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LATE PLIOCENE AND PLEISTOCENE ASSEMBLAGES OF CONTINENTAL MOLLUSCS IN ITALY. A SURVEY

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ABSTRACT - *Late Pliocene and Pleistocene assemblages of continental molluscs in Italy. A survey* - Il Quaternario, 4(1a), 1991, p. 137-150 - Upper Pliocene and Pleistocene sequences bearing continental mollusc faunae are surveyed. They have been grouped by age and considered in geographic-stratigraphic order. Paleontological analyses show that mollusc assemblages have chronostratigraphic as well as ecological significance. Early Villafranchian is well defined by Late Villafranchian is also well defined by an archaic complex of prosobranchs of wich five genera, one subgenus and half of the species became extinct by the end of the age. Endemic species are fairly well represented while pulmonates show modern features. Middle Pleistocene is characterized by a general renewal of the assemblages and the faunae become quite modern. Pulmonates supply climatic information by means of oligotypic assemblages of cold and dry climate which contrast with the rich faunae of mild climate. A few species of prosobranchs are good stratigraphic markers for mid-Pleistocene time. Late Pleistocene is characterized by species still living except one of mid-Pleistocene origin.

RIASSUNTO - *Rassegna delle associazioni a molluschi continentali del Pliocene superiore e del Pleistocene in Italia* - Il Quaternario, 4(1a), 1991, p. 137-150 - Vengono passate in rassegna quelle successioni stratigrafiche italiane, plioceniche superiori e pleistoceniche, che hanno fornito malacofaune continentali.Esse sono raggruppate per età ed esaminate in ordine geografico. L'analisi delle associazioni a molluschi ha permesso una loro caratterizzazione cronostratigrafica ed ecologica. Il Villafranchiano inferiore è biostratigraficamente definito dai polmonati, la maggior parte delle cui specie si estingue alla fine di questo periodo. Le cenosi nel loro complesso indicano condizioni di clima caldo. Il Villafranchiano superiore è invece definito biostratigraficamente da un complesso arcaico di prosobranchi.Metà delle specie e ben cinque generi ed un sottogenere di questi si estinguono alla fine del piano; è presente un discreto numero di specie endemiche. I polmonati, per contro, sono essenzialmente moderni. Il Pleistocene medio è caratterizzato da un sostanziale rinnovamento delle associazioni, e le faune hanno un'impronta senz'altro moderna. I polmonati danno indicazioni climatiche: da un lato associazioni oligotipiche di clima freddo e arido e dall'altro associazioni temperate ricche di specie. Alcune specie di prosobranchi sono buoni indicatori stratigrafici del Pleistocene medio. Nel Pleistocene superiore non si trovano specie estinte,tranne una di origine medio-pleistocenica. I polmonati danno buone indicazioni climatiche.

Key-words: Continental molluscs, Late Pliocene, Pleistocene, continental stratigraphy, Italy
Parole chiave: Molluschi continentali, Pliocene superiore, Pleistocene, stratigrafia continentale, Italia

1. INTRODUCTION

A survey of Italian Upper Pliocene and Pleistocene stratigraphic sequences containing non-marine molluscs, albeit incomplete, gave us the opportunity to update the knowledge of non-marine molluscs of that time span and to try to assess the chronostratigraphic and environmental significance of the assemblages identified.

Fossiliferous localities are grouped by age as follows: Early Villafranchian, Late Villafranchian, Middle Pleistocene, Late Pleistocene. For each age, the sites are ordered from North to South followed by Sardinia. Sites of uncertain stratigraphic position, species of dubious identification, and records from drillings and caves heve been omitted.

Figure 1 shows the location and age of the Italian fossiliferous localities. The unhomogeneous distribution is due to incompleteness of documentation. The position of each assemblage is identified by the name of the sedimentary basin or formation or stratigraphic section or topographic site where the assemblage is recognizable; essential bibliographic references are given. When possible, also stratigraphic information based on vertebrates or absolute age or other items are also supplied. The lists of molluscs, often restricted to the most significant species, are followed by short stratigraphic and/or ecologic considerations.

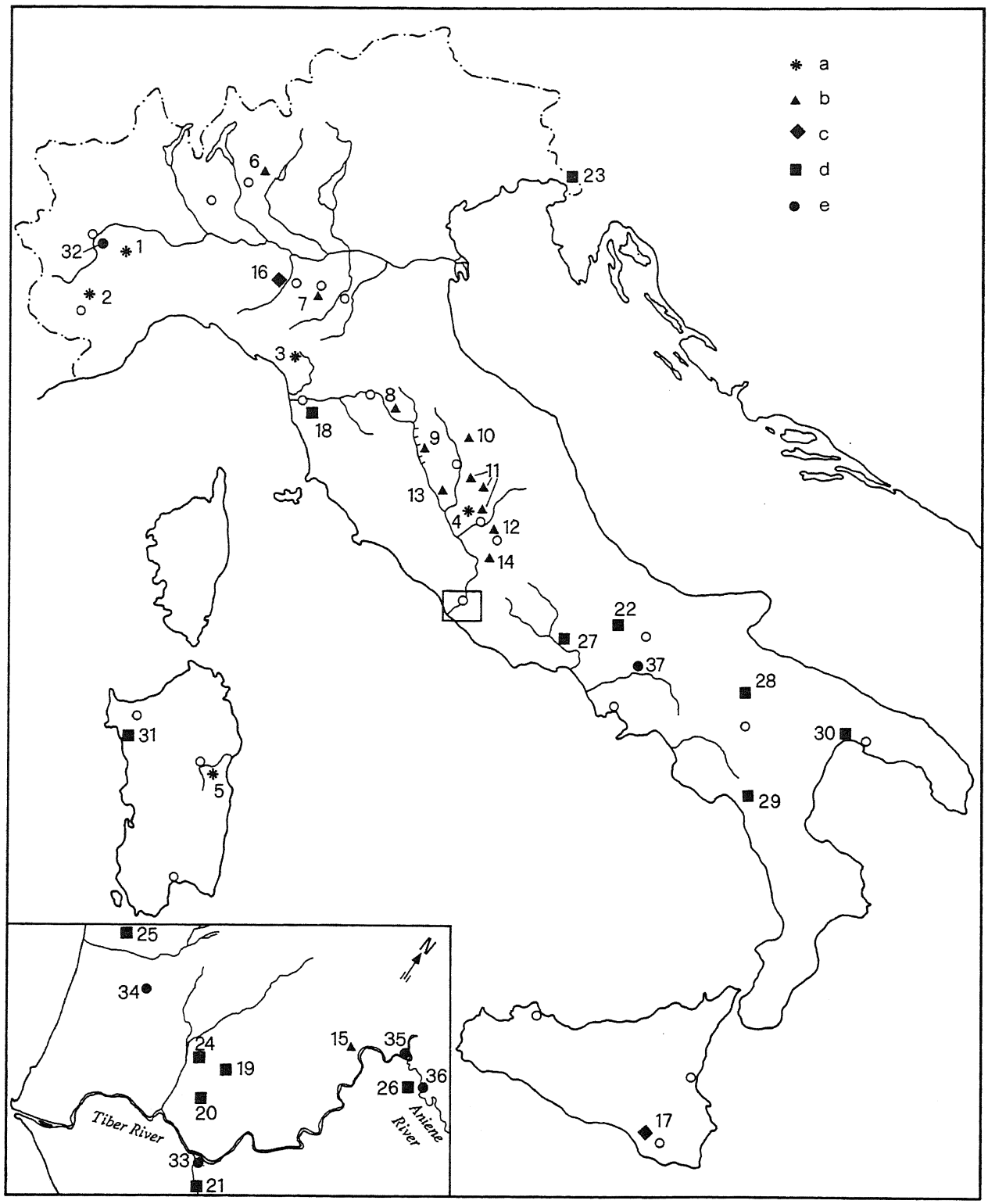
Finally, it must be emphasized that, among the localities considered, the Pliocene and/or Pleistocene continous stratigraphic sequences - passing from one stage or substage to the other - seem to be absent (with the possible exception of Pieve Fosciana).

2. THE FEATURES OF THE ASSEMBLAGES

On the whole, the assemblages of continental molluscs offer a fairly good tool for the biostratigraphic subdivision of Late Pliocene and Pleistocene deposits. Before examining the fossiliferous localities, we shall give a short biostratigraphic picture of the substages.

2.1 Early Villafranchian

The Early Villafranchian is characterized by pulmonates. In fact, the species we mention for the various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localities do not extend beyond the Plio - Pleistocene limit, with the only exception of *Glandina lunensis* which is recorded also from the Late Villafranchian of Central Italy.

The richest assemblage comes from the type basin of Villafranca d'Asti (Piedmont). The Sardinian fauna of the Nuraghe Su Casteddu Formation has a clearly western (Franco-Iberian) character. The presence of *Negulus villafranchianus*, however, allows a correlation with the Villafranca d'Asti basin as well as with the Tiberino basin (at Dunarobba). This correlation is very significant because the Nuraghe Su Casteddu Formation is dated between 3.6 and 2.8 m.y.B.P. (Savelli & Pasini, 1973; Esu & Kotsakis, 1983).

The Dunarobba site (Umbria) in the Tiberino basin is still under investigation (in collaboration with collegues of Siena) but, even at a preliminary examination, species common to the Villafranca basin were already identified: *N. villafranchianus*, *Gastrocopta (A.) acuminata fossanensis*, *Laminifera villafranchiana*.

Also at Pieve Fosciana (Tuscany) we found a species, *Mesodontopsis chaixi*, common to the Villafranca basin.

The Italian Early Villafranchian mollusc assemblages show affinities with those of the basins of Central - Western Europe. In fact, the Late Pliocene faunas of the Rhine and Rhone basins show a close relationship with the Italian ones at the genus level, *Emmericia*, *Nystia*, *Negulus*, *Schlickumia*, as well as at the species level, *Laminifera villafranchiana*, *Hygromia carinatissima* (Truc, 1971 a, b); *Viviparus pollonerae*, *G. (A.) acuminata fossanensis*, *Lymnaea bucciniformis* (Schlickum & Strauch, 1979); *Hydrocena (H.) puisseguri* (Schlickum, 1979); see also Esu (1982).

The Early Villafranchian mollusc fauna indicates on the whole a warm climate.

2.2 Late Villafranchian

In contrast with the previous sub-stage, the Late Villafranchian is well identified especially by prosobranchs. Half of the species and several genera and one subgenus referred to this age became extinct at the end of this time: *Stephania*, *Neumayria*, *Prososthenia*, *Tournouerina*, *Tanousia*, *Micromelania (Goniochilus)*.

The richest assemblage comes from the Tiberino basin (Umbria). Some of its species occurr also in the basins of Val di Chiana (Tuscany) and Upper Valdarno (Tuscany). *Valvata chalinei*, known in Lower and Upper Villafranchian deposits of France, is the only significant species for the Leffe basin (Lombardy).

The fauna of the Crostolo River succession (Emilia) is characterized by the abundance of pulmonates; the terrestrial species identified so far (material under investigation) are still living, but the stratigraphic position and the occurrence of *Viviparus ampullaceus* and *Lymnaea bucciniformis*, aquatic species, confirm a Late Villafranchian age.

On the whole, the Late Villafranchian fauna of Italy shows two aspects. The aquatic forms belong to an archaic stock (50% of species being extinct) having a good deal of endemic species; some species already occurr in Lower Villafranchian or pre-Villafranchian deposits of Italy (*Prososthenia etrusca*, *P. meneghiniana*, *P. ovata*, *Melanoides curvicosta*, *Neumayria priscillae*, *L. bucciniformis*). On the other hand the terrestrial forms are of clearly modern character (Esu & Girotti, 1974; Esu *et al.*, 1977).

Good faunal correspondence is recognizable with synchronous basins of France: the Rhone basin containing *V. chalinei*, *N. priscillae*, *Tournouerina belnensis*; the extinction of the last species seems to be well positioned in the Quaternary of Holland: Meijer (1986) states that *T. belnensis* became extinct in the lower part of the Waalian Interglacial before the Jaramillo normal event.

It is a known fact (Ambrosetti *et al.*, 1987) that the Tiberino basin was in communication with the sea in Santernian time. Marine sediments of this age outcrop mainly on the left bank of the Tiber. In fact, continental malacofaunas occurr abundantly also in these marine sediments, including the Monte Mario Formation in Rome: they consist of 16 species most of which are present in the Tiberino basin. This allows to a good correlation of the continental sequences with the marine ones (Girotti, 1972).

2.3 Middle Pleistocene

The Middle Pleistocene is mainly characterized by pulmonates even if prosobranchs may supply some sig-

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Fig. 1 - Late Pliocene and Pleistocene fossiliferous localities with continental malacofaunas. a) Late Pliocene (Early Villafranchian); b) Early Pleistocene (Late Villafranchian); c) early Middle Pleistocene (?); d) Middle Pleistocene; e) Late Pleistocene. 1) Villafranca d'Asti; 2) Fossano; 3) Pieve Fosciana; 4) Todi, Dunarobba; 5) Su Casteddu; 6) Leffe; 7) Crostolo; 8) Valdarno superiore; 9) Val di Chiana; 10) Gubbio; 11) Tiberino basin; 12) Rieti; 13) Chiani-Tevere; 14) Valli Sabine; 15) Monte Mario; 16) Stirone; 17) Vittoria; 18) Colle Salvetti; 19) Fontignano; 20) km 11 of Via Portuense; 21) Fosso di Malafede; 22) Isernia "La Pineta"; 23) Monrupino; 24) Fosso di S.Maria Nuova; 25) Torre del Pagliaccetto; 26) Sedia del Diavolo; 27) Liri basin; 28) Loreto; 29) Noce basin; 30) Fontana del Fico, Mar Piccolo; 31) Cala Bona; 32) Moncucco; 33) Fosso di Malafede; 34) Colle Sallustri; 35) Via Flaminia km 8.200; 36) Saccopastore; 37) Calore valley. In the inset: area of Rome. The open circles indicate the towns.

Località fossilifere con molluschi continentali del Pliocene superiore e del Pleistocene. a) Pliocene superiore (Villafranchiano inferiore); b) Pleistocene inferiore (Villafranchiano superiore); c) Pleistocene medio inferiore (?); d) Pleistocene medio; e) Pleistocene superiore. Nel riquadro: area di Roma. I cerchi bianchi indicano le città.

nificant element. The fauna is abundantly renewed in comparison with that of the Late Villafranchian and shows clear modern aspect. The assemblages supply mainly paleoclimatic indications for the various localities.

At the base of the lower Middle Pleistocene series ("blue - gray *Helicella* clays" of the Ponte Galeria Formation near Rome, gray clays of "La Pineta" by Isernia (Molise)), oligotypic assemblages of cold and/or dry climate occurr. Younger levels of Middle Pleistocene are characterized by rich assemblages of mild climate (or insignificant one). Some species of stratigraphic interest are also present. *Theodoxus isseli*, *"Nematurella" subovata*, *Belgrandia latina*(?), *B. zilchi*, are restricted to the Middle Pleistocene; it must be emphasized that these are aquatic species. *Pseudamnicola moussoni*, still living, seems to appear in the Late Villafranchian (studies in progress), whereas it broadly spreads in the Middle Pleistocene with extremely rich populations. *Jaminia malatestae* occurs exclusively in the Middle and Late Pleistocene where it is more abundant in assemblages of cold climate and rather scanty in the temperate ones.

Two pelecypods, *Corbicula fluminalis* and *Dreissena polymorpha*, well represented in the Late Villafranchian, disappear in Italy in the Middle Pleistocene.

2.4 Late Pleistocene

The fauna of this time-span is extremely modern in composition; only *J. malatestae* does not reach the Present. Therefore the assemblages are useful only for environmental and climatic purposes. For example oligotypic faunae generally indicate cold phases. It must be emphasized, however, that the Late Pleistocene record shows a lower number of species in comparison with the great numbers of the beginning of the Holocene, when warm-loving species spread widely (Lozek, 1986).

3. THE FOSSILIFEROUS LOCALITIES

3.1 Early Villafranchian

- *Villafranca d'Asti and Fossano (Piedmont Basin)* (Sacco, 1884; 1885; 1886; 1888, 1897; Martinis, 1949; Francavilla *et al.*, 1970; Azzaroli, 1977).

Lacustrine clays with vertebrates at Triversa Valley and Fossano. Triversa is the type-locality of the first Villafranchian Mammalian Faunal Unit (Azzaroli, 1977).

Viviparus pollonerae Sacco
Emmericia pliocenica (Sacco)
Lymnaea bucciniformis Sacco
Negulus villafranchianus (Sacco)
Gastrocopta (Albinula) acuminata fossanensis (Sacco)
Pagodulina bellardii (Sacco)
Laminifera villafranchiana (Sacco)
Polloneria pliocenica (Sacco)
Serrulella(?) decemplicata (Sacco)
Clausilia(?) portisi Sacco
Cochlodina prolaminata (Sacco)
Mesodontopsis chaixi (Michaud) (= *Helix (Galactochilus) exbrocchii* Sacco)
Schlickumia bottini (Sacco)
Hygromia carinatissima (Sacco)

With the exception of *L. bucciniformis*, occuring also in the Late Villafranchian, the species listed are only those which became extinct at the end of the Late Pliocene. Recently a species of the Tertiary genus *Nystia* was found near Villafranca d'Asti (R.D.B. quarry) by the Authors of this paper (material in study).

- *Pieve Fosciana (Castiglione di Garfagnana Basin, Tuscany)* (De Stefani, 1887; Azzaroli, 1977).

De Stefani reports two lists of molluscs. The first one, which includes also the Pliocene mammalian fauna, is composed by:

Viviparus sp.
Carychium rufolabiatum De Stefani
Retinella olivetorum (Gmelin)
Oxychilus cfr. *isselianus Paulucci*
Glandina lunensis (Ancona)
Helix vermicularia vermicularia (Michelotti) (= *Helix italica* De Stefani)
Mesodontopsis chaixi (Michaud) (= *Helix brocchii* Mayer)
Unio cfr. *pillae* De Stefani

M. chaixi is considered a Pliocene stratigraphic marker; *G. lunensis* and *U. pillae* are also present in Late Villafranchian. This fauna comes from a clayey lens included in sands alternating with lignitiferous clays. Between this sequence and upper conglomerates, gravelly sands yielded the second De Stefani's list:

Theodoxus (Neritaea) groyanus (Férussac) (= *Neritina bronni* Ancona)
Bithynia sp.
Prososthenia ovata (Bronn)
Melanoides sp.
Melanopsis sp.
Unio sp.

No Pliocene mammals are included in this list. Furthermore De Stefani reports only *"Mastodon" arvernensis* Croizet & Jobert from the upper part of the gravelly sands and from the overlying conglomerates. This fact suggests that the second list may indicate a Pleistocene age. In fact *T. groyanus* is held by Esu & Girotti (1974) only as Late Villafranchian. The other species also occurr commonly in Upper Villafranchian deposits.

- *Tiberino Basin (Umbria)* (Ambrosetti *et al.*, 1987 with references).

From the "argille grigie inferiori", specimens of *Prososthenia* and *Emmericia* were collected near Todi:

they are still under investigation and seem to be unknown elsewhere in Italy.

In the Dunarobba quarry (Avigliano Umbro) trunks of great Coniferae, still in life position, were unearthed from clayey - sandy sediments of apparent Late Villafranchian age. The following pulmonates, however were discovered from the filling deposit inside the holes and the fissures of the trunks:

Hydrocena (Hydrocena) puisseguri Schlickum
Carychium pseudotetrodon Strauch
Negulus villafranchianus (Sacco)
Gastrocopta (Albinula) acuminata fossanensis (Sacco)
Leiostyla gottschicki (Wenz)
Eostrobilops aloisii Manganelli, Delle Cave & Giusti
Laminifera villafranchiana (Sacco)

All the listed species seem to have become extinct at the end of the Early Villafranchian; the list is not final, the only published species is *E. aloisii* (see Manganelli *et al.*, 1989).

- *Nuraghe Su Casteddu Formation (Cedrino Basin, Sardinia)* (Massari & Dieni, 1973; Savelli & Pasini, 1973; Esu, 1978; Esu & Kotsakis, 1979, 1980, 1983).

Tudorella ferruginea (Lamarck)
Planorbarius thiollieri (Michaud)
Hypnophila girottii Esu
Negulus villafranchianus (Sacco)
Oestophora aff. *kuiperi* Gasull

N. villafranchianus characterizes the Villafranca d'Asti basin. The other numerous species of the assemblage, not listed here, are still living and several are endemic. The molluscs are associated with endemic vertebrate remains of Villafranchian age.

3.2 Late Villafranchian

- *Leffe Basin (Bergamo, Lombardy)* (Venzo, 1950; 1955).

An assemblage of scarce stratigraphic importance is tentatively referred (Venzo, 1950) as coming from the "Perani" lignite quarry. Further material of this basin coming from Venzo's "unity 6" (referred to the Donau/ Günz Interglacial) and includes the following species:

Valvata chalinei Schlickum & Puisségur
Valvata cristata Müller
Bithynia tentaculata (L.)
Lymnaea peregra (Müller)
Planorbis planorbis (L.)
Acroloxus lacustris (L.)

V. chalinei is meaningful because of its occurence in Early and Late Villafranchian of France (Schlickum & Puisségur, 1978; Esu, 1983).

- *Crostolo sequence (Reggio Emilia, Emilia)* (Pelosio & Raffi, 1973; Ambrosetti & Cremaschi, 1975).

The following assemblage was found in lacustrine clays overlying a "Calabrian" marine succession investigated by Pelosio & Raffi (1973) and containing also Late Villafranchian vertebrates (Ambrosetti & Cremaschi, 1975):

Viviparus ampullaceus (Bronn)
Bithynia tentaculata (L.)
Pomatias elegans (Müller)
Lymnaea bucciniformis Sacco
Zonites sp.
Cepaea sp.

This assemblage probably belongs to the Ca' Bacchi Unit (Ambrosetti & Cremaschi, 1975). In the same unit we collected nearly the same assemblage:

Viviparus ampullaceus (Bronn)
Pomatias elegans (Müller)
Clausilia sp.
Zonites sp.
Chilostoma sp.

The next assemblage comes from the overlying "Vasca di Corbelli Unit" (= Ca' Romanini Unit):

Pomatias elegans (Müller)
Lithoglyphus sp.
Carychium tridentatum Risso
Vertigo angustior Jeffreys
Zonites sp.
Clausilia sp.
Helicodonta obvoluta (Müller)
Cepaea sp.
Sphaerium sp.
Unio sp.

The Villafranchian elements are *L. bucciniformis* and *V. ampullaceus.* The few specimens of *Lithoglyphus* sp. mentioned here and the many others of the Stirone sequence (see below) constitute the first finding of the genus in Italy, where it is unknown as living form. This thermophilous genus is characteristic of warm Quaternary phases in Central and Eatern Europe (Lozek, 1986).The pulmonates are all of modern character.

- *Upper Valdarno (Tuscany)* (De Stefani, 1876-1880; Esu & Girotti, 1974; Azzaroli, 1977; Azzaroli & Lazzeri, 1977).

The following assemblage was found in the "Figline Clays", containing vertebrates of the Olivola Faunal Unit (Azzaroli, 1977), at the foot of the Montecarlo monastery, near S. Giovanni Valdarno (De Stefani, 1876-1880; Esu & Girotti, 1974).

Theodoxus (Neritaea) groyanus (Férussac)
Viviparus ampullaceus (Bronn)
Valvata anconae De Stefani
Stephania bronni (Ancona)
Prososthenia oblonga (Bronn)
Prososthenia ovata (Bronn)
Bithynia tentaculata (L.)
Anodonta bronni Ancona

The assemblage characterizes the Late Villa-

franchian, but *P. ovata* is known also in the Pliocene and *B. tentaculata* is still living.

- *Val di Chiana (Tuscany)* (De Stefani, 1876-1880; Verri, 1877; Pantanelli, 1878; Malatesta, 1964; Esu & Girotti, 1974).

Sandy clays, which we correlate with the "Complesso argilloso sabbioso" of the Tiberino basin, bear this assemblage:

Viviparus belluccii De Stefani
Valvata anconae De Stefani
Valvata interposita De Stefani
Prososthenia etrusca (De Stefani)
Melanoides curvicosta (Deshayes)
Unio pillae De Stefani
Dreissena polymorpha (Pallas)
Corbicula fluminalis (Müller)

M. curvicosta ranges from the Late Miocene to the Late Villafranchian; *C. fluminalis* seems to have become extinct in the Middle Pleistocene. *D. polymorpha* extinguished in Italy in the late Middle Pleistocene, but was reintroduced by man activity (Giusti & Oppi, 1973). The other species are exclusive of the Late Villafranchian.

- *Gubbio basin (Umbria)* (Verri, 1883; Bonarelli, 1891).

Bonarelli (1891) reports lignitiferous clays (Galvana lignite) bearing fresh-water molluscs in the lacustrine complex of the Gubbio basin. The species recognized are:

Dreissena polymorpha (Pallas)(= *Dreissena plebeja* (Dubois))
Pisidium sp. (= *Sphaerium priscum* Eichwald)
Valvata piscinalis Müller
Melanopsis affinis Férussac (= *Melanopsis flammulata* De Stefani and *Melanopsis esperii* Férussac)
Emmericia umbra De Stefani
Neumayria priscillae Girotti (= *Neumayria labiata* (Neumayr))
Belgrandia sp. (= *Belgrandia prototypica* (Brusina))

This fauna indicates undoubtedly a Late Villafranchian age for the fossiliferous clays. Also Lona & Ricciardi (1961) and Lona & Bertoldi (1972) state, on palynological base, an Early Pleistocene age for these deposits. In Bonarelli's list there is, however, a controversial point. This Author includes it in a passage literally taken, in brackets, from a previous work of Verri (1883) where the list is limited only to the first three species, which have no chronostratigraphic significance. We cannot explain this discrepancy, we can only confirm that the species added by Bonarelli (1891) are surely of Late Villafranchian age.

- *Tiberino basin (Umbria)* (Esu & Girotti, 1974 with references; Conti & Esu, 1981; Ambrosetti *et al.*, 1987).

The listed species come from the "sandy clayey complex", the "old travertines" and the "muds and peats" (Ambrosetti *et al.*, 1987):

Theodoxus (Neritaea) groyanus (Férussac)
Viviparus belluccii De Stefani
Valvata interposita De Stefani
Prososthenia oblonga (Bronn)
Prososthenia ovata (Bronn)
Prososthenia sp.
Tournouerina belnensis (Delafont & Depéret)
Tanousia lithoglyphoides (Girotti)
Belgrandia sp.
Neumayria priscillae Girotti
Micromelania (Goniochilus) zitteli (Schwartz von Mohrenstern)
Emmericia umbra De Stefani
Melanoides curvicosta (Deshayes)
Melanopsis affinis Férussac
Lymnaea bucciniformis Sacco
Ancylus parmophorus De Stefani
Corbicula fluminalis (Müller)
Dreissena polymorpha (Pallas)

The numerous species still living in Italy are omitted. As stated above, *C. fluminalis* and *D. polymorpha* became extinct in Italy in the Middle Pleistocene.

- *Rieti basin (Latium)*

Theodoxus groyanus and *Melanopsis affinis* were found recently in lignitiferous sediments in the northwestern part of the Rieti basin, at Madonna della Torricella. Thought unpublished, this record confirms the presence of a Late Villafranchian sequence in the Rieti basin (Ambrosetti & Azzaroli, 1973); this age is confirmed also by the presence of *Equus stenonis* Cocchi in the S. Rufina (Rieti basin) in levels referred to Villafranchian by Cavinato *et al.* (1987).

- *Continental strata in marine Lower Pleistocene sequences* "Argille Sabbiose del Chiani-Tevere" (Ambrosetti *et al.*, 1987); "Villafranchiano delle valli Sabine"(Tuccimei, 1889; Clerici, 1895); fresh-water molluscs in the Monte Mario Formation, Rome (Girotti, 1972).

Theodoxus (Neritaea) groyanus (Férussac)
Viviparus ampullaceus (Bronn)
Viviparus belluccii De Stefani
Valvata anconae De Stefani
Prososthenia etrusca (De Stefani)
Prososthenia meneghiniana (De Stefani)
Prososthenia ovata (Bronn)
Tanousia lithoglyphoides (Girotti)
Belgrandia sp.
Neumayria priscillae Girotti
Micromelania (Goniochilus) zitteli (Schwartz von Mohrenstern)
Melanopsis affinis Férussac
Ancylus parmophorus De Stefani
Glandina lunensis (Ancona)

Helix fabarensis Tuccimei
Corbicula fluminalis (Müller)

On the western slope of the folded apenninic reliefs of the Peglia-Amerini-Narnesi-Sabini M.ts the marine sandy-clayey Lower Pleistocene sediments lie unconformably on Pliocene deposits. Near the top of this sequence, continental (muds and travertines) and brackish (clays) strata alternate with the marine ones: they bear typical Villafranchian assemblages. Also in Rome, in the frankly marine Monte Mario Formation of Santernian age, Villafranchian freshwater molluscs were found.

3.3 Early Middle Pleistocene (?)

- *Stirone sequence (Parma,Emilia)* (Papani & Pelosio, 1962; Pelosio & Raffi, 1977).

Along the Stirone creek, fluvio-lacustrine beds rest unconformably on marine Lower Pleistocene deposits; they yielded aspecimen of *Dicerorhinus hemitoechus* (Falconer) as well as the species listed here:

Theodoxus isseli (Clerici)
Viviparus aff. *ampullaceus* (Bronn)
Lithoglyphus sp.
Bithynia tentaculata (L.)
Pomatias elegans (Müller)
Vallonia pulchella (Müller)

T. isseli was known till now only from the Middle Pleistocene of Central Italy (Clerici, 1888; Settepassi & Verdel, 1965). As stated above, *Lithoglyphus* sp. was found also in the Crostolo sequence and is mentioned here for the first time in Italy. The occurrence of this species in the Crostolo (Early Pleistocene) and in the Stirone may supply an element for correlation, being the two sequences not far from each other: but this is a suggestion that needs more stratigraphic support.

- *Vittoria (Comiso, Southern Sicily)* (Conti *et al.*, 1979).

In the lacustrine sediments of the ancient "Casmene Lake" and "Buffa Lake", referred partly to the Early - and partly to the Middle Pleistocene, the following species were found:

Mercuria confusa (von Frauenfeld)
Hauffenia minuta (Draparnaud)
Lymnaea peregra (Müller)
Lymnaea truncatula (Müller)
Planorbis planorbis (L.)
Gyraulus laevis (Alder)
Armiger crista (L.)
Ancylus fluviatilis (Müller)
Truncatellina cylindrica (Férussac)
Vertigo substriata (Jeffreys)
Punctum pygmaeum (Draparnaud)
Discus ruderatus (Férussac)
Aegopis sp.
Cernuella sp. (= *Candidula unifasciata vincae* (De Stefani))
Monacha cartusiana (Müller)
Pisidium sp.

M. confusa, a living species, was found here for the first time as fossil. It probably occurs very rarely in the Late Villafranchian of Sabina (investigation in progress). *V. substriata* is rare as fossil in Italy, it is known from the Middle Pleistocene of the Liri basin and in the Late Pleistocene from the 8.2 km site in Via Flaminia (Rome) (see below).

3.4 Middle Pleistocene

3.4.1 Early Middle Pleistocene

- *Colle Salvetti (Leghorn Hills, Tuscany)* (Lazzarotto *et al.*, 1990).

Few hundred meters South of Colle Salvetti and just 300 m South-East of Badia, a North-South elongated hill crops out from the Holocene alluvial plain on the left side of the Tora River. This hill is principally composed of Early Pleistocene marine sediments ("Sabbie di Nugola Vecchia") but, its northern part is covered by a marly-sandy tuffitic deposit, which overlies continental clays bearing two different molluscan assemblages, one in the lower part (a) and the other in the upper part (b):

a) *Lymnaea truncatula* (Müller)
Carychium tridentatum (Risso)
Vertigo antivertigo (Draparnaud)
Vertigo angustior Jeffreys
Vallonia pulchella (Müller)
Discus rotundatus (Müller)
Clausilia sp.

b) *Valvata cristata* (Müller)
Bithynia leachi (Sheppard)
Bithynia tentaculata (L.)
Lymnaea truncatula (Müller)
Planorbis planorbis (L.)
Acroloxus lacustris (L.)
Carychium tridentatum (Risso)
Succinea oblonga Draparnaud
Vertigo angustior Jeffreys
Punctum pygmaeum (Draparnaud)
Discus rotundatus (Müller)
Vitrea subrimata (Reinhardt)
Clausilia sp.
Testacella haliotidea (Draparnaud)

The assemblages indicate a warm-temperate climate. A personal communication of Prof. F.P. Bonadonna of Pisa University furnished an age of 0.62 m.y.B.P. for the upper part of the tuffitic deposit. We received from him also the samples with the fauna listed above. Lazzarotto *et al.* (1990) report the same communication of Bonadonna and give a geological section of the hill.

- *Fontignano (Rome, Latium)* (Conato *et al.*, 1980; Esu *et al.*, in press).

From the "Blue-gray *Helicella* Clays", 2nd member of

the Ponte Galeria Formation come:
Granaria frumentum (Draparnaud)
Pupilla muscorum (L.)
Vallonia pulchella (Müller)
Jaminia malatestae Esu
Helicella itala (L.) (= *Helicella ericetorum* (Müller))
Trichia hispida (L.)

It is an assemblage indicating cold and dry climatic conditions, supported by the occurrence of *(?) Predicrostonyx* sp. and *Prolagurus pannonicus* (Kormos), arvicolids of cold climate (Esu *et al.*, in press). For the exact position of the "Blue-gray *Helicella* Clays" see Kotsakis *et al.* (in press).

- *km 11, via Portuense (Rome, Latium)* (4th member of the Ponte Galeria Formation; Conato *et al.*, 1980).

From a lacustrine lentil in the cross-bedded gravels the following species are listed:
Valvata cristata Müller
Bithynia leachi (Sheppard)
Lymnaea truncatula (Müller)
Carychium minimum Müller
Vallonia pulchella (Müller)
Clausilia sp.

It is a non indicative assemblage.

- *Fosso di Malafede (Rome, Latium)* (7th member of the Ponte Galeria Formation, Conato *et al.*, 1980).

The outcrops of this creek contain:
Bithynia leachi (Sheppard)
Bithynia tentaculata (L.)
Valvata cristata Müller
Lymnaea peregra (Müller)
Lymnaea truncatula (Müller)
Anisus spirorbis (L.)
Planorbis planorbis (L.)
Hippeutis complanatus (L.)
Armiger crista (L.)
Acroloxus lacustris (L.)

It is a polytypic assemblage of mild-wet climate.

- *Isernia "La Pineta" (Molise)* (Esu, 1981; Coltorti *et al.*, 1982).

The fauna listed below comes from lacustrine clays, located about 12 m below the archeological levels and overlying a gravelly level. The archeological remains are associated with an early Middle Pleistocene mammalian fauna and are overlain by volcanics of 0.73 m.y.B.P. The sequence is referred to the reversed Matuyama Epoch.
Lymnaea truncatula (Müller)
Succinea oblonga Draparnaud
Vertigo moulinsiana (Dupuy)
Vertigo pygmaea (Draparnaud)
Pupilla muscorum (L.)
Vallonia pulchella (Müller)

This fauna indicates a wet-cold environment. *V. moulinsiana* represents here the oldest occurrence for Italy (Esu, 1981). The paleomagnetic data, the absolute age, the mammalian fauna as well as the climatic patterns of the molluscs, all provide good tools of correlation with the Ponte Galeria Formation.

3.4.2 Middle and Late Middle Pleistocene

- *Monrupino (karst district near Trieste)* (Coen *et al.* 1950).

The filling breccia of a karst-hole contains some micromammals and the following terrestrial gastropods:
Pomatias elegans (Müller)
Poiretia cornea (Brumati)
Helicigona cingulata (Studer) (= *Chilostoma preslii* (Rossmaessler))
Helicigona planospira (Lamarck)

Esu & Kotsakis (1987) attribute dubitatively the deposit to the Mindel - Riss Interglacial.

- *Fosso di Santa Maria Nuova (Rome, Latium)* (San Cosimato Formation; Conato *et al.*, 1980).

The lacustrine levels of the San Cosimato Formation contain:
Theodoxus isseli (Clerici)
Valvata piscinalis (Müller)
Bithynia leachi (Sheppard)
Bithynia tentaculata (L.)
Hydrobia stagnorum (Gmelin)
Lymnaea peregra (Müller)
Anisus spirorbis (L.)
Planorbis planorbis (L.)
Armiger crista (L.)
Acroloxus lacustris (L.)
Vallonia pulchella (Müller)

The assemblage is polytypic. From a stratigraphic point of view, the species are not significant with the exception of *T. isseli*, an extinct species occurring abundantly in the Middle Pleistocene of Central Italy; it appears, however, also somewhat earlier in Northern Italy (Stirone sequence).

- *Aurelian Formation (Rome, Latium)* (Conato *et al.*, 1980).

A rich land and fresh-water fauna of about 40 species, is contained in more or less diatomitic muds near Torre del Pagliaccetto (Durante & Settepassi, 1978a) and at Fosso di Malafede (Conato *et al.*, 1980). We mention:
Pseudamnicola moussoni (Calcara)
Lymnaea palustris (Müller)
Lymnaea peregra (Müller)
Lymnaea truncatula (Müller)
Anisus spirorbis (L.)
Anisus contortus (L.)
Planorbis planorbis (L.)
Carychium minimum Müller

Oxyloma elegans (Risso)
Vertigo antivertigo (Draparnaud)
Orcula dolium (Draparnaud)
Vallonia pulchella (Müller)
Jaminia malatestae Esu
Oxychilus draparnaudi (Beck)
Pisidium nitidum Jenyns

Only *J.malatestae* is extinct and ranges, as known till now (Esu, 1988), from early Middle to Late Pleistocene. *P. moussoni* seems to appear during the Late Villafranchian (not published data) and widely spreads (many specimens in many deposits) in Middle and Late Pleistocene times (see other localities in this paper). The fauna indicates a mild climate.

- *Sedia del Diavolo (Rome, Latium)* (Clerici, 1888; Blanc, 1955; Caloi & Palombo, 1986).

The following species are listed by Clerici (1888):
Theodoxus isseli (Clerici)
Valvata piscinalis (Müller)
Bithynia tentaculata (L.)
Anisus spirorbis (L.)
Carychium minimum Müller
Corbicula fluminalis (Müller)

The outcrop of Sedia del Diavolo is buried under the buildings of Rome: it was the *locus typicus* of *T. isseli. C. fluminalis* seems to occurr here for the last time in Italy. This pelecypod, however, is reported to occurr also in the area of Monte Verde (Rome)(Clerici, 1888), but the stratigraphic position is uncertain, probably older than that of Sedia del Diavolo.

- *Liri basin (Southern Latium)* (Devoto, 1965; Settepassi & Verdel, 1965; Esu *et al.*, 1989).

The following species are selected from the many ones described by Settepassi & Verdel (1965):
Theodoxus isseli (Clerici)
Viviparus contectus (Millet)
Valvata piscinalis (Müller)
"Nematurella" subovata Settepassi
Belgrandia latina (Settepassi)
Belgrandia zilchi (Settepassi)
Belgrandia marginata (Michaud)
Pyrgula annulata (L.)
Planorbarius corneus (L.)
Planorbis planorbis (L.)
Vertigo angustior Jeffreys
Vertigo substriata (Jeffreys)
Orcula dolium (Draparnaud)
Pupilla muscorum (L.)
Vallonia pulchella (Müller)
Discus rotundatus (Müller)
Aegopis italicus (Kobelt)
Helicodonta obvoluta (Müller)
Dreissena polymorpha (Pallas)

Some species seem to belong only to the Middle Pleistocene. *T. isseli* and *"N." subovata* are common to other basins (for *T. isseli* see also the comments on the Stirone sequence). *B. zilchi* and *B. latina* are known till now only in this basin. *P. annulata,* still living, occurr as fossil only here. For *D. polymorpha* see comments on the Val di Chiana basin.

- *Loreto sequence (Venosa basin, Basilicata)* (Segre, 1978; Durante & Settepassi, 1978b).

The middle terrace of the Loreto sequence contains 8 rich assemblages of molluscs in stratigraphical succession, located, in the Segre's (1978) stratigraphic column at 340-350 m a.s.l. They are referred to an age younger than 0.45 m.y.B.P. The following species are selected from the many ones described by Durante & Settepassi (1978b).
Bithynia leachi (Sheppard)
Lymnaea palustris (Müller)
Lymnaea peregra (Müller)
Planorbis planorbis (L.)
Armiger crista (L.)
Succinea oblonga Draparnaud
Oxyloma elegans (Risso)
Vallonia pulchella (Müller)
Chondrula tridens (Müller)
Oxychilus hydatinus (Rossmaessler)
Trochoidea pyramidata (Draparnaud)
Pisidium amnicum (Müller)
Pisidium casertanum (Poli)

The assemblages indicate alternatively warm-dry and forest-wet environments.

Noce basin (Basilicata) (Bonardi *et al.*, 1988).

Deposits of this basin are named "terraced lacustrine deposits of Middle - Lower Pleistocene" in the Geological Map of the Southern Apennines of Bonardi *et al.* (1988). We mention here the following species, for the first time:
Theodoxus isseli (Clerici)
Viviparus contectus (Millet)
Valvata piscinalis (Müller)
"Nematurella" subovata Settepassi
Dreissena polymorpha (Pallas)

The assemblage has a good correspondence with the Liri fauna: from the chronological point of view it indicates a late Middle Pleistocene age.

- *Fontana del Fico and Mar Piccolo (Taranto, Apulia)* (Cotecchia & Magri, 1967; Dai Pra & Stearns, 1977; Laviano & Pennetta, 1980).

The first locality belongs to a terrace named 4th marine terrace "Postcalabrian IV" in Sheet 201 "Taranto" of the Servizio Geologico d'Italia. It crops out at about 35 m a.s.l. and is ascribed to a Paleotyrrhenian age by Cotecchia & Magri, 1967). Laviano & Pennetta (1980) describe a section near Fontana del Fico, of continental

and transitional environment where they found:

Theodoxus fluviatilis (L.)
Valvata piscinalis (Müller)
Hydrobia stagnorum (Gmelin)
Pseudamnicola sp.
Bithynia leachi (Sheppard)
Melanoides tuberculata (Müller)
Physa fontinalis (L.)
Lymnaea auricularia (L.)
Lymnaea peregra (Müller)
Lymnaea stagnalis (L.)
Planorbis carinatus (Müller)
Planorbis planorbis (L.)
Gyraulus albus (Müller)
Gyraulus laevis (Alder)
Armiger crista (L.)
Acroloxus lacustris (L.)

The occurrence of *M. tuberculata* indicates waters warmer than present; this is the only finding of the species in Italy.

Not far from this section an other one is described by Dai Pra & Stearns (1977) along the beach of Mar Piccolo. It contains "*Planorbis, Limnaea, Bythinella*" and it is referred to a Paleotyrrhenian without *Strombus* whose age ranges from 0.29 to more than 0.35 m.y.B.P.

- *Cala Bona (Alghero, Sardinia)* (Malatesta, 1953, 1985; Pecorini, 1963; Esu, 1986).

A few km South of Alghero, travertinous muds of Pretyrrhenian age are crop out. Here Esu (1986) collected and described the following species:

Pseudamnicola moussoni (Calcara)
Carychium minimum Müller
Lymnaea truncatula (Müller)
Vertigo antivertigo (Draparnaud)
Vallonia pulchella (Müller)
Oxyloma elegans (Risso)
Oxychilus oppressus (Shuttleworth)
Euconulus fulvus (Müller)
Testacella (Testacelloides) gestroi (Issel)

This assemblage indicates a mild climate.

3.5 Late Pleistocene

- *Moncucco (Turin, Piedmont)* (Alessio *et al.*, 1982).

From gray muds with interbedded peat of the Turin Hill comes a prevailingly terrestrial polytypic fauna. An absolute age of about 0.04 m.y.B.P. is referred to the deposit, which corresponds to a Würmian Interstadial.

Acicula lineata (Draparnaud)
Carychium minimum Müller
Lymnaea peregra (Müller)
Lymnaea truncatula (Müller)
Succinea oblonga Draparnaud
Cochlicopa lubrica (Müller)
Columella columella (Martens)
Pupilla muscorum (L.)
Argna cfr. *blanci niciensis* (Pollonera)
Vallonia costata (Müller)
Discus rotundatus (Müller)
Vitrinobrachium cfr. *brevis* (Férussac)
Aegopinella clara Held
Vitrea subrimata (Reinhardt)
Euconulus fulvus (Müller)
Cochlodina laminata (Montagu)
Candidula unifasciata (Poiret)
Helicodonta obvoluta (Müller)
Pisidium casertanum (Poli)

The assemblage is indicative of mild-wet interstadials of cold periods.

- *Fosso di Malafede (Rome, Latium)* (Vitinia Formation; Conato *et al.*, 1980).

A rich assemblage come from deposits ascribed to the regressive phase of the Eutyrrhenian:

Valvata piscinalis (Müller)
Bithynia leachi (Sheppard)
Bithynia tentaculata (L.)
Belgrandia aff. *marginata* (Michaud)
Planorbarius corneus (L.)
Planorbis planorbis (L.)
Anisus contortus (L.)
Anisus spirorbis (L.)
Hippeutis complanatus (L.)
Armiger crista (L.)

These molluscs have no stratigraphic significance. They indicate a rather temperate climate.

- *"Old Tyrrhenian Dune" (Rome, Latium)* (Conato *et al.* 1980).

From the red sands of this formation (in Cava Rinaldi and Colle Sallustri) come the following species:

Valvata piscinalis (Müller)
Bithynia tentaculata (L.)
Pomatias elegans (Müller)
Lymnaea truncatula (Müller)
Succinea putris (L.)
Cochlicopa lubrica (Müller)
Vallonia pulchella (Müller)
Vitrea cfr. *crystallina* (Müller)

The fossil communities are indicative of a transitional environment, where terrestrial, swampy and brackish (*Hydrobia, Bittium, Cerastoderma*)forms were accumulated.

- *Via Flaminia, km 8.2 (Rome, Latium)* (Kotsakis *et al.*, 1978; Esu, 1980).

Mammal - bearing tufaceous levels overly travertinous muds which contain a fairly rich assemblage:

Bithynia leachi (Sheppard)
Pseudamnicola moussoni (Calcara)
Lymnaea palustris (Müller)

Lymnaea peregra (Müller)
Planorbis planorbis (L.)
Anisus spirorbis (L.)
Armiger crista (L.)
Oxyloma elegans (Risso)
Vertigo substriata (Jeffreys)
Orcula dolium (Draparnaud)
Pupilla muscorum (L.)
Hygromia cinctella (Draparnaud)

This assemblage indicates a lacustrine environment surrounded by open land, without arboreal cover, corresponding to a climate cooler than present.

· *Saccopastore (Rome, Latium)* (Blanc, 1948; 1958).

From the same fine sandy mud, which delivered the wo neandertal skulls "Saccopastore I" and 'Saccopastore II", a terrestrial assemblage was given by Blanc (1948). The same Author (Blanc, 1958) correlates his deposit with a regressive phase of Tyrrhenian II. This ocality is now covered by the town buildings.

Chondrula tridens (Müller)
Vitrea diaphana (Draparnaud)
Helicella conspurcata (Draparnaud)
Monacha cartusiana (Müller)
Perforatella incarnata (Müller)

The assemblage is composed by dwarf specimens which could suggest "non favourable environmental conditions" (Blanc, 1948).

Calore Valley *(Beneventum, Campania)* (Malatesta, 1958; Esu, 1988).

Near the mineral water - source "A'Uolla", from a evel of "loess with molluscs and fragments of mammalian ones" belonging to the Lower Terrace of the Calore river Malatesta, 1959), comes an assemblage described by Esu (1988). Malatesta (1959) ascribes the deposit to the Würm.

Jaminia malatestae Esu
Pupilla muscorum (L.)
Vallonia pulchella (Müller)
Helicella sp.

It is an oligotypic assemblage of cold and dry climatic conditions. *J. malatestae* is an extinct species which firstly appears in the early Middle Pleistocene.

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BIBLIOGRAFIA

Alessio M., Allegri L., Ambrosetti P., Bartolomei G., Bella F., Belluomini G., Calderoni G., Carraro F., Charrier G., Cortesi C., Esu D., Forno M.G., Improta S., Manfra L. & Petrone V. (1982) - *Il giacimento fossilifero pleistocenico superiore di Moncucco torinese.* Geogr. Fis. Dinam. Quat., **5**, 219-239.

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

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, 1 map.

Ambrosetti P. & Cremaschi M. (1975) - *Segnalazione di una fauna villafranchiana superiore con "Libralces gallicus" nei livelli fluviolacustri soprastanti alle faune calabriane ad "Arctica islandica" nei dintorni di Reggio Emilia.* Boll. Soc. Geol. Ital., **94**, 1361-1374.

Azzaroli A. (1977) - *The Villafranchian stage in Italy and the Plio-Pleistocene boundary.* Giorn. Geol., s.2, **41**, 61-79.

Azzaroli A. & Lazzeri L. (1977) - *I laghi del Valdarno superiore. The lakes of the Upper Valdarno.* Pubbl. Centro St. Geol. Appennino Geosincl. Mediterr., **26**, 1-4, 1 map.

Blanc A.C. (1948) - *Notizie sui trovamenti e sul giacimento di Saccopastore e sulla sua posizione nel Pleistocene laziale.* Palaeontogr. Ital., **42**, 1-23.

Blanc A.C. (1955) - *Ricerche sul Quaternario Laziale. III. Avifauna artica, crioturbazioni e testimonianze di soliflussi nel Pleistocene medio-superiore di Roma e di Torre in Pietra. Il periodo glaciale Nomentano, nel quadro della serie di glaciazioni riconosciute nel Lazio.* Quaternaria, **2**, 187-200.

Blanc A.C. (1958) - *Torre in Pietra, Saccopastore e Monte Circeo. La cronologia dei giacimenti e la paleogeografia quaternaria del Lazio.* Boll. Soc. Geogr. Ital., s.8, **11**, 196-214.

Bonardi G., D'Argenio B. & Perrone V. (in press) - *Carta geologica dell'Appennino Meridionale.* Napoli, 1 map.

Bonarelli G. (1891) - *Il territorio di Gubbio. Notizie geologiche.* Roma, 38 p.

Caloi L. & Palombo M.R. (1986) - *Le mammalofaune pliopleistoceniche dell'area laziale: problemi biostratigrafici ed implicazioni paleoclimatiche.* Mem. Soc. Geol. Ital., **35**, 99-126.

Cavinato G.P., Cerisola R. & Storoni Ridolfi S. (1987) - *Segnalazione del ritrovamento di denti di Equus stenonis (Cocchi) in località S. Rufina (Conca di Rieti, Lazio).* Geol. Romana, **26**, 255-261.

Clerici E. (1988) - *Sulla* Corbicula fluminalis *dei dintorni di Roma e sui fossili che l'accompagnano.* Boll. Soc. Geol. Ital., **7**, 105-127.

Clerici E. (1895) - *Presentazione di fossili della regione fra i monti Cornicolani e Lucani e digressione sulla pretesa epoca villafranchiana di detta regione.* Boll.

Soc. Geol. Ital., **14**, 315-320.

Coen G., Malaroda R. & Pasa A. (1950) - *Un pozzetto carsico nei pressi di Monrupino (Carso triestino).* Boll. Soc. Adriatica Sci. Nat., **45**, 59-62.

Coltorti M., Cremaschi M., Delitala M.C., Esu D., Fornaseri M., McPherron A., Nicoletti M., van Otterloo R., Peretto C., Sala B., Schmidt V. & Sevink J. (1982) - *Reversed magnetic polarity at an early Lower Palaeolithic site in Central Italy.* Nature, **300**, 173-176.

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

Conti M.A., Di Geronimo I., Esu D. & Grasso M. (1979) - *Il Pleistocene in facies limnica di Vittoria (Sicilia, meridionale).* Geol. Romana, **18**, 93-104.

Conti M.A. & Esu D. (1981) - *Considerazioni sul significato paleoclimatico e geodinamico di una serie lacustre pleistocenica inferiore presso Tavernelle (Perugia, Umbria).* Geogr. Fis. Dinam. Quat., **4**, 3-10.

Cotecchia V. & Magri G. (1967) - *Gli spostamenti delle linee di costa quaternarie del Mar Ionio, tra Capo Spulico e Taranto.* Geol. Appl. Idrogeol., **2**, 1-34.

Dai Pra G. & Stearns C.E. (1977) - Sul Tirreniano di Taranto. Datazioni sui coralli con il metodo Th^{230}/U^{234}. Geol. Romana, **16**, 231-242.

De Stefani C. (1876-1880) - *Molluschi continentali, fino ad ora notati in Italia nei terreni pliocenici, ed ordinamento di questi ultimi.* Atti Soc. Tosc. Sci. Nat., Mem., **2**(1876), 130-174; **3**(1877), 274-325; **5**(1880), 9-108.

De Stefani C. (1887) - *Le ligniti del bacino di Castelnuovo di Garfagnana.* Boll. R. Com. Geol. Ital., **18**, 212-241.

Devoto G. (1965) - *Lacustrine Pleistocene in the Lower Liri Valley (Southern Latium).* Geol. Romana, **4**, 291-368.

Durante S. & Settepassi F. (1978a) - *Nota sulla malacofauna di Torre in Pietra, Roma.* Quaternaria, **20**, 301-312.

Durante S. & Settepassi F. (1978b) - *Note sulle associazioni malacologiche del giacimento fluvio-lacustre di Loreto, Venosa.* Atti XX Riun. Sci. Ist. Ital. Preist. Protost., 141-145.

Esu D. (1978) - *La malacofauna continentale plio-pleistocenica della Formazione fluvio-lacustre di Nuraghe Su Casteddu (Sardegna orientale) e sue implicazioni paleogeografiche.* Geol. Romana, **17**, 1-33.

Esu D. (1980) - *Malacofauna continentale del giacimento pleistocenico superiore a vertebrati della Via Flaminia (Roma).* Rend. Accad. Naz. Lincei, s.8, **69**, 425-430.

Esu D. (1981) - *Significato paleoecologico e paleoclimatico di una malacofauna continentale pleistocenica dell'Italia centro-meridionale (Isernia, Molise).* Boll. Soc. Geol. Ital., **100**, 93-98.

Esu D. (1982) - *Les mollusques continentaux du Villafranchien de l'Italie: indications biostratigraphiques et paléoclimatiques.* Coll. Villafranchien Méditerr., Lille, **1**, 71-82.

Esu D. (1983) - *Présence de* Valvata chalinei *Schlickum & Puisségur dans le Villafranchien supérieur de Leffe (Italie). (Prosobranchia: Valvatidae).* Arch. Moll., **114**, 65-68.

Esu D. (1986) - *Contributo alla conoscenza delle malacofaune continentali quaternarie della Sardegna.* Geol. Romana, **25**, 181-190.

Esu D. (1988) - Jaminia (Jaminia) malatestae *n.sp. from the Italian Pleistocene (Pulmonata: Enidae).* Arch. Moll., **119**, 227-233.

Esu D. & Girotti O. (1974) - *La malacofauna continentale del Plio-Pleistocene dell'Italia centrale. I. Paleontologia.* Geol. Romana, **13**, 203-294.

Esu D., Girotti O. & Grisolia P. (1977) - *The characters of the Upper Villafranchian molluscs of Central Italy.* Abstr. X INQUA Congr., Norwich, 127.

Esu D., Girotti O. & Kotsakis T. (1989) - *Oligotipia nei vertebrati e nei molluschi continentali fossili.* Atti 3° Simp. Ecol. Paleoecol. Comun. Bentoniche, Catania-Taormina, 285-298.

Esu D.& Kotsakis T. (1979) - *Restes de vertébrés et de mollusques continentaux dans le Villafranchien de la Sardaigne.* Geobios, **12**, 101-106.

Esu D. & Kotsakis T. (1980) - *Presenza di Hypnomys Bate (Gliridae, Rodentia) nel Villafranchiano di Nuraghe Su Casteddu (Nuoro, Sardegna).* Rend. Accad. Naz. Lincei, s. 8, **68**, 123-127.

Esu D. & Kotsakis T. (1983) - *Les vertébrés et les mollusques continentaux du Tertiaire de la Sardaigne: paléobiogéographie et biostratigraphie.* Geol. Romana, **22**, 177-206.

Esu D. & Kotsakis T. (1987) - *Paleobiogeografia dei vertebrati e dei molluschi continentali dell'area alpina sud-orientale.* Biogeographia, n.s., **13**, 57-81.

Esu D., Kotsakis T. & Malatesta A. (in press) - *Rongeurs et mollusques continentaux "froids" au passage Pléistocène inférieur - Pléistocène moyen des environs de Rome (Italie).* Geobios.

Francavilla F., Bertolani Marchetti D. & Tomadin L. (1970) - *Ricerche stratigrafiche, sedimentologiche e palinologiche sul Villafranchiano tipo.* Giorn. Geol., s.2, **36**, 701-741.

Girotti O. (1972) - *Correlabilità, mediante molluschi d'acqua dolce, del Calabriano di Monte Mario (Roma) con il Villafranchiano superiore.* Geol. Romana, **11**, 229-235.

Giusti F. & Oppi E. (1973) - Dreissena polymorpha *(Pallas) nuovamente in Italia. (Bivalvia, Dreissenidae).* Mem. Mus. Civ. St. Nat. Verona, **20**, 45-49.

Kotsakis T., Esu D. & Girotti O. (in press) - *A post-Villafranchian cold event in Central Italy testified by continental molluscs and rodents.* Boll. Soc. Geol. Ital.

Kotsakis T., Palombo M.R. & Petronio C. (1978) - Mammuthus chosaricus e Cervus elaphus *del Pleistocene superiore di Via Flaminia (Roma).* Geol. Romana, **17**, 411-445.

Laviano A. & Pennetta L. (1980) - *Il deposito continentale pleistocenico di Fontana del Fico. Osservazioni stratigrafiche e paleontologiche.* Riv. Ital. Paleont. Stratigr., **86**, 429-452.

Lazzarotto A., Mazzanti R. & Nencini C. (1990) - *Geologia e morfologia dei Comuni di Livorno e Colle Salvetti.* Quad. Mus. St. Nat. Livorno, **11**(suppl. **2**), 1-85, 1 map.

Lona F. & Bertoldi R. (1972) - *La storia del Plio-Pleistocene italiano in alcune sequenze vegetazionali lacustri e marine.* Mem. Accad. Naz. Lincei, s.8, **11**, 1-47.

Lona F. & Ricciardi E. (1961) - *Studio pollinologico stratigrafico su una serie lacustre pleistocenica dell'Italia centrale (Bacino di Gubbio, Perugia).* Pollen et Spores, **3**, 93-100.

Lozek V. (1986) - *Mollusca analysis.* In: Berglund B.E. (ed.), *Handbook of Holocene Palaeoecology and Palaeohydrology*, J.Wiley & S., Chichester, 729-740.

Malatesta A. (1953) - *Risultati del rilevamento del Foglio 192 (Alghero - Isola di Sardegna). Note di stratigrafia quaternaria.* Boll. Serv. Geol. Ital., **75**, 371-395.

Malatesta A. (1958) - *Note di geologia e morfologia sulla Valle Caudina e sulla Valle del F. Calore.* Boll. Serv. Geol. Ital., **80**, 255-260.

Malatesta A. (1964) - *Über einige pleistozäne Süsswassermollusken aus Mittel-Italien, I.* Arch. Moll., **93**, 151-162.

Malatesta A. (1985) - *Geologia e paleobiologia dell'Era Glaciale.* NIS, Roma, 282 p.

Malatesta A. & Zarlenga F. (1986) - *Evoluzione paleogeografica-strutturale plio-pleistocenica del Basso Bacino Romano a Nord e a Sud del Tevere.* Mem. Soc. Geol. Ital., **35**, 75-85.

Manganelli G., Delle Cave L. & Giusti F. (1989) - *Notulae malacologiche, XLII. Strobilopsidae (Gastropoda, Pulmonata), a family new to the Villafranchian land snail fauna of Apenninic Italy.* Basteria, **53**, 3-13.

Martinis B. (1949) - *Introduzione allo studio del Villafranchiano nella Valle Padana.* Riv. Ital. Paleont. Stratigr., **55**, 45-72.

Massari F. & Dieni I. (1973) - *La Formazione fluvio-lacustre di Nuraghe Casteddu ed i suoi rapporti con i basalti di Orosei-Dorgali (Sardegna).* Mem. Soc. Geol. Ital., **12**, 377-410.

Meijer T. (1986) - *Non-marine mollusc biozonation of Quaternary deposits in the Netherlands.* Proc. 8th Intern. Malacol. Congr., Budapest, 161-163.

Pantanelli D. (1878) - *Sul Pliocene dei dintorni di Chianciano (Toscana).* Boll. R. Com. Geol. Ital., **9**, 10-19.

Papani G. & Pelosio G. (1962) - *La serie plio-pleistocenica del T. Stirone (Parmense occidentale).* Boll. Soc. Geol. Ital., **81**, 293-335.

Pecorini G. (1963) - *Contributo alla stratigrafia post-miocenica della Nurra di Alghero (Sardegna nord-occ.).* Rend. Sem. Fac. Sci. Univ. Cagliari, **33**, 1-10.

Pelosio G. & Raffi S. (1973) - *Considerazioni sul limite Plio-Pleistocene nella serie del T. Crostolo (Preappennino reggiano).* Ateneo Parmense, Acta Nat., **9**, 39-67.

Pelosio G. & Raffi S. (1977) - *Preliminary remarks on mollusc assemblages of the Stirone river Pleistocene series (Parma Province, Northern Italy).* X INQUA Congr, Norwich, Preprint, 19 p.

Ruggieri G., Rio D. & Sprovieri R. (1984) - *Remarks on the chronostratigraphic classification of Lower Pleistocene.* Boll. Soc. Geol. Ital., **103**, 251-259.

Sacco F. (1884) - *Nuove specie fossili di molluschi lacustri e terrestri in Piemonte.* Atti R. Accad. Sci. Torino, **19**, 337-354.

Sacco F. (1885) - *Fauna malacologica delle alluvioni plioceniche del Piemonte.* Mem. R. Accad. Sci. Torino, s.2, **37**, 1-40.

Sacco F. (1886) - *Rivista della fauna malacologica fossile, terrestre, lacustre e salmastra del Piemonte.* Boll. Soc. Malac. Ital., **12**, 135-203.

Sacco F. (1888) - *Aggiunte alla fauna malacologica extramarina fossile del Piemonte e della Liguria.* Mem. R. Accad. Sci. Torino, s.2, **39**, 61-98.

Sacco F. (1897) - *I molluschi dei terreni terziarii del Piemonte e della Liguria.* Torino, **22**, 148 p.

Savelli C. & Pasini G. (1973) - *Preliminary results of K-Ar dating basalts from eastern Sardinia and the gulf of Orosei (Tyrrhenian Sea).* Giorn. Geol., s.2, **39**, 303-312.

Schlickum W.R. (1979) - *Die Gattung* Hydrocena *im europäischen Tertiär.* Arch. Moll., **110**, 71-73.

Schlickum W.R. & Puisségur J.J. (1978) - *Die Molluskenfauna der Schichten mit* Viviparus burgundinus *und* Pyrgula nodotiana *von Montagny-les-Beaune (Dép. Côte d'Or).* Arch. Moll., **109**, 1-26.

Schlickum W.R. & Strauch F. (1979) - *Die Land- und Süsswassermollusken der pliozänen Deckschichten des rheinischen Braunkohle.* Abh. Senckenb. Naturfosch. Gesell., **536**, 1-144.

Segre A.G. (1978) - *Il Pleistocene ed il Paleolitico della Basilicata.* Atti XX Riun. Sci. Ist. Ital. Preist. Protost., 15-39.

Settepassi F. & Verdel U. (1965) - *Continental Quaternary Mollusca of the Lower Liri Valley (S*

Latium). Geol. Romana, **4**, 369-452.

Truc G. (1971a) - *Gastropodes continentaux néogènes du Bassin Rhodanien.* Docum. Lab. Géol. Univ. Lyon, **H.S.**, 79-129.

Truc G. (1971b) - *Heliceae (Gastropoda) du Néogène du Bassin Rhodanien (France).* Geobios, **4**, 273-327.

Tuccimei G. (1889) - *Il Villafranchiano nelle valli sabine e i suoi fossili caratteristici.* Boll. Soc. Geol. Ital., **8**, 95-132.

Venzo S. (1950) - *Rinvenimento di* Anancus arvernensis *nel Villafranchiano di Paderno, di* Archidiskodon meridionalis *e* Cervus *a Leffe. Stratigrafia e clima del Villafranchiano bergamasco.* Atti Soc. Ital. Sci. Nat., **89**, 43-122.

Venzo S. (1955) - *Stadi della glaciazione del "Donau" sotto al Günz ed al Mindel nella serie lacustre di Leffe (Bergamo) - Limite tra Pliocene e Pleistocene.* Actes IV Congr. INQUA, Pisa-Roma, **1**, 65-85.

Verri A. (1877) - *Alcune linee sulla Val di Chiana e luoghi adiacenti nella storia della Terra.* Pavia, 100 p.

Verri A. (1883) - *Appunti sui bacini del Chiascio e del Topino.* Boll. Soc. Geol. Ital., **2**, 108-121.

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