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THE CASTAGNONE SITE (CERRINA VALLEY, MONFERRATO HILLS, NW ITALY): EARLY PLEISTOCENE SEDIMENTARY RECORD AND BIOCHRONOLOGY

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Abstract. Geological researches carried out near the Castagnone hamlet in the Cerrina Valley (Northern Monferrato Hills, Piedmont, NW Italy), have brought to light a post-Messinian succession whose sedimentary record starts with a Lower Complex of pedogenized colluvial materials and with two superimposed Alluvial Units (I and II). The lower one of these units contains a Galerian macrofauna associated with microtine vole teeth (*Mimomys savini*, *Mimomys pusillus*, *Ungaromys* cf. *U. nanus*, *Microtus* (*Allophaiomys*) sp.), while the upper one yields only scarce faunal remains. Most of this sediments were deposited during a normal palaeomagnetic phase. The I Alluvial Unit, due to its biochronological correlation, must be referred to the Jaramillo Subchron, between 1,070,000 and 990,000 years ago. The II Alluvial Unit, being both unconformable with and younger than the first one, might be best referable to the Brunhes Chron. Overall, the bed dipping across the reported succession shows a progressive syn-sedimentary tilting, with accelerated deformation during the I Alluvial Unit deposition. This tectonic stress over the Castagnone area is seemingly related to the uplift of the north-easternmost ridge of the Monferrato Hills and appears to have been nearly exhausted before the II Alluvial Unit deposition.

Riassunto. Le ricerche geologiche condotte nei pressi dell'abitato di Castagnone di Pontestura, in Val Cerrina (Monferrato Settentrionale, Piemonte), hanno evidenziato una successione sedimentaria post-messiniana che inizia con un Complesso Inferiore costituito da colluvi pedogenizzati e da due unità sovrapposte formate da sedimenti alluvionali. L'Unità Alluvionale inferiore (I A.U.) contiene una macrofauna Galeriana associata con denti di micromammiferi (*Mimomys savini*, *Mimomys pusillus*, *Ungaromys* cf. *U. nanus*, *Microtus* (*Allophaiomys*) sp.), mentre la superiore (II A.U.) contiene solo scarsi resti faunistici. Tutta la serie sedimentaria risulta deposta in periodi a polarità magnetica normale. Per il suo contenuto in fossili la I A.U. deve essere attribuita al Subchron Jaramillo, datato tra 1.070.000-990.000 anni fa.

La II A.U. è più recente e discordante sulla I A.U. e sembra attribuibile al Chron Brunhes. L'inclinazione decrescente degli strati che formano la successione sedimentaria indica una deformazione sinsedimentaria progressiva, particolarmente evidente all'interno della I A.U. Lo stress tettonico dell'area di Castagnone sembra in relazione con il sollevamento del margine nord-orientale del Monferrato ed appare quasi completamete esaurito prima della sedimentazione della II A.U.

Introduction

The early Pleistocene sediments located in the Cerrina Valley (Northern Monferrato Hills, Piedmont, NW Italy) preserve both lithological and fossil record which document palaeoenvironmental variations, tectonic evolution and biochronology.

The Cerrina Valley is in a hilly area, mainly formed by Cenozoic marine sediments, with elevations of up to 455 m a.s.l. The Monferrato and the related Turin Hills form a central relief isolated from the main western Alpine ridge and are surrounded by the alluvial plains of two major rivers: the Po (N) and the Tanaro (S).

The reported Pleistocene succession locally and in patches outcrops on the left slope at the end of the Cerrina Valley (Fig. 1). Major exposures are preserved near Castagnone (Pontestura, Alessandria): on the local hillslope the sediments are covered by a thin aeolian layer, while in the valley bottom the lower succession merges under the recent alluvium.

In the late'70s fossiliferous gravelly-sandy alluvial sediments were first located by one of us (C.G.) during preliminary studies in a now disused quarry (Peratore quarry: C1 in the text and Fig. 1). There, some macrofaunal remains suggested as possible an early middle Pleistocene age (Giraudi 1981), though the severe sediment deformation and the lack of arvicolid finds biased the biochronologic interpretation. From the Peratore quarry other fossil remains were collected in ensuing years in a

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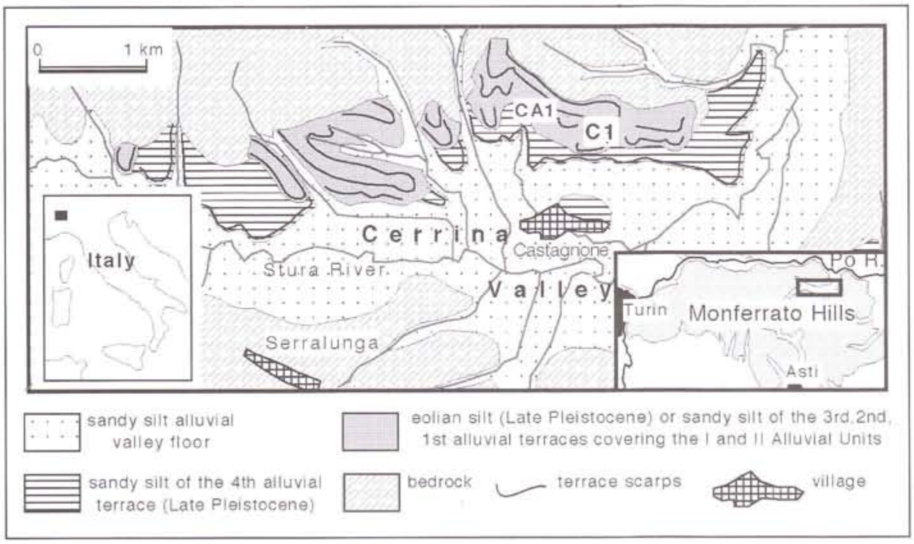

Fig. 1 - Geological sketch map of the lower Cerrina Valley. 1: sandy silt of the alluvial valley floor (Holocene); 2: sandy silt of the 4th alluvial terrace (late Pleistocene); 3: aeolian silt (late Pleistocene) or, locally, sandy silt of the 3rd, 2nd and 1st alluvial terraces (middle Pleistocene?), which cover the I and II Alluvial Units; 4: bedrock; 5: terrace scarps.

still doubtful stratigraphic context (Giraudi 1983; SITEC 1984). More recently, archaeological finds referable to different levels of the same succession (not examined in this report) led to new extensive and detailed researches.

Recent studies in a survey of the whole area have made it possible to localize new outcrops of the Castagnone sedimentary succession. In particular, in a newly opened quarry (Cascina Nuova: CA1), a network of trenches, with an overall extent of about 300 m^2 and a depth of up to 5 m, were cut for better control of the stratigraphy, along with archaeological, palaeontological and magnetostratigraphic sampling. The following preliminary updating results allow the overall geological framework to be better known.

Due to the small number of European locations with late early Pleistocene faunas, the reported Castagnone succession improves the resolution of the European biochronological scale.

The Castagnone/Pontestura sequence as exposed in the sections of the CA1 quarry

The CA1 quarry (Fig. 1) is in the upper part of the Castagnone hillslope, near the top (193 m) of the local relief. The bottom bed of the sedimentary succession lies with a slight unconformity over a bedrock of laminated clayey grey/yellow sediments with hardened (chalky or silicized) interbedded levels. Such sediments are evidence of a brackish water facies with malacofauna (Girotti O., Esu D., pers. comm. 2000) and were referred to a late Miocene «Messinian» formation (C.G.I. 1969).

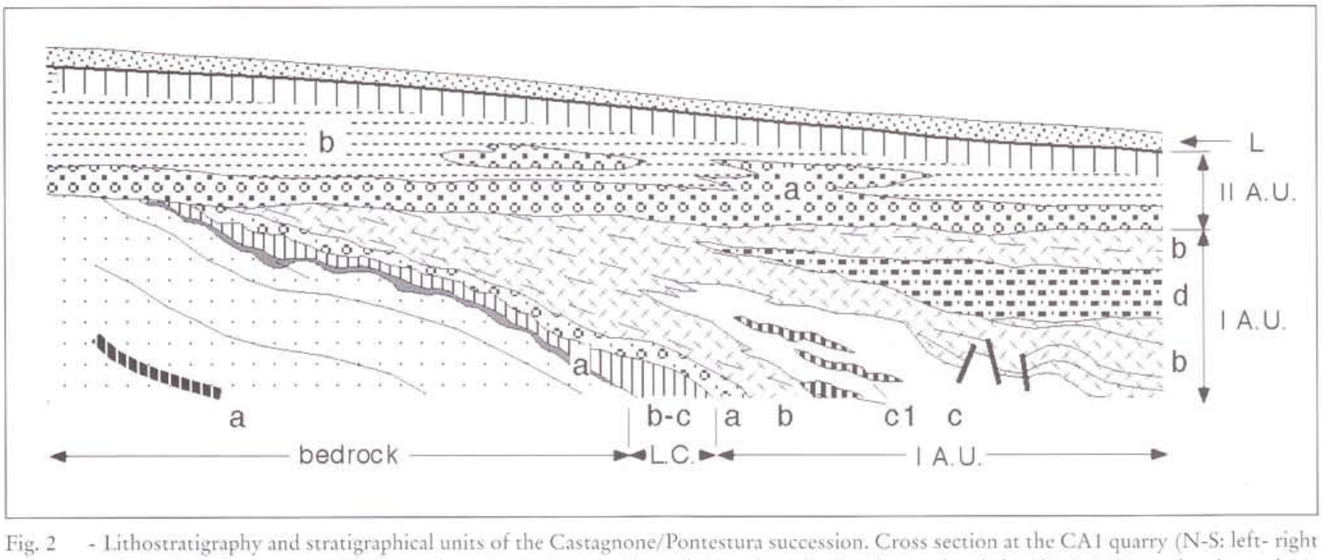

Fig. 2 - Lithostratigraphy and stratigraphical units of the Castagnone/Pontestura succession. Cross section at the CA1 quarry (N-S: left- right oriented). L: loess cover; II A.U.: pedogenized silty gravelly sand (a) and sandy silt, silty sand and clay (b); I A.U.: sand and gravel (a); silt and sandy silt with carbonatic concretions (b); sand (c) with thin and discontinuous calcrete layers (c1); gravelly sand and dark clay (d); L. C.: consolidated silt and clay (a); sand, gravel and silty clay with a discontinuous calcrete layer (b-c); bedrock: laminated clay with (a) hardened levels (Messinian).

The overlying succession starts, from the bottom upwards, with the «Lower Complex» unit, two alluvial units, and ends with a layer of loess, as below (Fig. 2).

The Lower Complex *(LC)*. It is formed by:

a) clayey, massive, light to dark-grey, consolidated and cracked silt of colluvial origin, up to 40 cm thick;
b) grey sand, gravel and silty clay of colluvial origin, with patchy rust oxidation, up to 20-30 cm thick;
c) at the top lies a pedogenic, more or less continuous calcrete, up to 10-15 cm thick.

The first Alluvial Unit *(I AU)*. This unit, about 10 m thick, lies in slight unconformity over the Lower Complex, and is formed by:

a) grey-yellowish sand and gravel containing both macro- and micromammal remains;
b) massive or poorly stratified grey-yellowish silt and sandy silt, with embedded carbonatic concretions, sized 1 to 15-20 cm, and some faunal remains;
c) yellowish and grey unconsolidated sand, with thin and discontinuous calcretes and leaf marks; this sand is interbedded in the middle part of the silt and sandy silt layer;
d) a heteropic facies of gravelly sand and dark clay overlies the above sandy silty sediments: the coarser fractions which increase at the top of the unit are fairly rich in fossil macro- and microfauna (the reported *Elephas* sp. remains from C1 were also in a correlated level: Giraudi 1983).

The largest raw clasts which occur in the I AU are constituted mainly by silicized wood or cherts. Actually, while other fluvial clasts (quartzites, jaspers and other alpine rocks) seldom exceed 6-7 cm in diameter, the silicized wood can attain here 50-60 cm in length and weigh more than 10 kg; likewise, the largest cherty cobbles may be up to 20-25 cm in diameter.

In the same unit, bony and cartilagineous marine fish teeth, echinoderm radiola and silicized inner casts of marine gastropods have been found, due to an intensive redeposition from the surrounding bedrock.

The second Alluvial Unit (II AU). This entire unit is weathered by a soil. It is 4-5 m thick, with definite unconformity with the former unit. It is formed by:

a) basal silty-gravelly sand with diffused yellowish clay chips: these sediments are weathered and contain badly preserved macrofaunal remains;
b) sandy silt and silt with interbedded scanty lenses of silty sand and clay. During the Palaeomagnetic studies a marked increase in the total amount of magnetic minerals with respect to the I A.U. has been observed.

The loess cover. In the uppermost slope of the hills, the topsoil which caps the above alluvial levels is buried in its turn by a loessic bed, everywhere thinner than 70-80 cm. Discontinuous concentrations of fresh, unpatinated Mousterian artifacts were embedded in this layer. Down the slope, the loessic covering and the underlying alluvial units occur in different relationships. As the latter were cut by the subsequent drainage evolution and before the former occurred, the aeolian deposition took place on terraced slopes (mostly erosional morphologies in the CA1 relief). Hence there, the loess is directly in contact with the lower I AU or with the Tertiary bedrock, while the upper II AU is altogether lacking.

The dip of the above different units progressively decreases from the bottom upwards: the undulate «Messinian» sediments of the bedrock have an areal inclination of about 14°-12°, from the base to the top; the Lower Complex, formed by colluvia and the calcareous crust, dips 12° to S (down the local slope); the I AU dip decreases from 10° at the bottom to 4° at the top; finally the II AU is nearly horizontal. Two major erosional breaks in the Pleistocene sequence (i. e. those between the Lower Complex and I AU, and between I and II AU) correspond actually to unconformable limits where the aggradation/tilting trend was also uncombined.

As seen so far, the units of the above succession are differently preserved along the hillslopes, both vertically and laterally: this fact is due to the mutual overlap and respective thickness and dip. Thus, in addition to its greater depth, the I AU is also more extensively preserved than the upper II AU: the latter, as it is nearly horizontal, is preserved only between the slope elevations of 193 m (the top) and 185 m.

Discussion and interpretation

The Lower Complex was characterized by a soil strongly affected by the calcrete and carbonatic concretions. These pedogenic features have so far been recorded in the Piedmont region only in the «Villafranchian» type succession (Boano & Forno 1996). They are related usually to high evaporation rates mostly controlled by the temperature (Birkeland 1984) and so indicate an fairly warm but chiefly dry climate.

The thin and discontinuous calcretes interbedded in the I AU dip S like the sand containing them, and therefore must be nearly coeval: otherwise in a place affected by tilting their dipping would be different. The presence of calcareous concretions and calcretes in the lower and middle part of the I AU, not affected by evident pedogenetic weathering, must be due to the rapid evaporation above the water table.

Towards the top of the I AU, a coarser deposition reappears with the energy renewal while the carbonatic precipitation decreases and stops: therefore a climatic change occurred during the sedimentation of this unit.

Regarding the presence of silicized wood and raw clasts of cherts larger than other alluvial clasts in the I AU, it should be noted also that today, in the whole Cerrina Valley basin as well as in the Monferrato Hills, no other known formation contains so many cherts (both as to va-

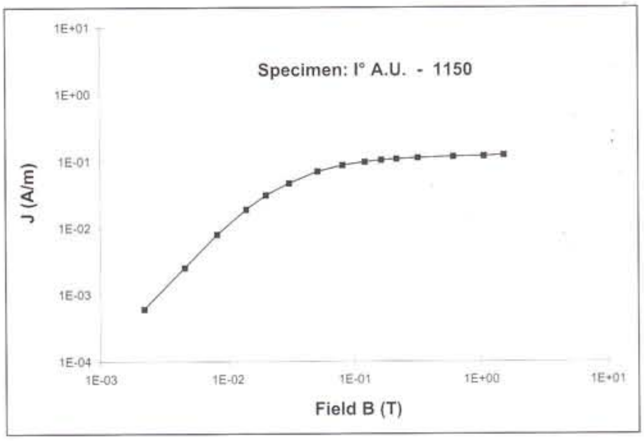

Fig. 3 - Acquisition curve of the isothermal remnant magnetization (IRM).

riety and overall amount) as this unit. Therefore, during the I AU deposition, fluvial erosion exposed some (Cenozoic?) cherty formation which is now entirely eroded or covered by more recent sediments. A comparable redeposition of cherts was not active in the older Plio/Pleistocene regional bedloads: e.g., in the «Villafranchian» ones such pebbles (far smaller in size) rarely occur. Thus, during the I AU deposition a sudden important supply of silex began in the regional clastic background. Silicized woods are frequent in the Cenozoic bedrock below the Castagnone sequence: their presence in the I AU is probably derived from the fluvial incision near this area, as inferable from the size range and minor reworking of such clasts. Also the bony and cartilagineous marine fish teeth, echinoderm radiola and silicized inner casts of marine gastropods were reworked from the bedrock.

About the II AU, in respect to the I AU, a lithological change may be observed mainly in the contents of large silicized wood, cherts and clastic load mineralogy; the content of reworked Tertiary fossils is smaller. These variations suggest possible drainage shifting and/or climate changes compared with the I AU deposition. The absence of calcareous concretions and calcrete levels shows a different climate from that of the I AU.

Magnetostratigraphy at CA1

The magnetostratigraphic study of the sections which were opened at CA1 allowed the palaeomagnetic trend across the entire outcropping succession to be recorded. The weakly consolidated sediments exposed in the cuts were previously cleaned from more superficial fractions in order to obtain optimized surfaces. The specimens were collected in commercial plastic boxes (inner volume = 2x2x2 cm) gently pushed into the soft rock keeping the front face vertical, at 25 cm intervals (from the Messinian sediments up to the top) leaving out a few levels with too much incoherent sandy lithologies; all the specimens were oriented with bubble level and compass. The sampled section was about 16 m high and 67 specimens were taken in all.

The magnetic mineralogy was investigated by isothermal remnant magnetization (IRM) using a Bussi pulse magnet. The resulting IRM acquisition graphs were characterized by a quick increase up to full saturation for magnetic field values of 0.2-0.4 T (Fig. 3). The remnant coercive force (Hrc) maintains values in the range of 40-50 mT. These results suggest that the magnetite is the main ferromagnetic mineral in the tested lithologies; nevertheless, since thermal tests were not possible because of the low coherence of the rock, the presence of iron sulphides cannot be excluded.

The natural remnant magnetization (NRM) was measured with a JR-5 spinner. Intensity stays around the value of 10^{-4} A/m, with the exception of the specimens collected over 13.40 m (from the I AU top upwards) whose intensity ranged between 10^{-2} and 10^{-3} A/m. All the directions, across the entire sampled succession, have a variable declination, ranging between N and E, and a positive inclination.

Stepwise alternating field (Af) demagnetization on pilot specimens, up to 100 mT peak-field, showed the presence of a viscous component which is removed after the first steps; successively the direction remains stable up to the field values of 30-50 mT (Fig. 4). Sometimes the situation was more complicated: the presence of different components whose coercive spectra overlap made impossible to recognize the primary component.

The systematic demagnetization of all the collected specimens made possible to detect the characteristic remnant magnetization (ChRM) direction in 50% of the cases. Fisher's statistics were used to calculate the mean ChRM directions for each of the sedimentary units in the CA1 succession; the results are reported in Tab. I and Fig. 5. The precision k-parameter and the half-angle confidence cone show a good grouping for the data.

The mean directions were then corrected for the respective inclination of the strata: 14°-12° for the Messinian sediments; 12° for the Lower Complex; 10° and 4° for the base and top, respectively, of the I AU; no correction was made for the II AU which has maintained sub-horizontal strata.

The inclination correction reduced the differences among all the recorded palaeomagnetic directions and so, in particular, the last three units probably assumed such corrected directions during the primary sediment deposition. All the corrected directions for the entire succession at CA1 correspond to a normal polarity time interval since they show an N-oriented declination and inclination of 57°, well compatible with the local co-ordinates (Tab. I).

The magnetic intensity values were correlated with those of the magnetic susceptibility for all the sampled

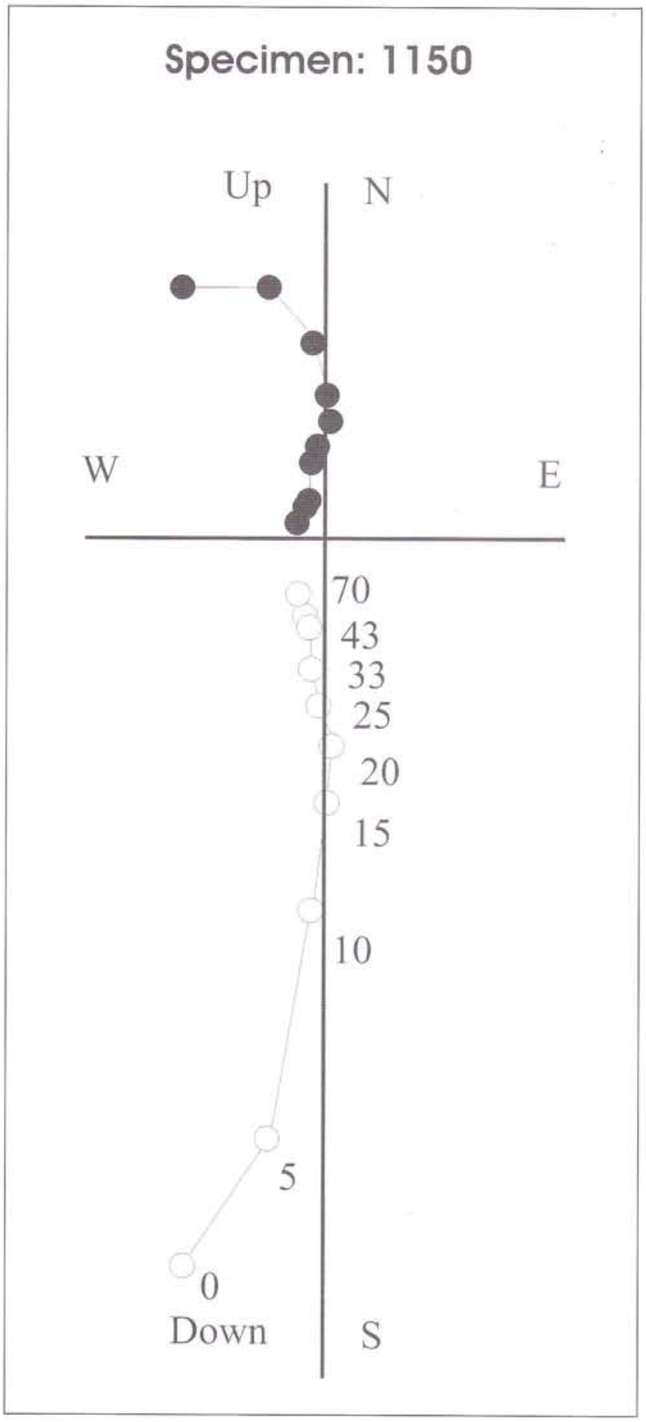

Fig. 4 - AF demagnetization diagram (specimen from LC + I AU). Symbols: full dots = declination; open dots = apparent inclination; figures = peak field value in mT.

specimens (Fig. 6). This graph shows a good correlation among all of them and evidences the narrow grouping of data for the Messinian sediments. One can observe also that the II AU shows a marked increase in the total amount of magnetic minerals, probably because of the more intensive clastic load discharges in this unit. This fact might be correlated with a more appreciable climate variation and/or with greater drainage changes since the final I AU deposition.

The palaeontological record and the biochronology at CA1

The vertebrate fauna remains from the Castagnone/Pontestura succession exclusively come from the two alluvial units and are best preserved in the lower one, according to the top soil weathering gradient. Indeed, the II AU is almost poor in such findings because of the pedogenic demineralization. On the contrary, the I AU is by far the richest in well mineralized fossils, although often fragmented and rolled by the stream.

The diagnostic macrofauna from the CA1 excavations is in fact mostly represented by isolated teeth, as more or less sorted within the sediments of the I AU (Fig. 7). Diagnostic (at the genus level) non-dentary remains are only a distal fragment of the perone of a *Hippopotamus* sp. and a basioccipital skull with the horns of a *Bison* sp., coming from the base and top, respectively, of the I AU.

A whole macromammal association, as has now been recognized in the lower unit, is represented by *Hippopotamus* sp., *Sus* sp., *Pseudodama* sp., *Stephanorhinus* cf. S. *hundsheimensis* (Toula, 1902), *Bison* sp. and other Proboscidae, Bovini and Cervidae indet. In the Peratore quarry (C1), the previously reported finds (Giraudi 1981) and other unpublished ones (Ambrosetti pers. comm.) were from basal levels of the same I AU: also *Dicerhorinus hemitoechus* (recte: *Stephanorhinus hundsheimensis*), *Megaceros* cf. *verticornis* (recte: *Megaceroides* cf. *verticornis*) (Dawkins, 1872) and *Ursus deningeri* Reichenau, 1906.

All these old and new findings from the I AU may indicate a generic Galerian (macro)Mammal age (sensu Gliozzi et al. 1997).

An arvicolid microfauna has been sampled at CA1 from two gravelly sandy levels of the I AU, at the base and the top respectively (Fig. 8). At the base of the unit *Mimomys savini* Hinton, 1910, *Mimomys pusillus* (Mehely, 1914), *Microtus* (*Allophaiomys*) sp. advanced form, and *Ungaromys* cf. *U. nanus* are recorded. Together with these, other rodents and Insectivora occur: *Sciurus* sp., *Apodemus* sp. and *Talpa* cf. *T. fossilis* Pétenyi,1864. Due to the presence of *Mimomys pusillus* this microfauna is referable to the early Biharian (Rodent age), as defined by Fejfar & Horacek (1990). Since *M. pusillus* is accompanied also by an advanced form of *Microtus* (*Allophaiomys*), the possible range must be constrained to a late or final time of the early Biharian. Besides *M.* (*Allophaiomys*), the *Ungaromys* genus is a further biochronological marker in Western Europe. Either or both of these taxa occur tardily in the Collecurti fauna (Torre et al. 1996) and the Vallonnet fauna (Chaline 1988). By their own palaeomagnetic data both localities are calibrated in the Jaramillo Subchron as well as, in spite of some biogeographic differences, the northern locality of Untermassfeld (Kahlke 1997).

	Jr (A/m)		NRM				ChRM				
			D,I	n	k	α_{95}	D,I	Dt,It	n	k	α_{95}
II° AU	1.19	10^{-2}	348°,49°	12	48	6°	357°,57°	357°,57°	8	170	4°
LC+I° AU	3.15	10^{-3}	339°,76°	26	5	14°	6°,57°	360°,57°	11	27	9°
Messinian bedrock	2.69	10^{-4}	10°,59°	29	10	9°	11°,59°	353°,57°	14	59	5°

Tab. I - Paleomagnetic results from sediments of CA1 succession. Jr = NRM intensity. NRM = natural remnant magnetization. ChRM = characteristic remnant magnetization after Af treatment. D, I = declination, inclination. Dt, It = declination, inclination after tilt correction. n = number of specimens. k = Fisher's precision parameter. 95° = semi-angle of confidence.

The microfauna at the top of the I AU is less represented because of the soil effects: apart from *Oryctolagus* cf. *lacosti* (Pomel, 1853), *Mimomys savini* and a single M^3 of *Microtus* sp. have been recorded. This latter (Fig. 8, n. 6) shows poorly differentiated enamel and closely corresponds to homologous teeth of *Microtus* (*Allophaiomys*) from the same I AU base (Fig. 8, n. 7) and from Monte Peglia (Meulen van der 1973). This material by itself cannot permit a sufficient biochronologic assessment. Nevertheless, along with a persistence of normal magnetic polarity up to the top of the unit, the cf. *M.* (*Allophaiomys*) occurrence (but taking it with prudence) keeps here the correlation within the Jaramillo Subchron as well as, seemingly, the whole lithostratigraphic evidence (Fig. 9).

Due to its normal magnetic polarity, at least the base of I AU must fall necessarily inside the minor reversal of the Jaramillo Subchron (in the Matuyama inverse age) and not in the Brunhes Chron, since the arvicolid evolution level there precludes it. Likewise, the association of *M. savini*, *Mimomys* small size form, *Microtus* (*Allophaiomys*) advanced form, and *Ungaromys* cf. *U. nanus* is very similar to that from Monte Peglia (Meulen van der 1973), a site which has been recently located not long before the Jaramillo Subchron (Masini et al. 1998).

At CA1 the arvicolid elements collected from the II AU are limited to some incisor teeth that do not support any determination. The macrofauna there is represented only by fragmentary teeth of *Stephanorhinus* sp. and of herbivorous indet. This upper unit, because of the top soil, lacks exhaustive biochronologic markers and remains at moment unresolved in its own correlation with the possible palaeomagnetic options: the Jaramillo Subchron or alternatively the Brunhes Chron.

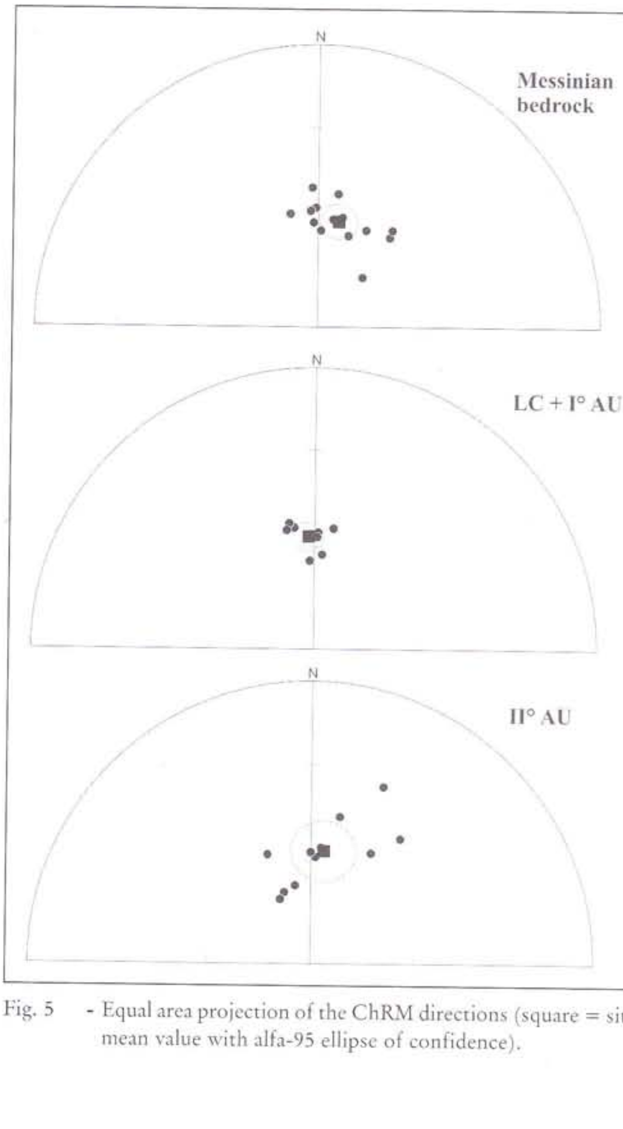

Fig. 5 - Equal area projection of the ChRM directions (square = site mean value with alfa-95 ellipse of confidence).

The evolution of the setting and environmental inferences

The above lithostratigraphic, palaeomagnetic and biochronologic data allow us to assume that at least the whole I AU was deposited during the Jaramillo Subchron (1.07 - 0.99 m.y., according to the «orbitally tuned time» scale of Cande & Kent (1995)).

The Lower Complex was deposited beneath the I AU under normal p.m. polarity but, due to the slightly unconformable contact between these units, one cannot exclude that the former deposition occurred well before the Jaramillo Subchron.

The chronology of the II AU is by far more problematic. Though this unit has a normal p.m. polarity, its unconformable contact over the I AU might be in favour of a somewhat younger age: if not in the same Jaramillo Subchron then necessarily within the Brunhes Chron. The age of this upper unit hence is possibly lower than 0.78 Ma.

In spite of the above gaps in the data, a preliminary reconstruction of the geologic evolution in the area is suggested as below.

After the major erosional phase supported by the top of the «Messinian» sediments (not yet deformed)

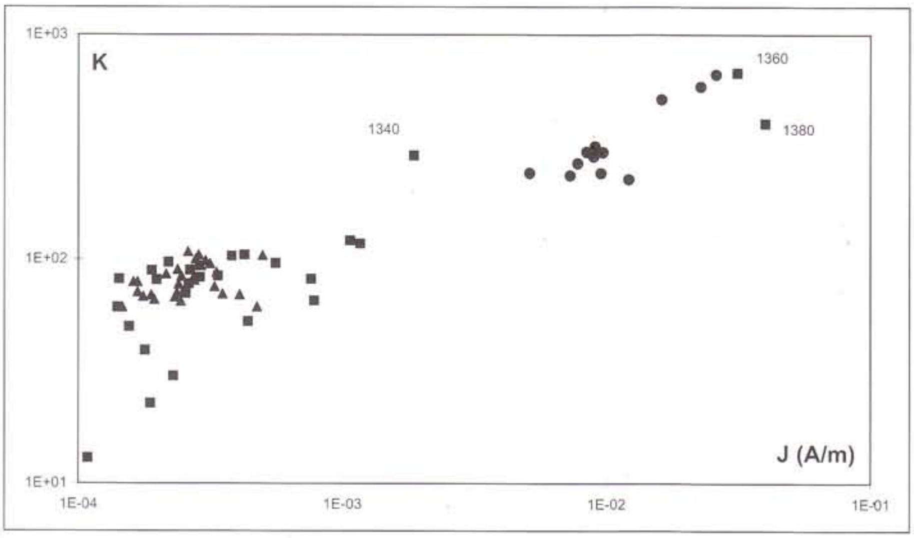

Fig. 6 - Relation between magnetic intensity (J) and magnetic susceptibility (K).
● = II° A.U.
▲ = Messinian bedrock
■ = I° A.U. + L.C.
Numbers refers to the position of the specimen in the succession.

and during a subsequent time span under stable conditions, more probably before the Jaramillo Subchron, a slow colluvial accretion with soil co-evolution occurred. This soil was characterized by the calcrete and carbonatic concretions which heavily affect the Lower Complex. Such pedogenic features have so far been recorded in the Piedmont region only in the «Villafranchian» type succession (Boano & Forno 1996).

After a further small erosional phase, the I AU sedimentation took place along a water channel with high energy. In the middle part of the I AU the energy decreased and a meandering pattern prevailed, with lateral migrations. Due to the fast evaporation, along with the sand and silt aggradation, thick calcretes and concretions formed above the water table.

Towards the top of the I AU, a coarser deposition reappeared with energy renewal while the carbonatic precipitation decreased and then stopped. The floodplain which developed during the Jaramillo Subchron was at the same time tectonically deformed, even though the progressive tilting rate remained compatible with the continued aggradation. This major landscape variation is hard to specify here at local detail but, on the whole, it is certainly linked with the uplift of the North-easternmost Monferrato ridge.

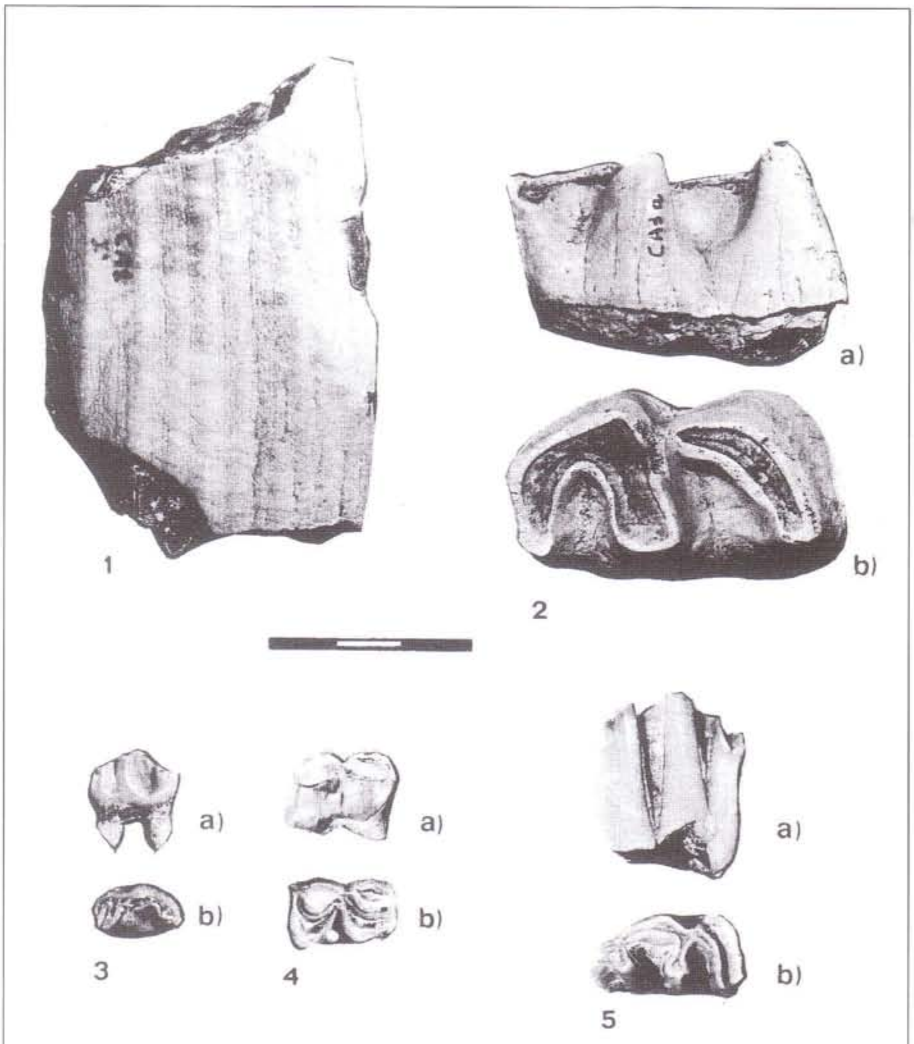

Fig. 7 - Dental remains of large Mammals from the I AU levels. 1: C_1 fragment of *Hippopotamus* sp.; 2: right M_3 of *Stephanorhinus* cf. *hundsheimensis*, a) lingual view, b) occlusal view; 3: left P_3 of *Pseudodama* sp., a) lingual view, b) occlusal view; 4: right M_1 of *Pseudodama* sp., a) buccal view, b) occlusal view; 5: right P_4 of *Bison* sp., a) lingual view, b) occlusal view. Scale bar: 3 cm.

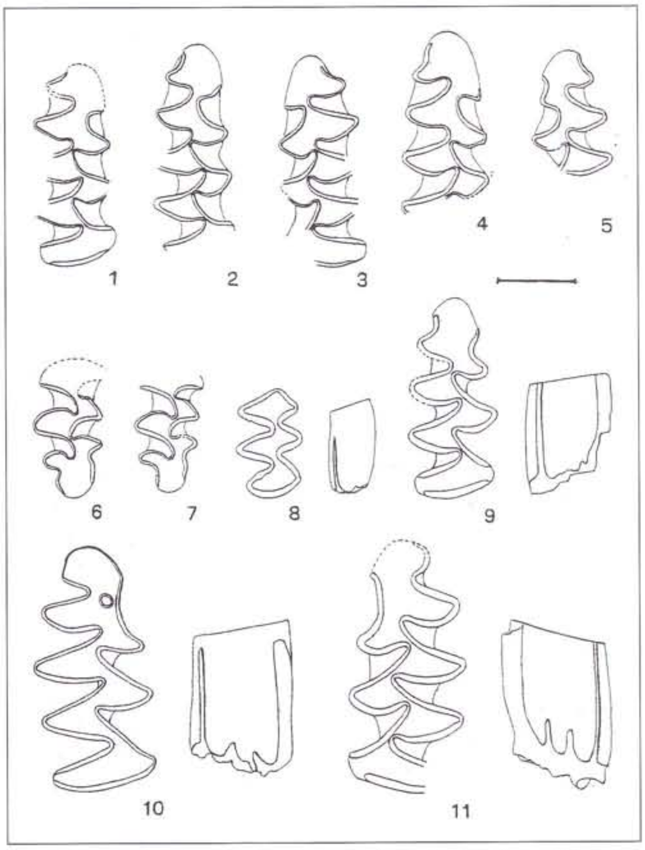

Fig. 8 - Arvicolid molar teeth from the I AU levels at CA1. 1-5: M/1, *Microtus (Allophaiomys)* sp.; 6: M3/, *Microtus* (?*Allophaiomys*); 7: M3/, *Microtus (Allophaiomys)* sp.; 8: M/2, *Ungaromys* cf. *U. nanus*; 9: M/1, *Mimomys pusillus*; 10: M/1, *Mimomys savini* (young); 11: M/1, *Mimomys savini* (adult). Scale bar: 1 mm

After a second erosional hiatus, the aggradation of the II AU is more recent than the offset of the major tectonic deformation event. Therefore the hiatus itself contains the end of the deformation. The following desiccation of the II AU floodplain was possibly due to climatic changes or to a final but altogether different tectonic renewal. A similar Pleistocene incision of the land surface is recorded from adjacent areas of central Piedmont (Carraro & Valpreda 1991) in the late middle Pleistocene. At this moment, such an age might reasonably be the case also of the reported situation.

Summary and Conclusions

The post-Messinian sedimentary succession preserved in the hills near Castagnone (Pontestura) has been studied again by means of a network of suitable cuts carried out expressly for the purpose of lithostratigraphic, magnetostratigraphic and biochronologic assessment.

This succession is formed by a Lower Complex of colluvial sediments with calcretes and carbonatic concretions of pedogenic origin, by a I Alluvial Unit of fluvial sediments with vertebrate macro- and microfauna (most significant is the arvicolid association with two *Mimomys* species together with *Ungaromys* cf. *U. nanus* and *Microtus (Allophaiomys)* sp. and by a II Alluvial Unit of fluvial sediments with scarce faunal remains, in its turn covered by a thin loessic layer with embedded Mousterian artifacts of «Würmian» age.

The same succession, though broken off by erosional hiatuses, is entirely formed by sediments with normal palaeomagnetic polarity. A reliable chronological framework has been obtained for the I AU which contains most of the faunal remains allowing for a direct correlation with the Jaramillo p.m. Subchron, between 1,070,000 and 990,000 years ago. No chronological information results from the «Lower Complex» whose true age still remains uncertain. Likewise, on the basis of the lithostratigraphic evidence alone, the upper and younger parts of the succession are apparently best referable to the Brunhes Chron.

The sedimentary facies in the I AU indicate a fluvial setting with energy decreasing from the bottom upwards, and a renewal of the flood energy at the top.

The progressive tilting of the sedimentary beds in the lowermost succession indicates also a syn-depositional tectonic deformation, more marked during the I AU deposition. Such a deformation which tilted the fluvial strata southwards would not seem to involve the II AU by itself.

The tectonic stress over the Castagnone area is seemingly related with the uplift of the North-eastern Monferrato Hills and, even though already noticeable in the earlier phases, it strengthened during the Jaramillo time span then becoming nearly exhausted before the II AU deposition.

As regards the time interval for the I A.U. mammal associations - with four arvicolid species – this must be limited to the late early Pleistocene.

The cross calibration between palaeomagnetic and palaeontological data makes it possible to refer the fossiliferous unit of the succession to the Jaramillo Subchron.

Together with the Vallonet, Untermassfeld and Collecurti localities (Chaline 1988; Kahlke 1997; Torre et al. 1996), the Castagnone site is one of the few European sites with a crucial and still poorly known early Pleistocene time span.

During the late early Pleistocene, indeed, the major Quaternary faunal turnover took place, along with the climate cooling towards the coldest middle Pleistocene glacial phases (Gliozzi et al. 1997; Markova & Kozharinov 1998; Rekovets & Nadachowski 1995; Sala et al. 1992; Turner 1992).

The reported succession thus represents an improvement of the whole European biochronological time scale.

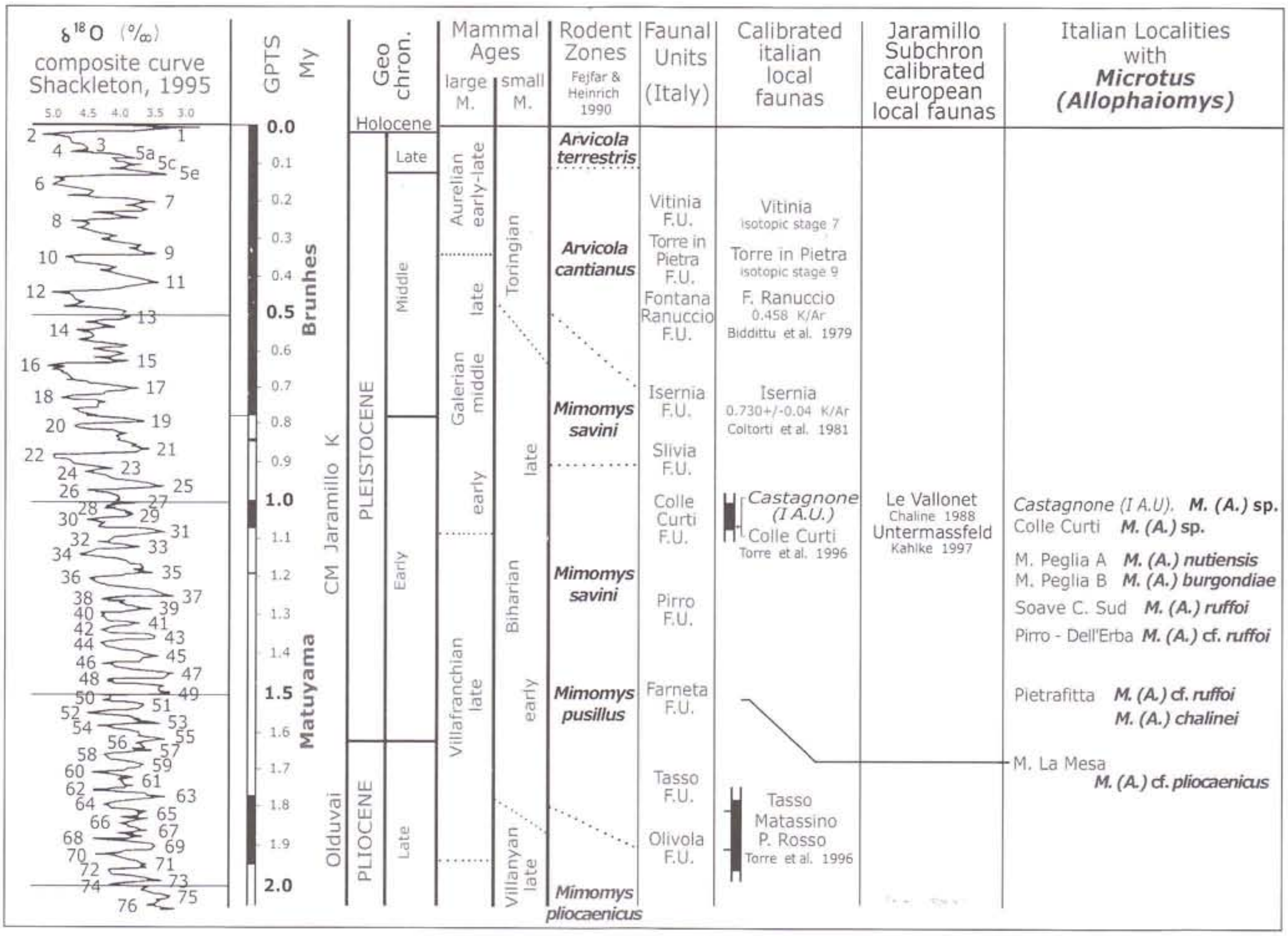

Fig. 9 - Biochronology of the Castagnone site in the frame of the Italian Pleistocene faunas (modified from Masini et al. 1998).

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REFERENCES

Birkeland P.W. (1984) - Soils and Geomorphology. Oxford (UK): Oxford University Press.

Boano P. & Forno M. G. (1996) - La successione tipo villafranchiana. Litostratigrafia. In: (F. Carraro Ed.) - Revisione del Villafranchiano nell'area-tipo di Villafranca d'Asti. *Il Quaternario,* 9(1): 38-62, Roma.

Cande S.C. & Kent D.V. (1995) - Revised calibration of the geomagnetic polarity time scale for the late Cretaceous and Cenozoic. *J. Geophys. Res.,* 100: 6093-6095, Washington.

Carraro F. & Valpreda E. (1991) - The Middle-Upper Quaternary of the Asti Basin. *Il Quaternario,* 4: 151-172, Roma.

C.G.I., 1969 - Carta Geologica d'Italia (1:100.000): Foglio n° 57, "Vercelli". Servizio Geologico d'Italia - I.G.M, Firenze.

Chaline J. (1988) - Les Rongeurs de la Grotte du Vallonet (Alpes-Maritimes), l'environnement et l'age du site. *L'Anthropologie,* 92(2), 497-499, Paris.

Fejfar O. & Horacek I. (1990) - Review of fossil arvicolids (Mammalia, Rodentia) of the Pliocene and Quaternary of Czechoslovakia. *Acta Int. Symp. Evol. Phyl. Biostr. Arvicolids,* pp. 125-132, Praha.

Giraudi C. (1981) - Presenza di depositi medio-pleistocenici intensamente deformati in Val Cerrina (Monferrato Settentrionale). *Geogr. Fis. Din. Quat.,* 4: 69-74, Torino.

Giraudi C. (1983) - Pontestura, Loc. Roletto (prov. Alessandria). Scavo paleontologico. *Quaderni della Soprintendenza Archeologica del Piemonte* 2: 143-144, Torino.

Gliozzi E., Abbazzi L., Argenti P., Azzaroli A., Caloi L., Capasso Barbato L., Di Stefano G., Esu D., Ficcarelli G., Girotti O., 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 on Italy. The status of the art. *Riv. Ital. Paleont. Strat.*, 103: 369-388, Milano.

Kahlke R.D. (1997) - Das Pleistozän von Untermassfeld bei Meiningen (Thuringen). *Monogr. Römisch-Germanisches Zentralmuseum - Forschungsinstitut für vor- und frühgeschichte,* 40/1. 418 pp, Bonn: Rudolf Habelt GMBH.

Masini F., Abbazi L., Lippi P., Sala B. & Torre D. (1998) - Review and new finds of *Microtus (Allophaiomys)* (Rodentia, Arvicolidae) from the Early Pleistocene of the italian peninsula. *Paludicola,* 2(1): 78-90, New York

Markova A. & Kozharinov A. (1998) - *Allophaiomys* of the Southern Russian plain. *Paludicola,* 2(1): 62-69. New York.

Meulen A.J., van der, (1973) - Middle Pleistocene smaller mammals from the Monte Peglia (Orvieto, Italy), with special reference to the Phylogeny of *Microtus* (Arvicolidae, Rodentia). *Quaternaria*,17: 1-144, Roma.

Rekovets L.I. & Nadachowski A. (1995) - Pleistocene voles (Arvicolidae) of the Ukraine. *Paleontologia i evolucio,* 28-29: 145-245. Sabadell.

Sala B., Masini F., Ficcarelli G., Rook L. & Torre D. (1992) – Mammal dispersal events in the Middle and Late Pleistocene of Italy and western Europe. *Courier Forsch. Senckenberg,* 153: 59-68, Frankfurt a M.

SITEC (1984) - *Studio geologico e geomorfologico dell'Area PO 1.* ENEL: Internal Report.

Torre D., Albianelli A., Bertini A., Ficcarelli G., Masini F. & Napoleone G. (1996) - Paleomagnetic calibration of Plio-Pleistocene mammmal localities in central Italy. *Acta Zool. Cracov.*, 39(1): 559-570, Krakow.

Turner A. (1992) - Villafranchian-Galerian larger carnivores of Europe: dispersion and estinctions. *Courier Forsch. Senckenberg,* 153: 153-160, Frankfurt am M.