

# 1. Geological and tectonic setting of the Apennines and Calabrian arc

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Most reviews of the late-Tertiary evolution of the Tyrrhenian-Apennines system emphasize the eastward migration during the Neogene of paired extensional (in the west) and compressional (in the east) belts, together with flexural subsidence of the Adriatic foredeep and volcanism, all of which are envisaged as responses to the 'roll-back' of the subducting Adriatic-Ionian lithosphere (Fig. 1, Elter *et al.*, 1975; Royden, 1993; Serri *et al.*, 1993; Malinverno and Ryan 1996; Faccenna *et al.*, 1996; Jolivet *et al.*, 1998). Thus the progressively eastward-younging foredeep and syn-rift deposits in the Apennines record the coeval activity and migration of the paired compressional-extensional belts in the Neogene (Patacca *et al.*, 1990). However, during the Quaternary the flexural subsidence, compressional deformation and eastward retreat of the subduction hinge all decreased dramatically (Patacca *et al.*, 1990; Kruse and Royden, 1994; Cinque *et al.*, 1993) and the Apennines became dominated by crustal extension and vertical movements. Seismic reflection profiles in the Adriatic Sea show that the Mesozoic-Cenozoic sequence which is deformed by thrust anticlines is in turn overlain by prograding Quaternary deltaic sequences fed by streams draining the eastern flank of the Apennines, with little evidence of compressional deformation after the Early Pleistocene (Dondi *et al.*, 1985; Ori *et al.*, 1993; Argnani *et al.*, 1997). This Quaternary depositional pattern marks a dramatic change in subsidence rate and sediment supply from the Pliocene, during which up to 7,000 m of sediment accumulated in a flexural trough close to the thrust front (Bigi *et al.*, 1992). The Quaternary evolution thus involves the final infilling and extinction of the Mio-Pliocene Adriatic foredeep (Ori *et al.*, 1993) and a regional NE tilting of the whole Adriatic coastal belt of central Italy (Dufaure *et al.*, 1989; Dramis, 1992; Kruse and Royden, 1994).

Evidence of present-day thrusting is contained in weakly deformed and tilted Quaternary deposits (Bigi *et al.*, 1997) and moderate compressional seismicity on the NE side of the Northern Apennines (Frepoli and Amato, 1997) where intermediate seismicity down to a depth of 90 km may suggest that subduction is still active (Selvaggi and Amato 1992). In the area of the central Apennines that is currently undergoing extension, normal faulting has been active since the Upper Pliocene-Early Pleistocene (Patacca *et al.*, 1990; Bosi and Messina, 1991). Normal faults cut a bedrock sequence dominated by resistant Mesozoic limestones and

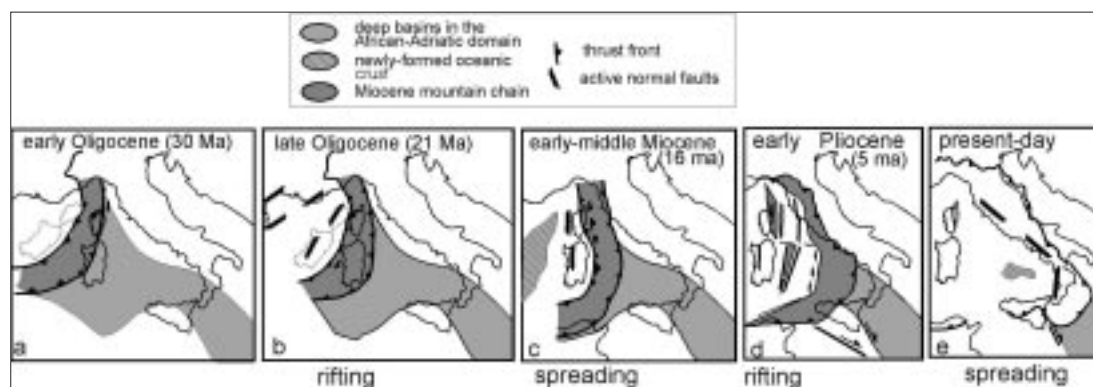
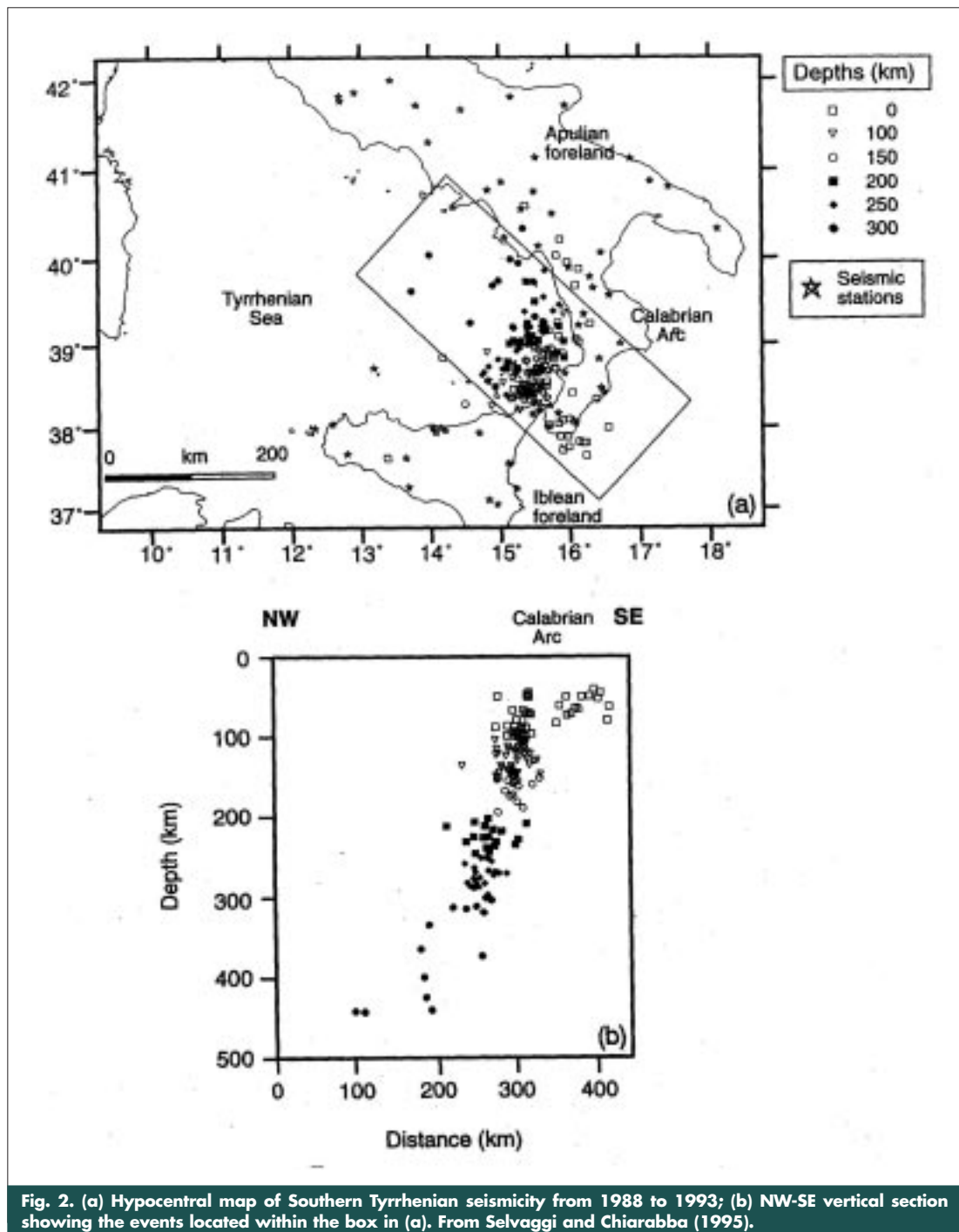


Fig. 1 – Simplified scheme of the evolution of the Tyrrhenian-Apennines system (modified from Faccenna *et al.*, 1999).

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less resistant Upper Miocene flysch that were previously deformed by NW-SE striking Neogene thrust faults (Parotto and Pratlun, 1975; Bigi *et al.*, 1992). This extension is responsible for Pleistocene intermontane basins that are partially filled with alluvial, fluvial and lacustrine deposits and coarse conglomerates or breccias (Cavinato *et al.*, 1993b; Cavinato and DeCelles, 1999).



More to the south, in the Calabrian arc, the Apennines are a narrow, rugged peninsula, underlain by pre-Alpine plutonic and metamorphic rocks, continental and oceanic metamorphic rocks ("Complesso Ofiolitico", Auct.) overlain tectonically Mesozoic carbonates and flysches (Ogniben, 1973; Amodio-Morelli *et al.*, 1976; Dietrich, 1976; Lanzafame *et al.*, 1979; Critelli, 1990). Similarly to the rest of Italy, since the late lower Pleistocene, the Calabrian arc was affected by extensional tectonics and regional uplift (Vezzani, 1968; Tortorici, 1980, Tortorici, 1981; Ciaranfi *et al.*, 1983; Lanzafame and Tortorici, 1981; Boccaletti *et al.*, 1984; Colella *et al.*, 1987; Moretti, 1993; Tortorici *et al.*, 1995; Moretti and Guerra, 1997) and its present dynamics is well expressed by crustal and subcrustal seismicity (Gasparini *et al.*, 1982; Ghisetti and Vezzani, 1982; Cristofolini *et al.*, 1985; Tortorici *et al.*, 1995; Monaco and Tortorici, 2000). The distribution of epicenters and the relative focal mechanisms indicate the activity of extensional N-S fault systems mainly inland and strike-slip and compressional activity off-shore the Ionian coast (Amato *et al.*, 1997; Frepoli and Amato, 2000; Monaco and Tortorici, 2000). The location of intermediate and deep earthquakes (Fig. 2) allows to define the geometry of the southern Tyrrhenian subduction zone (Amato *et al.*, 1997). The seismicity distribution and tomographic images reveal a continuous 40-50 km thick slab that abruptly increases its W-NW dip from sub-horizontal in the Ionian Sea to a 70° dip in the Tyrrhenian (Gasparini *et al.*, 1982; Kiratzi, 1994; Bruno *et al.*, 1995; Selvaggi and Chiarabba, 1995; Lucente *et al.*, 1995; Frepoli *et al.*, 1996; Piromallo and Morelli, 1997).

## 2. Geological and geomorphological evidence of Quaternary regional uplift

Various geological and geomorphological data indicate that a widespread surface uplift occurred during the Quaternary (Demangeot, 1965; Ambrosetti *et al.*, 1982; Dufaure *et al.*, 1989; Dramis, 1992), when the tectonics of the Apennines was already dominated by crustal extension. Scattered outcrops of highly dissected marine Messinian—Lower Pliocene conglomerates, weakly deformed by later compressional structures and frequently made up of clasts (granites, metamorphic rocks) whose source area is hundreds of kilometers distant (Accordi and Carbone, 1988), are found in the Apennines at high elevations (>1,500m in the Gran Sasso range), indicating that profound changes in elevation and morphology occurred in the Quaternary. One of the most significant effects of the uplift is found in the Tiber river valley close to the Tyrrhenian coast (Fig. 3). Here an Early Pleistocene shoreline that is continuously exposed for almost 100km has been uplifted to an elevation of 200—400m (Ambrosetti *et al.*, 1987; Alfonsi *et al.*, 1991; Girotti and Piccardi, 1994). This ancient shoreline follows the long-axis of the Apennines and provides an important reference for the evaluation of vertical movements. It shows almost no short-wavelength deformation over its nearly continuous exposure, but smoothly decreases in elevation to the south, suggesting that it was raised by a large-wavelength regional uplift rather than by localized fault activity, which is apparently responsible only for minor local effects (Alfonsi *et al.*, 1991).

Paleontological analyses (Gliozzi and Mazzini, 1998) in the more western parts of the Rieti and Terni basin fills showed the existence of brackish marshes influenced by the contiguous Early Pleistocene Tyrrhenian Sea, showing that the basin floors were approximately at sea-level and that were significantly uplifted after the Early Pleistocene. Remnant Neogene-Pleistocene marine deposits found by Marinelli *et al.* (1993) in the Latium and Tuscany areas on the Tyrrhenian side of the Apennines increase in elevation to the NE, also supporting the suggestion of regional uplift. On the NE side of the Apennines the Adriatic foothills are characterized by a NE-dipping Pleistocene sequence made up of fine-grained marine deposits passing upward into sandy and conglomeratic deltaic deposits at the top of the



Quaternary sequence (Cantalamessa *et al.*, 1986; Ori *et al.*, 1993). From the geomorphological point of view the whole Adriatic coastal region of central Italy displays a homogeneous evolution in the Quaternary, characterized by a regional NE tilting that is clearly reflected in the NE-trending parallel drainage network (Demangeot, 1965; Dufaure, *et al.*, 1989; Dramis, 1992). Furthermore, transitional fluvial to marine Lower-Middle Pleistocene deposits at the top of the Quaternary sequence are uplifted up to 500 m some kilometers inland of the coastline (Fig. 3; Cantalamessa *et al.*, 1986; Bigi *et al.*, 1995), giving

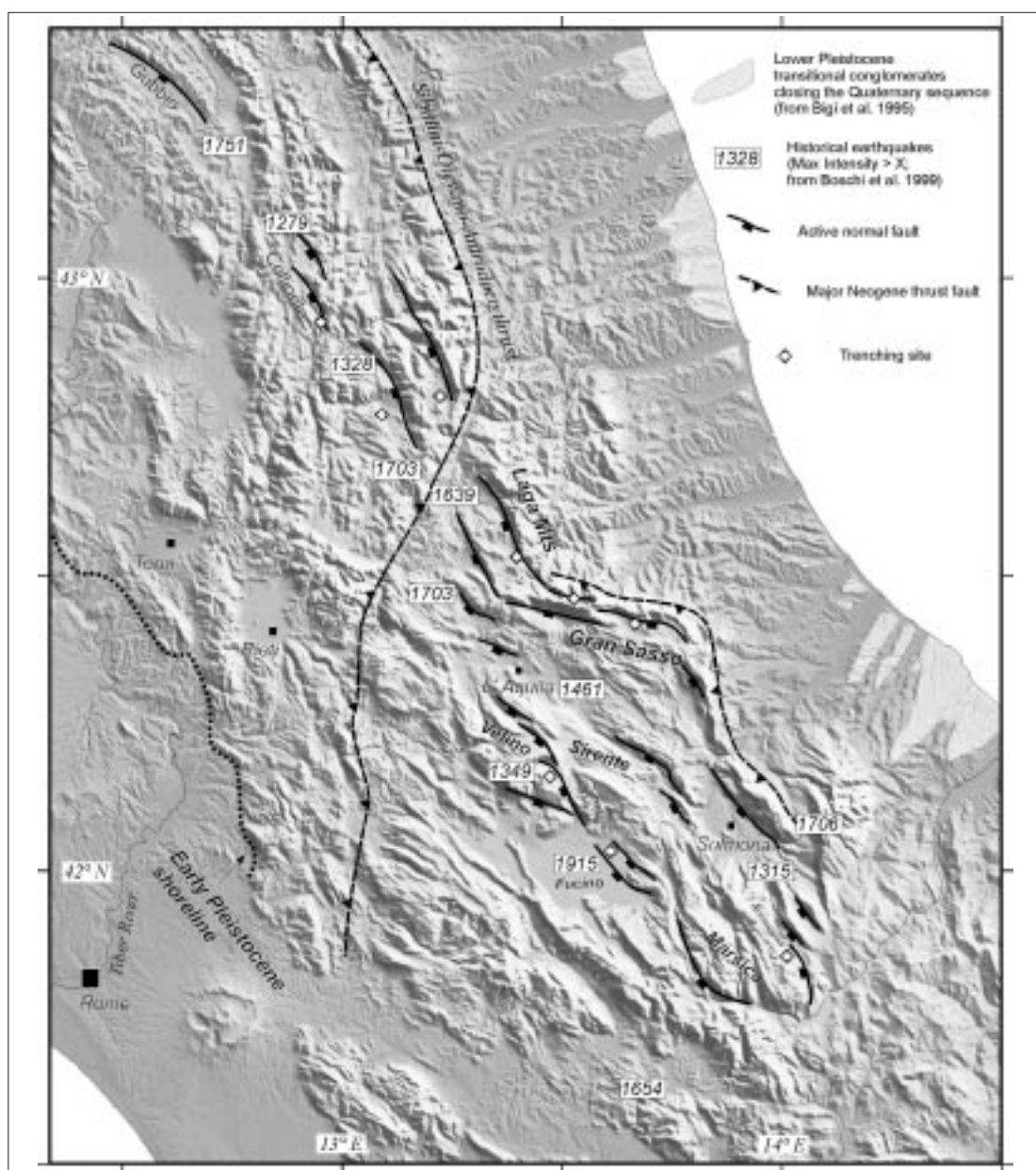


Fig. 3. Shaded relief map with faults active in the Late Pleistocene-Holocene from Galadini and Galli (2000), major Neogene thrust fronts and historical earthquakes. Soft shading on the Adriatic side of the Apennines represents Lower Pleistocene transitional conglomerates closing the Quaternary sequence. On the Tyrrhenian side the trace of the Early Pleistocene shoreline is also shown.

an indication of the amount of uplift on the Adriatic side. A precise evaluation of regional uplift rates in the Middle-Late Pleistocene is hampered by the relative scarcity of remnant shoreline deposits and uncertainties in their ages, especially on the Adriatic coast. Nevertheless, approximate long-term uplift rates have been derived by Bigi *et al.*, (1995) obtaining values ranging between 0.3 and 0.5 mm/yr over the last 1 Ma. Similar values (0.1–0.26 mm/yr) can be estimated for the long-term uplift on the Tyrrhenian side on the basis of the elevation (200–400 m) of the Early Pleistocene shoreline (1.5–2 Ma). These rates are likely to be higher along the central axis of the Apennines itself. The geological and geomorphological data summarized above suggest a general doming of the Central Apennines on a wavelength larger than 150–200 km during the Quaternary. A post-700kyr regional bulging of the Southern Apennines is envisaged by Bordoni and Valensise (1999), based on the elevations of marine deposits of 'Tyrrhenian' age (corresponding to isotopic stage 5e of 125 ka). A similar Quaternary evolutionary pattern has been also described by Argnani *et al.* (1997) for the Northern Apennines, showing that the regional Pleistocene doming is a process that affected the whole Italian peninsula.

The effects of the regional uplift that affected the whole Italian peninsula in the Quaternary are also present in the Calabrian arc, where in previous subsiding basins the uplift produced a marine regression in the late lower Pleistocene (Tortorici, 1980; Colella *et al.*, 1987; Moretti, 1993). In middle-upper Pleistocene the interaction between the regional uplift and the glacio-eustatic variations generated sequences of both marine and fluvial terraces that allow to compute an uplift rate of 0.6–1.0 mm/yr (Tortorici, 1980; Lanzafame and Tortorici, 1981; Carobene and Damiani, 1985; Carobene *et al.*, 1986; Colella *et al.*, 1987; Colella, 1988a,b; Gliozzi, 1988; Carobene *et al.*, 1989; Carobene and Dai Prà, 1990; Palmentola *et al.*, 1990; Carobene and Ferrini, 1991; Moretti, 1993; Sorriso-Valvo and Sylvester, 1993; Westaway, 1993; Sorriso-Valvo *et al.*, 1996b; Cucci and Cinti, 1998; Mauz and Hassler, 2000; Molin *et al.*, 2001). Another morphological evidence of the broad uplift is a rolling upland of subdued local relief standing at the higher elevations of the present topography (van Genderen, 1970; Dramis *et al.*, 1990; Sorriso-Valvo and Sylvester, 1993; AA.VV., 1995; Gabriele *et al.*, 1997; La Pera and Sorriso-Valvo, 2000; Molin, 2001). This landform is a relic of an ancient landscape that developed before late lower Pleistocene, in conditions of base level stability, of very low tectonic activity or of compensation between surface processes and morphological effects of tectonics (van Genderen, 1970; Dramis *et al.*, 1990; Gabriele *et al.*, 1997; Molin, 2001).

### 3. Quaternary stratigraphy of the Apennines intermontane basins

The stratigraphy of the Quaternary intermontane basins in the central Apennines basins has been studied closely and synthesized in the studies by Cavinato *et al.* (1993b) and Bosi and Messina (1991) among others. Lithological and paleontological correlations throughout these basins highlight common regional tectonic and climatic controls in addition to the influence of the basin-bounding normal faults. The first deposits associated with the formation of the intermontane basins consist of coarse-grained breccias and conglomerates generally assigned to the Upper Pliocene - Early Pleistocene (Demangeot, 1965; Cavinato *et al.*, 1993b; Bosi and Messina, 1991; Bagnaia *et al.*, 1989). Low-relief surfaces, locally preserved above the major calcareous ridges (Demangeot, 1965; Bosi and Messina, 1991; Dramis, 1992) and occasionally corresponding to outcrops of these early breccia deposits, are significantly dissected and fragmented by erosion and tectonic deformation. A progressive younging in the age of the oldest deposits of the intermontane basins is observed from west to east, with Middle-Late Pliocene sediments at the bottom of the the westernmost basins (Terni and Rieti)

and Early Pleistocene sediments at the bottom of the more eastern ones (Sulmona and Colfiorito; see Fig. 3 for location). The Early Pleistocene is characterized by lacustrine environments in most of the intermontane depressions, recorded by widespread lake beds that are revealed within the incised basin fills (Michetti and Serva, 1990; Bosi and Messina, 1991; Cavinato *et al.*, 1993b) or have been drilled (G.E.M.I.N.A., 1962). The Early-Middle Pleistocene lacustrine deposits are generally overlain by units that are transitional from lacustrine and low-gradient fluvial environments to coarser deposits representative of alluvial fans (Blumetti and Dramis, 1992; Miccadei *et al.*, 1998). This transition is frequently marked by erosion and incision of the lake beds so that the Middle Pleistocene deposits are often entrenched and unconformably overlie the fluvial-lacustrine units. In some cases depositional surfaces are preserved within the lacustrine and fluvial deposits while in others it is more difficult to estimate the amount of incision of the fluvial-lacustrine sequences. After the Middle Pleistocene, deposition of lacustrine sediments in the intermontane basins was drastically reduced and continued only in basins that maintained internal drainage. During the Pleistocene abundant pyroclastic materials derived from alkaline-potassic volcanic centers on the Tyrrhenian coast provide radiometrically datable tephra layers interbedded within the continental sequences (Cavinato *et al.*, 1993b; Miccadei *et al.*, 1998).

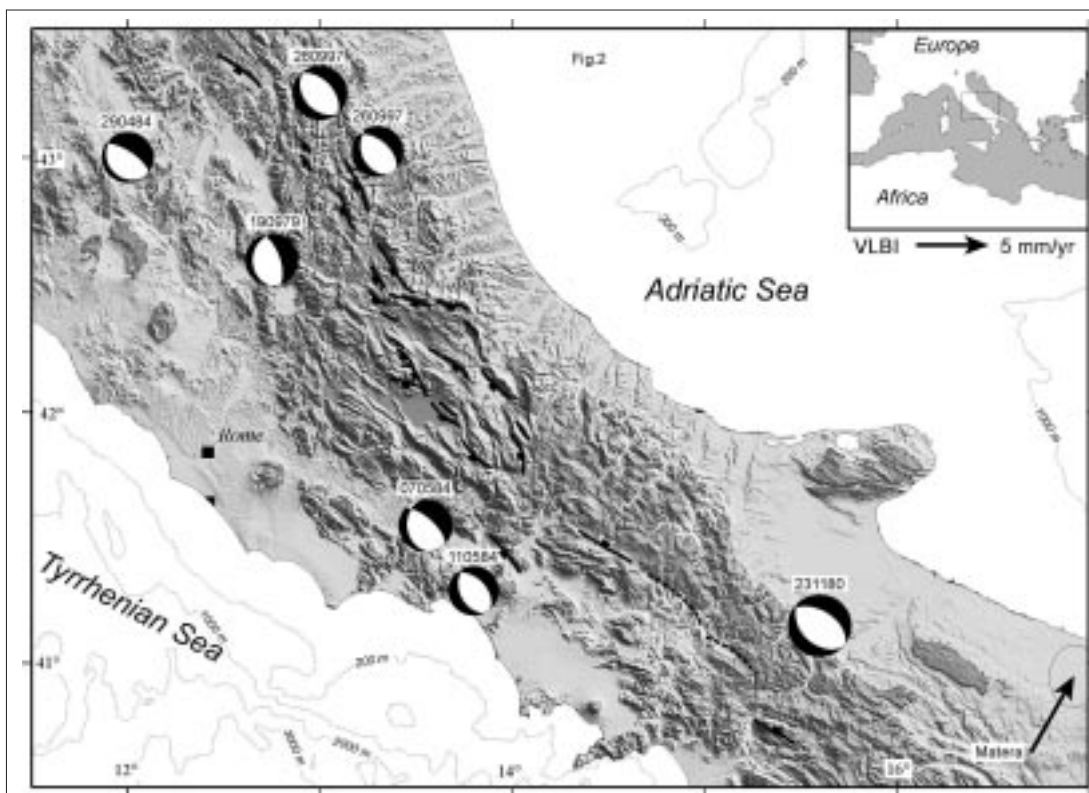
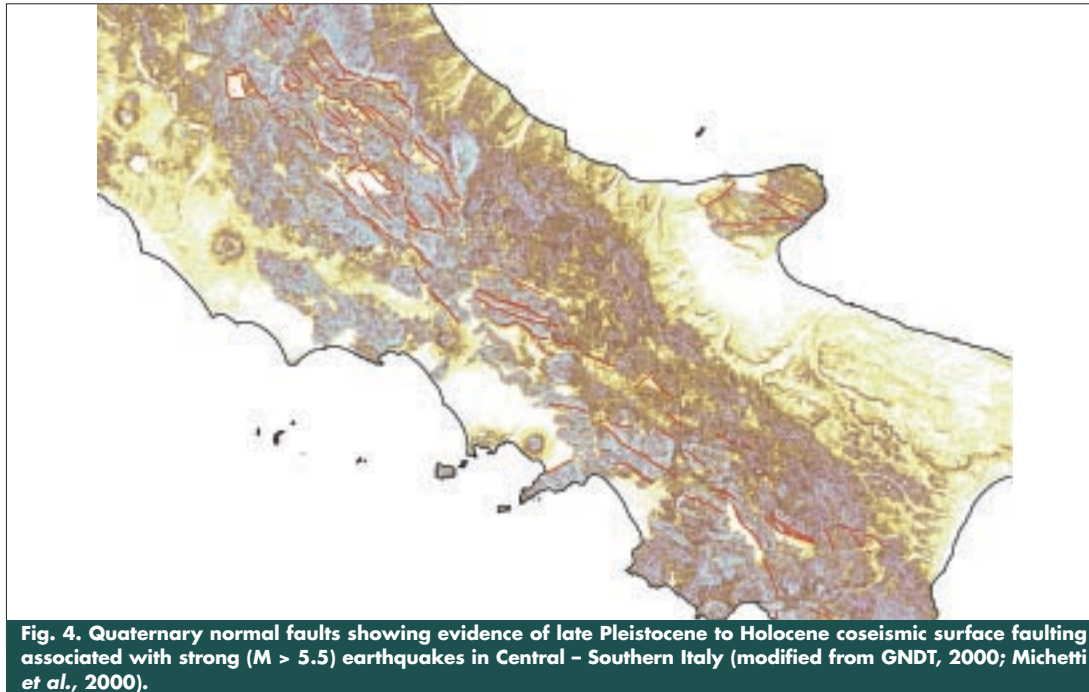
In summary, the intermontane basins generally record a history in which the Early-Middle Pleistocene continental fluvial-lacustrine environments were later incised and covered by alluvial fans. This succession is consistent with the capture of internally-draining, fault-bounded basins by the regressive headward erosion of major regional streams cutting down to a lower base level. The changes in facies and environment are unlikely to be climatically induced, since some closed lake basins, such as Fucino, have survived to modern times. Over the Quaternary as a whole, this evolution is also typical, with slightly different timing, of the intermontane basins of the Northern (Argnani *et al.*, 1997) and Southern Apennines (Capaldi *et al.*, 1988).

#### 4. Distribution of active deformation in the Apennines and Calabrian arc

Earthquake focal mechanisms show that the central Apennines are undergoing NW-SE extension, with seismicity concentrated along the main topographic ridge (Anderson and Jackson, 1987; Amato *et al.*, 1997) on active normal faults that overprint earlier compressional structures (Vittori *et al.*, 1997; D'Agostino *et al.*, 1998; Fig. 4).

The total rate of extension across the Apennines is not yet well constrained. Seismic moment summations yield estimates between 0.9 and 3.5 mm/yr (Jackson and McKenzie, 1988; Pondrelli *et al.*, 1995) but are likely to be imprecise as the seismicity is relatively low and dominated by a few large events. Analysis of the deformation revealed by the Italian first-order triangulation networks in the interval 1865-1963 yields estimates of 3 mm/yr as an upper bound for the extension rate accommodated in the central Apennines (Hunstad and England, 1999). Both earthquake slip vectors and VLBI measurements suggest the motion of the Adriatic relative to Europe can be described by rotation about a pole in northern Italy (Anderson and Jackson, 1987; Ward, 1994), with the VLBI data predicting an extension rate in the Apennines of about 3 mm/yr at the 43°N increasing southward to 6 mm/yr at the latitude of Matera (Fig. 5). First GPS estimates of active crustal extension (D'Agostino *et al.*, 2001) show that strain accumulation in the interval 1994-1999 is concentrated in a 40 km wide belt extending at a rate of  $6 \pm 2$  mm/yr (1  $\sigma$ ). The low levels of internal deformation in the Adriatic Sea suggest that much of the extension in the Apennines is absorbed by shortening in the Dinarides (Anderson and Jackson, 1987) with some also accommodated in the external part of the Northern Apennines (Frepoli and Amato, 1997). The pattern of active deformation in the Apennines (Figs. 4 and 5) is revealed by the historical and instrumental seismicity and





by the distribution of faults that have been active in the Late Pleistocene and Holocene. The historical and instrumental seismicity is generally confined to a belt whose width varies along the length of the Italian peninsula. In the northern and southern Apennines the active belt is only 20–30 km wide and may correspond to a single active fault system (Valensise and Pantosti, 2000). However, in the central Apennines (approximately between the latitudes of 41.5° N and 42.5° N) the largest earthquakes (Selvaggi, 1998) and the faults active in Late Pleistocene and Holocene time seem to be distributed over a broader width of at least 50 km and involve at least two major sub-parallel fault systems.

The increase in width of the actively extending belt in the central Apennines is associated also with an increase in average elevation and the across-strike width of the Apennine topographic belt itself. In this central area the eastern normal fault system bounds the Laga and Gran Sasso massifs (Blumetti *et al.*, 1993; Giraudi and Frezzotti, 1995) and the Sulmona basin (Vittori *et al.*, 1995), while the western one starts from the northern end of the l'Aquila basin, crosses the Velino-Sirente massif, bounds the Fucino basin, and continues southward through the Marsica region. The western fault system has produced several substantial earthquakes in the last thousand years (Fig. 2). The last shock ( $I_{\max} = X$  MCS; Boschi *et al.*, 1999) of a sequence that occurred in 1703 is thought to have ruptured the fault system in the upper Aterno valley (Blumetti, 1995; Cello *et al.*, 1998a). Trenching studies along the Ovindoli fault in the Velino-Sirente massif have revealed a previously unknown earthquake that occurred between 860 AD and 1,300 AD (Pantosti *et al.*, 1996). The normal fault system bounding the Fucino basin is known to have ruptured in 1915 ( $M$  6.9) when co-seismic surface faulting was described at the time by Oddone (1915) and later re-investigated by others (Serva *et al.*, 1988; Michetti *et al.*, 1996). In 1984 the southern Latium earthquakes ( $M$  5.8 and 5.2) occurred in the Marsica region SE of the Fucino basin (Westaway *et al.*, 1989). The eastern fault system shows evidence of Late-Pleistocene to Holocene activity (Galadini and Galli, 2000) but can not be associated with any known historical earthquakes with the possible exception of the Aremogna fault which may have been activated in the 1349 earthquake (Valensise and Pantosti, 2000).

This apparent quiescence may suggest that the eastern system is now inactive and that extension is taken up only by the western fault system. Alternatively, it may indicate that seismicity is clustered episodically on to a single fault system with cycles whose time scale (perhaps  $10^4$ – $10^5$  years) is longer than the historical or paleoseismological catalogue: a suggestion that has also been inferred from geomorphological or historical data in Nevada, Turkey and Greece (Wallace, 1987; Ambraseys, 1989; Jackson and Leeder, 1994; Jackson, 1999) and which has some support from numerical models (Cowie, 1998). Further insights are provided by GPS measurements in the interval 1994–1999 (D'Agostino *et al.*, 2001) showing significant active strain accumulation across the western fault system suggesting also the possible existence of another undetected active fault system more to the SW. This summary of the active deformation in the central Apennines highlights two main points: (1) that the active extension is concentrated along the main topographic ridge of the Apennines, and (2) that the increase in width of the actively extending belt between 41.5° N and 42.5° N correlates with the higher elevation and increased width of the topographic belt.

The Quaternary tectonic activity of the Calabrian arc (Fig. 6) is mainly represented by N-S and NNE-SSW extensional fault systems that extend all along the inner flank of the arc (Tortorici *et al.*, 1995). According to the age of faulted rocks and to morphological features of the fault scarps, vertical slip rates of 0.5–1.2 mm/yr for the last 700 kyr have been computed (Monaco and Tortorici, 2000). This strong activity is confirmed by historical and instrumental data about earthquakes occurred since 1,000 AD (Postpischl, 1985; Boschi *et al.*, 1995, 1997). These data show a distribution of crustal seismicity of  $M$  5, concentrated mostly along the above mentioned fault systems, although several



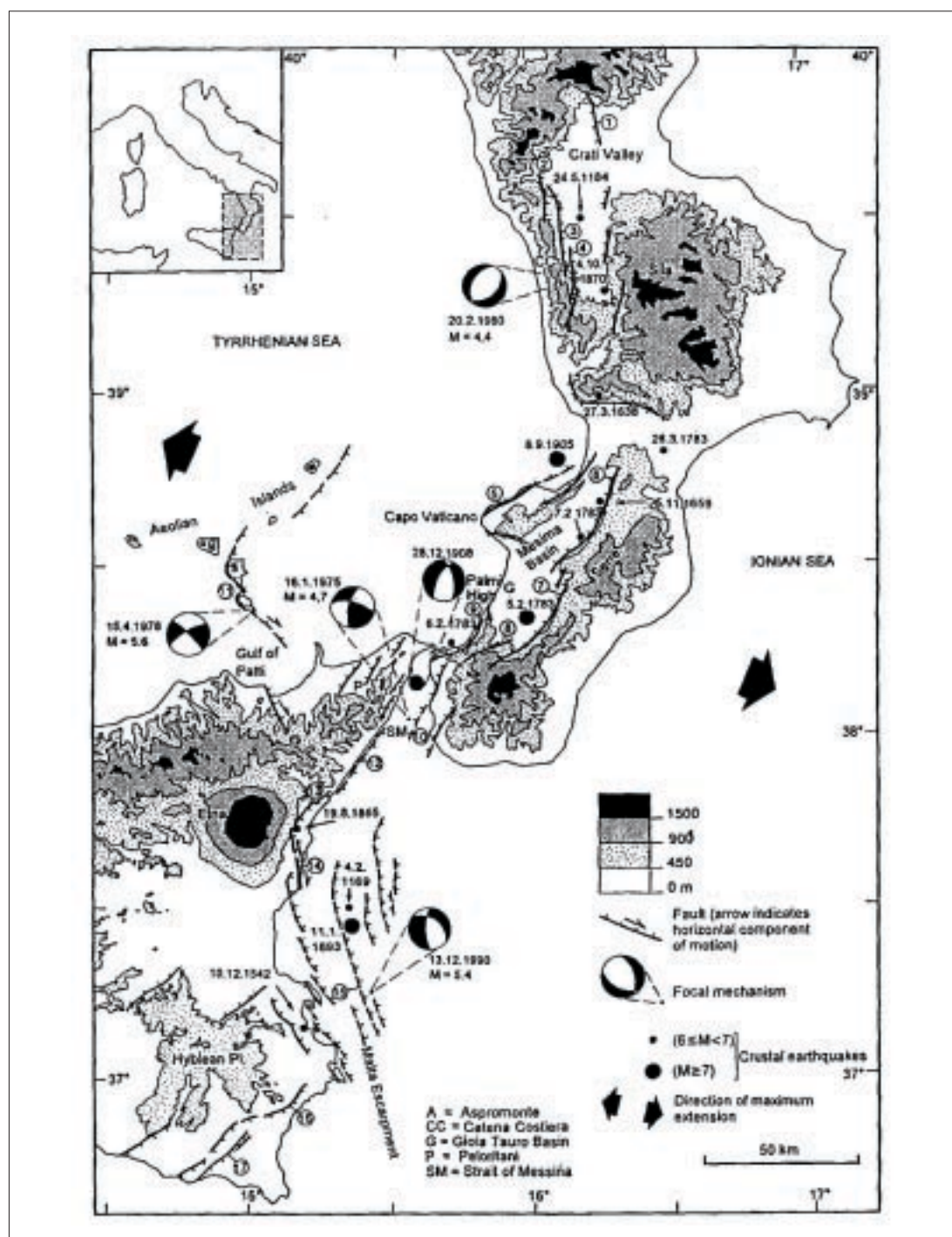


Fig. 6. Seismotectonic map of the Calabrian arc and eastern Sicily. Topography is from 1:100.000 topographic maps of Istituto Geografico Militare. Crustal seismicity ( $H < 35$  km) (Postpischl, 1985; Boschi et al., 1995, 1997) and focal mechanisms of more recent events are from Cello et al. (1982), Gasparini et al. (1982), Anderson and Jackson (1987) and Amato et al. (1991). Numbers refer to fault segments: 1, Castrovillari; 2, Fagnano Castello; 3, S. Marco-S. Fili; 4, Montalto-Rende; 5, Capo Vaticano; 6, Serre; 7, Cittanova; 8, S. Eufemia; 9, Scilla; 10, Reggio Calabria; 11, Lipari Vulcano; 12, Messina-Taormina; 13, Piedimonte; 14, S. Alfio-Acireale; 15, Western offshore; 16, Avola; 17, Rosolini-Pozzallo. (From Monaco and Tortorici, 2000).

events occurred more to the east inland and in the Ionian sea (Moretti *et al.*, 1990; Chiodo *et al.*, 1992; Monaco and Tortorici, 2000).

#### REFERENCES

- AA. VV.**, 1995: Carta Geomorfologica del bacino del Trionto, C.N.R. – Gruppo Nazionale Geografia Fisica e Geomorfologia, SELCA, Firenze
- ACCORDI G. & CARBONE, F.**, (eds), 1988. Carta delle litofacies del Lazio-Abruzzo ed aree limitrofe. P.G.F.-C.N.R., Quad. Ric. Sci., 114(5).
- ALFONSI L., FUNICIELLO, R., MATTEI, M., GIROTTI, O., MAIORANI, A., MARTINEZ, M.P., TRUDU, C. & TURI B.**, 1991. Structural and geochemical features on the Sabina strike-slip fault (central Apennines), Boll. Soc. Geol. It., 110, 217-230.
- AMATO A., CHIARABBA C. AND SELVAGGI G.**, 1997: Crustal and deep seismicity in Italy (30 years after), Ann. Geof., 40 (5), 981-993
- Amato A., Chiarabba C. & Selvaggi G.**, 1997: Crustal and deep seismicity in Italy (30 years after), Ann. Geofis., 40(5), 981-993.
- Amato A., Cinque A. & Santangelo N.**, 1995: Il controllo della struttura e della tettonica plio-quadernaria sull'evoluzione del reticolo idrografico dell'Appennino meridionale, Studi Geologici Camerti, Vol. Spec. 1995/2, 23-30.
- AMBROSEYS N.N.**, 1989. Temporary seismic quiescence: SE Turkey, Geophys. J. Int., 96, 311-331.
- AMBROSETTI P., CARBONI M.G., CONTI M.A., ESU D., GIROTTI O., LA MONICA G.B., LANDINI, B. & PARISI G.**, 1987. Il Pliocene ed il Pleistocene inferiore del bacino del Fiume Tevere nell'Umbria meridionale, Geogr. Fis. Din. Quat., 10(1), 1033.
- AMBROSETTI P., CARRARO F., DEIANA G. & DRAMIS F.**, 1982. Il sollevamento dell'Italia Centrale tra il Pleistocene inferiore e il Pleistocene medio, Pubbl. n. 513 C.N.R. P.F.G., 219-223.
- AMODIO-MORELLI L., BONARDI G., COLONNA V., DIETRICH D., GIUNTA G., IPPOLITI F., LIGUORI V., LORENZONI S., PAGLIANICO A., PERRONE V., PICCARRETA G., RUSSO M., SCANDONE P., ZANETTIN LORENZONI E. and ZUPPETTA A.**, 1976: "L'arco calabro-peloritano nell'orogene appennino-maghrebide", Mem. Soc. Geol. It., 17, 1-60.
- ANDERSON H. & JACKSON J.A.**, 1987: Active tectonics of the Adriatic region. Geophys. J. R. Astr. Soc., 91, 937-983.
- ARGNANI A., BERNINI M., DI DIO G.M., PAPANI G. & ROGLEDI S.**, 1997. Stratigraphic record of crustal-scale tectonics in the Quaternary of the Northern Apennines (Italy), Il Quaternario, 10(2), 595-602.
- BAGNAIA R., D'EPIFANIO A. & SYLOS LABINI S.**, 1989. Aquila and Subequan basins: an example of quaternary evolution in central Apennines, Italy, Quaternaria Nova, 1, 1-23.
- BERTINI T. & BOSI C.**, 1993. La tettonica quaternaria della conca di Fossa (L'Aquila), Il Quaternario, (2), 293-314.
- BIGI G., COSENTINO D., PAROTTO M., SARTORI R. & SCANDONE P.**, 1992: Structural Model of Italy. Scale :500,000, Quad. Ric. Sci., 114(3).
- BIGI S., CANTALAMESSA G., CENTAMORE E., DIDASKALOU P., DRAMIS F., FARABOLLINI P., GENTILI B., INVERNIZZI C., MICARELLI A., NISIO S., PAMBIANCHI G. & POTETTI M.**, 1995. La fascia periadriatica archigiano-abruzzese dal Pliocene medio ai tempi attuali: evoluzione tettonico-sedimentaria e geomorfologica, Studi Geologici Camerti, Vol. Spec. 1995/2, 37-49.
- BIGI S., CANTALAMESSA G., CENTAMORE E., DIDASKALOU P., MICARELLI A., NISIO S., PENNESI T. & POTETTI M.**, 1997. The Periadriatic basin (Marche-Abruzzi sector, central Italy) during the Plio-Pleistocene, Giorn. Geol., 59, 245-259.
- BLUMETTI A. M., DRAMIS F. & MICHETTI A.**, 1993. Fault-generated mountain fronts in the central Apennines (central Italy): Geomorphological features and seismotectonics implications. Earth Surf. Proc. Land., 18, 203-223.
- BLUMETTI A. M., DRAMIS F.**, 1992: Il Pleistocene inferiore nell'area Nursina. Studi Geologici

Camerti, Vol. Spec. 1992/1, 55-64.

**BLUMETTI A.M.**, 1995: Neotectonic investigations and evidence of paleoseismicity in the epicentral area of the January-February 1703, central Italy, earthquake. Spec. Publ., Ass.Eng. Geol., textbf 6, 83-100.

**BOCCALETTI M., NICOLICH R. and TORTORICI L.**, 1984: "The calabrian arc and the ionian sea in the dynamic evolution of the central Mediterranean", Marine Geology, 55, 219-245.

**BORDONI P. & VALENSISE G.**, 1998: Deformation of the 125ka marine terrace in Italy: Tectonic implications. In: Stewart, I.S. & Vita-Finzi, C. (eds.), Coastal Tectonics. Geological Society, London, Special Publications, 146, 71-110.

**BOSCHI E., FERRARI G., GASPERINI P., GUIDOBONI E., SMRIGLIO G. and VALENSISE G.**, 1995: Catalogo dei forti terremoti in Italia dal 461 a.C. al 1980. Istituto Nazionale di Geofisica, S.G.A. Rome

**BOSCHI E., GUIDOBONI E., FERRARI G., VALENSISE G. and GASPERINI P.**, 1997: Catalogo dei forti terremoti in Italia dal 461 a.C. al 1990. Istituto Nazionale di Geofisica, S.G.A. Rome.

**BOSCHI E.**, et al., 1999. Catalogo Parametrico dei Terremoti Italiani. ING, GNDT, SGA, SSN, Bologna, 92 pp.

**BOSI C. & MESSINA P.**, 1991: Ipotesi di correlazione fra successioni morfo-litostratigrafiche plio-pleistoceniche nell'Appennino laziale-abruzzese. Studi Geologici Camerti, Special Volume CROP 11, 257-263.

**BRUNO G., MORETTI A. and GUERRA I.**, 1995: Meccanismi focali di terremoti intermedi e profondi del Tirreno meridionale, Atti del 14° Convegno GNGTS, Roma 23-25 ottobre 1995, 1103-114.

**CANTALAMESSA G., CENTAMORE E., CHIOCCHINI U., COLALONGO M.L., MICARELLI A., NANNI T., PASINI G., POTETTI M. & RICCI LUCCHI F.**, 1986: Il Plio-Pleistocene delle Marche, In: E., Centamore & Deiana, G. (eds) "La geologia delle Marche", Studi Geologici Camerti, Vol. Spec., 61-81.

**CAPALDI G., CINQUE A. & ROMANO P.**, 1988: Ricostruzione di sequenze morfoevolutive nei Picentini Meridionali (Campania, Appennino Meridionale), Geogr. Fis. Din. Quat., 1, 207-222.

**CAROBENE L. and DAI PRÀ G.**, 1990: Genesis, chronology and tectonics of the Quaternary marine terraces of the Tyrrhenian coast of the northern Calabria (Italy). their correlation with climatic conditions, Il Quaternario, 3 (2), 75-94.

**CAROBENE L. and DAMIANI A. V.**, 1985: Tettonica e sedimentazione pleistocenica nella media valle del Fiume Crati. Area tra il t. Pescara e il F. Mucone (Calabria), Boll. Soc. Geol. It., 104, 93-114.

**CAROBENE L. and FERRINI G.**, 1991: The lower Pleistocene Monte Carpinoso terrace (Tyrrhenian coast of Calabria, southern Italy), Geogr. Fis. Din. Quat., 14, 209-219.

**CAROBENE L., MENGANI M. E. and OLIVIERO M.**, 1989: Superfici terrazzate pleistoceniche nella media valle del Fiume Crati (Calabria), Il Quaternario, 2 (1), 15-39.

**CAROBENE L., DAI PRÀ G. and GEWELT M.**, 1986: Niveaux marins du Pléistocène moyen-supérieur de la côte tyrrhénienne de la Calabre (Italie méridionale). Datations  $^{230}\text{Th}/^{234}\text{U}$  et tectonique récente, Z. Geomorph. N. F., Suppl.-Bd., 62, 141-158.

**CAVINATO G.P. & DE CELLES P.**, 1999: Extensional basins in the tectonically bimodal central Apennines fold-thrust belt, Italy: Response to corner flow above a subducting slab in retrograde motion. Geology, 27, 955-958.

**CAVINATO G.P., COSENTINO D., DE RITA D., FUNICIELLO R. & PAROTTO P.**, 1993b: Tectonic sedimentary evolution of intrapenninic basins and correlation with the volcano-tectonic activity in central Italy. Mem. Descr. Carta Geol. Ital., 49, 63-75.

**CAVINATO G.P., DALL'ASTA M., MICCADEI E., PAROTTO M. & VITTORI E.**, 1993a: Extensional tectonics in the central Apennines: The Fucino basin, Paper presented at ILP Task Force: Origin of Sedimentary Basins, 4th Workshop, Int. Lithosphere, Benevento, Italy.

**CELLO G., MAZZOLI S., TONDI E. & TURCO E.**, 1997: Active tectonics in the central Apennines and possible implications for seismic hazard analysis in peninsular Italy. Tectonophysics, 272, 43-68.

**CELLO G., MAZZOLI S., TONDI E.**, 1998a: The crustal structure responsible for the 1703 earthquake sequence of central Italy, Journ. Geodyn., 26, 443-460.



- CHIDO G., MORETTI A. AND GUERRA I.**, 1992: Nuove informazioni sulla sismicità storica del crotonese, Atti del XI Convegno GNGTS, Roma 9-11 dicembre 1992, 41-53.
- CIARANFI N., GHISETTI F., GUIDA M., IACCARINO G., PIERI P., RAPISARDI L., RICCHETTI G., TORRE M., TORTORICI L. AND VEZZANI L.**, 1983: "Carta neotettonica dell'Italia meridionale", Pubbl. n° 515 del P. F. Geodinamica (Bari, 1983).
- CINQUE A., PATACCA A., SCANDONE P. & TOZZI M.**, 1993. Quaternary kinematic evolution of the Southern Apennines. Relationships between surface geological features and deep lithospheric structures, *Ann. Geofis.*, 36, 249-260.
- COLELLA A.**, 1988a: Fault-controlled marine Gilbert-type fan deltas, *Geology*, 16, 1031-1034
- COLELLA A.**, 1988b: Pliocene-Holocene fan deltas and braided deltas in the Crati Basin, southern Italy: a consequence of varying tectonic conditions, in Nemec W. and Steel R. J. (eds.), *Fan deltas: sedimentology and tectonic settings*, 1988 Blackie and son.
- COLELLA A., DE BOER P.L. and NIO S.D.**, 1987: "Sedimentology of a marine intermontane Pleistocene Gilbert-type fan-delta complex in the Crati basin, Calabria, Southern Italy", *Sedimentology*, 34, 721-736.
- COLTORTI M., CONSOLI M., DRAMIS F., GENTILI B. & PAMBIANCHI G.**, 1991. Evoluzione geomorfologica delle piane alluvionali delle Marche centro-meridionali, *Geogr. Fis. Din. Quat.*, 14(1), 87-100.
- COWIE P.A.**, 1998. A healing-reloading feedback control on the growth rate of seismogenic faults.
- CRISTOFOLINI R., GHISETTI F., SCARPA R. AND VEZZANI L.**, 1985: "Character of the stress field in the Calabrian arc and southern Apennines (Italy) as deduced by geological, seismological and volcanological information", *Tectonophysics*, 117, 39-58.
- CUCCI L. and CINTI F. R.**, 1998: Regional uplift and local tectonic deformation recorded by the Quaternary marine terraces on the Ionian coast of northern Calabria, *Tectonophysics*, 292, 67-83.
- D'AGOSTINO, N., CHAMOT-ROOKE, N., FUNICIELLO R., JOLIVET L. & SPERANZA F.**, 1998. The role of pre-existing thrust faults and topography on the styles of extension in the Gran Sasso range (Central Italy), *Tectonophysics*, 292, 229-254.
- D'AGOSTINO R., GIULIANI R., MATTONE M. & BONCI L.**, 2001: Active crustal extension in the central Apennines (Italy) inferred from GPS measurements in the interval 1994-1999. *Geophys. Res. Lett.*, 28, 2121-2124.
- DEMANGEOT, J.**, 1965. *Geomorphologie des Abruzzes Adriatiques*. Centre Recherche et Documentation Cartographiques Memoires et Documents, Numero hors serie, 1-403, Paris.
- DIETRICH D.**, (1976): La geologia della Catena Costiera calabrese tra Cetraro e Guardia Piemontese, *Mem. Soc. Geol. It.*, 17, 61-121.
- DONDI L., RIZZINI A. & ROSSI P.**, 1985. Recent Geological evolution of the Adriatic Sea. in *Geological Evolution of the Mediterranean Basin* edited by D.J. Stanley and F.C. Wezel, pp.195-214., Springer-Verlag, New York.
- DRAMIS F., GENTILI B. and PAMBIANCHI G.**, 1990: Geomorphological scheme of the River Trionto basin, Excursion guidebook, IGU-COMTAG and CNR, "Symposium on geomorphology of active tectonic areas", Cosenza, June 1990, 63-66.
- DRAMIS F.**, 1992: Il ruolo dei sollevamenti tettonici a largo raggio nella genesi del rilievo appenninico.
- DUFAURE J.J., BOSSUYT D. & RASSE M.**, 1989: Deformations quaternaires et morphogenese de l'Apennin Central adriatique, *Physio-Geo*, 18, 9-46.
- ELTER P., GIGLIA G., TONGIORGI M. & TREVISAN L.**, 1975: Tensional and compressional areas in the recent (Tortonian to present) evolution of North Apennines, *Boll. Geof. teor. Appl.*, 17, 3-18.
- FACCENNA C., DAVY P., BRUN J.P., FUNICIELLO R., GIARDINI D., MATTEI M. & NALPAS T.**, 1996: **FREPOLI A. AND AMATO A.**, 2000: Spatial variation in stresses in peninsular Italy and Sicily from background seismicity, *Tectonophysics*, 317, 109-124.

- FREPOLI A., SELVAGGI G., CHIARABBA C. and AMATO A.** 1996: State of stress in the southern Tyrrhenian subduction zone from fault-plane solutions, *Geophys. J. Int.*, 125, 879-891.
- FREPOLI A. & AMATO A.**, 1997: Contemporaneous extension and compression in the Northern Apennines from earthquakes fault plane solutions, *Geophys. J. Int.*, 129, 368-388.
- GABRIELE S., PETRUCCI O., SORRISO-VALVO M. AND TANSI C.**, 1997: The River Trionto basin, *Suppl. Geogr. Fis. Din. Quat.*, III, T. 2, 145-146.
- GALADINI F. & GALLI P.**, 1999. The Holocene paleoearthquakes on the 1915 Avezzano earthquake faults (central Italy): implications for active tectonics in the central Apennines. *Tectonophysics*, 308, 143-170.
- Galadini F. & Galli P.**, 2000: Active Tectonics in the Central Apennines (Italy) - Input Data for Seismic Hazard Assessment, *Natural Hazards*, 22, 225-270.
- GASPARINI C., IANNACONE G., SCANDONE P. AND SCARPA R.**, 1982: Seismotectonics of the calabrian Arc, *Tectonophysics*, 84, 267-286.
- GE.MI.NA.**, 1962. Ligniti e torbe dell'Italia continentale, *Geomina Geomineraria Nazionale*, Roma. p.320 *Geophys. J. Int.*, 126, 781-795.
- GHISETTI F. and VEZZANI L.** 1982: - Different styles of deformation in the Calabrian arc (southern Italy): implications for a seismotectonic zoning, *Tectonophysics*, 85, 149-165.
- GIRAUDI C. & FREZZOTTI F.**, 1995: Paleoseismicity in the Gran Sasso massif (Abruzzo, Central Italy), *Quat. Int.*, 25, 81-93.
- GIRAUDI C.**, 1986: Inversione pleistocenica del drenaggio in Alta Val Roveto (Abruzzo sud-occidentale), *Mem. Soc. Geol. It.*, 35, 847-853.
- GIROTTI O. & PICCARDI E.**, 1994: Linee di riva del Pleistocene inferiore sul versante sinistro della Media Valle del fiume Tevere, *Il Quaternario*, 7(2), 525-536.
- GLIOZZI E.**, 1988: I terrazzi marini del Pleistocene superiore della penisola di Crotone, *Tesi di Dottorato*, Dipartimento di Scienze della Terra, Università degli Studi di Napoli, pp. 153.
- GLIOZZI E. & MAZZINI I.**, 1998: Paleoenvironmental analysis of Early Pleistocene brackish marshes in the Rieti and Tiberino intrapenninic basins (Latium and Umbria, Italy) using ostracods (Crustacea), *Paleogeography, Paleoclimatology, Paleoecology*, 140, 325-333.
- GNDT, 2000**: Gruppo Nazionale per la Difesa dai Terremoti. Sintesi delle conoscenze sulle faglie attive in Italia Centrale. **M. BARCHI, F. GALADINI, G. LAVECCHIA, P. MESSINA, A. M. MICHETTI, L. PERUZZA, A. PIZZI, E. TONDI and E. VITTORI.** Published by GNDT, Rome. ISBN 88-900449-7-7, pp 62.
- HUNSTAD I. & ENGLAND P.**, 1999: An upper bound on the rate of strain in the central Apennines, Italy, from triangulation measurements between 1869 and 1963. *Earth Planet. Sci. Lett.*, 169, 261-267.
- JOLIVET L., FACCENNA C., GOFFE B., MATTEI M., ROSSETTI F., BRUNET C., STORTI F., FUNICIELLO R., CADET J.P., D'AGOSTINO N. & PARRA T.**, 1998: Midcrustal shear zones in postorogenic extension: the Northern Tyrrhenian Sea case, *J. Geophys. Res.*, 88, 12123-12160.
- KIRATZI A. A.**, 1994: Active seismic deformation in the Italian peninsula and Sicily, *Ann. Geofis.*, 38 (1), 2745.
- KRUSE S. & ROYDEN L. H.**, 1994: Bending and unbending of an elastic lithosphere: The Cenozoic history of the Apennine and Dinaride foredeep basins, *Tectonics*, 13, 278-302.
- LA PERA E. and SORRISO-VALVO**, 2000: Weathering and morphogenesis in a mediterranean climate, Calabria, Italy, *Geomorphology*, 34, 251-270.
- LANZAFAME G. AND TORTORICI L.**, 1981: La tettonica recente della Valle del Fiume Crati (Calabria), *Geogr. Fis. Din. Quat.*, 4, 11-21.
- LANZAFAME G., SPADEA P. and TORTORICI L.**, 1979: Mesozoic ophiolites of the northern Calabria and lucanian Apennine (southern Italy), *Ofioliti*, 4 (2), 173-182.
- LUCENTE F. P., CHIARABBA C. and CIMINI G. B.**, 1995: Immagini tomografiche della zona di subduzione del basso Tirreno, atti del 14° Convegno GNGTS, Roma 23-25 ottobre 1995, 1,

6974.

- MALINVERNO A. & RYAN W.B.**, 1986: Extension in the Tyrrhenian Sea and shortening in the Apennines as a result of arc migration driven by sinking of the lithosphere, *Tectonics*, 5(2), 227-246.
- MARINELLI G., BARBERI F. & CIONI R.**, 1993: Sollevamenti neogenici e intrusioni acide della Toscana e del Lazio settentrionale, *Mem. Soc. Geol. It.*, 49, 279-288.
- MAUZ B. and HASSLER U.**, 2000: Luminescence chronology of Late Pleistocene raised beaches in southern Italy: new data of relative sea-level changes, *Marine Geology*, 170, 187-203.
- MAZZANTI R. & TREVISAN L.**, 1978: Evoluzione della rete idrografica nell'Appennino centro-settentrionale. *Geogr. Fis. Din. Quat.*, 1, 55-62.
- MESSINA P.**, 1996: Tettonica meso-pleistocenica dei terrazzi nord-orientali del Fucino (Italia centrale), *Il Quaternario*, 9, 293-298.
- MICCADEI E., BARBIERI R. & CAVINATO G.P.**, 1998: La geologia quaternaria della conca di Sulmona (Abruzzo, Italia centrale), *Geologica Romana*, 34, 59-86.
- MICHETTI A.M. & SERVA L.**, 1990: New data on the seismotectonic potential of the Leonessa fault area (Rieti, central Italy), *Rend. Soc. Geol. It.*, 13, 37-46.
- MICHETTI A.M., BRUNAMONTE F., SERVA L. & VITTORI E.**, 1996: Trench investigations of the 1915 Fucino earthquakes fault scarp (Abruzzo, central Italy): geological evidence of large historical events. *J. Geophys. Res.*, 101, 5921-5936.
- MICHETTI A.M., SERVA L., VITTORI E.**, 2000: ITHACA Italy Hazard from Capable Faults: a database of active faults of the Italian onshore territory. Cd-rom and explication notes, published by ANPA, Roma. (copies available from E. Vittori: vittori@anpa.it).
- MOLIN P., DRAMIS F. and LUPA PALMIERI E.**, 2001: The Plio-Quaternary uplift of the ionian northern Calabria coastal belt between Corigliano Calabro e Capo Trionto, *Studi Geologici Camerti* (in press).
- MOLIN P.**, 2001: L'analisi topografica come strumento per definire il ruolo morfogenetico della tettonica distensiva e del sollevamento regionale in un transetto della Calabria settentrionale, [Ph.D. dissertation]: Roma, Università degli Studi Roma Tre, p.100.
- MONACO C. and TORTORICI L.** (2000): Active faulting in the Calabrian arc and eastern Sicily, *J. Geodyn.*, 29, 407-424.
- MORETTI A.**, 1993: Note sull'evoluzione tettono-stratigrafica del bacino crotonese dopo la fine del Miocene. *Boll. Soc. Geol. It.*, 112, 845-867.
- MORETTI A. and GUERRA I.**, 1997: Tettonica dal Messiniano ad oggi in Calabria: implicazioni sulla geodinamica del sistema Tirreno-Arco calabro, *Boll. Soc. Geol. It.*, 116, 125-142.
- MORETTI A., COREA I. and GUERRA I.**, 1990: Sismicità attuale e fratture superficiali in Calabria, *Atti del Convegno GNDT 1990*, 1, 89-101.
- OGNIBEN L.** (1973): Schema geologico della Calabria in base ai dati odierni, *Geol. Rom.*, 12, 243-585.
- ORI G.G., SERAFINI G., VISENTINI G., LUCCHI F.R., CASNEDI R., COLALONGO M.L. & MOSNA S.**, 1993: Depositional history of the Pliocene-Pleistocene Adriatic foredeep (Central Italy) from surface and subsurface data, In "Generation, accumulation and production of Europe's hydrocarbon III" by Specer A.M. (ed.), Spec. Pubbl., Eur. Ass. Petr. Geosc., 3, 233-258.
- PALMENTOLA G., CAROBENE L., MASTRONUZZI G. AND SANSÒ P.**, 1990: "I terrazzi pleistocenici della Penisola di Crotone (Calabria)", *Geogr. Fis. Dinam. Quat.*, 13, 75-80.
- PANTOSTI D., D'ADDEZIO G. & CINTI F.**, 1996: Paleoseismicity of the Ovindoli-Pezza fault, central Apennines, Italy: A history including a large previously unrecorded earthquake in the Middle Age (860-1300 A.D.), *J. Geophys. Res.*, 101, 5937-5959.
- PAROTTO M. & PRATURLON A.**, 1975: Geological Summary of the Central Apennines. In: C.N.R., *Structural Model of Italy*, Quad. Ric. Sci., 90, 257-311.
- PATACCA E., SARTORI R. & SCANDONE P.**, 1990: Tyrrhenian basin and Apenninic arcs: kinematic



- relations since late Tortonian times, *Mem. Soc. Geol. It.*, 45, 425-451.
- PIROMALLO C. and MORETTI A.**, 1997: Imaging the Mediterranean upper mantle by p-wave travel time tomography, *Ann. Geofis.*, 40, 963-979.
- PONDRELLI S., MORELLI A. & BOSCHI E.**, 1995: Seismic deformation in the Mediterranean area estimated by moment tensor summation, *Geophys. J. Int.*, 122, 938-952.
- POSTPISCHL D.**, 1985: Catalogo dei terremoti italiani dall'anno 1000 al 1980. CNR P.F. Geodinamica, Graficoop Bologna.
- ROYDEN L.H.**, 1993: Evolution of retreating subduction boundaries formed during continental collision.
- SELVAGGI G. and CHIARABBA C.**, 1995: Seismicity and p-wave velocity image of the southern Tyrrhenian subduction zone, *Geophys. J. Int.*, 121, 818-826.
- SELVAGGI G. & AMATO A.**, 1992: Intermediate-depth earthquakes in the Northern Apennines (Italy): evidence for a still active subduction?, *Geoph. Res. Letters*, 19, 2127-2130.
- SELVAGGI G.**, 1998: Spatial distribution of horizontal seismic strain in the Apennines from historical earthquakes, *Ann. Geofis.*, 41(2), 241-251.
- SELVAGGI G., FERULANO F., DI BONA M., FREPOLI A., AZZARA A., BASILI A., CHIARABBA C., CACCIO M.G., DI LUCCIO F., LUCENTE F.P., MARGHERITI M. & NOSTRO C.**, 2001: The  $M_w$  5.4 Reggio Emilia 1996 earthquake: active compressional tectonics in the Po Plain, Italy, *Geophys. J. Int.*, 144, 1-13.
- SERVA L., BLUMETTI A.M. & MICHETTI A.M.**, 1988: Gli effetti sul terreno del terremoto del Fucino (13 gennaio 1915): Tentativo di interpretazione della evoluzione tettonica recente di alcune strutture. *Mem. Soc. Geol. It.*, 35 (2), 1986, 893-907.
- SORRISO-VALVO M. AND SYLVESTER A. G.**, 1993: The relationship between geology and landforms along a coastal mountain front, northern Calabria, Italy, *Earth Surf. Proc. Landf.*, 18, 257-273.
- SORRISO-VALVO M. TANSI C. AND ANTRONICO L.**, 1996: "Relazioni tra frane, forme del rilievo e strutture tettoniche nella media Valle del Fiume Crati (Calabria)", *Geogr. Fis. Din. Quat.*, 19, 107-117.
- TORTORICI L.**, 1980: Osservazioni su una sintesi tettonica preliminare della Calabria settentrionale, *Contributi per la realizzazione della carta neotettonica d'Italia*, PFG - CNR - Sottoprogetto "Neotettonica", Pubbl. n. 356.
- TORTORICI L.**, 1981: Analisi delle deformazioni fragili dei sedimenti postorogeni della Calabria settentrionale, *Boll. Soc. Geol. It.*, 100, 291-308.
- TORTORICI L., MONACO C., TANSI C. and COCINA O.**, 1995: Recent and active tectonics in the Calabrian arc (southern Italy), *Tectonophysics*, 243, 37-55.
- VALENSISE G. & PANTOSTI D.**, in press. Seismogenic faulting, moment release pattern and seismic hazard along the central and southern Apennines and the Calabrian Arc, In "Anatomy of an orogen: the Apennines and adjacent Mediterranean basins" by B. Vai & Martini I.P. (eds), Kluwer Academic Publisher, Dordrecht.
- VAN GENDEREN J. L.**, (1970): The morpho-dynamics of the Crati River basin, Calabria, Italy, *Delft. ITC*, 1970, p. 43.
- VEZZANI L.**, 1968: I terreni plio-pleistocenici del basso Crati (Cosenza), *Atti Acc. Gioenia Sc. Nat. Catania*, ser. VI, 20, 28-84.
- VITTORI E., CAVINATO G.P. & MICCADEI E.**, 1995: Active faulting along the northeast edge of the Sulmona basin, central Apennines, Italy, *Spec. Publ., Ass. Eng. Geol.*, 6, 115-126.
- VITTORI E., MASCHIO L., FERRELLI L., MICHETTI A. M. and SERVA L.**, 1997. Carta e base di dati delle faglie capaci per l'Italia centro-meridionale: presentazione e stato di avanzamento del progetto ITHACA. *Il Quaternario* 10 (2), 305-321.
- WALLACE R.**, 1987: Grouping and migration of surface faulting and variations in slip rates on faults in the Great Basin Province. *Bull. Seism. Soc. Am.*, 77, 868-876.
- WESTAWAY R.**, (1993): Quaternary uplift of southern Italy, *J. Geoph. Res.*, 98 (B12), 21741-21772.