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SOME PRELIMINARY DATA ON TWO SMALL MAMMAL BEARING PALEOSOLS FROM THE TYRRHENIAN AND ADRIATIC SIDES OF ITALY

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Abstract : Two Middle Pleistocene paleosols from the Tyrrhenian (Campani quarry, Pisa, Lower Valdarno) and Adriatic (Catignano, Pescara) sides of Italy, both covered by tephra layers, were studied for their paleontological content (molluscs and small mammals). At Campani quarry the volcanic ash level was dated by fission tracks both on glass (0.59±0.08 Ma; 0.62±0.07 Ma) and on the apatites (0.46±0.05 Ma). Stratigraphic evidences suggest a Middle Pleistocene age for Catignano paleosol. However, age determination on the apatites belonging to the Catignano volcanic level is currently under way.

The Campani quarry paleosol yielded a rich assemblage of land molluscs characterised by high species diversity indicating that a wooded environment developed in conditions of mild climate. The small mammal assemblage is dominated by murids, confirming the presence of a developed wood cover. Catignano paleosol shows a lower number for species of both small mammals and molluscs, the latter dominated by open ground and steppe taxa. A comparison between these two Middle Pleistocene levels shows that molluscs and small mammals data agree suggesting that different environmental conditions prevailed when the two paleosols developed.

Key Words: Biochronology, Small mammals, Molluscs, Middle Pleistocene, Central Italy

Considérations préliminaires sur deux paléosols avec micromammifères des parties tyrrhénienne et adriatique de l'Italie

Résumé : Deux paléosols du Pléistocène Moyen de la partie tyrrhénienne (Carrière Campani) et adriatique (Catignano) de l'Italie, couverts d'un niveau de tephra, ont fait l'objet d'une étude paléontologique (mollusques et petits mammifères). La couche volcanique de la carrière Campani a été datée avec la méthode des traces de fission sur les verres (0.59±0.08 Ma; 0.62±0.07 Ma) et sur les apatites (0.46±0.05 Ma). Des arguments stratigraphiques montrent que le paléosol de Catignano peut être d'âge Pléistocène Moyen aussi. Les apatites de la couche volcanique de Catignano sont actuellement en train d'être étudiées pour obtenir une datation.

Une riche association des mollusques continentaux caractérisée par une diversité spécifique élevée a été découverte dans le paléosol de la Carrière Campani. Cette diversité spécifique témoigne du développement d'un environnement boisé dans une phase climatique tempérée. Les petits mammifères sont dominées par les muridés, ce qui confirme la présence d'une couverture forestière. Dans le paléosol de Catignano, le nombre d'espèces de petit mammifères et de mollusques est inférieur. Les mollusques sont dominés par les espèces steppiques et d'environnements ouverts. Une comparaison entre les deux paléosols montre que les mollusques et les petits mammifères sont en accord pour suggérer des différences de conditions climatiques pendant le développement des deux niveaux du Pléistocène Moyen.

Mots clés : Biochronologie, Petits Mammifères, Mollusques, Pléistocène Moyen, Italie Centrale

INTRODUCTION

Paleosols, which usually have a defined stratigraphic position, are commonly considered a powerful tool in continental biochronologic reconstructions because of their fossil content, even if scanty or badly preserved (Bown & Kraus, 1981). Moreover, valuable results can be achieved when datable volcanic levels overlie them.

Two paleosols covered by pyroclastic levels were sampled in order to obtain a better insight on the chronology of the Italian Pleistocene small mammal. So far, only for Isernia La Pineta site radiometric data are available (Delitala *et al.*, 1983). In the paleosol of Campani quarry (Pisa, Lower Valdarno, Tuscany) the volcanic-ash level has been dated by fission tracks both on glass (0.59±0.08 Ma; 0.62±0.07 Ma) and on apatites (0.46±0.05 Ma) (Bigazzi *et al.*, 2000). The apatites sampled from the pyroclastic level that covers the paleosol studied at Catignano (Pescara, Abruzzo) are currently under study.

The presence of terrestrial mollusc assemblages in both paleosols allows the paleoenvironmental informations given by them and that of small mammals to be compared.

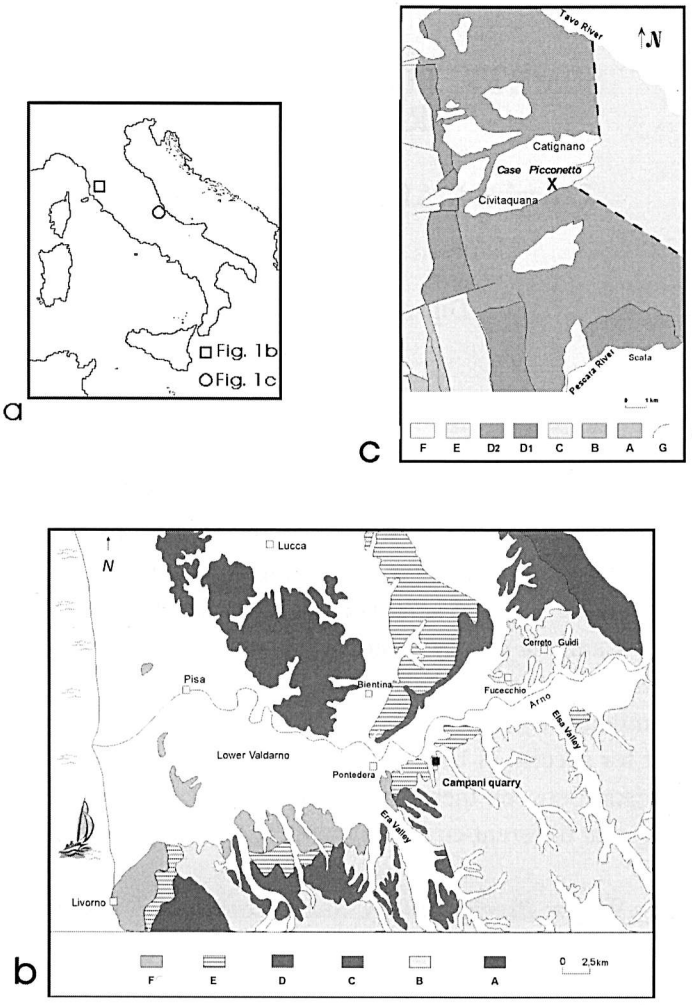

Figure. 1 : a. Geographic location of the two sites.
b. Schematic geologic map of Lower Valdarno. A: Pre-Neogene; B: Pliocene; C: Lower Pleistocene (marine deposits); D: Lower Pleistocene (continental deposits; Late Villafranchian); E: Middle Pleistocene (Cava Erta and San Romano Units, undifferentiated); F: Upper Pleistocene.
c. Schematic geologic map of Cellino Basin. A: Pre-Messinian; B: Gessoso Solfifera Formation (Messinian); C: Laga Formation (Upper Messinian-Lower Pliocene, undifferentiated); D: Cellino Formation (D1: Arenaceous-pelitic association and basal arenaceous member, undifferentiated; D2: Basal pelitic association, undifferentiated); E: Middle Pliocene-Pleistocene marine deposits; F: Middle Pleistocene continental deposits; G: Faults and overthrusts.
Figure. 1 : a. Localisation des deux gisements.
b. Carte géologique schématique du Valdarno inférieur. A : Pre-Néogène; B : Pliocène; C : Pléistocène inférieur (dépôts marins); D : Pléistocène inférieur (dépôts continentaux; Villafranchien supérieur); E : Pléistocène moyen (Unités de Cava Erta et San Romano, non différenciées); D : Pléistocène supérieur;
c. Carte géologique schématique du Bassin du Cellino. A : Pre-Messinien; B : Formation Gessoso-Solfifera (Messinien); C : Formation Laga (Messinien supérieur-Pliocène inférieur, non différencié); D : Formation Cellino (1: Association arenacéo-pélitique et membre basal, non différentiés; 2: Association basale pelitique, non différenciée); E : Pliocène moyen-Pléistocène (dépôts marins); F : Pléistocène (dépôts continentaux); G : Failles et surglissements.

LOWER VALDARNO GEOLOGICAL SETTING

Campani quarry is located in the Lower Valdarno area on the orographic left-hand of the Arno River (fig. 1b) between the west side of the Elsa graben and the eastern border of the Era graben. Six sedimentary units outcrop on the left-hand side of the Arno: Middle Pliocene marine "Sabbie Gialle" Formation, representing the end of the Pliocene marine cycle in Lower Valdarno; Lower Pleistocene marine "Sabbie e Argille ad *Arctica islandica* " and "Sabbie di Nugola Vecchia" Formations, which represent the transgressive and regressive deposits of Pleistocene marine cycle, respectively; Middle Pleistocene continental terraced deposits ("Cava Erta" and "S. Romano" Units) and Upper Pleistocene "Sabbie e Limi di Vicarello" Formation (Zanchetta *et al*, 1998; Tani & Gazzerro, 1999).

Campani quarry

The Middle Pleistocene sequence of Campani quarry (Zanchetta *et al.*, 1998) studied in this work belongs to the S. Romano Unit (fig. 2). This sequence consists of two members.The lower member consists of fluvial gravels and is described in Tani & Gazzerro (1999) and Zanchetta *et al.* (1998). Sandy sediments enclosed in the basal gravelly body of the lower member yielded an oligotypical assemblage of land molluscs, which suggests semi-arid and cold climatic conditions. The upper member is characterised by finer grained facies, namely sands, silty sands and laminated clays. Laterally continuous bodies of massive sandy clays with abundant root traces and carbonate nodules are interbedded within the finer levels of the upper portion. Some of them yielded large mammal bony fragments and continental molluscs. These bodies have been interpreted as poorly developed soils (Zanchetta *et al.*, 1998). The upper member of Campani quarry can be related to an alluvial plain and channel belt depositional environment. The ash level, repeatedly dated at about 0.5 Ma (Arias *et al.*, 1980; Bigazzi *et al.*, 1994; Bigazzi *et al.*, 2000) occurs at the top of the sequence (fig. 2).

A detailed study of non marine molluscs from all the paleosols of the Campani Quarry section is given in Zanchetta *et al.* (1998). The highest paleosol, identified as F in fig. 2, contains a rich assemblage of land molluscs (tabl. 1) and some small mammal remains. The mollusc species, typical of a woody environment (ecological group 1 and 2), prevail both in number of species (57,2%) and specimens (47,2%). In particular *Argna biplicata*, *Vitrea subrimata*, *Macrogastra lineolata*, *Clausilia cruciata, Discus rotundatus* and *Hygromia cinctella* indicate a moist woody environment. The mesophilous species (ecological group 7) are fairly well represented (18%). Within this group *Lauria cylindracea, Punctum pigmaeum, Oxychilus draparnaudi* prefer moist places. The aquatic species are very scanty (0.2%). The hygrophilous group (8) is well represented by the two species *Carychium tridentatum* and *Succinea oblonga*, living in very wet places, which represent 29.2% of the assemblage. Moreover, *Carychium tridentatum* is often associated with shaded conditions. The high species diversity and the ecology of the species point to a wooded and probably moist environment. Large mammals have been recovered from other paleosols of the section

Table 1

Ecological Group	Species name	N° of individuals	Percentages
1	*Platyla* sp.	1	0.2
	Vertigo pusillus	23	5.2
	Pagodulina sp.	1	0.2
	Argna biplicata	36	8.1
	Acanthinula aculeata	5	1.1
	Vitrea subrimata	71	16
	Macrogastra linoleata	5	1.1
	Clausilia cf. *C. cruciata*	15	3.4
	Helicodonta obvoluta	10	2.2
2	*Pomatias elegans*	18	4.1
	Discus rotundatus	16	3.6
	Hygromia cinctella	4	0.9
	Cepaea nemoralis	5	1.1
5	*Vertigo pygmaea*	10	2.2
7	*Lauria cylindracea*	5	1.1
	Punctum pygmaeum	1	0.2
	Oxychilus draparnaudi	32	7.2
	Testacella haliotidea	42	9.5
7'	*Milax* sp.	3	0.7
	Limax sp.	10	2.2
8	*Carychium tridentatum*	125	28.1
	Succinea oblonga	5	1.1
10	*Bithynia leachi*	1	0.2
TOTAL		**444**	**99.9**

Table. 1 : Campani quarry non marine molluscs species grouped by ecological classes; number of individuals and their percentages are indicated. Ecological classes: 1) Forest species; 2) Semi-forest species; 4) Steppe species; 5) Open land species; 7) and 7') Mesophilous species; 8) Hygrophilous species; 10) Freshwater species. (Modified from: Zanchetta *et al.*,1998).

Table 1 : Espèces de mollusques non-marins de la Carrière Campani groupés par classes écologiques; le nombre d'individus et leur pourcentage dans l'association sont indiqués. Classes écologiques: 1) Espèces de forêt; 2) Espèces semi-forestières; 4) Espèces de steppe; 5) Espèces d'espaces ouverts; 7) et 7') Espèces mésophiles; 8) Espèces hygrophiles; 10) Espèces d'eau douce. (Modifié d'après: Zanchetta *et al.*, 1998).

(paleosol B and A fig. 2). A fragmental right mandible of *Sus strozzii*, bearing part of the M_1 and the anterior part of the M_2, and the talons of both the left and right M^3, have been found in B. An incomplete left humerus of *Dama clactoniana* lacking the proximal epiphysis comes from paleosol A. The latter finding is significant from a biochronologic point of view, since its occurrence in Europe is limited to middle to late Middle Pleistocene. On the contrary, *Sus strozzii*, also according to its very bad state of preservation, is most likely a reworked element in the sequence. According to Zanchetta *et al.* (1998), the whole Campani quarry sequence could be correlated with stage 13 of the marine isotope scale.

All the paleosols have also been investigated for small mammals, but rodent and insectivore remains were found only in paleosol F

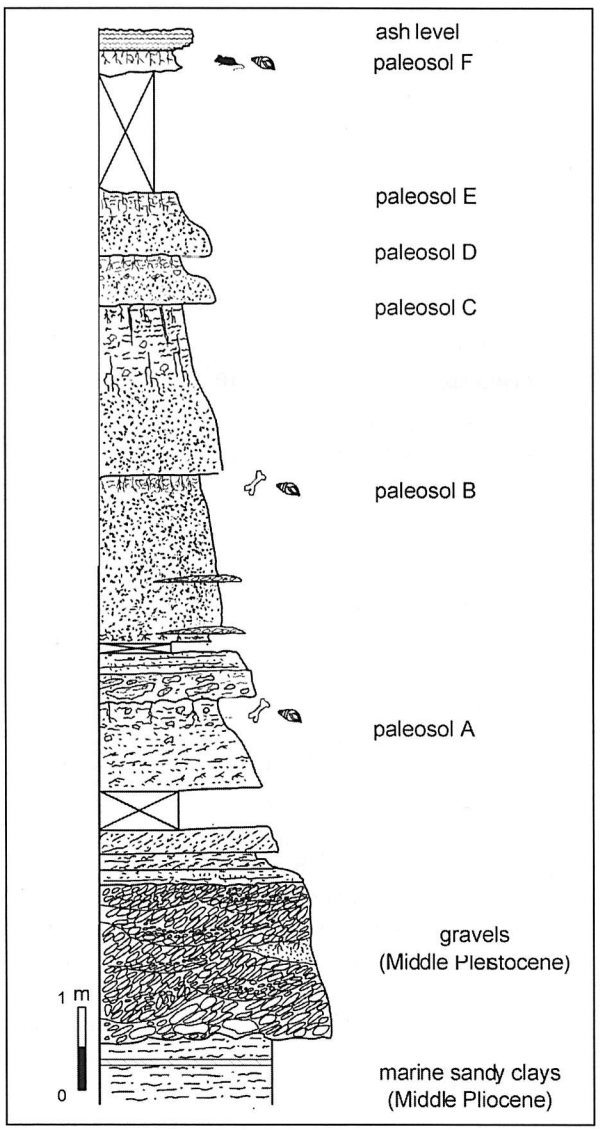

Figure. 2 : Schematic sketch of Campani quarry Middle Pleistocene succession.

Figure. 2 : Section schématique de la succession du Pléistocène Moyen de la Carrière Campani.

Campani Quarry small mammals

Insectivores and rodents of level F are very important because of their stratigraphic situation. The ash level, covering paleosol F, allows its fauna to be dated. It represents the second example of radiometrically dated local fauna in Italy, but unfortunately this assemblage is not well preserved and specimens are quite scarce (30 identifiable specimens). Therefore, identifications are sometimes limited to a generic range.

Small mammals are represented by: *Crocidura* sp., *Muscardinus avellanarius*, *Arvicola* sp., *Pliomys* sp., *Terricola* gr. *savii (fig. 4)*, *Apodemus* cf. *A. sylvaticus (fig. 4)*.

Order INSECTIVORA Gray, 1827
Family SORICIDAE Fischer von Waldheim, 1817
Genus *CROCIDURA* Wagler, 1832
CROCIDURA sp.

Three molars and an incisor belonging to the genus *Crocidura* were found. The first representatives of this insectivore are known from Pirro Nord (Pirro Faunal Unit), which is correlated with the late Early Biharian (Gliozzi *et al.*, 1997). Present day *Crocidura* live in wooded environments of temperate areas.

Order RODENTIA Bowdich, 1821
Family GLIRIDAE Thomas, 1897
Genus *MUSCARDINUS* Kaup, 1829
MUSCARDINUS AVELLANARIUS (Linnaeus, 1758)

The few molars of the glirid found in Campani quarry level F clearly belong to the extant species of *Muscardinus*. This arboreal species also first appears in Italy in the Pirro Nord Faunal Unit (F.U.) and is indicative of an open wooded environment.

Family ARVICOLIDAE Gray, 1821
Genus *TERRICOLA* Fatio, 1867
TERRICOLA gr. *SAVII*

Very few complete M_1 were recovered (Table 3), but the morphology of this rootless arvicolid is clearly pitymyan. A morphometric analysis was tried using Brunet-Lecomte (1988) method, although the amount of recovered material was scanty. The specimens of Campani quarry are similar to *T. multiplex* FATIO, 1905 and to *T. savii* DE SÉLYS LONGCHAMPS, 1838 (Brunet-Lecomte, pers. com.), according to the size and to the relative length of the anterior part. However, the pitytmyan rhombus' low inclination and the anterior loop width show a closer relation to the group *savii*.

Genus *ARVICOLA* Lacépède, 1799
ARVICOLA sp.

Only two second lower molars were found, nevertheless the size strongly suggests their attribution to the genus *Arvicola*. According to Maul *et al.* (1997), the SDQ index (Heinrich, 1978; Van Kolfschoten, 1990) of these M_2 (of 117-121) seems to point out to *Arvicola cantianus* (HINTON, 1910), the *Arvicola* species widespread in Italy before 0.5 Ma ago (Gliozzi *et al.*, 1997).

Genus *PLIOMYS* Méhely, 1914
PLIOMYS sp.

A left M_1, lacking the anterior part of the occlusal surface and with evidence of roots and a typical Anteroconid Complex, was found. It is attributed to the genus *Pliomys*, also considering the enamel thickness.

Family MURIDAE Illiger, 1815
Genus *APODEMUS* Kaup, 1829
APODEMUS cf. *A. SYLVATICUS*

Several molars are attributed to the genus *Apodemus*. On the basis of their morphology and size, they can be referred to the group *sylvaticus-flavicollis*. Argenti (1998) reviewed the italian fossil *Apodemus* and the dimensions of our specimens fall within the variantion range of both species. Since very few M^1 were recovered, the discrimination between *A. sylvaticus* (LINNAEUS, 1758) and *A. flavicollis* (MELCHIOR, 1854) is very hard (Pasquier, 1974), but the M^1 small dimensions seems to point out to a closer relationship to *A. sylvaticus* (Argenti, 1998).

Cellino Basin - Geological setting

The area between the Pescara and Tavo Rivers (fig. 1c), in Eastern Abruzzo (Central Apennines), represents the southward extension of the Cellino Basin. It has been interpreted as a turbiditic foredeep basin migrating toward east and northeast (Centamore *et al.*, 1992). The Upper Messinian - Lower Pliocene sequence of the Laga Formation outcrops on the Middle Messinian Gessoso-Solfifera Formation and it is mainly covered by the foredeep turbiditic deposits of the Cellino Formation, Early Pliocene in age. The deposits of the Middle Pliocene-Pleistocene marine ingression only outcrop in the eastern part of the area. The latter deposits are discontinuosly covered by continental Middle Pleistocene deposits.

Catignano paleosol

The fossiliferous site (fig. 3) is located near Catignano village, at Case Picconetto (336 m. a.s.l.), on the orographic right-hand side of Nora Creek. Apatites were separated for fission track dating from the pyroclastic level, which overlays a silty clay paleosol (Berti *et al.*, 1992) and consists of volcanic ash, lava fragments and pyroxene crystals.

The paleosol yielded many land snails (tabl. 2) and several small mammals.

Continental molluscs were studied using the Lozek (1964) and Puisségur (1976) methods, already applied by Esu (1978; 1981), Esu & Girotti (1991), Zanchetta *et al.* (1998) and Di Vito *et al.* (1999) to Central and Southern Italy assemblages. About 50 kg. of sediments were sieved using 71, 325, and 500 μm mesh screens. All identifiable shells and fragments were considered.

The malacological association consists of a low number of land mollusc species: *Jaminia malatestae, J. quadridens, Granaria frumentum, Truncatellina cylindrica, Vitrea contracta, Pupilla muscorum, Vallonia pulchella, Vertigo angustior, V. pigmaea, Orcula* cf. *O. doliolum*. All these land snail species are still living in the Italian peninsula, with the exception of the extinct species *J. malatestae*, endemic in Italy during Middle to Late Pleistocene (Esu, 1988; Esu & Girotti, 1991).

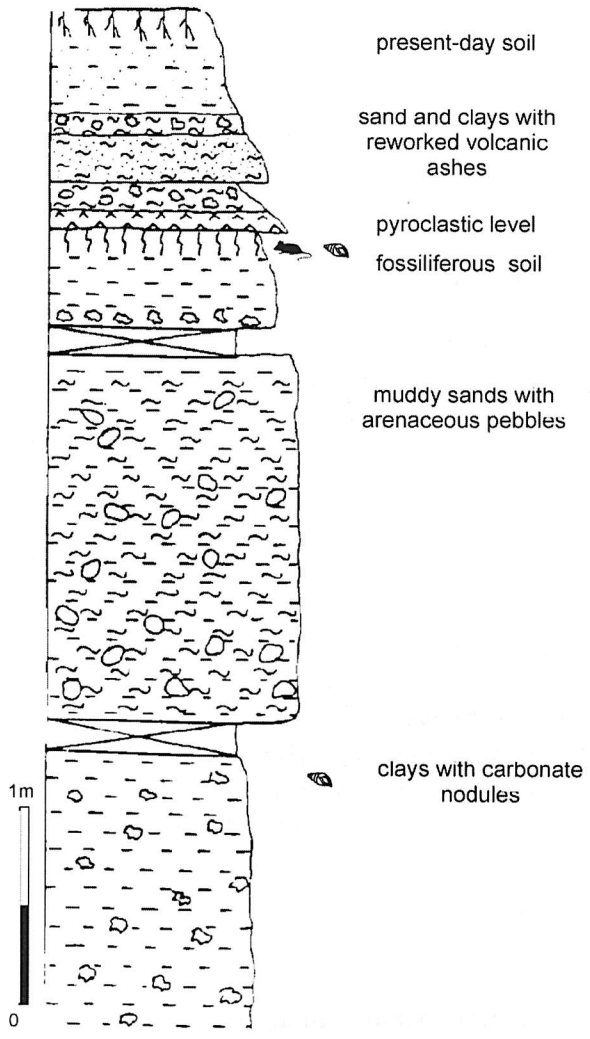

Figure. 3: Schematic sketch of Catignano succession.
Figure. 3 : Section schématique de la succession de Catignano.

Table 2

Ecological Group	Species	N° of individuals	Percentages
1	*Orcula* cf. *O. doliolum*	1	0.1
4	*Jaminia quadridens*	8	0.6
	Jaminia malatestae	103	7.6
	Granaria frumentum	172	12.7
5	*Truncatellina cylindrica*	194	14.3
	Vertigo pygmaea	6	0.4
	Pupilla muscorum	206	15.2
	Vallonia pulchella	608	44.8
7	*Vitrea contracta*	56	4.1
8	*Vertigo angustior*	1	0.1
10	*Gyraulus crista*	1	0.1
	Gyraulus albus	2	0.15
TOTAL		***1358***	**100,1**

Table. 2 : Catignano land snails and freshwater molluscs species grouped by ecological classes; number of individuals and their percentages are indicated. Ecological classes: 1) Forest species; 4) Steppe species; 5) Open land species; 7) Mesophilous species; 8) Hygrophilous species; 10) Freshwater species.
Table 2 : Espèces de mollusques continentaux de Catignano groupés par classes écologiques; le nombre d'individus et leur pourcentage dans l'association sont indiqués. Classes écologiques: 1) Espèces de forêt; 4) Espèces de steppe; 5) Espèces d'espaces ouverts; 7) Espèces mésophiles; 8) Espèces hygrophiles; 10) Espèces d'eau douce.

The youngest finding of *J. malatestae* comes from a Southern Italy level dated about 18-20 ka (Di Vito *et al.*, 1999). A few individuals of freshwater molluscs (*Gyraulus crista* and *G. albus*) were also recovered within Catignano assemblage.

Open ground (ecological group 5) taxa and steppe taxa (ecological group 4) dominate the assemblage, when both species and individuals are considered (tab. 2). Among these two groups, the remains of *Jaminia malatestae, Granaria frumentum, Truncatellina cylindrica, Pupilla muscorum* and *Vallonia pulchella* represent 94.5% of the fauna. Mesophilous species of ecological group 7 are represented only by *Vitrea contracta* (4.1%), while the forest group (ecological group 1) is represented by only the last whorl of one Orculidea (*Orcula* cf. *O. doliolum*).

These data suggest that open ground environment dominated during the soil development. Cool conditions may be hypothesised since many land snail species of this assemblage reach nowadays high latitudes and/or high altitude on mountains. Moreover, many of these species (such as *G. frumentum, P. muscorum, V. pulchella* and *J. malatestae*)

characterise the land mollusc assemblages of the cool and arid phases of Middle to Upper Pleistocene levels of Central and Southern Italy (Esu & Girotti, 1991). On the other hand, the presence of *Vitrea contracta*, which prefers mesophilous environments, and that of *J. quadridens*, a more termophilous element (Zanchetta *et al.*, 1998), attenuate the cold character we attribute to Catignano assemblage.

Catignano small mammals

Seventy-five percent of the remains are arvicolids. The remaining 25% are murids and insectivores for a total amount of about 30 specimens. The small mammal assemblage shows a very low number of species, as well as the molluscs assemblage. Preliminary data seem to show only one species of arvicolids, one of murids and one of insectivores.

The recognised mammals are: *Crocidura* sp., *Terricola* gr. *savii* (fig. 4), *and Apodemus* gr. *sylvaticus-flavicollis* (fig. 4).

Order INSECTIVORA Gray, 1827
Family SORICIDAE Fischer von Waldheim, 1817
Genus *CROCIDURA* Wagler, 1832
CROCIDURA sp.

Only two molars were attributed to the genus *Crocidura*, the shrew widespread in Italy since the late Early Biharian (Gliozzi *et al.*, 1997). Given the limited amount of material, no specific attribution is possible. This insectivore lives in a temperate wooded habitat and is nowadays present in the Mediterranean areas, in Northern Italy, in Sardinia and Sicily.

Order RODENTIA Bowdich, 1821
Family ARVICOLIDAE Gray, 1821
Genus *TERRICOLA* Fatio, 1867
TERRICOLA gr. *SAVII*

Several rootless arvicolid M_1 and M^3 were found. The morphology is not clearly pitymyan, since the pitymyan rhombus is not entirely developed in some specimens. However, a morphometric analysis using the Brunet-Lecomte (1988) method indicates, as in Campani quarry specimens, a pitymyan morphology that is intermediate between *T. multiplex* FATIO, 1905 and *T. savii* DE SÉLYS LONGCHAMPS, 1838 (Brunet-Lecomte, pers. com.). Some characters, such as the inclination of the Pitymyan Rhombus in the Anteroconid Complex of M_1 and the width of the triangles of M^3 seems to be morphologically closer to *savii* group.

Table 3

	Risc 1	Risc 11	Cat 1	Cat 13	Cat 8
L	2.9	2.53	2.75	2.88	
W	0.99	0.98	1.08	1.04	0.98
A	1.48	1.23	1.43	1.55	1.38
B	0	0.03	0.03	0	0.04
C	0.15	0.15	0.1	0.13	0.11
A/L	51.03	48.62	52	53.82	
B/W	0	3.06	2.78	0	4.08
C/W	15.15	15.31	9.26	12.5	11.22

Table. 3 : Principal measurements of M_1 of the arvicolids of Campani quarry and Catignano outcrop.
Table 3 : Mesures principales des M_1 des arvicolides de la Carrière Campani et de Catignano.

Family MURIDAE Illiger, 1815
Genus *APODEMUS* Kaup, 1829
APODEMUS gr. *SYLVATICUS-FLAVICOLLIS*

Very few molars are attributed to the genus *Apodemus*. Also in this case, their morphology and size suggest they belong to the group *sylvaticus-flavicollis*. Both species are widespread in Europe since Early Pleistocene. First upper molars allows *A. sylvaticus* (LINNAEUS, 1758) and *A. flavicollis* (MELCHIOR, 1854) to be distinguished (Pasquier, 1974), but a more precise attribution could not be done, because of the lack of these teeth in the assemblage.

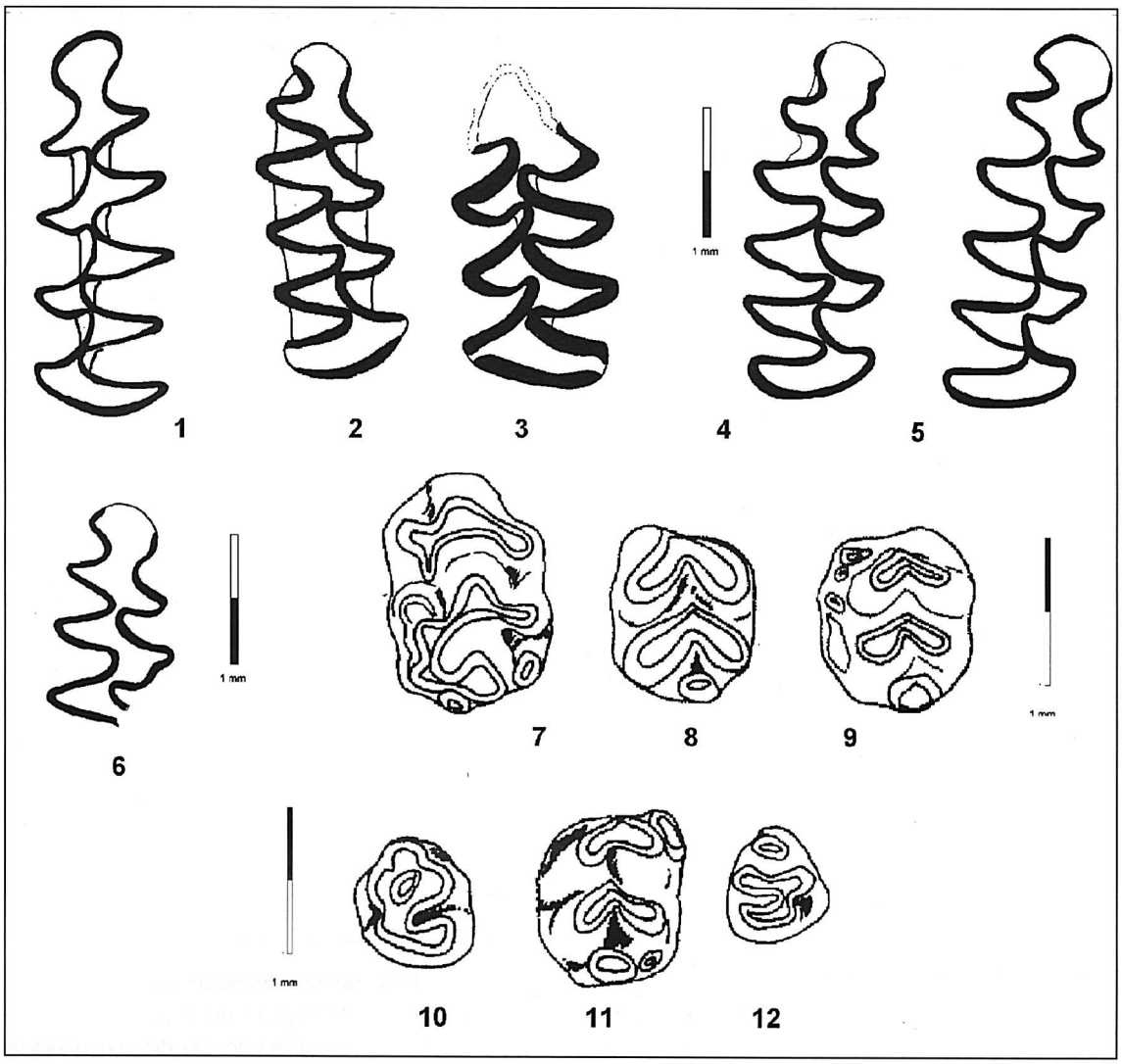

Figure. 4: Campani quarry and Case Picconetto small mammals. Campani quarry: 1-2: *Terricola* gr. *savii* RISC 1 left M_1, RISC 11 right M_1; 3: *Pliomys* sp. RISC 3 left M_1; 7-9: *Apodemus* cf. *A. sylvaticus* RISC 16 right M^1, RISC 10 left M_2, RISC 11 left M_2. Catignano: 4-6: *Terricola* gr *savii* CAT 1 right M_1, CAT 13 right M_1, CAT 8 part of right M_1; 10-12: *Apodemus* gr. *sylvaticus-flavicollis* CAT 16 left M^3, CAT 17 right M_2, CAT 35 right M^3 .

Figure. 4 : Petits mammifères de la Carrière Campani et de Catignano: Carrière Campani. 1-2 : *Terricola* gr. *savii* RISC 1 M_1 gauche, RISC 11 M_1 droite; 3 : *Pliomys* sp. RISC 3 M_1 gauche; 7-9 : *Apodemus* cf. *A. sylvaticus* RISC 16 M^1 droite, RISC 10 M_2 gauche, RISC 11 M_2 gauche. Catignano. 4-6 : *Terricola* gr *savii* CAT 1 M_1 droite, CAT 13 M_1 droite, CAT 8 M_1 droite (pars); 10-12 : *Apodemus* gr. *sylvaticus-flavicollis* CAT 16 M^3 gauche, CAT 17 M_2 droite, CAT 35 M^3 droite.

DISCUSSION

We have identified the *Terricola* as *Terricola.* gr. *savii* even though the morphometric data indicate a relationship with both *multiplex* and *savii* groups. However, the Anteroconid Complex characters are closer to the latter group, thus the specimens from Campani quarry and Catignano are identified as *Terricola.* gr. *savii*.The small mammals of Catignano were found also in Campani quarry level F, where there is a higher number of species. Murids represents 40% of the whole assemblage at Campani quarry. In contrast, at Catignano there is a marked dominance of arvicolids and a very few number of murids.The relative abundance of murids and the presence of glirids (absent at Catignano) at Campani quarry suggests a wood cover, in agreement with molluscs data. In fact, non-marine molluscs of level F indicate a wooded environment in a mild climate.

This mild climatic phase was dated around 0.5 Ma by the age of the volcanic ash. The studied paleosols are thought to have same age as the volcanic-ash layers as they were found underneath them (Bigazzi *et al.*, 2000).

Preliminary data from the oligotypical molluscan assemblage of Catignano suggest prevailing open land and relatively colder conditions than paleosol F of Campani Quarry. Very few considerations can be made on the basis of small mammal data. The scantiness of murid and the dominance of arvicolid remains suggest an open ground environment, with a scarce wood cover. Moreover, the presence of only one species of arvicolids and the oligotypical character of the mammal assemblage, as well as the land snails assemblage, are remarkable.

These data support different environmental conditions were present during the formation of the two paleosols. The differences from both paleosols may arise from two different climatic phase and in this case may indicate different ages for their formation. This difference needs to be confirmed by dating the pyroclastic level from Catignano.

Finally, the different geographic location and altitude of the two levels might also have played an important role. Both sites are quite close to the sea, but Campani quarry is at about 50 m a.s.l., whereas Catignano is at about 300 m. Moreover, Catignano site is enough close to Maiella massif and to Southern Apennine chain to be influenced by them so that the different environment could be the results of the different geographical setting and not due to different climatic phase.

Mollusc and small mammal assemblages appear to be in good agreement both for Catignano, and for the Campani quarry assemblages. Molluscs, being the more abundant and the longer studied in both cases, give a better information than small mammals.

These studies show how the compared study of vertebrate and invertebrate assemblages in paleosols can be used as a powerful tool for paleoenvironmental reconstructions, even if paleosols are typically characterised by a low number of vertebrate fossils and with a bad state of preservation.

As far as the small mammals found in both the outcrops, further investigations are certainly needed in order to increase the number of determined species.

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REFERENCES

ARGENTI, P. 1998. La biocronologia dei Roditori del Plio-Pleistocene dell'Umbria e l'evoluzione del genere *Apodemus* in Italia. *Tesi, Università di Perugia*, 280 pp.

ARIAS, C.; AZZAROLI, A.; BIGAZZI, G. & BONADONNA, F.P. 1980. Magnetostratigraphy and Plio-Pleistocene boundary in Italy. *Quaternary Research*, **13**: 65-74.

BERTI, D.; BIGI, S.; CENTAMORE, E.; DRAMIS, F.; FARABOLLINI, P. & MAZZEI, A. 1992. Segnalazione di livelli vulcanoclastici nel pescarese. *Studi Geologici Camerti, Vol. Spec. 1991/2*: 307-311.

BIGAZZI, G.; BONADONNA, F.P.; CIONI, R.; LEONE, G.; SBRANA, A. & ZANCHETTA, G. 1994. Nuovi dati geochimici, petrografici e geocronologici su alcune cineriti plio-pleistoceniche del Lazio e della Toscana. *Memorie Descrittive Carta Geologica d'Italia,* **49**: 135-150.

_____; ZANCHETTA, G.; BONADONNA, F.P. & LEONE, G. 2000. Ulteriori dati cronologici sui depositi cineritici del Valdarno inferiore (Toscana). *Bollettino della Società Geologica Italiana,* **119**: 121-124.

BOWN, T.M. & KRAUS, M.J. 1981. Vertebrate fossil-bearing paleo-sols units (Willwood Formation, Lower Eocene, NW Wyoming, USA): implications for taphonomy, biostratigraphy and assemblage analysis. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **34**: 31-56.

BRUNET-LECOMTE, P. 1988. Les campagnols souterraines (*Terricola*, Arvicolidae, Rodentia) actuels et fossiles d'Europe Occidentale. *Thèse de Doctorat, Université de Bourgogne*, 143 pp.

CENTAMORE, E.; BIGI, S.; BERTI, D.; MICARELLI, A. & MORELLI, C. 1992. Nuovi dati sui depositi Neogenici di avanfossa del pescarese. *Bollettino della Società Geologica Italiana*, **11**: 437-447.

DELITALA, M.C.; FORNASERI, M. & NICOLETTI, M. 1983. Datazioni Argon-Potassio sulla serie pleistocenica di Isernia La Pineta; pp. 65-66. *In* CALDERINI (ed.), *Isernia la Pineta un accampamento più antico di 700.000 anni*, Bologna.

DI VITO, M.; SULPIZIO, R. & ZANCHETTA, G. 1999. I depositi ghiaiosi della valle dei torrenti Clanio e Acqualonga (Campania centro-orientale) significato stratigrafico e ricostruzione paleoambientale. *Il Quaternario,* **11**: 273-286.

ESU, D. 1978. La malacofauna continentale plio-pleistocenica della Formazione fluvio-lacustre di Nuraghe Su Casteddu (Sardegna Orientale) e sue implicazioni paleogeografiche. *Geologica*

Romana, **17**: 1-33.

_____ 1981. Significato paleoecologico e paleoclimatico di una malacofauna continentale pleistocenica dell'Italia centr-meridionale (Isernia, Molise). *Bollettino della Società Paleontologica Italiana,* **100**: 93-98.

_____ 1988. *Jaminia (Jaminia) malatestae* n. sp. from the Italian Pleistocene. *Archiv für Molluskenkunde der Senckenbergischen Naturforschenden Gesellschaft,* **119**: 227-233.

_____ & GIROTTI, O. 1991. Late Pliocene and Pleistocene assemblages of continental molluscs in Italy. A survey. *Il Quaternario,* **4**: 137-150.

GLIOZZI, E.; ABBAZZI, L.; AMBROSETTI, P.; ARGENTI, P.; AZZAROLI, A.; CALOI, L.; CAPASSO BARBATO, L.; DI STEFANO, G.; FICCARELLI, G.; KOTSAKIS, T.; MASINI, F.; MAZZA, P.; MEZZABOTTA, C.; PALOMBO, M.R.; PETRONIO, C.; ROOK, L.; SALA, B.; SARDELLA, R.; ZANALDA, E. & TORRE, D. 1997. Biochronology of selected mammals, molluscs and ostracods from the Middle Pliocene to the Late Pleistocene in Italy. *Rivista Italana di Paleontologia e Stratigrafia*, **103** (3): 369-388.

HEINRICH, W. D. 1978. Zur biometrischen Erfassung eines Evolutionstrends bei *Arvicola* (Rodentia, Mammalia) aus dem Pleistozän Thüringes. *Säugertierkund Information*, **2**: 3-21.

LOZEK, V. 1964. Quartärmollusken der Tschchoslowakei.*Rozpravyi Ústradniho Ústavu Geologického*, 31, pp.374.

MAUL, L. ; MASINI, F. ; ABBAZZI, L. & TURNER, A. 1998. The use of different morphometric data for absolute age calibration of some South and Middle European arvicolid population. *Palaeontographia Italica*, 85: 111-151.

PASQUIER, L. 1974. Dynamique évolutive d'un sous-genre de Muridae, Apodemus (Sylvaemus). Étude biométrique des caractères dentaires de populations fossiles et actuelles d'Europe occidentale. *Thèse de Doctorat, Académie de Montpellier,* 184 pp.

PUISSÉGUR, J.J. 1976. Mollusques continentaux quaternaires de Bourgogne. *Thèse Mém. Géol. Univ. Dijon,* 3, pp.241.

TANI, F. & GAZZERRO, M. 1999. Nuove osservazioni sui depositi plio-pleistocenici nel bacino del Torrente Cascina. *Bollettino della Società Geologica Italiana*, **118**: 237-241.

VAN KOLFSCHOTEN, T. 1990. The evolution of the mammal fauna in the Netherlands and the middle Rhine Area (Western Germany) during the late Middle Pleistocene. *Mededelingen Rijks Geologisch Dienst*, 43: 1-69.

ZANCHETTA, G.; BONADONNA, F.P.; ESU, D.; GRASSI, R.; LEONE, G. & MAZZA, P. 1998. Stratigraphic and palaeontologic aspects of Middle Pleistocene continental deposits from Lower Valdarno (Tuscany). *Bollettino della Società Geologica Italiana*, **117**: 113-132.