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PLIO-PLEISTOCENE STRATIGRAPHY AND RELATIONS BETWEEN MARINE AND NON-MARINE SUCCESSIONS IN THE MIDDLE VALLEY OF THE TIBER RIVER (LATIUM, UMBRIA)

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ABSTRACT
The Middle Valley of the Tiber River (MVT) corresponds to the "Paglia-Tevere Graben", a "neoautochthonous" basin developed since the latest Early Pliocene. The basin is in part linked with the intrapenninic Tiberino and Rieti Basins to the east, and with the Roman Basin to the south. The filling is mostly made up of Plio-Pleistocene marine deposits, unconformably overlaying the meso-cenozoic substratum. Two outcropping 3rd order depositional sequences have been recognised: 1) the older is composed of Lower Pliocene-earliest Upper Pliocene shelfal clays and sands (*G. puncticulata* and *G. aemiliana* Chronozones) and rarer continental deposits; 2) the younger is late Gelasian-Santernian in age (*G. inflata* and *G. cariacoensis-B. elegans marginata* Chronozones) and mostly corresponds to the "Chiani-Tevere formation", composed of neritic clayey-sandy sediments interfingered with fluvial-deltaic gravelly-sandy deposits.
The correlation between marine and non-marine deposits is based both on physical-stratigraphic observations and data (lithostratigraphy, facies analysis, sequence stratigraphy) and on their integration with biostratigraphic (foraminifera) and magnetostratigraphic data and with the numerical values of the $^{87}Sr/^{86}Sr$ ratio measured on mollusc shells, for the marine deposits, and with biochronological data (fresh- and brackish-water molluscs and ostracods, mammals) for the non-marine and transitional deposits.
As for the younger successions from the latest Early Pleistocene to Holocene, which are characterised by travertines and gravelly fluvial terraced deposits, the correlation with the marine successions of the Roman Basin is indirect and mostly based on biochronology and on relations between sedimentary and volcanic units.

RIASSUNTO
La media valle del Fiume Tevere (MVT) tra Orvieto e Fiano rappresenta un'area ideale per lo studio delle correlazioni tra depositi marini e continentali Plio-Pleistocenici. Infatti essa corrisponde al "Bacino del Paglia-Tevere", a prevalente sedimentazione marina, parzialmente contiguo ad Est ai bacini intrappenninici di Rieti e Tiberino e al bacino romano a Sud. Viene intodotto un nuovo schema stratigrafico, che aggiorna il precedente di Ambrosetti et al. (1987) e pone in evidenza la presenza di cicli sedimentari di III e IV ordine controllati dall'evoluzione tettonico-regionale tramite fasi di subsidenza e di sollevamento. La correlabilità tra bacini si basa su: 1) dati stratigrafico-fisici ottenuti mediante rilevamenti litostratigrafici e analisi di facies; 2) biostratigrafia a foraminiferi; 3) biocronologia a mammiferi e molluschi continentali; 4) magnetostratigrafia delle successioni marine e datazioni Ar/Ar e K/Ar di unità vulcaniche; 5) nuovi dati stratigrafico-isotopici ottenuti mediante misure del rapporto $^{87}Sr/^{86}Sr$ su gusci di molluschi e idrozoi.
La fase di subsidenza è caratterizzata da due cicli sedimentari marino-continentali di III ordine. Il primo ciclo (tardo Zancleano-Gelasiano iniziale) è composto dai depositi terrigeni marini delle "unità di Fabro", "formazione di Tenaglie-Fosso San Martino" e "unità di Città della Pieve", cui localmente si intercalano sedimenti fluvio-lacustri. Il secondo ciclo (tardo Gelasiano-Santerniano) è caratterizzato dalla eteropia tra i depositi marini di piattaforma e transizionali della "formazione del Chiani-Tevere" e i depositi fluviali della "formazione di Santa Maria di Ciciliano" e della "formazione di Poggio Mirteto". In particolare all'interno della formazione marina, sono stati riconosciuti tre grandi episodi progradazionali intercalati a fasi trasgressive ed evidenziati dai sedimenti ghiaiosi deltizi dei "membri di Civitella San Paolo", "Torrita Tiberina", "Vasanello". Il primo episodio progradazionale ricade al passaggio Gelasiano-Santerniano, mentre i successivi sono di età Santerniana.
La fase regionale di sollevamento (Emiliano-Olocene) è caratterizzata dai depositi misti carbonatico-terrigeni della "unità di Giove" (Pleistocene Inferiore pp.), da vulcaniti, e dai depositi terrazzati fluviali ghiaioso-sabbiosi delle "unità di Civita Castellana" (Pleistocene Inferiore pp.-Pleistocene Medio pp.), "Graffignano" (Pleistocene Medio), "Rio Fratta" (tardo Pleistocene Medio) e "Sipicciano"(Pleistocene Superiore). Sulla base dei dati di terreno (biocronologia, rapporti con unità vulcaniche) e di interpretazioni paleogeografiche si ipotizzano correlazioni tra le unità continentali della MVT e le unità marino-transizionali dell'area romana, per il tardo Pleistocene Inferiore e l'inizio del Pleistocene Medio.

Keywords: Late Pliocene, Early Pleistocene, Latium, Umbria, stratigraphy, paleogeography, Sr isotope stratigraphy.

Parole chiave: Pliocene Superiore, Pleistocene Inferiore, Lazio, Umbria, stratigrafia, paleogeografia, stratigrafia isotopica dello Sr

1. INTRODUCTION

The middle Valley of the Tiber River (MVT) represents a good example of how to correlate marine with non-marine successions, using both direct field observations and analytical techniques like facies analysis, paleontologic and isotope-stratigraphic analyses and their integration, for chronologic and paleoevironmental purposes.

The MVT is located at the border between Latium and Umbria and widens up to 60 km, between the Orvieto and Fiano towns (Fig. 1). Structurally it corresponds to the "Paglia-Tevere Graben" (Funiciello *et al.*, 1981), a NNW-SSE trending extensional basin developed since the late Early Pliocene, in concomitance with the *Globorotalia puncticulata* Chronozone (Barberi *et al.*,

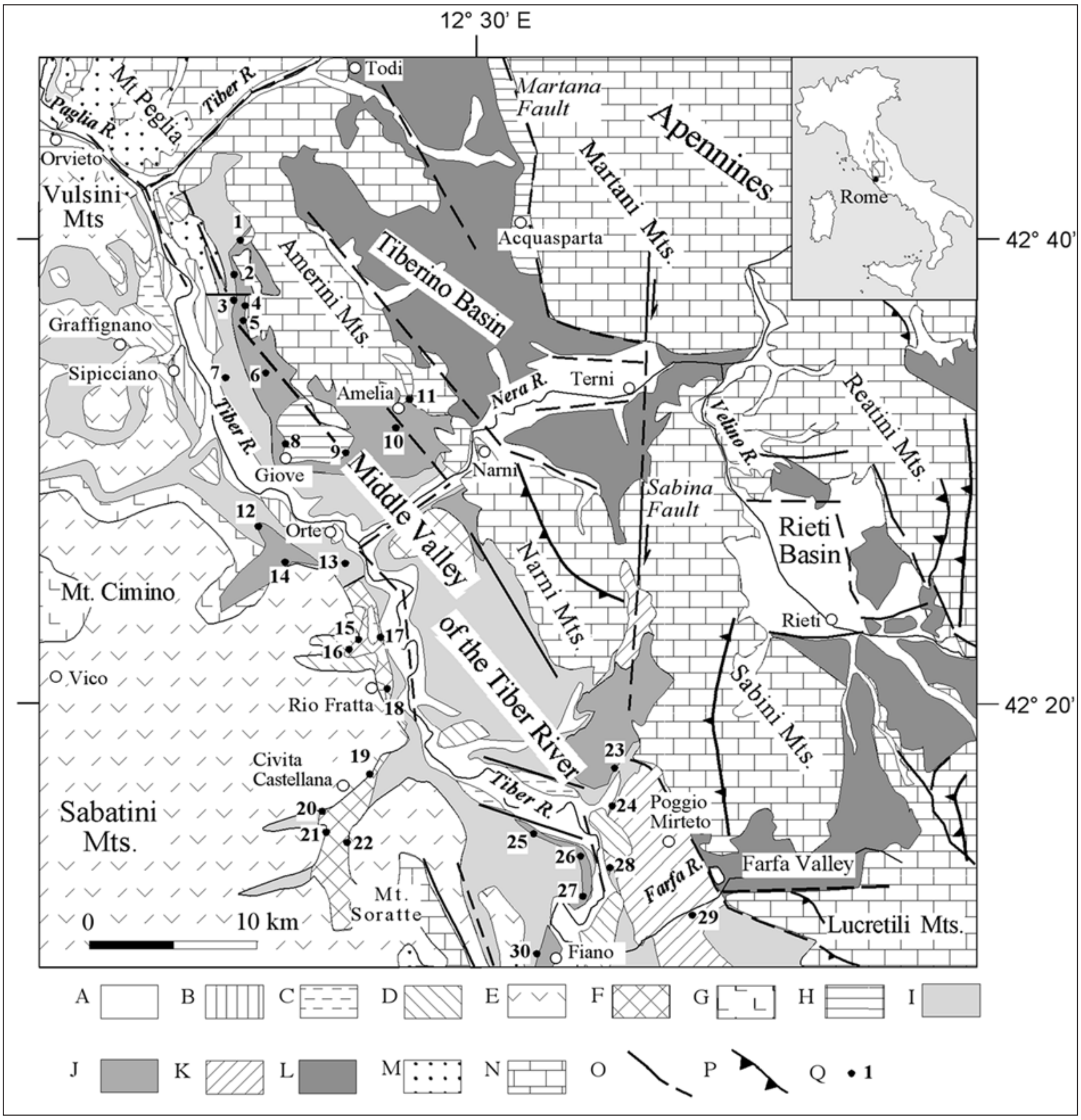


Fig. 1 - Geological map of the MVT. Legend: A) **Recent alluvial deposits** (Holocene). B) **Sipicciano unit**: IV order fluvial terrace of the Tiber River (Late Pleistocene). C) **Rio Fratta unit:** III order fluvial terrace (Middle Pleistocene). D) **Graffignano unit**: II order fluvial terrace (Middle Pleistocene). E) **Volcanic and volcano-sedimentary successions of the 2nd volcanic phase** (Middle Pleistocene). F) **Civita Castellana unit:** I order fluvial terrace (Early-Middle Pleistocene). G) **Pyroclastites and lavas of the 1st volcanic phase** (Early Pleistocene). H) **Giove and Acquasparta formations**: travertines (Early Pleistocene). I) **Chiani-Tevere formation**: marine, fine-grained terrigenous deposits (Late Pliocene-Early Pleistocene). J) **Chiani-Tevere formation**: transitional, coarse-grained terrigenous (**Civitella S. Paolo, Torrita Tiberina** and **Vasanello members**) and carbonatic deposits (Late Pliocene-Early Pleistocene). K) **Poggio Mirteto formation**: fluvial deposits (Late Pliocene-Early Pleistocene). L) **Intramontane lacustrine and alluvial deposits** (Middle Pliocene-Early Pleistocene). M) **Tenaglie-Fosso S. Martino formation**: marine deposits (Middle-Late Pliocene). N) **Carbonatic and siliciclastic successions** (Trias-Miocene). O) Normal fault. P) Thrust. Q) Stratigraphic log.

1994). It is bordered to the east by the Mt Peglia-Amerini-Narni-Sabini-Lucretili Mts ridge, where Triassic to Miocene marine, carbonatic and siliciclastic successions crop out. The western borders of the basin are the Castell'Azzara-Mt Razzano ridge (Barberi *et al.*, 1994), almost totally overlain by the Quaternary volcanites of the Vulsini, Cimini and Sabatini Mts volcanic districts, and the Mt Soratte horst. The basin is prevalently filled with Plio-Pleistocene marine terrigenous deposits. However, coeval non-marine and transitional terrigenous and carbonatic deposits extensively crop out along the western margin of the Mt Peglia-Lucretili Mts ridge (Ambrosetti *et al.*, 1987; Barberi *et al.*, 1994; Girotti & Piccardi, 1994), while Pleistocene volcano-sedimentary successions are well exposed west of the Tiber River (Fig. 1).

The present paper represents an update on the information about the Neogene-Quaternary stratigraphy of the MVT, both derived from the re-examinations of previously collected and published data and from new geological mapping and stratigraphic, sedimentologic and paleontologic analyses (Mancini, 2000; Mancini *et al.*, 2001). In particular this work deals with: 1) the introduction of a new stratigraphic scheme; 2) detailed analyses of the relationships among Late Pliocene-Early Pleistocene marine, transitional and non-marine deposits; 3) paleogeographic reconstructions of the MVT and surrounding areas during the Late Pliocene-earliest Middle Pleistocene.

2. PREVIOUS WORKS

The study of the relations between Plio-Pleistocene marine and non-marine deposits in the Umbria-Latium region was a topic for geologists since the late XIX century, with particular interest in the stratigraphic, paleontologic and geomorphic features (Tuccimei 1888; 1889; 1891; 1895; Clerici 1895; 1929). In fact the "Villafranchiano" stage was introduced for the first time in central Italy just in the MVT, near Poggio Mirteto (Tuccimei, 1889), after the discovery of a rich mammalian and molluscan fauna characterising that period (1). The non-marine deposits bearing such an assemblage were considered Pliocene in age and overlaying, with angular unconformity, "Astian" marine deposits (Tuccimei, 1888; 1895). On the other hand, Clerici (1895) disproved the angular unconformity proposing the lateral continuity between the Villafranchian and the marine deposits.

The heteropic relations between non-marine and marine deposits were recurrently considered in order to understand the geology of the Tiber River's valley and its surrounding areas. In particular, discoveries of marine and transitional sediments within fluvial and lacustrine successions near Terni (Terrenzi, 1886) and Todi (Principi, 1922), based on malacological observations, should be mentioned. Therefore, the possibility of correlating marine and non-marine deposits was later put in evidence by discoveries of fresh-water molluscs and mammals within marine and nearshore successions and of brackish-water assemblages into non-marine successions, in particular in the roman area (Bonadonna, 1968; Girotti, 1972) and in the south-western Tiberino Basin (Ippolito 1947; Girotti, 1967; Conti & Girotti, 1977; Ambrosetti *et al.*, 1987), which are laterally continuous to the MVT southward and eastward respectively.

Progress in the stratigraphical knowledge of the MVT, mainly due to micropaleontological studies (Ambrosetti *et al.*, 1987; Buonasorte *et al.*, 1991), led to the introduction of two marine sedimentary cycles (Fig. 2): 1) the first cycle developed during the latest Early Pliocene and the earliest Late Pliocene, between the *G. puncticulata* and *G. aemiliana* zones. It includes the "Argille di Fabro", the "Sabbie a Flabellipecten" and the "Conglomerato di Città della Pieve" units (Ambrosetti *et al.*, 1987). 2) The second cycle is chronologically limited to the Santernian and corresponds to the "Argille sabbiose del Chiani-Tevere" unit (asCT), which indicates marine and brackish-water environments, laterally continuous with the "Complesso argilloso-sabbioso" unit (cas), of fluvial and lacustrine environment (Ambrosetti *et al.*, 1987). The two cycles are separated by an unconformity of regional importance known as the "Fase erosiva dell'Acquatraversa" (Bonadonna, 1968) coinciding with the *G. inflata* zone.

As a result of the new stratigraphic setting and mapping, most of the marine deposits, previously thought of Pliocene age, are actually Early Pleistocene, while the heteropic relations among fully marine, transitional and non-marine units were detected only within the second sedimentary cycle (Ambrosetti *et al.*, 1987; Piccardi, 1993).

3. METHODOLOGY

Thirty surface stratigraphic sections (Fig. 1) have been analysed using the standard methods of field geology and facies analysis (Miall, 2000), examining in particular their lithologic, textural and paleontologic features.

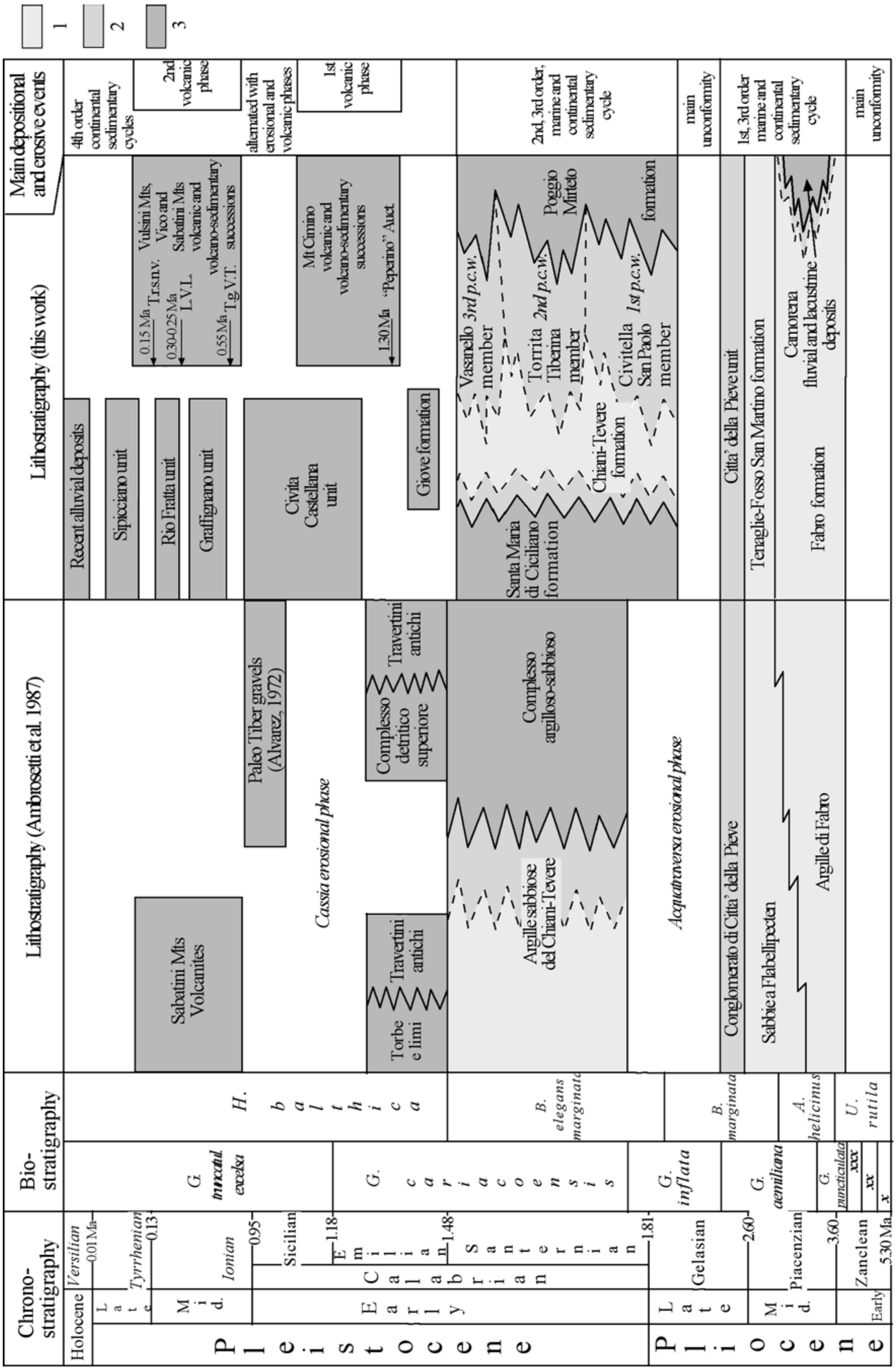
Micropaleontologic data have been obtained by collecting 73 samples of pelite or sand (Mancini, 2000), for qualitative analyses on micro-molluscs and forams, and have been added to the bibliographic data about the same topic (Ambrosetti *et al.*, 1987; Carboni *et al.*, 1993; Piccardi, 1993; Di Bella, 1994; Carboni & Di Bella, 1994; Carboni & Di Bella, 1996; Ciangherotti *et al.*, 1998). Each sample, having a 200 cm^3 volume, was treated with a H_2O and H_2O_2 solution, and washed through a 125 μm sieve. The >125 μm size fraction of the wash residue was considered for the collection and recognition of the microfauna; up to 300 specimens for sample were counted. The biostratigraphic scheme used is from Cita (1975) and Iaccarino (1985), while the chronostratigraphic scheme is based on Sprovieri (1993) and Cita & Castradori (1995).

Twelve measures of the $^{87}Sr/^{86}Sr$ ratio on fragments of marine molluscs and hydrozoa have been carried out by Prof. Mario Barbieri, at the "Istituto di Geologia Ambientale e Geoingegneria" (CNR-Rome), for chronostratigraphic purposes; the analytical method is described in Barbieri *et al.* (1998).

Several radiometric (Arias *et al.*, 1980; Borghetti *et al.*, 1981; Sollevanti, 1983; Laurenzi & Villa, 1987; Cioni *et al.*, 1993; Barberi *et al.*, 1994; Perini *et al.*, 1997) and magnetostratigraphic (Florindo & Sagnotti, 1995; Borzi *et al.*, 1998) data were used to directly date several volcanic and sedimentary units.

4. STATIGRAPHIC SETTING OF THE MVT

The sedimentary units decribed below are of the lithostratigraphic and of the UBSU type (Salvador, 1994). In part they have already been introduced, while the others are presented here for the first time; in both cases they are going to be formalised. Such units are separated on the basis of their ages, also considering the sedimentary cyclicity previously introduced (Ambrosetti *et al.*, 1987; Bossio *et al.*, 1998) and the regional geological evolution with reference to the Latial volcanism and its cyclicity (Barberi *et al.*, 1994; Mancini, 2000). Consequently, these units are grouped into: latest Early Pliocene-earliest Late Pliocene units, latest Late



x = *Sphaerodinellopsis*, *xx* = *G. margaritae*; *xxx* = *G. margaritae/G. puncticulata*, *p.c.w.* = prograding clastic wedge ("*cuneo clastico progradante*").

T.g.V.T.=*Tufo giallo della Via Tiberina*, L.V.L.= Lake Vico lava flows (*Lave del Lago di Vico*), T.r.s.n.v.= *Tufo rosso a scorie nere*

1 = marine deposits (*depositi di ambiente marino*); 2 = transitional deposits (*depositi di ambiente di transizione*); 3 = non-marine deposits (*depositi continentali*)

Fig. 2 - Stratigraphic scheme of the MVT

Pliocene-earliest Early Pleistocene units, middle Early Pleistocene-earliest Middle Pleistocene units, Middle Pleistocene-Holocene units.

4.1. Latest Early Pliocene-earliest Late Pliocene units

These units crop out along the western margin of the Mt Peglia and of the northern Amerini Mts, south of Orvieto, and near the Mt Soratte (Fig. 1). They constitute the first MVT "neoautochthonous" sedimentary cycle and are: the *Fabro formation*, the *Tenaglie-Fosso San Martino formation* and the *Città della Pieve unit.*

4.1.1. The Fabro formation

The Fabro formation, already known as *Argille di Fabro* (Ambrosetti *et al.*, 1987), crops out in the northernmost MVT along the Paglia River banks. It is composed of blue-grey, marine, sandy clays, mostly massive or tabular bedded. The strata, which are tectonically tilted, gently dip toward east, 8-10°. The thickness of the formation is up to 100 metres. The malacologic content, which was fully detailed by Malatesta (1974), indicates the neritic circalittoral stage. The presence of *G. puncticulata* and *G. aemiliana* is indicative of the Early-Middle Pliocene age.

Non-marine and presumably transitional deposits were recently discovered near Orvieto, in the Camorena site (Barberi *et al.*, 1994), and near Fabro (Petronio *et al.*, in press). These deposits are interlayered with the marine ones, at the base of the *G. aemiliana* zone (about 3.0 Ma). The malacologic content suggests that such sediments are of fluvial and lacustrine environments and of Early Villafranchian age (2) (Ciangherotti *et al.*, 1998; Petronio *et al.*, in press).

4.1.2. The Tenaglie-Fosso San Martino formation

The Tenaglie-Fosso San Martino formation crops out in the Mt Peglia and northern Amerini Mts areas, where it corresponds to the *Sabbie a Flabellipecten* formation (Ambrosetti *et al.*, 1987), and west of Mt Soratte. It unconformably overlays the Meso-Cenozoic substratum, vertically continuous above the Fabro formation. Its maximum thickness is up to 200 m.

The formation is commonly composed of massive or tabular stratified sands, in some cases well cemented by calcium carbonate. Structures like hummocky and swaley cross stratification and gravelly lenses, few metres thick, are common. In the Mt Soratte area the sands laterally pass to well cemented, oligomittic, poorly sorted conglomerates and breccias, almost exclusively calcareous. The clast size ranges from a few centimetres up to 1 metre.

The paleontologic content is very rich and composed of *Pecten (Flabellipecten) flabelliformis, Chlamys (Gigantopecten) latissima, Terebratula ampulla, Ostrea* spp., Balanidae, Bryozoa and Rhodophyceae. The foraminifer assemblage is characterised by *G. aemiliana, Bulimina marginata* and *Amphistegina* spp., typical of the late Middle Pliocene and of the earliest Late Pliocene. The sedimentologic and paleontologic data indicate the shoreface and the offshore-shoreface transition environments.

4.1.3. The Città della Pieve unit

This unit, already known as *Conglomerato di Città della Pieve* (Ambrosetti *et al.*, 1987), crops out in few sites of the northern MVT. It is composed of well cemented cobblestones, up to 10 metres thick, conformably overlaying the Tenaglie-Fosso San Martino formation. These rudites are interpreted as gravelly beach deposits (Ambrosetti *et al.*, 1987).

4.2. The latest Late Pliocene-earliest Early Pleisto-cene units

Such units, which form the second "neoautochthonous" marine and non-marine cycle, widely crop out in the entire MVT. The units described below are: the *Chiani-Tevere formation,* the *Poggio Mirteto formation* and the *Santa Maria di Ciciliano formation*.

4.2.1. The Chiani-Tevere formation

The Chiani-Tevere formation, which corresponds to the *Argille sabbiose del Chiani-Tevere* (Ambrosetti *et al.*, 1987), is composed of marine, transitional and more limited non-marine deposits. It unconformably overlays the Tenaglie-Fosso San Martino formation and the Meso-Cenozoic substratum (Fig. 3). Its maximum thickness in outcrop is up to 350 m, but as the base rarely crops out the formation may be thicker.

The marine deposits are composed of blue-grey sandy clays, commonly massive or planar bedded, vertically passing to massive sandy silts and fine silty sands, where structures like hummocky cross stratification and turbiditic beds are common. Such fine lithofacies vertically pass to coarse grained sands, with frequent amalgamated hummocky and swaley cross stratifications and trace fossils like *Scolicia* and *Thalassinoides*. Strata are commonly sub-horizontal. The entire succession of lithofacies described above, which is well exposed in the northern MVT, indicates a regressive trend from inner shelf to shoreface deposits (Mancini, 2000).

East of Mt Soratte a few metres thick, bioclastic calcarenitic level (Fig. 4), almost totally composed of chaotically amalgamated nearshore molluscs, echinids and corals, and well rounded pebbles, covers the underlaying coastal and fluvial deposits (see the discussion below). It is interpreted as a transgressive lag deposit, which is laterally continuous to the cemented sands, very rich in forams, that crop out at Vallericca (Carboni *et al.*, 1993) few km far from the MVT southward (Fig. 4). Still in the Vallericca section, a several decimetres thick horizon of resedimented pyroclastites also crops out (Arias *et al.*, 1980) (Fig. 4), which is placed within the *B. marginata* zone (Carboni *et al.,* 1993). This level is dated 2.1 ± 0.2 Ma by fission track analyses on volcanic glass shards (Arias *et al.*, 1980), and 1.8 ± 0.3 Ma by analyses on zircons (Arias *et al.*, 1990). Furthermore, recent magneto-stratigraphic analyses (Florindo & Sagnotti, 1995; Borzi *et al.* 1998), carried out several metres above and below the volcanoclastic level, suggest that the investigated section may be placed at the C2r.1r polarity subchron of the Geomagnetic Polarity Time Scale (Cande & Kent, 1992), between the Reunion and Olduvai subchrons. This horizon is the only dated layer and one of the lowermost outcropping beds of the formation.

The microfauna is abundant and contains: *Bulimina marginata* and *Globorotalia inflata*, only found in the lower part of the formation (Piccardi, 1993; Carboni & Di Bella, 1996), and *Bulimina elegans marginata, Bulimina etnea, Cassidulina carinata, Valvulinerina bradyana, Bolivina alata, Uvigerina peregrina, Globigerina cariacoensis, Globigerinoides tenellus, Globigerina calabra,*

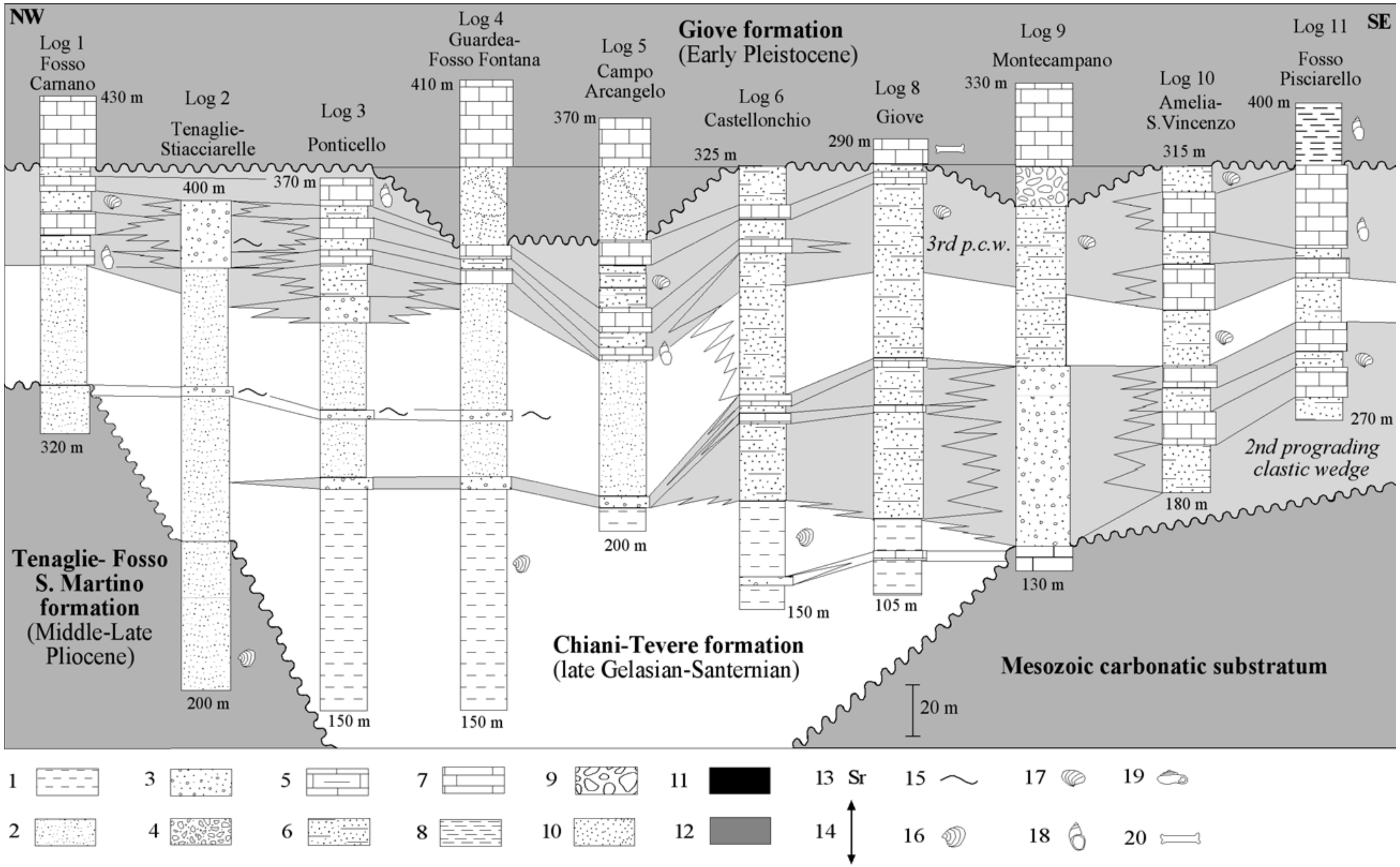


Fig. 3 – Stratigraphic and sedimentologic relationships among plio-pleistocene marine, transitional and non-marine deposits along the western margin of the Amerini Mts. Legend (symbols are the same as in figures 4 and 5): 1 = transition offshore-shoreface sandy silts and offshore clays; 2 = upper and lower shoreface sands; 3 = prograding beach gravels; 4 = bioclastic calcarenitic level; 5 = cemented carbonatic sands; 6 = lagoonal and delta-front sandy clays; 7 = travertines; 8 = lacustrine and floodplain clays; 9 = fluvial cross bedded gravels; 10 = fluvial cross bedded sands; 11 = lignite; 12 = pyroclastites; 13 = molluscs sampled for isotopic analyses; 14 = section investigated for magneto-stratigraphic analyses; 15 = Lithophaga borings; 16 = marine molluscs; 17 = brackish water molluscs; 18 = fresh water molluscs; 19 = land snails; 20 = vertebrate remains.

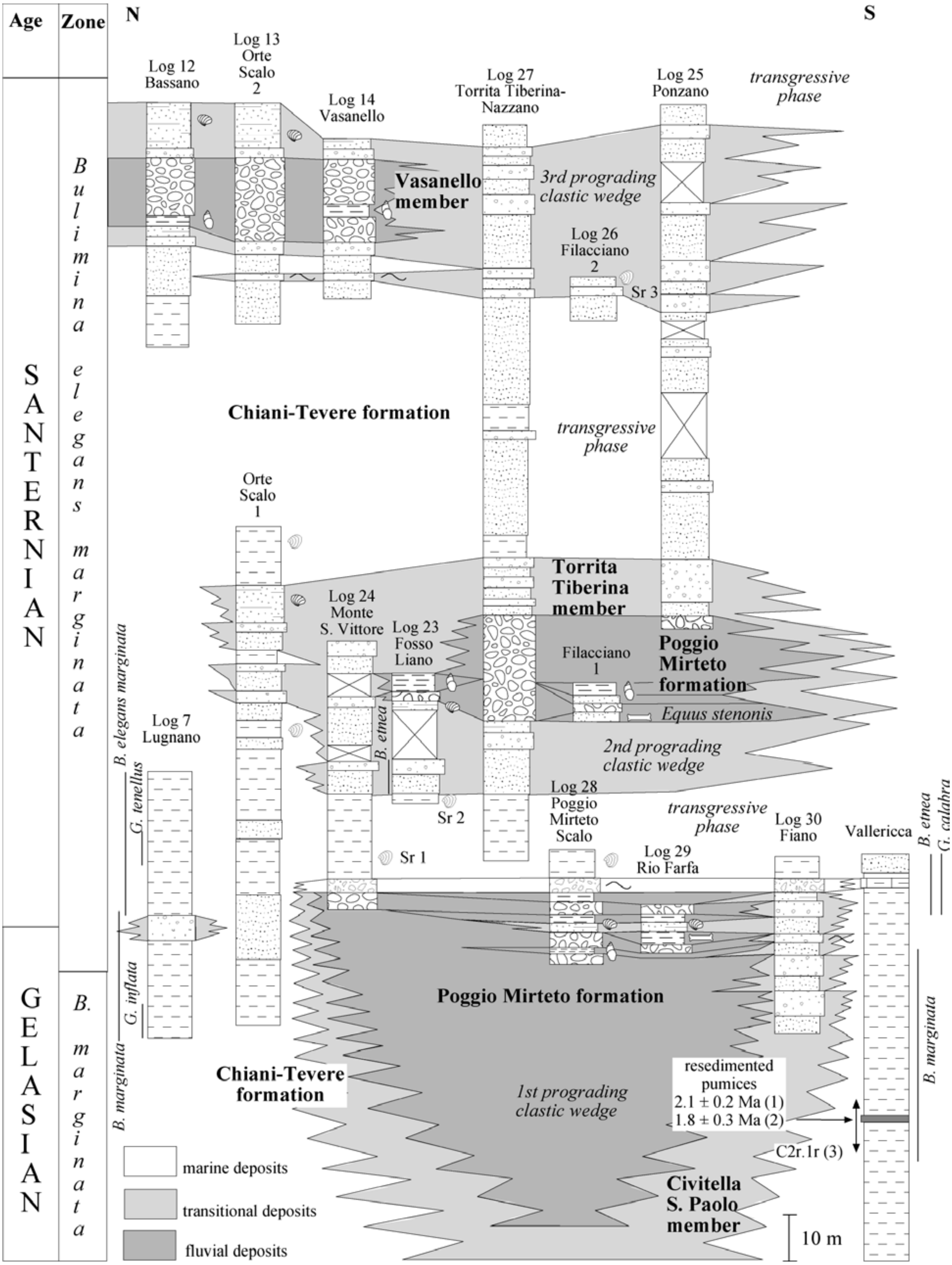


Fig. 4 - Stratigraphic and sedimentologic relationships among marine, transitional and fluvial deposits in the central and southern part of the MVT. (1) = data after Arias et al. (1980); (2) = Arias et al. (1990); (3) = Florindo & Sagnotti (1995).

Globigerina aff. *calida calida* (Carboni *et al*., 1993; Di Bella, 1994; Carboni & Di Bella, 1994; Mancini, 2000). It indicates the late Gelasian-Santernian age, in concomitance with the *G. inflata-G.* cariacoensis and the *B. marginata-B elegans marginata* zones. The macrofauna is characterised by *Corbula (Vericorbula) gibba, Natica tigrina, Archimediella spirata, Amyclina semistriata, Sinodia brocchii, Panopaea glycimeris, Venus (Ventricoloidaea) multilamella, Pinna tetragona, Cladocora coespitosa* (Piccardi, 1993; Mancini, 2000).

The analysis of the $^{87}Sr/^{86}Sr$ ratio carried out on several fragments of molluscs and hydrozoa (Mancini, 2000) provided numerical values between 0.709068 and 0.709083 (Tab. 1), which correspond to 1.5 and 1.7 Ma.

The Chiani-Tevere formation's transitional and non-marine deposits extensively crop out along the eastern sector of the basin and are represented by the lithofacies assemblages described below.

1) *Fine clayey sands of brackish-water environment.* These deposits are widespread along the western margin of the Amerini-Narni Mts and correspond to the "facies salmastra" of the "asCT" (Am-brosetti *et al*., 1987). They are mainly composed of tabular stratified sands, which are laterally continuous westward to marine pelitic sands, and to the sandy fluvial deposits of the Santa Ma-ria di Ciciliano formation (see below) to the east. A rich brackish water fauna has been found: *Cera-stoderma glaucum, Bittium deshayesi, Potamides tricinctus, Thericium vulgatum, Anadara darwini, Trunculariopsis truncula conglobata, Ammonia tepida*. Such deposits may be considered of the delta front environment (Mancini, 2000).
2) *Travertines and calcareous silts*. These non-marine deposits crop out near the top of the formation and commonly overlay the carbonatic substratum. They constitute tabular or lenticular bodies, few metres to several decametres thick (Fig. 3), that are alternated with the brackish-water clayey sands. These lithofacies are rich in Late Villafranchian fresh water molluscs and pulmonates like *Melanopsis affinis, Theodoxus groyanus, Viviparus belluccii, Emmericia umbra, Neumayria priscillae, Bithynia tentaculata, B. leachi, Micromelania (Goniochilus) zitteli, Prososthenia meneghiniana, Valvata cristata.*
3) *Cross bedded coarse grained sands alternated with clinostratified gravels*. They are coarsening-up alternances of sands and gravels interpreted as parasequences, marked at the base by a flooding surface. Each parasequence is generally 2 to 10 metres thick. The lower sands are cross bedded and of the shoreface environment; they vertically and landward pass to clinostratified, westward prograding gravels, overlain by planar bedded gravels of the beachface environment (Massari & Parea, 1988). Rarely at the top, thin horizons of massive clay bearing brackish water molluscs have been found. The gravels are commonly well sorted, rich in sandy matrix and composed of well rounded calcareous, cherty and arenaceous cobbles and pebbles; in many cases the clasts are perforated by *Lithophaga*. Balanids, *Anomia ephippium*, and *Ostrea* spp. are the most frequent fossils.
Three, very thick (50 to 100 metres), gravelly-sandy bodies, composed of several vertically stacked parasequences, crop out in the Orte-Amelia area and east of Mt Soratte. Each of them represents a set of parasequences that interfingers with the nearshore marine deposits to the west and with fluvial deposits to the east. They correspond to the *Civitella San Paolo member*, the *Torrita Tiberina member* and the *Vasanello member* (Figs. 2, 4).
4) *Cross bedded talus*. These deposits crop out at the

Tab. 1

	Site	Altitude	Latitude N	Longitude (E of Monte Mario)	specie	numerical valu
Sr 1	Monte S. Vittore (Poggio Mirteto)	80 m	42° 16’ 06”	0° 11’ 30”	*Venus multilamella*	0.709075
					V. multilamella	0.709075
					Amyclina semistriata	0.709083
					Panopaea glycimeris	0.709082
Sr 2	Fosso Liano (Cantalupo)	102 m	42° 17’ 32”	0° 11’ 33”	*Sinodia brocchii*	0.709078
Sr 3	S. Egidio (Filacciano)	155 m	42° 15’ 21”	0° 09’ 14”	*Callista italica*	0.709073
Sr 4	Monte Coci (Faleria)	188 m	42° 14’ 12”	0° 00’ 25”	*Cladocora coespitosa*	0.709075
Sr 5	Monte Ulivo (Calcata)	90 m	42° 14’ 39”	0° 02’ 44” (W of MM)	*Natica tigrina*	0.709068
					Archimediella spirata	0.709080
					N. tigrina	0.709073
					A. semistriata	0.709075
					A. spirata	0.709072

top of the formation in several sites along the western margin of the Amerini-Lucretili Mts, where they ovelay the Mesozoic substratum and are in part covered by nearshore sands. This lithofacies is composed of poorly sorted rudites, rich in sandy and clayey matrix, and subangular clasts. The depositional architecture is characterised by alternated channelized and tabular bodies, seaward interfingering with the marine and transitional sands. The total thickness ranges between 50 and 80 metres. Such deposits are interpreted as fan-delta deposits (Girotti & Piccardi, 1994; Mancini *et al*., 2001).

5) *Breccias and conglomerates with abundant sandy-clayey matrix.* They are poorly sorted rudites, with subangular clasts commonly borrowed by *Lithophaga*. Such rudites crop out in many sites of the Amerini-Lucretili Mts western margin, directly onlapping the Meso-Cenozoic substratum, and laterally continuous seaward to shoreface sands. They are interpreted as transgressive beach deposits and cliff breccias (Girotti & Piccardi, 1994).

4.2.2. The Poggio Mirteto formation

The Poggio Mirteto formation is heteropic to the Chiani-Tevere formation's transitional deposits. It crops out in the south-eastern MVT along the western margin of the Sabini Mts and in the lower Farfa River valley, areas historically known as *Valli sabine* (Tuccimei, 1889).

The formation is up to 300 m thick and is composed of cross bedded, well sorted gravels, alternated with lenses of trough cross stratified silty sands. At a large scale the gravels and sands are arranged into multistorey-multilateral channel-bodies and are interpreted as fluvial deposits filling active channels. They are also interbedded with tabular bodies of massive or thinly laminated clays, the thickness of which ranges between 1 and 20 m. The clays, which commonly contain lignite, may be interpreted as fluvial-overbank or lacustrine deposits.

Such fine sediments are rich in fresh water molluscs like *M. affinis, T. groyanus, Viviparus ampullaceus, Prososthenia etrusca, P. meneghiniana, Negulus villafranchianus, E. umbra, M. (G.) zitteli, Belgrandia* sp. (Ciangherotti *et al*., 1998; Mancini, 2000; Petronio *et al*., in press); in several cases sandy and clayey horizons that bear brackish water molluscs have been found (see logs 28 and 29 in Fig. 4). Vertebrate fossils are rarer: few remains of *Equus stenonis* were discovered at Filacciano (Di Bella, 1995) (Fig. 4), Bocchignano and Castel S. Pietro (Tuccimei, 1891, 1893), and bones of *Anancus arvernensis* and *Stephanorinus etruscus* at Castel S. Pietro (Tuccimei, 1891; Petronio *et al*., in press). The malacologic and mammal content indicates the Olivola-Tasso Faunal Units (Ciangherotti *et al*., 1998; Petronio *et al*., in press).

4.2.3. Santa Maria di Ciciliano formation

The Santa Maria di Ciciliano formation (Basilici, 1993) crops out very limitedly in the Amelia-Narni area, where the MVT basin is directly linked with the south-western branch of the Tiberino Basin. This formation is composed of cross bedded silty sands, that laterally pass to the transitional sands of the Chiani-Tevere formation. More detailed data are dealt with in Ambrosetti *et al.* (1995).

4.3. The middle Early Pleistocene –earliest Middle Pleistocene units

The units of this period are in the chronological order: the *Giove formation*, the *Mt Cimino volcanic and volcano-sedimentary successions*, the *Civita Castellana unit*.

4.3.1. The Giove formation

The Giove formation limitedly crops out along the western margin of the Amerini Mts, where it corresponds to the *travertini antichi* (Ambrosetti *et al*., 1987). It unconformably overlays the Chiani-Tevere formation and laterally rests on the Meso-Cenozoic substratum.

Its base is generally subplanar, although it is locally incised for a few tens of metres into the Chiani-Tevere formation (see logs 4, 5 and 9, in Fig. 3). Its planar top surface gently dips toward SW from 350 to 280 metres a.s.l., providing a terraced appearence to the formation. The maximum thickness is 60 m.

The lower part of the Giove formation, which is 25 m thick, is composed of cross bedded, calcareous or quartz-bearing sands and gravels, commonly cemented by calcium carbonate and interspersed with lenses of travertines. Such mixed carbonatic and silicilcastic facies vertically pass to thick layers of well cemented travertines or, more rarely (see log 11, Fig. 3), to planar bedded calcareous silts bearing *V. belluccii, M. affinis, T. groyanus, Carychium minimum, E. umbra, Hauffenia minuta, Bithynia* spp., *Lymnaea* spp. (Piccardi, 1993). At Bandita di Giove (see log 8, Fig. 3) several remains of Late Villafranchian mammals have been found (Petronio *et al*., in press): *Stephanorhinus etruscus, Leptobos* sp., Elephantidae indet..

The sedimentologic and paleontologic data indicate that the Giove formation deposited firstly in a fluvial environment of relatively high energy, and successively in little lakes and swamps dominated by carbonatic production. The probable age is middle Early Pleistocene.

4.3.2. The Mt Cimino volcanic and volcano-sedimentary successions

These deposits crop out in the western bank of the Tiber River near Orte and Viterbo. They form a wide tabular body with undulate base placed at 200 to 220 metres a.s.l., about 150 m above the modern Tiber River's plain. They are mostly riodacitic pyroclastic flow deposits, locally interlayered with lavas and travertines. The maximum thickness exceedes 100 m.

The activity of the Mt Cimino Complex ranges between 1.35 and 0.95 Ma (Borghetti *et al*., 1981; Sollevanti, 1983), and the most widespread formation is the "Peperino" formation Auct., a 1.30 Ma old latitic ignimbrite (Barberi *et al*., 1994).

4.3.3. The Civita Castellana unit

The Civita Castellana unit partly corresponds to the *Paleotiber gravels* (Alvarez 1972; 1973). It is an unconformity-bounded unit, mostly composed of fluvial gravels (Mancini, 2000) overlaying the Chiani-Tevere formation; its unconformable base may be correlated to the "Cassia erosional phase" (Bonadonna, 1968; Alvarez, 1972). No direct stratigraphic relationships with the Giove formation and the Mt Cimino volcanites are evident.

In the northern MVT as far as Orte, this unit forms the highest fluvial terraced deposits, which represents the I order terrace of the Tiber River. Its tread gently decreases southward from 280 to 170 metres a.s.l., while the thickness is up to 80 m. South of Orte and west of the Mt Soratte the Civita Castellana unit fills a deep incision carved into the Chiani-Tevere formation (Fig. 5); there, the base is at 50 metres a.s.l. and the thickness reaches 120 m.

The most frequent lithofacies are tabular and cross bedded gravels (Gh, Gt and Gp facies sensu Miall (1996)), while trough cross-bedded sands are rarer. The gravels, in general well rounded and lamellar or discoidal in shape, are mainly of calcareous nature, although arenaceous and siliceous clasts are also present. Frequent imbricate structures indicate prevalent southward-directed flows. The sandy matrix is abundant and rich in quartz and muscovite, although the calcite may locally dominate. In some cases the sandy lenses are rich in biotite and sanidine, probably supplied after the erosion of the Mt Cimino volcanites; furthermore volcanic clasts belonging to the Peperino formation were also found (Brandi *et al.*, 1970).

The textural data and the depositional architecture, which shows multistorey-multilateral channel bodies, suggest that the Civita Castellana unit was deposited in a braidplain environment. The gravels and sands are rarely interbedded with few metres thick, tabular or lenticular, pelitic beds of the floodplain environment (Fig. 5), and with travertines, lignites and buried paleosols. The pelitic levels are rich in fresh water molluscs like *Valvata piscinalis, Bithynia* spp., *Planorbis planorbis* and more rarely *M. affinis* and T. *groyanus* (logs 18 and 21, Fig. 5), characteristic of the Early Pleistocene. In the lowermost part of the formation few remains of *Bison* cfr. *B. degiulii*, which indicates the Farneta and Pirro Faunal Units (latest Late Villafranchian) (Gliozzi *et al.*, 1997; Di Stefano *et al.*, 1998), have been discovered (log 18, Fig. 5).

This unit is late Early Pleistocene-earliest Middle Pleistocene in age, as it is overlain by the initial products of the Vulsini and Sabatini Mts volcanic complexes, placed at around 600-500 ka (Barberi *et al.*, 1994).

4.4. The Middle Pleistocene-Holocene units

A staircase of fluvial terraced deposits borders the modern course of the Tiber River. The *Graffignano unit* (Middle Pleistocene), *Rio Fratta unit* (late Middle Pleistocene), *Sipicciano unit* (Late Pleistocene) and the *recent alluvial deposits* (Holocene) (Figs 1 and 2) represent the II, III and IV order terraces. Their respective treads decrease southward: 1) from 210 to 65 m a.s.l.; 2) from 150 to 40 m a.s.l.; 3) from 100 to 35 m a.s.l.; 4)

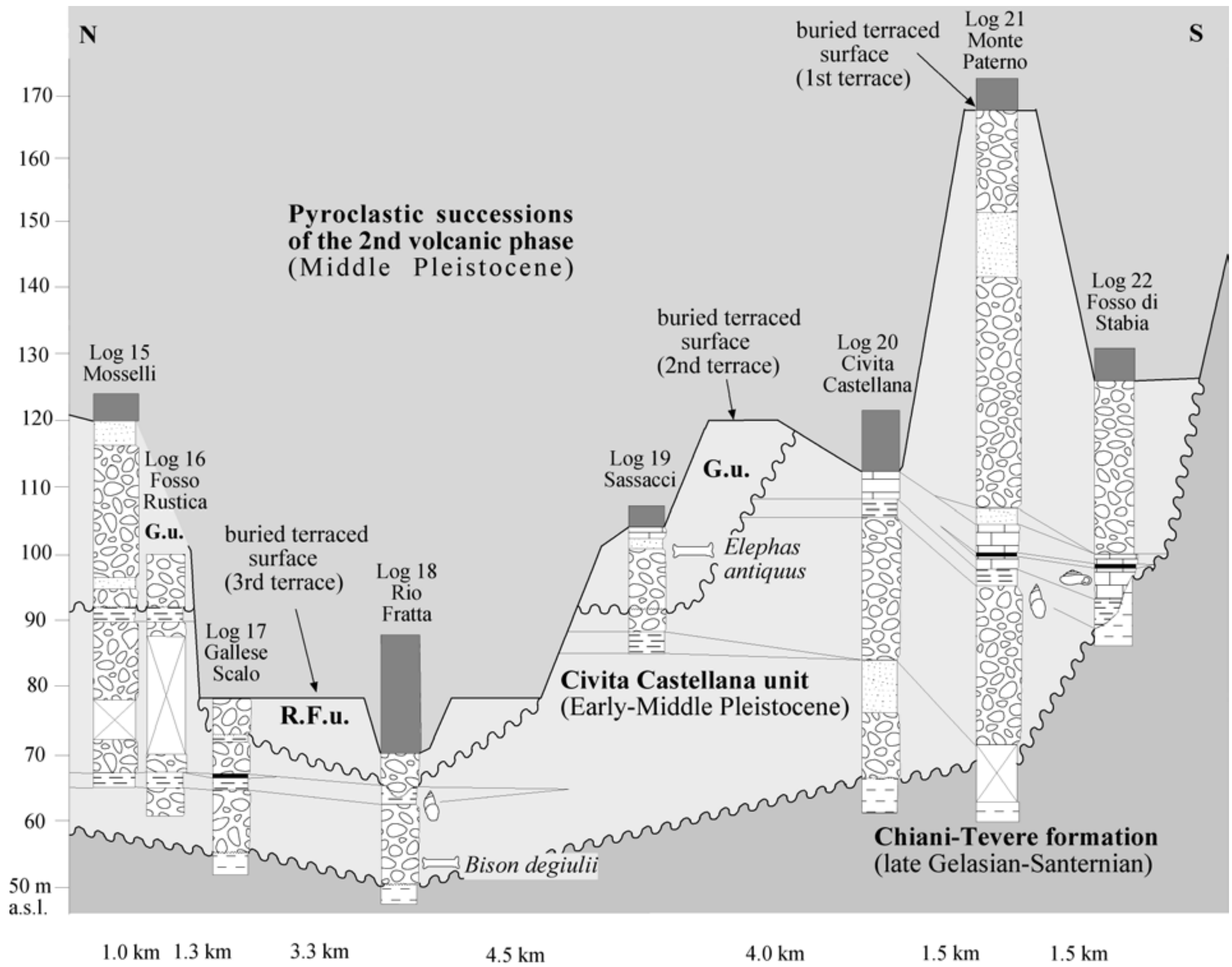


Fig. 5 - Stratigraphic relationships among Pleistocene fluvial deposits in the western part of the MVT. G.u. = Graffignano unit; R.F.u. = Rio Fratta unit.

from 70 to 25 m a.s.l. All the terraced deposits are mostly composed of cross bedded gravels and sands of the braided river environment; overbank deposits, paleosols and travertines are less frequent.

The *volcanic and volcano-sedimentary successions of the Vulsini Mts, Vico and Sabatini Mts* are widely exposed along the western bank of the Tiber, and are mainly composed of pyroclastites interbedded with lavas and travertines. The stratigraphic relationships between some dated volcanic formations and the terraced deposits provide a fairly precise chronological framework for the fluvial units (Mancini, 2000) (Fig. 2). The Graffignano unit, indeed, is more recent than the *Tufo giallo della Via Tiberina formation*, dated 550 ± 10 ka (Cioni *et al.*, 1993), but it precedes the *Lake Vico lava Formation* (Perini *et al.*, 1997), with ages between 305 ± 9 e 258 ± 2 ka. The Rio Fratta unit is younger than the above mentioned lavas, but it is older than the *Tufo rosso a scorie nere vicano formation*, 151 ± 3 ka old (Laurenzi & Villa, 1987). Finally, the Sipicciano unit is younger than the Tufo rosso a scorie nere vicano formation.

5. DISCUSSION

5.1. Inferences on sedimentary cyclicity during the Pliocene and the earliest Early Pleistocene.

The sedimentary units of the MVT are separated into two main groups. 1) The first group spans from late Zanclean to Santernian and is characterised by the preponderance of marine deposits on transitional and continental ones. It represents a subsidence-dominated stratigraphic domain as the basin fill occurred during phases of subsidence (Ambrosetti *et al.*, 1987; Barberi *et al.*, 1994; Bossio *et al.*, 1998). 2) The second group, which ranges from middle Early Pleistocene to Holocene, is solely characterized by terraced continental deposits interlayered with volcanic and volcano-sedimentary successions, and indicates an uplift-dominated stratigraphic domain.

The subsidence-dominated domain is composed of the two main marine-non-marine cycles described above (Fig. 2): 1) the first cycle (late Zanclean-early Gelasian), which started at about 3.6 Ma, corresponds to the I and II sedimentary cycles described in Barberi *et al.* (1994) and to the P2 and P3 units of Bossio *et al.* (1998), spanning 1.2-1.3 Ma; 2) the second cycle corresponds to the III cycle of Barberi *et al.* (1994) and to the unit Q1 (Bossio *et al.*, 1998). It spans 0.65 Ma (Bossio *et al.*, 1998) and probably began at 2.1 Ma. The first cycle is up to 300 m thick, while the second cycle is 350 m thick. The time spans and thicknesses therefore suggest that the two cycles may be considered as III order depositional sequences (Vail *et al.*, 1990).

The Acquatraversa erosional phase, which separates the two cycles, spans 0.2-0.3 Ma (Bossio *et al.*, 1998). The related unconformable surface indicates a sea level drop probably due to local infra-Gelasian tectonism, that caused the emersion and the eastward tilting of I cycle's units, in the northern MVT and near Mt Soratte. The Acquatraversa erosional phase may also be correlated to the global eustatic sea level fall that occurred at 2.4 Ma, when a major event of cooling was recorded (Haq *et al.*, 1987; Bossio *et al.*, 1998). Similarly, the older fluvial and lacustrine deposits interfingered with marine sediments at Camorena (Barberi *et al.*, 1994) and Fabro (Fig. 2) may be interpreted as a sedimentary response to the global cooling event that occurred at about 3.0 Ma (Channel *et al.*, 1992; Bossio *et al.*, 1998). In the central MVT, the Acquatraversa unconformable surface may be present in the subsoil, below the lowermost outcropping levels of the II sedimentary cycle. It may be possible that the unconformity laterally passes to a conformable surface as well. The few subsurface data from the MVT do not verify any hypotheses, as the drilled sediments only belong to the II cycle (Di Bella, 1994; Carboni & Di Bella, 1994). Nevertheless, subsurface data from the bordering Sabatini Mts area, at Bracciano (Carboni & Palagi, 1998)), and from Vallericca (Arias et al., 1990; Carboni et al., 1993) in the lower Tiber Valley indicate the stratigraphic continuity from late Zanclaean to Santernian (Figs 6 and 7).

5.2. Relations between marine and non-marine successions and late Gelasian-Santernian paleogeography

The MVT II sedimentary cycle is characterized by the heteropic relations between the Chiani-Tevere and Poggio Mirteto formations, east of Mt Soratte, and between the Chiani-Tevere and Santa Maria di Ciciliano formations near Amelia. The main architectural feature is represented by three large clastic wedges interfingering with the Chiani-Tevere formation's shelf deposits. The clastic wedges are composed of the gravelly-sandy beach deposits of the Civitella San Paolo, Torrita Tiberina and Vasanello members, and of their laterally continuous fluvial deposits (Figs 2-4). Each wedge indicates a phase of basinward progradation of fluvial, deltaic and coastal sediments alternated with transgressive phases, that are evidenced by the shelf deposits (Fig. 4).

The first prograding wedge may have developed at the Gelasian-Santernian transition; this is suggested by the correlation with those marine successions where the Plio-Pleistocene boundary is present or inferred, like Lugnano, Orte Scalo, Vallericca (Carboni *et al.* 1993; Carboni & Di Bella 1994; Borzi *et al.* 1998) (Fig. 4). The younger wedges are Santernian in age. Such progradational phases are also evidenced by other transitional and continental lithofacies: 1) the "fine clayey sands of brackish water environment" and the "travertines and calcareous silts" are related to the II and III progradational episodes (Fig. 3); 2) the fan deltas occurring at Fosso Marutana, Camartana, Montasola, Poggio Catino and Marcellina (Fig. 7) are only related to the III episode.

The transgressive phases are evidenced not only by the rapid deepenig of facies, but also by the progressive onlap of the "breccias and conglomerates with abundant matrix" above the substratum, and by alignements of *Lithophaga* borings and notches (Fig. 7a). Such depositional and erosive elements indicate short-term sea level stands that punctuated the transgressions. The latter also caused an eastward shifting of the transitional facies, that reached the southwestern Tiberino Basin, as it is indicated by the discovery of brackish water molluscs (Fig. 7a). The paleogeographic thresholds linking the MVT and the Tiberino Basin were located east of Amelia at the San Pellegrino pass and, perhaps, at the Forello gorge near Todi and at Configni in Sabina (Fig. 7); they are considered as outlets of ancient fluvial systems (Ambrosetti *et al.*, 1987; Girotti & Piccardi, 1994; D'Agostino *et al.*, 2001). The Rieti Basin

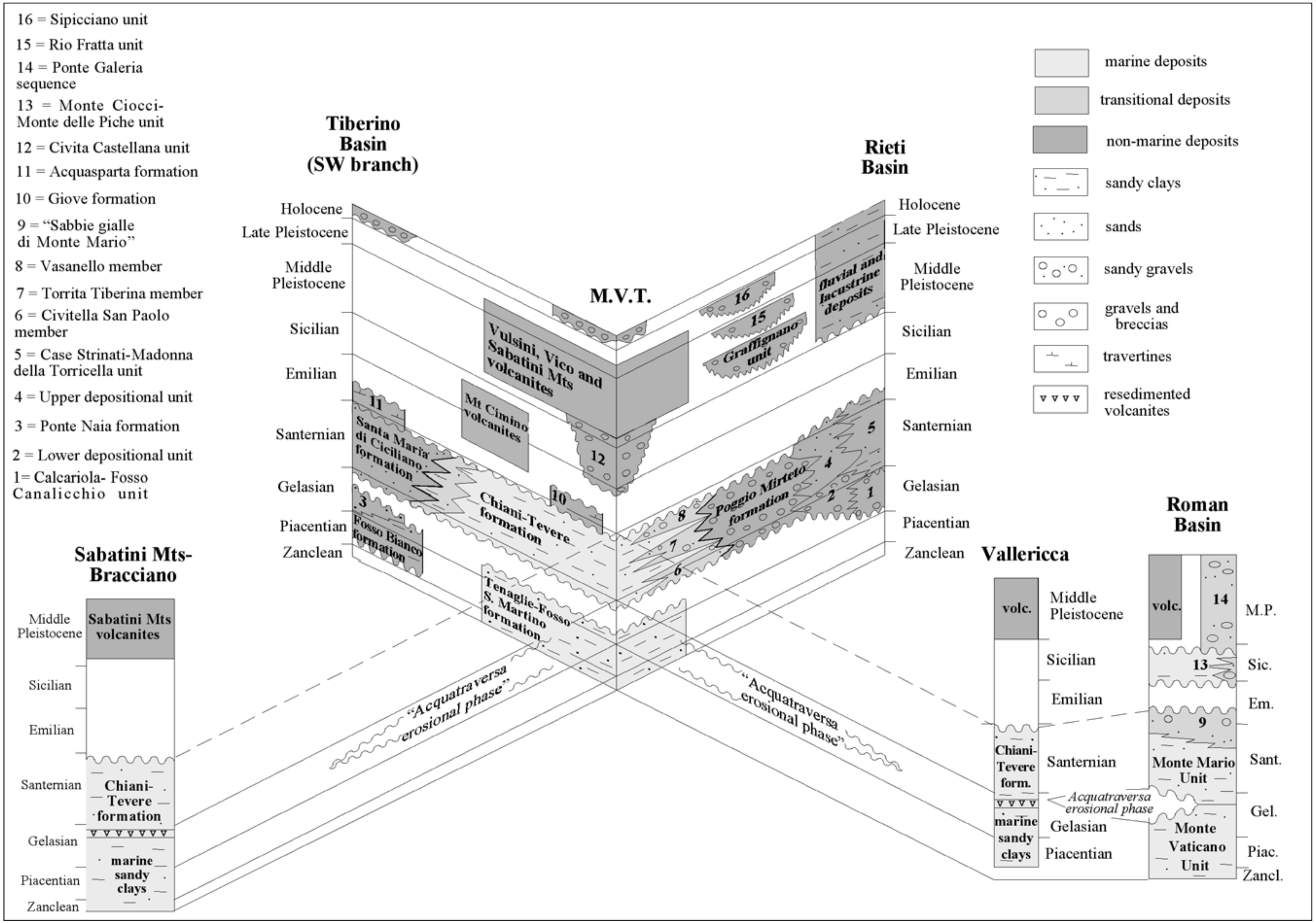


Fig. 6 - Correlation between the MVT and surroundings basins (data partly modified after Bonadonna (1968), Basilici (1993), Carboni *et al.* (1993), Barberi *et al.* (1995), Marra *et al.* (1995), Milli (1997), Carboni & Palagi (1998), Bergamin *et al.* (2000).

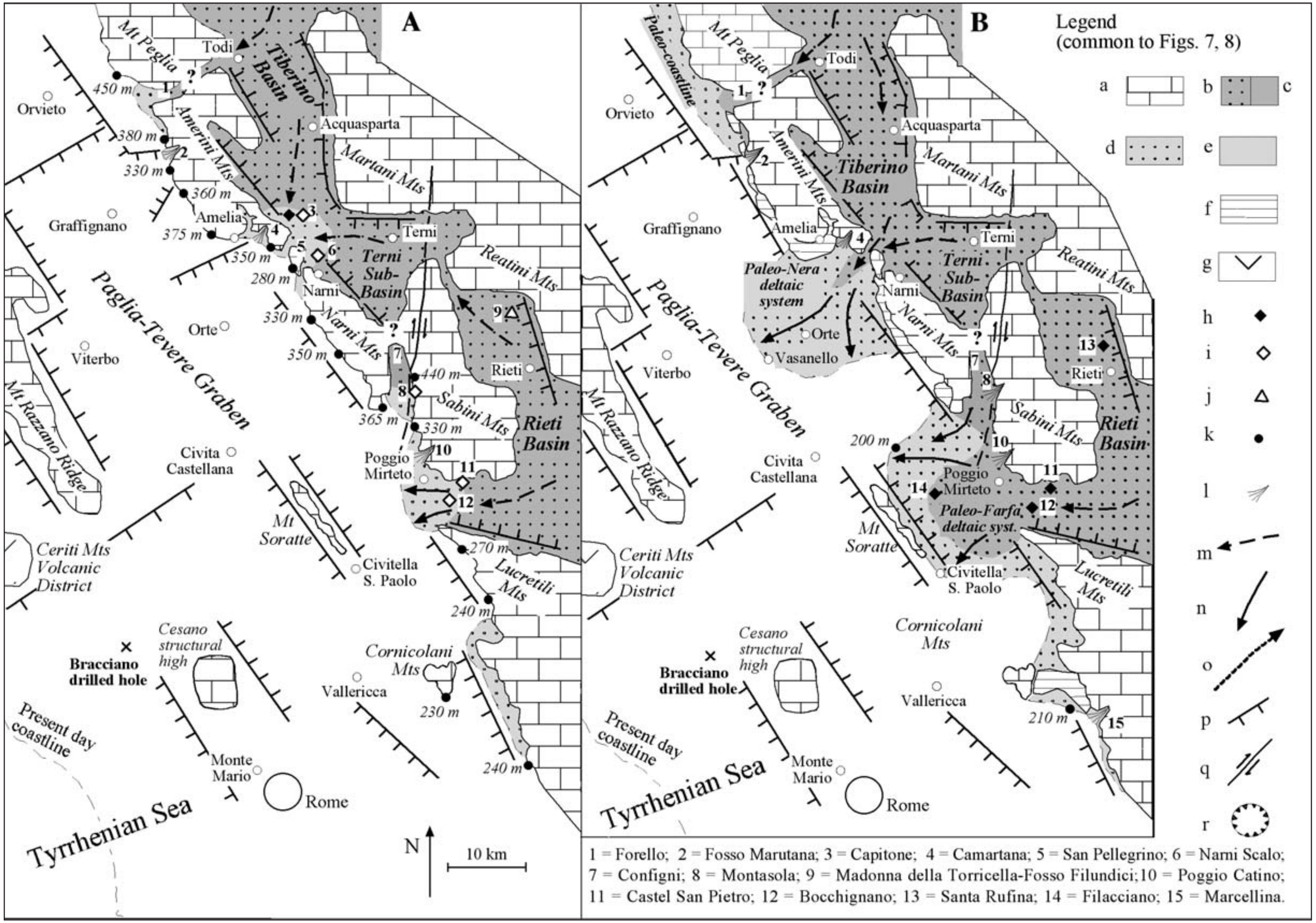


Fig. 7 - Paleogeography of the Latium-Umbria region during the late Gelasian-Santernian: (A) transgressive and (B) progradational phases. Legend: a) carbonatic and siliciclastic meso-cenozoic substratum, b) alluvial and lacustrine deposits, c) plio-quaternary non-marine deposits subjected to erosion, d) deltaic and coastal deposits, e) emerged marine deposits, f) travertines, g) volcanites, h) vertebrate remains, i) brackish-water molluscs, j) oligohaline ostracods, k) Lithophaga borings (with altitude a.s.l.), l) fan-delta and alluviall-fan, m) direction of ancient river, n) direction of deltaic progradation, o) direction of pyroclastic flow, p) normal fault, q) strike-slip fault, r) main crater.

was probably affected indirectly by transgessions too, as it is evidenced by the presence of olighoaline ostracods in its northern sector, at Fosso Filundici and Madonna della Torricella (Barberi *et al.*, 1995; Gliozzi & Mazzini, 1998) (Fig. 7a). It would be likely that the Rieti Basin was linked with the MVT basin through the Terni sub-basin and/or the Farfa valley (Figs 1 and 7).

On the other hand, the paleocoastline's seaward shiftings, which occurred at the progradational phases, may be estimated at 12-15 km with respect to the western margin of Mt Peglia-Lucretili Mts ridge. Such progradations are clearly evident in the Vasanello-Orte-Amelia and Mt Soratte-Sabini Mts areas in front of the deltaic systems of the Paleo-Nera and Paleo-Farfa rivers, that respectively drained the Tiberino and Rieti Basins (Fig. 7b). Each progradation is related to periods of increased sedimentary supply coming down from the intramontane basins and their surrounding mountainous areas. This increment may be due to: 1) tectonics, that caused differential uplifts of the inner areas with respect to the subsiding marine basin. This twofold movement may have led to an increment of relief energy and consequent erosion in the emerged areas, and to an increase of accomodation space in the MVT basin. 2) Climate changes, that may have been characterised by alternations between temperate and cold phases. In fact cooling episodes, if coupled with rainy periods and limited vegetation covers, may produce a great amount of eroded sediments and facilitate their transport. Furthermore, they are in general associated with eustatic sea level falls.

In the Chiani-Tevere formation the effects of climatically-induced sea level falls have been detected only within the fan-delta deposits (III progradational episode). The related base level drop is estimated at 70 m, although neither the tectonic nor the eustatic component have been fully distinguished (Girotti & Piccardi, 1994). As for the older progradational episodes, no erosive or depositional elements linked to sea level falls, like incisions or downward shifts of coastal facies, have been observed. In fact, it seems likely that the progradational and transgressive deposits progressively filled the basin in concomitance with the subsidence throughout the entire late Gelasian-Santernian. Therefore, negative eustatic movements have not been recorded by erosive surfaces, as their rates were of the same magnitude or slower than the subsidence rate. On the other hand, the sedimentologic and erosive effects of periodical sea level rises and transgressions are clearly evident, as it is discussed above.

Although the triggering mechanism that control the alternating progradational and transgressive phases is not clear at all, each couple of main progradation-transgression may suggest a IV order cyclicity within the main III order cycle.

5.3. Sedimentary and paleogeographic evolution during the middle Early Pleistocene-earliest Middle Pleistocene.

The regional uplift started at the earliest-middle Early Pleistocene between 1.5 and 1.3 Ma (Ambrosetti *et al*., 1987; Cavinato *et al*., 1994) and continued throughout the rest of Quaternary, determining the alternance of erosional and depositional phases in concomitance with climate changes. Each sedimentary unit deposited during this period represents a cycle of degradation-aggradation. In particular, the late Middle Pleistocene-Holocene terraced units were cyclically deposited every 100 ka, with a recurrence due to global climatic changes related to variations of the orbital eccentricity (Imbrie, 1985). As for the middle Early Pleistocene-earliest Middle Pleistocene units, chronological data are less precise, so making uncertain the linkage between the alternances of depositional and erosional phases and the 100 ka spanning cyclicity. However, all the sedimentary units may indicate a IV order cyclicity, although the inferred time span of the Civita Castellana unit is about 600 ka, a bit longer than a IV order cycle.

The most evident paleogeographic change after the early uplift was the south-westward shifting of the coastline for more than 30 km away from the Mt Peglia-Lucretili Mts ridge. In this way the Roman area was reached, where coastal facies developed (Fig. 8a). During the Emilian, the developing juvenile Tiber River caused at first the incision of the just emerged Gelasian-Santernian sediments, and then the deposition of the Giove formation in concomitance with the Mt Cimino volcanic activity. The ancient river flowed parallel to the axis of the Paglia-Tevere graben west of Mt Soratte (Alvarez, 1972; 1973).

The ancient Tiber mouth may be represented by the transitional deposits of the "Sabbie gialle di Monte Mario" (Bonadonna, 1968); the latter crops out at Monte Mario in Rome, covers Santernian sediments and bears Late Villafranchian molluscs and vertebrates (Girotti, 1972; Caloi & Palombo, 1988; Petronio *et al*., in press) (Figs. 6 and 8a). The Tiber's upper catchment was mainly affected by erosion, although local sedimentation persisted with the deposition of the lacustrine pelites of the "Case Strinati-Madonna della Torricella unit" in the northern Rieti Basin (Cavinato *et al*., 2000), and of the travertines of the "Acquasparta formation" in the southwestern Tiberino Basin (Basilici, 1992) (Figs. 6 and 8a).

During the Sicilian-earliest Middle Pleistocene, the coastline continued to migrate westward reaching the Ponte Galeria area, where fluvial-deltaic sediments were deposited (Conato *et al*., 1980; Milli, 1997; Karner *et al*., 2000) (Figs 6 and 8b). In the MVT the ongoing uplift caused a renewal of the fluvial incision - the "Cassia erosional phase" Auct. – which may be estimated at more than 100 m (Mancini, 2000). Such an incision cuts the Chiani-Tevere and Giove formations and caused the "cannibalization" of the oldest Tiber River's deposits. This downcutting also affected the Meso-Cenozoic substratum at the Forello and Stifone gorges (Fig. 8b), where the activity of local antiapennic-trending faults may have caused captures and deviations of the Tiber and Nera river courses (Cattuto *et al*., 1997) (Figs. 8a-b).

The erosional phase was followed by the aggrading Civita Castellana unit. This unit may be correlated with the fluvial deposits outcropping at Marcigliana in the lower Tiber valley (Basili, 1996), and with those filling the small ongoing "Paleotiber graben" in the northern Roman area (Karner *et al*., 2001) (Fig. 8 b). The correlation is suggested by both the lateral continuity between fluvial units, detected below the Middle Pleistocene Sabatini Mts volcanites (Funiciello et al., 1994), and by biochronological data after the discove-

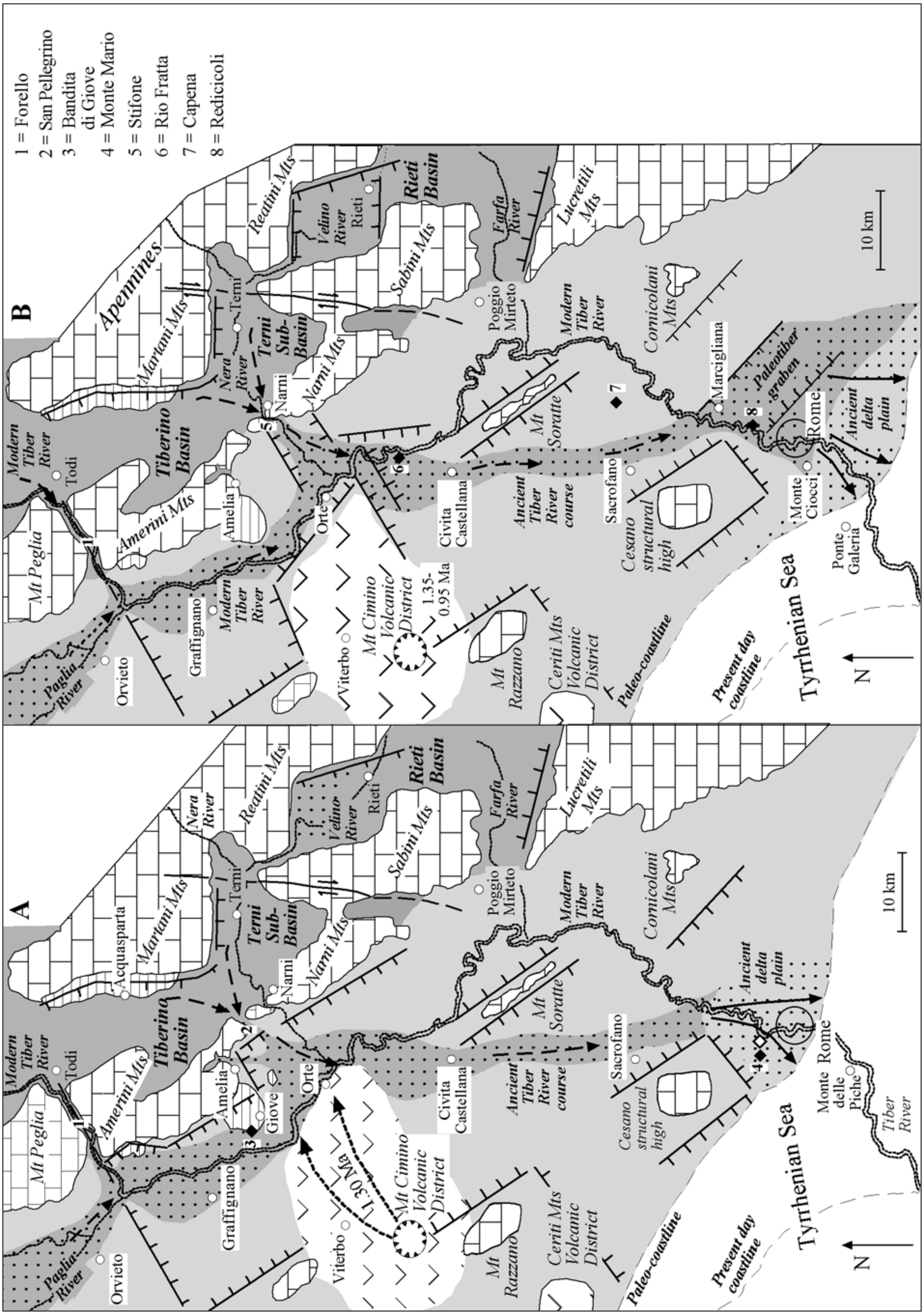


Fig. 8 -Paleogeography of the Latium-Umbria region during: (A) the Emilian; (B) the Sicilian-earliest Middle Pleistocene.

ries of vertebrates belonging to the Farneta-Pirro Faunal Units (late Early Pleistocene) in several sites as Rio Fratta, Capena, Redicicoli 1 (Di Stefano *et al*., 1998; Petronio *et al*., in press).

6. CONCLUSIONS

The stratigraphic data and the consequent interpretation of the paleogeographic evolution of the MVT and surrounding basins delineate a Late Pliocene-earliest Early Pleistocene subsidence-dominated tectono-sedimentary phase and a middle Early Pleistocene-Holocene uplift-dominated phase. The first phase provides direct chronostratigraphic elements, based on biostratigraphic, biochronologic, physical-, isotopic- and magneto-stratigraphic analyses and observations which are of great relevance in correlating the interfingered marine, transitional and non-marine successions, widely outcropping at the borders of the MVT, Tiberino and Rieti Basins. For the second phase, the new biochronologic data, the relations between fluvial and volcanic deposits and the inferred regional paleogeography provide indirect tools for the correlation between the fully non-marine MVT basin and the Roman area, characterised by marine, transitional and fluvial successions, in particular for the Emilian-early Middle Pleistocene interval.

Notes:

(1) Recent and exhaustive re-examinations of the ancient paleontologic findings in the Valli sabine are published in Kotsakis (1988), Esu & Girotti (1991), Gliozzi *et al.* (1997), Ciangherotti *et al.* (1998), Petronio *et al.* (in press).

(2) Pareto (1865) introduced the Villafranchian Stage and attributed to it those non-marine sediments that were deposited above the Pliocene marine successions as a consequence of a general withdrawal of the sea. He applied the term Villafranchian to all the non-marine deposits of North- and Central-Italy and considered it as Quaternary in age. Hürzeler (1967) recognized a Pliocene age for the vertebrates of Villafranca d'Asti (the type locality of the stage) and Azzaroli (1977) subdivided the Villafranchian into Early (Middle Pliocene), Middle (Late Pliocene) and Late (Early Pleistocene). Most of the non-marine sediments ranging from Middle Pliocene to Early Pleistocene are actually mapped as Villafranchian on the Geologic Map of Italy. The succession of the type locality is Middle Pliocene. In recent times some doubt was expressed about the validity of the Villafranchian as chronostratigraphic unit (Carraro, 1996), whereas Gliozzi *et al.* (1997) introduced and defined the Villafranchian in the biochronological scale of the mammal ages. Nevertheless, the Plio-Pleistocene non-marine successions are so widespread in Italy that, in our opinion, they need to be classified in an independent chronostratigraphical scale; in fact, an attribution to the marine one is rarely possible. Therefore, we think that, in order to classify the huge amount of non-marine successions outcropping in Italy, the Villafranchian should not be abandoned and a formalization is to be hoped for. The lower boundaries of Early and Late Villafranchian, at least, may be defined on sections at Villafranca d'Asti and in the Upper Valdarno respectively, where continuous sedimentation occured and litostratigraphy as well as palaeontological and magnetostratigraphical data are available.

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