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GEOLOGICAL EVOLUTION AND BIOCHRONOLOGICAL EVIDENCES OF THE MONTE RICCIO SECTION (TARQUINIA, CENTRAL ITALY)

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Riassunto. Lo studio della successione geologica affiorante a M.te Riccio ha consentito di delineare una ricostruzione dell'evoluzione dell'area per il Plio-Pleistocene. L'analisi stratigrafica indica il passaggio da un ambiente marino poco profondo durante il Pliocene, a costiero durante il Pleistocene Inferiore (testimoniato da evidenti linee di riva) a condizioni continentali nella parte alta del Pleistocene Inferiore.

L'analisi di resti di mammiferi provenienti da un livello sovrastante depositi marini ("Macco" auct.) ha permesso di riferire l'associazione faunistica al Villafranchiano superiore (Unità Faunistica Tasso) correlabile all'inizio del Pleistocene. È questa la prima segnalazione di una fauna a mammiferi del Pleistocene Inferiore nel Lazio settentrionale.

Abstracts. The geological evolution of the area of M.te Riccio for the Plio-Pleistocene time span has been pointed out. The M.te Riccio area was probably an high during Gelasian-Santernian times. The stratigraphical sequence shows the passage from a coastal marine environment during Pliocene, to a coastal environment during Early Pleistocene (testified by evidences of shorelines) to continental conditions during the upper part of Pleistocene. The analysis of the mammal bones coming from a level overlying a marine formation ("Macco" auct.) allow us to ascribe the faunal association to the late Villafranchian (Tasso F.U.) referable to the beginning of the Pleistocene. It is the first signalation of an Early Pleistocene mammal fauna in the Northern Latium.

Geological background.

The sequence outcropping in the Monte Riccio area is already known in the literature (Fazzini et al., 1972; Colalongo et al., 1973; Conti et al., 1983). These authors pointed out detailed studies of the Early and Middle Pliocene parts, while the Late Pliocene-Early Pleistocene parts were mainly studied in a closely area, named Macchia della Turchina (Conato & Dai Pra, 1980; Carboni & Palagi, 1997) (Fig. 1).

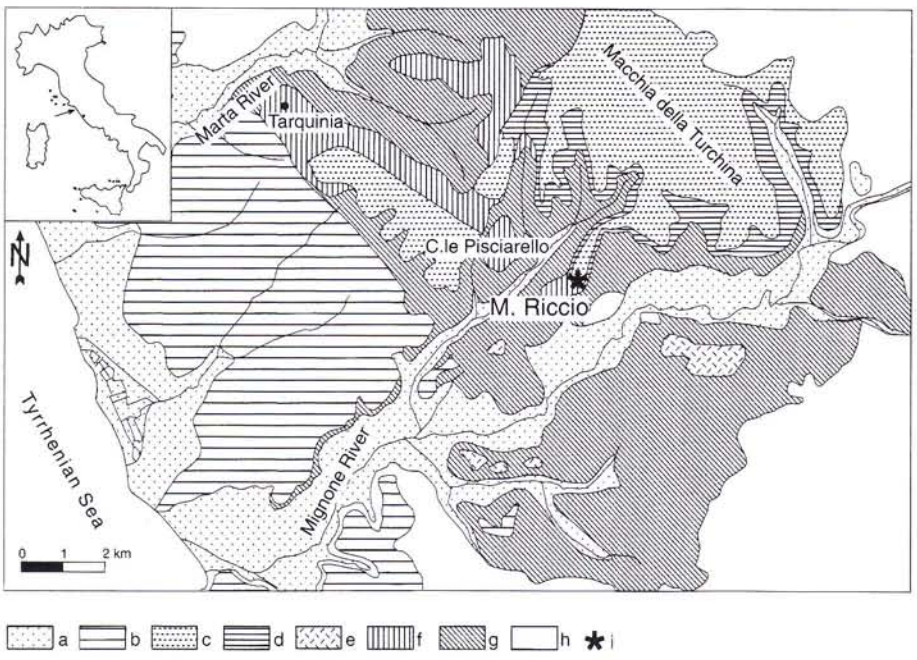

Fig. 1 - Geological sketch map (modified from Conato & Dai Pra, 1980): a) Alluvial deposits (Holocene); b) Marine deposits rich in volcanoclastic material (Middle Pleistocene); c) Marine deposits of Macchia della Turchina sequence (Early Pleistocene); d) Clays and marls with *Cladocora caespitosa* (Early Pleistocene); e) Ignimbrites of Vulsini and Tolfa intrusive volcanics (Late Pliocene-Middle Pleistocene); f) Biodetritical calcarenites and limestones ("Macco", Middle-Late Pliocene); g) greysh -blue clays (Early Pliocene); i) location of the site.

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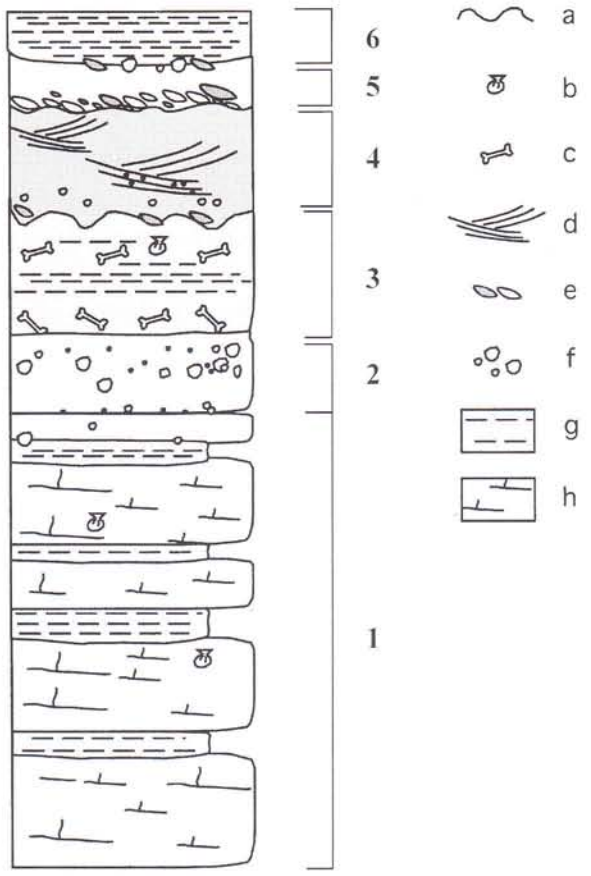

Fig. 2 - Geological log: a) unconformity surface; b) molluscs remains; c) mammal bones; d) crossing bedding; e) intrusive volcanic pebbles (dark) and marly-limestones pebbles; f) "Macco" pebbles; g) sandy and clayey intervals; h) biodetritical calcarenitic intervals.

Fazzini et al. (1972) describe the Calcare di Tarquinia (called "Macco" in Central Italy, where it widely outcrops) as an alternating sequence of biodetritical sands and calcarenites. They assigned it to a dubitative time interval that spans from Early Pliocene to the lower part of Middle Pliocene. Overlying the "Macco" they found a level of cemented, coarse, calcareous sands assigned to Late Pliocene-Early Pleistocene. Conglomerates in sandy matrix ("Conglomerati di incerta attribuzione") locally close the sequence but they are not assigned to a precise stratigraphic interval.

Colalongo et al. (1973) identified a stratigraphical disconformity by means of the foraminifer assemblages. The disconformity was referred to late Early Pliocene and late Middle Pliocene time interval (lacuna mediopliocenica).

Conti et al. (1983) described, within the "Macco", a Pliocene *Amphistegina* level recognised in Central Italy and they refer it to the upper part of the Middle Pliocene.

Both Conato & Dai Pra (1980) and Carboni & Palagi (1997, 1998) indicated at an altitude of over 80 m a.s.l., a series of transgressive events of marine shallow waters ascribed generically to Middle-Late Pliocene and Early Pleistocene for the presence of *Bulimina etnea* in the upper levels.

Stratigraphic section.

The stratigraphical study has been carried out on different quarries located at different heights in locality Monte Riccio. The stratigraphical section illustrated in Fig. 2 is a synthesis of all the outcrops. In Fig. 3 the upper quarry is illustrated. Numbers in both figures refers to the following description, top to the bottom.

6) Grey clay characterised by a clastic level at the base and organised in channelised bodies. Locally a complete alteration in caolinite is evident, probably due to hydrothermal fluids circulation, (0.5-2 m).

5) Conglomerate in abundant sandy matrix. Clasts are marly, calcareous, of calcarenites and flint; their dimensions reach 20-cm of diameter. An erosive surface is evident at the bottom, (0.15-1.5 m).

4) Coarse ocraceous sand, clast-supported with cemented levels. Conglomerate in lenses and levels. In the upper part, sub-horizontal parallel structures are visible. Locally lenses of pebbles with crossing sets are present. Clasts are constituted by marly limestone and intrusive volcanic material. Fragments of marine molluscs are often found. At the base it is characterised by clasts of intrusive volcanic laying on an unconformity surface, N dipping, (0.4-3 m).

3) Biodetritical coarse sands, with abundant silty-clay matrix in the upper part. Calcareous sandy concretions and small clayey lenses are often found. High frequency of molluscs remains and abundant internal moulds of marine molluscs in the upper part. Within this level abundant vertebrate remains were found. A slightly undulated surface is at the base, (3-4m).

2) Alternance of conglomerates and sands constituted, respectively, by well sorted, round calcarenites clasts (25-30 cm of diameter) and biodetritical, coarse sands. In the last centimetres some clasts of micritic limestone are present. The molluscs frequency is very low, (1.5 m). The passage to the underlying level is gradual.

1) Alternance of cemented and loose calcareous biodetritical coarse sands. They contain a rich malacofauna and have a horizontal stratification, (12 m). At the top it is characterised by intense karstic processes and by the increasing occurrence of clasts.

Levels 2 and 3 (Fig. 2) were formerly referred to the "Macco" auct. (Fazzini et al., 1972; Carboni et al., 1994). From our point of view the conglomerate *facies* of level 2 testifies the beginning of the Santernian regression and it is a typical beach *facies*, with a rocky

Fig. 3 - Stratigraphy of the M.te Riccio quarry: numbers correspond to description in the text.

coast (made of Macco) behind. Level 3 testifies a lagoon environment where the detritus component is abundant. There is not a clear unconformity surface between levels 2 and 1 (Fig. 3) but observations on other sections of the quarry and on nearby outcrops allow to say that the M.te Riccio area was probably a morphological high during Gelasian-Santernian times (Bettelli et al., 1980). In fact, in M.te Riccio and C.le Pisciarello levels 2 and 3 are always found while in the surroundings they lack completely and level 1 is directly overlaid by level 4 or correlated levels. In this case, an evident erosive surface marks the passage between the two. Probably the emplacement of the Tolfa domes, during the upper part of the Gelasian period (De Rita et al., 1997), took part in the progressive rising of the area and the relative sea lowering until the development of coastal lagoons and, finally, of continental conditions.

In level 2, at a height of around 125 m a.s.l., the presence of *Lithophaga* boreholes induces to the following considerations: since level 4 testifies the last evidence of marine deposition, this coastline should be chronologically linked to levels 5 and 6 or even younger. Moreover in deposits correlated to levels 5 and 6 several teeth of *Equus altidens* were found (unpublished data) while volcanic material from the Volsini-Sabatini complex is completely absent, constraining these levels to the late Early Pleistocene. Since level 5 contains volcanic intrusive pebbles coming from the Tolfa intrusion, the lower boundary could be the emplacement and subsequent erosion of the Tolfa dome occurred after Late Pliocene (De Rita et al., 1997). The deposits related to this coastline are found near Tarquinia, laying directly over the Macco (cf. Fig. 1, d).

Marine faunas.

Samples from levels 6 and 5 were analysed but they were completely barren.

In level 4 fragments of marine molluscs are frequent. In some cases it was possible to recognise *Ostrea* sp. and *Pecten* sp. remains.

In level 3, together with the bone bearing level, some internal moulds of bivalves were found. In clayey

lenses an oligospecific assemblage, constitute by *Cyprideis torosa* (Jones) was found. The first appearance of this ostracod species is generally referred to the beginning of the Early Pleistocene (Bossio, pers. com.). Foraminifer species with very different palaeoecological characteristics form an assemblage affected by intense reworking.

Level 2 is characterised by the presence of *Lithophaga* boreholes on Macco clasts. The orientation of the boreholes allows to assume that they are in life position.

Level 1 has the same elements (very abundant pectinids and ostreid) recognised by Compagnoni (1966) in the Macco at Palo.

The taxa represented in this level are: *Ostrea (Ostrea) lamellosa* Brocchi, *Chlamys (Aequipecten) opercularis* Linnaeus, *Chlamys (Aequipecten) seniensis* Lamarck, *Chlamys (Chlamys) multistriata* (Poli), *Pecten (Pecten) jacobaeus* (Linnaeus), *Pecten (Pecten) bipartitus* (Foresti), *Pecten (Flabellipecten) flabelliformis* (Brocchi).

The analysis of the macrofossil record in level 1 ("Macco" auct.) shows some variations in the different taxa frequency. The lower part of the deposit is characterised by high equitability of pectinids, while the upper part is marked by the great abundance of the species *Chlamys* (A.) *opercularis* and *Chlamys* (A.) *seniensis*. The upper part of the biocalcarenite is characterized also by the high frequency of fragments of *Ditrupa cornea* (Linnaeus). These data suggests a progressive lowering of the sea level and a relative increasing of the environmental instability during the deposition of level 1.

Ostracods relative to the base of level 1 are characterised by a low specific diversity and low frequency (10 species assigned to 6 genera). At the top the frequency is medium-low but the specific diversity rises (25 species assigned to 19 genera). The palaeoecological indications allow defining a marine infralittoral environment, with dominant species *Loxoconcha ovulata* (Costa) and *Aurila* cf. *Aurila (Aurila) convexa* (Baird).

In levels 2 and 1 the forams assemblage is characterised mainly by benthic species such as *Ammonia* spp., *Elphidium* spp., *Florilus boueanus* (d'Orbigny) and rare *Lobatula lobatula* (Walker & Jacob), typical of the infralittoral environment.

Mammal fauna.

Almost the totality of the mammal bones have been collected from the top the calcarenites and from the detritic clays overlying level 1 ("Macco" auct.) (Figg. 2; 3). Unfortunately the large mammal remains (elephants and rhinos) have been destroyed during the quarry works. Some *Testudo* sp. remains were found too. The following taxa have been checked:

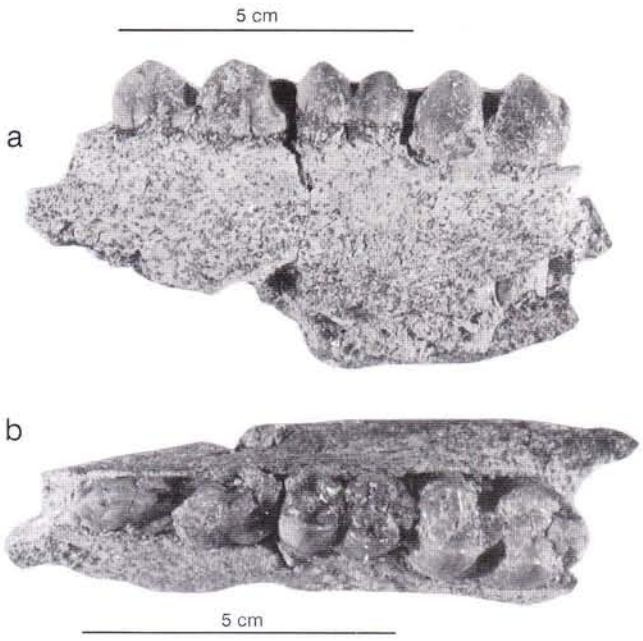

Fig. 4 - *Sus strozzii* Major, fragmentary mandible with P/3, P/4, M/1, M/2: a) lateral view, b) occlusal view.

Prolagus sp., *Elephantidae* cf. *Mammuthus meridionalis* (Nesti), *Sus strozzi* Major, *Hippopotamus antiquus* Desmarest, *Leptobos* cf. *Leptobos etruscus* (Falconer), *Procapreolus* sp., *Eucladoceros ctenoides* (Nesti), *Axis nestii* (Major), *Stephanorhinus* cf. *Stephanorhinus etruscus* (Falconer), *Equus stenonis* Cocchi, *Vulpes* cf. *Vulpes alopecoides* Major, *Canis etruscus* Falconer and *Megantereon cultridens* (Cuvier *partim*).

Prolagus sp.

Only two fragmentary molars represent this taxon but the scantiness of the fossil record do not allow any further taxonomic consideration. The genus occurred in the early Villafranchian (Arondelli) to the late Villafranchian of Upper Valdarno (Gliozzi et al., 1997).

Elephantidae cf. *Mammuthus meridionalis* (Nesti)

Some juvenile diaphysis of limb bones and a dental lamina are referable to this family. The thickness of the enamel of the tooth is similar to those of the specimen of *Mammuthus meridionalis* of the late Villafranchian faunas.

Sus strozzii Major

A fragmentary mandible with P/3, P/4, M/1, M/2 (Fig. 4) and a metapodial showing the typical features of this species represent the taxon. This suid quite commonly occurs in the middle and late Villafranchian faunas.

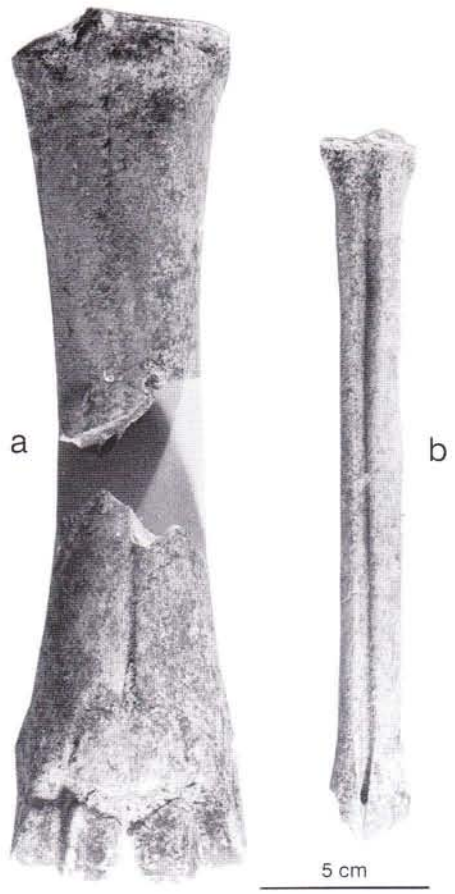

Fig. 5 - a) *Leptobos* cf. *Leptobos etruscus* (Falconer): proximal and distal ephiphysis of a metacarpal bone (frontal view); b) *Axis nestii* (Major): metatarsal bone (frontal view).

Hippopotamus antiquus Desmarest

A partially crushed fragment of the skull with the temporal and the upper part of the occipital bones, with the linea nucalis testify the occurrence of the hippo. The short sagittal crest forms a wide acute angle with the frontal plan. This morphology and the large size are characteristic features of this species, which widespread in Italy from Africa in the Early Pleistocene (late Villafranchian, Tasso F.U., Petronio, 1986). It seems to survive in Europe until the beginning of the Late Pleistocene (Mazza, 1991; Petronio, 1995).

Leptobos cf. *Leptobos etruscus* (Falconer)

The occurrence of a slender bovid is testified by two frontal bones with the basis of the horn core, some jugal teeth, the proximal and the distal ephiphysis of a metacarpal (Fig. 5a). The size and the morphological features of the metacarpal bone of the specimen from Monte Riccio show great similarities with the fossil record of *Leptobos* etruscus from Olivola and Upper Valdarno studied by Masini (1989), while the late Villafranchian *Leptobos vallisarni* and *Bison (Eobison) degiulii* show more bisontine features.

Leptobos etruscus characterised the late Villafranchian (Olivola-Farneta F.U.) (Gliozzi et al., 1997).

Procapreolus sp.

The occurrence of the roe deer in the Early Pleistocene deposits of Italy is not well defined. This cervid is represented by a fragment of the frontal bone with the basal part of the antler. The roedeer is a very rare element in the villafranchian faunas. It occurs in the Cava Toppetti deposit referred to the end of Pliocene, Costa S. Giacomo F.U. (Abbazzi et al., 1997), while there are no sure data about the late Villafranchian faunas.

Eucladoceros ctenoides (Nesti)

The occurrence of this large cervid is testified by the basal part of an antler (Fig. 6b), some molar teeth, a

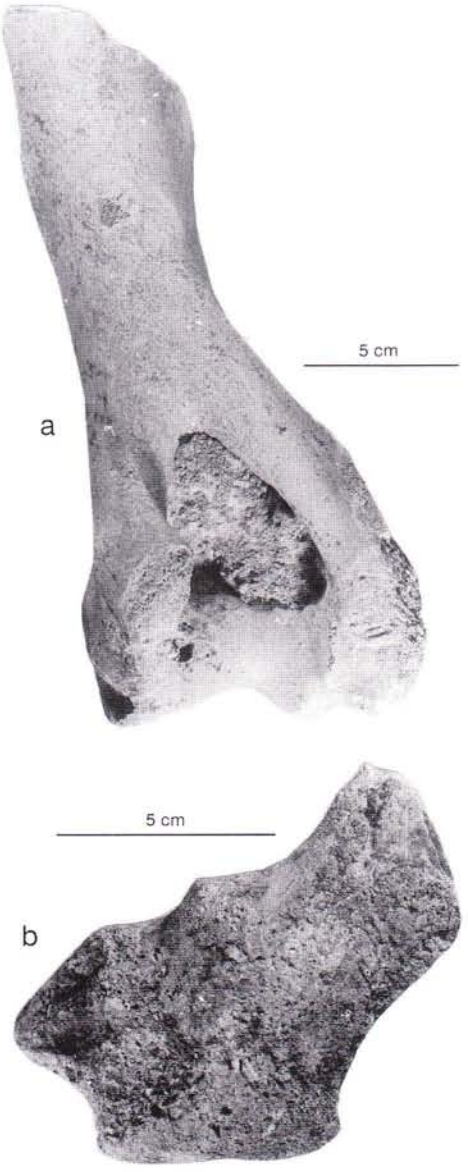

Fig. 6 - a) *Stephanorhinus* cf. *Stephanorhinus etruscus* (Falconer): distal part of a humerus (posterior view); b) *Eucladoceros ctenoides* (Nesti): basal part of an antler (lateral view)

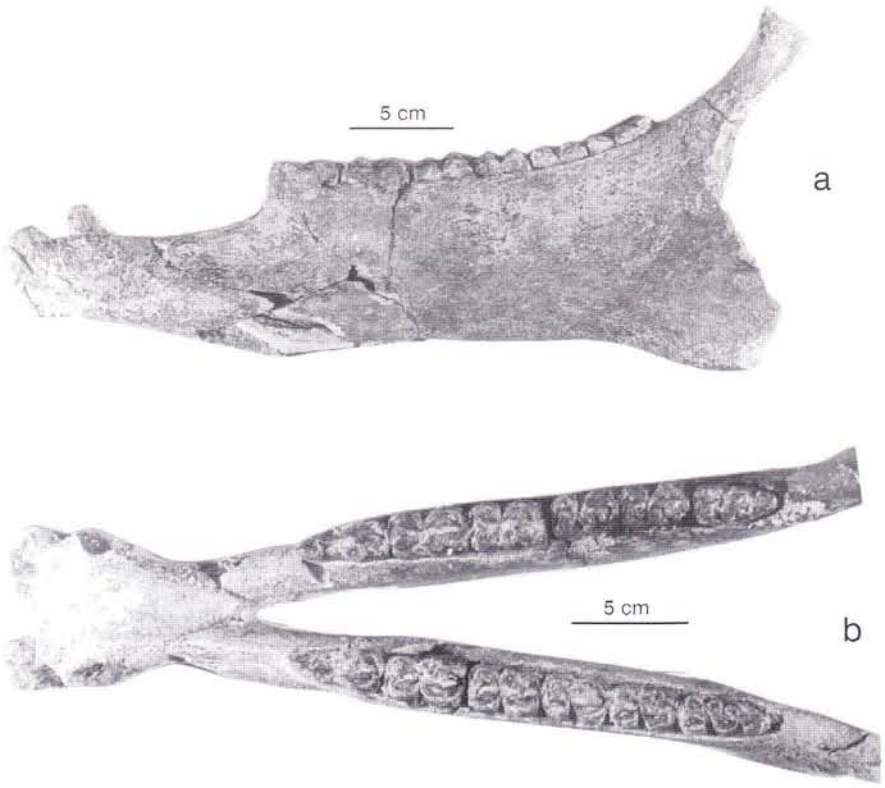

Fig. 7 - *Equus stenonis* Cocchi: mandible a) lateral view; b) occlusal view.

distal end of a tibia and a calcaneum of a juvenile specimen. In particular, the size and the peculiar morphology of the antler allow taxonomic considerations. The rose is rounded in shape, with a diameter of 70 mm; the outer tine is strong and starts directly from the rose. It forms with the beam a moderately obtuse angle. A very peculiar inner tine is placed between the beam and the outer tine, very similar to the other specimens of *Eucladoceros ctenoides* (Azzaroli & Mazza, 1992). This species, associated with *Eucladoceros dicranios*, is a quite common element of the Upper Valdarno deposits and characterises the Olivola and Tasso F.U. (Gliozzi et al., 1997).

Axis nestii (Major)

Several metapodials (Fig. 5b), some fragmentary limb bones, a great number of jugal teeth and the basal part of an antler testify the occurrence of this cervid. The slenderness of the limb bones, the index of the metapodials, the morphology of the antler and the teeth allow to refer these fossil to *Axis nestii*, which, from a biochronological point of view, characterises the earliest late Villafranchian faunas (Olivola and Tasso F.U.) (Di Stefano & Petronio, 1998).

Stephanorhinus cf. *Stephanorhinus etruscus* (Falconer)

A fragmentary humerus (Fig. 6a), radius and tibia testify the occurrence of a rhino. The morphological features (i.e. the slenderness of the diaphyses) and the size are close to those of the specimens collected from the Upper Valdarno and Val di Chiana deposits (Mazza, 1988) and the specimen from Capitone (TR), Tiber River Basin (Ambrosetti, 1972).

Equus stenonis Cocchi

This taxon is represented by an almost complete mandible (Fig. 7), a fragmentary scapula and a metapodial. All the teeth, with the exception of the left I/2 (lost by the living animal). The mandible size falls in the dimensional field of the specimens from Upper Valdarno. In particular, it is very similar in shape to the holotype from Terranova (Azzaroli, 1965), and shows the classical stenonoid features: a strong and high horizontal branch, the shape of the lower and of the upper profile and a wide, short, very curved rostrum. All the teeth, including the very strong canines, are worn and very similar in morphology and in size to those of the stenonoid horses from Upper Valdarno. The chronological range of *Equus stenonis* in Italy goes from Costa S. Giacomo to Tasso F.U. (Caloi, 1994; Gliozzi et al., 1997).

Vulpes cf. *Vulpes alopecoides* Major

Part of the horizontal branch of a mandible with the M/2 and M/3 represents this small canid. Both size and morphology agree with those of the alopecoid fox, occurring in Italy during middle and late Villafranchian (Di Stefano et al., 1994).

Canis etruscus Falconer

A partial P/4, a fragmentary mandible with M/1 and M/2, and a complete left hand in anatomical connection (Fig. 8) can be referred to this wolf-like dog. The lower carnassial is moderately worn, but the morphology of the talonid is very similar to those of the wolves s.l. The size of the teeth and of the metacarpals of this dog fall in the average of the data of *Canis etruscus* from Olivola and different localities of Upper Valdarno (Torre, 1967), while the coeval *Canis arnensis* is more reduced in size and shows more slender metacarpals.

Azzaroli (1977) considered the first occurrence of *Canis etruscus* in Italy was as one the biological events, which characterised the faunal renewal of the late Villafranchian (the wolf event). In recent times, Rook & Torre (1996) referred to *Canis* cfr. *etruscus* some fossils

Fig. 8 - *Canis etruscus* Falconer: left hand in anatomical connection.

from the middle Villafranchian fauna of Costa S. Giacomo, while a very similar canid occurs in the almost coeval deposit of Senéze (France).

The biochronological distribution of *Canis etruscus* ranges from Costa S. Giacomo to Farneta F.U. (Gliozzi et al., 1997).

Megantereon cultridens (Cuvier *partim*)

A second right metatarsal can be referred to this smilodontine cat. The limb bones of the middle sized villafranchian felid are quite rare and incompletely known because the scantiness of the fossil record. The size and the morphological features are very similar to that of the specimens from Senéze (France), until now the most complete basis of comparison for the genus *Megantereon* (Sardella, 1998). According to the available data, *Panthera gombaszoegensis* show stronger and stouter metapodials. In Italy *Megantereon* ex gr. *cultridens* biochronological range is Costa S. Giacomo- Pirro F.U. (Sardella, 1998).

Biochronology.

The mammal fauna of Monte Riccio is an association referable to the beginning of late Villafranchian, Tasso F.U. (fig. 9) (Gliozzi et al., 1997).

Besides taxa as elephant, rhino and some carnivores, in the faunal association of Monte Riccio species of great biochronological significance occur such as *Leptobos etruscus*, *Eucladoceros ctenoides* and *Axis nestii*. These taxa, together with *Hippopotamus antiquus*, which widespread in Europe during the late Villafranchian, clearly suggest a biochronological collocation in a time span very close to the Plio-Pleistocene boundary.

In Italy, the occurrence of the genus *Procapreolus* has been recorded only in the early Villafranchian fauna of Montopoli (*Procapreolus cusanus*, Montopoli F.U., Azzaroli,1992) and in the middle Villafranchian fauna of Cava Toppetti (C. S. Giacomo F.U., Abbazzi et al., 1997).

The presence of *Procapreolus* in this section allows to wide the range of this cervid to the late Villafranchian.

Biochronological Units / Faunal List	MIDDLE VILLAFRANCHIAN	LATE VILLAFRANCHIAN			
	C. S. Giacomo F.U.	Olivola F.U.	Tasso F.U.	Farneta F.U.	Pirro F.U.
Prolagus sp.					
cf. *Mammuthus meridionalis*					
Sus strozzii					
Hippopotamus antiquus					
Leptobos cf. *L. etruscus*					
Procapreolus sp.					
Eucladoceros ctenoides					
Axis nestii					
Stephanorhinus cf. *S. etruscus*					
Equus stenonis					
Vulpes cf. *V. alopecoides*					
Canis etruscus	— —				
Megantereon cultridens					

Fig. 9 - Biochronological framework of the middle and late Villafranchian mammal faunas.

Conclusions.

The peculiar geological evolution of the M.te Riccio - C.le Pisciarello area has allowed the preservation of levels formerly ascribed to Pliocene marine deposits ("Macco" auct.), here distinguished as overlying the marine succession. The occurrence in these levels of a mammal fauna referable to the beginning of the Early Pleistocene have a great importance from both a stratigraphical and a biochronological point of view. This mammal fauna is referable, as pointed out above, to the Tasso F.U., and is the first signalation of an Early Pleistocene mammal fauna in the Northern Latium. It confirms the only datum available for the Early Pleistocene of the area, published by Conato & Dai Pra (1980). In that work the occurrence of *Bulimina etnea* in the Macchia della Turchina series suggested an Early Pleistocene age. Finally, also the occurrence of the ostracod *Cyprideis torosa*, confirms an attribution of the mammal fauna to the beginning of late Villafranchian.

The Monte Riccio section represents a succession developing from marine to continental environments. The occurrence of a mammal fauna within marine sediments (referred to shallow waters) allows the correlation, not often possible, between marine and continental deposits at the Plio-Pleistocene boundary.

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