Il Quaternario
Italian Journal of Quaternary Sciences
10(2), 1997, 521-528

MIDDLE-UPPER PLIOCENE 'COMPRESSION' AND MIDDLE PLEISTOCENE 'EXTENSION' IN THE EAST-TIBER BASIN: FROM 'SYNFORM' TO 'EXTENSIONAL' BASINS IN THE TYRRHENIAN SIDE OF THE NORTHERN APENNINES (CENTRAL ITALY)

M. Coltorti - P. Pieruccini
Dip.to di Scienze della Terra, Università di Siena, Siena
e-mail: pieruccini@unisi.it

RIASSUNTO - *Dalla 'compressione' (Pliocene Medio-Superiore) alla 'distensione' (Pleistocene Medio) nel Bacino Est-Tiberino: da bacino 'sinforme' a bacino 'estensionale' nel versante tirrenico dell'Appennino settentrionale (Italia centrale)* - Il Quaternario *Italian Journal of Quaternary Sciences* , **10**(2), 1997, 521-528 - Nel Bacino Est-Tiberino sono state riconosciute due distinte fasi evolutive plio-pleistoceniche: durante la più antica (Pliocene Inferiore Medio - Pleistocene Inferiore) si è sviluppato un bacino sinforme all'interno del quale si aveva la deposizione di conoidi alluvionali ghiaiosi e sedimenti fluviali e lacustri. Tale bacino era delimitato ad ovest da una scarpata generata dalla riattivazione del sovrascorrimento dei M.Martani. La fase più recente (Pleistocene Medio-Superiore) è caratterizzata da varie unità terrazzate deposte all'interno di un graben delimitato da faglie dirette sintetiche e antitetiche. Le deformazioni e i rigetti durante le due fasi sono rivelati anche dalla presenza di una 'superficie di spianamento' che affiora sia alla base del bacino pliocenico sia alla sommità dei rilievi appenninici, tagliando tutte le formazioni pre-plioceniche già deformate e strutturate. Il suo modellamento è avvenuto in prossimità del livello del mare durante o subito dopo la messa in posto delle principali unità tettoniche sovrascorse (fase tettogenetica). Simili osservazioni sono state estese ai circostanti bacini appenninici e al bacino Periadriatico. Alcuni bacini pliocenici possono essere considerati bacini 'satellite', legati alla riattivazione 'superficiale'di strutture compressive. Durante il Quaternario l'intera catena è stata interessata da movimenti di sollevamento più generalizzato e dall'attivazione di bacini estensionali associabili all'approfondimento del Bacino Tirrenico.

Parole chiave: Bacini sedimentari 'sinformi' ed 'estensionali', neotettonica, Plio-Pleistocene, Bacino Est-Tiberino, Italia centrale
Key words: 'Synform' and 'extensional' sedimentary basins, neotectonics, Plio-Pleistocene, East-Tiber Basin, Central Italy

1. THE EAST-TIBER BASIN

The Tiber Basin (Fig. 1) is located in the Umbria-Marche-Sabina Apennines, and is delimited by the Umbro-Marchean Ridge to the east and the Amelia Mts and Peglia Mt ridges to the west. South of Perugia, the northernmost portion of the Martani Mts splits the basin into two branches: to the south, the western branch ends in the Terni area; whereas the eastern branch ends at Spoleto (Conti & Girotti, 1977; Ambrosetti *et al.*, 1987).

The tectonic evolution of the Apennines chain probably commenced during the Burdigalian, with the beginning of the eastward migration of the main overthrusted units (Elter *et al.*, 1975; Ambrosetti *et al.*, 1978; 1987; Calamita & Deiana, 1988; Damiani *et al.*, 1991; Deiana & Pialli, 1994). The eastward migration of the compressive fronts was followed by an extensional activity on the western flank of the chain.

The sedimentary sequence involved in the tectogenesis is the Umbro-Marchean sequence (Centamore & Deiana, Eds., 1986) up to the *'Marnoso-Arenacea'* Formation (Upper Miocene). The structuring of the Apennines chain, from the Umbrian Pre-Apennines to the Umbro-Marchean Ridge, occurred between the Upper Serravallian and the Lower Pliocene and the literature attributes the emersion to the Messinian (Damiani *et al.*, 1991; Calamita *et al.*, 1991; 1995).

After tectogenesis, a 'planation surface' was modelled cutting all the formations already deformed in the entire Apenninic area (Coltorti & Farabollini, 1995: Coltorti & Pieruccini, 1997). This surface is the oldest element indicating the subaerial evolution of the area. It is very flat and generally better preserved at the top of carbonate ridges and arenaceous reliefs. After modelling, it was affected by uplifting and was locally deformed by faulting or tilting in all directions. There is a general agreement that planation surfaces are modelled close to the sea level during periods of relative tectonic stasis (Davis, 1898; Ollier, 1981). Recently, it has been suggested that the 'planation surface' was subsequently incised by wide valleys containing Lower to Middle Pleistocene sediments (Coltorti *et al.*, in press; 1995). The deriving surface corresponds to the 'Villafranchian surface' of Demangeot (1965) and to the 'low energy landscape' of Dramis (1992).

The Tiber Basin was considered to be a peripheral basin undirectly related to the opening of the Tyrrhenian sea (Brozzetti *et al.*, 1991; Martini & Sagri, 1993). Barchi *et al.* (1991) suggested that the structural setting of the East-Tiber Basin is an asimmetrical or half-graben basin with a synthetic master fault on the eastern side. The basin was filled with continental sedimentary sequences which are hundreds of meters thick in both branches. The western branch is filled with Middle-Upper Pliocene lacustrine and alluvial fan deposits, which are mostly fine sediments unconformably overlain by Pleistocene

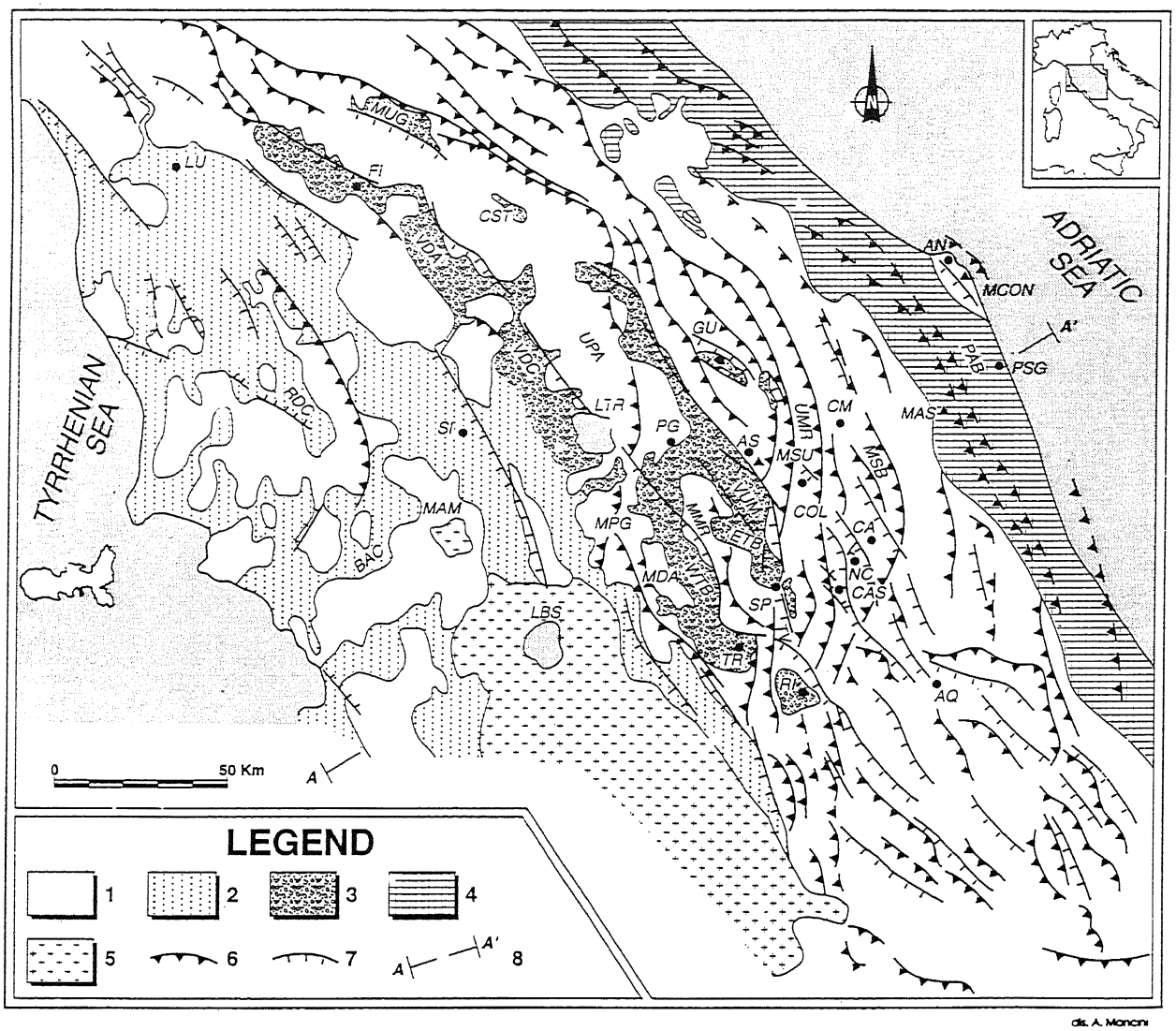

Fig. 1 - Structural scheme of Central Italy: 1) Structural units of the Apennines chain; 2) Neogenic-Quaternary deposits in the Tyrrhenian side; 3) Plio-Pleistocene deposits of the intramontane basins; 4) Periadriatic basin deposits; 5) volcanic terrains of the Latium province; 6) main overthrusts; 7) main extensional faults; 8) approximate location of the schematic cross section of Fig. 2. AN = Ancona; AS - Assisi; AQ - L'Aquila; BAC - Baccinello basin; CA - Castelluccio basin; CAS - Cascia basin; CM - Camerino; COL - Colfiorito basin; CST - Casentino basin; ETB - East-Tiber basin; FI - Firenze; GU - Gubbio basin; LBS - Bolsena lake; LTR - Trasimeno Lake; LU - Lucca; MAM - Amiata Mt.; MAS - Ascensione Mt.; MCON - Conero Mt.; MDA - Amelia Mts.; MMR - Martani Mts.; MPG - Peglia Mt.; MSB - Sibillini Mts.; MSU - Subasio Mt.; MUG - Mugello basin; NC - Norcia basin; PAB - Periadriatic basin; PG - Perugia; PSG - Porto S.Giorgio; RDC - Radicondoli basin; RI - Rieti; SI - Siena; SP - Spoleto; TR - Terni; TV - Tessino valley; UMR - Umbro-Marchean ridge; UPA - Umbrian pre-Apennines; VCA - Valdichiana basin; VDA - Valdarno basin; VUM - Valle Umbra; WTB - West Tiber basin.

Schema strutturale dell'Italia centrale. 1) Unità strutturali della catena appenninica; 2) Depositi-neogenico-quaternari sul lato tirrenico; 3) Depositi plio-pleistocenici delle conche intermontane; 4) Depositi dei bacini periadriadici; 5) Materiali vulcanici laziali; 6) Principali sovrascorrimenti; 7) Principali fagli distensive; 8) Ubicazione approssimata delle sezioni di Fig. 2; AN = Ancona; AS = Assisi; AQ = L'Aquila; BAC = Conca di Baccinello; CA = Bacino di Castelluccio; CAS = Bacino di Cascia; CM = Camerino; COL = Bacino di Colfiorito; CST = Bacino del Casentino; ETB = Bacino Est-Tiberino; FI = Firenze; GU = Bacino di Gubbio; LBS = Lago di Bolsena; LTR = Lago Trasimeno; LU = Lucca; MAM = Monte Amiata; MAS = M. Ascensione; MCON = M. Conero; MDA = Montagne d'Amelia; PAB = Bacino Periadriatico; PG = Perugia; PSG = Porto S.Giorgio; RDC = Bacino di Radicondoli; RI = Rieti; SI = Siena; SP = Spoleto; TR = Terni; TV = Valle del Tessino; UMR = Catena Umbro-Marchigiana; UPA = Pre-Apennino umbro; VCA = Bacino della Valdichiana; VDA = Bacino del Valdarno; VUM = Valle Umbra; WTB = Bacino Tiberino occidentale.

fluvial-lacustrine sediments (Conti & Girotti, 1978; Ambrosetti *et al.*, 1987; 1995; Basilici, 1995). In the eastern branch, various studies were carried out because of lignite and peat exploitation. A recent sedimentological and stratigraphical study (Coltorti & Pieruccini, 1997) has led to a re-definition of the tectonic and sedimentary evolution of the southern part of the East-Tiber Basin. Two sequences have been recognized: one of mainly Pliocene age and the other of Pleistocene age. The first sequence is composed of coarse-grained alluvial fan deposits with an eastward transition to sandy fluvial sediments and to fine-grained lacustrine and palustrine deposits. No sediments containing lignite crop out but boreholes crossed them in depth. The total thickness of the deposits is ca.

400 m and the sedimentary filling reaches 86 m below sea-level. These sediments overlie a flat surface which cuts all the terrains of the Umbro-Marchean sequence and is correlated to the 'planation surface'. The beginning of the Pliocene deposition, is based on the identification of *Castor fiber, Tapirus arvernensis, Mastodon arvernensis* and *Mastodon borsonii* close to the base of the sequence, which was dated to the Lower-Middle Pliocene (Triversa Unit of Azzaroli *et al.*, 1988). The age of the upper part of the sequence is however unknown.

Facies analysis and architectural element analysis (following Miall, 1985; 1996) indicate a western provenance of the coarsest fraction, with frequent variations of facies from gravelly alluvial fan environments to sand-dominated alluvial plain and silty-clayey palustrine and lacustrine environments. Only a few debris-flow bodies from the Umbro-Marchean Ridges indicated the presence of low reliefs to the east. The sedimentological characteristics and their setting are consistent with the deposition into an asimmetrical, downwarping basin with a steeper side to the west (Martani Mts.), where extensional faults have so far never been observed, although an overthrust plane is present. The creation of the steeper slope to the west, as well as the downwarping, is supposed to be associated with a limited re-activation of the thrust(1). Subsequently, the area was subjected to uplifting and the sequence underwent severe erosion.

High-angle extensional faults were activated either during or at the end of Lower Pleistocene leading to the formation of a graben (the present-day Valle Umbra) delimited by the main NNW-SSE (Assisi-Campello sul Clitunno) master fault (with displacements up to 2000 m) to the east and by a set of smaller antithetic faults displacing the Pliocene sequence to the west. Associated with this basin there are fluvial and alluvial fan sediments showing a transition to lacustrine deposits. The alluvial fan sediments are mainly of southern (Tessino valley) and eastern provenance, where the master fault escarpment is located. At least four periods of aggradation-downcutting, with hanging fluvial terraces, are recorded. Each sequence is bounded by an unconformity at the lower surface. This indicates that a continuous uplifting interfered with climatic changes and, thus, the unconformities bounding the 5 UBSU described by Boccaletti *et al.* (1994; 1995) may not be related to different compressional tectonic events.

2. NEARBY AREAS IN THE MIDDLE-UPPER PLIOCENE

In the West-Tiber Basin, the deposits are Middle-Upper Pliocene lacustrine clay sediments (Fosso Bianco Formation) unconformably overlain by Lower-Middle (?) Pleistocene sandy and silty-clayey alluvial plain sediments (S.Maria di Ciciliano Formation of Ambrosetti *et al.*,1995). The western side of the Amelia ridge is bordered by overthrusts (Cosentino *et al.*, 1992), however no coarse sediments came from this side. Nevertheless, the scarcity of coarse sediments in this basin indicates that there were no remarkable escarpments along the sides of the basin. The basin was very close to the sea level because, further to the west, marine deposits are present almost at the top of the ridge (Conti & Girotti, 1978; Ambrosetti *et al.*, 1978; Girotti *et al.*, 1995).

Near Gubbio, a more than 400 m thick sequence of mostly fine-grained lacustrine and alluvial plain sediments has been described (Coltorti, 1994) as the filling of a synform basin delimited westward by overthrusts (Deiana & Pialli, 1994). However, no coarse sedimentation is recorded in this sequence.

The sediments filling tectonic depressions in the Abruzzi areas are of uncertain age but it was pointed out that the early cycle of deposition is characterized by fine sediments with no coarse components both in the Fucino and L'Aquila basins and in the Salto Valley (Bertini & Bosi, 1976; Bosi & Messina, 1992).

Although the genesis of the tectonic basins of the Northern Apennines is associated with extensional movements (Bossio *et al.*, 1992; Martini & Sagri, 1993; Barberi *et al.*, 1994), also many compressive structures have been described by Boccaletti *et al.* (1995), who interpret most of these basins (Radicondoli-Volterra, Cinigiano-Baccinello, Valdarno Superiore and Mugello) and the Tiber Basin as compressional basins, the sediments of which underwent syndepositional compressive deformations from the Pliocene to the end of the Lower Pleistocene. Compressional structures are recognizable in the Siena and Upper Valdarno Basins, which, however, have been associated with extensional or gravity tectonic movements (Lazzarotto & Liotta, 1991; Liotta & Salvatorini, 1994). Also the geological sections of the eastern side of the Val di Chiana Basin (Buonasorte *et al.*, 1988) suggest the existence of a synform basin of Pliocene age. In the Val di Magra and Garfagnana Basins, Lower-Middle Pliocene sediments constituted mainly of fine-grained sediments with lignite, are tilted and unconformably overlain by Pleistocene sediments (Calistri, 1974; Federici, 1978; Raggi, 1985). Based on geometric relationships between thrust units, Calamita & Deiana (1995) hypothesised the Messinian and Lower Pliocene re-activation of major overthrusts in Central Italy.

The Umbro-Marchean chain is subdivided into several overthrusted units (Calamita *et al.*, 1991), which involve 'minor turbiditic basins' (Ricci Lucchi, 1986; 1987) whose younger deposits are Messinian in age. The overthrust fronts are located along the western margin of the turbiditic terrains; to the east, these sediments conformably overlie the Jurassic-Oligocene terrains. The 'planation surface' is located at higher elevations to the west of the overthrust fronts (Umbro-Marchean Ridge) and is lowered to the east. This corresponds to outcrops of turbiditic sediments, suggesting a limited re-activation of the overthrusts inside the chain (*i.e.* M.Maggio-Camerino). Also in the Subasio ridge, relief creation was associated with the Lower Pliocene re-activation of one of the main thrusts (Damiani *et al.*, 1995).

Middle-Upper Pliocene and Lower Pleistocene sediments in the Periadriatic Basin constitute the filling of a

(1) We introduce the term *'synform'* basin as a descriptive term for these basins. However, 'compressional' features are not necessarily linked to a deeper tectonic stress field.

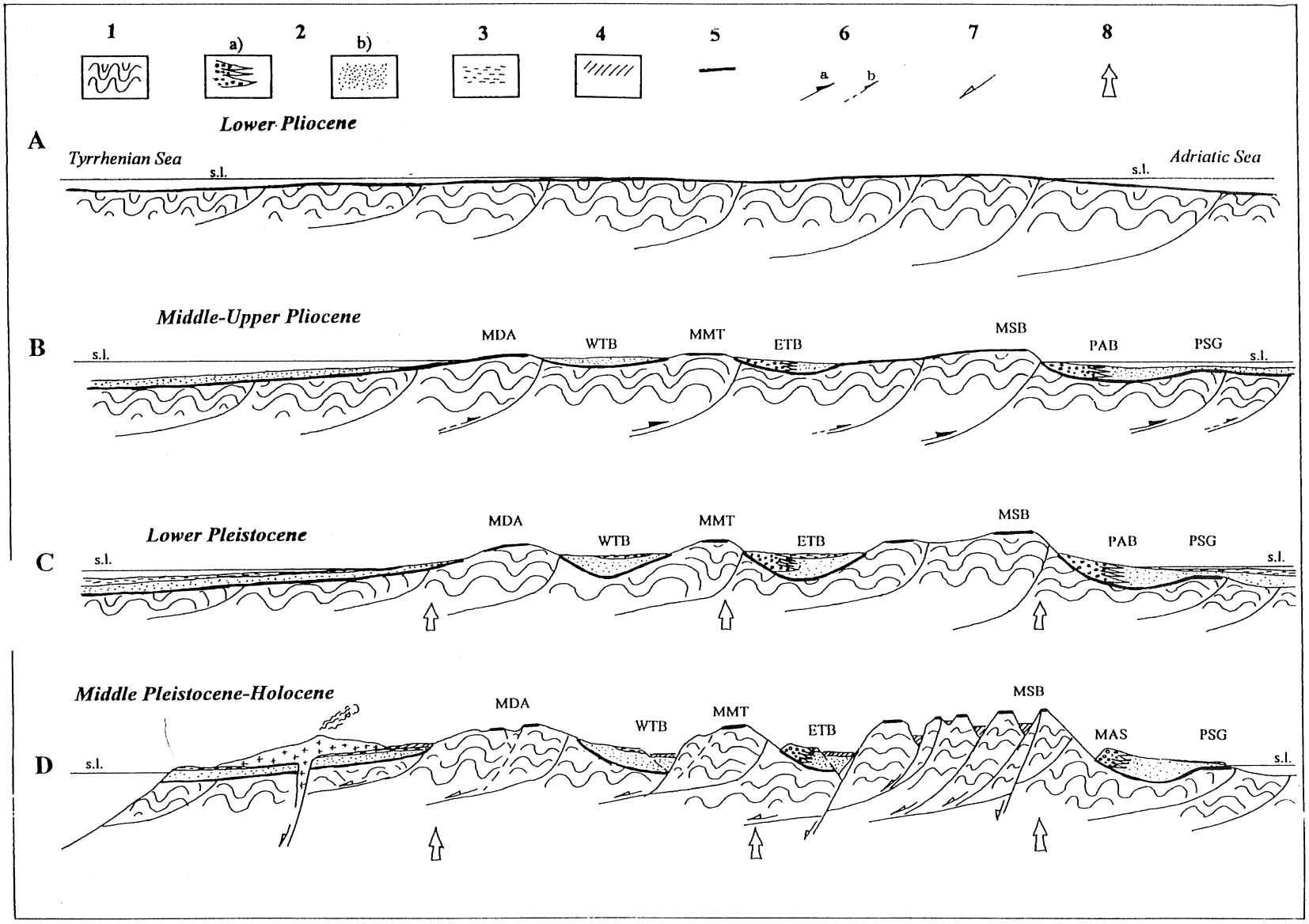

Fig. 2 - Schematic representation of the tecto-sedimentary events occurred during the Plio-Pleistocene in the Apennines. A) The planation surface cutting all units of the Apennines was modeled very close to sea level during the Lower Pliocene; on the Tyrrhenian side fine-grained sediments with lignite were deposited on top of the 'planation surface'; B) re-activation of some of the main overthrusts, which caused the formation of 'synform' basins bordered by fault escarpments and filled by coarse-grained alluvial fan sediments in the proximity of the faults; downwarping or mild re-activation of minor thrust delimited basins with scarce coarse sedimentation (Middle-Upper Pliocene); C) the whole area underwent a generalized uplifting that was fol- cont. p.525 ⟶

new cycle of coastal-marine sedimentation. These sediments unconformably overlie (Lower-Middle Pliocene trans-gression) the Lower Pliocene as well as the Upper Miocene marine and coastal sediments, which were severely folded and thrusted together with the Umbro-Marchean sedimentary multilayered formations (Calamita *et al.*, 1991). The main source of sediments of the synform basin was the Umbro-Marchean chain, from which a thick sequence of fanglomerates (Mt Ascensione) was deposited (Cantalamessa *et al.*, 1986). Such as in the East-Tiber Basin this suggests that the western reliefs were rising and being dissected up to the Upper Pliocene, due to the re-activation of the Sibillini Mts overthrust (Calamita & Deiana, 1988), which delimits the basin to the west. Therefore, at that time, the 'planation surface' modelling had already terminated. Therefore, the 'planation surface', which at present is found at the top of the chain, is correlated in coastal areas with the modelling of the Lower-Middle Pliocene transgressional surface. To the east, the basin was delimited by a ridge (Mt Conero-Porto S.Giorgio) located close to the sea level (Cantalamessa *et al.*, 1987).

(cont. da/*from* p.524)

lowed by valleys incision (Lower Pleistocene); D) the continue uplifting was associated with the activation of extensional faults originating 'graben' basins in the Tyrrhenian side of the peninsula; these high-angle faults re-activated both superficial and deep thrust planes toward the Tyrrhenian sea, which was rapidly sinking. The extensional activity in Western Italy was accompanied by a strong volcanic activity. In the meantime, the Periadriatic area was emerging and sedimentation migrated to the east. Legend: 1 = main overthrusted units; 2 = a) alluvial fan deposits; b) fluvial-lacustrine and marine deposits (Middle-Upper Pliocene); 3 = fluvial-lacustrine and marine deposits (Lower Pleistocene); 4 = continental deposits of extensional basins; 5 = planation surface; 6 = a) major and b) minor overthrust re-activation; 7) extensional fault and reverse thrust plane re-activation; 8) uplifting.

Rappresentazione schematica degli eventi tettonico-sedimentari avvenuti in Appennino nel Plio-Pleistocene. A) La superficie di spianamento che taglia tutte le unità degli Appennini si formò durante il Pliocene inferiore a quote molto prossime al livello del mare; verso il Tirreno, sulla superficie di spianamento si ebbe deposizione di sedimenti fini con ligniti; B) riattivazione di alcuni dei principali sovrascorrimenti con formazione di bacini "sinformi" delimitati da scarpate di faglia e riempiti da sedimenti grossolani di conoide alluvionale in vicinanza delle faglie; l'accavallamento o la limitata riattivazione di piccoli sovrascorrimenti portò alla demarcazione di bacino con scarsa sedimentazione grossolana (Pliocene medio-superiore); C) un sollevamento generalizzato interessò tutta l'area che fu, poi, incisa (Pleistocene inferiore); D) il continuo sollevamento fu accompagnato dall'attività di faglie distensive che hanno dato luogo a graben-bacini sul lato tirrenico della penisola; tali faglie ad alto angolo rimisero in moto piani di scorrimento sia superficiali che profondi verso il Tirreno che stava subsidendo rapidamente. In Italia occidentale, la distensione si accompagnò ad attività vulcanica. L'area periadriatica, nel frattempo, stava emergendo con migrazione verso est della sedimentazione. Legenda: 1 = principali unità sovrascorse; 2 = a) depositi di conoide alluvionale; b) depositi fluvio-lacustri e marini del Pliocene medio-superiore; 3 = depositi fluvio-lacustri e marini del Pleistocene inferiore; 4 = depositi continentali di bacini distensivi; 5 = superficie di spianamento; 6 = riattivazione di sovrascorrimenti a) di minore e b) maggiore entità; 7) faglie distensive e riattivazione di piani di scorrimento inverso; 8) sollevamento.

3. NEARBY AREAS IN THE PLEISTOCENE

Terraced deposits characterize the whole Apennines chain from the Adriatic to the Tyrrhenian sea showing that, after the Pliocene sedimentary cycle, the Apennines area was affected by a more generalized uplifting. Under this regime, during the final part of the Lower Pleistocene and the Middle Pleistocene, there was the activation of extensional basins bordered by high-angle normal faults on the Tyrrhenian side of the Peninsula. The Pleistocene age of the infilling of some of these basins (Colfiorito, Norcia, Cascia, Tiber Basin, Leonessa, Rieti) was recognized years ago (Calamita *et al.*, 1982; Barberi *et al.*, 1995). The same observations can be made in the Southern Apennines (Fucino, Subequana, Sulmona, Tirino etc.; Demangeot, 1965; Raffy, 1981; Bosi & Messina 1992). An extensional regime is also testified by volcanic activity after 0.7 Ma (Barberi *et al.*, 1994). Extensional faults, which played an important role in displacing the Middle Pleistocene deposits in the Umbrian area, do not show to have had a marked activity after that period.

The Periadriatic area continued to evolve as a synform basin until the end of the Calabrian (Cantalamessa *et al.*, 1986) approximately 1.0-0.7 Ma ago. Subsequently, coastal deposits underwent uplifting movements and today are found at elevations higher than 400 m a.s.l. Fluvial terraces hanging on valley floors became the main feature. Downcutting followed antiapenninic NW-SE faults (Coltorti *et al.*, 1995) but extensional faults stretching in the Apennines direction (NE-SW) were also recognized. One of these delimits the western side of Mt Conero (Coltorti *et al.*, 1987). The activity of 'compressive fronts' in the Adriatic Sea, became less important up to the Calabrian (Ori *et al.*, 1986).

4. DISCUSSION

The most significant element in the Plio-Pleistocene evolution of the superficial part of the Apennine chain is the 'planation surface'. It has been correlated to the unconformity which marks the Lower-Middle Pliocene transgression. The whole area was easily flattened by erosion, from the Adriatic to the Thyrrenian sea, because of the proximity of the sea level on both side of the Peninsula (Fig. 2a). This phase postdates the structuring of the Apennines chain (tectogenesis) since the planation affected units already overthrusted. The study of typology and chronology of movements is a link to any model dealing with the deeper structural setting of the Apennines. The re-activation of some of the main thrust fronts during the Middle-Upper Pliocene (Fig. 2b) created topographic irregularities, ridges and synform basins, which can be considered 'piggyback basins' (Ori & Friend, 1984), 'floated satellite basins' (Ricci-Lucchi, 1986), or 'perched basins' (Butler & Grasso, 1993). The thrust activity on the western flank of the East-Tiber and Periadriatic Basins are also revealed by coeval coarse alluvial fan sediments, lying unconformably on the 'planation surface'. There is no chronological evidence for the end of this cycle in the Apennines but the 'Pliocene' sequence was

affected by many dozens and even hundreds of metres of erosion suggesting a long erosive time span. In the Periadriatic Basin it ended about 1.0-0.8 Ma ago. Since the Lower Pleistocene the whole area has undergone a general uplifting (Fig. 2c).

The new basins created at the end of the Lower Pleistocene are asymmetrical grabens with a master fault located on the eastern side (Fig. 2d). Some of faults are listric which re-activated the thrust planes in opposite direction (Calamita *et al.*, 1994). Displacements in the order of many hundreds of meters occurred along superficial planes even if deeper thrust planes had also been re-activated.

At the base of many Pliocene basins, sediments are mostly fine-grained with lignite layers, whose relationship with the overlaying deposits is generally masked. It is possible that the sedimentation occurred either: 1) inside newly formed 'perched basins' or 2) onto wide alluvial and coastal plains bordering the western side of the peninsula and lately dismembered by the thrust re-activation. In the latter case the sequence would have to be subdivided into pre- (fine sediments with lignite) and post-thrust re-activation (coarser sediments). The buried sediments with lignite deposits of the Tiber Basin, in Gubbio and in many depressions of north-central Italy might correspond to the pre-thrust re-activation. The fine-grained sediments carried to the top of the Apennines Ridge, after the thrust re-activation, were subsequently affected by erosion leading to the exhumation of the 'planation surface'. However, only in the East-Tiber Basin and in the front of the Umbro-Marchean Apennines there was an important re-activation of thrusts in the Middle-Upper Pliocene as indicated by the presence of thick fanglomerates and alluvial fan deposits. These displacements were in the order of some hundreds of metres and, therefore, the ridges were still low and close to the sea level.

The Upper Pliocene-Pleistocene history of the peninsula is a new event in the frame of the Apennines evolution. It cannot be associated to an eastward migration of the compressional-extensional stress field because the Apennines chain originated entirely during this period and there are no evidence that high reliefs had never existed before. The thick turbiditic sedimentation ended in the Periadriatic Basin with the surrection of the chain which occurred after the Lower Pliocene transgression and the modelling of the 'planation surface'. The phase of activation of the extensional faults — with which it is, at places, connected the formation of basins in the western side of the Apennines at the end of the Lower Pleistocene — seems to be related to the uplifting of the chain and to the contemporaneous deepening of the Tyrrhenian sea.

AKNOWLEDGEMENTS

Many thanks are due to Prof. F.A. Decandia for the critical reading of the paper and to Dr.N. Branch for improvement of the English text.

REFERENCES

Ambrosetti P., Conti M.A., Parisi G., Kotsakis T. & Nicosia U., 1977 - *Neotettonica e cicli sedimentari plio-pleistocenici nei dintorni di Città della Pieve (Umbria).* Boll. Soc. Geol. It., **96**(4), 605-635.

Ambrosetti P., Carboni M., Conti M., Costantini A., Esu D., Gandin A., Girotti O., Lazzarotto A., Mazzanti R., Nicosia U., Parisi G. & Sandrelli F., 1978 - *Evoluzione paleogeografica e tettonica nei bacini Tosco-Umbro-Laziali nel Pliocene e nel Pleistocene inferiore.* Mem. Soc. Geol. It., **19**, 573-580.

Ambrosetti P., Carboni M., Conti M., Esu D., Girotti O., La Monica G., Landini B. & Parisi G., 1987 - *Il Pliocene ed il Pleistocene inferiore del Bacino del fiume Tevere nell'Umbria Meridionale.* Geogr. fis. e Dinam. Quat., **10**(1), 10-33.

Ambrosetti P., Carraro F., Deiana G. & Dramis F., 1982 - *Il sollevamento dell'Italia centrale tra il Pleistocene inferiore e il Pleistocene medio.* In: *Contributi preliminari alla realizzazione della Carta Neotettonica d'Italia.* Prog. Fin. 'Geodinamica'/ Sottoprog. 'Neotettonica' (C.N.R.)., Pubbl. n°513, 219-223.

Ambrosetti P., Basilici G., Capasso Barbato L., Carboni M.G., Di Stefano G., Esu D., Gliozzi E., Petronio C., Sardella R., & Squazzini E., 1995 - *Il Pleistocene inferiore nel ramo sud occidentale del Bacino Tiberino (Umbria): aspetti litostratigrafici e biostratigrafici.* Il Quaternario, **8**(1), 19-36.

Azzaroli A., De Giuli C., Ficcarelli G. & Torre D., 1988 - *Late Pliocene to Early Mid-Pleistocene mammals in Eurasia: faunal succession and dispersal events.* Palaeo, Palaeo, Palaeo, **66**, 77-100.

Barberi F., Buonasorte G., Cioni R., Fiordelisi A., Foresi L., Iaccarino S., Laurenzi M.A., Sbrana A., Vernia L. & Villa I.M., 1994 - *Plio-Pleistocene geological evolution of the geothermal area of Tuscany and Latium.* Mem. Descr. Carta Geol. d'It., **XLX**, 77-134.

Barberi R., Cavinato G.P., Gliozzi E. & Mazzini I., 1995 - *Late Pliocene-Early Pleistocene plaeoenvironmental evolution of the Rieti basin (Central Apennines).* Il Quaternario, **8**, 515-535.

Barchi M., Brozzetti F. & Lavecchia G., 1991 - *Analisi strutturale e geometrica dei bacini della media valle del Tevere e della Valle Umbra.* Boll. Soc. Geol. It., **110**, 65-76.

Basilici G., 1997 - *Sedimentary facies in an extentional and deep-lacustrine system: the Pliocene Tiberino Basin, Central Italy.* Sedimentary Geology, **109**(1-2), 73-94.

Bertini T. & Bosi C., 1976 - *Sedimenti continentali probabilmente pliocenici nella Valle del Salto e nella Conca del Fucino (Rieti-L'Aquila).* Boll. Soc. Geol. It., **95**(4), 767-801.

Boccaletti M., Cerrina Feroni A., Martinelli P., Moratti G., Plesi G. & Sani F., 1994 - *L'area tosco-laziale come dominio di transizione tra il bacino tirrenico ed i thrusts esterni: rassegna di dati mesostrutturali e possibili relazioni con le discontinuità del ciclo "neoautoctono".* Mem. Descr. Carta Geol. d'It., **49**, 9-22.

Boccaletti M., Bonini M., Moratti G. & Sani F., 1995 - *Le fasi compressive neogenico-quaternarie nell'Appennino settentrionale: relazioni con l'evoluzione dei bacini interni e con la tettonica del basamento.* Studi Geol. Camerti Vol. Spec., **1**, 51-73.

Bosi C. & Messina P., 1992 - *Ipotesi di correlazione fra successioni morfo-litostratigrafiche plio-pleistoceniche nell'Appennino Laziale-Abruzzese.* Studi Geol. Camerti, Vol. Spec. (1991/2) CROP 11, 257-263.

Bossio A., Cerri R., Costantini A., Gandin A., Lazzarotto A., Magi M., Mazzanti R., Mazzei R., Sagri M., Salvatorini G. & Sandrelli F., 1992 - *I bacini distensivi neogenici e quaternari della Toscana.* Guida Escurs. B4, 76°Riun. Est. Soc. Geol. It., Firenze 21-23/9/1992, 199-277.

Brozzetti F., Lavecchia G. & Stoppa F., 1991 - *Presentazione di alcuni aspetti tettonico strutturali e petrologici del distretto ultra-alcalino umbro-laziale.* Studi Geol. Camerti, Vol. Spec., **2**, 327-337.

Buonasorte G., Cataldi R., Ceccarelli A., Costantini A., D'Offizi S., Lazzarotto A., Ridolfi A., Baldi P., Barelli A., Bertini G., Bertrami R., Calamai A., Cameli G., Corsi R., D'Acquino C., Fiordelisi A., Ghezzo C. & Lovari F., 1988 - *Ricerca ed asplorazione nell'area geotermica di Torre Alfina (Lazio-Umbria).* Boll. Soc. Geol. It., **107**, 265-337.

Butler R.H.W. & Grasso M., 1993 - *Tectonic controls on base-level variations and depositional sequences within thrus-top and foredeep basins: examples from the Neogene thrust belt of central Sicily.* Basin Research, **5**, 137-151.

Calamita F., Cello G., Centamore E., Deiana G., Micarelli A., Paltrinieri W. & Ridolfi M., 1991 - *Stile deformativo e cronologia della deformazione lungo tre sezioni bilanciate dall'Appennino Umbro Marchigiano alla costa Adriatica.* St. Geol. Camerti, Vol. Spec., **1**, 295-314.

Calamita F., Coltorti M., Deiana G., Dramis F. & Pambianchi G., 1982 - *Neotectonic evolution and geomorphology of the Cascia and Norcia depressions (Umbria-Marche Apennines).* Geogr. Fis. e Dinam. Quat., **5**, 263-276.

Calamita F. & Deiana G., 1988 - *The arcuate shape of the Umbria-Marche-Sabina Apennines (Central Italy).* Tectonophysics , **146**, 139-147.

Calamita F., Coltorti M., Farabollini P. & Pizzi A., 1994 - *Le faglie normali quaternarie nella dorsale appenninica Umbro-Marchigiana: proposta di un modello tettonico di inversione.* St. Geol. Camerti, Vol. Spec., **1**, 211-225.

Calamita F. & Deiana G., 1995 - *Correlazione tra gli eventi deformativi neogenico-quaternari del settore tosco-umbro-marchigiano.* Studi Geol. Camerti, Vol. Spec., **1**, 137-153

Calamita F., Coltorti M., Pieruccini P. & Pizzi A., 1995 - *Evoluzione geomorfologica e strutturale plio-quaternaria dell'appennino Umbro-Marchigiano tra il preappennino umbro e la costa adriatica.* Convegno 'Geodinamica e tettonica attiva del sistema Tirreno-Appennino', Camerino 9-10/2/1995, Abs., 51-54.

Calistri M., 1974 - *Studi di geomorfologia e neotettonica: 2 - Il Pliocene fluvio-lacustre della conca di Barga.* Mem. Soc. Geol. It., **13**, 1-21.

Cantalamessa G., Centamore E., Chiocchini U., Colalongo M.L., Micarelli A., Nanni T., Pasini G., Potetti M., Ricci Lucchi F. (con la collaborazione di Cristallini C. & Di Lorito L.), 1986 - *Il Plio-Pleistocene delle Marche.* In: Centamore E. & Deiana G. (eds) - *La geologia delle Marche.* Studi Geol. Camerti, Vol. Spec., 61-81.

Cantalamessa G., Centamore E., Cristallini C., Invernizzi C., Matteucci R., Micarelli A., Piccini M., Pontoni F. & Potetti M., 1987 - *Nuovi dati sulla geologia dell'area di P.to S. Giorgio (Marche meridionali).* Geol. Romana, **26**, 359-371.

Centamore E. & Deiana G. (Ed.), 1986 - *La geologia delle Marche.* Studi Geol. Camerti, Vol. Spec., 145 pp.

Coltorti M., 1994 - *The Pleistocene Basin of Gubbio (Central Italy): geomorphology, genesis and evolution.* In: C. Malone & S.Stoddart (Eds.), *The archaeological development of the Gubbio Basin.* Cambridge University Press, 17-25.

Coltorti M., Nanni T. & Rainone M., 1987 - *Il contributo delle scienze della terra nell'elaborazione di un piano paesistico: l'esempio del Monte Conero (Marche).* Mem. Soc. Geol. It., **37**, 629-647.

Coltorti M., Albianelli A., Bertini A., Ficarelli G., Laurenzi M., Napoleone G. & Torre D., 1997 (in stampa) - *The Colle Curti mammal site in the Colfiorito area (Umbria-Marchean Apennine, Italy): geomorphology, stratigraphy,paleomagnetism and palynology.* Quat. Internat.

Coltorti M., Pierantoni P.P. & Pieruccini P., 1995 - *I depositi fluvio-lacustri di Montebibico (M.ti Martani meridionali ed il loro significato nell'evoluzione tettonico-sedimentaria del Bacino Tiberino.* Studi Geol. Camerti, Vol. Spec., **1**, 305-315.

Coltorti M. & Farabollini P., 1995 - *Quaternary evolution of the Castelluccio di Norcia basin (Umbria-Marche apennines, Italy).* Il Quaternario, **8**(1), 149-166.

Coltorti M. & Pieruccini P., 1997 - *The southern East-Tiber Basin (Spoleto, Central Italy): geology and stratigraphy of the Plio-Pleistocene sediments.* Il Quaternario, questo volume.

Conti M. A. & Girotti O., 1978 - *Il Villafranchiano nel 'Lago Tiberino', ramo sud-occidentale: schema stratigrafico e tettonica.* Geol. Romana, **16**, 67-80.

Cosentino D., Scoppola C., Scrocca D. & Veccia P., 1992 - *Stile strutturale dei Monti Reatini e dei Monti Sabini settentrionali (Appennino Centrale) a confronto.* Studi Geol. Camerti, Vol. Spec., 1991/2, CROP 11, 55-62.

Damiani A.V., Minelli G. & Pialli G., 1991 - *L'unità Falterona-Trasimeno nell'area compresa tra la Val di Chiana e la Val Tiberina: sezione Terontola-Abbazia di Cassiano.* St. Geol. Camerti, Vol. Spec., CROP 03, 235-241.

Damiani A.V., Tuscano F. & Vecchia P., 1995 - *Assetto stratigrafico-strutturale del M.Subasio e delle circostanti successioni silico-clastichemioceniche (Umbria).* Studi Geol. Camerti, Vol. Spec., **1**, 349-359.

Davis W.M., 1889 - *The geographical cycle.* Geogr. J., **14**, 481-504.

Deiana G. & Pialli G., 1994 - *The structural provinces of the Umbro-Marchean Apennines.* Mem. Soc. Geol. It., **48**, 473-484.

Demangeot J., 1965 - Géomorfologie des Abruzzes adriatiques. Mem. et Docum. CNRS, 403 pp.

Dramis F., 1992 - *Il ruolo dei sollevamenti tettonici a largo raggio nella genesi del rilievo appenninico.* St. Geol. Camerti, Vol. Spec., **1**, 9-15.

Elter P., Giglia G., Tongiorgi M. & Trevisan L., 1975 - *Tensional and compressional areas in the recent (Tortonian to present) evolution of the Northern Apennines.* Boll. Geof. Teor. Appl., **65**(17), 13-19.

Federici P.R., 1978 - *La tettonica recente dell'Appennino: 2- il banco fluvio-lacustre di Pontremoli (Alta Val di Magra) e le sue implicazioni neotettoniche.* Gruppo Studio Quaternario Padano, Quad. n°4, 121-131.

Girotti O. & Piccardi E., 1994 - *Linee di riva del Pleistocene inferiore sul versante sinistro della media valle del fiume Tevere.* Il Quaternario, **7**, 525-536.

Lazzarotto A. & Liotta D., 1991 - *Structural features of the lignitiferous basin of Santa Barbara, Upper Valdarno area.* Boll. Soc. Geol. It., **110**, 459-467.

Liotta D. & Salvatorini G.F., 1994 - *Evoluzione sedimentaria e tettonica della parte centro-meridionale del bacino pliocenico di Radicofani.* Studi Geol. Camerti, Vol. Spec., **1**, 65-77.

Martini I.P. & Sagri M., 1993 - *Tectono-sedimentary characteristics of Late Miocene-Quaternary extensional basins of the Northern Apennines, Italy.* Earth Sci. Rev., **34**, 197-233.

Miall A.D., 1985 - *Architectural-element analysis: a new method of facies analysis applied to fluvial deposit.* Earth Sc. Rev., **22**, 261-308.

Ollier C.D., 1981 - *Tectonics and landforms.* Longman, London.

Ori G.G. & Friend P.F., 1984 - *Sedimentary basins formed and carried piggyback on active thrust sheets.* Geology, **12**, 475-478

Ori G.G., Roveri M. & Vannoni F., 1986 - *Plio-Pleistocene sedimentation in the Apenninic foredeep (central Adriatic Sea, Italy).* Spec. Publ. Int. Ass. Sediment., **8**, 183-198.

Raffy J., 1981 - *Orogenes et dislocations quaternaires du versant tyrrhenien des Abruzzes (Italie Centrale).* Revue Geol. Dinam. et Phys., **23**(1), 55-72

Raggi G., 1985 - *Neotettonica ed evoluzione paleogeografica plio-pleistocenica del bacino del fiume Magra.* Mem. Soc. Geol. It., **30**, 35-62.

Ricci Lucchi F., 1986 - *The Oligocene to Recent foreland basins of the northern Apennines.* Spec. Publs. Int. Ass. Sediment., **8**, 105-139.

Ricci Lucchi F., 1987 - *Semi-allochtonous sedimentation in the Apenninic thrust belt.* Sedim. Geol., **50**, 119-134.

Ms. ricevuto il: 13. 6. 1997
Inviato all'A. per la revisione il: 30. 8. 1997
Testo definitivo ricevuto il: 10. 11. 1997

Ms received: June 13, 1997
Sent to the A. for a revision: Aug. 30, 1997
Final text received: Nov. 10, 1997