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# LATE PLIOCENE-EARLY PLEISTOCENE PALAEOENVIRONMENTAL EVOLUTION OF THE RIETI BASIN (CENTRAL APENNINES)*

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RIASSUNTO - *Evoluzione paleoambientale del Bacino di Rieti (Appennino Centrale) durante il Pliocene superiore-Pleistocene inferiore* - Il Quaternario *Italian Journal of Quaternary Sciences,* **8**(2), 1995, 515-534 - Viene illustrata l'analisi di facies dei depositi del Bacino di Rieti relativi al Pliocene superiore ed al Pleistocene inferiore, allo scopo di ricavare informazioni sull'evoluzione paleoambientale e tettonica dell'area. In particolare sono state analizzate le strutture sedimentarie, la composizione litologica ed il contenuto paleontologico (ostracodi di acqua dolce e molluschi continentali) dei sedimenti affioranti sia nel settore meridionale che in quello settentrionale. I dati discussi nel presente lavoro permettono di delineare la seguente evoluzione del Bacino di Rieti. 1) Identificazione del bacino intrappenninico di Rieti legata ad un evento tettonico distensivo da collocare nel Pliocene superiore. 2) 1° fase di colmamento (messa in posto dell'Unità Deposizionale Inferiore e dell'Unità di Calcariola-Fosso Canalicchio) in facies di *semi-arid alluvial fan.* La messa in posto di questo materiale grossolano è legata a cause tettoniche e climatiche. La fase di deterioramento climatico più probabile potrebbe essere quella verificatasi al passaggio Plio-Pleistocene (Eburoniano, fase erosiva di Aulla *sensu* Azzaroli *et al.,* 1988). Negli intervalli tra la deposizione di conoidi successive si verificava la colonizzazione da parte della vegetazione. 3) Nella parte bassa del Pleistocene inferiore l'antica depressione morfologica risulta colmata dai depositi della 1° fase. Il nuovo assetto pianeggiante del bacino è testimoniato da una sedimentazione successiva in facies di *braided plain.* 4) 2° fase di colmamento (messa in posto dell'Unità Deposizionale Superiore nel settore meridionale e di una unità ancora da formalizzare, ad essa eteropica, nel settore settentrionale) in un ambiente deposizionale di piana alluvionale. I sedimenti sono meno grossolani di quelli della 1° fase e prevalgono sabbie, limi ed argille. In questa seconda fase nell'area settentrionale del bacino esistevano una o più paludi permanenti mentre nell'area meridionale gli specchi d'acqua erano effimeri e legati ad aree sorgentizie locali. a) i sedimenti alla base della successione sedimentaria della 2° fase di colmamento indicano l'esistenza di depositi palustri caratterizzati da un'alternanza di acque oligoaline e dolci. La presenza di ostracofaune dominate da *Cyprideis torosa* evidenzia un'influenza, seppure indiretta, del vicino mare sulle acque continentali. La correlazione di questi depositi con quelli di Villa S. Faustino (Bacino Tiberino), in cui le ostracofaune salmastre e dolci associate con mammalofaune riferibili all'U.F. del Tasso sono influenzate da oscillazioni del vicino mare santerniano, permette di riferirli alla parte bassa del Pleistocene inferiore. b) i depositi della parte alta della successione sedimentaria della 2° fase di colmamento non presentano tracce di influenza salmastra da parte del mare. I paleoambienti riconosciuti sulla base dell'analisi delle ostracofaune mostrano la presenza di paludi (a nord) e di lame d'acqua effimere (a sud) caratterizzate da acque dolci. E' possibile dunque riferire questi sedimenti ad un momento successivo sempre individuabile all'interno del Pleistocene inferiore per il ritrovamento in questi depositi di *Belgrandia* sp., *Mammuthus meridionalis* (forma evoluta) ed *Equus stenonis.* All'interno di questo intervallo è riconoscibile un'alternanza climatica umido-arido-umido forse da correlare con cause globali. 5) L'attività tettonica che ha ribassato il settore settentrionale del bacino individuando l'attuale Conca di Rieti è collocabile nell'intervallo che va dalla parte alta del Pleistocene inferiore al Pleistocene medio inferiore. La correlazione tra i vari depositi del Pleistocene inferiore del Bacino di Rieti ha permesso di calcolare rigetti variabili tra 60 e 350 m.

ABSTRACT - *Late Pliocene-Early Pleistocene palaeoenvironmental evolution of the Rieti Basin (Central Apennines)* - Il Quaternario *Italian Journal of Quaternary Sciences,* **8**(2), 1995, 515-534 - Facies analysis of Late Pliocene-Early Pleistocene deposits in the Rieti Basin is used as the basis for the paleoenvironmental and tectonic reconstruction of the area. In particular, the sedimentary structures, the lithological composition and paleontological content (fresh-water ostracods and continental molluscs) of sediments cropping out in the southern and northern sectors of the basin are discussed. Available data are used to reconstruct the main phases which lead to the origin and evolution of the Rieti Basin. 1) The origin of the intra-apenninic Rieti basin is linked to an extensional tectonic event probably occurring during the Late Pliocene. 2) First infilling phase with semi-arid alluvial fan facies. The sedimentation of this coarse material is due both to tectonic and climatic events (probably during the climatic deterioration near the Plio-Pleistocene boundary). 3) The ancient morphological depression is filled by the beginning of the Pleistocene. 4) Second phase of infilling occurs in a braided plain sedimentary environment. One or more marshes occupied the northern sector, while in the southern sector only an alluvial plain is identified: a) sediments at the base of this sedimentary succession indicate palustrine environments characterised by alternating fresh and oligohaline water-bodies influenced by the nearby sea (lower part of the Early Pleistocene, Santernian substage); b) deposits of the upper part of the sedimentary sequence of the second infilling phase do not show any marine influence. Identified fresh-water palaeoenvironments must still referred to the Early Pleistocene due to the presence of *Belgrandia* sp., *Mammuthus meridionalis* (evolute form) and *Equus stenonis.* 5) Tectonic activity which downthrew the northern sector of the basin, originating the present-day Rieti Basin, is referable to the late Early Pleistocene-early Middle Pleistocene phase.

Key words: Intramontane basin, Late Pliocene, Early Pleistocene, sedimentological analysis, fresh-water ostracods, continental molluscs, palaeoenvironmental evolution, Central Italy
Parole chiave: Bacino intramontano, Pliocene superiore, Pleistocene inferiore, analisi sedimentologica, ostracodi dulcicoli, molluschi continentali, evoluzione paleoambientale, Italia Centrale

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*Lavoro presentato al Convegno "Il significato del Villafranchiano nella stratigrafia del Plio-Pleistocene", Peveragno-Villafranca d'Asti 24-29 giugno 1994.*

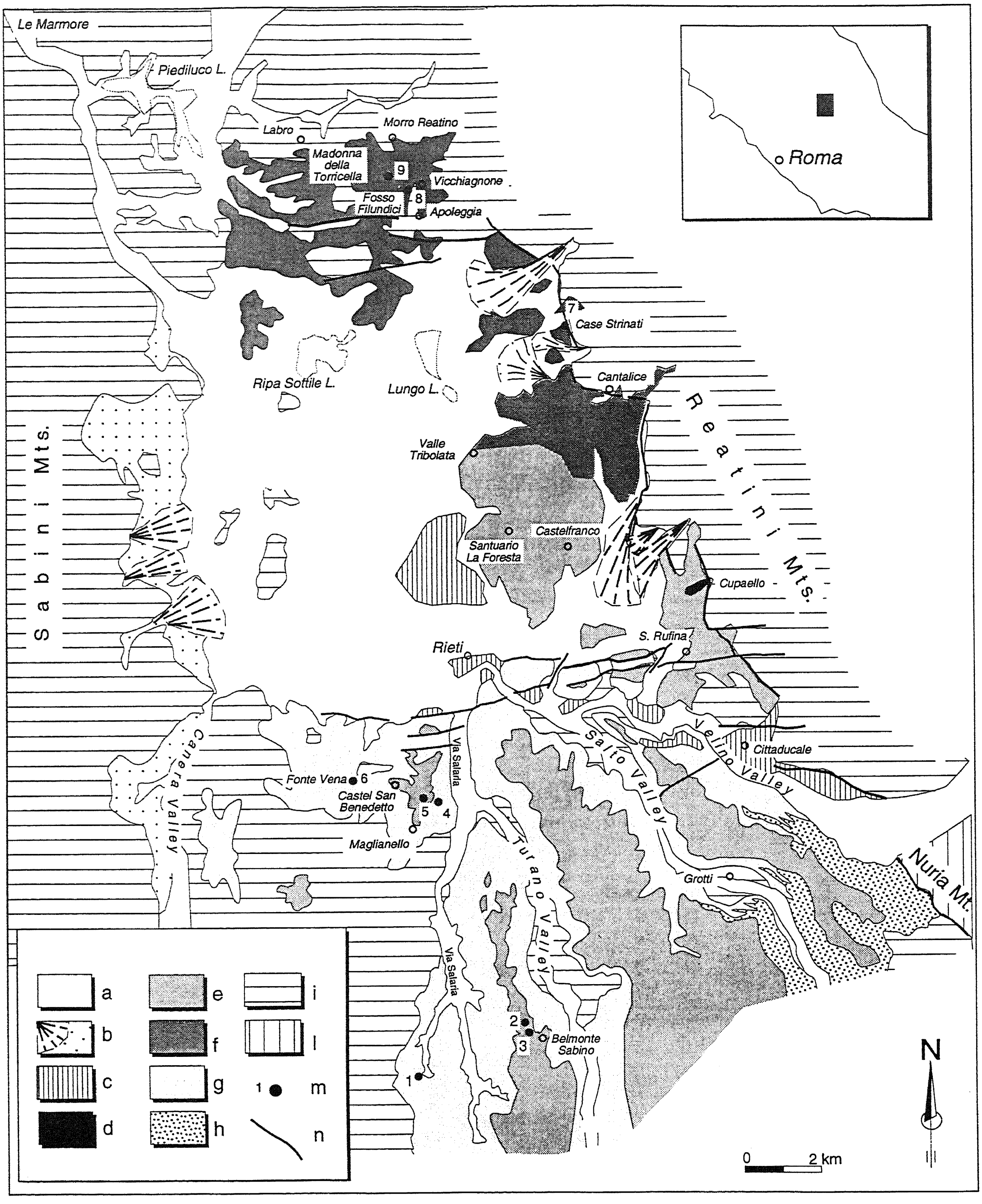


Fig. 1 - Geological scheme of the Rieti Basin with the location of studied sections. Legend: **a**: Holocene deposits; **b**: recent talus fans; **c**: Middle and Late Pleistocene deposits; **d**: Cupaello lava flow; **e**: Upper Depositional Unit (UDU) (Early Pleistocene); **f**: Early Pleistocene deposits of the northern sector; **g**: Lower Depositional Unit (LDU) (Late Pliocene-Early Pleistocene); **h**: Calcariola-Fosso Canalicchio Unit (Late Pliocene-Early Pleistocene); **i**: Meso-Cenozoic units of the Umbro-Sabina domain; **l**: Meso-Cenozoic units of the Latium-Abruzzi domain; **m**: location of the studied sections (1. Via Salaria km 65.200; 2. Belmonte Sabino cemetery; 3. Belmonte Sabino sports field; 4. Road between Maglianello Alto and Maglianello Basso; 5.: Castel S. Benedetto quarry; 6. Fonte Vena; 7. Case Strinati; 8. Fosso Filundici; 9. Madonna della Torricella); **n**: main normal faults.

*Schema geologico del bacino di Rieti con l'ubicazione delle sezioni studiate. Legenda: **a**: depositi olocenici; **b**: conoidi detritiche recenti; **c**: depositi del Pleistocene medio e superiore; **d**: colata lavica di Cupaello; **e**: Unità deposizionale Superiore (Pleistocene inferiore); **f**: depositi del Pleistocene inferiore affioranti nel settore settentrionale; **g**: Unità Deposizionale Inferiore* (cont. p.517) ⟶

## 1. INTRODUCTION

During the last few years much research has been carried out to reconstruct the lithostratigraphical and facies characteristics, the tectonics, the morphostratigraphy and the palaeoenvironmental evolution of the Rieti Basin (see Bosi *et al.*, 1989; Cavinato *et al.*, 1989a & 1989b; Barberi & Cavinato, 1993; Cavinato, 1993 for the Plio-Pleistocene deposits; Ferreli *et al.*, 1992 & 1993; Brunamonte *et al.*, 1993, Carrara *et al.*, 1993; Lorenzoni *et al.*, 1993 for Pleistocene-Holocene deposits).

The Rieti Basin, unlike the other Apenninic intramontane basins, is characterised by areas where it is possible to observe the continental sequences almost in their entire thickness, disposition and horizontal and vertical geometries. Outcrops were brought to light by a combination of tectonic and erosive events which occurred mainly during the Middle-Late Pleistocene, causing the collapse of a small part of the basin ("Conca di Rieti") and the quick erosion of deposits (Cavinato, 1993).

In the above-quoted papers only the lithostratigraphical and tectonic characteristics of the Plio-Pleistocene deposits of the southern part of the basin have been investigated. In the present paper deposits outcropping in the northern part are discussed and data are used to reconstruct the evolution of the whole basin.

## 2. LITHOSTRATIGRAPHICAL AND FACIES CHARACTERISTICS OF PLIO-PLEISTOCENE DEPOSITS

### 2.1 Southern sector of the Rieti Basin

In the area extending from the Canera Valley in the west (Sabini Mts.) to the Nuria Mt. foothill (Fig. 1), the geological survey of the continental sequences (Cavinato, 1993) allowed to subdivide the Upper Pliocene-Lower Pleistocene deposits into three depositional units: the Lower Depositional Unit (LDU), the Calcariola-Fosso Canalicchio Unit (CFCU) and the Upper Depositional Unit (UDU). These units have been distinguished on the basis of their different lithostratigraphical and facies characteristics, which are related to different depositional processes occurring during the basin-filling phases (Cavinato, 1993; Barberi & Cavinato, 1993).

The LDU and the CFCU represent the first post-orogenic filling deposits of the southern part of the basin and lie, with angular unconformity, directly over the Meso-Cenozoic marine carbonate bedrock. Deposits related to the LDU are located in the area between Canera and the Salto Valleys; those related to the CFCU between the Salto and the Velino Valleys. Their deposition is probably coeval. These deposits have been distinguished mainly on the basis of the different source areas of clastic sediments (the LDU carbonate clasts derives only from the Umbro-Sabina succession, while the CFCU carbonate and sandstone clasts are derived from the Latium-Abruzzi carbonate platform sequence).

The LDU deposits consist of clast-supported conglomerates, with a calcareous matrix; carbonate clasts show a mean size from 5 to 25 cm and belong to the Umbro-Sabina succession. Such deposits are characterised by horizontal tabular bodies with a broad lateral extension and a vertical development variable from 5 to 20 m. Mudstone matrix supported deposits (as debris-flow deposits), laminated and bioturbated calcarenites with interbedded palaeosoils have been often observed. The outcropping thickness is up to 350 m.

The CFCU is also characterised by conglomerate deposits, with intercalation of debris-flow deposits. Clasts reach large sizes (5 ÷ 50 cm and locally up to several metres). Bodies of breccia ("Brecce di Rocca Ranieri") are interbedded in several levels in the whole CFCU (Bosi *et al.*, 1989; Cavinato, 1993). These breccias are heterometric, and monogenic. The clast composition indicates their provenance both from the carbonate sequence of the Latium-Abruzzi platform and from the Miocene calcarenites. Lithofacies analysis suggests that the depositional processes of the LDU and of the CFCU are on the whole related to the development of alluvial fan systems along the north-eastern border of the basin. Such deposits progressively filled several morphological depressions. In the western area small fan systems, extending towards the depocentre of the basin, also developed (for a more detailed analysis of sedimentological and facies characteristics and geometrical relations see Barberi & Cavinato, 1993).

The survey has shown the central importance that the palaeomorphology of the carbonate bedrock played in the first phases of basin-filling. The lithological composition and the palaeocurrent data show that the clastic provenance of the LDU is from the north-east, while that of the CFCU is from the north-eastern and south-western areas (Reatini Mts. and Nuria Mt.) (Fig. 2). Initially, deposits were channelised towards existing morphological depressions, progressively infilling them. The two units were separated by the morphological high of Grotti (Barberi &

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(cont'd from/da p. 516) *(Pliocene superiore-Pleistocene inferiore);* ***h:*** *Unità di Calcariola-F.so Canalicchio (Pliocene superiore-Pleistocene inferiore);* ***i:*** *unità meso-cenozoiche del dominio Umbro-Sabino;* ***l:*** *unità meso-cenozoiche del dominio Laziale-Abruzzese;* ***m:*** *ubicazione delle sezioni studiate (1. Via Salaria km 65,200; 2. Cimitero di Belmonte Sabino; 3. Campo Sportivo di Belmonte Sabino; 4. Strada tra Maglianello Alto e Maglianello Basso; 5.: Cava di Castel S. Benedetto; 6. Fonte Vena; 7. Case Strinati; 8. Fosso Filundici; 9. Madonna della Torricella);* ***n:*** *principali faglie dirette.*

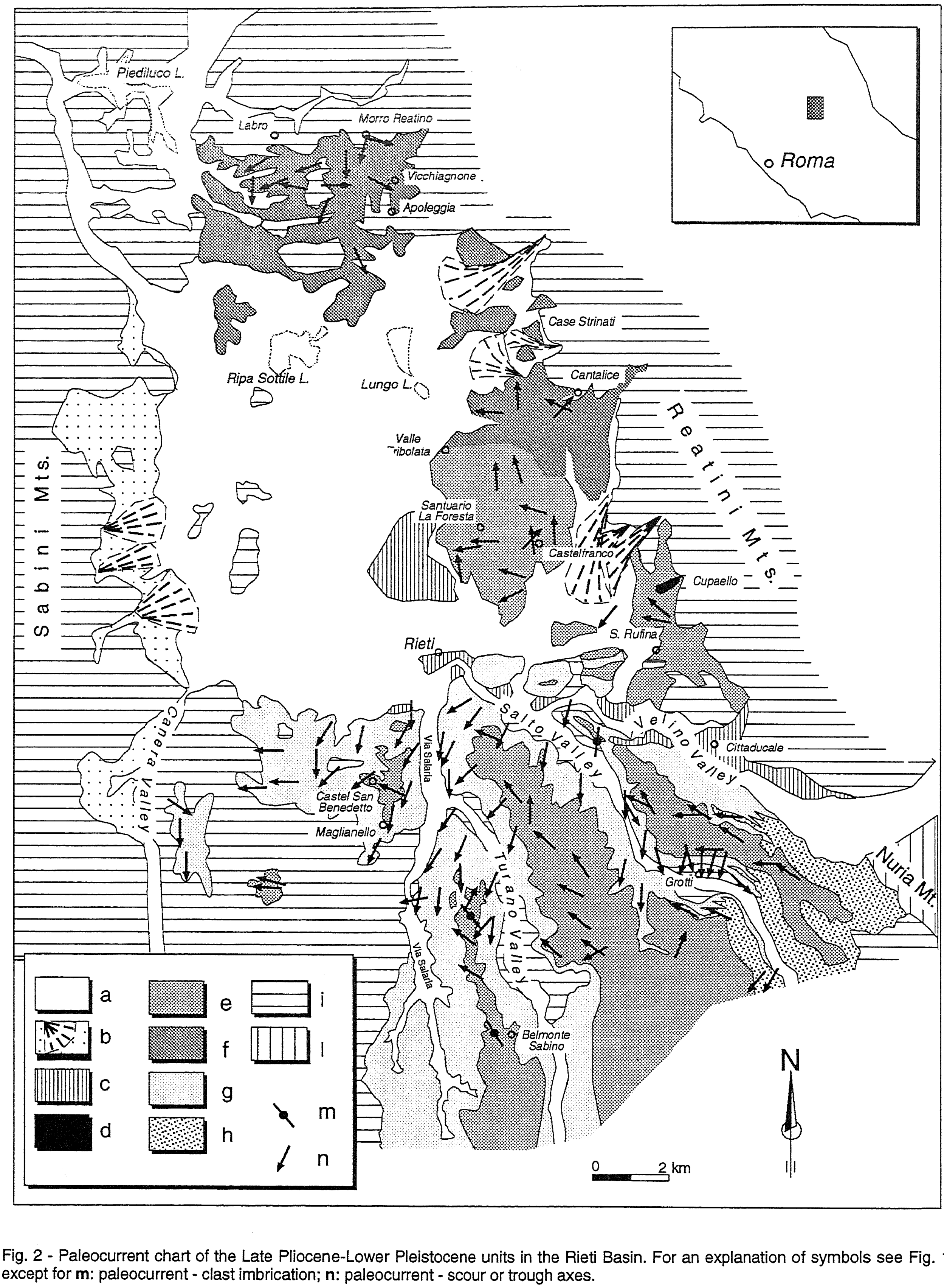


Fig. 2 - Paleocurrent chart of the Late Pliocene-Lower Pleistocene units in the Rieti Basin. For an explanation of symbols see Fig. 1 except for **m**: paleocurrent - clast imbrication; **n**: paleocurrent - scour or trough axes.

*Carta delle paleocorrenti rilevate nelle unit' del Pliocene superiore-Pleistocene inferiore del bacino di Rieti. Per la spiegazione dei simboli vedi Fig. 1 tranne che* ***m****: paleocorrenti - clasti embricati;* ***n****: paleocorrenti - solchi longitudinali o assi di* trough.

Cavinato, 1993). After they exceeded it, they began to be coalescent and heterotopic.

During this cycle the palaeodrainage pattern was always centripetal with regard to the long axis of the basin (NNW-SSE). From the north-eastern (Salto and Velino Valleys) to the south-western sectors of the basin, clast sizes and debris-flow deposits progressively reduce while pelitic and psammitic fractions increase. Nearer the Sabini Mts. particle sizes again fit the ruditic fractions.

The considerable vertical development of coarse deposits is generally considered to be related both to climatic and tectonic events. These events cause a constant lifting and erosion of the source areas and a progressive subsidence of the filling areas (Reading, 1984; Rust & Koster, 1984; Miall, 1991). The large presence of hyperconcentrated flows (as debris flow in the lower units) are interpreted as semi-arid alluvial fans deposits (Reading, 1984; Rust & Koster, 1984; Miall, 1991) and their deposition is related to several conditions: lack of vegetation that permits a rapid erosion of reliefs and a strong surface runoff; steep reliefs; short periods with high rainfall concentrations; lithological characteristics of eroded materials (presence of pelitic-psammitic material).

In the Rieti basin the large vertical and horizontal development of conglomeratic deposits seems to be related to the activity of the N140°÷N160° border faults system (Cavinato, 1993) that is located along the eastern border of the basin. Inside the sequences, several depositional alluvial fan systems were distinguished (Barberi & Cavinato, 1993), with progradation and recession of fans. These changes can be related both to the activity of the boundary fault system and to the alternance of cold-warm climatic events.

The UDU is characterised essentially by conglomerate and lenses of sands, silts, marls and marly-clays interbedded. Sometimes peaty and peaty-clays horizons have been found. The rudites are commonly clast-supported with sandy matrix. Clasts show a mean size from 5 to 25 cm. Sedimentary structures are evident (cross-bedded stratification) and gravel bodies have a lens shape, with an erosion basal surface. Clasts are mainly of carbonate and sandstones related to the Latium-Abruzzi sequence, with limited contributions from the Reatini and Sabini Mts. ("Umbro-Sabina" succession).

The change of facies and depositional energy observed between the UDU and the units below (LDU and CFCU) is remarkable. Facies characteristic of the UDU deposits show a braided-plain fluvial system and systems of marshes or fleeting water blades. Moreover, the palaeodrainage pattern become parallel to the principal axis of the basin (NNW-SSE) with a SSE to NNW orientation. Clastic contributions from the north-eastern borders continue but to a less extent (Fig. 2).

These changes are also shown by palaeocurrent analysis which, through prevailing clasts composition, confirms the pattern of the fluvial system derived from the Latium-Abruzzi succession (source areas located at E and SE of the basin), as well as by decreasing clast size from the south-eastern areas to the north-western one (Barberi & Cavinato, 1993).

Unfortunately, the contact between units (LDU/CFCU and UDU) is only seldom visible but the facies characteristics and the observed geometries suggest a continuity of sedimentation and a progressive change of facies within the sequences. This progressive change is related to the palaeogeographical evolution of the basin, linked to a minor activity of border faults (sedimentation/subsidence equilibrium).

## 2.2 Northern sector of the Rieti Basin

The analysis of continental deposits in the northern sector of the basin is still in progress, so available data are incomplete and only preliminary remarks are outlined.

Outcropping lithofacies can be related to a marshy fluvial plain within which two different environments can be distinguished. In the Cantalice area (Fig. 1), cross-bedded gravels and sands (with rare conglomerate bodies characterised by clasts of larger sizes) crop out, together with more fine-grained sediments such as sands, muds and clays (Valle Tribolata) with rare gravel lenses. Gravel-conglomerates facies represent fluvial channel deposits, while fine-grained facies represent alluvial plain deposits with breach and/or minor channel deposits. Palaeocurrent analyses indicate that source areas are located S and SE (Fig. 2).

Coarse, massive conglomerates (5-25 cm), characterised by a slight sub-horizontal stratification, are interbedded in the fluvial plain deposits. Conglomerates crop out near Villa Ferrari (along the road to the "La Foresta" sanctuary) and in the area of Morro Reatino and Labro. This lithofacies is characteristic of an alluvial fan environment. Carbonate, cherty and marly clasts are usually poorly sorted. Lithological composition indicates the Umbro-Sabina carbonatic sequence outcropping NE and N of the basin (Reatini Mts.) as the source area. Palaeocurrent analyses show a clast provenance from E in the area between Cantalice and "La Foresta" Sanctuary and a prevailing provenance from N, in the area between Morro Reatino and Labro.

It is possible to reconstruct the existence of some alluvial fans, flowing into a fluvial plain, and fed by streams coming from the Reatini Mts.

In the Morro Reatino area, at the top of the conglomerate deposits, there are alternations of massive and/or laminated carbonate silts, marls and clay. Lignite levels, up to 1 m thick, can also be found (at Madonna della Torricella, Case Strinati, and Fosso Filundici). These lithofacies represent a marshy environment; their thickness cannot be determined because there are few outcrops, but it is estimated to be some tens of metres (20-30 m).

These sediments crop out in several areas south of Labro and Morro Reatino. They are downthrown towards the center of the basin by E-W normal faults.

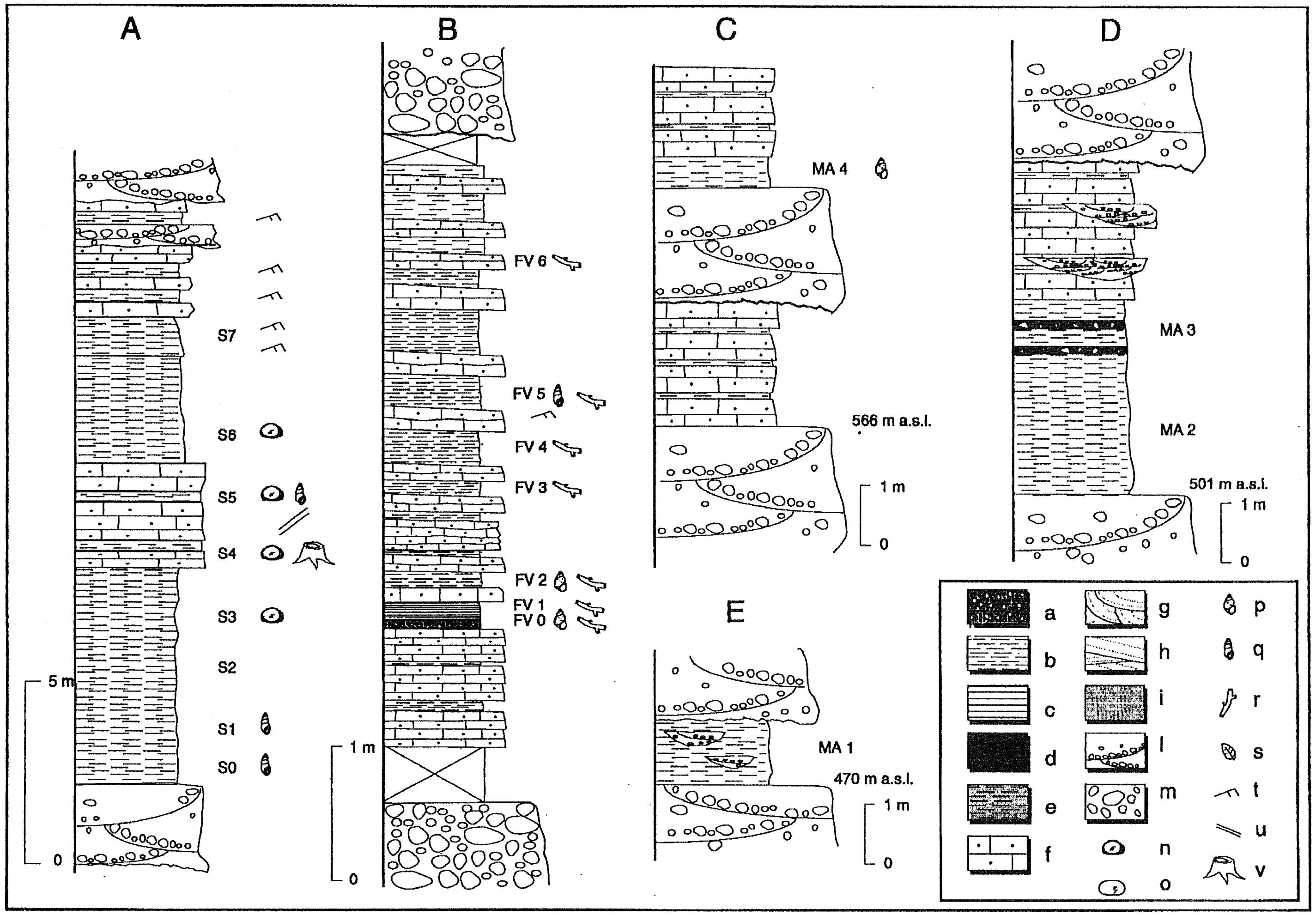


Fig. 3 - Stratigraphic logs of the LDU successions with the location of samples collected for paleontological analyses. **A**: Via Salaria km 65.200 section; **B**: Fonte Vena section; **C, D, E**: road between Maglianello Alto and Maglianello Basso. Legend: **a**: paleosol; **b**: marl; **c**: clay; **d**: lignite; **e**: calcareous mud; **f**: cement-ed calcarenite and calcareous mud; **g**: sand with trough crossed laminations; **h**: sand with planar crossed laminations; **i**: cement-ed sand; **l**: cross-bedded conglomerate; **m**: massive conglom-erate; **n**: fresh-water ostracod associations; **o**: oligo-mesohaline ostracod associations; **p**: fresh-water mollusc associations; **q**: ter-restrial molluscs; **r**: plant threads; **s**: leaves; **t**: cross laminations; **u**: horizontal laminations; **v**: trunk remains.

Logs *stratigrafici delle successioni della LDU studiate in dettaglio con l'ubicazione dei campioni prelevati per l'analisi paleontologica.* ***A****: Sezione di Via Salaria km 65, 200;* ***B****: Sezione di Fonte Vena;* ***C, D, E****: Sezioni lungo la strada tra Maglianello Alto e Maglianello Basso. Legenda:* ***a****: paleosuoli;* ***b****: marne;* ***c****: argille;* ***d****: ligniti;* ***e****: limi calcarei;* ***f****: calcareniti e limi calcarei cementati;* ***g****: sabbie con laminazione incrociata concava;* ***h****: sabbie con laminazione incro-ciata piano-parallela;* ***i****: sabbie cementate;* ***l****: con-glomerati con stratificazione incrociata;* ***m****: conglomerati massivi;* ***n****: ostracodi dulcicoli;* ***o****: ostracodi oligo-mesoalini;* ***p****: molluschi dulcicoli;* ***q****: molluschi terrestri;* ***r****: frustoli vegetali;* ***s****: foglie;* ***t****: la-minazioni incrociate.;* ***u****: laminazioni orizzontali;* ***v****: resti di tronco d'albero.*

## 3. DESCRIPTION OF THE STUDIED SECTIONS

During the geological survey it has been possible to observe outcrops of considerable thickness (5-20 m); nine sections were analysed in some detail:

1) Southern sector: road between Maglianello Alto and Maglianello Basso (MA); Fonte Vena (FV); Via Salaria km 65. 200 (VS); Castel San Benedetto quarry (CB); Belmonte Sabino cemetery (BS 1-4); Belmonte Sabino sports field (BS 5-8);

2) Northern sector: Case Strinati (CS); Fosso Filundici (FF); Madonna della Torricella (MT).

Among these, the sections of Fonte Vena (FV) and Via Salaria km 65. 200 (VS) represent pelitic-psammitic events within deposits belonging to the first phase of filling (Cavinato, 1993); the section along the road between Maglianello Alto and Maglianello Basso is prevalently made up of LDU conglomerates with irregular intercalations of marly-clays, some ten centimetre thick (Cavinato, 1993). These intercalations were sampled and analysed. All the other sections are related to sediments belonging to the second phase of filling (to the UDU in the southern sector and a not yet named unit, heterotopic to the UDU, in the northern sector).

### 3.1 Via Salaria km 65. 200

This section is located at 590 m a.s.l. on the Via Salaria at the kilometer 65. 200 (Figs. 1 and 3).

On the western edge of the roadway, a conglomeratic sequence crops out. Conglomerates are characterised by calcareous clasts and small lenses of silty material. On the eastern edge the pelitic component increases considerably: a sequence of calcareous silts crops out up to a thickness of 15 metres. This sequence lies on a conglomerate, gentle dipping to the north, with well sorted clasts of different sizes. Calcareous silts have both planar and cross laminations. Some levels are cemented and oxidized. At the top of the sequence two intervals can be recognised. In the first one, an alternance of cemented and non-laminated silts and thick cross laminated calcareous silts are recognisable. The second is characterised by cemented and cross-laminated calcareous silt levels which alternate with thin conglomerate layers. In the upper part of the sequence the sharp contact between pelitic and ruditic sediments is underlined by a well cemented calcareous silt level. In all the fragments of the pelitic sequence wood has been found; at about ten metres from the base of the section a small portion of a trunk crops out, in physiological position.

### 3.2 Fonte Vena

This section is located on the reliefs bordering the southern part of the Rieti basin (Figs. 1 and 3). It crops out near the homonymous spring, at 590 m a.s.l. The sequence of pelitic material is about 5 m thick and is interbedded in the conglomerate facies of LDU.

At the bottom a well cemented level of calcareous silt, 80 cm thick, crops out. The passage to the following gray clays is characterised by a 5 cm thick reddish clay with manganese patinas. The gray clays also exhibit manganese patinas, small clasts and bioturbation structures. Their thickness is about 15 cm. Calcareous silts follow, alternating with more or less cemented levels. This alternance stops for about 50 cm, and the calcareous silts are characterised by a thin cross lamination. Locally reddish and manganese patinas can be found.

### 3.3 Road between Maglianello Alto and Maglianello Basso

This section is made up of pelitic sediments, with a variable thickness from 1 to 3 m (Figs. 1 and 3), interbedded in a conglomerate sequence outcropping at different heights along the road leading from Maglianello Alto to Maglianello Basso. The following description does not cover the whole sequence but only a selection of sampled sites.

At 479 m a.s.l. a cross-bedded conglomerate body, 12 m thick, crops out and in which a marly horizon (sample MA1) 1 m thick is interbedded. Inside this horizon thin lenses of small gravels are visible.

At 500 m a.s.l., 2-3 metres of conglomerate crop out and are overlaid by 3 m of massive calcareous silts with dark-reddish interbedded levels (samples MA2 and MA3). These levels, 10 cm thick, are characterised by an abundant clayey component. Over these silts a thick alternation of calcarenites and cross-bedded conglomerates crops out. The conglomerates become prevalent upwards and clast size increases.

At 557 m a.s.l. cross-bedded 9 m thick conglomerates interbedded with marly and calcarenitic levels crop out. They are overlain by 2 m of laminated calcarenites and calcareous silts cut at the top by a 2 m thick conglomerate. Over this lens there are levels of alternating marls and calcarenites (2 m of thickness, sample MA4).

### 3.4 Belmonte Sabino sportsfield

This section is located inside the sportsfield fence of the village of Belmonte Sabino, at 703 m a.s.l. (Figs. 1 and 4). At the base there is a laminated sandy layer more than 3 m thick, over which 2 m thick dark silty clays crop out; then an alternation, a few decimeter thick, of marls and sands is visible. The overlying dark silty clays are enclosed between two lignite horizons. The lignite at the top is followed by gray silty clays, 80 cm thick. The outcropping sequence is closed by partially pedogenized 2.5 m thick sands.

### 3.5 Belmonte Sabino cemetery

This section crops out inside the cemetery of the Belmonte Sabino village, at 706 m a.s.l. (Figs. 1 and 4).

The whole outcrop shows a thickness of 3 metres. Only the first 120 cm at the bottom are made up of pelites, while the remainder is of ruditic material. In the lower part clays are found, with two levels of lignite a few cm thick. The contact between the lower clays and the first level of lignite is underlined by a gradual passage to sandy clays. The top of the section is closed by a cross-bedded conglomerate body with sandy matrix. It is made up of well-sorted calcareous and arenaceous clasts, with diameters ranging from 2 to 5 cm.

### 3.6 Castel San Benedetto quarry

The section is located along the southern border of the Rieti basin, at 725 m a.s.l. (Figs. 1 and 4), near the village of Castel San Benedetto. At the bottom a level of laminated sands crops out, followed by marly clays. The contact between these two lithotypes is covered by vegetation. The upper contact between the marly clays and the conglomerates is sharp. Conglomerates are characterised by a 10 m thick body with small lenses of enclosed clayey material. They are followed by 130 cm of alternating marly clays and cemented sandstones cut by locally cemented and reddish sands. The pelitic-psammitic sequence is closed by 50 cm thick marly clays followed by sandstones at the top. The base of these sandstones is characterised by a reddish level, a few cm thick.

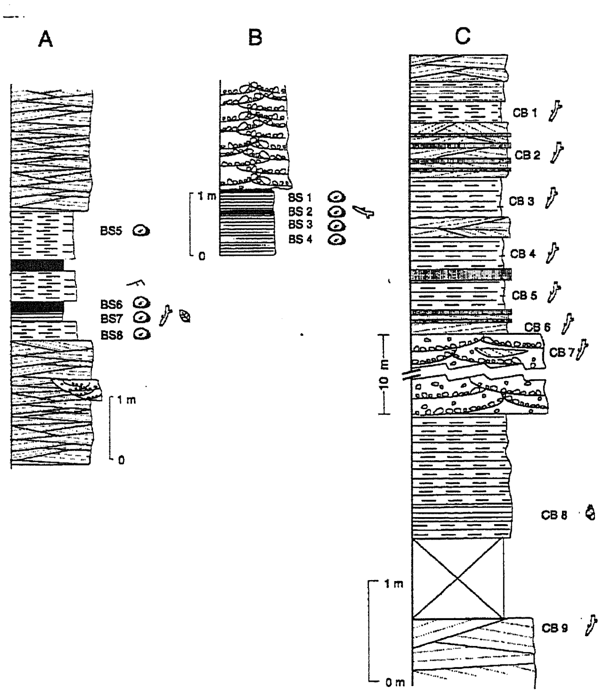


Fig. 4 - Stratigraphic logs of the UDU successions with the location of samples collected for paleontological analyses. **A**: section outcropping inside the Belmonte Sabino sportsfield; **B**: section outcropping inside the Belmonte Sabino cemetery; **C**: section of the Castel San. Benedetto quarry. Symbols as in Fig. 3.

*Logs stratigrafici delle successioni della UDU studiate in dettaglio con l'ubicazione dei campioni prelevati per l'analisi paleontologica.* ***A****: sezione affiorante all'interno del campo sportivo di Belmonte Sabino;* ***B****: sezione affiorante all'interno del cimitero di Belmonte Sabino;* ***C****: sezione affiorante nella cava di Castel S. Benedetto. Per la spiegazione dei simboli vedere Fig. 3*

### 3.7 Case Strinati

Along the road that leads from the village of Case Strinati to Lago Lungo, a sequence of diatomitic pelites crops out at 470 m a.s.l. (Figs. 1 and 5) with a thickness of about 3 m. The base is made up of diatomitic silts with thin parallel laminations, rich in plant remains, well preserved leaves and crushed mollusc shells. They are followed by 130 cm of clayey silt with parallel laminations, within which two darker levels can be recognised: the first one is at the bottom, the second one is rich in mollusc fragments. Near the top, pale and dark silty levels are interbedded, a few mm thick and slightly ondulating at the bottom and at the top. The passage to the following diatomitic silts is gradual. Diatomitic silts are about 1 m thick and, at the bottom, are rich in mollusc shell fragments. Almost at half thickness there is a 25 cm thick horizon made up of a dark brown clayey silt, followed by well cemented white carbonate silts. The passage to the diatomitic silts which close the sequence is gradual.

### 3.8 Fosso Filundici

This section crops out on the northern border of the basin, at 650 m a.s.l. (Figs. 1 and 5) and shows a total thickness of 6 m. It lies directly over the carbonatic bedrock (*Scaglia* Formation). The bottom of the sequence consists of a conglomerate layer (3-4 m thick), characterised by well sorted and heterometric carbonate clasts. A dark clayey palaeosol marks the passage between the clastic and pelitic sedimentation. This palaeosol is rich in lignite fragments and in small calcareous clasts with angular shape. Pelitic sedimentation begins with a calcareous silt, some dm thick, characterised by laminations and plant frustuls. It is followed by a 60 cm thick alternance of dark clays and calcareous silts with no laminations. Parallel and cross laminations are evident in the overlying calcareous silts and clays (1.5 m thick) which also bear some mollusc shells. The laminations thicken towards the top of the sequence, with laminae some cm thick. The section is closed by a calcareous silt with well marked alteration levels.

### 3.9 Madonna della Torricella

Samples near Madonna della Torricella (720 m a.s.l.) were taken at different times, on the basis of lithotypes emerging in man-made excavations (Figs. 1 and 5). It is therefore difficult to make a detailed description of the section. In 1988, during the excavations for a house foundation, a level of lignite, very rich in molluscs cropped out. More recently (September, 1994), in a cut for sewege pipes, it was possible to extend the sequence a

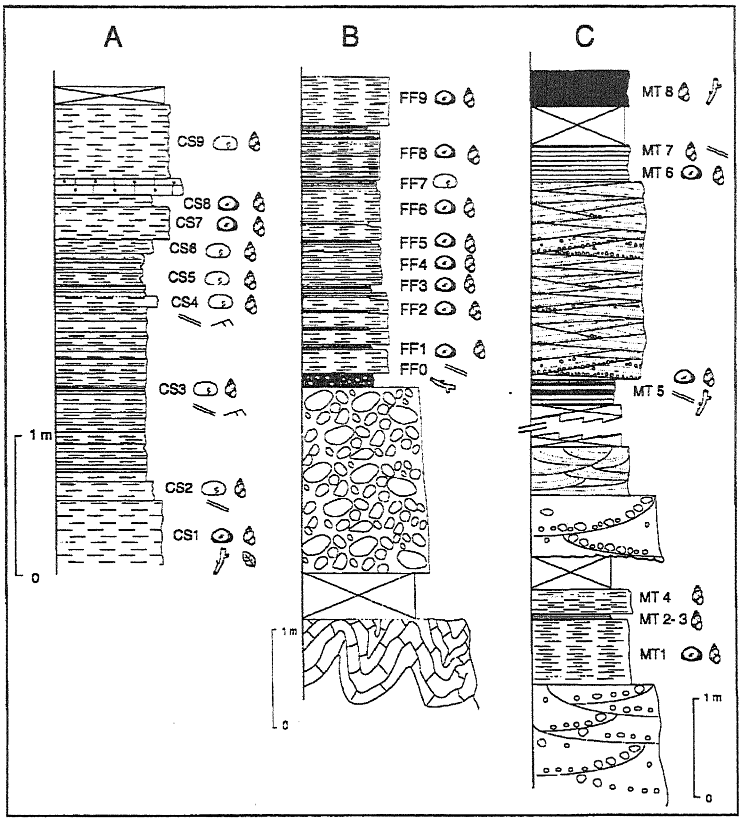


Fig. 5 - Stratigraphic logs of successions cropping out in the norther sector of the Rieti basin with the location of samples collected for paleontological analysis. A. Case Strinati section; B. Fosso Filundici section; C. Madonna della Torricella section. For the explanation of symbols see Fig. 3.

Logs stratigrafici della successioni studiate in dettaglio, affioranti nel settore settentrionale del bacino di Rieti con l'ubicazione dei campioni prelevati per l'analisi paleontologica. A. sezione di Case Strinati; B. sezione di Fosso Filundici; C. sezione di Madonna della Torricella. Per la spiegazione dei simboli vedere Fig. 3.

few metres in depth, into lead-gray clays with lignite levels which overlie a sandy level. An even lower sampling (688 m a.s.l.) was made from an outcrop near the road between Madonna della Torricella to San Valentino. At the base this sequence exhibits a fractured and locally laminated gray calcareous silt 1 m thick, rich at the base in mollusc shells and opercula. At half height, two thin leyers of clays (total thickness of 10 cm) are interbedded, the first made up of marly clays rich in thread-like plant fragments, the second of gray clays. Over the calcareous silts the outcrop is covered by vegetation for about 1 m in thickness, then about 1 m of gravels and concave cross laminated sands are visible.

## 4. PALEONTOLOGICAL ANALYSES

Paleontological analyses were carried out on several samples scattered throughout the Rieti Basin (Fig. 1). Owing to the scarcity of pelitic-psammitic outcrops, only 9 sections of relevant thickness were sampled and studied in detail with other samples taken from small outcrops only a few tens of centimetres thick. However, their distribution led us to extend the palaeonvironmental interpretation to wider sections of the basin.

Paleontological analyses of continental sediments mainly dealt with fossil molluscs and ostracods, but sometimes included seeds, leaves and woods.

### 4.1 Sediments pertaining to the 1st phase of filling

Nineteen samples were analysed, mostly sterile or very poor in fossil content (rare and fragmentary molluscs and ostracods).

Four samples were collected from the section along the road between Maglianello Alto and Maglianello Basso (Fig. 3) and only the uppermost sample (MA4) yielded one specimen of *Lymnaea* sp.

Seven samples were collected from the Fonte Vena section (Fig. 3). All the dry sieved residuals bore abundant thread-like plant fragments. Ostracods were absent and molluscs were represented by very few shell fragments or opercula: at the base of the succession (FV0) one operculum of *Bithynia* sp., in FV2 and FV5 only terrestrial molluscs (one operculum of *Pomatias elegans* (Müller) and two shell fragments of *Cochlostoma* sp. and *Carichium* sp.) were identified.

Nine samples were collected in the section along Via Salaria at km 65. 200 (Fig. 3) and, on the whole, fossil remains were very scarce and fragmentary. In the lower part of the succession only rare shell fragments of terrestrial molluscs were recognised: *Carichyum* cf. *C. tridentatum* (Risso) (VS0), *Limax* sp. (VS1), *Cochlostoma* sp. *vel Achantinula* sp. (VS3); in the upper part (VS4, VS5, VS6) very rare ostracod valves were found, all referable to *Candona* sp. instars. In the sample VS5 a fragment of terrestrial mollusc (*Vitrea* sp.) was also found. At the level of the sample VS4 a portion of an *in-situ* trunk of Taxodiacea was recognised (determined by Dr. Alessandra Celant). The wood was rather dried and deformed and did not permit a generic determination.

The scarcity of the fossil record makes any palaeoenvironmental interpretation difficult. Both at Fonte Vena and at Via Salaria km 65. 200 only terrestrial molluscs were collected (apart from rare and clearly displaced instars of *Candona* sp. and one operculum of *Bithynia* sp.).

From a biostratigraphical point of view only the presence of one operculum of *Pomatias elegans,* species distributed from the Late Pliocene to the Present (Prof.

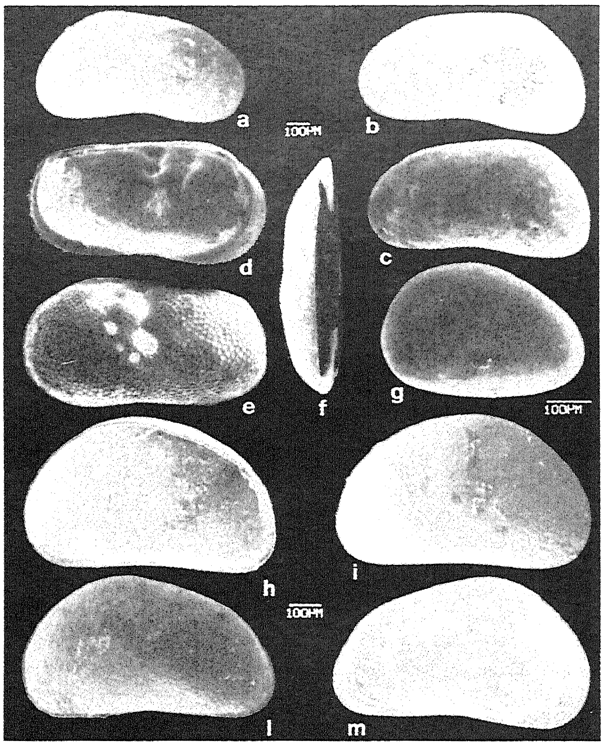


Fig. 6 - Ostracods collected from Belmonte Sabino sections. **a - c**: *Candona neglecta* (BS1, **a**: r.v. in outer view; **b**, **c**: l. v. in outer view); **d - f**: *Ilyocypris bradyi* (**d**: l.v. in inner view, BS1; **e**: l.v. in outer view, BS4; **f**: l. v. in dorsal view, BS1); **g**: *Cyclocypris laevis* (BS4, r.v., outer view); **h - m**: *Potamocypris zschokkei* (BS3, **h**: r.v. in inner view; **i**: r.v. in outer view; **l**: l.v. in outer view; **m**: l.v. in inner view).

*Ostracodi raccolti nelle sezioni di Belmonte Sabino.* ***a - c:*** Candona neglecta *(BS1,* ***a:*** *v.d. in norma esterna;* ***b, c:*** *v.s. in norma esterna, x55);* ***d - f:*** Ilyocypris bradyi *(**d:** v.s. in norma interna, BS1;* ***e:*** *v.s. in norma esterna, BS4;* ***f:*** *v.s in norma dorsale, BS1);* ***g:*** Cyclocypris laevis *(BS4, v.d. in norma esterna);* ***h - m:*** Potamocypris zschokkei *(BS3,* ***h:*** *v.d. in norma interna;* ***i:*** *v.d. in norma esterna;* ***l:*** *v.s. in norma esterna;* ***m:*** *v.s. in norma interna).*

D. Esu, pers. comm.) limits the antiquity of the 1st phase of filling.

## 4.2 Sediments pertaining to the 2nd phase of filling

Forty-four samples from 6 pelitic-sandy successions were collected and studied.

Nine samples from the Cava di Castel S. Benedetto succession (Fig. 4) contain rather abundant thread-like plant fragments but no molluscs or ostracods, except for sample CB8 taken at the base of the succession, in which fragmentary remains of *Lymnaea truncatula* (Müller), *Pisidium* sp., *Planorbis* sp., *Limax* sp. and *Helicella* sp. were found.

Sediments of the Belmonte Sabino cemetery section (Fig. 4) bore a rather abundand ostracofauna, characterised by the dominance of *Ilyocypris bradyi* Sars, *Candona neglecta* Sars and *Potamocypris zschokkei* (Kaufmann) (Fig. 6). They are oligothermophilous or cold-demanding, rheoeuryplastic (*I. bradyi* and *C. neglecta*) or rheopilous (*P. zschokkei*) and often have been collected in cold spring waters (*P. zschokkei* is a crenophil species). These dominant species are associated with rare valves of *Cyclocypris laevis* (Müller) Vavra at the base of the succession and with rare valves of *Herpetocypris* sp. at the top.

The Belmonte Sabino sportsfield section (Fig. 4) bore a less abundant but more diversified ostracofauna. *Candona neglecta* is accompanied by other two Candoninae species, *Candona* cf. *C. fabaeformis* Fischer and *Pseudocandona* cf. *P. parallela* (Müller) which are oligorheopilouss (preferring still waters) and mesothermophils. *Potamocypris zschokkei* is present only in one sample, and at the top of the succession valves of *Cyclocypris* sp., *Herpetocypris* cf. *H. chevreuxi* (Sars) and cf. *Ste-nocypria* (Fig. 7) were collected.

On the whole, the dominant species of the cemetery section suggest a shallow pool influenced by springs (Fig. 8). Probably this influence was areally limited, because the sportsfield assemblages do not record it (*P. zschokkei* and *I. Bradyi* were not dominant) (Fig. 9) and, by contrast, mesothermophil Candoninae are present. An slight environmental change is recognisable in correspondence with the lignite level of the cemetery section; in fact in this level *I. bradyi, C. neglecta* and *P. zschokkei* are present with only 1-3 valves. The body of water, previously well-oxygenated and rich in vegetation becomes still, probably owing to reduced incoming spring-waters. Probably the top of the sportsfield section, with *C.* cf. *C. fabaeformis, Cyclocypris* sp., *H.* cf. *H. chevreuxi* and cf. *Stenocypria,* which prefer a muddy bottom with rich vegetation, corresponds to this drier interval. The gray clays with thread-like plant fragments at the top of the cemetery succession record the restoration of the initial conditions with cold spring-waters.

Ostracofaunas of the Belmonte Sabino area suggest alternating humid-arid-humid climatic conditions.

Nine samples were collected in the Case Strinati section (Fig. 5). Among the ostracods, the dominant species (represented by more than 100 valves) are *Cyprideis torosa* (Jones), *Ilyocypris bradyi* and *Candona angulata* Müller (Figg. 10, 11).

*Cyprideis torosa* is a euryhaline species (0.4-150‰, Neale 1988) typical of estuarine environments. It is echophenotypically very sensitive to the salinity and chemical composition of the water-body (Rosenfeld & Vesper, 1977; Bodergat, 1983). Adult specimens collected at Case Strinati show thick valves with strongly reticulate ornamentation and, sometimes, with two or three nodes; the abundant instar valves are almost always characterised by pronounced nodes. These morphological characteristics are linked to oligo-mesohaline, well-oxygenated waters, rich in $Mg^{++}$ (Bodergat, 1983). Nodosity indicates the presence of dissolved $Ba^{++}$ and, in general salinity conditions below 8‰ (Carbonel, 1988). The presence of abundant dissolved $Mg^{++}$ and $Ba^{++}$ ions is typical of

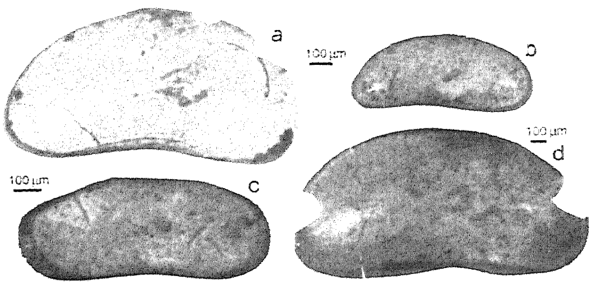


Fig. 7 - Subordinate ostracods species collected in the Belmonte Sabino sections. **a** - **b**: cfr. *Stenocypria* (**a**: r.v., **b**: juv. r.v., BS5); **c**: *Candona fabaeformis* (r.v., BS5); **d**: *Herpetocypris* cfr. *H. chevreuxi* (r.v., BS5).

*Ostracodi accompagnanti raccolti nelle sezioni di Belmonte Sabino. **a** - **b**: cfr.* Stenocypria *(**a**: v.d., **b**: v.d. juv. , BS5, ); **c**:* Candona fabaeformis *(v.d., BS5); **d**:* Herpetocypris *cfr.* H. chevreuxi *(v.d., BS5).*

environments with terrigenous sedimentation (Bodergat, 1983) as in the case of the Case Strinati succession. The thick shell of *C. torosa* and of other associated species could indicate an elevated rate of sedimentation.

*Candona angulata* lives in fresh or slightly saline waters (0.4÷13.4‰ Neale, 1988; De Dekker, 1979) and is often associated with *C. torosa* in estuarine environments or in marshes and lakes near the shore.

*Ilyocypris bradyi* is oligothermophilous and rheoeuryplastic; it tolerates low salinities. In almost all samples, valves referable to the genus *Ilyocypris* were collected, with outlines and proportions which do not correspond to those of *Ilyocypris bradyi* (Fig. 12). Unfortunately the scarcity of these different morphotypes makes it difficult to decide whether they correspond to different *Ilyocypris* species or whether they are phenotypical modifications of *Ilyocypris bradyi* linked to the salinity.

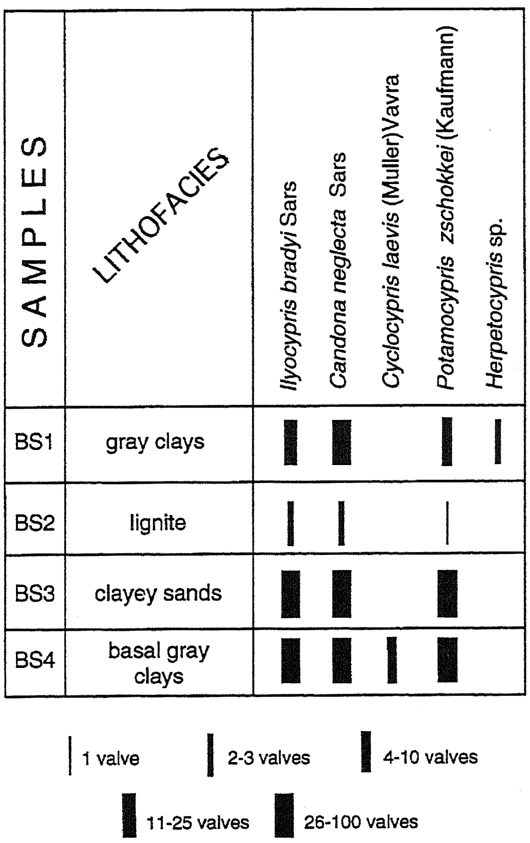


Fig. 8 - Distribution and frequencies the ostracods in the Belmonte Sabino cemetery section.

*Distribuzione e frequenze degli ostracodi nella sezione del cimitero di Belmonte Sabino.*

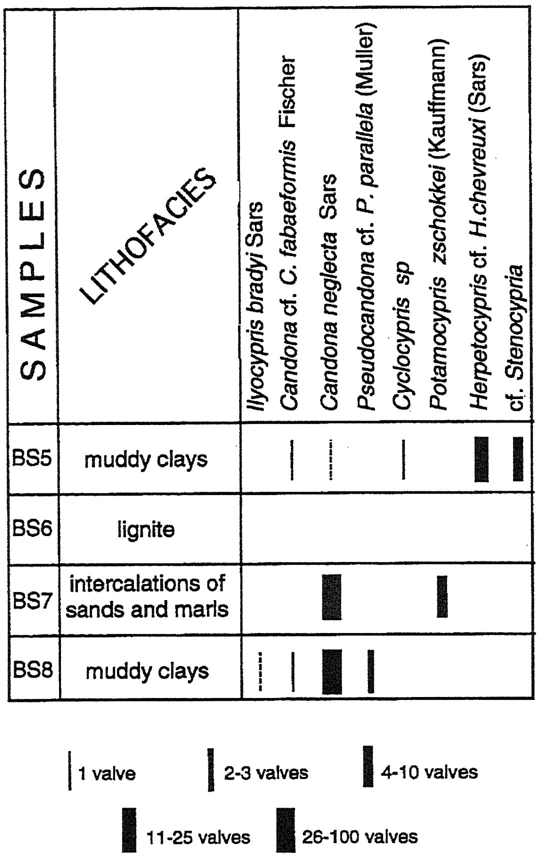


Fig. 9 - Distribution and frequencies of ostracods in the Belmonte Sabino sports field section.

*Distribuzione e frequenze degli ostracodi nella sezione del campo sportivo di Belmonte Sabino.*

Subordinate to the dominant species above, but always associated with them, is *Cypria ophtalmica* (Jurine), which is eurytherme, tolerates some salt content (6.4‰, Bronshtein, 1947) and is characteristic of muddy bottoms with decaying organic matter.

The dominant species are also accompanied by *Darwinula stevensoni* (Brady & Robertson), *Candona candida* Müller, *Candona* cf. *C. levanderi* Hirschmann,

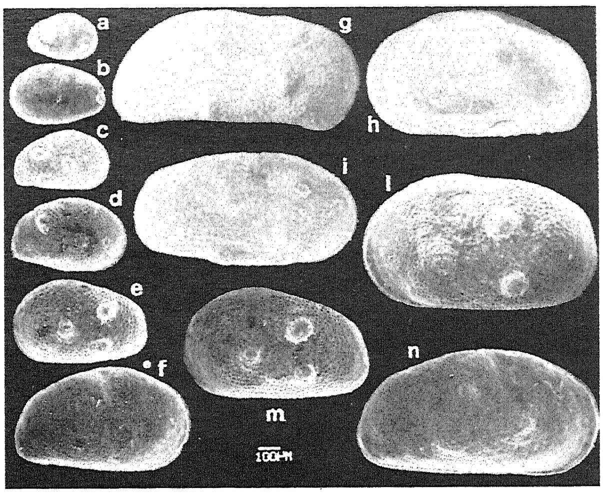

Fig. 10 - *Cyprideis torosa* from the Case Strinati and Fosso Filundici sections. **a**: III larval stage (r.v., FF7); **b** - **c**: IV larval stage (l.v., r.v., FF7); **d**: V larval stage (r.v., FF7); **e**: VI larval stage (l.v., FF7); **f**: VII larval stage (r.v., FF7); **g**: adult male (r.v., CS2); **h**: adult female in inner view (r.v., CS2); **i**: adult male (r.v., CS2); **l**: adult female (l.v., FF7); **m**: VIII larval stage (l.v., FF7); **n**: adult male (r.v., FF7).

*Valve di* Cyprideis torosa *raccolte nelle sezioni di Case Strinati e Fosso Filundici.* ***a****: III stadio larvale (v.d., FF7);* ***b*** *-* ***c****: IV stadio larvale (v.s., v.d., FF7);* ***d****: V stadio larvale (v.d., FF7);* ***e****: VI stadio larvale (v.s., FF7);* ***f****: VII stadio larvale (v.d., FF7);* ***g****: valva maschile adulta (v.d., CS2);* ***h****: valva femminile adulta in norma interna (v.d., CS2);* ***i****: valva maschile adulta (v.d., CS2);* ***l****: valva femminile adulta (v.s., FF7);* ***m****: VIII stadio larvale (v.s., FF7);* ***n****: valva maschile adulta (v.d.).*

*Candonopsis* cf. *C. kingsleii* Hartwig, *Pseudocandona* cf. *P. parallela* (Müller) and *Eucypris* sp. which are scattered in the succession and represented by a few valves (Fig. 13). *Darwinula stevensoni* lives in shallow waters (0÷10 m), is thermoeuryplastic, oligorheophilous and prefers limemud bottoms into which it can burrow; and tolerates waters with a low salt content (0÷15‰, Neale, 1988). *Candona candida* is oligothermophilous, rheophobic and lives on muddy bottoms rich in vegetation (Sokac, 1978). *Candona levanderi* is a shallow-water dweller (0÷3 m, Sokac, 1978) and tolerates a slight salinity (6.4‰, Bronshtein, 1947 = *Candona balatonica,* Daday, 1894). In the CS1 and CS8 *C.* cf. *C. levanderi* is present with a few, fragmentary valves. *Candonopsis* cf. *C. kingsleii* is recorded with three juvenile valves collected in sample CS1; the species is polythermophilic, rheophobic and inhabits still waters and large lakes rich of vegetation (Sokac, 1978). *Pseudocandona* cf. *P. parallela* is represented only by instar valves; it is considered as ubiquitary, rheoeuryplastic, mesothermophilic and prefers waters rich in aquatic vegetation.

Molluscs were found in all samples, but are always represented by undeterminable shell fragments or by opercula of *Bithynia* sp. At the base of the succession, together with the opercula, abundant shell fragments of Neritinae are recognisable.

Moreover, at the base of the succession abundant leaf remains referable to *Phragmites* and some *Charophyta gyrogonites* were collected.

The graph in Figure 14 shows the distribution and frequencies of ostracods species recognised in the Case Strinati section. It highlights the palaeonvironmental modifications recorded in this section. At the base, the faunal assemblage is characterised by a scarcity of dominant forms, often represented by instars. Candoninae are abundant and represented by several species. They disappear in the overlying sample, except for *C. angulata* which becomes dominant together with *C. torosa* and *I. bradyi.* The succession of these two different ostracod

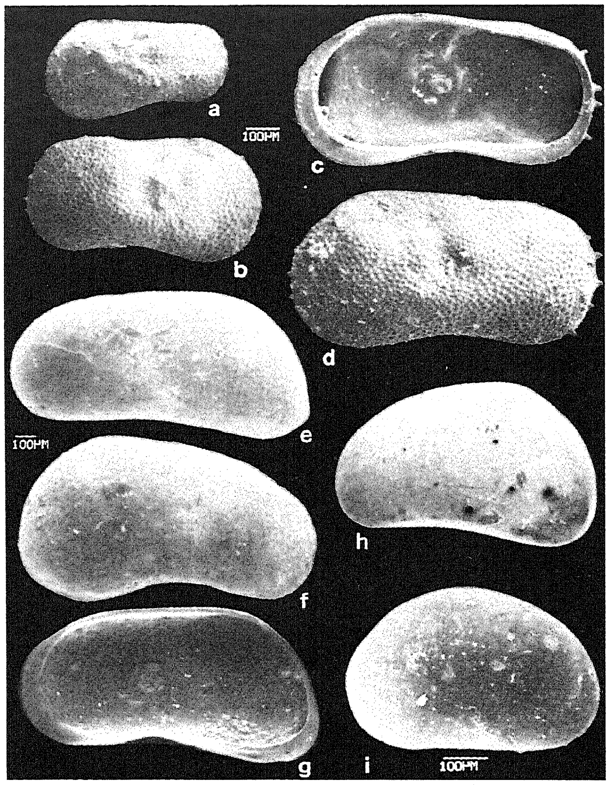

Fig. 11 - Ostracods collected from the Case Strinati section. **a** - **d**: *Ilyocypris bradyi* (CS2, **a**: l.v. of an instar in outer view; **b**: r.v. of an instar in outer view; **c**: r.v. in inner view; **d**: l. v. in outer view); **e** - **g**: *Candona angulata* (**e**: female l.v. in outer view, CS2; **f**: male r.v. in outer view, CS2; **g**: female r.v. in inner view, CS9); **h**: *Candona candida* (CS7, l.v. in outer view); **i**: *Cypria ophtalmica* (CS9, r.v. in outer view).

*Ostracodi raccolti nella sezione di Case Strinati.* ***a*** *-* ***d****:* Ilyo-cypris bradyi *(CS2,* ***a****: v.s. juv. in norma esterna;* ***b****: v.d. juv. in norma esterna;* ***c****: v.d. in norma esterna;* ***d****: v.s. in norma esterna);* ***e*** *-* ***g****:* Candona angulata *(****e****: v.s. femminile in norma esterna, CS2;* ***f****: v.d. maschile in norma esterna, CS2;* ***g****: v.d. femminile in norma interna, CS9, );* ***h****:* Candona candida *(CS7, v.s. in norma esterna);* ***i****:* Cypria ophtalmica *(CS9, v.d. in norma esterna).*

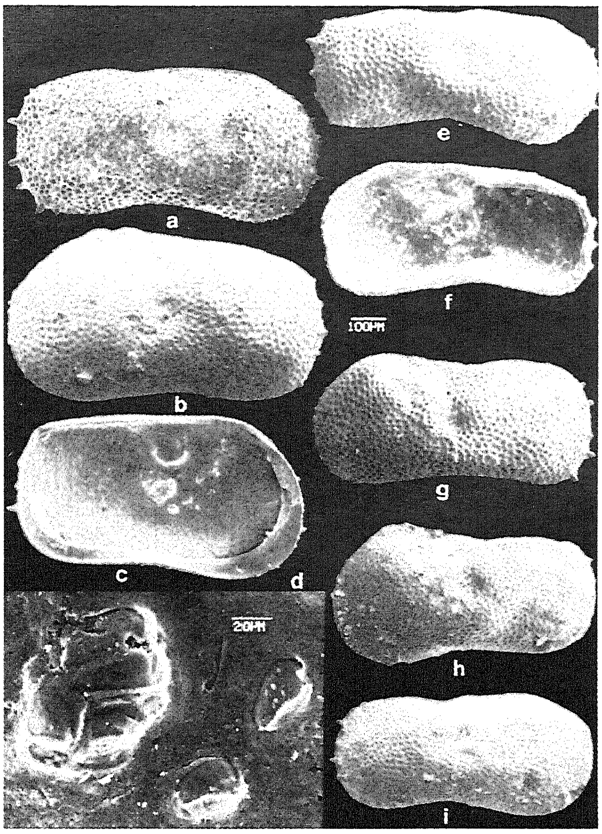

Fig. 12 - Different morphotypes of *Ilyocypris* collected from the Case Strinati and Fosso Filundici sections. **a**: morphotype A characterised by a flat surface in the mid-dorsal portion of the valve and by an elongated and dorso-ventral short valve (FF8, r.v. in outer view); **b** - **d**: morphotype B characterised by a short and high valve with rectilinear posterior border (CS2, **b**: l.v. in outer view; **c**: l.v. in inner view; **d**: l.v. muscular scars); **e** - **g**: morphotype C characterised by a very elongated and dorso-ventrally short valve and by a pronounced mid-ventral sinuosity (CS2, **e**: r.v. in outer view, **f**: r. v. in inner view, **g**: l.v. in outer view); **h** - **i**: morphotype D characterised by a flat surface in the mid-dorsal portion of the valves (CS2, **h**: l.v. in outer view, **i**: r.v. in outer view).

*Diversi morfotipi di* Ilyocypris *raccolti nelle sezioni di Case Strinati e Fosso Filundici.* ***a**: morfotipo A caratterizzato da una area medio-dorsale appiattita e da una forma allungata e bassa (FF8, v.d. in norma esterna);* ***b** - **d**: morfotipo B caratterizzato da una valva corta ed alta con bordo posteriore rettilineo (CS2,* ***b**: v.s. in norma esterna;* ***c**: v.s. in norma interna;* ***d**: impronte muscolari di v.s.);* ***e** - **g**: morfotipo C caratterizzato da una valva molto allungata e bassa e da una sinuosit` ventrale accentuata (CS2,* ***e**: v.d. in norma esterna,* ***f**: v.d. in norma interna,* ***g**: v.s. in norma esterna);* ***h** - **i**: morfotipo D caratterizzato da una area medio-dorsale appiattita (CS2,* ***h**: v.s. in norma esterna,* ***i**: v.d. in norma esterna).*

assemblages records the environmental change from a fresh-water marsh to a oligohaline marsh, with waters chemically influenced by the proximity to the sea.

The oligohaline assemblage is recorded for several decimetres in the central part of the succession even if (CS3, CS5) the faunal contents is sometimes very poor, oligotypical or, at least, monospecifical. Near the top (CS7, CS8) fresh-water Candoninae such as *Candona candida* (CS7) and *Candona* cf. *C. levanderi* (CS8) were again collected, while *C. torosa* and *I. bradyi* are represented by a few valves and *C. angulata* is absent. This interval suggests the restoration of a fresh-water marsh with rich vegetation. In the uppermost sample the oligohaline assemblage with dominant *C. torosa, I. bradyi, C. angulata* and subordinate *C. ophtalmica* is again recognisable.

On the whole, the sedimentary succession of Case Strinati testifies to the existence of a marsh or a small lake with aquatic vegetation. The alternance of fresh and oligohaline waters indicates an important discontinuous influence of the nearby sea on the chemical composition of dissolved ions.

The Fosso Filundici section (Fig. 5) located, as at Case Strinati, in the northern sector of the Rieti Basin, bore a scarce ostracofauna, similar however in composition. The following species were recognised: *Cyprideis torosa, Ilyocypris bradyi, Candona angulata, Candona* sp., *Pseudocandona* sp., *Cypria ophtalmica* and *Eucypris* sp. (Figg. 11, 12). Amongst molluscs, abundant opercula of *Bithynia* sp. were collected and in sample FF3 a shell fragment of *Valvata* sp. was identified.

The lower portion of the succession (FF1-FF6) is characterised by the presence of dominant *I. bradyi,* to which rare valves of *C. torosa, C. angulata* (with many instars) and *Pseudocandona* sp. are associated (in the sample FF2 one valve of *Aurila* sp. was found, clearly displaced). In sample FF7 an abundant ostracofauna was collected, compositionally the same oligohaline association recognised at Case Strinati, with a dominant *C. torosa, I. bradyi, C. angulata* and a subordinate *C. ophtal-*

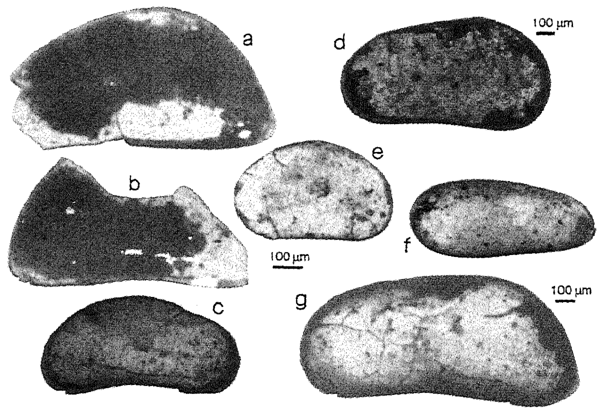

Fig. 13 - Subordinate ostracod species of the Case Strinati section. **a** - **b**: *Candona* cf. *C. levanderi* (**a**: l.v., **b**: r.v., CS1); **c**: *Candonopsis* cf. *C. kingsleii* (r.v., CS1); **d**: *Eucypris* sp. (r.v., CS2); **e**: *Cypria ophtalmica* (r.v., CS4); **f**: *Darwinula stevensoni* (r.v., CS2); **g**: *Candona angulata* (female l.v., CS2).

*Ostracodi accompagnanti raccolti nella sezione di Case Strinati.* ***a** - **b**:* Candona *cf.* C. levanderi *(**a**: v.s., **b**: v.d., CS1);* ***c**:* Candonopsis *cf.* C. kingsleii *(v.d., CS1, x80);* ***d**:* Eucypris *sp. (v.d., CS2);* ***e**:* Cypria ophtalmica *(v.d., CS4);* ***f**:* Darwinula stevensoni *(v.d., CS2);* ***g**:* Candona angulata *(v.d. femminile, CS2).*

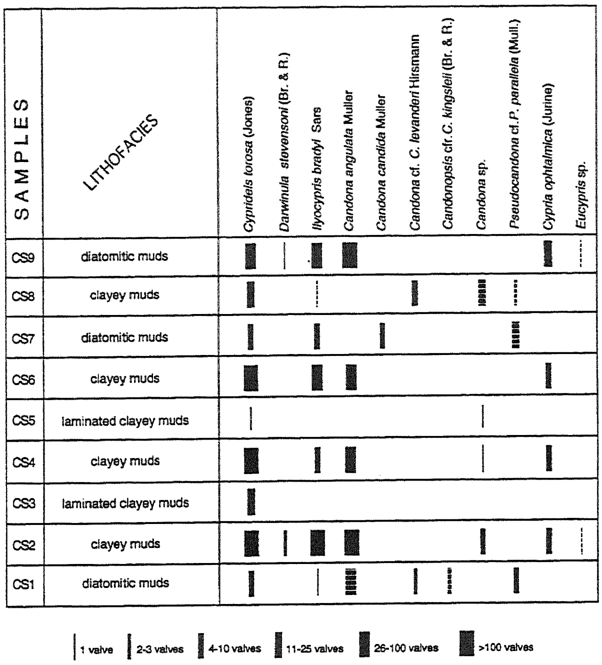


Fig. 14 - Distribution and frequencies of ostracods in the Case Strinati section.

*Distribuzione e frequenze degli ostracodi nella sezione di Case Strinati.*

*mica*. In overlying samples (FF8 and FF9) ostracods are scarce: *C. angulata* and *I. bradyi* are represented only by instars or are absent, *C. ophtalmica* disappears, and *C. torosa* is less frequent.

The analysis of the Fosso Filundici ostracofauna (Fig. 15) shows the presence of a marsh or a small lake with waters influenced by the sea. It differs from Case Strinati in the vertical extension of the brackish episode that here is limited to a few tens of centimetres (FF7).

The last studied section is that of Madonna della Torricella (Fig. 5). Fossil remains are scarce and fragmentary, but of interest becouse they constitute new assemblages not previously found (Fig. 16). The MT1 sample bore rare valves of Ilyocypris bradyi and *Candona* cfr. *C. candida* (Müller). In sample MT5 dominant *Pseudocandona parallela, Candona* cf. *C. candida* and *Candona* cf. *C. fragilis* were collected (represented mainly by instars), with associated fragmentary shells of *I. bradyi* and *Cyclocypris* cf. *C. laevis*. This assemblage was also recognised in sample MT6, but ostracods were always fragmentary. Ostracods of this section are always characterised by a fragile shell. This is considered to be a signal of a low sedimentation rate and of a scarcity of dissolved ions.

Molluscs are rather rare along the whole succession (represented mainly by opercula of *Bithynia* sp. and by fragmentary specimens of *Valvata cristata* (Müller), *Acroloxus lacustris* (Linnaeus) and *Belgrandia* sp. They are abundant only in correspondence with the lignitic level (MT8) where the following species were collected: *Teodoxus (Neritea) groyanus* (Férussac), *Emmericia umbra* De Stefani, *Prososthenia* sp., *Melanopsis affinis* Férussac, *Hydrobia* cf. *H. stagnorum* (Gmelin), *Hydrobia* sp., *Valvata piscinalis* (Müller), *Valvata cristata* and *Viviparus* sp. (Fig. 14).

These assemblages would suggest that the Madonna della Torricella succession sedimented in a freshwater pool fed by springs (*Belgrandia* sp.), with abundant vegetation.

From a biostratigraphic point of view *T. (N.) groyanus, M. affinis, E. umbra* and *Prososthenia* sp. disappear at the end of the Early Pleistocene. The first two species, traditionally considered to be Pleistocene species, were recently found in Late Pliocene sediments of the Tiber Basin (Ponte Naja Unit and Fosso Bianco Unit, Ambrosetti et al., 1995). *Belgrandia* sp. is probably to be referred to a new species which has until now only been found in the Early Pleistocene of the Tiber Basin and in continental carbonates at the top of the A.S.C.T. (Prof. O. Girotti and Prof. D. Esu, pers. comm.).

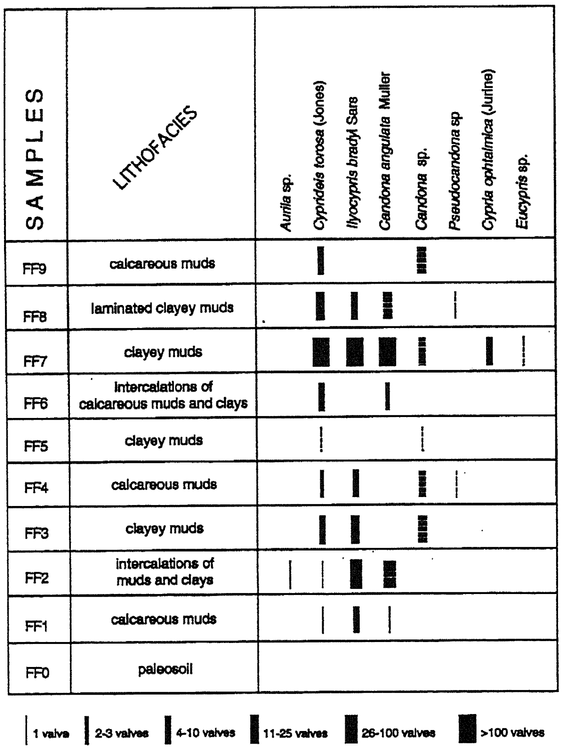


Fig. 15 - Distribution and frequencies of ostracods in the Fosso Filundici section.

*Distribuzione e frequenze degli ostracodi nella sezione di Fosso Filundici.*

## 5. DISCUSSION

Data from the paleontological and facies analyses described in this paper are used to reconstruct the evolutionary phases of the Rieti Basin and their chronological positioning.

The first phase of filling is linked to the sedimentation of coarse deposits in proximal fan and alluvial fan facies (Lower Depositional Unit and Calcariola-Fosso Canalicchio Unit; Cavinato, 1993). The geological survey pointed out the existence of several adjacent and superimposed conoids, initially channelised into morfological depressions of the substratum. Sedimentological analyses of conglomerates show open work, clast-supported and matrix-supported structures, with prevailing clast-supported levels, but no cyclicity of these lithofacies was observed (Barberi & Cavinato, 1993). Clasts, always calcareous or marly-calcareous from the nearby Umbro-Sabina and Latium-Abruzzi domains, are generally rounded and of variable size, from a few centimetres to 50-60 cm, with a prevailing size of 20÷30 cm. Taking into account the present-day location of source areas, it is possible to hypothesise some kilometres to ten kilometres transport.

The most frequently observed facies is the coarse one (Gm, Barberi & Cavinato, 1993), but probably the debris-flow facies is more characteristic one and this allows to relate the alluvial deposition to a semi-arid alluvial fan environment (Collinson, 1986). This interpretation is reinforced by the paleontological analyses, because the pelitic successions of Fonte Vena and Via Salaria km 65. 200, interbedded with the conglomerates, were generally sterile or bore terrestrial hygrophilous molluscs, thread-like plant fragments and a Taxodiacea trunk. A transported Taxodiacea trunk was also found inside conglomeratic units during the excavation for a gallery along the Rieti-Terni freeway.

It is possible to hypothesise that the deposition of these thick conglomeratic alluvial fans could be strictly linked to the tectonic phase that re-activated the N160°-N140° and E-W fault system along the eastern border of the basin. These events caused the sinking of the basin and a great catchment area for the coarse sediments generated by the erosion of the circumstant reliefs developed along the intersection of N160°-N140° and E-W faults. The coarse nature of the sediments suggests a high rate of deposition. Unfortunately it is impossible at present to indicate the time-interval of their deposition due to the lack of fossil markers. The presence of *Pomatias elegans,* together with the Taxodiacea, concur to limit the long interval spanning to between Late Pliocene and Early Pleistocene.

The alternance of glacial and interglacial climatic conditions which characterises the Late Pliocene and Pleistocene has lead many Authors to carry out a comparative study between climate evolution and coarse sediments deposition, pointing out the close relationship between clastic deposits and climatic deterioration (Coltorti & Dramis, 1987; 1988). It is probable that the sedimentation of the Lower Depositional Unit and of the Calcariola-Fosso Canalicchio Unit, mainly linked to tectonics (Barberi & Cavinato, 1993; Cavinato, 1993), was influenced by climate. In particular the frequency of debris-flow facies, the recognised progradation and recession of conoid fronts (Fraser & De Celles, 1992) and the thick breccias observed inside the Calcariola-Fosso Canalicchio Unit (Rocca Ranieri Breccias, Bosi et al., 1989) could be related to climatic causes. It would be possible to correlate coarse deposits of the first phase of filling of the Rieti Basin either with the climatic deterioration of 2.5 Ma (Shackleton *et al.,* 1984) or with the glacial phase around the Plio-Pleistocene boundary (Eburonian, Aullan erosive phase; Azzaroli *et al.*, 1988). According to the chronological indication obtained from the study of sediments belonging to the second phase of filling (outlined below), it is more reliable to hypothesise a correlation with this last climatic deterioration.

Deposits of the first phase of infilling, filled the ancient depression giving rise to a more or less flat surface on which the second phase of infilling was superimposed. The change of depositional regime is probably linked to an equilibrium between uplifting/subsidence rate and sedimentation rate. Deposits of the second phase of infilling, referable to the Upper Depositional Unit (Cavinato, 1993) cropping out in the southern sector of the Rieti Basin and to a still unnameded heteropic unit in the northern sector, are fine-grained (mainly pelites, sands and scarce conglomerates). Often intercalated lignite episodes are observable, sometimes of considerable thickness (lignite mines of Apoleggia and Vicchiagnone, near

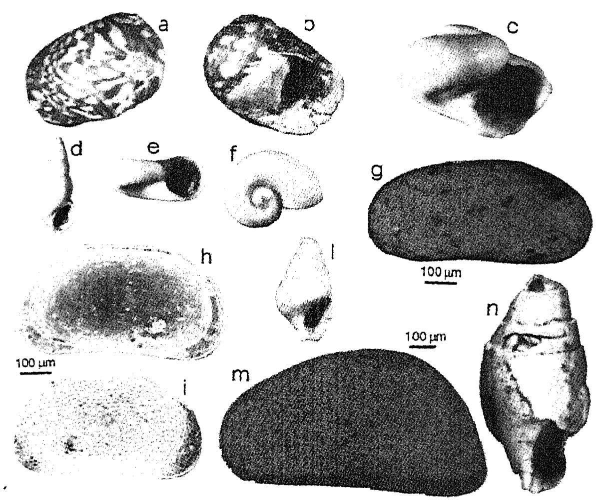


Fig. 16 - Molluscs and ostracods collected from the Madonna della Torricella section. **a - b**: *Teodoxus (Nerinea) groyanus* (x6.5); **c**: *Valvata piscinalis* (x18); **d**: *Hydrobia* cf. *H. stagnorum* (x6); **e - f**: *Valvata cristata* (x24); **g**: *Candona* cf. *C. fragilis* (juv. l.v. , MT5); **h - i**: *Pseudocandona parallela* (**h**: juv. l.v. in inner view, **i**: juv. r.v, MT5); **l**: *Emmericia umbra* (x6); **m**: *Candona candida* (l.v., MT6); **n**: *Melanopsis affinis* (x6)

*Molluschi ed ostracodi raccolti nella sezione di Madonna della Torricella. **a - b:*** Teodoxus (Nerinea) groyanus *(x6, 5); **c:*** Valvata piscinalis *(x18); **d:*** Hydrobia *cf.* H. stagnorum *(x6); **e - f:*** Valvata cristata *(x24); **g:*** Candona *cf.* C. fragilis *(v.s. juv., MT5); **h - i:*** Pseudocandona parallela *(**h:** v.s. juv. in norma interna, **i:** v.d. juv., MT5); **l:*** Emmericia umbra *(x6); **m:*** Candona candida *(v.s., MT6); **n:*** Melanopsis affinis *(x6).*

Fosso Filundici, Mazzetti 1934).

In the northern sector of the basin sedimentary successions cropping out in the sections of Case Strinati, Fosso Filundici and Madonna della Torricella point to the existence of a permanent marsh-like pond. Faunas, sedimentary structures such as parallel and crossed laminations and the presence of diatomites would indicate little bathymetric variation. In the first part of its existence this pond was probably a fresh-water marsh which later on evolved into an oligohaline marsh without any direct contact with the sea, from which it was divided by the reliefs of Mts. Sabini less elevated than at present. Among the ostracods and molluscs of Case Strinati and Fosso Filundici no typical marine and marine-brackish species were present (except for one valve of *Aurila* sp. from Fosso Filundici, probably displaced by aquatic birds); on the contrary, is it possible to recognise oligohaline ostracods, amongst which *Cyprideis torosa* (indicating a water contents of $Na^+$ and $Cl^-$) is abundant. The paleontological study indicated that the influence of the sea was discontinuous: both the sections of Case Strinati and Fosso Filundici record an alternance of fresh water and oligohaline water which is influenced bu the sea. It is noteworthy that the two sections crop out far from one another and at very different elevations a.s.l. (Case Strinati 460 m a.s.l., Fosso Filundici 650 m a.s.l.), but are divided by an important E-W fault system that lowers the Case Strinati sector. The correlation between these sections makes it possible to calculate the displacement of this fault system to around 180-190 m.

An ostracofauna similar to that collected at Case Strinati and Fosso Filundici was studied at Villa S. Faustino, located in the south-western branch of the Tiberino Basin (Ambrosetti *et al.*, 1995). Here, oligohaline assemblages are dominated by *Cyprideis torosa, Ilyocypris bradyi* and the subordinate *Candona angulata* alternates with fresh-water associations. The ostracofaunas of Villa S. Faustino were collected inside pelitic sediments bearing abundant mammal bones referable to the Early Pleistocene (probably to the Tasso Faunal Unit).

By constrast with the Rieti Basin, direct contacts in the Tiber River Basin between the continental braided plain environment of the basin and the sea were recognised in the field in the south-western sector (Amelia) where brackish deposits with *Cerastoderma* and *Potamides* crop out (Ambrosetti *et al.*, 1987).

During the lowermost part of the Early Pleistocene (Santernian substage) the shoreline was located against the reliefs of the Narnesi-Amerini and Sabini Mts. at a present-day elevation of 300-470 m a.s.l. (Girotti & Piccardi, 1994). These Authors recognise a negative oscillation of the Santernian sea level which can be correlated with the continental erosive phase of Aulla (*sensu* Azzaroli *et al.*, 1988). The alternance of fresh-water and oligohaline environments recorded in the Tiber and Rieti basins must be related to a regression-trangression cycle of the sea. The synchronism of Villa S. Faustino ostracods with mammalofaunas referable to the Tasso F.U. suggests the existence of a transgressive-regressive marine cycle also in the upper part of the Santernian.

The Madonna della Torricella section, located north and not far from Fosso Filundici section, on the same side of the faulted block but at an elevation of 700 m a.s.l., must surely be assigned to Early Pleistocene be-cause of the presence of *Belgrandia* sp., (Esu & Girotti, pers. comm.). As described in previous paragraph the fossil assemblages recognised at Madonna della Tor-ricella records a fresh-water palustrine environment lack-ing any halophil species. Probably the sediments of this succession were deposited when the shoreline reatreat-ed W. This regression could have occurred within the Santernian (linked to an eustatic lowering) or at the end of the Santernian, owing both to an eustatic lowering and to a marked uplift phase of the Central Appennine chain. In the Tiber Valley the marine clays bearing *Hyalinea balthica* (Emilian substage) exhibit their most eastward outcrop at Monte delle Piche (Monte Mario; Conato *et al.*, 1980).

The palaeoenvironmental and chronological reconstruction of the southern sector of the Rieti Basin is more difficult owing to the scarcity of fossil remains. Fossil assemblages seem to point out the absence of a large permanent palustrine environment and, on the contrary, suggest the existence of an alluvial plain with more or less temporary ponds, sometimes colonized by vegetation, fed by springs. The scarcity of outcrops pertaining to the lowermost portion of the Upper Depositional Unit limited the findings of *Cyprideis torosa* to only one sample bearing very rare valves, from the Poggio Lama section (400 m a.s.l.). These scarce valves are, however, important because they show that the influence of the Santernian sea extended to the whole basin.

In the southern sector of the basin *Equus stenonis* Cocchi teeth were collected (515 m a.s.l., S. Rufina; Cavinato *et al.*, 1989a) and a tusk of *Mammuthus meridionalis* (evolute form) was recorded from "I Cappuccini" locality (480 m a.s.l.), south of Sanctuary of "La Foresta" (Ambrosetti & Azzaroli, 1977).

Deposits cropping out at Belmonte Sabino (706 m a.s.l.) do not show evidence of brackish influence in the ostracod assemblages (like those of Madonna della Torricella). Ostracods record a fresh water-body influenced by springs. In detail, the paleoecological reconstruction based on ostracofaunas from Belmonte Sabino Cemetery indicate the existence of an alternance of humid-arid-humid climatic conditions.

No certain chronological data are available on the extensional tectonic activity that caused the collapse of the basin after the deposition of the sediments described in this paper, and originating in the northern sector of the present-day Conca di Rieti. The marginal southern, eastern and northern fault systems were surely active in the time-interval between the upper part of the Early Pleistocene and the early Middle Pleistocene. This upper chronological limit is suggested 1) by the volcanic depo-

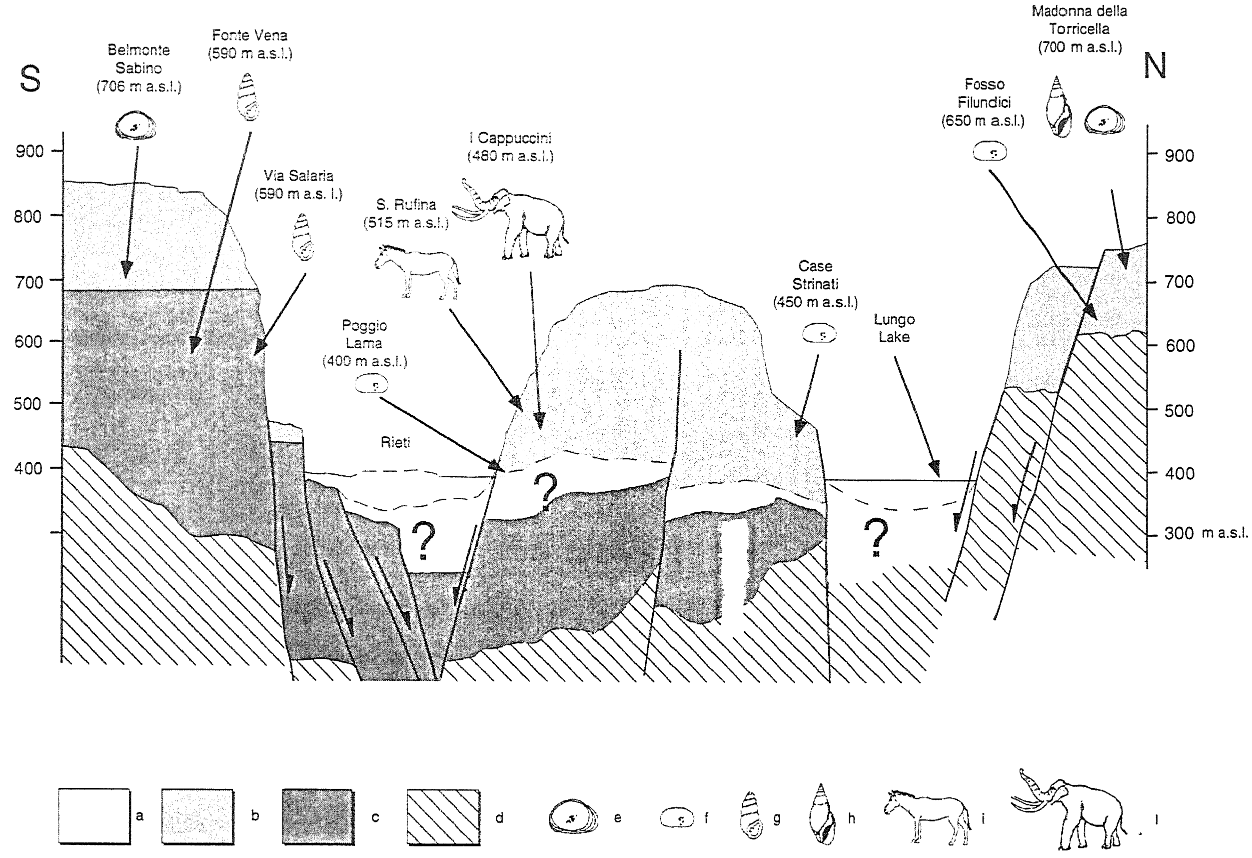


Fig. 17 - N-S schematic section through the Rieti Basin with the location of the main fossils collected (from a chronological and palæoenvironmental perspective) and of the main fault systems. Legend: a: Middle Pleistocene-Holocene deposits; b: Early Pleistocene deposits; c: Late Pliocene-Early Pleistocene deposits; d: carbonate bedrock; e: fresh-water ostracod associations; f: oligo-mesohaline ostracod associations; g: terrestrial molluscs; h.: fresh-water mollusc associations; i: *Equus stenonis*; l: *Mammuthus meridionalis.*

*Profilo schematico N-S attraverso il Bacino di Rieti nel quale sono riportati in maniera sintetica i ritrovamenti paleontologici più significativi dal punto di vista cronologico ed ambientale ed i principali lineamenti tettonici. Legenda: a: depositi del Pleistocene medio - Olocene; b: depositi del Pleistocene inferiore; c: depositi del Pliocene superiore - Pleistocene inferiore; d: substrato carbonatico; e: ostracodi dulcicoli; f: ostracodi oligo-mesoalini; g: molluschi terrestri, h: molluschi dulcicoli; i:* Equus stenonis; *l:* Mammuthus meridionalis.

sits of Cupaello (0.6 Ma B.P.; Laurenzi *et al.*, 1994) deposited against the faulted blocks; 2) by fluvial terraces, observable along the Velino Valley (Brunamonte *et al.*, 1993; Carrara *et al.*, 1992) and whcih cut into the Lower Depositional Unit. The relevant fluvial erosion recognisable in the area must be linked to a remarkable lowering of the ground level, probably due to the tectonic activity which downthrew the Conca di Rieti. The Authors recognised different orders of terraces, the oldest (1st order) made up of sediments without volcanic elements.

The schematic section of Figure 17 summarizes the biochronological and palaeoenvironmental constraints which lead to the reconstruction of the Rieti Basin evolution from the Late Pliocene to the Early Pleistocene, and the main tectonic elements which affected the studied sedimentary successions. The correlations between deposits throughout the basin indicate the amount of throws of the main fault systems. On the basis of present-day elevation of correlatable sections at Case Strinati and Fosso Filundici, it is possible to calculate that the displacement of the E-W northern fault systems was around 170-190 m. Moreover, making a huge correlation between the Belmonte Sabino sections and S. Rufina and Sacntuary "La Foresta" (where mammal remains were collected), and taking into account the different outcropping elevation of the limit LDU/UDU, it is possible to calculate the displacement of the E-W southern fault systems to around 200-350 m. Finally, the hypothesised existence of a fault in the Castelfranco area (hypothesised on the basis of strips of chaotic and broken conglomerates) is reinforced: in fact by correlating the sections of Poggio Lama and Case Strinati a southwards displacement of about 60 m can be estimated.

## 6. CONCLUSIONS

Data discussed in this paper suggest the following evolutionaty phases of the Rieti Basin.

1) The origin of the intra-Appenninic basin of Rieti is linked to an extensional tectonic event occurring prob-

ably during the Late Pliocene.

2) The first filling phase (deposition of the Lower Depositional Unit and of the Calcariola-Fosso Canalicchio Unit) occurs in semi-arid alluvial fan facies. The sedimentation of this coarse material is due both to tectonic and climatic causes. The corresponding phase of climatic deterioration could be that occurring at the Plio-Pleistocene boundary (Eburonian, Aullan erosional phase, *sensu* Azzaroli , 1988).

3) The ancient morphological depression is filled by the beginning of the Pleistocene. The new flat morphology of the Rieti Basin is shown by a successive braided plain sedimentation.

4) The second phase of filling (deposition of the Upper Depositional Unit in the southern sector and of a still unnamed heteropic unit in the northern sector) occurs in a braided plain sedimentary environment. Sediments are fine-grained, with prevailing sands, muds and clays. During the second phase one or more marshes occupied the northern sector, while in the southern sector only an alluvial plain with temporary and localised ponds sometimes fed by springs existed.

a) Sediments at the base of the sedimentary succession of the second filling phase show the existence of palustrine environments, characterised by an alternance of fresh and oligohaline water-bodies influenced by the nearby sea. The correlation of these deposits with those of Villa S. Faustino (Tiber Basin) suggests an age corresponding to the lower part of the Early Pleistocene.

b) Deposits of the upper part of the sedimentary sequence of the second filling phase do not show any marine influence. Identified fresh-water palaeoenvironments must be referred to the Early Pleistocene due to the presence of *Belgrandia* sp., *Mammuthus meridionalis* (evolute form) and *Equus stenonis.* During this time-interval an alternance of humid-arid-humid climatic conditions was recorded.

5) Tectonic activity which downthrew the northern sector of the basin and which gave origin to the present-day Rieti Basin is referable to the time-interval late Early Pleistocene-early Middle Pleistocene. The correlation of different Early Pleistocene deposits outcropping in the Rieti Basin allowed to calculate relevant displacements to between 60 and 350 m.

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## REFERENCES

Ambrosetti P. & Azzaroli A., 1973 - *Alluvioni fossilifere dei bacini lacustri.* In: Desio A., *Geologia dell'Italia,* 739-753, UTET, Torino.

Ambrosetti P., Carboni M. G., Conti M.A., Esu D., Girotti O., La Monica G.B., Landini B. & Parisi G., 1987 - *Il Pliocene ed il Pleistocene inferiore del bacino del Fiume Tevere nell'Umbria meridionale.* Geogr. Fis. Dinam. Quat., **10**, 10-33, Torino.

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 del ramo sud-occidentale del Bacino Tiberino (Umbria): aspetti litostratigrafici e biostratigrafici.* Il Quaternario, **8**(1), 19-36, Roma.

Azzaroli A., 1977 - *Evolutionary patterns of Villafranchian elephants in Central Italy.* Mem. Atti Acc. Naz. Lincei , **14**(4), 149-170, Roma.

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

Barberi R. & Cavinato G. P., 1993 - *Analisi sedimentologiche ed evoluzione paleogeografica del settore meridionale del bacino di Rieti.* Studi Geol. Camerti, vol. spec., 1992/1, 45-54, Camerino.

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

Bertoldi R., Rio D. & Thunell R., 1989 - *Pliocene-Pleistocene vegetational and climatic evolution of the South-Central Mediterranean.* Palaeogeogr., Palaeoclim. Palaeoecol., **72**, 263-275, Amsterdam.

Bodergat A.-M., 1983 - *Les ostracods, temoins de leur environment: approche chimique et ecologie en milieu lagunaire et oceanique.* Doc. Labo. géol. Lyon, **88**, 1-246, Lyon.

Bosi C., 1987 - *Neotectonic map of Italy (scale 1: 500.000).* Quaderni de "La Ricerca Scientifica" P.F.G. CNR, **114**(4), Roma.

Bosi C., Messina P. & Sposato A., 1989 - *La depressione del Salto.* In: Soc. Geol. It. - *Guida all' Escursione "Elementi di tettonica pliocenica-Quaternaria ed indizi di simicità olocenica nell'Appennino laziale-Abruzzese",* 89-96, Roma.

Bronshtein Z.S., 1947 - *Fresh-water ostracoda.* 470 pp., Balkema Ed., Rotterdam (English translation, 1988).

Brunamonte F., Gaeta M., Michetti A. M., Mottana A., & Paladino D.M., 1992 - *Caratterizzazione mineralogi-*

*co-petrografica ed inquadramento stratigrafico preliminare di alcuni depositi vulcanoclastici dell'area Reatina.* Studi Geol. Camerti, vol. spec., 1992/1, 65-72, Camerino.

Brunamonte F., Carrara C., Cavinato G.P., Ferreli L., Serva L., Michetti A.M. & Raglione M., 1993 - *La conca di Rieti.* Il Quaternario, Ê(2), 396-401, Roma.

Carbonel P., 1988 - *Ostracods and the transition between fresh and saline waters.* In: De Deckker P., Colin J.-P. & Peypouquet J.-P. (Eds.) *"Ostracoda in the Earth Sciences"*, 157-173, Elsevier, Amsterdam.

Carrara C., Brunamonte F., Ferreli L., Lorenzoni P., Margheriti L., Michetti A.M., Raglione M., Rosati M. & Serva L., 1992 - *I terrazzi della medio-bassa valle del F. Velino.* Studi Geol. Camerti, Vol. Spec. 1992/1, 97-102, Camerino .

Cavinato G. P., Cerisola R. & Storoni Ridolfi S., 1989a - *Segnalazione del ritrovamento di denti di* Equus stenonis *(Cocchi) in località S.Rufina (Conca di Rieti - Lazio).* Geol. Rom., **26**, 255-257, Roma.

Cavinato G. P., Chiaretti F., Cosentino D. & Serva L., 1989b - *Caratteri geologico-strutturali del margine orientale della Conca di Rieti.* Boll. Soc. Geol. It., **108**(2), 207-218, Roma.

Cavinato G.P., 1993 - *Recent tectonic evolution of the Quaternary deposits of the Rieti Basin (Central Apennines, Italy): southern area.* Geol. Rom., **29**, 411-434, Roma.

Collinson J.D., 1986 - *Alluvial sediments.* In: Reading H.G. (Ed.) *"Sedimentary Environments and Facies"*, 20-62, Blakwell's Sc. Publ., Oxford.

Coltorti M. & Dramis F., 1987 - *Sedimentological characteristics of stratified slope-waste deposits in the Umbria-Marche Apennines (Central Italy) and their genetic implications.* In: *"Processus et mesure de l'erosion"*, 145-152, Ed. C.N.R.S., Paris.

Coltorti M. & Dramis F., 1988 - *The significance of stratified slope-waste deposits in the Quaternary of Umbria-Marche Apennines, Central Italy.* Z. Geomorph. N.F., **71**(Suppl.), 59-70, Berlin-Stuttgart.

Conato V., Esu D., Malatesta A. & Zarlenga F., 1980 - *New data on the Pleistocene of Rome.* Quaternaria, **22**, 131-176, Roma.

De Deckker P., 1979 - *The middle Pleistocene ostracod fauna of the West Runton freshwater bed, Norfolk.* Paleontology, **22**(2), 293-316, London.

Diebel K. & Pietrzeniuk E., 1990 - *Pleistocene Ostracods from Véresszolos.* In: Kretzoi M. & Dobosi V.T. (Eds.) *"Vértesszolos man site and culture"*, 145-161, Akadémiai Kiad, Budapest.

Esu D. & Girotti O., 1991 - *Late Pliocene and Pleistocene assemblages of continental molluscs in Italy. A survey.* Il Quaternario, **4**(1a), 137-150, Roma.

Ferreli L., Brunamonte F., Filippi G., Margheriti L. & Michetti A.M., 1992 - *Riconoscimento di un livello lacustre della prima etˆ del Ferro nel Bacino di Rieti e possibili implicazioni neotettoniche.* Studi Geol. Camerti, vol. spec., 1992/1, 127-135, Camerino.

Ferreli L., Parotto M. & Serva L., 1992 - *Evoluzione del reticolo idrografico nella piana di Rieti negli ultimi 4000 anni.* Mem. Soc. Geol. It., **45**, 901-910, 5 ff., Roma.

Fraser G.S. & De Celles P.G. (1992) - *Geomorphic controls on sediment accumulation at margins of foreland basins.* Basin Research **4**(3/4), 233-252, Oxford.

Girotti O. & Piccardi E., 1994 - *Linee di riva del Pleistocene inferiore sul versante sinistro della media valle del fiume Tevere.* Il Quaternario, **7**(2): 525-536, Roma.

Henderson P.A., 1990 - *Fresh-water Ostracods.* Synopses of the British Fauna (N.S.), **42**, 1-228, London.

Klie W., 1938 - *Die Tierwelt Deutschlands und der angrenzenden Meeresteile nach ihren Merkmalen und nach ihrer Lebensweise: Krebstiere oder Crustacea III: Ostracoda, Muschelkrebse.* Gustav Fischer Verl., Jena, 230 pp.

Laurenzi M., Stoppa F., Villa I., 1994 - *Eventi ignei monogenici e depositi piroclastici nel distretto ultra-alcalino umbro-laziale (ULUD): revisione, aggiornamento e comparazione dei dati cronologici.* Plinius, **12**, 61-66.

Lorenzoni P., Raglione M., Brunamonte F., Michetti A.M. & Pennacchioni M., 1992 - *Stratigrafia dei depositi di versante tardo-quaternari del Bacino di Rieti: la sezione de "La Casetta".* Studi Geol. Camerti , vol. spec., 1992/1, 145-153, Camerino.

Mazzetti C., 1934 - *Rassegna statistica dei combustibili italiani.* Consiglio Nazionale delle Ricerche, Commissione per i combustibili, fasc. 8, Roma.

Miall A. D., 1991 - *Principles of sedimentary basin analysis.* 490 pp., Springer & Verlag, New York.

Neale J.V., 1988 - *Ostracods and paleosalinity reconstruction.* In: De Deckker P., Colin J.-P. & Peypouquet J.-P. (Eds.) *"Ostracoda in the Earth Sciences"*, 125-155, Elsevier, Amsterdam.

Pasini G. & Colalongo M.L., 1994 - *Proposal for the erection of the Santernian-Emilian boundary-stratotype (lower Pleistocene) and new data on the Plio/Pleistocene boundary-stratotype.* Boll. Soc. Paleont. It., **33**(1), 101-120, Modena.

Rosenfled A. & Vesper B., 1977 - *The variability of the sieve-pores in recent and fossil species of* Cyprideis torosa *(JONES, 1850) as an indicator for salinity and paleosalinity.* In: Löffler H. & Danielopol D. (Eds.) *"Aspects of Zoology and Zoogeography of Recent and fossil Ostracoda"*. 6th Intern. Ostracod Symp., Saafelden, 1976, 55-67, La Hague.

Rust B.R. & Koster E.H., 1984 - *Coarse alluvial deposits.* In: Walker R. G., (Ed.) *"Facies Models"*, 53-69, Geos. Can. Repr., Series 1., 2d Ed. Geoscience. Canada.

Servizio Geologico d'Italia, 1975 - *Note illustrative della Carta geologica d'Italia 1:100.000 Fogli 138-144 (Terni-Palombara Sabina).*

Shackleton N.J., Backman J., Zimmermann H., Kent D.V., Hall M.A., Roberts D.G., Schnitker D., Baldauf J.G., Desprairies A., Homrighausen R., Huddlestun P., Keene J.B., Kaltenback A.J., Krumsier K.A.O., Morton A.C., Murray J.W. & Westberg-Smith J., 1984 - *Oxygen isotope calibration of the onset of ice-rafting and the history of glaciation in the North Atlantic region.* Nature, **307**, 620-623.

Sokac A., 1978 - *Pleistocene Ostracode fauna of the Panninian Basin in Croatia.* Palaeont. Jugosl., **20**, 1-51, Zagreb.

Torre D., Ficcarelli G., Masini F., Rook L. & Sala B., 1992 - *Mammal dispersal events in the Early Pleistocene of Western Europe.* Courier Forsch.-Inst. Senkenberg, **153**, 51-58, Frankfurt a. M.

Torre D., Albianelli A., Azzaroli A., Ficcarelli G., Magi M., Napoleone G. & Sagri M., 1993 - *Palaeomagnetic calibration of Late Villafrancan mammalian faunas from the Upper Valdarno, Central Italy.* Mem. Soc. Gel. It., **49**, 335-344, Roma.

Wagner C.W., 1957 - *Sur les Ostracods du Quaternaire récent des Pays-Bas et leur utilization dans l'étude géologique des depôts Holocènes.* Mouton & Co., Gravenhage, 259 pp.

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