclastic flysch deposits. 7) Monte Alpi unit. The small outcrop of Jurassic to Upper Miocene carbonates of Monte Alpi is the only emergence in the area of the buried carbonate thrust belt (eastern platform) 8) Mesozoic-Tertiary carbonates of the Apulia foreland. 9) Frontal ramp of the Apennine thrust sheets. 10) Out-of-sequence thrust.

Pleistocene post-orogenic deposits (Bradano Cycle). The latter appears presently gently dipping towards NE: due to this tilting, the youngest deposits of the Bradano cycle lie at (800÷850) meters along the border of the Apennines and at (300÷350) meters along the western border of the exposed Apulia carbonates.

The Tyrrhenian margin of the Apennines has been dissected in Early Pleistocene times by NW-SE normal faults («Apenninic system» of the geological literature) which have caused vertical displacements of some kilometers towards the Tyrrhenian Sea. From the Cilento region to the Pollino mountains, the Apenninic normal faults have been later on reactivated (when parallel) or slantwise cut across by N120° sinistral strike-slip faults. Younger normal faults which follow an arcuate trend parallel to the Pleistocene compressional structures are developed along the whole Campania-Lucania segment from the southern slope of the Picentini-Marzano mountains to the Noce Valley via Vallo di Diano. The current geological literature (*e.g.*, Ortolani, 1974, 1978; Ortolani and Pagliuca, 1988) emphasizes the role of a NE-SW fault system («anti-Apenninic system») which should dissect the entire mountain chain from the Tyrrhenian coast to the Apulia foreland, causing also horizontal displacements. Field evidences actually show that the Apenninic orographic divide is never cut across by the NE-SW system, so that the latter appears to form an extensional system geographycally confined within a narrow belt parallel to the Tyrrhenian margin. Here, NW-SE– and NE-SW–trending faults bound strongly subsiding basins filled with clastic deposits some thousands of meters thick (*e.g.*, Campania Plain, Sele Plain; see Amato *et al.*, 1991). At least in the Campania-Lucania segment, there seems to exist a genetic connection between the NE-SW normal faults and the N120° strike-slip faults, the latter having acted as transfers for the NW-SE extension which dissected during the Pleistocene the south-eastern portion of the Tyrrhenian basin and the inner margin of the Southern Apennines.

First-order morpho-structural features allow one to identify in the Campania-Lucania segment three main longitudinal belts that we shall call outer, axial and inner belts (fig. 2).

The outer belt forms a wide synform developed along the Adriatic slope of the Apennines from the Sannio-Irpinia region to the Taranto Gulf. The eastern margin of this belt is outlined by a sudden change of morphology going from the Apennine frontal embricates to the Bradano clayey deposits. The western boundary, less defined in the landscape, is established by an alignment of higher mountains whose maximal elevations (up to about 2000 meters) correspond to the culmination of an antiformal stack of the buried carbonate thrust sheets. The morphology of the outer belt is characterized by broad remnants of hanging mature landscapes unconformably superimposed on Lower Pleistocene morpho-tectonic features mostly related to the compressional tectonics. The modeling took place between the upper part of the Early Pleistocene and the lower part of the Middle Pleistocene (Amato and Cinque, 1992). The elevation of these landscapes up to 1000 meters and the deep fluvial dissection they have undergone indicate that this part of the mountain belt was strongly uplifted after the end of the Early Pleistocene. The lack of important tectonic fragmentation by normal block-faulting and the absence of reactivation of the Apennine frontal scarp (still unconformably overlain by the Bradano post-orogenic deposits) suggest that the uplift of the mountain chain may be related to a gentle north-eastwards tilt which affected the lower Pleistocene Bradano sequence and the south-western margin of the Apulia foreland too. This correlation is also supported by the pattern of the river drainage which shows flow directions often perpendicular to the main tectonic structures, in agreement with the regional slope of the belt.

The axial belt is mostly formed by thrust sheets piled up during late Miocene times, transported during the Pliocene over the eastern platform domain and passively deformed by the stacking of the buried carbonate thrust sheets in Pliocene and Pleistocene times. Fault line scarps are widespread, but it is usually difficult to discriminate the Quaternary dislocations from the older ones merely on the base of the scarp maturity. The large occurrence of hard and morphologically conservative rock units has allowed the local preservation of ancient erosional surfaces some of which date as back as to Late Miocene-Early Pliocene times. The latter lack regional

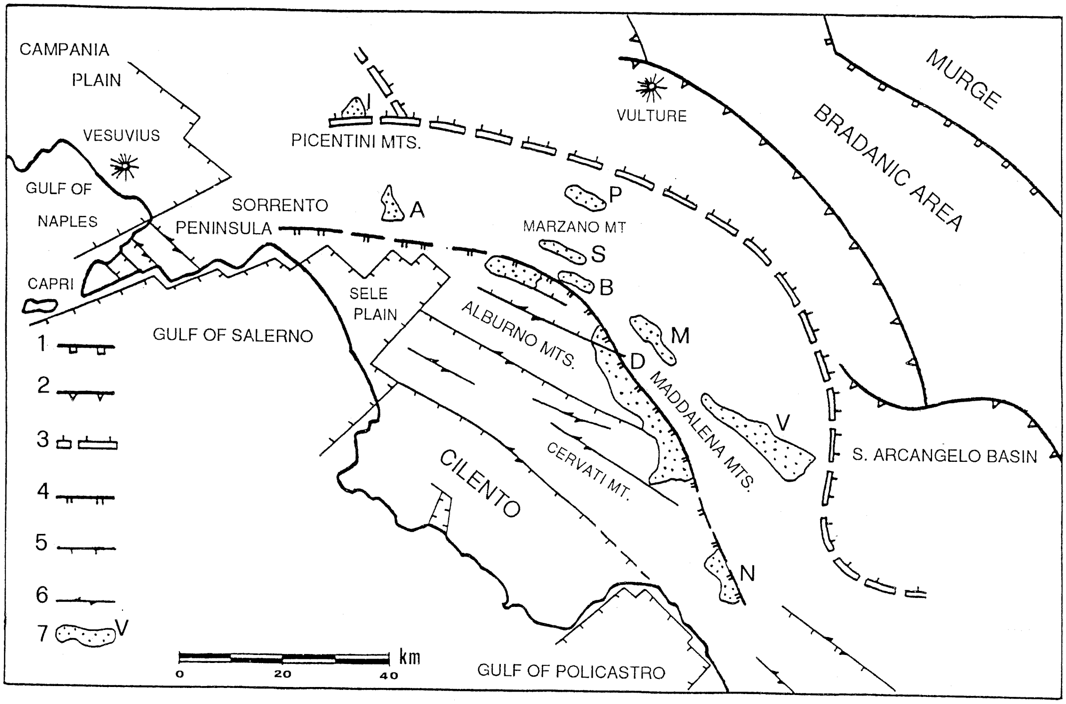

Fig. 2. Morpho-structural scheme of the Campania-Lucania Apennines. 1) Western scarp of the Apulian foreland plateau; 2) Eastern boundary of the outer belt; 3) approximate boundary between outer and axial belts; 4) possible boundary between axial and inner belts; 5)-6) main fault scarps of the Tyrrhenian margin: dots for vertical throw, arrows for transcurrent activity; 7) main intramontane basins of the Campania-Lucania segment of the Southern Apennines. I) Volturara Irpina, A) Acerno, P) Muro Lucano, S) Buccino-San Gregorio, T) Tanagro, M) Sant'Angelo delle Fratte-Brienza, D) Vallo di Diano, V) Val d'Agri, N) Noce.

continuity because they have been tectonically fragmentated during later phases of orogenic transport. Remnants of Late Pliocene-Lower Pleistocene mature landscapes presently lie between 1500 and 800 meters of altitude, displaced by fault scarps. Block faulting was responsible for the forming of small intramontane basins usually elongated parallel with the previous Lower Pleistocene compressional features. Geomorphological considerations and some radiometric ages indicate that most of these depressions (*e.g.*, Acerno lake, Volturara and Laceno poljes in the Picentini Mts.; Buccino and San Gregorio Magno depressions in the Marzano massif; Sant'Angelo Le Fratte-Brienza basin west of the Monti della Maddalena Mts.) formed probably between the end of Lower Pleistocene and the beginning of Middle Pleistocene. In the north-western termination of the Lucania-Campania segment (Sorrento Peninsula and Capri), Quaternary marine deposits and terraces state that block-faulting and uplift ceased around the end of the Middle Pleistocene (Cinque and Romano, 1990). The oldest remnants of mature landscapes, upper Pliocene(?)-lower Pleistocene in age, reach 1100 meters of altitude, while the highest Pleistocene marine terraces have been found at about 300 meters above sea level (Barattolo *et al.*, 1991).

The boundary between the axial and the inner belts is marked by an almost continuous and curved alignment of morpho-structural depressions partly filled with Lower-Middle Pleistocene lacustrine and fluvial deposits. These depressions extend from the lower reach of the Tanagro Valley to the Noce River (southern termination of the Campania-Lucania segment) via Vallo di Diano (La Rocca and Santangelo, 1992). North-westwards, the boundary is represented by fault scarps dissecting the southern slopes of the Piacentini Mountains and Sorrento peninsula. Near Salerno, coarse-grained clastic deposits (Eboli conglomerates) crop out, accumulated at the foot of the fault scarps (Capaldi *et al.*, 1988). In the inner belt, hanging and dissected remnants of ancient and mature erosonial landscapes have been found up to (600÷700) meters in the Cilento area and up to 1000 meters in the Alburno and Bulgheria massifs. Due to their older age, these landscapes cannot be correlated with the hanging landscapes of the axial belt which lie at the same elevations. In fact, the erosional surfaces lying over 1000 meters of elevation in the axial belt link with the uppermost Bradano deposits (Sicilian) of the outer belt. In the inner belt, on the contrary, more ancient marine deposits (Emilian) do not exceed (300÷350) meters of elevation (Borelli *et al.*, 1992). Middle Pleistocene marine terraces of the Tyrrhenian coast, on the other hand, have been scarcely uplifted (no more than few tens of meters). In conclusion, the differentiation between the axial belt and the inner belt took place near the end of the Early Pleistocene when the axial belt underwent strong uplift which did not affect the inner belt. At the same time, the Sorrento Peninsula was incorporated into the inner belt as it is suggested by the modest elevations of the Middle Pleistocene terraces. Nevertheless, the stop of uplift in the inner belt did not coincide with the tectonic quiescence of the area since severe block-faulting created seaward-open transversal depressions (Sele coastal plain, Policastro basin) strongly subsiding in Middle Pleistocene times (Brancaccio *et al.*, 1987). This block-faulting, responsible for a relief rejuvenation, ceased near the end of the Middle Pleistocene, the Upper Pleistocene eustatic coast lines crossing the previously active fault zones without any evidence of important displacement.

3. Quaternary kinematic evolution

The kinematic reconstruction presented in this paper starts from the Pliocene-Pleistocene boundary, when the Molise-Sannio and the Campania-Lucania segments were not yet differentiated and uppermost Pliocene-lower Pleistocene marine deposits were sealing the frontal ramp of the Pliocene Apennines from the Maiella region to the Taranto Gulf. No Pleistocene compression has been recognized up to now in the Molise-Sannio segment, the upper Pliocene-lower Pleistocene sequence in this area appearing only gently tilted towards ENE. In the Campania-Lucania segment, on the contrary, the uppermost Pliocene-lower Pleistocene deposits, which in the north form a post-orogenic sequence, are largely involved into younger orogenic transport. The present-day geometrical relationships between the Molise-Sannio and the Campania-Lucania segments suggest that important counterclockwise rotations had to occur in the southern sector during early Pleistocene times. This suggestion is confirmed by the results of recent paleomagnetic investigations carried out from Campania to Northern Calabria (see Sagnotti. 1992; Sagnotti and Meloni, this volume; Scheepers *et al.*, 1991). The Pleistocene age of this compressional tectonics is well constrained by the occurrence of *H. baltica* (Emilian stage) beneath the Apennine frontal ramp (marine deposits stratigraphically overlying the Apulia carbonates), as well as in clayey deposits unconformably covering the Apenninic nappes and involved in out-of-sequence imbricates. Out-of-sequence thrusting (see fig. 3) is well characterized also at the outcrop scale by a wide typology of deformational features including shear zones, mesofolds and cleavage which throw again at the small scale the regional imbricate system.

In the southern part of the Campania-Lucania segment, the shortening related to the out-of-sequence Stigliano imbricates was entirely transferred to the buried Rotondella ridge and a piggy-back basin (see also Hippolyte *et al.*, 1991) developed behind an imbricate triangle zone (fig. 3). South of the Sant'Angelo basin, finally, new compressional structures developed, which depict an arc convex towards NE extended from the Policastro Gulf to the Pollino mountains. While thrust propagation was active along the Adriatic border of the Apennines, normal block faulting due to the progressive advancing of the back-arc extension dissected the Tyrrhenian mar-

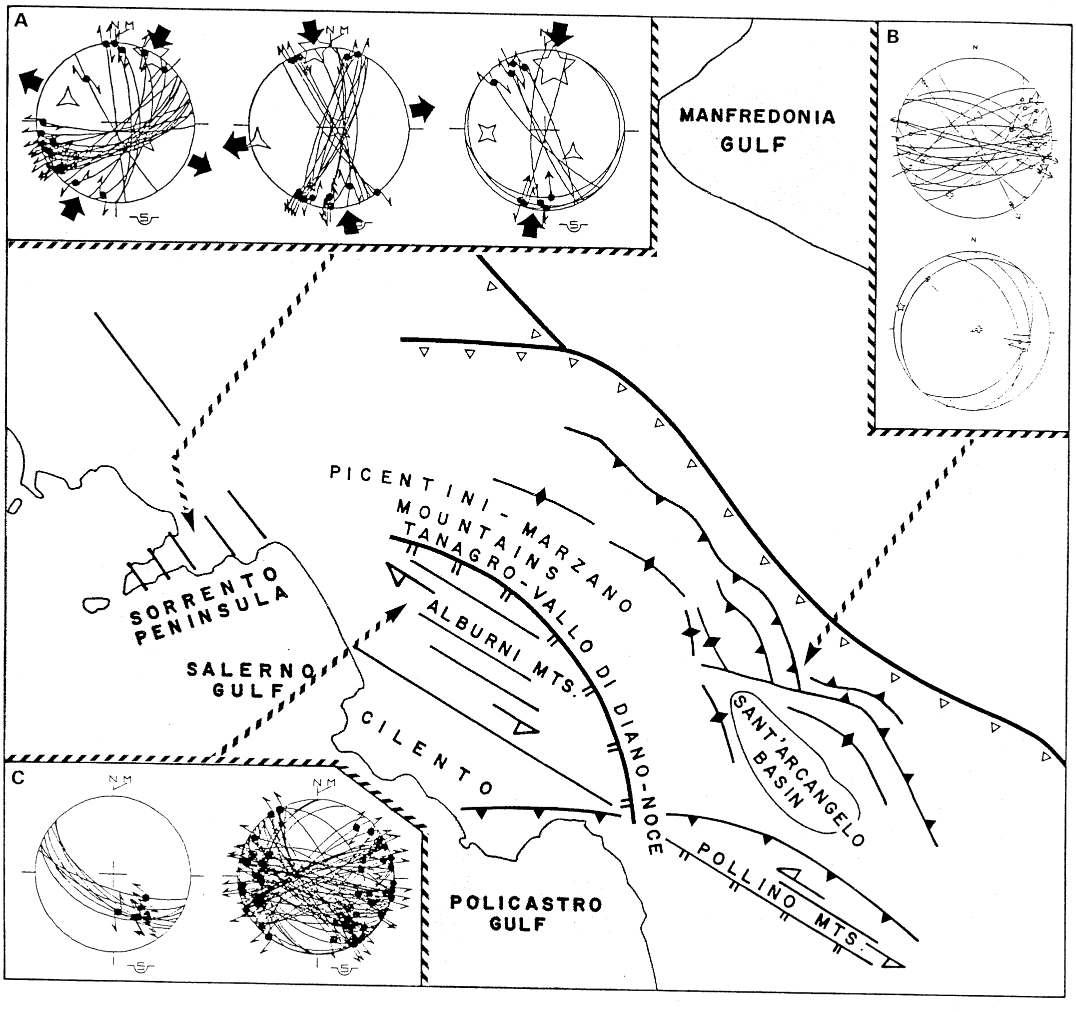

Fig. 3. Main structural data related to strike-slip tectonics along the Cilento-Pollino shear zone: the Lower Pleistocene Alburni Mts. arc and the younger Pollino arc have been affected by a regional pervasive shear zone N120° trending with a left-lateral strike-slip motion. The N140°-150° stike-slip major faults in the Northern sector are probably part of an older shear zone (perhaps rotated). Structural evidence of block-faulting rotations along vertical axes are shown in A (Sorrento peninsula). In B are shown strike-slip and thrust fault systems probably related to the out-of-sequence thrusting of the outer arcs (Sant'Arcangelo). In C are shown as example the mesostructural results of the Alburni Mts. in which the role played by the transtensive tectonic phase along the Tyrrhenian margin and the presence of well-developed strike-slip conjugate systems is very clear. Schmidt stereonets (lower emisphere) in which slickensides are represented by black dots and little arrows; black bigger arrows and stars represent sigma 1 attitude estimated by Angelier's inversion method. Data for Sant'Arcangelo (B) are due to Cavinato and Vittori (in preparation).

gin of the mountain chain. The lower portion of Eboli conglomerates containing pyroclastic intercalations with K/Ar ages of (1.5÷1.25) MA may be possibly related to this extensional tectonics (Cinque *et al.*, 1988).

As we said before, Sicilian clastic deposits seal the tectonic contact between the Apennine thrust sheets and the Apulian Plio-Pleistocene deposits. Starting from this moment, flexure retreat in the foreland areas and thrust propagation in the mountain chain ceased at all from the Vulture region to the Taranto Gulf. Careful structural investigations in the post-orogenic Bradano deposits showed no evidence of compressional features either at the regional scale or at the outcrop one.

In the External Calabrian Arc, on the contrary, seismic evidences show that the same Sicilian deposits which were representing a post-orogenic sequence in the Campania-Lucania segment are here largely involved in the orogenic transport. We believe that the N120° strike-slip system took origin during the Sicilian, when flexural retreat stopped in Apulia and continued in the Ionian area.

Due to the differential flexure retreat, N120° sinistral strike-slip faults developed, forming a narrow and pervasive shear zone extended from Cilento to the Pollino mountains (see also Dewey *et al.*, 1989; Knott and Turco, 1991). In spite of the small offset of the single faults, the summatory of them may be considerable so that it could accommodate block-fault rotations around vertical axes.

Another important system of strike-slip faults has been recognized in the Sorrento peninsula and in the Caserta mountains (see fig. 3). This N140° trending system, however, is probably older than the N120° strike-slip system. In fact, it seems to predate the Lower Pleistocene marine terracing of Capri island and many continental deposits and landforms of similar age in the Sorrento peninsula.

The Cilento-Pollino shear zone represents, in our opinion, the surface expression of a deep-seated lithospheric tear which allowed flexure retreat in the Ionian foreland cutting slantwise a previous wider Wadati-Benioff zone continuous from the Campania-Lucania Apennines to the Calabrian Arc (see Patacca and Scandone, 1986, 1989). This fracture zone was probably responsible for the differentiation of the mountain chain into the axial and inner Apenninic belts. The Apulian segment, in fact, free of the detached lithospheric slab, could undergo visco-elastic rebound with consequent tilting of the outer and axial Apenninic belts.

We are not able, presently, to establish whether the bulk of the uplift in the axial belt was coeval with the strike-slip motions in the inner belt or, as it seems more probable, the latter ceased in Middle Pleistocene times while uplift was still active. This N120° strike-slip motion was accompanied by NE-SW extensional block faulting which caused the accumulation of syntectonic clastic wedges several hundred meters thick on the foundered blocks and significant morpho-structural changes in the land areas, related to the landscape rejuvenation. The uplift of the axial belt was accompanied by normal faults which follow an arcuate trend closely parallel to the previous frontal thrusts. Due to the block faulting, narrow intramontane basins were created starting from Early/Middle Pleistocene times (around 0.8 MA).

It is important to underline that the Sorrento peninsula was incorporated in the inner Apenninic belt near the end of the Early Pleistocene and did not experience the strong Middle Pleistocene uplift of the axial belt. North of Salerno, therefore, the boundary between the inner and the axial belts does not follow the arcuate trend of the Campania-Lucania segment, but is directed towards the Molise-Sannio segment passing somewhere between the Sorrento peninsula and the Picentini mountains. We did not investigate in details the recent evolution of the Molise-Sannio segment. Nevertheless, the available information allows one to distinguish also in this region three longitudinal belts with Pleistocene uplift both in the axial and outer belts and normal block-faulting between the axial belt and the inner one, as well as within the axial belt. It seems, therefore, that both Molise-Sannio and Campania-Lucania segments have undergone comparable morphotectonic evolutions starting from Middle Pleistocene times, in spite of the time-space migration of the last orogenic transport. Still active uplifting and block-faulting should be responsible, in our opinion, for the present-day seismicity of the

Southern Apennines. Almost all epicenters of the historical disastrous earthquakes lie within the axial belt (see fig. 4). The external position of the well-documented 1930 earthquake and the transversal elongation of the isoseismals should testify a still persisting activity along the fracture zone in the Apulian crust which allowed the differentiation of the Molise-Sannio and Campania-Lucania segments in early Pleistocene times.

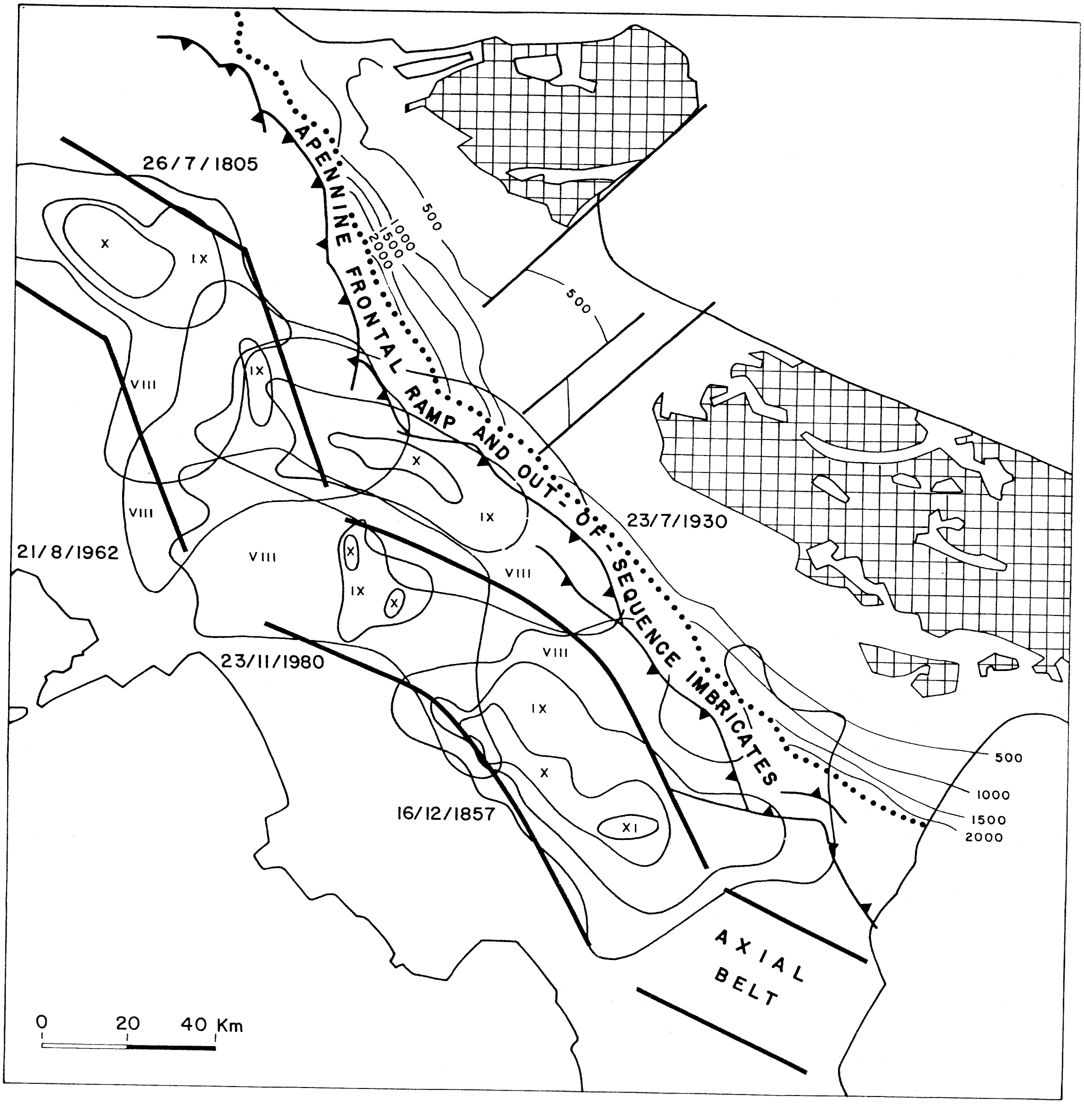

Fig. 4. Maximal isoseismals of some historical disastrous earthquakes of the Southern Apennines (from Branno *et al.*, 1985; Esposito *et al.*, 1987; Postpischl *et al.*, 1985; Spadea *et al.*, 1985a, b). The base-of-Pliocene/Quaternary isobaths (solid lines, depth in metres) show the Apulian carbonates dipping beneath the Apennine thrust belt. The elongation of the isoseismal follows the Apennine axial belt, with the exception of the 23/07/1930 earthquake.

4. Conclusions

The present-day structural configuration of the Southern Apennines is the product of very young geodynamic processes responsible for thrust propagation, normal block-faulting and sinistral stike-slip motion. The whole tectonic activity is deeply sculptured in the landscape physiography, making the geomorphological analysis a powerful tool for kinematic reconstructions. Important changes of tectonic regime have occurred in a very short time interval, smaller than 2 MA, in apparent contrast with the long-term duration of the geodynamic processes. The contrast disappears if we consider the Quaternary evolution of the Southern Apennines as the last stage of a longer process which took origin in late Tortonian times (passive sinking of the Padan-Adriatic-Ionian lithosphere and early rift of the Tyrrhenian back-arc) and ended in Quaternary times because of the complete detachment of the previously subducting lithospheric slab (Patacca and Scandone, 1989). In agreement with these assumptions, we propose the following interpretation of the Southern Apennine kinematic evolution:

– The roll-back of the foreland lithosphere may account for the back-arc extension and for the astenosphere uprising in the Tyrrhenian Sea, as well as for the thrust belt-foredeep migration in the Apennines.

– Differential flexure retreat accomodated by tear faults in the lower plate may be responsible for differential thrust propagation and for arc generation, as well as for rotations of entire segments of mountain chain in the upper plate. In the Southern Apennines, the foreland flexure retreat ceased (or drastically reduced) near the end of the Late Pliocene in the Molise-Sannio segment and during early Pleistocene times (Sicilian) in the Campania-Lucania segment. The Pleistocene Vulture volcano probably lies on the projection at the surface of deep-seated tear fault which accommodated the differential flexure retreat of the Apulian lithosphere.

– High-rate flexure retreat at the apex of major arcs may produce the dissection of a previously continuous subduction zone, with consequent detachment of huge lithospheric slabs. The N120° Cilento-Pollino shear zone is interpreted as the surface expression of the lithospheric tear fault which allowed a further advancing of the Calabrian Arc, while flexure retreat had already ceased along Apulia.

– Detachment of huge lithospheric slabs may be responsible for viscous-elastic rebound along the free boundary of the foreland plate. The strong uplift of the axial and outer Apenninic belts, devoid of any crustal root, may be easily explained in terms of rebound of the lower plate when it has got free from its subducted portion. This interpretation agree with the observed regional tilting which affected both the mountain chain and the western margin of the Apulia foreland.

– Viscous-elastic rebound in the lower plate may cause block faulting and gravitational collapses in the overlying mountain chain, with consequent earthquake generation.

– Differential amounts of rebound at the two sides of a previous tear fault may reactivate the fault plane causing additional sources for disastrous earthquakes.

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